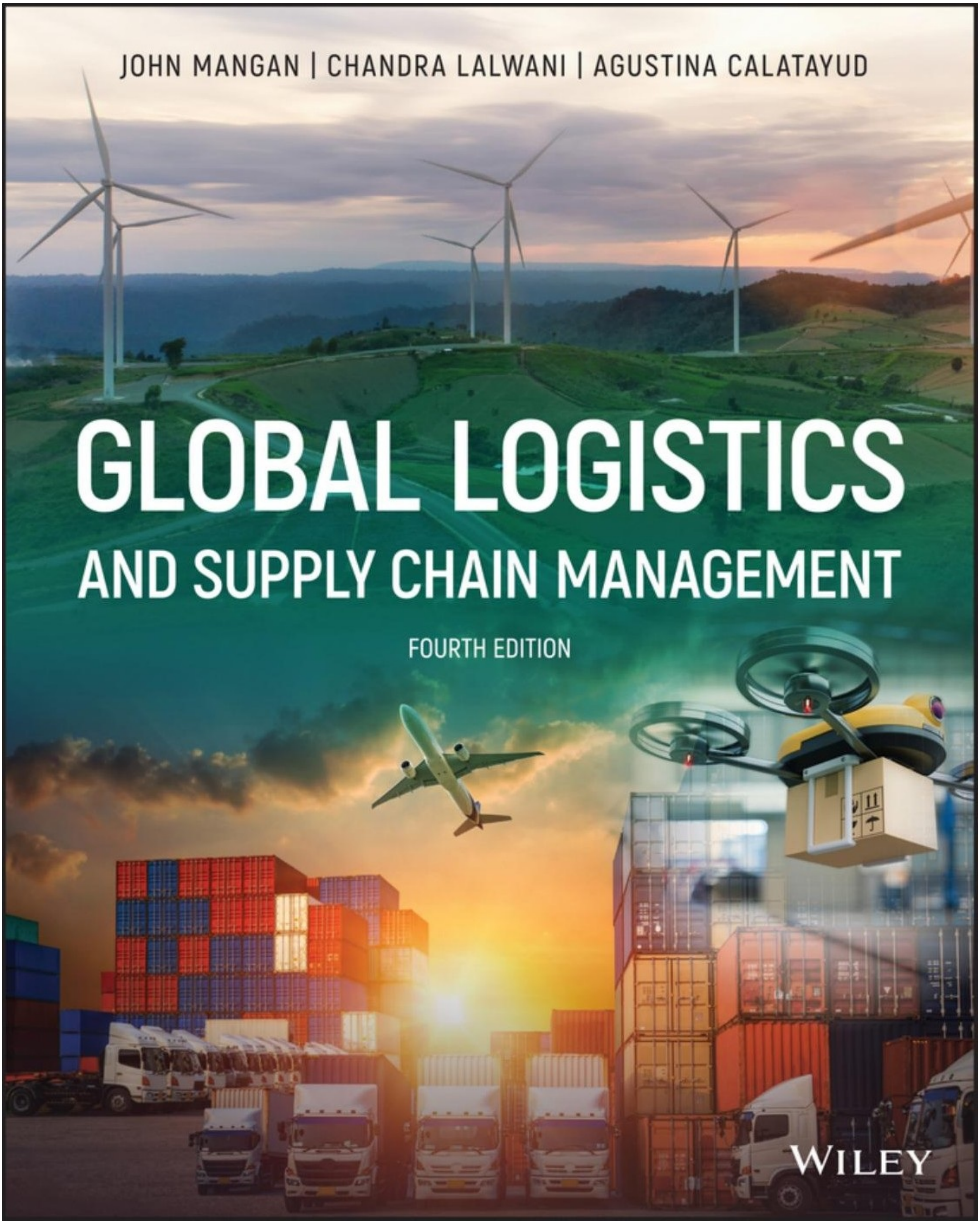
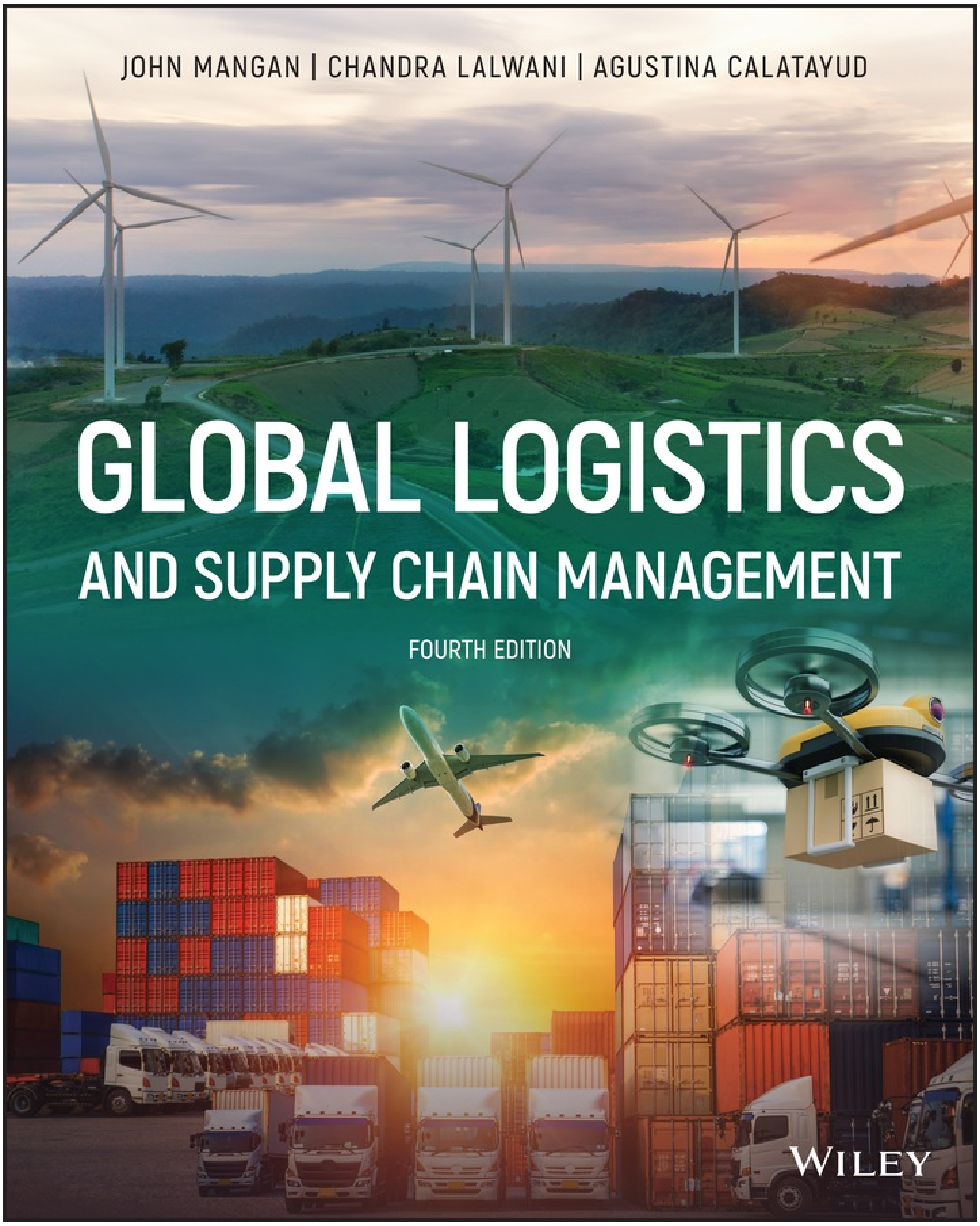


JOHN MANGAN | CHANDRA LALWANI | AGUSTINA CALATAYUD

GLOBAL LOGISTICS AND SUPPLY CHAIN MANAGEMENT

FOURTH EDITION

WILEY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Global Logistics and Supply Chain Management

Fourth Edition

John Mangan

Chandra Lalwani

Agustina Calatayud

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Dedication

Maeve, Cathal, Eibhlín and Eoghan

Mohini, Nikita, Nishant,

Anoushka, Ishika and Shay

Juan, Marcela and Oscar

About the Authors

D. John Mangan is Professor of Marine Transport and Logistics in the School of Engineering at Newcastle University in the UK and Visiting Professor at the School of Business, Trinity College Dublin. He has spent his entire career around the logistics sector, starting as an air freight clerk, then as a civil servant focused on marine transport, and following this he commenced his academic career – his qualifications include Master's Degrees from both Lancaster and Cranfield Universities, and he completed his PhD at the Logistics Systems Dynamics Group in Cardiff University. He previously held academic roles at: University College Dublin, the Irish Management Institute, as a Fulbright Scholar at Boston College, and the University of Hull (where he was founding Director of the University of Hull Logistics Institute) prior to taking up his current position at Newcastle University in 2008.

Chandra Lalwani is Emeritus Professor of Supply Chain Management at the University of Hull Business School. He has also held positions as Adjunct Professor at RMIT University in Australia and as Visiting Professor at Newcastle University in the UK. He holds a BEng in Electrical Engineering, an MEng in Control Systems and another MEng in Systems Engineering. He obtained his PhD from the University of Wales in 1978 based on his research on the dynamic modelling of commodity flow systems. Prior to joining the University of Hull, he taught at Cardiff University Business School where he was also responsible for doctoral research in logistics and operations management. He is editor emeritus of the *International Journal of Logistics Management* published by Emerald.

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[*] The opinions expressed in this publication are those of the author and do not necessarily reflect the views of the Inter-American Development Bank, its Board of Directors or the countries they represent.

Preface

Semper Discens – Always Learning

We are delighted to present the fourth edition of our textbook which builds upon our first edition (published in 2008), second edition (published in 2012) and third edition (published in 2016) and to welcome Dr Agustina Calatayud to the author team. We acknowledge the contributions of Dr Tim Butcher (University of Tasmania) who was co-author on the first and second editions and Dr Roya Javadpour (California Polytechnic State University) who was also co-author on the second edition. We acknowledge too the contributions of the following colleagues who provided various chapters in previous editions: Dr Peter Baker, Professor Chuda Basnet, Professor Paul Childerhouse, Mr Noel McGlynn, Mr Martin Murphy, Dr Helen Peck, Professor Shams Rahman, Dr Risto Talas and Professor Mike Tayles. This book traces its origins to the University of Hull Logistics Institute in the UK where Mangan, Lalwani and Butcher worked together between 2005 and 2008. It was during this time that we recognised the need for this textbook which we are glad to say has been very well received by students, practitioners and lecturers. In this fourth edition, we have endeavoured to again produce a comprehensive book with the following key characteristics:

- *Be concise* – logistics is a very pragmatic subject, and it has been our intention throughout to 'stick to the point'. We hope that you, the reader, will appreciate this. Notwithstanding such intended brevity, we have endeavoured to cover both practical and strategic aspects of the subject matter. The book is neither a 'how to' cook book, nor is it a high-level strategy book with little relevance to practice. The aim of the book is to convey to both advanced students and practitioners the diverse operational and strategic content of the subjects of logistics and supply chain management.
- *Truly global, up-to-date perspective* – the world is changing daily, and the typical 'Western' worldview no longer dominates. As we will see in the book, logistics is a key driver of globalisation and a facilitator of international trade and development. We have thus endeavoured to reflect these characteristics by adopting a truly global perspective and hope that the book will appeal to students regardless of where they are located. The context of logistics is constantly shaped by emerging trends and new technologies, and we have tried to ensure that the book is as up to date as possible and takes cognisance of these trends and technologies. As we note above *semper discens* – we too are always learning in this fascinating and fast moving subject.
- Sadly, despite much progress, today's world still contains many divisions, conflicts, tensions and inequalities. We have attempted to be aware of these while fully embracing a *neutral and non-political perspective*.
- *Pedagogical approach* – we have endeavoured to use a variety of pedagogies in this book, which we hope will create a fertile learning platform for the reader. Both long(er) and short(er) case studies are included and are intended to highlight key issues in a focused manner. Key points are detailed in separate text boxes, and this should also help with revision. Key terms are in **bold** when first used to indicate that explanations for these terms are also given in the **glossary** at the end of the book. We hope that you find these various features useful. There are two other features of our pedagogical approach which we believe are especially important.

Firstly, the authors named on the cover are not the only people to have contributed to this book. We are very fortunate to have contributions from various experts in specific areas of logistics and supply chain management. They have written case studies based on their specific areas of expertise and which we believe add to the richness of this book over and above what we could have achieved working on our own. The second pedagogical feature we wish to highlight is the mix of qualitative and quantitative content in this book. We are of the view that many logistics and supply chain management books tend to occupy one of two opposite positions, either containing a large share of quantitative material or else none at all. We believe that a certain level of quantitative aptitude and knowledge is an important feature of most logistics and supply chain managers' jobs (for example in the areas of logistics costs analysis and inventory management). Many such managers, however, do not routinely engage in sophisticated mathematical analysis; this is usually the domain of operations researchers, engineers and management accountants. We thus aim to convey the necessary quantitative features of logistics and supply chain management, and at the same time not burdening the reader with excessive quantitative analysis.

These various characteristics and perspectives adopted in the book are discussed further in Chapter 1 which details the book's framework. The book is divided into five parts, again this is discussed and the content of each part elaborated in Chapter 1. In this fourth edition, we have restructured the book and updated relevant content from the third edition. For example, new cases have been added, data in all chapters have been updated and new chapters have been added on topics such as systems and networks and data flows and digitisation.

BOOK COMPANION WEBSITE

Our text is also supported by additional teaching and learning resources, which are available on the companion website at www.wiley.com/go/mangan/globallogistics4e. They include PowerPoint slides, suggested answers to end-of-chapter questions and case teaching notes for lecturers. Instructors will also find an online glossary and multiple choice quizzes (we are especially grateful to Professor Vivek Natarajan at Lamar University for his kind help with these quizzes).

RELATIONSHIP TO OTHER DISCIPLINES

Chapter 1 details the various factors that have led to the evolution of logistics and supply chain management. Figure 1 outlines the various disciplines which we believe logistics and supply chain management are closely linked to. In fact, it is only in recent years that third-level courses and explicit career paths have emerged in logistics and supply chain management. It is thus often the case that many practitioners today will have backgrounds in one or other of the disciplines illustrated in Figure 1. Various issues pertaining to some of these disciplines are discussed in this book.

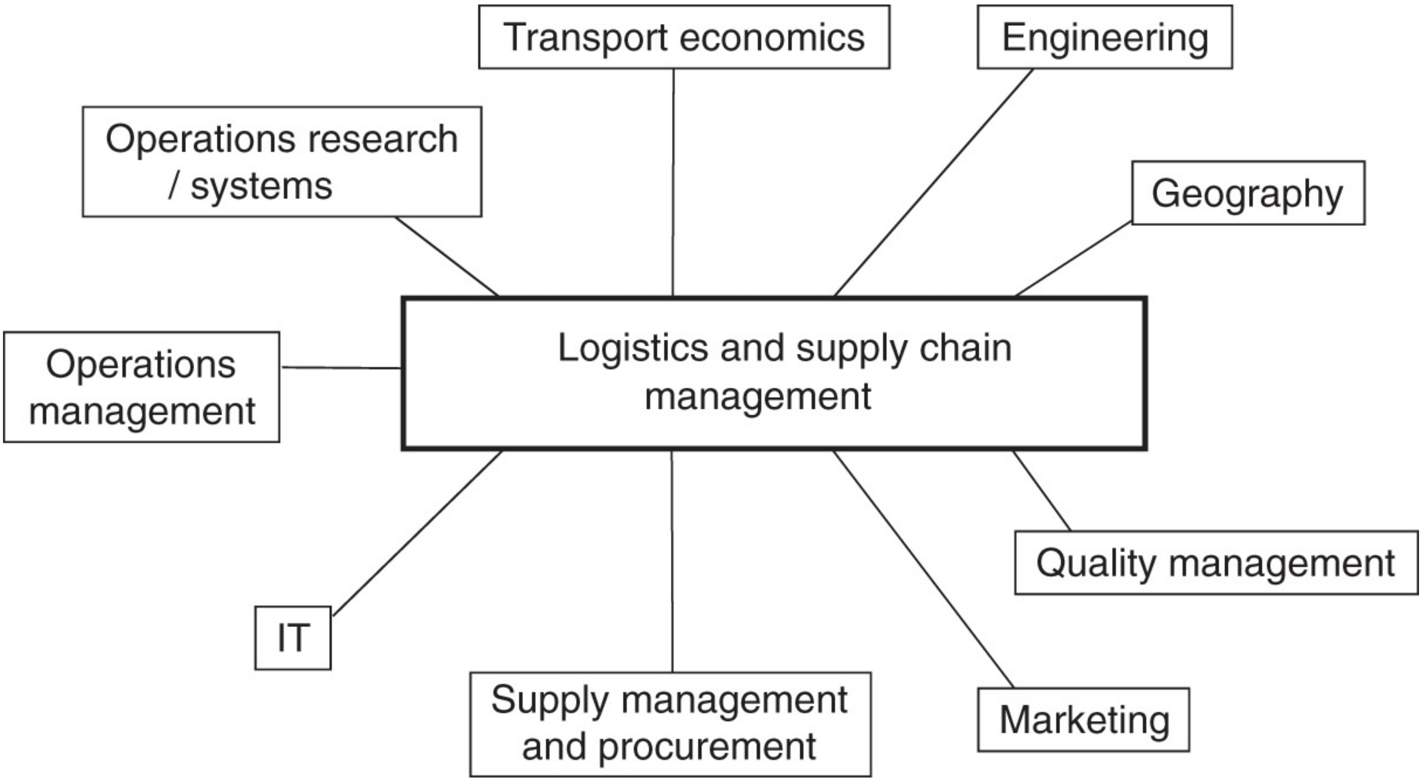

Figure 1 Links to other disciplines

Perhaps the discipline to which logistics and supply chain management is most often closely linked to is *operations management*. As we will see in Chapter 1, supply chains involve three interdependent flows: materials, data, and resources. We discuss these flows in depth throughout the book. The study of operations management is also concerned with these flows. We are, in fact, of the view that this book could also be effectively used for teaching more general operations management courses, and especially those with a particular emphasis on logistics and supply chain issues. It is becoming increasingly apparent that many operations managers today are engaging more and more in wider supply chain management activities. As processes become increasingly automated and simplified, the focus of many operations managers is shifting to service issues beyond core manufacturing and to flows and interactions along the supply chain. All of these issues are discussed in this book.

Logistics and supply chain management are ever-changing and demanding disciplines, but provide attractive and rewarding opportunities to people who wish to work in these areas. The purpose of this book has been to equip you, the reader, regardless of whether you are a student or a practitioner, with the necessary knowledge and skills to allow you to work more effectively in these areas. We hope you enjoy working with this book and find it of benefit.

John Mangan, Chandra Lalwani and Agustina Calatayud

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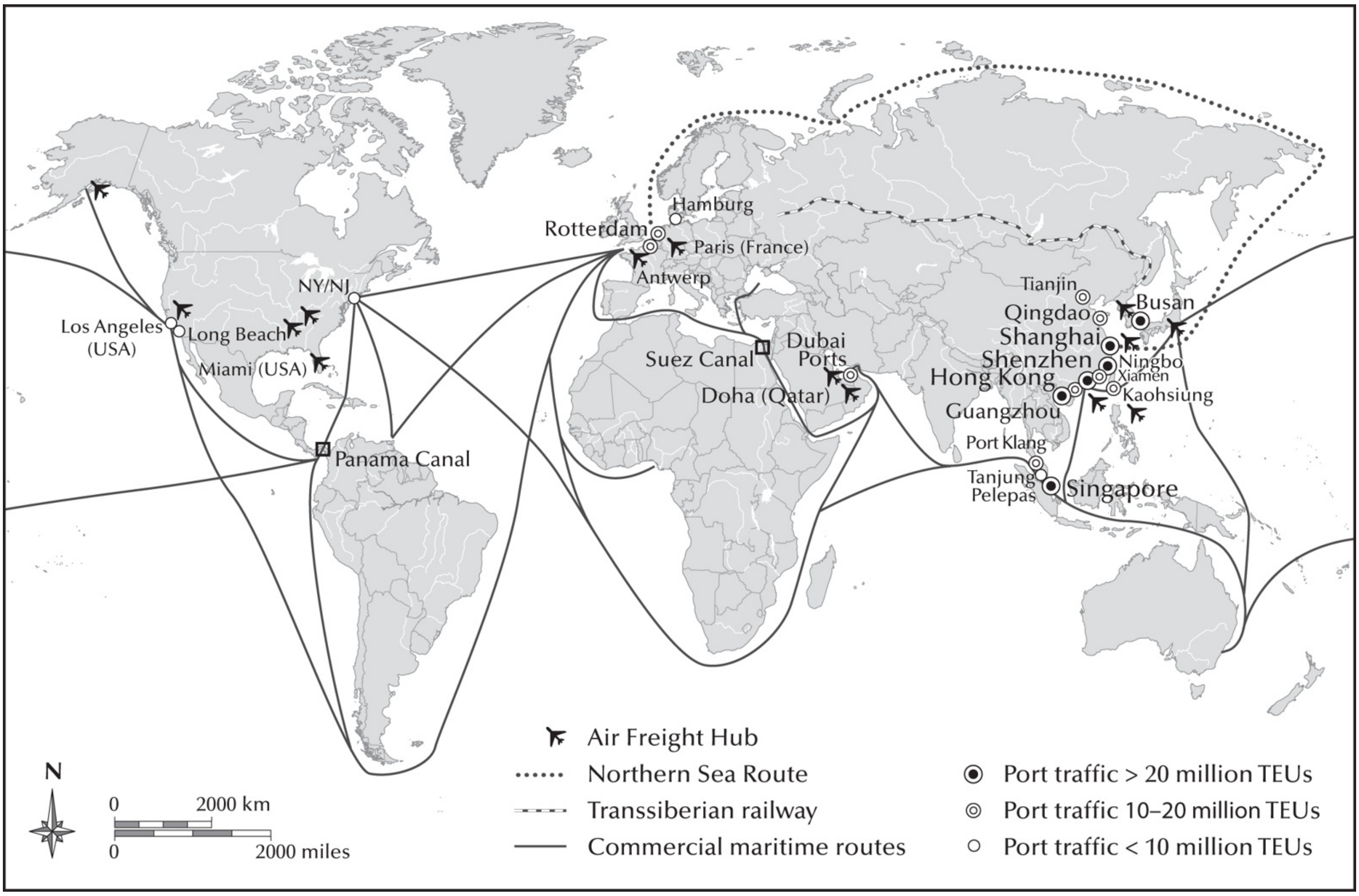
Many people have helped us on our journey to produce the first, second, third and now fourth editions of this book over the past 12 or so years. First and foremost, the book would not exist but for the continuing support and advice received from many people at John Wiley & Sons Ltd. These include Lise Johnson, Judy Howarth, Jennifer Manias and Vinolia Benedict Fernando; special thanks too to the various anonymous reviewers, professional proof readers and typesetters whom we have dealt with across all four editions. We thank them all for their professionalism and patience. Thanks also to the many lecturers and students who have used the previous editions: we thank them for their feedback which is always beneficial. Thanks too to our Universities, our many colleagues and our families, all of whom have given us the space and encouragement to complete this time-consuming, yet rewarding, project. We wish to acknowledge with gratitude the various copyright holders for allowing us to use certain material. Special thanks to Dr Hassiba Benamara from UNCTAD's Trade Facilitation Section who kindly provided us with very valuable data for Chapter 2.

Our esteemed colleague Dr Tim Butcher (University of Tasmania) was our co-author on the first and second editions; we are most grateful for his contributions. Similarly, Dr Roya Javadpour (California Polytechnic State University) was a co-author on the second edition and we thank her too for her contribution.

We sincerely thank the various case study contributors whose expert inputs have added considerably to our own endeavours: Mr Ciarán Brady (PLS Pharma Ireland and UK), Dr Elizabeth Jackson (Curtin University), Professor Andrew Potter (Cardiff University), Ms Anne Nagle (Nagle Business Solutions), Dr Seamus O'Reilly (University College Cork), Dr Aris Matopoulos (Aston University), Dr Panagiotis Nikolaou (Oman Logistics Centre), Professor Jason Monios (Kedge Business School) and Professor Rickard Bergqvist (Gothenburg University).

Map



Part One
Context

1
Introduction

LEARNING OBJECTIVES

- Explain the origins of both logistics and supply chain management.
- Define both terms and outline how logistics and supply chain management differ from each other.
- Outline how theory develops in logistics and supply chain management.
- Highlight the importance of these areas in both manufacturing *and* services contexts.
- Identify how best practice logistics and supply chain management can yield both cost reduction *and* value addition.

Show how supply chains have a major influence on society.

INTRODUCTION

This chapter lays the foundations of the textbook and explains the origins and applications of logistics and supply chain management, as well as giving descriptions of key concepts. A framework for the textbook is developed and this illustrates where each chapter fits in the overall schema of the book, while the various perspectives adopted by the authors when writing this book are also described.

The chapter comprises seven core sections:

- The evolution of logistics and supply chain management (SCM)
- What is logistics?
- What is supply chain management?
- Distinguishing logistics and supply chain management
- Theory development in logistics and supply chain management
- Applications to manufacturing *and* services
- Book framework

THE EVOLUTION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT (SCM)

Both **logistics** and SCM are fascinating and exciting areas that touch all of our lives. Just think of the many different products that are purchased and consumed each day – how do they reach the customer and at what cost? Although logistics and SCM are areas that have only come to widespread prominence in the last couple of decades, the reality is that they have roots which run much longer than that. Later in the chapter we will trace the word 'logistics' back to its original military application in ancient Roman and Byzantine times. One of the first references in the academic literature to the notion of taking a supply chain view (although that specific term was not used) is in what is widely regarded as a seminal paper by the MIT academic Jay Forrester published in the *Harvard Business Review* in 1958.[1] In that paper, Forrester put forward a schematic of the production–distribution system (what we would call today a supply chain) and he simulated how inventory levels can fluctuate along that chain.

> The commonly accepted abbreviation for supply chain management is SCM, so that abbreviation will be used in the remainder of this book.

Not only are logistics and SCM key aspects of today's business world, but they are also of importance in the not-for-profit and public sectors. In addition, while the origins of much logistics thinking and practice are in a manufacturing context, we are witnessing increased and highly successful application of logistics and SCM principles in a services context also (just think of the efficiencies which have been driven into many service-based activities such as banking and hospitals where the emphasis has shifted to serving more customers, better, faster, cheaper). We will return to this topic in Chapter 4, which will focus on services supply chains and also introduces the concept of servitisation.

The terms logistics and SCM, although often used interchangeably, are distinct and will be defined later in the chapter. First, however, it is appropriate to examine how some key developments over the past couple of decades have shaped the evolution of these important areas. In fact six separate and important developments, each of which evolved largely independently, can be identified and are now detailed.

Reduced transport intensity of freight

In the past, international trade was dominated by bulky raw materials. Times have, however, changed and in-process and finished products, not raw materials, now play a much greater role in world trade. Some simple examples illustrate this clearly. Compare the value of the various consumer electronics products transported around the world today with the bulky, low value products that were being transported 100 years ago. Agricultural produce, and indeed other comparatively high-volume/low-value freight, does still of course traverse the world but, in general, the size and value of the freight which is transported today is very different to that of times past. In the case of agriculture, many food producers, rather than transporting bulky foodstuffs, now tend to try and 'add value' to the product: for example rather than ship live chickens, the international poultry trade generally comprises processed, ready-to-cook chicken. The same is true for many other trades, across a range of industries, whereby manufacturers try and increase the value-to-volume ratio of products being shipped. We will see in later chapters that there is also an increasing trend towards having the final value-adding stages in the production of various products as close as possible to the final customer; in fact, in some cases the customer actually completes these latter stages of production (facilitated, for example, by 3D printing).

In logistics when we use the term 'to ship' we do not necessarily mean that the freight travels onboard a ship – the term is generally used to mean that the freight travels (by any mode(s) of transport) from one place to another.

Higher value freight is better able to 'absorb' transport costs than is lower value freight, with the 'transport cost penalty' imposed by having to move freight over greater distances often being somewhat offset by the fact that the freight is of higher value. Hence, we refer to a generally reducing **transport cost sensitivity** of freight.

For many individual shipments: increased value/decreased volume = lower transport cost sensitivity.

Indeed for some products it is now not even necessary to ship physical product at all. Just think for example of the way much software is now transmitted around the world via the internet. This replacement of physical product by virtual product is referred to as **material substitution**.

Falling product prices

In many markets, increased competition and falling marketplace prices have forced numerous companies to reduce costs. Just think of the falling prices of various electronics products in recent years such as DVD players, or that the prices of many automobiles have stayed flat in real terms at best, despite the fact that product specifications, performance and quality have improved dramatically. This has forced companies to focus on other areas where savings can be made, and the storage and movement of inventory is a key area in this regard. Thus companies will seek to ensure that any products (especially those with flat or declining value) being transported are configured (in terms of product design, packaging, etc.) so as to reduce as much as possible their transport cost sensitivity.

Deregulation of transport

The important role played by transport in logistics will be discussed later in the book. There are five principal modes of transport namely air, road, water, rail and pipeline (in addition the Internet can be regarded as a sixth transport mode). In recent decades transport markets in many countries have been **deregulated** by various governments. The essence of effective deregulation is that by removing unnecessary barriers to competition, markets become more contestable and (in theory at least) prices should come down and service should improve. We say 'in theory' because the reality in some deregulated markets has been somewhat different (with private monopolies sometimes replacing public ones) but, in general and over the long run, deregulation has had a positive impact on many transport markets, leading to the provision of both more and cheaper services. This of course in turn makes it easier and more efficient to move freight around the world.

A good example is that of *FedEx*, a company which today has one of the world's largest fleets of freighter aircraft. Constrained by burdensome government regulations in the United States in the 1970s, it was not until the late 1970s with the deregulation of the US air freight market (which relaxed the rules governing both who could participate in the market and how they would be allowed to operate) that the company was able to expand and grow.

Productivity improvements

Up to the mid-1950s most maritime freight was carried on bulk vessels. This began to change, however, when some ship owners started to carry freight containers. In 1956 an iconoclastic entrepreneur Malcom McLean put 58 aluminium truck bodies aboard an ageing tanker ship (called the *Ideal-X*) which set sail from Newark, NJ to Houston, TX in the United States. This marked the start of containerised transport as we know it today.[2] Containers can be stacked on top of each other onboard the ship, thus allowing very efficient space utilisation and cargo handling. Furthermore, freight could now move from origin to destination across many modes and services with greater ease of handling. The introduction and growth of containerisation led to huge changes in ports which previously were dominated by large workforces responsible for manual handling of bulk cargo. Containerisation also reduced the costs of transporting freight by maritime transport and significantly improved its efficiency. Containerisation spread to other modes and various alliances were formed between combinations of transport companies. Chapter 7 discusses containerisation in detail.

There were of course many other improvements in transport, for example in propulsion technologies (faster transport) and the application of various information and communications technologies. Companies such as DHL, FedEx and UPS have pioneered the use of barcoding and online tracking and tracing of freight, developments which also increase the efficiencies of logistics systems. More recent technologies, such as radio frequency identification (RFID) and blockchain, should also drive more efficiencies into logistics systems. Technology is a very important component and enabler of logistics and SCM, and subsequent chapters will look in detail at information flows and technology applications.

Emphasis on inventory reduction

The penultimate trend to consider has been a shift of management and financial attention into analysing where an organisation's funds are tied up. Inventory management will be covered in detail in Chapter 10, but suffice to say for now that many organisations have become increasingly aware of the fact that often significant funds are tied up in unnecessary inventory. Furthermore it became obvious in the latter years of the 20th century that often inventory was not well managed. During the decades which followed World War II the responsibility for, and management of, inventory in many firms was very fragmented. The various functions in which inventory played a key role, for example transport, warehousing, purchasing and marketing, were usually considered by managers to be separate and distinct. However, firms began to realise that cost savings and significant efficiency gains could be harnessed from more integrated and focused management of inventory. As far back as 1962 the late Peter Drucker, one of the foremost management thinkers of the 20th century, wrote a celebrated *Fortune* magazine article entitled 'The Economy's Dark Continent'.[3] In this article he suggested that distribution represented the last frontier for significant cost reduction potential in the firm.

Increased market competition and customer requirements also led to the necessity to see improvements in the management of inventory as an essential competitive weapon. In the increasingly competitive, global marketplace firms began to realise that they could leverage marketplace advantage through superior logistics performance. Cost savings were identified through eliminating unnecessary inventory and just-in-time (JIT) deliveries became normal operating practice in many industries. Indeed many companies came to recognise the risks associated with holding too much stock which rendered them less flexible in their ability to respond to changing demand conditions.

Changes in company structure

A more recent trend concerns changes in how companies are structured and operate. In recent years many companies have become less **vertically integrated** (a concept that implies ownership or at least control of upstream suppliers and downstream customers) and more specialised. Outsourcing has become more common, with suppliers playing a more central role for many manufacturers (subsequent chapters in the book will consider in detail strategies and practices such as JIT, outsourcing, etc.). Many companies have also come to realise that so-called functional or silo-based thinking (viewing the various departments within the firm as separate and non-overlapping entities) will only hinder the overall performance of the company and they have as a result endeavoured to ensure that the various functions and activities across the company are integrated more closely. In more recent years in particular, competition based on *time*, for example order to delivery time, has become a key success factor (KSF) in many markets.

All of the above six trends, while they emerged independently, have both placed an increased emphasis on the role of transport and inventory, and have led to improvements in the way freight is handled and moved around the world. They have led to what is often termed the *supply chain revolution*.

Before proceeding further it is important to highlight one small, but important, distinction. People often use the terms 'freight' and 'cargo' interchangeably, however, they are in fact distinct, at least in terms of their use within the logistics sector. In essence: *cargo = freight + mail*. Mail, also known as post, is of course still a very important component of trade and commerce, despite the many technological advances which shape today's world. It is an important and regular source of revenue for many transport companies, especially airlines. Sometimes people also use the term 'goods', usually to refer to freight (not cargo), but we will try to avoid use of this term. Another term worth defining at this juncture is **consignment** which the *Collins English Dictionary* defines as 'a shipment of goods consigned'; the **consignor** is the term used for the company (e.g. a manufacturer) who sends the consignment and the **consignee** is the term used for the company (e.g. a retailer) who receives the consignment.

THE ROLE OF LOGISTICS IN NATIONAL ECONOMIES

The size of the logistics sector varies from country to country. In the United States for example, business logistics costs reached €1.6 trillion in 2018 (accounting for approximately 8% of GDP that year).[4]

Economists note that a variety of factors determine the wealth and rate of growth of national economies. These factors are many and varied, and range from available energy sources to institutional factors such as a good banking system. In the late 1990s the US economy experienced a rapid rise in productivity. Closer examination of the economic data by researchers at the McKinsey and Company Global Institute revealed the impact on national productivity of developments in the retail sector, and most notably the impact of the giant retailer Walmart.

According to Beinhocker (2006)[5] 'Walmart's innovations in large-store formats and highly efficient logistical systems in the late 1980s and early 1990s enabled the company to be 40 percent more productive than its competitors'. Walmart has been a global leader in best practice retail logistics, with many other retailers imitating some of its strategies. In the case of the US economy, the increases in Walmart's productivity led to an 'innovation race' with suppliers and other retailers also seeking to enhance their productivity, in turn leading to a rise in whole-sector productivity. Walmart is one of the world's largest companies and in the context of the discussion in this chapter it is interesting to observe the considerable impact and importance of how it organises its logistical systems.

WHAT IS LOGISTICS?

Now that the key developments which have shaped the evolution of logistics and SCM have been outlined, it is appropriate to attempt to describe and define these concepts. Some authors have pointed to the often confusing and overlapping 'plethora of terminology' that is used in logistics and SCM.[6] While at one level defining logistics and SCM might seem an elementary task, it is in fact critically important to define, and differentiate, these terms correctly at this juncture as this will shape your understanding and interpretation of the contents of this book. First to logistics. The *New Oxford Dictionary of English* defines logistics as:

> the detailed coordination of a complex operation involving many people, facilities, or supplies. Origin late 19th century in the sense 'movement and supplying of troops and equipment', from French *logistique*, from *loger* lodge

There are various views with regard to the linguistic origins of the word, with some pointing to the Greek adjective *logistikos* which means 'skilled in calculating' (and which most likely gave us the mathematical term *logistic*). It has also been noted that in Roman and Byzantine times there was a military official called *Logista*. In more recent times we have seen, as in the above definition, the French words *logistique* and *loger*. Most agree that the word entered the English language in the 19th century, with its application generally seen in military terms and concerned with the organisation of moving, lodging and supplying troops and equipment.

These origins suggest then that logistics has something to do with applications of mathematics and is primarily a military concern. Indeed the field of military logistics has evolved quite considerably and is now quite sophisticated. Similarly there are many useful applications of mathematics to logistics. Today, however, logistics spans beyond the military and mathematical domains. It was in fact only in the latter decades of the 20th century that the term logistics entered into common non-military use. The US-based Council of Supply Chain Management Professionals (www.cscmp.org) suggests the following definition of logistics and which we adopt in this book (note: we have added the underlining (of transportation and storage) to the original definition):

> **Logistics** is the process of planning, implementing, and controlling procedures for the efficient and effective <u>transportation</u> and <u>storage</u> of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements. This definition includes inbound, outbound, internal, and external movements.

Another way of understanding what is involved in logistics is to see it as including various (actually we can think of at least eight) 'rights': getting, in the right way, the right product, in the right quantity and right quality, in the right place at the right time, for the right customer at the right cost. Some of these 'rights' may be obvious, others perhaps less so. For example, the right customer: in many industrial locations today typically many different companies will be co-located on the one site. Even on the one production line there may be various subcontractors collaborating with the manufacturer and there will be clear demarcation lines with regard to who has ownership of what, where and when. Therefore getting the product to the right place may be only half the journey; the challenge would be to get it to the right customer at this right place. To consider briefly 'the right way': there is now a substantial and growing interest in environmental and related issues, and Chapter 16 deals in detail with sustainability. There is thus a necessity to get the product to the customer in the 'right way', meaning in such a way as to cause as little damage as possible to the environment.

> Logistics involves getting
> ... the right product
> ... in the right way
> ... in the right quantity and right quality
> ... in the right place at the right time
> ... for the right customer at the right cost

Logistics has been described as 'just trucks and sheds' and concerned with 'just wheels and walls'. As the discussion above illustrates, and notwithstanding the fact that trucks and sheds (warehouses) are indeed important components of logistics systems, it is obvious that logistics encapsulates much more than this.

Ensuring optimum performance with regard to some of these 'rights' may be easy for many, but getting all correct together can be quite a challenge. For example in both retail distribution and in high-value manufacturing, it is now quite common to offer suppliers quite specific and narrow time windows within which to deliver freight. Not only will the suppliers be expected to execute deliveries within these strict time limits, but also they may be expected to deliver directly onto a specific retail outlet shelf or factory production cell.

WHAT IS SUPPLY CHAIN MANAGEMENT?

The various functions that now comprise the discipline of supply chain management were regarded as separate and distinct, and managed accordingly, up to the 1960s and 1970s. This began to change radically, however, in the 1980s and beyond with firms realising the benefits of integration and, more recently, collaboration.

The term supply chain management (SCM) was originally introduced by consultants in the early 1980s and, since then, has received considerable attention. The supply chain is a much wider, intercompany, boundary-spanning concept, than is the case with logistics. Figure 1.1 illustrates the evolution and structure of the integrated supply chain.

> The **supply chain** is the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.

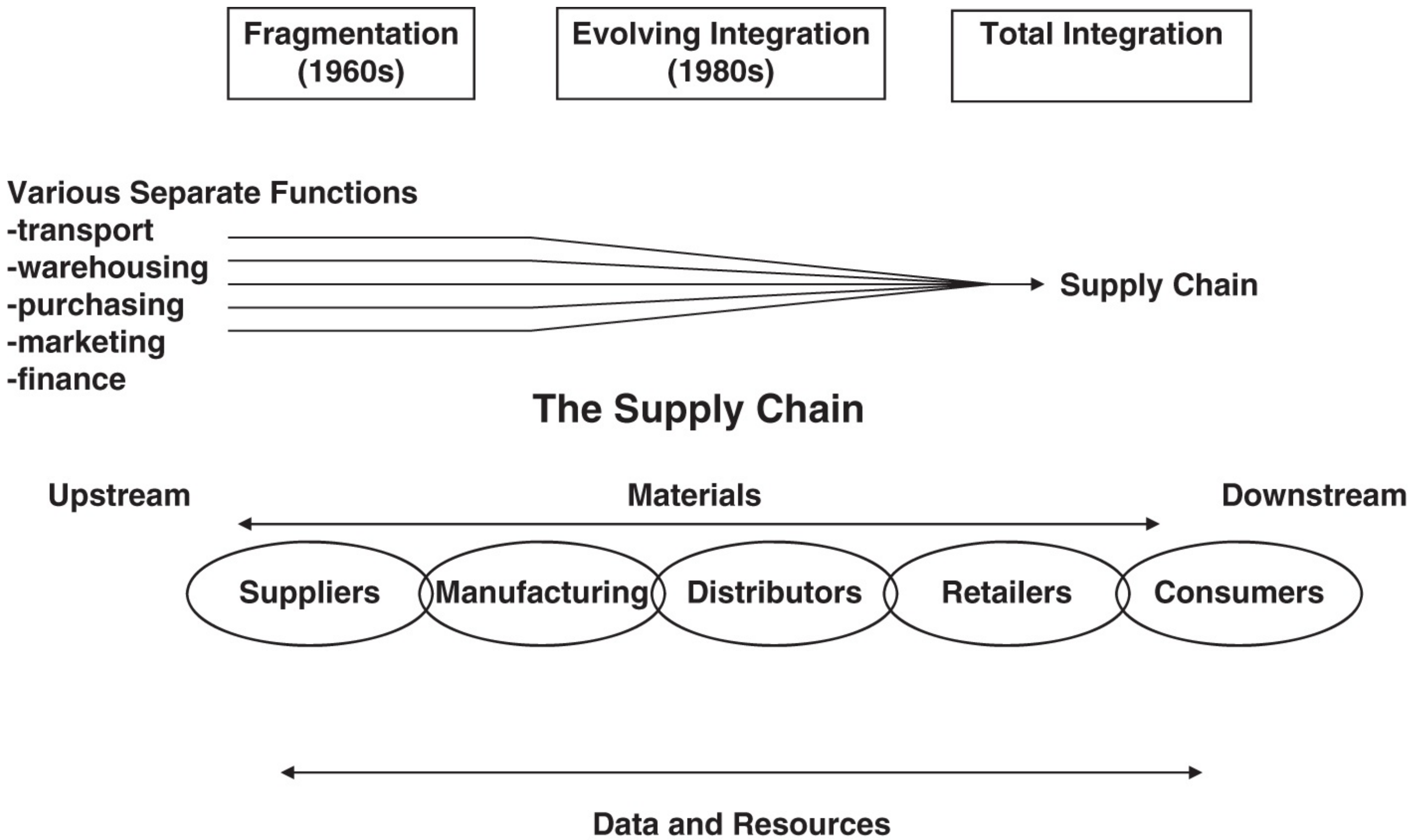


Figure 1.1 The evolution of the integrated supply chain

Martin Christopher, Emeritus Professor of Marketing and Logistics at Cranfield School of Management and one of the key thought leaders in logistics and SCM spanning the past several decades, suggests that the **supply chain** is the network of organisations that are involved, through **upstream** (supplier end of the supply chain) and **downstream** (customer end of the supply chain) linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.[7] He distinguishes SCM from vertical integration as SCM does not necessarily imply any ownership or control of supply chain partners. In this book we adopt Professor Christopher's description of the supply chain.

It is our view that supply chains encompass a number of key flows:

- Physical flows of materials
- Flows of data and information that inform the supply chain
- Resources (especially finance, but also others such as people and equipment) which help the supply chain to operate effectively. Furthermore, not all resources in the supply chain are tangible, for example good quality intercompany relationships are often cited as a highly important – yet intangible – ingredient of effective supply chains.

We put forward the following definition of SCM:

> **Supply chain management (SCM)** is the management, across and within a network of upstream and downstream organisations, of both relationships and flows of material, information and resources. The purposes of SCM are to create value, enhance efficiency and satisfy customers.

This definition largely concurs with what can be regarded as a consensus definition of SCM. To develop such a definition, Stock and Boyer examined a total of 166 definitions of SCM that appeared in the literature, and using various analytical techniques developed the following consensus definition of SCM. It is longer than our definition above, but worth noting as it is more detailed:

> SCM is the management of a network of relationships within a firm and between interdependent organisations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximising profitability through efficiencies and achieving customer satisfaction.[8]

An important feature to note with regard to SCM is that it involves taking an 'end-to-end' perspective from the upstream to the downstream end of the supply chain. Depending upon the sector being looked at, terminology such as the following can be used to describe the end-to-end supply chain:

- Farm to fork (Food)
- Sketch to store (Clothing)
- Dust to rust (Cars and Machinery)
- Teeth to tail (Military)

We have seen many other variations of this terminology – for example, in the mushroom industry they take a supply chain perspective of 'spore to store'. A final important point to note at this juncture is that increasingly it is the case that supply chains compete more so than individual firms and products (this concept was first mooted by Professor Christopher in the early 1990s). This represents something of a paradigm shift in terms of how people usually view the global business environment; this important issue is discussed further in particular in Chapter 3 which deals with supply chain strategy.

> Note the use of the word *network* in the definition of the supply chain above. While the supply chain is usually depicted as a linear chain (as in Figure 1.1), it is perhaps better to envisage it as a *multidimensional network of collaborating entities*. Furthermore, such networks can be more fully understood as *systems*; taking a systems view highlights the impact of the interaction that occurs between the various entities. In logistics and SCM these various entities are sometimes referred to as *links* (for example transport services) and *nodes* (for example warehouses). The various links and nodes can of course contemporaneously play different roles across multiple supply chains. The term 'echelon' is sometimes also used to refer to different parts of the supply chain.

DISTINGUISHING LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Now that logistics and SCM have been defined, the issue of how both terms differ needs to be considered. This is in fact a question which has led to much debate with people often coming up with their own distinctions. It has also been studied by a number of academics.[9] Larson and Halldorsson for example surveyed international logistics/SCM experts and identified four different perspectives which are illustrated in Figure 1.2.

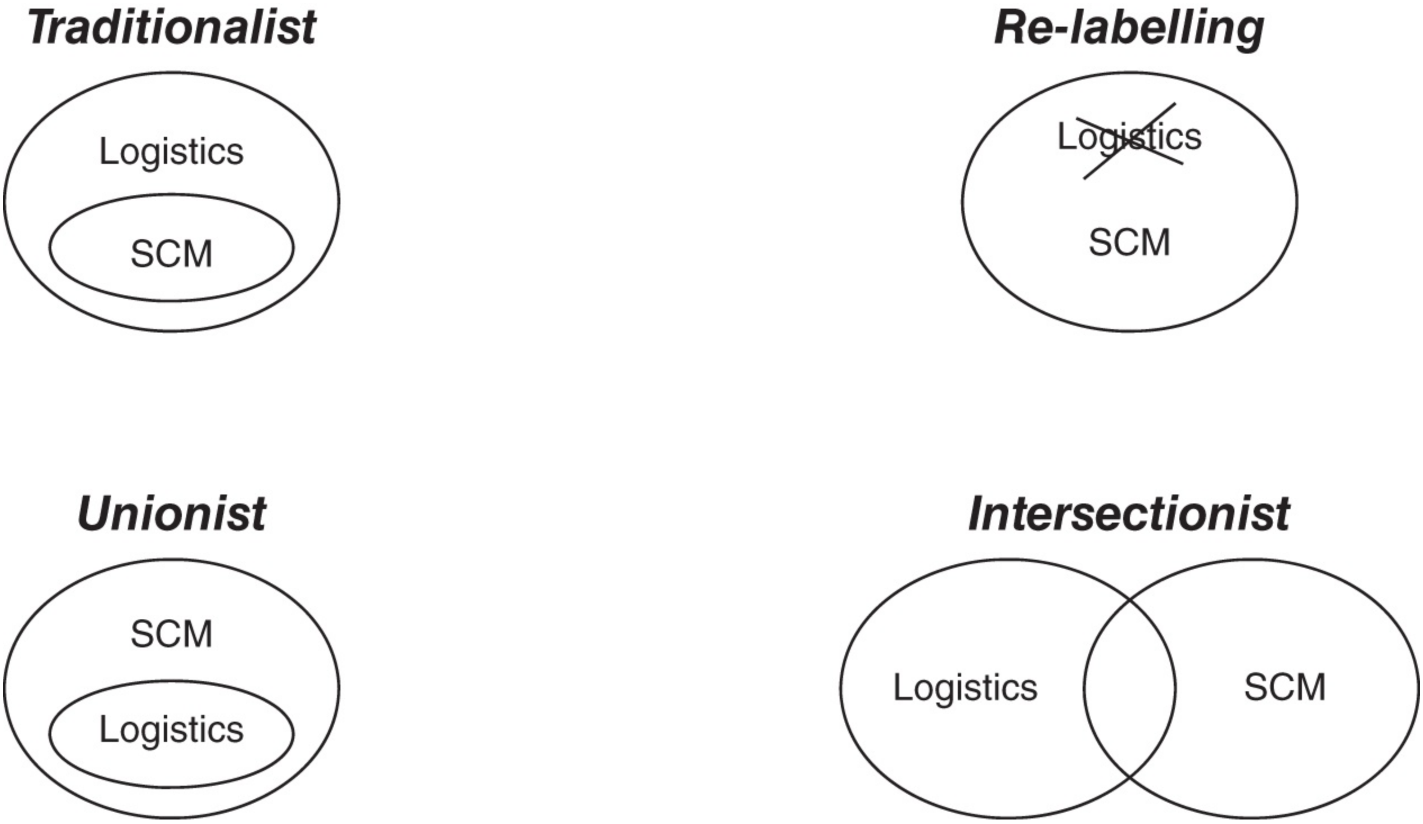


Figure 1.2 Four perspectives on logistics versus SCM (Source: Larson, P. & Halldorsson, A. 2004; reproduced with permission of Taylor and Francis.)[10]

SCM in many respects evolved from logistics and the **traditionalist view** thus regards SCM as a subset of logistics, as if it were an add-on to logistics. In the **re-labelling view** it is contended that logistics has been re-labelled by the more recent term SCM. Indeed it is worth noting here that sometimes transport gets re-labelled as logistics, for example the authors have observed heavy goods vehicles (HGVs) where the word 'logistics' is painted over the word 'transport' on the side of the vehicle! Becoming a professional logistics company requires more than just a name change. In the **unionist view** logistics is seen as part of a wider entity, SCM. Finally the **intersectionist view** suggests that there is overlap between parts of both logistics and SCM, but also that each has parts that are separate and distinct.

In this book we will use the abbreviation '**LSCM**' to refer to Logistics and Supply Chain Management.

In this book our approach is to adopt the *unionist view*, i.e. that logistics is part of the wider entity which is SCM – Figure 1.3. This approach is in keeping with recent research on this topic.[11] To reiterate what was stated earlier, the supply chain is a much wider, intercompany, boundary-spanning concept, than is the case with logistics. We believe that if you now look again at the definitions of logistics and SCM that are outlined above and the surrounding discussion in this chapter then this will be quite evident.

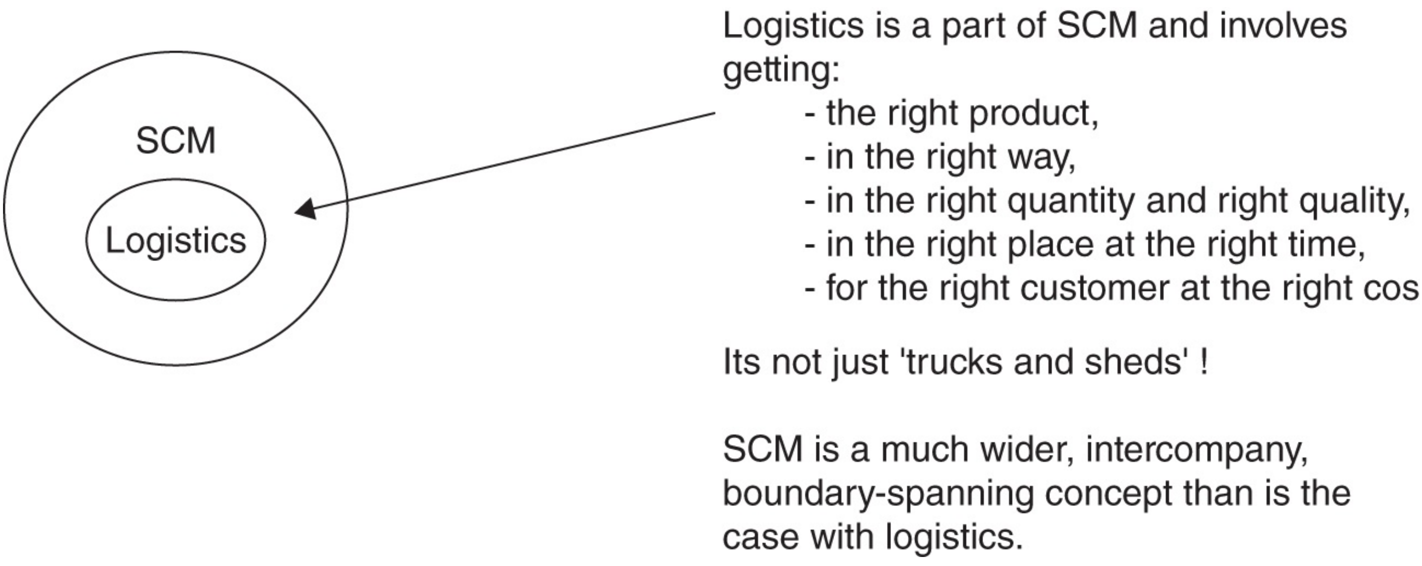


Figure 1.3 Logistics is a key component of Supply Chain Management

THEORY DEVELOPMENT IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

As the disciplines of logistics and SCM have developed they have received increasing attention from researchers. In turn there is – albeit only in the past few years – an increasing emphasis on developing theories of LSCM.[12] A theory is – as defined by the *Collins English Dictionary* – a set of ideas, or suppositions, to explain something. Many theories used in LSCM research are rooted in other disciplines such as Economics (e.g. transaction cost economics (TCE)) and Business Strategy (e.g. resource-based view). Some scholars have proposed additional theories that supply chain researchers can use to help address supply chain phenomena.[13] Other scholars too – such as Britta Gammelgaard from Copenhagen Business School[14] and Theodore Stank at the University of Tennessee[15] – have noted that while general, or grand, theories will of course always be important, so-called middle range theory (i.e. theories that are concrete and specific) that delves deeply into the inner workings of logistics management is also needed.

An example of theory development in SCM is that of Craig Carter and colleagues at Arizona State University[16] who – using a conceptual theory building approach – introduced six foundational premises (FPs) as a basis for a theory of the supply chain:

> FP1 – The supply chain is a network, consisting of nodes and links.
>
> FP2 – The supply chain as a network operates as a complex adaptive system, where every agent grapples with the tension between control and emergence.
>
> FP3 – The supply chain is relative to a particular product and agent.
>
> FP4 – The supply chain consists of both a physical supply chain and a support supply chain.
>
> FP5 – The supply chain is bounded by the visible horizon of the focal agent.
>
> FP6 – The visible horizon of the focal agent is subject to attenuation, where distance is based on factors including physical distance, cultural distance and closeness centrality.

APPLICATIONS TO MANUFACTURING AND SERVICES

The previous sections have given an insight into the origins and forces shaping the evolution of logistics and SCM. Much of the early application of both logistics and supply chain thinking has been in a manufacturing context and this will be considered in more detail in Chapter 3. It is now generally agreed that for those who take a supply chain view, two dimensions of value often arise, namely cost savings and service enhancements. This is evident in the *Dell* case at the end of Part I of the book where the PC maker uses robust logistics strategies and competes using its entire supply chain. Not only does Dell sell relatively cheap PCs, but it also competes on the basis of certain service attributes (for example the ability for customers to purchase their products online and the fast delivery of purchased products to customers).

More and more then manufacturers are using service criteria (for example after sales service and delivery add-ons) in order to compete. Such has been their success that now many service companies are waking up to the advantages that can be gained from adopting best-in-class logistics practices and taking an end-to-end supply chain view. This is evident across a diverse range of service sectors such as retail, financial services, healthcare and tourism. Services in the context of LSCM are discussed in more detail in Chapter 4.

> Logistics and SCM can be used to generate both cost savings and service enhancements.

In the healthcare sector, for example, expensive increases in medical technology and increasing life expectancy are leading to greater demands on healthcare services with hospitals striving to offer better services at less cost. The average length of stay of patients within hospitals is declining, partly due to technological advances in healthcare, but partly also because increasingly hospitals take a more holistic supply chain perspective on all aspects of patient care and also increasingly apply core logistics principles to their everyday activities. By eliminating unnecessary blockages and delays (for example by ensuring that required expertise in terms of medical skills and equipment is available when needed), patients get faster access to a range of services allowing them to get better sooner and leave hospital earlier, thus leading to improvements in whole system efficiency.

IKEA (WWW.IKEA.COM)

The Scandinavian home furnishings retailer *IKEA* is a good example of a company that uses best practice logistics and SCM in the manufacturing and services aspects of its business. Many products are manufactured for self-assembly by the customer. They are 'flat packed', making them easier to ship and store. Self-assembly is generally straightforward, with many products comprising components which easily assemble together. Even the instruction leaflets often have no words, only pictures, cutting down on the need for copies in multiple languages. Its network of worldwide stores are usually easily accessible and have similar layouts, making the shopping experience as easy and user friendly as possible for customers.

TRIAGE[17]

The concept of triage, originally devised by the French military, is now widely applied in medical emergency situations. Triage involves rapid assessment of patient needs and thus allows those most in need of care to be attended to first. The concept has evolved considerably and has moved beyond merely deciding between those who are critically ill and those who are not, into an activity which tries to match patients with the right care stream. This may involve various downstream activities from trauma care to bypassing hospital emergency departments completely and going straight to an appropriate community care facility. Importantly, more recent applications of triage involve not just assessment once the patient reaches the hospital, but also triage at other upstream points of contact (for example via telephone or when an ambulance first arrives at an accident scene). Medical triage is a good example of the application of logistics thinking in a services context and is especially relevant given the pressures on many modern healthcare systems.

THE NEED FOR SUPPLY CHAIN TRANSPARENCY

Many supply chains can be long, complex, involve many entities and cross international borders. Governments and other stakeholders are now becoming increasingly concerned that supply chains are not infiltrated by unethical and criminal practices, such as modern slavery, and as a result there is now renewed effort to ensure more transparency within supply chains. Chapter 17 deals with the important topic of Corporate Social Responsibility (CSR) in the context of LSCM.

BOOK FRAMEWORK

A number of perspectives were adopted by the authors when writing this book and these are reflected in its content and summarised below.

Global perspective

Logistics and SCM are truly global disciplines that underpin international trade and span international borders. Consequently, this book seeks to reflect the global nature of the subject matter and draws upon diverse examples from multiple geographies. It is not our intention to present a particular 'Western' perspective on the subject matter, but instead to present a global worldview of what is happening in LSCM today.

The terms *international* and *global* are often used interchangeably in a logistics context, but this is not in fact accurate. *International* is defined by the *Collins English Dictionary* as 'of, concerning, or involving two or more nations or nationalities', while the same dictionary defines *global* as 'covering, influencing, or relating to the whole world'. This book aims then to go beyond a focus on international logistics and to take a broader, whole world, global perspective on LSCM issues.

Both practical and strategic perspectives

This book aims to comprise both a *practical element*, that is to help the reader to 'do' logistics (for example select carriers, determine how much inventory to carry, select appropriate performance metrics, etc.) and a *strategic element* (understand the role of LSCM in the wider business context and how it fits with the various functional areas).

In Chapter 17 the desired 'T-shaped' profile of the effective logistics manager is discussed; suffice to note for now that logistics managers, as well as needing to know how to 'do' logistics, also require good interpersonal skills and in addition need to be able to work effectively with various functions such as marketing and finance. As well as this they need to be good strategic thinkers. In this book, the aim is to present a balanced insight across all of these areas. We contend that while it is important to understand how global supply chain strategies are developed, it is also equally important to know how to, for example, calculate the costs incurred by carrying inventory in a warehouse or what Incoterm to list on an invoice. For a student at any level to have knowledge of supply chain strategy is vacuous without concomitant knowledge of how to 'do' logistics.

Logistics is a part of SCM

As discussed above, the book adopts the *unionist view* of logistics, that is, that logistics is part of the wider entity which is SCM.

Focus on material, information and resource flows

The three flows across supply chains detailed above (material, data and resources) are each considered. None is regarded as more important than the other, rather the book recognises the interdependency of each.

Neutral and non-political perspective adopted

Despite the economic successes pointed to in Chapter 2, the world is not a perfect place, with too many conflicts, injustices and poverty pervading many regions. In this book we have adopted a neutral and non-political perspective; any reference to individuals, situations or countries is only done to illustrate LSCM issues. Our hope is that best practice LSCM, which this book hopes to advance, can help *all* regions to prosper.

The book is divided into five parts and these are now detailed.

Part One – Context

This first section sets the context for the book. The growth of LSCM correlates directly with both increasing globalisation and international trade and this is the focus of Chapter 2. Pertinent issues such as trends in the location of manufacturing activity and the need to decouple growth in transport from economic growth are also considered in Chapter 2. Chapter 1 has already given an historical perspective vis-à-vis the origins of LSCM and in Chapter 3 we will see how in recent decades various approaches (e.g. leanness, agility) have emerged and shaped the discipline, especially moving it from a producer–push paradigm to one of consumer–pull. In this chapter then we explore in particular process design and outline the key elements of supply chain strategy. Chapter 4 focuses on services in the context of LSCM and the important topic of servitisation (combining products and services) is introduced. Supply chains are not standalone, independent entities but are part of – and influenced by – the wider systems (geopolitical systems, ecosystems, etc.) within which they exist. The purpose of Chapter 5 is to show how logistics and supply chains fit into wider systems and to also outline the various complexities that are associated with LSCM. In that chapter we will also introduce an important supply chain behaviour – the so-called Bullwhip Effect – and we will look at how logistics networks are designed. The aim of Part One of the book will be to bring the reader to a position whereby they accept the now generally held maxim that it is increasingly supply chains that compete and not individual products and/or companies. The reader will then be sufficiently informed to progress to Part Two, which focuses on transport and logistics.

Part Two – Transport and Logistics

The second section of the book focuses on transport and operational logistics. Chapter 6 deals with transportation, a key enabler of logistics. One particular sub-mode of transportation – maritime containerisation – was one of the key commercial developments in the 20th century. It was in fact a key driver of trade growth since the 1950s and the advance of globalisation. It plays a key role in many LSCM systems and is covered in detail in Chapter 7. Chapter 8 details a sector of activity that also plays a key role in LSCM, namely the logistics service providers (LSPs) sector. The physical carriage of freight is only one part of logistics – much documentation is also needed as are rules of engagement; in addition, governments and other public bodies play a key role in facilitating logistics flows. Chapter 9 details all of these topics and in particular outlines the universally accepted Incoterms which help in the allocation of responsibility to the various actors along the logistics chain.

Part Three – Managing Operations

The three chapters in Part Three of the book explore how operations are managed along the supply chain. As we have seen already, inventory is one of the key flows along the supply chain. It can also tie up a lot of working capital, and both the analysis of inventory movement and visibility of inventory (what, where, how much, in what condition, etc.) are especially important concerns. All of these topics are covered in Chapter 10. In this important chapter (inventory is at the core of LSCM) we introduce common inventory control systems and strategies used to reduce inventory-related costs. We also illustrate techniques used for supply chain planning and control, and outline how performance metrics are established. Inventory needs to be handled and also stored when necessary. Warehouses have evolved from being just simple storage locations and there have been a lot of developments too in automated and smart materials handling. These subjects are discussed in Chapter 11. The final chapter in Part 3 covers a number of related and important topics in LSCM: procurement (sourcing and purchasing) of materials and other inputs; many activities along the supply chain are often conducted in both disparate locations and performed by third parties – both outsourcing and the various approaches to rightshoring are also detailed in this chapter; finally the chapter also considers the various LSCM costing approaches and concepts.

Part Four – Data and Analysis

The first section of the book shows how logistics and supply chain systems are complex and multidimensional – in such systems there is usually much to analyse and to control and this is the focus of the three chapters in Part Four. Chapter 13 details the different types of data and the use of digitisation in LSCM. Management Science – traditionally known as Operations Research (OR) – is a discipline that aids management decision making by applying quantitative and other tools. Many such tools can help in the design, analysis and improvement of logistics and supply chain systems and this is the focus of Chapter 14. In recent years a major focus in LSCM concerns business continuity management and ensuring LSCM systems can cope with both uncertainty and the equally strong challenges which arise as a result of growing marketplace competition. This is the focus of Chapter 15 which deals with vulnerability and risk; this chapter also considers the important topic of security and describes the various initiatives employed to enhance security.

Part Five – Supply Chain Design and Improvement

The final section of the book considers how supply chains can be designed and improved, especially in the context of current and emerging challenges. One of the key challenges of the 21st century is environmental sustainability and LSCM has a central role to play in efforts to reduce the impact of economic activity on the environment. Chapter 16 focuses on these concerns and outlines how LSCM activities can be decarbonised. It is important to know and if possible quantify the impact of such activities on the environment and thus in this chapter we also introduce the technique of carbon footprinting. Not all product flows downstream in the supply chain from consignors to consignees – sometimes product needs to also flow back upstream for example for repair or recycling. This is the area commonly referred to as reverse logistics and is also considered in Chapter 16. The final topic considered in Chapter 16 is the so-called circular economy: in the linear economy products are manufactured, used and disposed whereas the circular economy aims to eliminate waste by designing and optimising products for a cycle of disassembly and reuse. There are other important societal concerns too beyond environmental impact where LSCM has a role – Chapter 17 considers topics such as the growing, and very important, area of humanitarian logistics ('humlog') and also the need, in the context of rising corporate social responsibility (CSR) concerns, for more transparency in the supply chain. Chapter 17 also considers, in light of the many trends and challenges outlined in the book, new and emerging supply chain designs and we will see especially how there is a growing need to synchronise product design with supply chain design. The final topic we discuss is the skills and knowledge areas needed by the next generation of logistics and supply chain managers.

Part One of the book aims to take you to the point whereby you understand that increasingly it is now supply chains that compete. The end point of the book will be to take you to the position whereby you understand that not only is it true that supply chains compete, but that, more and more, these supply chains are not simple, linear chains, but are instead complex, global, multidimensional, and multipartner networks. Furthermore you will see that LSCM can be a powerful force for good and – when LSCM systems are properly designed and managed – can help us to address many of today's key global challenges.

LEARNING REVIEW

This chapter sought to explain the origins of LSCM and to define and differentiate both terms. The importance of these areas to both manufacturing *and* services has been highlighted and the chapter showed how best practice LSCM can yield both cost reductions *and* value addition. A framework for the book was outlined and the particular perspectives embraced in the book were elucidated.

Now that the origins and meaning of both logistics and SCM have been described, other developments which have been closely associated with the growth of LSCM can be discussed. Chapter 2 looks at both increasing globalisation and international trade. Growth in these two areas correlates closely with the growth in LSCM, and indeed there is a significant level of interdependence between all of these areas.

QUESTIONS

- Are logistics and SCM only of interest to manufacturers?
- Explain the key developments behind the evolution of logistics and SCM.
- How do logistics and SCM differ?
- How can best practice logistics and SCM lead to both cost reduction and service enhancement?
- What are the benefits of deregulation of transport markets? Why does such deregulation sometimes not work out quite as planned?

APPLICATIONS OF LOGISTICS AND SCM IN A SERVICES CONTEXT

In this chapter we outlined key principles and concepts of LSCM and how both can be applied in manufacturing and services contexts. Many application examples will be developed in the following chapters of this book (while both manufacturing and services examples are used throughout the book, Chapter 4 in particular focuses on services supply chains). At this juncture, however, it is worth pausing to consider the application of LSCM in a services context, as many students regard LSCM as only of relevance in a manufacturing context (which of course is not the case). Think of examples of sectors and organisations where logistics and SCM principles and concepts can be, or are already, applied. Earlier in this chapter we illustrated the application of logistics and SCM principles and concepts to the medical context (the 'Triage' caselet). Are there other services contexts where similar application is evident?

NOTES

1. Forrester, J. (1958) Industrial dynamics: a major breakthrough for decision makers, *Harvard Business Review*, July–August.

2. For a fascinating insight into the life of McLean and the growth of containerisation see: Levinson, P. (2006) *The Box*, Princeton University Press, Princeton, NJ.

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9. See for example: Cooper, M.C., Lambert, D.M. & Pagh, J.D. (1997) Supply chain management: more than a new name for logistics, *International Journal of Logistics Management*, 8(1), 1–13; Lambert, D.M., Cooper, M.C. & Pagh, J.D. (1998) Supply chain management: implementation issues and research opportunities, *International Journal of Logistics Management*, 9(2), 1–19 and Larson, P. & Halldorsson, A. (2004) Logistics versus supply chain management: an international survey, *International Journal of Logistics: Research and Applications*, 7(1), 17–31.

10. Larson, P. & Halldorsson, A. (2004) Logistics versus supply chain management: an international survey, *International Journal of Logistics: Research and Applications*, 7(1), 17–31.

11. Other empirical studies support this view, see, for example: Larson, P., Poist, R. & Halldorsson, A. (2007), Perspectives on logistics vs SCM: a survey of SCM professionals, *Journal of Business Logistics*, 28(1), 1–25 and more recently: Sweeney, E., Grant, D. & Mangan, J. (2018) Strategic adoption of logistics and supply chain management, *International Journal of Operations and Production Management*, 38(3), 852–873. In fact in the latter study 88% of respondents thought of themselves as unionists.

12. See for example: Sweeney, E., Grant, D. & Mangan, J. (2015) The implementation of supply chain management theory in practice: an empirical investigation, *Supply Chain Management: An International Journal*, 20(1), 56–57; and Liu, X. & McKinnon, A. (2019), Practical relevance of theory-driven supply chain research: evidence from China, *International Journal of Logistics Management*, 30(1), 76–95.

13. Gligor, D., Bozkurt, S., Russo, I. & Ayman, O. (2019) A look into the past and future: theories within supply chain management, marketing and management, *Supply Chain Management: An International Journal*, 24(1), 170–186.

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15. Stank, T., Pellathy, D., In, J., Mollenkopf, D. & Bell, J. (2017) New frontiers in logistics research: theorizing at the middle range, *Journal of Business Logistics*, 38(1), 6–17.

16. Carter, C., Rogers, D. & Choi, T. (2015) Toward the theory of the supply chain, *Journal of Supply Chain Management*, 51(2), 89–97.

17. For more on medical triage see, for example: Robertson-Steel, I. (2006) Evolution of triage systems, *Emergency Medicine Journal*, 23, 154–155.

2
Globalisation and International Trade

LEARNING OBJECTIVES

- Highlight the growth that has occurred in recent decades in international merchandise trade and the important role played by LSCM in this regard.
- Explain what is meant by globalisation, discuss the drivers for globalisation and review recent trends that are impacting globalisation.
- Finally, look at what happens when unequal volumes or types of freight flow in opposite directions in freight markets.

INTRODUCTION

Chapter 1 both introduced and differentiated logistics and SCM and their application in manufacturing and services contexts. It also noted that best practice LSCM can lead to both cost reduction and value addition. This chapter now turns to areas which over the last number of decades have been closely associated with the evolution and growth of LSCM, namely the growth of international trade and increased globalisation. We will study these trends in this chapter and both their impact on and relationship to LSCM. We will also explore related topics such as regional differences in trade and directional imbalances: differences in freight volumes in opposite directions are a characteristic of many freight markets, how this arises and its consequences will also be discussed.

Chapter 2 comprises three core sections:

- Growth in international trade
- Globalisation
- Directional imbalances

GROWTH IN INTERNATIONAL TRADE

Global trade has grown considerably in recent decades (Figure 2.1). Much of this growth has been facilitated by the reduction of trade barriers between countries and regions, thus making it easier for countries to trade with each other. **Regional trade agreements**, such as the EU (European Union) and AFTA (Association of South East Asian Nations Free Trade Area), have been and continue to be developed, and allow more open trading within regions.[1] The 20th century saw considerable growth in world merchandise trade (i.e. freight – as opposed to other trades such as services and finance flows) especially in the decades following on from World War II. We mentioned briefly in Chapter 1 that this trade growth has been fuelled in part by developments in logistics, especially containerisation (we will discuss this further in Chapter 7), which has played an increasingly important role in the global economy. Figure 2.1 illustrates the growth in world merchandise trade, world seaborne trade, world GDP and the OECD's industrial production index in recent decades. The figure shows that while global trade has been on a more or less continuous upward trajectory for many decades, trade declined with economic recession around 2008. While trade has grown since then, the pattern of trade growth has become less stable, and, while it is obviously difficult to predict future growth patterns, this volatility in trade growth is likely to continue into the future.

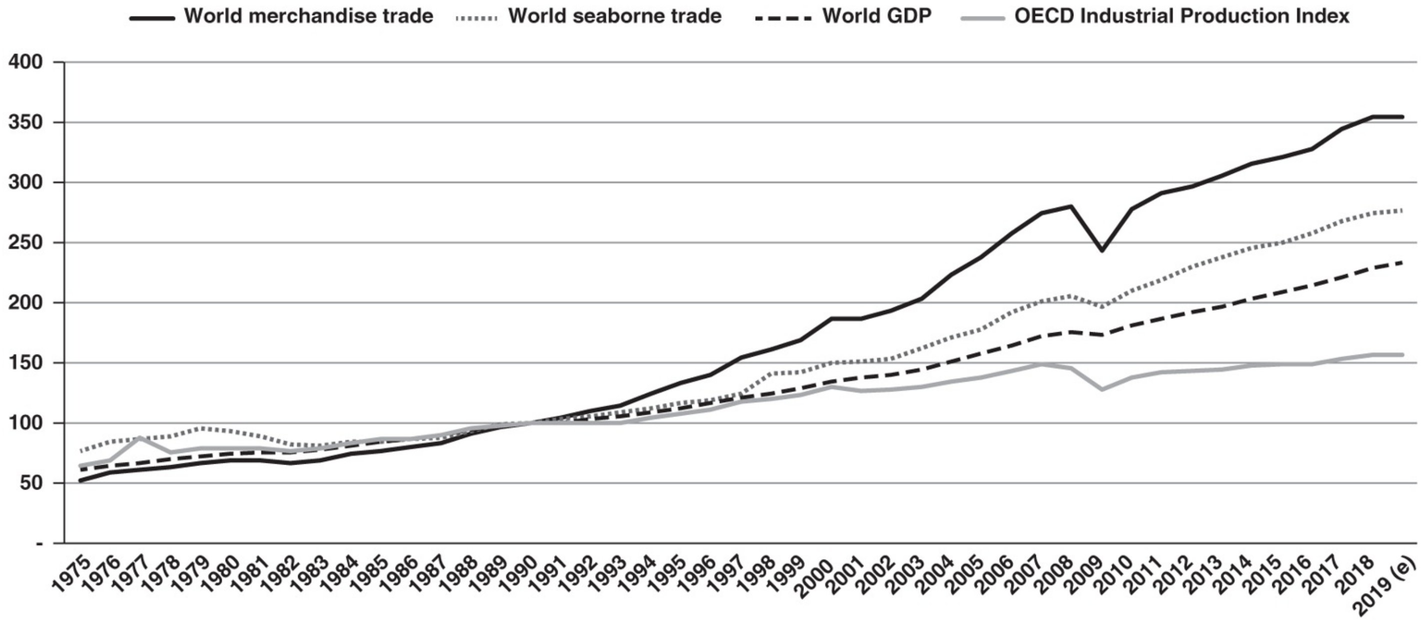


Figure 2.1 Growth in world merchandise trade, seaborne trade, GDP and OCED industrial production, 1975–2019 (Baseline 1990 = 100)

(Source: UNCTAD based on data in the Annual Review of Maritime Transport, various years; WTO and OECD statistical databases)

Note: Seaborne trade measured in goods loaded in metric tons. Merchandise trade refers to exports in dollar value (nominal terms) but deflated using unit value indices to remove the effects of price movements and exchange rate variations (the result of this adjustment is to capture growth in merchandise exports then in real terms). GDP in constant (2015) prices. OECD industrial production refers to the volume of output generated by production units classified under Mining, Manufacturing, Electricity, Gas and Water industrial sectors of the International Standard Industrial Classification of all Economic Activities (ISIC Rev. 4).

Decoupling economic growth and transport growth

When we look in more detail at transport in Chapter 6, we will observe how the demand for transport is a *derived demand*, i.e. the demand for transport is dependent upon someone wishing to move freight from one point to another. It is not surprising then to see the close correlation (Figure 2.1) between seaborne trade, merchandise trade and GDP (i.e. as GDP grows so too does merchandise trade, which in turn depends in part on seaborne trade so that too generally rises). A key concern for transport policymakers is to weaken the link (the term often used here is to *decouple*) between transport growth and GDP growth – in essence trying to ensure that an economy can grow without concomitant growth in the negative environmental impacts associated with increased transport demand (we will explore these further in Chapters 6 and 16). In Chapter 6, for example, we will see that there is an economic indicator known as *freight transport intensity,* which measures the ratio of tonne-kilometres to GDP and thus how dependent an economy is on freight transport. In Chapter 16, we will explore how to make LSCM – and transport in particular – more efficient. A key focus of policymakers worldwide is to shift freight to more environmentally friendly modes (e.g. from road to rail).

In examining these relationships between trade and transport, there are various practices and statistical nuances that we need to be aware of and that play an important role in dictating freight flows. We will see in Chapter 12 that growth in both outsourcing and offshoring leads to supply chains becoming more stretched, and this also leads to increased freight movements between the various nodes in the supply chain. It is important, too, to note the influence of 'product tourism' in international freight flows. This is where there may be unnecessary flows of freight to take advantage of lower tax rates, etc. (a company may manufacture a base product in one country but move it to another country for the final stages of manufacturing if this latter country offers certain tax and export advantages). This is known as transfer pricing: when goods or services are transferred between divisions of the same company, a value is attributed to them called a **transfer price**, multinational companies can thus move work-in-progress materials between countries and use transfer pricing to minimise their tax exposure. A somewhat related concept is that of parallel imports (also referred to as grey markets): this is where a product moves through a particular distribution channel that is not authorised by the original manufacturer or copyright owner. For example, companies sometimes sell products for different prices in different markets depending upon prevailing local market conditions (higher prices applying in a rich country and so forth) – distributors might thus import the product into the country where it is cheapest to do so and then re-export it to another country where it can be sold for a higher price (but less than were it imported directly to that country). There are a wealth of statistics available on trade and transport, but you need to be careful with regard to how you analyse them and what you infer from your analysis. Note, for example, how we took account of influencing factors such as inflation and exchange rates in Figure 2.1. Indeed, if you look at certain trade categories – such as fuels and agricultural produce for example – you can have situations where trade values fall but tonnes moved actually rises due to factors such as volatility in market prices (supply and demand imbalances) and exchange rate fluctuations. The opposite too can apply – trade value rising but tonnes moved declining – we will explore this in the next section in the context of ongoing changes in globalisation.

GLOBALISATION

The term **globalisation** has been in use for a number of decades and is generally regarded as an umbrella term for a complex series of economic, social, technological, cultural and political changes which continue to take place throughout the world. Some argue that it is a force for good, allowing people and companies throughout the world to be interconnected. Others oppose it, some vehemently, and see it largely as a proxy for global capital flows exploiting especially the poor. You can make up your own mind. Perhaps in truth globalisation is a mix of both viewpoints. In this chapter, we can only give a brief introduction to globalisation, which is both a large area of study and also a topic of much discourse and debate – for more in-depth insights, see some of the many textbooks which cover this area in depth. From our standpoint as logisticians, globalisation and LSCM have been inextricably linked with the latter benefiting greatly from the former. It is important to note too that globalisation can carry risks[2] – with the world and its systems increasingly connected threats can spread rapidly (see, for example, how quickly financial contagion spread in the 2008 recession and more recently the rapid spread worldwide of the COVID-19 virus). We will return to the important topics of risk and vulnerability in LSCM in Chapter 15. There is much debate around the future of globalisation – whether it is: dead and we need a new world order (sometimes referred to as deglobalisation), slowing down, or just evolving.[3] Just as LSCM has been a driver of, and beneficiary from, globalisation it also needs to ensure it is part of whatever new order evolves.

It is important at this juncture too to distinguish two terms which are often conflated[4]: *globalisation* is a process that describes global linkages in trade and other areas; *globalism,* however, is a philosophy which believes that everything should be submitted to the neoliberal forces of the markets. Many people then while favouring the former do not necessarily favour the latter.

WHAT FLOWS WHERE

Have a look at www.sourcemap.com and open.sourcemap.com for examples of global product flows from raw material sources, through manufacturing and on to final customers. This will give you a sense of the truly global and stretched nature of many supply chains. A wonderful book – *The Travels of a T-Shirt in the Global Economy* – also gives insights into many of the issues considered in this chapter.[5]

It is important to recognise the important role played by large companies in the context of global logistics flows. Some of the world's largest companies have annual turnovers greater than the GDP of some smaller countries. Given their scale, how they move product around the world can have major implications for logistics network structure and operations. For example, large flows in one direction can create opportunities for other companies to use the empty containers on the return leg.

Commercial shipping activity is a good example of globalisation. Kumar and Hoffmann[6] give the following example: 'a Greek owned vessel, built in Korea, may be chartered to a Danish operator, who employs Philippine seafarers via a Cypriot crewing agent, is registered in Panama, insured in the UK, and transports German made cargo in the name of a Swiss freight forwarder from a Dutch port to Argentina, through terminals that are concessioned to port operators from Hong Kong and Australia.' Surely an example of globalisation in action!

One writer credited with bringing the term globalisation into mainstream use is the American academic Theodore Levitt. In a now famous 1983 article in the *Harvard Business Review*,[7] Levitt suggested that companies must learn to operate as if the world were one large market – ignoring superficial regional and national differences.

'GLOCALISATION' – THINK GLOBAL, ACT LOCAL

Much of what Levitt asserted in his famous 1983 *Harvard Business Review* article has stood the test of time and no doubt one can think of many global companies with global products. Conscious though of subtle, yet often important, regional and local differences, many companies now adopt a policy which some refer to as **glocalisation** – thinking on a *global*, world-market scale, but adapting to *local* wants as appropriate. Just think, for example, of how McDonald's customises burgers by varying toppings etc. to suit local tastes in different countries. We will also see in later chapters how companies can employ modern manufacturing and distribution strategies that allow them to tailor, often at little extra cost, global products to satisfy local wants.

All of this is not to deny that cultural and other differences exist between countries. Such differences do exist and can impact on how effectively logistics systems work in practice. We will return to some of these issues later in the book when dealing with sourcing and procurement, areas where understanding cultural differences is a matter of considerable importance as companies negotiate and manage across cultures.[8]

In terms of trading relationships, a number of different stages can be identified in the path towards globalisation. First, countries begin to trade with each other, importing and exporting products. As trade develops, sometimes companies will establish a presence in an overseas market. Such companies are usually referred to as **multinational companies (MNCs)** when they have operations in areas beyond their home country. In turn, entities sometimes referred to as **transnational corporations (TNCs)** emerge, these are companies that trade across many borders, with operations in multiple countries. Often it can be difficult to identify the 'home' country of a TNC, as they will typically portray a truly global identity. Three other terms are also worth noting, and these relate to how companies think and behave as they internationalise:

- **Ethnocentricity**: where the company when doing business abroad thinks only in terms of the home country environment (thinks and acts as if it were still operating in, for example, the US, where the company may be headquartered, notwithstanding the fact that many business environments outside of the US can be quite dissimilar to that country).
- **Polycentricity**: where the company adopts the host country perspective (to coin the old phrase: 'when in Rome, do as the Romans do').
- **Geocentricity**: where the company acts completely independent of geography and adopts a global perspective, and will tailor to the local environment as appropriate (see the box on 'glocalisation').

As companies internationalise, they set up operations in overseas locations. This can range from relatively simple activities, such as having a sales presence in an overseas market, to setting up production facilities, and even (in the case of TNCs) having core company functions located in countries other than where the company was originally established. Behind such developments lie what are referred to as **foreign direct investment (FDI)** flows. FDI flows are financial flows from a company in one country to invest (for example in a factory) in another country. Such flows are very significant in the overall global economy and in some cases can be key to dictating a country's success. Indeed many countries, and regions, compete quite strongly to attract FDI, and some will put in place certain conditions (for example low rates of corporate taxation) in order to attract more FDI.

Table 2.1 outlines some of the many factors that have to be considered when deciding on an optimum location for an overseas facility.[9] Indeed, many of the factors listed arise regardless of the type or location of facility being considered, and in addition to their relevance in the context of the discussion here on FDI, they are also relevant in the context of issues considered in subsequent chapters of this book (for example those dealing with outsourcing and offshoring in Chapter 12 and with warehousing in Chapter 11).

Participation by a country in global trade is predicated on access to logistics networks. UNCTAD and other stakeholders are at the vanguard of efforts to facilitate international trade through improved logistics. We will return to this topic in Chapter 9 which looks at trade facilitation. We will come back to globalisation too in Chapter 5 when we will look at networks and connectivity and, in particular, draw upon some excellent analysis that DHL do in this area. In fact, their analysis suggests that most people believe the world is more globalised than it really is, and such misperceptions exacerbate fears of globalisation. They note that while the world is more connected than at almost any previous point in history, international flows are far smaller than most people presume, with most business still taking place within rather than across national borders.[10]

Globalisation is not a static entity and shifts are evident in globalisation patterns.[11] In Chapter 12, we will look at changing patterns in offshoring (a politically important topic in many countries ('more jobs at home')). Geopolitical issues and trade tensions can have a major bearing on globalisation patterns. Some argue that globalisation is becoming regionalisation.[12] One way to assess this is to examine the share of imported products/components in a country's exports. We can observe that this is declining for some (especially developing) economies indicating shifts in the value chain (i.e. they are producing, rather than importing, in their countries more of the raw materials and components (so-called intermediate goods) needed to manufacture export products).[13]

In the previous section we looked at decoupling growth in transport from growth in GDP. There is some evidence too that growth in merchandise trade is also starting to decouple from growth in GDP in some regions and sectors. Growth in merchandise trade associated with rising GDP has long been a feature in the spread of globalisation; however, in recent years we are observing a minor shift (Figure 2.2). We can identify two factors in particular which are driving this: the value chain shifts discussed in the previous paragraph (i.e. domestic production – rather than import – of some intermediate products) and a growth in services as a share of GDP. So GDP still grows, but it is less dependent upon merchandise imports and exports.

TABLE 2.1	
Site selection factors	
Labour costs	Political stability
Employment regulations	Environmental regulations
Available skills	Taxation rates
Land costs and availability of suitable sites	Government supports
Energy costs	Currency stability
Availability of suitable suppliers	Benefits of being part of a cluster of similar companies
Transport and logistics costs	Preferred locations of competitors
Transport linkages	Access to markets
Communications infrastructure and costs	Community issues and quality of life

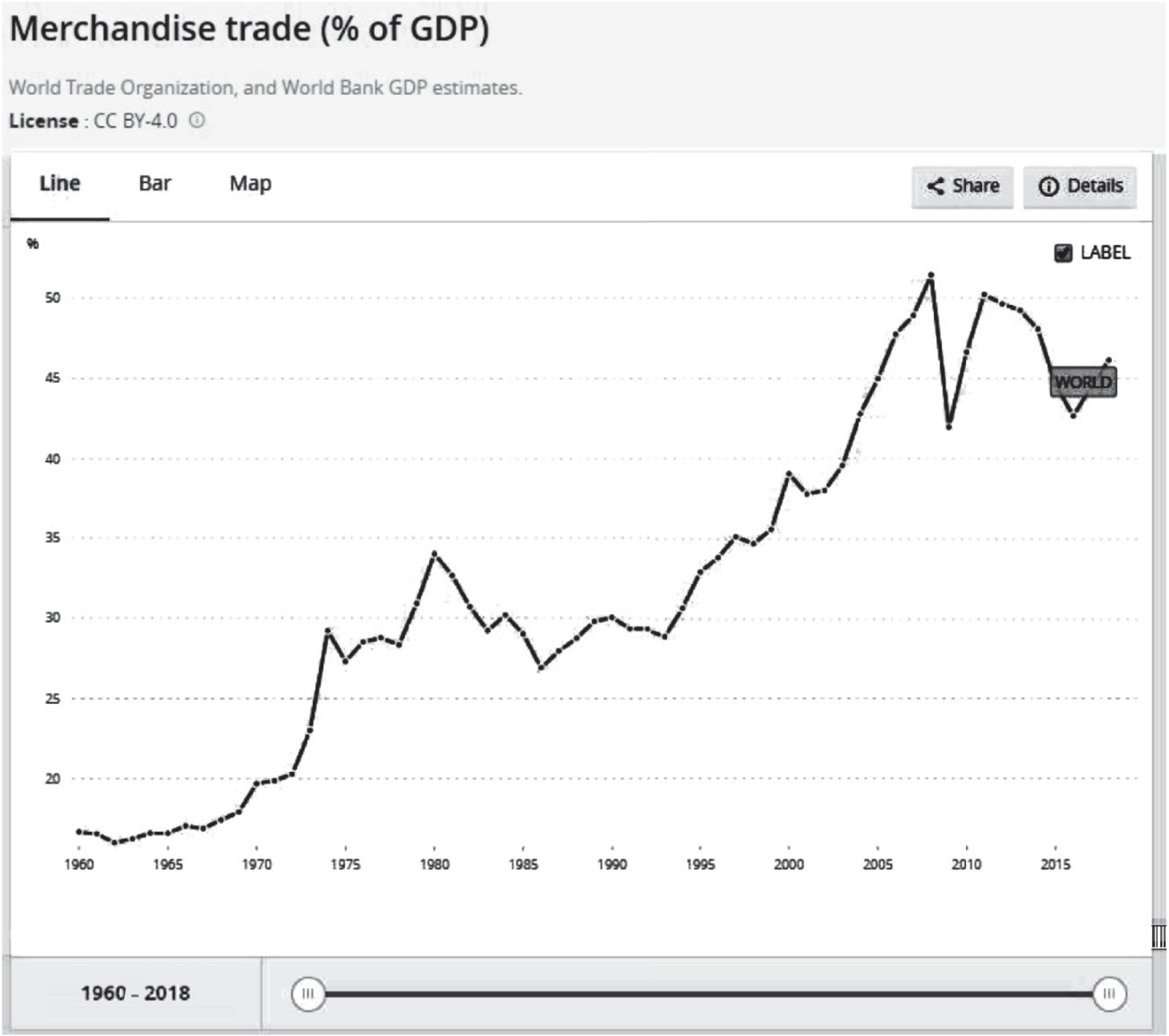


Figure 2.2 Merchandise trade (% of GDP) (Source: World Bank. Licensed under CC BY 4.0.)[14]

DIRECTIONAL IMBALANCES

As Figure 2.1 illustrates, world trade has grown considerably in recent decades. One particular characteristic of freight markets, which distinguishes them from passenger markets, is what are commonly referred to as **directional imbalances**. A simple analogy explains this. Most people who make a journey today aim to make a return trip at some point. This, however, is not the case with freight, which usually moves to either be consumed at the destination point or have further value added to it before making another journey. In other words, most freight makes one-way, and not return, journeys. This, of course, would be fine if the same volume and type of freight (certain types of freight have particular handling and equipment characteristics, e.g. refrigerated containers for perishable freight) went in both directions on all routes. But of course it doesn't, and in some cases the differences can be quite pronounced. This in turn raises interesting challenges for the transport companies who are faced with variable directional utilisation of their equipment. According to UNCTAD, in

2018 there were[15]:

- 20.9 million TEUs[16] on the East Asia–North America trade routes but just 7.4 million TEUs in the opposite direction (North America–East Asia).
- 17.4 million TEUs on the East Asia–Northern Europe and Mediterranean trade routes but 7.0 million TEUs in the opposite direction (Mediterranean and Northern Europe–East Asia).

As a result of such imbalances, rates will vary considerably, for example, on the China–EU container market:

- It can cost the same amount to transport a container unit by road between Munich and Hamburg in Germany as it does to ship the same container by sea from Shanghai in China to Hamburg in Germany.
- It can cost twice as much to ship a typical 20-foot container between Hong Kong and the EU when compared with the opposite direction (EU–Hong Kong).

Sometimes directional imbalances can exist in opposite directions on the same route for different commodities. This can arise with, for example, perishable products such as foodstuffs and flowers, which usually require refrigerated containers. There could be a surplus of empty containers in one direction, thus allowing low rates to be charged for freight in that direction. Perishable products might not, however, be able to use this available equipment, and special refrigerated containers would have to be imported to carry such products. The challenge for carriers is obviously to match as much inbound freight capacity with outbound freight capacity as possible. When, however, there are gross imbalances in import and export volumes and cargo types, this is not always possible. As a result, empty containers may need to be repositioned to where they are required. Furthermore, this can lead to problems for ports, which sometimes have to store such empty containers. We will return to the topic of directional imbalances in Chapter 7 which focuses on containerisation.

Directional imbalances arise in freight markets when there are mismatches in the volumes or types of freight moving in opposite directions in a freight market.

LEARNING REVIEW

The chapter sought to introduce the concept of globalisation and the nature of international trade in the global economy and in turn the interrelationship of both with logistics systems. Issues such as the role played by multinational companies and the impact of directional imbalances in freight markets were also explored. The global economy today is increasingly interconnected with logistics playing an essential *lubricating* role – just as oil lubricates a car engine (without oil the engine would quickly seize up), so too the global economy relies on efficient and effective logistics systems in order to function (just look, for example, at what happens when transport services are delayed or there is industrial action at a port or airport). As the data and trends outlined in this chapter have attempted to illustrate, the global economy has evolved and grown quite considerably, especially in the latter decades of the 20th century and into the current century. To facilitate this, the logistics sector has also had to evolve and grow. And the global economy continues to evolve with new trends – such as regionalisation, shifting trade imbalances and new manufacturing techniques – necessitating logistics systems too to adjust.

Chapters 1 and 2 have sought to give an understanding of both the drivers for the evolution of logistics and SCM, and the global context within which both operate. The next chapter will now turn to the important topic of supply chain strategy.

QUESTIONS

- Explain the linkages between economic growth, trade and shipping. How can they be decoupled and why might this occur?
- Identify examples of companies/products which attempt to think global and act local ('glocalisation').
- Differentiate ethnocentricity, polycentricity and geocentricity, and give examples of companies from your own country that you believe fit into each category.
- Taking your own country as an example, identify freight routes where you believe directional imbalances exist.

LARGE COMPANIES AND THEIR LOGISTICS ACTIVITIES

It was noted above that some very large companies can be bigger than some small countries (for example in terms of company revenue when compared to country GDP). How such large companies arrange their logistics activities is thus highly relevant for various stakeholders.

Take a large company with which you are familiar and attempt to evaluate its logistics activities. Examining company annual reports, company websites and other information sources should generate information of interest. Detailed investigation may highlight specific issues of interest from a logistics perspective: for example, it is not uncommon for some sea ports to be highly dependent on individual large manufacturers in their hinterland. Try to identify linkages such as these and their implications. For example, what would happen to such a port if the manufacturer decided to relocate production to another factory in its global network?

NOTES

1. Many of these have evolved from being just trading agreements into wider social, political and economic entities (a good example being the EU, which started life originally as an agreement for trading coal and steel between a small number of countries).
2. See for example: Goldin, I. & Mariathasan, M. (2014) *The Butterfly Defect: How Globalization Creates Systemic Risks, and What*

to Do About It, Princeton University Press, Upper Saddle River, NJ.

3. See for example https://www.economist.com/open-future/2019/06/28/globalisation-is-dead-and-we-need-to-invent-a-new-world-order and https://www.mckinsey.com/featured-insights/innovation-and-growth/globalization-in-transition-the-future-of-trade-and-value-chains.

4. Klaus Schwab, founder of the World Economic Forum (WEF), quoted in: Walsh, J. (2019) *The Globalist*, William Collins, London. The book gives a fascinating insight into the life of the late Peter Sutherland – sometimes referred to as 'the father of globalisation' – who played the leading role in world trade negotiations in the late 20th century.

5. Rivoli, P. (2009) *The Travels of a T-Shirt in the Global Economy*, John Wiley & Sons, Inc., Hoboken, NJ.

6. Kumar, S. & Hoffmann, J. (2002) Globalization – the Maritime Nexus, in *The Handbook of Maritime Economics and Business*, LLP Professional Publishing, London.

7. Levitt, T. (1983) The globalization of markets, *Harvard Business Review*, May–June, 92–102.

8. For further reading on the issue of cultural differences, we recommend you look at some of the many writings of the Dutch academic Geert Hofstede who has pioneered research in this area.

9. See too Exhibit #4 (which assesses the significance of various factors (including labour) in affecting the location of production) in: *Container shipping: the next 50 years*, McKinsey and Company, October 2017.

10. https://www.logistics.dhl/global-en/home/insights-and-innovation/thought-leadership/case-studies/global-connectedness-index.html.

11. See again the references under endnote 2 above.

12. Supply chains for different industries are fragmenting in different ways, *The Economist*, 11 July 2019.

13. See again https://www.mckinsey.com/featured-insights/innovation-and-growth/globalization-in-transition-the-future-of-trade-and-value-chains#part3. For a review of trends in global manufacturing and their impact on global supply chains, see https://www.gov.uk/government/publications/future-of-mobility-changing-supply-chains-and-uk-freight.

14. Data source: https://data.worldbank.org/indicator/TG.VAL.TOTL.GD.ZS?end=2018&start=1960&view=chart.

15. Table 1.9 in UNCTAD's *2019 Review of Maritime Transport*.

16. Container volumes are calculated in twenty-foot-equivalent measures (TEUs) – we will discuss this further in Chapter 7.

3
Supply Chain Strategy: Lean and Agile

LEARNING OBJECTIVES

- Highlight the role of logistics and supply chain strategy in the context of firm strategy, and see how logistics and supply chain strategy can actually sometimes drive firm strategy.
- Distinguish supply chains and value chains.
- Outline the evolution of production, from which various logistics and supply chain strategies have emerged.
- Look at both lean and agile logistics strategies, and the role of mass customisation in the latter.
- Develop a taxonomy of supply chain strategies.

INTRODUCTION

The preceding two chapters gave us an understanding of the drivers for the evolution of logistics and SCM, and the global context within which both operate. This chapter now turns to introducing the various logistics and supply chain strategies that organisations employ in order to survive and compete within this complex and dynamic environment. Logistics and supply chain strategy is not, however, divorced from a firm's strategy, and so we first have to look at firm strategy and examine its relationship to logistics and supply chain strategy. We will also see in this chapter that not only is logistics and supply chain strategy part of a firm's strategy, but also in many instances logistics and supply chain strategy can be the key component within, and driver of, a firm's strategy.

Chapter 3 comprises seven core sections:

- Strategy
- Value chains versus supply chains
- The evolution of production
- Lean production
- Agile supply chains and mass customisation
- Combined logistics strategies
- Critical factors to consider in supply chain planning

STRATEGY

The field of business strategy is a wide, fascinating and varied subject. It is also of crucial importance because an organisation without a strategy is, in our view, like a ship without a navigation system. Strategy can generally be described as being concerned with planning and configuring the organisation for the future in accordance with certain stakeholder expectations. More simply, the *Collins English Dictionary* defines strategy as ‘a particular long term plan for success’. Our specific purpose in this chapter is not, however, to explore the whole field of strategy, but instead to examine the link between strategy and both logistics and SCM, and to consider specific logistics and supply chain strategies. In fact we will view logistics strategy and supply chain strategy together – as we already noted above in Chapter 1, in this book we adopt the *unionist view*, i.e. logistics is part of the wider entity which is SCM. It follows then that logistics strategy and supply chain strategy will be closely connected and for the purposes of this book we consider both conjointly.

A usual starting point when considering a firm's strategy is to work from the ‘top down’. Thus people will often first consider the wider whole organisation so-called *corporate strategy* and its objectives. For example, what are the overall financial and growth targets for the organisation? Similarly, organisations need to decide what technologies and markets they want to focus upon. Increasingly, organisations are also turning to consider the impact of their operations on the environment. We will return to this issue of sustainability, and its link to global logistics, in Chapter 16.

Below the whole organisation level is what is often referred to as the *business unit* level. Many large organisations are divided into such business units, which focus on specific products and markets. For example, some large logistics service providers may have separate warehousing, transport and other business units, and may develop separate strategies for each of these areas.

The final level is often referred to as *functional strategy* and refers to the development of strategies for specific areas of activity within a business unit (e.g. marketing, IT and logistics). Figure 3.1 depicts this top–down structure.

Not everyone agrees, however, that this is the best way to formulate strategy. Two questions which arise are: (i) it doesn't allow for a ‘bottom–up’ perspective and (ii) in the case of logistics and to a lesser extent SCM, it assumes that these are functions just like other functions within the organisation. Furthermore, there is an increasingly held view that much of what constitutes strategy is *emergent*, that is, that companies need to evolve their strategies to meet the challenges of the dynamic, ever-changing business environment. More and more then the view that a strategy can be dictated from the ‘top’ of an organisation and not revised for a number of years is becoming redundant.

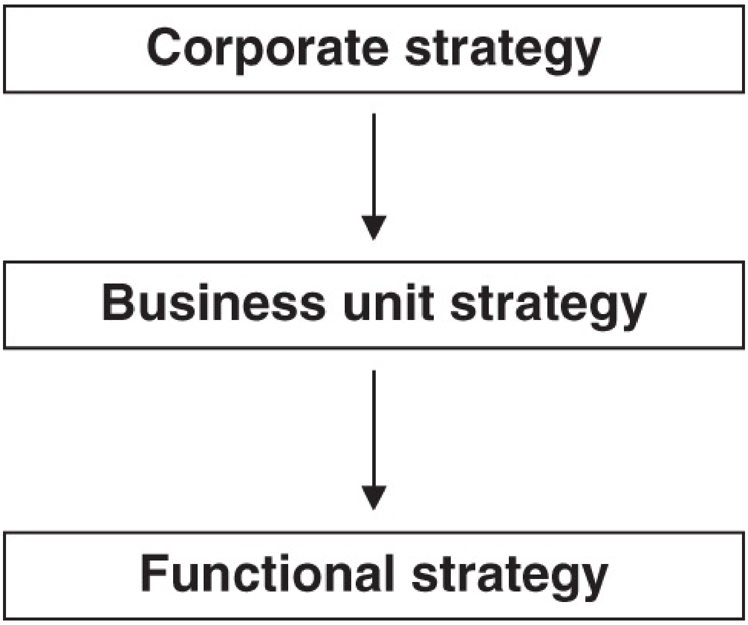


Figure 3.1 **Top–down perspective on strategy**

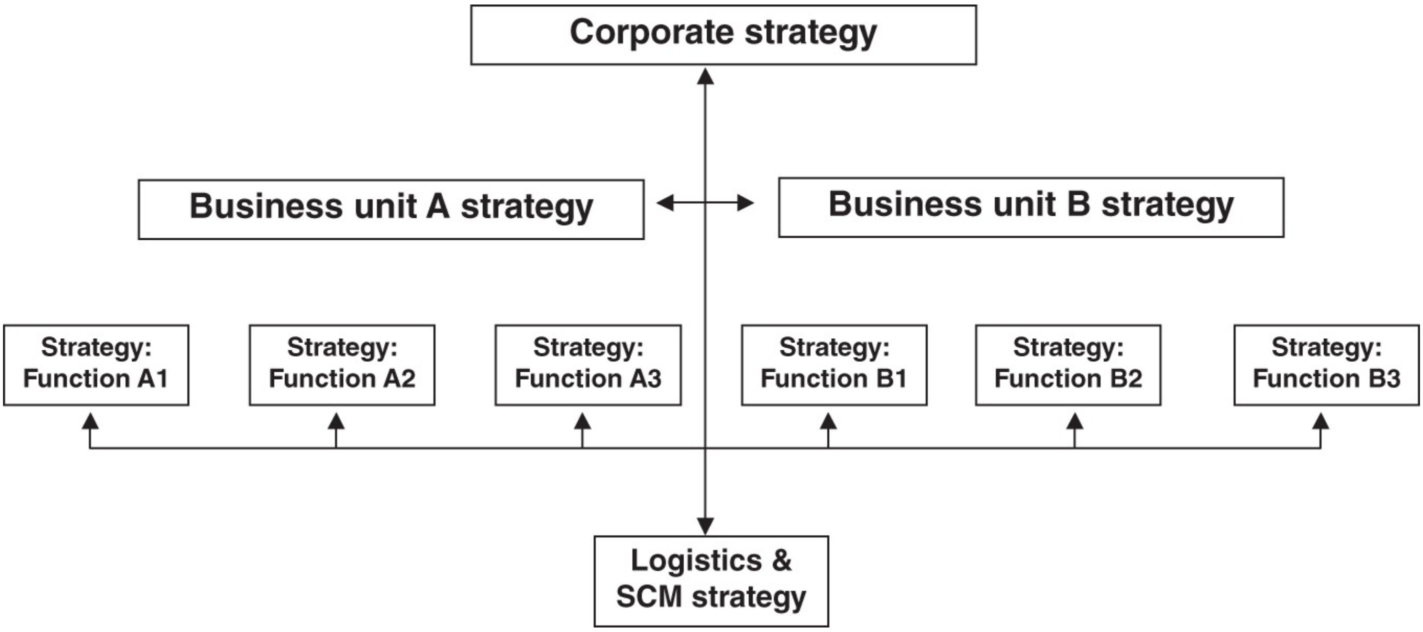


Figure 3.2 **A holistic view of logistics and SCM strategy formulation**

Taking a 'bottom–up' perspective of strategy allows us to see how logistics can contribute to the wider business unit and firm strategies. Some argue that logistics can in fact be the foundation for overall strategic action.[1] In this context it would seem to be inappropriate to reduce the formulation of logistics and supply chain strategy to the same level as that which pertains to most other functions. Furthermore SCM is an activity which is truly cross-functional and not limited to one functional area. Many firms are organised into what are sometimes referred to as functional **silos**, for example marketing and production, and often the various functions do not integrate sufficiently with each other. Such a structure, however, is often not sufficiently responsive to meeting customer demands, which typically do not (and should not) respect internal organisational barriers.

SCM in contrast seeks to take a cross-functional, process-based perspective. To quote Fabbe-Costes and Colin,[2] there is a mature perception of logistics as a cross-functional and deliberately open-ended management domain in the firm, and as a proactive interface with external partners in the supply chain. Figure 3.2 attempts to capture a more holistic view of strategy formulation as it applies to logistics and SCM.

We started out this section by highlighting the importance of strategy, and this is indeed the case. We must not lose sight, however, of the fact that what is also very important is that organisations effectively implement their strategies (some call this strategy execution), as many elaborate strategy planning exercises and the subsequent strategic plans no doubt just remain sitting on office shelves. To quote the famous management thinker Henry Mintzberg, 90% of strategy is implementation. What is important then is that the organisation monitors the implementation of its strategy, and makes whatever changes are necessary and appropriate in the following weeks, months and indeed years, without being bound to a plan which may not be working out in practice.

> Formulating a strategy for logistics and SCM should not be restricted to the logistics function: instead it should involve taking a cross-functional, process-based perspective.

Two principal logistics and supply chain strategies (although there are others, and indeed combinations of strategies are also used – more on this later) have emerged in recent decades, namely **lean** and **agile**. We will review these in turn in subsequent sections. We will then progress on to an understanding that a 'one-size-fits-all' approach to logistics strategy increasingly makes less sense, and thus we will consider combined logistics strategies.

VALUE CHAINS VERSUS SUPPLY CHAINS

One of the key concepts in the field of strategy is that of the value chain developed in the 1980s by the esteemed Harvard professor Michael Porter. A question we are often asked is: how does the value chain differ from the supply chain? The answer to this question can be as simple or as complex as you wish! In simple terms the supply chain usually views material flows moving downstream from source to customer (the flow is down) – in contrast, the value chain is more so focused on flows of value and demand which generally move in the opposite direction in that the end customer is the source of value and thus value flows from the customer in the form of demand on the supplier (the flow is up). So while SCM and value chain management are both concerned with the processes necessary to produce the products and services that customers will buy, each discipline views the process from a unique standpoint and with different objectives. While the supply chain can sometimes add value to a product (just having the product available is of course a form of value – recall our eight rights definition of logistics from Chapter 1), the main purpose of a value chain is to add as much value to the product as the customer is willing to pay for – and this can often be achieved via, for example, packaging or marketing and sales. Both concepts, then, are important and necessary. In a White Paper by the IDB and the WEF,[3] for example, it is noted that the concept of supply chain is different from value chain. In their view, a value chain is used either as a set of interrelated activities a company relies upon to create value and build competitive advantage or as a combination of different industry players to meet a market requirement. Golini and Kalchschmidt (2019)[4] also explore the connection between the fields of global value chain analysis and SCM and cite other work too that shows how global value chain analyses and frameworks can be applied to SCM. A focus of global value chain analysis is, for example, upgrading – how can organisations upgrade processes, move into more sophisticated products, acquire new functions and enhance skills sets and apply competencies elsewhere.

Traditionally, the focus of value chain management was on the activities that create value *within* firms. We will see, however, in Chapter 12 the prevalence of outsourcing where activities are outsourced to other firms who can provide a cost and/or value advantage. The effect of this is to extend the value chain beyond the boundaries of the firm. To quote Martin Christopher, Emeritus Professor of Marketing and Logistics at Cranfield School of Management, 'the supply chain becomes the value chain' with value (and cost) created not just by the focal firm but also by all of the firms that connect to each other.[5]

> The *supply chain* can be viewed as the network of organisations and relationships that flow products and services to customers, while the *value chain* can be viewed as the combination of entities, activities and competencies that add value and satisfy customer demand.

In essence then (and reminding ourselves of our definition of SCM from Chapter 1), we can regard the supply chain as a network of organisations and relationships that flow products and services to customers, while the value chain is that combination of entities, activities and competencies that add value and satisfy customer demand.

THE EVOLUTION OF PRODUCTION[6]

Before we start to look specifically at lean and agile logistics and supply chain strategies, it is useful to first briefly look at how different models of production have evolved over the last 100 years or so. In the evolution of production, two key output criteria, namely output volume and output variety, have been separate goals that firms have worked towards. It is, however, only in recent years that the goal of simultaneously achieving both has really been accomplished.

Figure 3.3 illustrates the evolution of production strategies over the past 200 years. Other things being equal, most production units will endeavour to produce goods and services which satisfy high levels of customer demand (via a high level of output variety), while at the same time producing large volumes so as to enjoy economies of scale in production. It was not always like this. Prior to the Industrial Revolution, and indeed for many years during and after it in some industries, skilled artisans produced single items customised for individual customer needs. This was called *craft production*. Just think of the history of shoe production, for example. While this undoubtedly satisfied customer needs, it was a costly form of production. Craft production still of course exists today in certain specialist, high-value industries.

If we fast forward to the early 20th century, one of the most exciting advancements was the widespread development of *mass production*. A notable example is that of car manufacturing by Henry Ford. His company maximised economies of scale in manufacturing and enjoyed tremendous success for many years. The choice of products was, however, quite limited – just think of his famous maxim concerning the *Model T* motor car that customers could have any colour as long as it was black! So while this production strategy was very successful, we had yet to arrive at a situation where both volume and variety of output could be maximised.

We will detail the next two stages in the evolution of production strategies and their key features – the emergence of lean production and mass customisation – in the sections that follow. But first to introduce briefly the other most recent trends shown on the top right side of Figure 3.3. Up to the late 20th century, success in production was largely predicated on possession of key capabilities – if, for example, a factory or service entity (e.g. an office processing insurance claims) had lean production capabilities, then it would likely steal an advantage on its competitors. Today, however, such capabilities are almost ubiquitous – and if you don't have them, you can still leverage their advantages by outsourcing to providers who have those capabilities. In essence, many organisations no longer compete on the basis of how good or fast they can make a product or provide a service. Such capabilities are no longer regarded as **order winners** (i.e. I will win this contract because I can produce better/quicker than my competitors) but as **order qualifiers** (i.e. to survive in this business I need to be able to produce at least as good/fast as my competitors). In practice then today mass and lean production capabilities are regarded as standard capabilities in many industries. Organisations use other ways to compete – especially by using the supply chain. We will return to this concept of order qualifiers and order winners, and to the growth in outsourcing, in Chapter 12. The other trends shown in Figure 3.3 include the following:

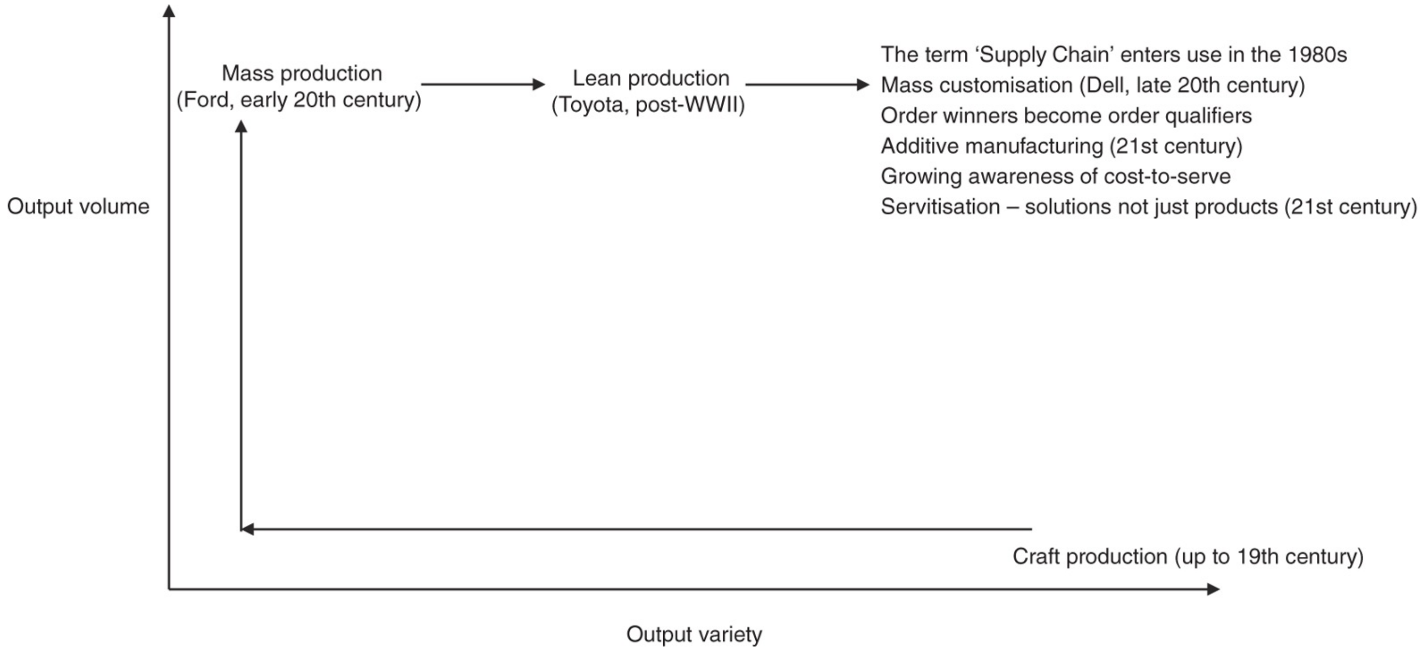


Figure 3.3 The evolution of production Strategies[7]

- Additive manufacturing, more commonly known as 3D printing, will be discussed in Chapter 11 when we look at materials handling and automation.
- Organisations are increasingly aware of the detailed costs associated with all aspects of the products and services that they produce and deliver. For example, where previously a company may have known the unit cost to produce a washing machine, it now also knows what it costs to deliver the product to different customer locations, what it will cost to fix or return it if something goes wrong and so forth. The same goes for services: organisations increasingly know the detailed breakdown of costs associated with serving different customer groups. Key in all of this is the supply chain, as that's where most of the costs lie and can be managed. Chapter 12 deals in detail with costing and pricing in LSCM.
- The next chapter – on services – deals in detail with servitisation which is where manufacturers offer services with their products.

LEAN PRODUCTION

The origins of **lean** production and logistics can be traced back in particular to the car company Toyota and its ingenious Toyota Production System, pioneered by people such as Kiichiro Toyoda (son of the company's founder), Taiichi Ohno and others during the 1930s and especially after World War II. In developing the Toyota Production System they drew heavily on the work of Ford and identified areas in the Ford model that could be improved. They also drew on the work of the American quality guru, W. Edwards Deming. In fact much of Deming's early work received a richer response in Japan than it did in the US, and the Japanese were to enjoy significant competitive advantage as a result of their embracing of what came to be called total quality management (TQM).

Toyota sought to develop a production system where the emphasis was not on the efficiency of individual machines, but on total flows through a system. Significant emphasis was placed on quick machine turnovers, elimination of waste (known in Japanese as *muda*), even production flows, low levels of inventory, faster total process time and achieving total quality. Where many production systems are '**push**' based, Toyota sought to develop a system where inventory is '**pulled**' downstream through the system. This prevents stockpiling and inefficiency and is known as **just-in-time (JIT) inventory replenishment**, where inventory is kept to a minimum and replenished only as it is used. The **Toyota Production System (TPS)** was born and in particular it sought to eliminate waste (in the form of unnecessary inventory and inefficient processes) in seven key areas (evaluating these areas – commonly referred to as the Seven Wastes – gives us insights into much of the thinking behind lean production):

1. Overproduction – basically producing too much. In this instance some inventory ends up being held in a warehouse or other holding area. This is referred to as **make-to-stock (MTS)**, as opposed to the more efficient (from a waste minimisation perspective) **make-to-order (MTO)**.
2. Waiting – poor process design and/or poor planning may result in work-in-progress inventory waiting until a machine or operator becomes available so that it can go through the next stage of production. Many aspects of the TPS philosophy also find application outside of manufacturing contexts. In the case of 'waiting' think, for example, of the inefficiencies that arise in some healthcare systems where patients have to wait in hospital, sometimes for days, for the appropriate doctor to decide on the best course of treatment or they get delayed going for an expensive procedure because there isn't a porter available to take them.
3. Transportation – except in the case of products such as software, invariably most products have to be physically transported to the marketplace. In a sense this is non-value adding time with the freight just sitting on the truck. Again, adopting the TPS philosophy, one might try to think of ways in which value could be added to the product during this idle time. Just think, for example, of bananas ripening or onions drying in transit. Another example concerns certain medical devices which have to be sterilised after production but before they can be used. Some manufacturers have developed special packaging which allows chemicals to dissipate from the post-production sterilised product within the package over a fixed period of time. During this fixed period the devices can of course still be transported to the market, the only caveat is that the product is not opened until the due date.
4. Inappropriate processing – in some production systems sometimes all products may enjoy the same level of processing, even though this might only be required for some of the products. An example might be using a certain advanced type of packaging on all products, even though this might only be required in certain markets.
5. Unnecessary inventory – inventory has various costs associated with it which we will study in detail in Chapter 10. Suffice to note for now that holding unnecessary inventory *just-in-case* it may be required is costly and may also actually hide problems.

6. Unnecessary motion – in a poorly designed production system it may be the case that work-in-progress inventory moves in an erratic route between stages around the factory. In a retail distribution example in Chapter 6 a similar scenario (albeit on a larger scale) is illustrated whereby a supplier delivers product from region X to a consolidation centre in region Y, only for the product to then be moved back to a regional distribution centre operated by the retailer near region X.
7. Defects – product that is defective invariably can cause production delays as it may be necessary to see what caused the defect. Furthermore, if the defect is only observed at the end stage of production, it may take time to discover where exactly the problem arose. This is all wasteful downtime which total quality systems, by their emphasis on zero defects, seek to minimise.

THE BOOZE BUS

The wastes identified by lean are not mutually exclusive – some processes may display many of the wastes. To take another example from the healthcare sector: a major source of annoyance and waste for many hospital emergency departments is dealing with late night revellers who become too intoxicated. They may need some medical care, but most often all they need is a supervised sleep – and is a busy, expensive hospital emergency department the most appropriate place? Treating this need in this manner suggests the following wastes at least are evident: possibly waiting, transportation, inappropriate processing and unnecessary motion. To respond to this need and to minimise such wastes, many healthcare systems have introduced ‘booze buses’, vehicles with the necessary staff and facilities which can go to the locations of most demand and treat the ‘patients’ there.

A key aspect of lean is ensuring that value is added at each stage of the process (this is known as ‘the value stream’) and steps in the process that do not add value are eliminated.

Traditionally, many production systems worked on a *push* mentality, that is, materials are produced according to a planned forecast (which may or may not be accurate) and moved to the next stage of the supply chain; in *pull*-based systems inventory is only produced and moved when it is required, and thus is more closely aligned with actual demand. (In essence then push systems relate to MTS, while pull systems relate to MTO – see the first waste above (Overproduction).)

In recent years an eighth waste, underutilisation of resources, has been added to the list. Toyota became one of the world's most successful manufacturers and while companies in the West were initially sceptical of Toyota's ideas, they quickly began to embrace them. A key study of the worldwide auto industry, the International Motor Vehicle Programme, by Womack, Roos and Jones in 1990 brought the world of lean to a wide audience. The study was published in a highly influential book called *The Machine That Changed the World*[8] and resulted from a five-year, $5 million, 14-country study conducted by MIT, apparently one of the largest and most thorough studies ever undertaken in any industry.

As well as the 7/8 wastes, the essence of lean is often summarised in five key principles:

- Identify where – from the perspective of the customer – value is created.
- Map the value stream – i.e. the process that creates customer value.
- Ensure that all steps in the process flow efficiently and that any waiting is eliminated.
- Pull not push: produce in response to customer demand.
- Identify the root cause of any problems and strive for perfection.

Lean production and logistics is concerned with eliminating waste in a pull-based value stream of activities with level production (i.e. even production runs with neither idle time nor surges in demand) and just-in-time inventory management.

Such has been the success of lean production and logistics that in recent years many of these insights and techniques have been translated to the services sector. Two of the authors of the aforementioned book *The Machine That Changed the World*, Womack and Jones, wrote that ‘lean production transformed manufacturing. Now it's time to apply lean thinking to the processes of consumption. By minimising customers’ time and effort and delivering exactly what they want when and where they want it, companies can reap huge benefits'.[9] Womack and Jones developed their own principles of lean consumption[10]:

- Solve the customer's problem completely.
- Don't waste the customer's time.
- Provide exactly what the customer wants.
- Provide what's wanted exactly where it's wanted.

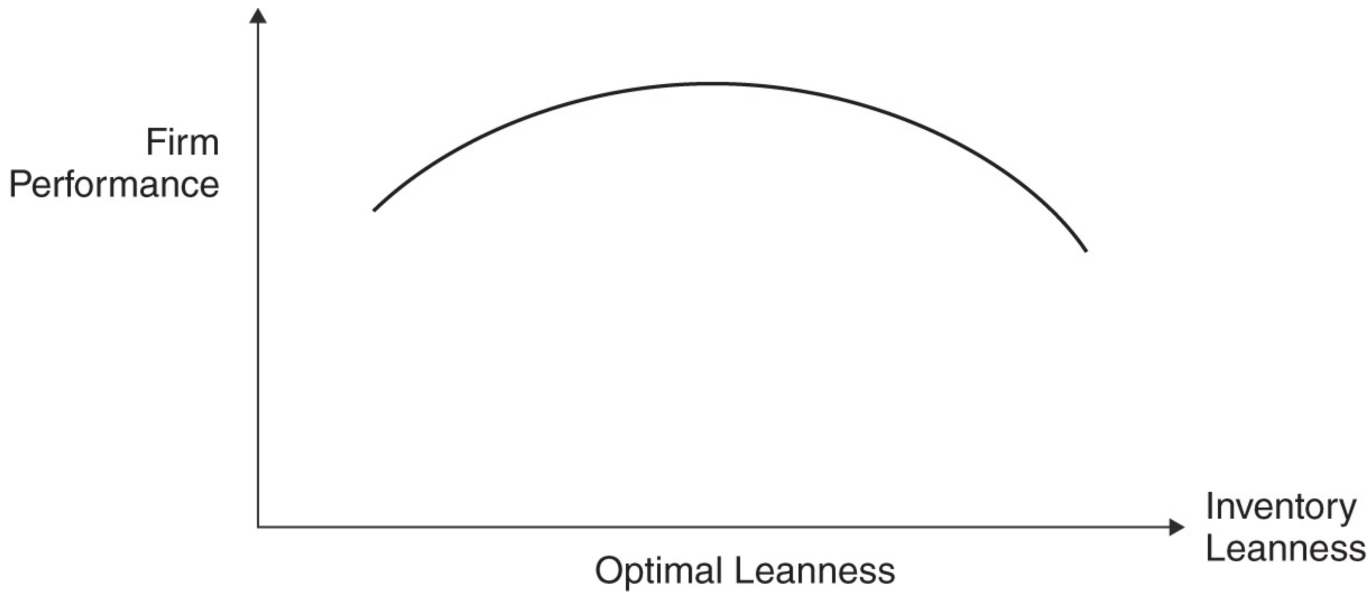


Figure 3.4 The inventory leanness – firm performance relationship

(Source: Based on Eroglu and Hofer, 2014).[13] Note that the shape of the curve (arched vs flat) will vary by industry and influencing conditions

- Provide what's wanted where it's wanted exactly when it's wanted.
- Continually aggregate solutions to reduce the customer's time and hassle.

Lean has been enormously popular and effective. A range of concepts, tools and techniques have been developed to assist organisations in lean implementation, e.g. 5S (for workplace organisation – and sometimes called 6S to include safety), continuous improvement (kaizen), production levelling (heijunka) and reduced changeover time (SMED). Lean initiatives too are often progressed in tandem with quality improvement initiatives such as Six Sigma. Some argue, however, that too great a degree of lean implementation in an organisation can hinder its responsiveness and adaptability, two key goals of effective supply chains and the focus of the next section (agile supply chains and mass customisation). But clearly performance and productivity gaps exist for many organisations – and effective implementation of lean can help reduce these gaps. A number of researchers have investigated the link between inventory leanness and firm performance. Eroglu and Hofer (2011, 2014)[11] suggest that a concave relationship exists between inventory leanness and firm performance (Figure 3.4). They note that this relationship varies substantially across industries and firms and that it can be influenced by environmental conditions (such as demand uncertainty and competitive intensity). In other studies, Ferdows and Thurnheer (2010)[12] introduced a concept of factory fitness (building agility, improving and expanding core capabilities), and they noted that a factory can become too lean but it can never be too fit.

AGILE SUPPLY CHAINS AND MASS CUSTOMISATION

Managing supply chains effectively is a complex and challenging task due to the influence of various trends including increased demands from consumers for greater product variety, shorter product life cycles, increased outsourcing, globalisation and continuous advances in technology. In recent years the area of risk in supply chains, whether from natural sources (for example disease in the food supply chain) or human sources (for example terrorism), is adding to the challenges in SCM (we will return to the growing and important area of supply chain vulnerability in Chapter 15). All of these disparate factors have led to a high level of volatility in demand for products.

To mitigate such volatility another supply chain model emerged in the early 2000s, the agile supply chain. Pioneered by Professor Martin Christopher and colleagues at Cranfield University, and others, the agile supply chain is designed so as to cope with such volatility. According to Professor Christopher, 'to a truly agile business volatility of demand is not a problem; its processes and organisational structure as well as its supply chain relationships enable it to cope with whatever demands are placed upon it'.[14] A particular characteristic of the agile supply chain is that it in effect seeks to act as a 'demand chain' with all movement upstream in the supply chain dictated by customer demand.

One of the key enablers of agile supply chains is the use of a technique known as **mass customisation**. This involves *customisation* into various different finished products of what are often largely *mass*-produced products. Even when different product configurations contain a majority of shared components and features, the customer will usually concentrate more upon the dissimilar features among the similar products.

Mass customisation makes use of a production philosophy known as the **principle of postponement** (Figure 3.5). Think of the dark dots in the diagrams as work-in-progress inventory with the light squares on the right of each diagram as the (8) finished products. Both of the production processes depicted thus comprise two intermediate production stages prior to production of the finished products. Production processes with many different parallel production lines can be very inefficient (left-hand side of Figure 3.5), especially if demand reduces for the output of one line and increases for that of another. In effect, you end up with increased redundancy in the former production line. However, by reconfiguring the production lines and making more steps common, the impact of variability in demand for finished products can be reduced. We can see on the right-hand side of Figure 3.5 that if it is discovered during the production process that demand for some finished product lines reduces, semi-processed product can easily be 'diverted' into the production of other finished product lines.

Mass customisation is enabled by a production philosophy known as postponement, which involves the reconfiguration of product and process design so as to allow postponement of final product customisation as far downstream (i.e. near to the customer) as possible. Other names for this approach are simply ‘delayed product configuration’, ‘delayed product differentiation’ and ‘late stage customisation’.

The postponement approach doesn't just apply to manufacturing. *Packaging postponement,* for example, is simply delaying final packaging of products until customer orders are received (different packaging may be required for different customers, and rather than make different packaged product lines to stock, product could be quickly packaged as required once specific orders are received). Similarly, there are many examples in services – your typical fast-food restaurant, for example, will have the main components of your meal ready, but won't finalise everything until your order is received. In healthcare, the providers will typically try and channel most patients through the common diagnostics tests first (e.g. bloods, patient history) before separating patients into different care-specific streams.

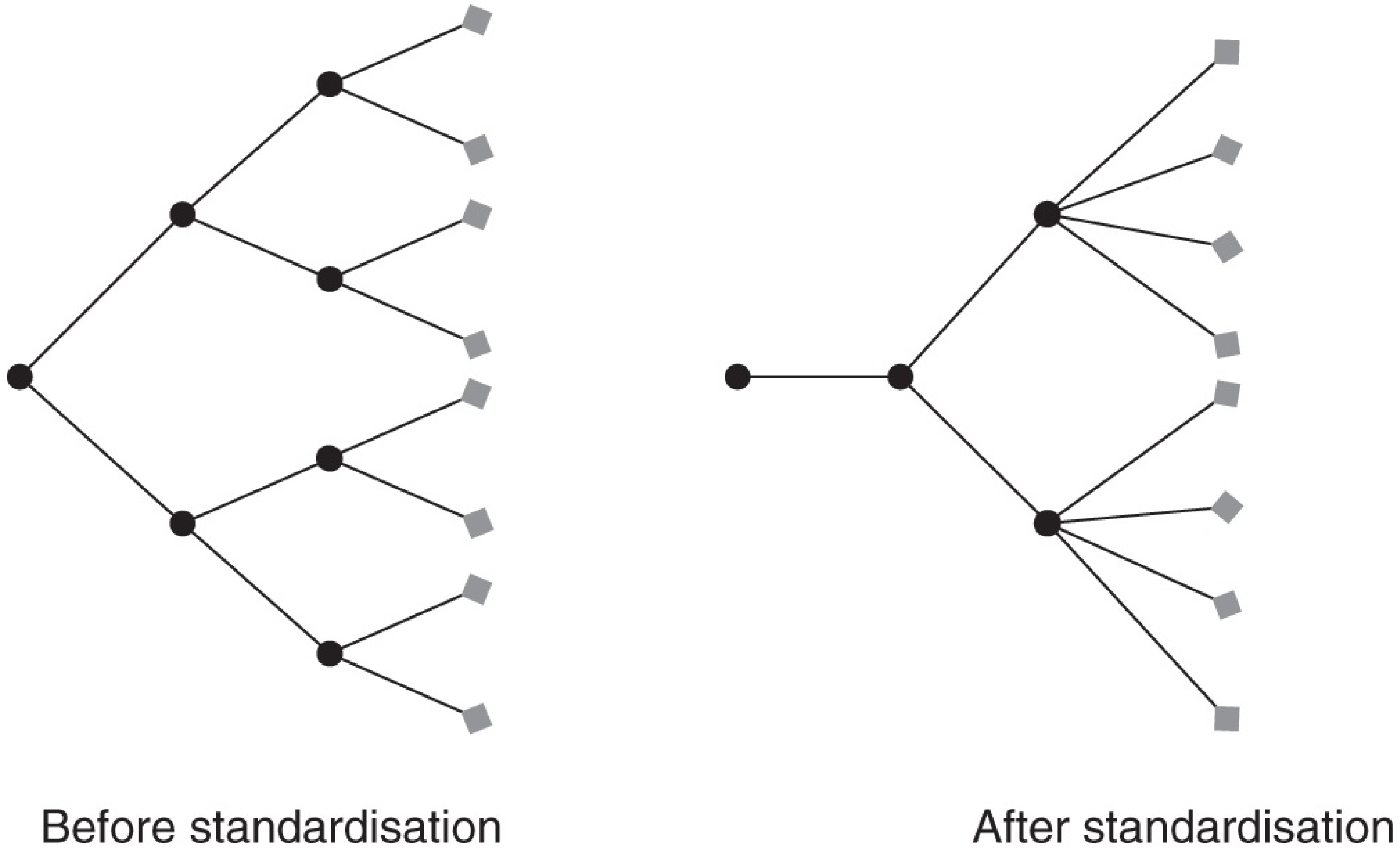


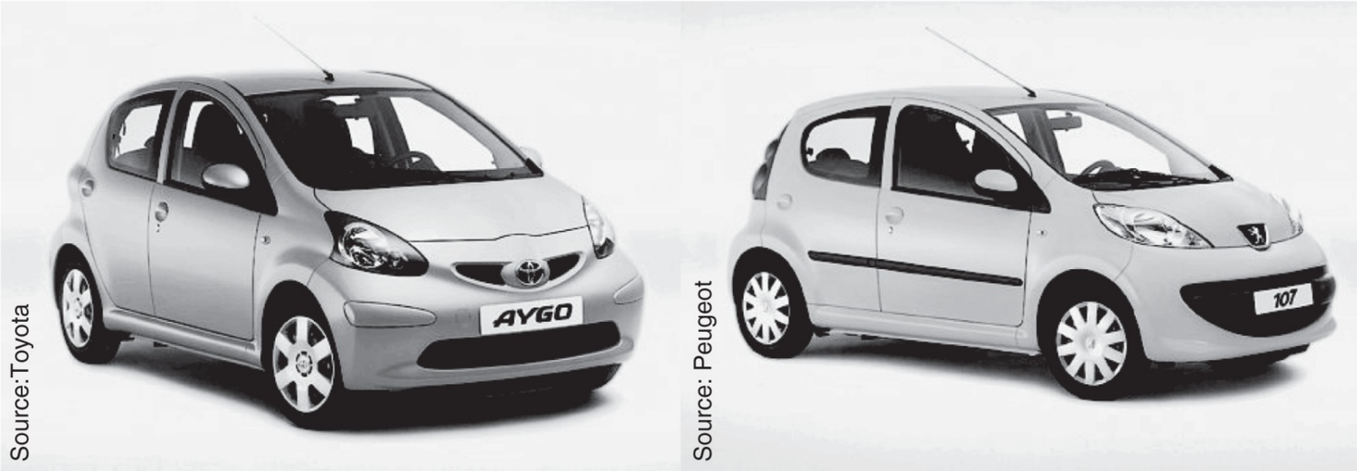
Figure 3.5 The principle of postponement

Many manufacturers are now realising the benefits of producing products on what have come to be known as common or shared platforms. Various labels have been given to these shared platforms in different industries, for example the base product, the core product, the vanilla product (using the ice cream analogy of undyed plain ice cream), the generic product and the grey product (a term used in garment manufacturing to refer to undyed fabric). In a postponed production system, ideally the final value-adding activities in the supply chain are delayed until customer orders are received.

The point at which we move from the base product to customised products is called the **decoupling point** (see Figure 3.7 in the next section). If you look at the case study on Dell at the end of Part One of the book, the decoupling point is the point in the production process where the core PC platforms are configured into final products demanded by customers. Another name for the decoupling point (more commonly applied in other contexts such as military and software) is the – rather self-explanatory – last responsible moment.

The automobile manufacturing industry has been a keen user of mass customisation (see the example below with regard to cooperation between Toyota, Peugeot and Citroën). Indeed Toyota, Peugeot and Citroën were not the first in the automobile industry to do so. Other advocates of the approach include the Volkswagen Group which comprises among others the brands Volkswagen, Audi, Skoda and Seat. Many of the product offerings in the different car models across these brands share similar platforms and components. Apart from making sense from production and financial perspectives, consolidation in the automobile manufacturing sector, where once many companies were keen competitors but are now working together and sometimes even merging, is now driving increased application of mass customisation in the industry.

Other Examples of Mass Customisation



Toyota, Citroën and Peugeot decided to adopt a different approach for the manufacture of a range of cars and in 2002 set up a new, purpose-built joint TPCA factory in Kolin in the Czech Republic to manufacture cars which are separately branded and compete on the open market.

From 2021 Toyota will take financial ownership of the plant (which will continue to make the separately branded cars) as part of a wider range of developments which see the partnership in Europe between the companies deepen.

In the diagram, all three cars (the Toyota Aygo, Citroën C1 and Peugeot 107/108) share 92% of the same components.

Small Car Manufacturing: Cooperation between Toyota, Peugeot and Citroën

It's not just the automobile manufacturing industry that employs mass customisation, many other industries have also adopted the technique. Just think of the way in which the purchase of *paint* has changed. Because of developments in both production technology and the marketing of paint, the range of different paint colours it is now possible to purchase has increased dramatically. In addition, it is usually possible to buy paint in various different can sizes (e.g. 1 litre, 5 litres). The range of potential **stock-keeping units (SKUs)** (see the textbox for an explanation of SKU) in paint distribution is thus huge. Rather than keeping all possible SKUs in each store, mass customisation has become very popular in paint distribution. Each store holds the primary colours of paint and a machine then mixes these to a specific formula to produce the exact required colour of paint from a range of possible colours. All that is otherwise required are paint cans in the different sizes and a simple printing machine that can produce labels with the name of the paint. Yet another example is breakfast cereal – the company mymuesli (www.mymuesli.com) allows you to order organic muesli online for delivery to your home, claiming ‘with over 80 different ingredients there are 566 quadrillion possible mixes!’

> An SKU (stock-keeping unit) is a unique version in terms of size, packaging etc. of a particular product type, e.g. 2-litre cans of white paint would be one unique SKU, 2-litre cans of harvest yellow paint would be another unique SKU, while 1-litre cartons of harvest yellow paint would be yet another unique SKU and so forth.

Now back to agility. Professor Christopher describes agility as ‘the ability to respond rapidly to unpredictable changes in demand’.[15] In his view ‘agility is not a single company concept, it extends from one end of the supply chain to the other’.

Christopher points out that ‘agility is concerned primarily with responsiveness. It is about the ability to match supply and demand in turbulent and unpredictable markets’.[16]

> The agile supply chain is a demand-pull chain designed to cope with volatile demand. It is structured so as to allow maximum flexibility and will often incorporate postponed production.

The questions which now arise are: which approach is better, lean or agile? And are the lean and agile supply chain approaches mutually exclusive, i.e. can we have both together? These are questions of much debate in the academic literature and which we attempt to answer in the next section.

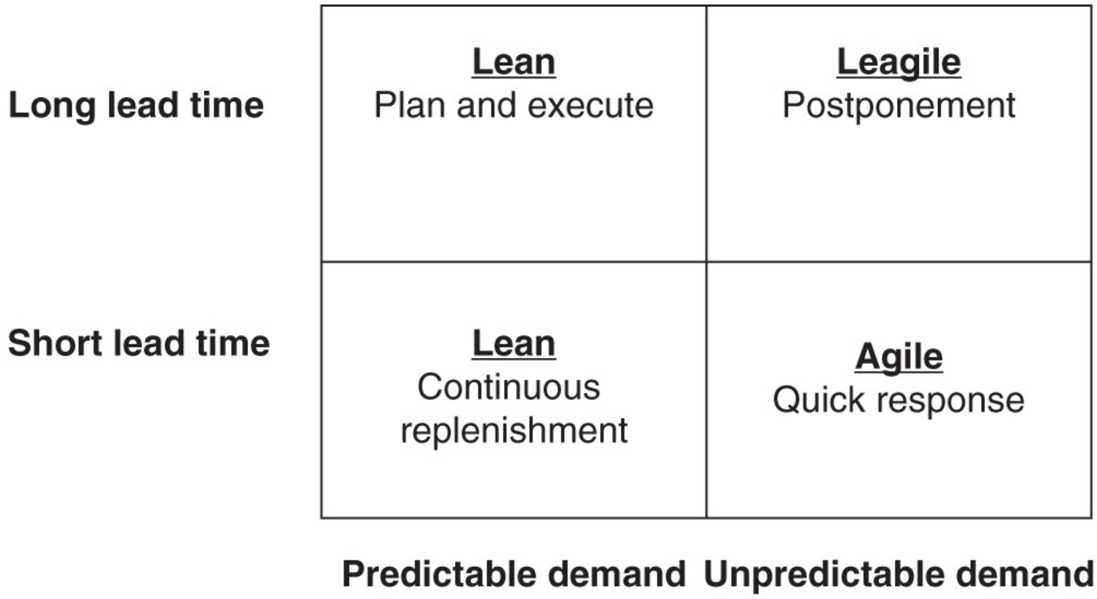
COMBINED LOGISTICS STRATEGIES

So which is better, a lean or agile supply chain strategy? And can we have both together? Certainly it is now becoming apparent that there is no one generic supply chain typology that works in all situations. A simple scenario is to use lean strategies to manage base demand (a forecast-driven approach) and to use agile strategies to manage surge demand (a demand-driven approach). We can build further upon this as we consider the variable nature of product lead times, life cycles, marketplace demand, etc.

In an often quoted paper from the *Harvard Business Review* in 1997, Professor Marshall Fisher from the University of Pennsylvania put forward a framework for supply chain selection based upon the nature of product demand.[17] He distinguished functional products, which have predictable demand, long product life cycles, low variety and long lead times, from innovative products, which have unpredictable demand, short product life cycles, high variety and short lead times. Fisher suggested that two different types of supply chains are required for these two different types of products, which he termed efficient supply chains for functional products and responsive supply chains for innovative products.

Christopher *et al.*, building upon the work of Fisher and others, put forward a taxonomy (Figure 3.6) for selecting global supply chain strategies and which uses both predictability of demand for products and replenishment lead times.[18] It also incorporates lean and agile philosophies as appropriate. They again argue that a 'one-size-fits-all' approach will not work and that companies need to continually assess their product range and market characteristics so that changing scenarios may be identified and appropriate supply chain designs configured. This is the approach also taken by other authors, such as Professor John Gattorna whom we will discuss in the next section. He argues for a dynamic capability in supply chain designs so that they can respond to any changes and he argues against designing supply chains for specific products because, as he argues, different types of demand can in fact exist for the same product, even among the same customer depending on when and why he/she wants to buy the product.

Lean, continuous replenishment: this applies in situations where demand is predictable and replenishment lead times are relatively short. This would apply, for example, in the case of a supplier making regular deliveries to a retailer. Over time a steady demand pattern will likely be apparent, allowing the supplier to 'lean' the supply chain with a high level of certainty. In such situations it is often the case that the supplier will take total responsibility for stock replenishment (we refer to this as vendor-managed inventory – it will be discussed further in Chapter 10), sometimes even directly onto retailers' shelves.



Supply demand characteristics	Resulting pipelines
Short lead time + predictable demand	Lean, continuous replenishment
Short lead time + unpredictable demand	Agile, quick response
Long lead time + predictable demand	Lean, planning and execution
Long lead time + unpredictable demand	Leagile production / logistics postponement

Figure 3.6 A taxonomy for selecting global supply chain strategies

(Source: Christopher *et al.*, 2006. Reproduced with permission of Emerald Publishing Limited.)[19]

Agile, quick response: this applies in situations where replenishment lead times are still short but where demand is now unpredictable. In such situations suppliers need to respond rapidly to changes in demand. A good example is that of the Spanish clothing manufacturer and retailer Zara (see the case study below) who have designed a highly responsive supply chain which can translate the latest fashion trends into new products and deliver them to stores within a very short space of time. Because of the unpredictability in demand, manufacturers such as Zara can make use of postponed production/delayed configuration so that they can quickly configure the base product (referred to in the case of clothing manufacturers as the *grey* garment) into the required final product.

Lean, planning and execution: this applies in situations where demand is predictable and replenishment lead times are long. It is a similar scenario to 'lean, continuous replenishment' described above, except here lead times are longer so more planning is required at a point well ahead of when demand will actually be realised. Lean principles can be applied in such supply chains once any uncertainty caused by long lead times can be managed. A classic example cited by Christopher *et al.* is that of artificial Christmas trees sourced into Europe each year from Asia.

Leagile: this applies in situations where replenishment lead times are still long, but now to add to the complexity demand is unpredictable. In this scenario we can combine both lean and agile logistics philosophies to create what is termed the **leagile supply chain** (this is sometimes referred to as a 'hybrid strategy'). Using postponed production/delayed configuration as described above, the base product can be manufactured at a remote location and shipped to locations nearer the final market (with both manufacturing and distribution using lean principles), where it is then configured into the required final product (using agile principles). The final postponement could range from something as simple as using different types of packaging for different markets to manufacturing postponement where different components are added to the base product downstream as required. In the electronics industry, for example, generic products are produced and shipped to distribution centres in different geographies where they are then customised as orders come in. For example, packaging, language and peripherals, such as power cables, will vary quite significantly by market.

If we now consider the concept of the decoupling point which was introduced in the previous section, in the leagile supply chain lean principles can apply up to the decoupling point, and agile principles can apply downstream beyond the decoupling point (Figure 3.7). The leagile model is a simple and generally accepted paradigm for combining the best attributes of lean and agile approaches into an effective supply chain strategy. It is important to recognise, however, that it may not be valid in all contexts. Qamar and Hall (2018),[20] for example, investigated the distinctions between firms implementing lean and agile strategies within the UK automotive sector and noted that in some product sectors the reverse applies, i.e. lean firms are downstream and agile firms upstream. They note, however, that this might be most applicable when the final product is complex, requiring thousands of components. They note that in terms of supply chains producing simpler final goods, which only require few components, a leagile model (such as described in Figure 3.7) may be more applicable.

Whilst there is ongoing debate around the correct sequencing of lean and agile capabilities/processes/supply chain nodes – there is, nevertheless, an emerging consensus in both the literature and in practice that:

- judicious application of lean can result in performance benefits;
- agile capabilities are a key pillar of many supply chains, allowing quick response and facilitate supply chains in becoming more adaptable and
- lean and agile approaches are not mutually exclusive.

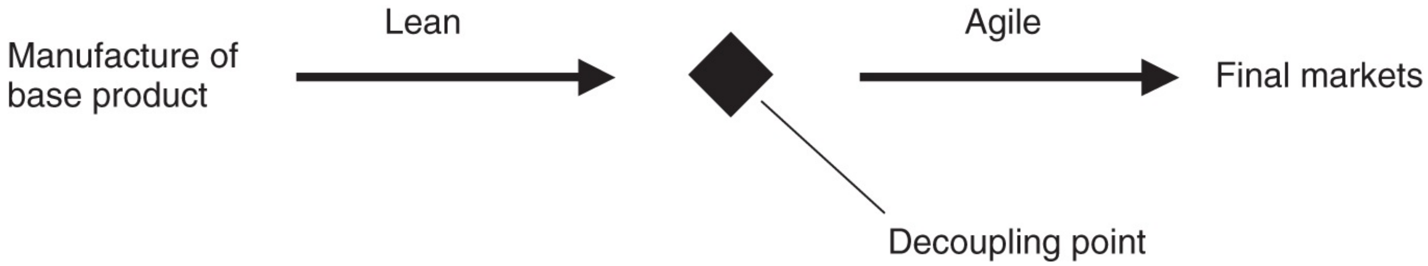


Figure 3.7 The leagile supply chain

ZARA

Based in La Coruna in North Western Spain, Zara is one of the largest apparel companies in the world. Its supply chain is key to its success, in particular, in terms of speed and lower inventory levels than its peers. As a result, it is not hindered by product obsolescence, a key difficulty for many apparel manufacturers who are often stuck with fashion lines that the market does not want and which they cannot get rid of.

Zara's designers stay close to the latest fashion trends and design and manufacture new products within a short time frame. All of this is done within the same facility to minimise delays and ensure maximum interaction among colleagues. Industry observers describe the Zara model as ‘fast fashion’ where buyers don't have to wait months for the latest fashions. After manufacture, product is shipped to Zara's various stores according to a fixed distribution schedule. Most store managers use handheld electronic devices to post real-time orders from the distribution centre, which organises twice weekly deliveries according to a fixed schedule. Products contain multi-country labels so if a line is not selling, the store manager simply puts it back on the truck and it is redistributed to another store via Zara's hub-and-spoke network where it may fare better.

From the store managers with their handheld ordering devices all the way back upstream to the single design and manufacturing site, Zara has full visibility of its supply chain. Another key feature of Zara's supply chain is that it has spare capacity on hand (in terms of trucks, warehousing and production not always being full) and it can facilitate fast response when needed. Professor Kasra Ferdows of Georgetown University and co-writers labelled this ‘rapid fire fulfilment’.[21] Many other companies in the retail sector have closely examined Zara so see where they themselves can apply some of its key success factors.

Zara is hugely successful and its products bring happiness to many. But can you think of any downsides to this method of clothing production and selling? We will return to this in Chapter 17 where we discuss Corporate Social Responsibility (CSR) in LSCM.

CRITICAL FACTORS TO CONSIDER IN SUPPLY CHAIN PLANNING

THE SEVEN PRINCIPLES OF SUPPLY CHAIN MANAGEMENT

In 1997 the journal *Supply Chain Management Review* published an article titled 'The Seven Principles of Supply Chain Management'[22] which outlined seven key actions for successful SCM. That article has been one of the most popular articles in the journal's history and its salient points are even more valid today:

1. Segment customers based on the service needs of distinct groups and adapt the supply chain to serve these segments profitably.
2. Customise the logistics network to the service requirements and profitability of customer segments.
3. Listen to market signals and align demand planning accordingly across the supply chain, ensuring consistent forecasts and optimal resource allocation.
4. Differentiate product closer to the customer and speed conversion across the supply chain.
5. Manage sources of supply strategically to reduce the total cost of owning materials and services.
6. Develop a supply chain-wide technology strategy that supports multiple levels of decision making and gives a clear view of the flow of products, services and information.
7. Adopt channel-spanning performance measures to gauge collective success in reaching the end-user effectively and efficiently.

Now that we have looked in detail at various aspects of different supply chain strategies, it is useful to look at some guidelines that help managers develop their supply chain strategies and facilitate best fit with overall firm strategy. Hopefully the preceding section has shown that a one-size-fits-all approach to supply chain design will not work. There is just too much variability in terms of lead times, product life cycles, marketplace demand, etc. to allow this to be the case.

Focus on processes and flows

Many companies get stuck in what we call a functional or silo mentality where they focus individually on separate areas, instead of configuring according to customer needs (which accords with a demand-driven supply chain approach). This is one of the advantages of taking a supply chain approach in that it allows a full end-to-end perspective to be taken.

Some authors argue that the functional (or silo) nature of many organisations at an operational level acts as a barrier to aligning supply chains effectively with the markets they serve, thus working against a customer responsive supply chain strategy being pursued.[23]

Another way to understand supply chain strategy is to observe some of the many strategic activities that take place along typical supply chains. Tang,[24] for example, identified nine areas which facilitate more robust supply chain strategies: postponement, strategic stock, flexible supply base, make-and-buy, economic supply incentives, flexible transportation, revenue management, assortment planning and silent product rollover. While Tang's focus was on robust strategies to mitigate supply chain disruptions (we will return to this topic in Chapter 15), the list of nine areas is useful because it gives an insight into the many strategies and activities that can be pursued along supply chains. Indeed there are several other strategies that can also be pursued such as factory gate pricing and cross-docking. We will look at many of these in various parts of the book. It is also important to note that companies can have different roles in different supply chains, for example a company may lead one supply chain and be a participating member of another.

Focus on high-level objectives

Some writers argue that supply chains need to meet certain high-level objectives. Professor Hau Lee from Stanford, for example, argued that the best supply chains are *agile, adaptable* and have *aligned* interests among the firms in the supply chain.[25] He called this the 'Triple A Supply Chain'. It is also important to note of course that the supply chain cannot be, and is not, the solution to all ills. Professor Christopher and colleagues highlighted this when they stated that 'responsive supply chains … cannot overcome poor design and buying decisions which fail to introduce attractive products in the first place'.[26]

The importance of people

It is obvious that SCM has grown in significance in recent years. As we will see in later chapters, SCM is benefiting from the application of some powerful technologies. But often overlooked is the role played by people in the supply chain. Professor John Gattorna noted that 'In fact it's people who really drive the dynamic supply chains that are at the heart of your business'.[27] Similarly Quinn noted that to achieve any measure of supply chain success, three critical elements (people, process and technology) need to be kept in balance.[28] He adds that there is no single answer as to which of these three is the most important to supply chain success, although he does add that 'you can't do *anything* without the right people'.

It's supply chains that compete

You will see in the Dell case study at the end of Part One of the book that the PC maker uses robust logistics strategies and competes using its entire supply chain. The idea of supply chains competing was put forward by Professor Martin Christopher in his seminal book *Logistics and Supply Chain Management*, the first edition of which appeared in 1992. It is a powerful concept, and one that is becoming more and more relevant as we see the way companies structure their supply chains often being a key determinant of success. A company can have the best and most sophisticated product in the world, but if it doesn't have a good supply chain, then it will most likely not be able to compete, especially in terms of cost and speed, and indeed many other attributes also. Christopher notes that when supply chain excellence is achieved, often two key shifts are apparent:

- Relative customer value increases.
- Relative delivered cost decreases.

Increasingly it is supply chains that compete more so than individual firms and products.

MANAGING SUPPLY CHAINS IN THE ERA OF TURBULENCE*

We noted above, when introducing the concept of agility, the impact of risk on SCM. We will return to this important topic in Chapter 15. Christopher and Holweg argued that in the light of increasing turbulence a different approach to SCM was needed. They emphasised the impact of growing volatility on supply chains and pointed out that many of our current supply chain designs are predicated on stability and control. They suggested that we need to embrace volatility and revisit the management accounting assumptions and procedures that we currently use to evaluate different supply chain decisions. They argued that what is needed to master the era of turbulence is structural flexibility which builds flexible options into the design of supply chains.

* Christopher, M. & Holweg, M. (2011) 'Supply Chain 2.0': Managing supply chains in the era of turbulence, *International Journal of Physical Distribution and Logistics Management*, 41(1), 63–82.

LEARNING REVIEW

The chapter sought to identify the various different logistics and supply chain strategies, and their origins and evolution. This culminates in particular in strategies based around lean and agile principles, and varying combinations of both. We saw a useful taxonomy which helps choose strategies appropriate to various demand and lead-time characteristics. The importance of logistics and supply chain strategy in the context of overall firm strategy was also highlighted. To again quote Fabbe-Costes and Colin, at the least logistics offers new ways of thinking about strategy.[29] In their view, because it motivates and supports organisational change, it also offers new frames for piloting managerial action in a strategic way. And in their view this is why logistics and SCM are now of such strategic importance.

You will have observed by now that much of the discussion in LSCM draws from a manufacturing origin and context – focusing on logistics operations and supply chains that deliver freight – there is, however, a relatively new body of research that analyses the operations and SCM practices that are required for the delivery of services and this is the focus of the next chapter.

QUESTIONS

- What are the three typical levels of firm strategy?
- Outline the various stages in the evolution of production.
- Explain how mass customisation works.
- How does the supply chain differ from the value chain?
- Outline the various scenarios in which we can use combined logistics strategies.
- Outline how some of the key principles of lean can be applied in a services context.

LOGISTICS AND THE WIDER STRATEGY OF THE FIRM

In this chapter we illustrated examples of companies such as Zara where a good logistics and supply strategy is at the core of the company's wider strategy. Can you think of other examples of companies where their logistics and supply chain strategies are central both to the company's wider strategy and in turn to their success?

NOTES

1. See, for example, Fabbe-Costes, N. & Colin, J. (2001) Formulating logistics strategy, in D. Waters (ed.), *Global Logistics: New Directions in Supply Chain Management*, Kogan Page, London.

2. Ibid., p. 37.

3. See endnote #2 in: Calatayud, M., Katz, R. Betti, F. & Lechmacher, W. (2019) *Supply Chain 4.0: Global Practices and Lessons Learned for Latin America and the Caribbean*, World Economic Forum, Cologny.

4. Golini, R. & Kalchschmidt, M. (2019) Supply chain management and global value chains, in S. Ponte, G. Gereffi & G. Raj-Reichert (eds.) *Handbook on Global Value Chains*, Edward Elgar, Cheltenham.

5. Christopher, M. (2011) *Logistics and Supply Chain Management*, 3rd edition, Financial Times/Prentice Hall, London, pp. 13–14.

6. Readers may also be interested in an insightful article which charts the evolution of management (not just production) from 1910 to the 21st century with nice illustrations of key events and thinkers – see The management century by Kiechel, W. in *Harvard Business Review*, June 2012.

7. This diagram has its origins in a diagram originally contained in a seminal book entitled *The Machine That Changed the World: The Story of Lean Production* (J. Womack, D. Roos & D. Jones, Harper Perennial, 1991).

8. Womack *et al.* (1991), op. cit.

9. Womack, J. & Jones, D. (2005) Lean consumption, *Harvard Business Review*, March, 5–68.

10. Ibid.

11. Eroglu, C. & Hofer, C. (2011) Lean, leaner, too lean? The inventory-performance link revisited, *Journal of Operations Management*, 29, 356–369; Eroglu, C. & Hofer, C. (2014) The effect of environmental dynamism on returns to inventory leanness, *Journal of Operations Management*, 32, 347–356.

12. Ferdows, K. & Thurnheer, F. (2011) Building factory fitness, *International Journal of Operations & Production Management*, 31(9), 356–369.

13. Eroglu & Hofer (2014), op. cit.

14. For a wider elucidation of Professor Christopher's work, see his website www.martin-christopher.info and also his seminal textbook, now in its fourth edition, *Logistics and Supply Chain Management* (2011), Financial Times/Prentice Hall, London.

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20. Qamar, A. & Hall, M. (2018) Can lean and agile organisations within the UK automotive supply chain be distinguished based upon contextual factors?*Supply Chain Management: An International Journal*, 23(3), 239–254.

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24. Tang, C. (2006) Robust strategies for mitigating supply chain disruptions, *International Journal of Logistics: Research and Applications*, 9(1), 33–45.

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26. Christopher *et al.* (2006), op. cit.

27. Gattorna, J. (2010) *Dynamic Supply Chains*, 2nd edition, Financial Times/Prentice Hall, London.

28. Quinn, F. (2004) People, process, technology, *Supply Chain Management Review*, January/February, 3.

29. Fabbe-Costes & Colin (2001), op. cit., p. 53.

4
Service Supply Chains

LEARNING OBJECTIVES

- To highlight the increasing importance of service supply chains in the global economy.
- To define service, service science and service supply chains.
- To distinguish service supply chains from conventional manufacturing supply chains.
- To conceptualise service supply chain models.

INTRODUCTION

While most of the discussions concerning supply chain management take place in the manufacturing context – focusing on logistics operations and supply chains that deliver freight – there is, however, a relatively new body of research that analyses the operations and SCM practices that are required for the delivery of services. Hence in this chapter we now focus on **service supply chains** to identify their importance, their distinctions, their contexts and their future.

Chapter 4 comprises four core sections:

- The transition to service economies
- Service science
- Service supply chains versus manufacturing supply chains
- Service supply chain models

THE TRANSITION TO SERVICE ECONOMIES

The rapid development of the world's leading economies during the 20th century resulted from the Industrial Revolution of the 18th and 19th centuries. This key event in history saw countries such as the UK, US and Germany shift from predominantly agricultural economies to manufacturing economies. People moved off the land and into the mass production systems that would sustain those countries' burgeoning populations. This period can be termed as 'post-agricultural'.[1]

In the second half of the 20th century, another macroeconomic shift could be observed; the transition of those (then) advanced economies from manufacturing to services. In addition, it has been observed that more recently some economies from the developing world have skipped the manufacturing phase and gone directly from having an economy focused on agriculture to one focused on services. This 'post-manufacturing'[2] world has emerged from the demand for value-added services by those countries' populations. Simply put, people migrated from rural to urban areas to work in factories to earn far more than they could on the land. In so doing, they increased their personal wealth and leisure time. Consequently those workers demanded more and better services to complement their lives, such as healthcare, retail and tourism. Hence, businesses and organisations have developed to provide such services. Table 4.1 illustrates the transition to service-oriented employment using the UK, Malaysia and Colombia as examples.

Globalisation and the more recent emergence of the digital economy have provided a further push towards service-based economies. On the one hand, globalisation has enabled many countries to offshore to lower-cost economies not only their manufacturing capabilities but also entire service activities such as product maintenance and customer service. Indeed, international trade in services almost doubled in the past 15 years, accounting for 25% of global exports in 2018. Five Asian countries (China, India, Singapore, Hong Kong SAR and the Republic of Korea) are leading the world market, with a share of nearly 15%.[4] On the other hand, the digital economy – an economy based on digital computing technologies – is enabling the creation of new services (think, for example, of video streaming platforms like Netflix or Amazon Prime) and improving the delivery of traditional services (such as websites that enable detailed travel customisation or online medical interviews). The transition to service economies is a global trend which will continue, and economies have become more dependent on service organisations for continued national prosperity.

At the microeconomic level, organisations are refocusing their strategies and operations to define themselves as service-centric rather than manufacturing-centric. Major enterprises such as General Electric (GE) and IBM were founded on their manufacturing excellence. Today, however, they have reshaped their organisations to focus more on the provision of value-added services. Indeed, the distinction between what constitutes a manufacturing company versus what constitutes a services company is becoming less clear. Baines and Lightfoot in their insightful book *Made to Serve* have introduced the concept of **servitisation**, which involves manufacturers not just delivering tangible, physical products but also offering services which enhance their value proposition and of course add to profitability.[5] There are many examples of servitisation: many manufacturers now offer finance packages to go with their products (e.g. most car manufacturers now also offer finance to their customers) as well as extended warranties, repair services, remote performance monitoring of the product (in trucking, for example) and so forth. Rolls-Royce, for instance, is reported to earn around 50% of its revenue from services.

Servitisation: manufacturers offering services with their products

TABLE 4.1

Share of total employment in services

(Source: Data extracted from World Bank, 2019)[3]

	1980	2018
UK	62%	81%
Malaysia	38%	62%
Colombia	45%	64%

Digital platforms and new technologies such as remote sensing and artificial intelligence are fuelling this trend. Going back to the example of Rolls-Royce, the company is using sensors that report on engine performance. Data is analysed through advanced algorithms that indicate when maintenance is required and when machinery is likely to fail. Through this service, the company is providing a solution to their customers aimed at avoiding product damage and the cost of downtime. Servitisation is becoming even more evident in the automotive industry, where companies such as BMW and GM are offering access to vehicles on a pay-as-you-go basis. This model involves the leasing of vehicles by the consumer whilst the car maker takes on responsibility for cost of ownership, including insurance, maintenance and repair. By doing so, car makers are seeking not just to sell cars anymore but to provide a mobility service solution to their customers. At the core of this shift is what is called Mobility as a Service (MaaS). In its simplest form, MaaS can be thought as a digital clearinghouse for mobility options at a given location. In a more advanced fashion yet to be achieved, the goal of MaaS is to integrate various forms of transport modes into a single mobility service accessible on demand. A single app should allow users to see schedules, search for multimodal travel solutions, book and pay. Car rides would be an option in the mobility menu offered by MaaS and tailored to the customer's need.

MaaS: multimodal travel solutions available through a single digital platform accessible on demand

SERVICE SCIENCE

Early in the 21st century, researchers recognised the need to address the service sector differently from the manufacturing sector. A definition of service was sought to provide a foundation for this emerging body of knowledge. To a service scientist, the term service is defined as 'the application of competences (knowledge, resources) for the benefit of another'.[6] We explore this definition further in the supply chain context to distinguish it from the delivery of manufactured goods in a later section.

Based on the above definition of service, the term service science was coined to capture and consolidate research into the various business functions that combine to provide a service. Service science is 'the study of the application of the resources of one or more systems for the benefit of another system in economic exchange'.[7] In so doing, this unifying term brings together researchers from related but often previously disparate disciplines, such as operations management, economics and computer science. SCM researchers who focus explicitly on service supply chains can thus also be said to be service scientists.

What informs service science research is the need to create value in the provision of a service. Hence much of the research in this field is focused on service innovation. Service innovation is what is driving the expansion of the service sector. As discussed above, for many people personal wealth and leisure time are increasing, so they are able to afford to consume a greater diversity of services. As a consequence, they will also expect greater value from those services. Hence organisations must perpetually innovate to at least meet, if not exceed, consumers' expectations. For example, as a student, you might work out at the university gym, which offers basic equipment. When you graduate, your income will increase and your work–life balance will change; you may therefore join a gym that offers a wider variety of resources such as a swimming pool, sauna and a personal trainer. These are all value-added services. Organisations such as Virgin Active and Equinox are examples of such gyms and in fact brand themselves as 'health clubs' as opposed to gyms. Membership of such clubs aims to offer greater value than that offered by your university gym. Such organisations recognise the market opportunity and develop innovative service solutions to offer value-added propositions.

Service science is the study of the application of the resources of one or more systems for the benefit of another system in economic exchange.

THIRD-PARTY LOGISTICS SERVICE INNOVATION

An excellent example of service innovation in the supply chain context is online package tracking. When we order items from a retailer, they are often shipped by a 3PL service provider from a regional distribution centre. Delivery can typically take a couple of days and the 3PL may route the items through staging posts (e.g. from the RDC via heavy goods vehicle to a local DC, and on to their final destination via light goods vehicle) before we receive them. We, the customers, are provided with a unique order tracking number and a link to the 3PL's order tracking web service when the order is confirmed. We can then use this to track our order. This transparency adds value to the 3PL service by assuring us of where our package is and when it will be delivered. We, the consumers, become part of the supply chain. Transparency is often a key driver for service innovation.[8]

SERVICE SUPPLY CHAINS VERSUS MANUFACTURING SUPPLY CHAINS

As a key component of service operations, service-specific supply chains are now also recognised as being distinct from manufacturing supply chains. A service supply chain is the network of suppliers, service providers, consumers and other supporting units that performs the functions of transaction of resources required to produce services; transformation of these resources into supporting and core services and the delivery of these services to customers. This is the definition suggested by the Global Supply Chain Forum.[9] This helps us to distinguish service supply chains from manufacturing supply chains. Furthermore, the distinction is clarified in Table 4.2 in terms of intangibility, heterogeneity, perishability and inseparability (i.e. simultaneity). This table illustrates that services portray very different characteristics and cannot therefore be managed along a supply chain in the same way as manufactured goods (i.e. freight). Services are less tangible, more heterogeneous, more perishable (i.e. can't be stored) and inseparable from the point of consumption (i.e. the customer is directly and simultaneously involved in the service).

> A service supply chain is the network of suppliers, service providers, consumers and other supporting units that performs the functions of transaction of resources required to produce services; transformation of these resources into supporting and core services and the delivery of these services to customers.

The distinct characteristics of services compared with manufactured products dictate that their supply chain must be managed differently. The emphasis of a service supply chain is predominantly on the creation of value through labour and knowledge, whereas a manufacturing supply chain will create value through the provision of standardised, repeatable processes that ensure the delivery of freight to the end customer in a timely fashion. Standardisation and repeatability are less easy to achieve in a service setting because customers require more variety and in some cases bespoke solutions. That is to say that in Apple's iPhone supply chain, for example, its manufacturers and logistics providers use standard, repeatable processes to make and deliver the millions of iPhones sold globally every day to the high standards we expect. However, the service we gain from the cellular network provider or retailer when we purchase our iPhone will be tailored to our needs (e.g. they will offer various prepaid and post-paid call and data plans that meet a variety of customer needs). Although we all have the same iPhone, the network service attached to it will vary depending on our usage and other personal requirements. Hence the labour and knowledge input into a service offer adaptability to a given situation or customer requirement, which is not commonly found in manufacturing supply chains.[10] The challenge for service providers is to structure and automate where possible their processes in such a way that they can gain economies similar to those enjoyed by manufacturers.

TABLE 4.2

Characteristics of freight versus services[11]

[Source: Ellram, L., et. al. (2007), reproduced with permission of Sage Publications, Inc.]

Service attribute	Impact of attribute on purchasing	Freight	Services
Intangibility	Expectations	Specifications are precise	Vague service-level agreements
	Predictability of demand	Dependent on the accuracy of forecasts for final customer demand	Vary with project scope
	Problem resolution	Formal processes, clear responsibilities	Lack of set processes, more subjectivity
	Cost	Pre-negotiated, per unit, easy to determine in advance	Dependent on changing scope and requirements, situation specific, often is re-negotiated or changes with scope
	Payment	Match receipts with purchase orders, verifiable	Bills submitted without tangible evidence, pay-as-you-go
	Verification of contract completion	Physical evidence in shipment	Internal sign off
Heterogeneity	Quality	Measureable, pre-specified	Subjective, user dependent
	Consistency of output	Clear specifications, tight quality control	Services vary with the provider. Broader specifications with range-acceptable outcomes
Perishability	Interface between providers	Planning and inventory allow for easier transitions	Requires more communication, can't store services
	Inventory policies	Buffer demand fluctuations with inventory	Buffer demand fluctuations with capacity
Inseparability	Points of contact	Few points of contact, usually purchasing or project manager. Limited to no customer contact	Increases the interactions both from a B2B perspective and a B2C perspective
	Physical separation of host firm and provider facilities	Physical distance between buyer and seller	Service is created at point of use, tight coupling
	Security of information/data	High due to physical separation	More difficult to control due to low physical proximity

Having said that, some similar functions exist in both service SCM and manufacturing SCM. For example, demand management, customer relationship management and supplier relationship management are required in both sectors, and will be practised in very similar ways.[12] Hence some basic principles of SCM are transferable across sectors in those management functions.

As is the case in the manufacturing sector, the operational performance of a service supply chain is improved by increased information sharing, and financial performance is improved by focusing strategically on the distribution network. And as is increasingly the case in the manufacturing sector due to ever more fluctuating demand patterns, service supply chain operational performance is also improved through increased customisation.[13] In other words, quick response logistics and supply chain operations are fundamental enablers of value-added service provision. It is therefore important to involve supply chain professionals in procuring and delivering the inputs into a service organisation. Whilst the service provision professionals (e.g. lawyers, surgeons, call centre managers, sales staff) have a comprehensive understanding of how to provide their particular service, they are not necessarily best placed to source the resources they require. Their knowledge should therefore be supported by the procurement and logistics expertise of supply chain professionals to optimise service delivery. Table 4.3 shows how the two skill sets can complement each other. This point is further illustrated in the healthcare inventory management and procurement caselet below.

HEALTHCARE INVENTORY MANAGEMENT AND PROCUREMENT

Supply chain costs are today widely recognised as the second highest costs, after labour costs, to healthcare providers such as hospitals. To provide effective healthcare services requires the input of various resources. From surgical supplies for operating theatres to drugs and wound care supplies onwards, and from cleaning supplies to laundry services, there is a multitude of inventory that healthcare providers must replenish on a regular basis. By adopting inventory management and procurement principles and practices commonly found in manufacturing and retail supply chains, healthcare providers have gained significant cost savings and service improvements.

Today it is not unusual to find hospital wards, for example, with local storage organised and managed as might be found in factories or supermarkets. Regular replenishment of inventory can be achieved by ward staff scanning the bar codes of storage bins with a handheld RF reader when they remove items. Capturing that data informs the inventory management module of the hospital's ERP system that particular items require replenishment.

This, in turn, informs the purchasing module of the system to place orders with the necessary suppliers. The system will be preset to determine the safety stock levels, reorder quantities and delivery lead times to: (a) minimise stock-outs at the ward, and (b) not burden ward staff with inventory management tasks so that they can focus on their core activities of servicing patients. In some cases, vendor managed inventory (VMI) might also be employed to further streamline replenishment.

TABLE 4.3

Relative expertise of supply chain and service provision professionals[14]

[Source: Ellram, L., et. al. (2007), reproduced with permission of Sage Publications, Inc.]

	Supply chain professionals' expertise	Service provision professionals' expertise
Providing a comprehensive, competitive process for managing selection	Bring discipline to process Consistency in analysis methods	Deep understanding of true needs
Identifying opportunities and sourcing	Identify multiple qualified sources to consider Source/qualify supplier Educate management/team on importance of choosing right supplier as well as ongoing analysis	Knowledge of some key suppliers and past performance issues Articulate needs, including timing, duration and specific skills
Aiding the selection of sources	Run competitive process Market analysis Qualitative and quantitative issues Understand true cost picture/total cost of ownership	Provide major input into supplier selection criteria Major voice in selecting supplier
Developing and negotiating contracts and ordering	Commercial skills Negotiate relationship breadth/services/performance Contract process/management Gain sharing arrangements	Provide specifications for contract terms related to service performance
Receipt and payment	Specify in the contract the payment terms Work with accounts and service provision professionals to set up payment system that conforms to contract, with proper controls	Supervise/benefit from the work performed Ensure that work is performed to contract before approving payment
Identifying potential relationship issues and ongoing monitoring/ management	Set up measurement process and systems Identify potential benefits and risks Train service provision professionals to identify issues and manage the supplier Manage supplier relations if major issues arise Manage strategic risks Support ‘re-sourcing’ relationship if needed	Manage ongoing relationship Provide supplier performance feedback Manage the operating risks communicated to the supplier Manage day-to-day supplier relations

SERVICE SUPPLY CHAIN MODELS

Referring back to Chapter 1, we discuss a simplified representation of a supply chain. This is replicated here in Figure 4.1(a) with materials, data and resources flowing along the chain. In a service setting it is knowledge and resources that flow along the chain instead. This is represented in Figure 4.1(b) as a simplified model of a service supply chain.

Referring back to Table 4.2, it is important here to pick up on the inseparability (i.e. simultaneity) attribute listed above. The customer (who is also usually the consumer) is directly and simultaneously involved in the service. Hence the service provision usually occurs when the service provider is in direct contact with the consumer. For example, consider when you the consumer go to a restaurant for a meal.

You must be present at the time it is cooked and brought to your table to consume the food and drink. What Figure 4.1(b) also illustrates is that the service provider is supplied with resources (and in some cases knowledge) prior to service provision. In the case of a restaurant, the chef will order the ingredients for your meal to be ready to cook it. The restaurant manager will also coordinate the setting up of the restaurant before 'service' begins. This will likely include having tablecloths, etc. laundered by a specialist supplier.

However, Figure 4.1(b) is an oversimplification. Whilst service supply chains receive inputs from suppliers to provide outputs to customers, they very often also receive inputs from the customers. This may be in the form of knowledge (e.g. advising a doctor of my symptoms before s/he can diagnose), but may also be resources (e.g. taking my bicycle (the resource) to a bike shop mechanic for 'servicing' and repair). Hence there exists a bi-directional duality between the supplier and customer (i.e. knowledge and/or resources flowing in both directions), where the customer supplies inputs to the service provision and receives outputs from it.

In some cases, the bi-directional duality may be single level or two level. In the former, the duality exists only at the interface between the service provider and the customer (see Figure 4.2(a)). There may also be some resources received by the service provider as inputs from a supplier. In the example above where I visited the doctor, I input my knowledge (a description of my symptoms) and resources (my body for examination). To treat me, my doctor will have a small inventory of drugs and wound care resources delivered prior to the service provision by a third-party supplier.

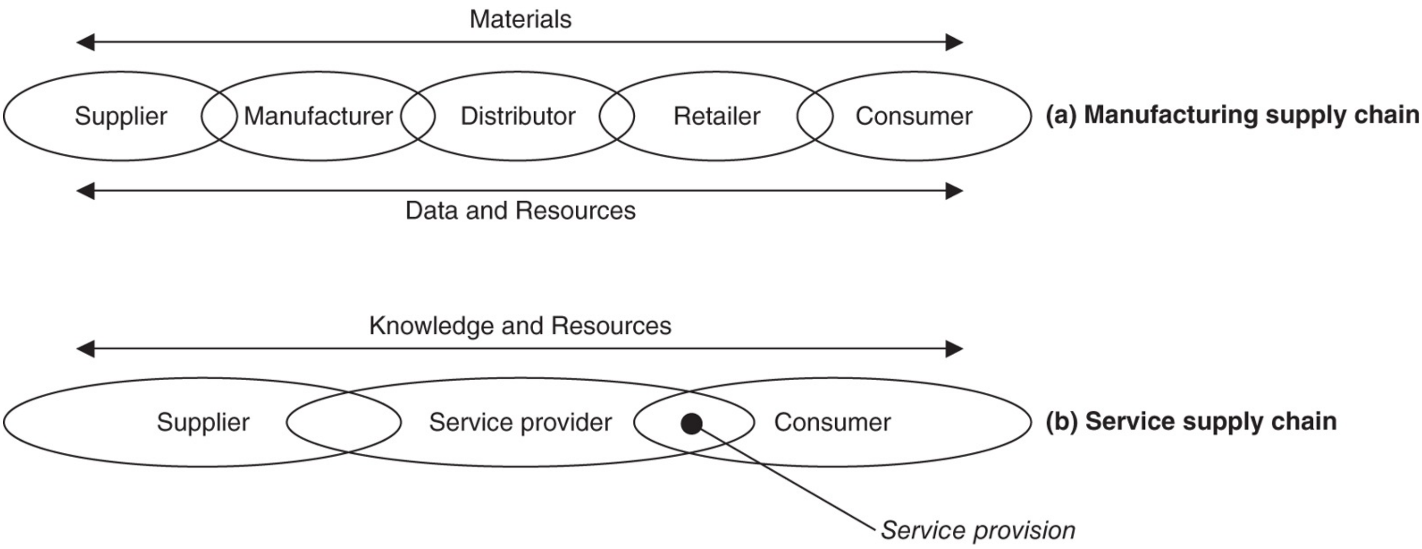

Figure 4.1 The manufacturing supply chain model versus the service supply chain model

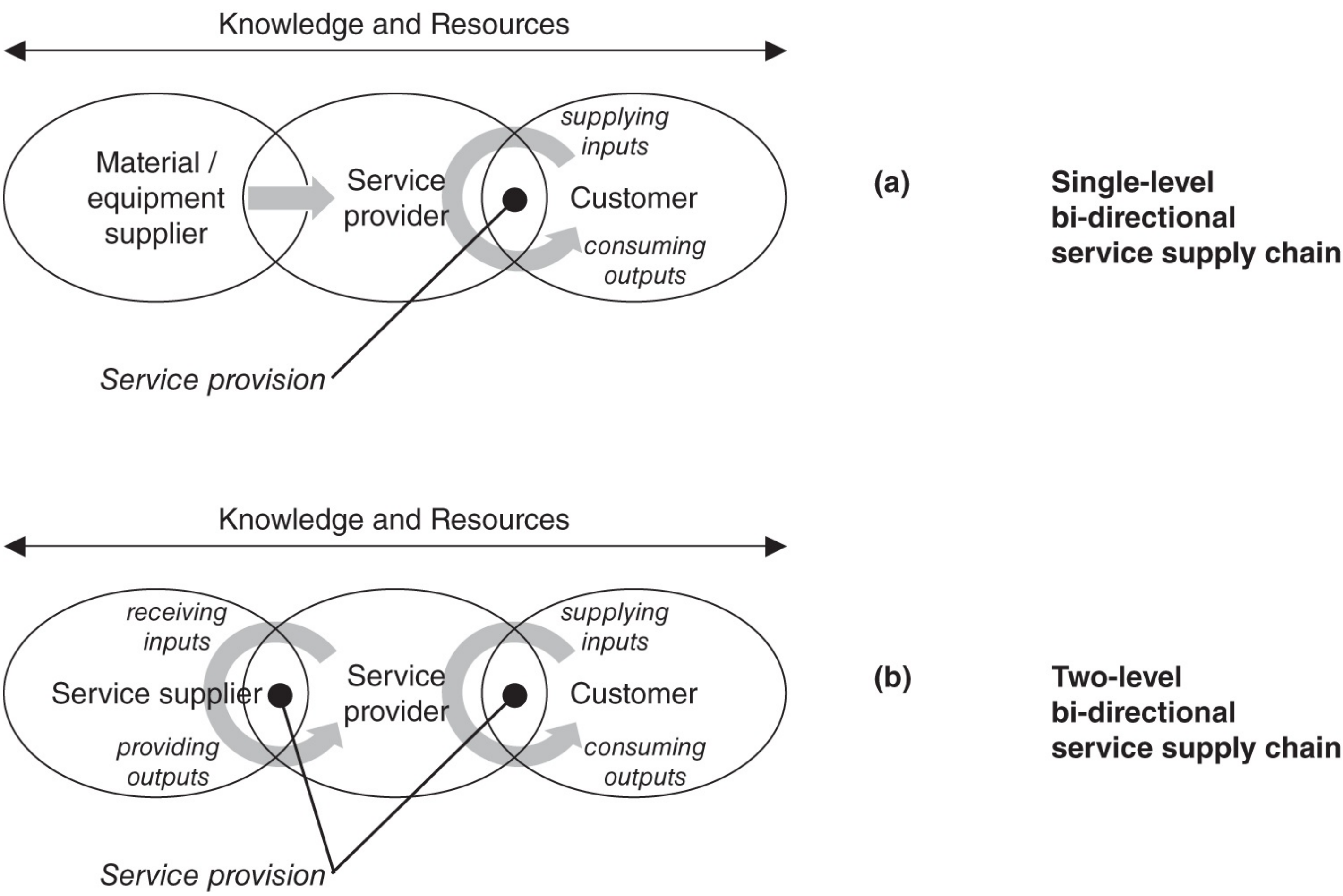

Figure 4.2 The supplier–customer duality and bi-directional service supply chains

(Source: Sampson, 2000; Reproduced with permission of Emerald Publishing Limited.)[15]

In the case of a two-level bi-directional duality, a duality will not only exist between the service provider and customer, but also between the supplier and service provider (see Figure 4.2(b)). Hence knowledge and/or resources are input from the customer to the service provider, *and* from the service provider to the supplier. They in turn supply the outputs necessary to complete the original service provision. In the case of taking my bicycle to a bike shop mechanic, I provide one input, the bicycle. When the mechanic examines the bike, s/he might find that it requires the replacement of a component that is no longer manufactured due to the bike's age. Thus a replacement component if possible will have to be manufactured by a specialist engineering company. To do so, they will have to be provided with the broken original component and any knowledge that is available about its dimensions, materials, function or how it may have broken. This represents a two-level bi-directional duality. Thus service supply chains vary in their complexity depending on where they receive their inputs.

LEARNING REVIEW

This chapter discussed the growing importance of services. Many of the world's economies are increasingly dependent on services for wealth creation, more so than agriculture and manufacturing. Hence researchers and practitioners alike are focusing on service innovation to develop the sophistication of the services we consumers receive. Service science is a new and burgeoning academic discipline that brings together scholars from related fields of study to address service sector-specific issues. This includes service supply chains.

We find that service supply chains cannot be managed in the same way as manufacturing supply chains. While some similar functions exist, there are attributes of services that dictate that their supply chains must be managed differently. The models we present in Figures 4.1 and 4.2 illustrate this.

Now that we have an understanding of and appreciation for the role and importance of services in LSCM, Chapter 5 – the final chapter in Part One (context setting) of the book – will next discuss how logistics and supply chain systems sit within and interact with wider business and other systems. In addition we will explore the increasing complexity that has accompanied the evolution of logistics and supply chain systems.

QUESTIONS

- With the global transition of developed and developing countries to service economies, consider the implications for manufacturing supply chains. How will the world look 100 years from now if this trend continues?
- Consider how many services you have encountered today (e.g. your mail being delivered, the café where you bought your morning coffee, the lunch queue at the university cafeteria, the shop where you bought groceries, the call centre you called to query your mobile phone bill). List them, reflect on how the service provider performed and score them out of 10 for speed, quality and cost. Evaluate their scores and suggest how they might improve.
- Consider the role technology plays in both of this chapter's caselets. How do you think advances in technology (e.g. mobile communications, cloud computing, social media) will influence the service sector? Consider potential technology-based service innovations.
- Referring to Figures 4.2(a) and (b), list five single-level bi-directional service supply chain examples and five two-level bi-directional service supply chain examples. Compare and contrast these examples. What are the factors that distinguish a single-level bi-directional service supply chain from a two-level one?

THIRD-PARTY LOGISTICS SERVICE INNOVATION

Review the 3PL service innovation caselet above and our discussions in this book on outsourcing logistics activities to third parties. As an outsourcee, a 3PL offers a value proposition that reflects its specialist knowledge and resources (i.e. services) being superior to those of the outsourcer's for those activities (refer to Chapter 12). For the outsourcee to offer improved service and for it to maintain competitive advantage against other 3PLs, it must innovate to extend its value proposition.

List the core activities a 3PL undertakes to move freight through a supply chain. Review the websites of the major 3PLs (e.g. FedEx, UPS, DHL) and list the value-added service innovations they offer that complement those core activities. Evaluate those service innovations and consider what else they could do to add value to their customers and maintain their competitive position.

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5
Systems and Networks

LEARNING OBJECTIVES

- Appreciate how logistics and supply chains fit into wider systems.
- Understand how the characteristics and behaviours of such systems influence supply chains.
- Recognise the bullwhip effect and how it can be tamed.
- Understand the many different complexities that can be a feature of supply chains.
- Show how nodes in supply chains are connected and how networks are designed.
- Review some indices on connectivity and logistics performance.

INTRODUCTION

Supply chains are not stand alone, independent entities but are part of – and influenced by – the wider systems (geopolitical systems, ecosystems, political systems, regulatory systems, etc.) within which they exist. 'Systems thinking' is the study of such systems and their characteristics, behaviours and influences. Such characteristics, behaviour and influences can have a significant impact on supply chains, and thus it is important that we understand such impacts. This then is what we might term the macro context within which LSCM operates – at the micro (operational) level within LSCM systems, it is notable that as LSCM systems have evolved and developed they have become ever more complex and multidimensional. There is a growing interest – and emerging literature – on the topic of supply chain complexity, which we will thus review in this chapter. In addition, we will consider how supply chains also sometimes exhibit typical systems behaviours, in particular the so-called bullwhip effect. A related topic to both LSCM and Systems thinking is that of how nodes in supply chains are connected and in turn how networks are designed – we will thus also review these topics in this chapter.

Chapter 5 comprises four core sections:

- Systems thinking and the bullwhip effect
- Supply chain complexity
- Connectivity and network design
- Connectivity and related logistics performance indices

SYSTEMS THINKING

Systems thinking is a well-developed academic discipline.[1] It notes a contrast between reductionism, reducing the system to its constituent parts, and holism, which is an alternative to reductionism and considers systems to be more than the sum of their parts. For example, the marketing manager may insist that a certain type of promotional packaging is used on a company's products. However, now the logistics manager can no longer fit as many of the newly packaged products onto a pallet as before. So while fixing one problem (nice new packaging for marketing purposes), another problem (higher logistics costs) has been created! It is important then in any logistics and supply chain analysis exercise that you take a systems-wide perspective if possible. Of course, this may not always be fully possible, and thus the key issue is to decide on a realistic system boundary which delimits what you will analyse. Systems thinking has many applications in diverse disciplines. From this brief introduction, you will perhaps see where else it can be applied (think, for example, of a social policy example where a policing intervention may reduce crime in one area of a city only for the crime to then re-emerge in another area of the city).

The 'Bullwhip effect'

In Chapter 1 we briefly mentioned the work of Jay Forrester who showed how inventory levels can fluctuate along the supply chain. Today we call this the **bullwhip effect** (Figure 5.1). This is the distortion of orders along the supply chain, where small fluctuations in end customer demand can result in wide variation in inventory levels the further upstream we go in the supply chain. Hence, the term 'bullwhip', where just a small flick of the wrist at the handle will create a large crack of the whip at its tip. Each echelon in the supply chain endeavours to satisfy the demand created by the next downstream echelon. In practice, it may, however, decide to carry more or less inventory depending upon how it perceives the actual demand at the next echelon (as opposed to basing its decision solely on what the customer orders). Perhaps it would like to carry a little extra inventory 'just in case' demand is higher; conversely it may worry about cancelled orders and the costs associated with overstocking inventory and thus decide to carry a little less inventory. Importantly, each echelon may not have full and correct visibility of inventory levels all along the supply chain. If we aggregate all inventory carrying decisions of each supply chain echelon, we can easily see – because of these behaviours – how inventory levels can widely fluctuate.

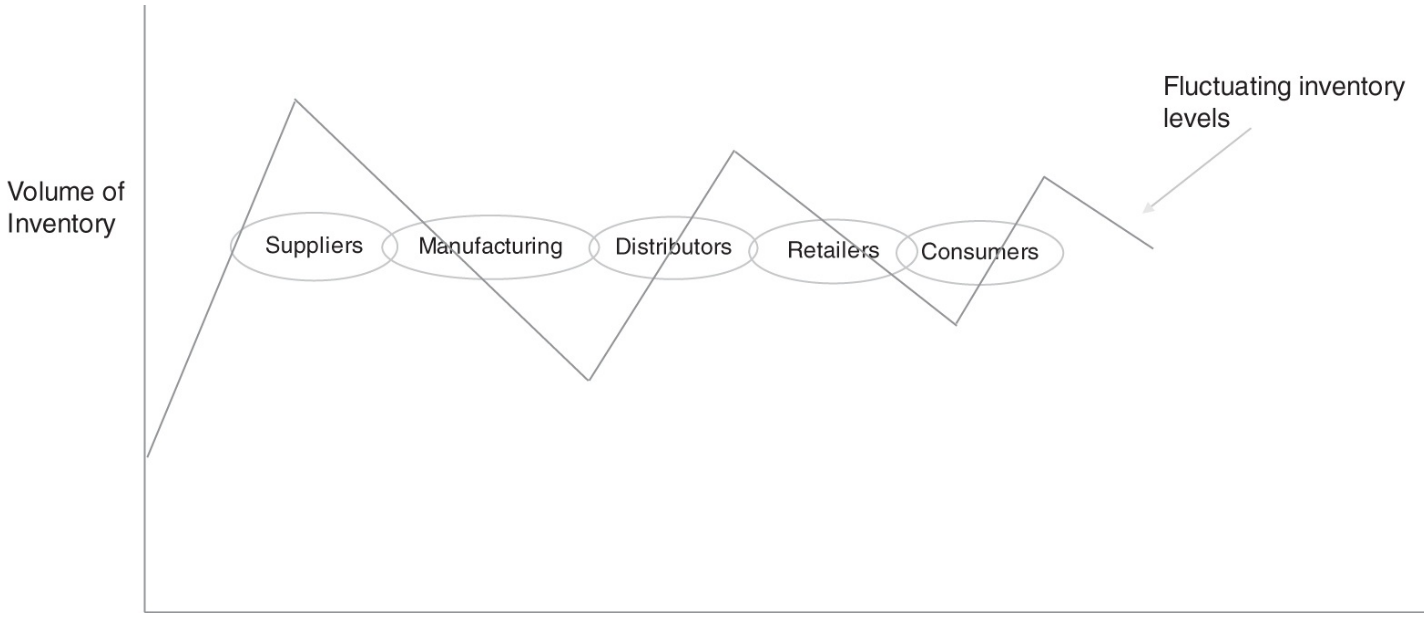


Figure 5.1 The bullwhip effect

The bullwhip effect is a serious problem then for any supply chain as it can lead to excess inventory being carried but which may never be used and / or not enough inventory available to meet demand. Short-term/opportunistic behaviour by one set of actors in the supply chain can have a disproportionate impact on other sets of actors further upstream in the supply chain. Thus, inventory levels can *oscillate* (increase and decrease) and furthermore such oscillation tends to *amplify* (i.e. get bigger) further up the supply chain – thus we say that the bullwhip effect is characterised by an amplifying oscillation of inventory levels upstream in the supply chain.

So how can we *tame* the bullwhip? In essence, the solution lies in ensuring better communication among all actors along the supply chain and ensuring greater visibility of both inventory levels and demand (actual and forecast – predictive analytics have a key role to play in this regard and we will return to this in Chapter 13).

SUPPLY CHAIN COMPLEXITY

Logistics systems and supply chains can be both complicated and complex, and this raises many challenges. By 'complicated', we mean that they are often not simple to comprehend and analyse. 'Complexity' implies something else. It refers to the interdependency among parts of a system. Professor Martin Christopher – who first made this distinction – describes eight types of supply chain complexity[2]:

- Network complexity, e.g. too many nodes and links
- Process complexity, e.g. too many steps
- Range complexity, e.g. too wide a range of products offered
- Product complexity, e.g. too many unique components
- Customer complexity, e.g. too many service options
- Supplier complexity, e.g. too many suppliers
- Organisational complexity, e.g. too many levels and 'silos'
- Information complexity, e.g. too much data flowing in all directions and not necessarily always accurate.

So should a supply chain seek to reduce any inherent complexity? This is a complicated (!) question – invariably such complexities lead to costs, increased risk and so forth. Yet they may also be an advantage in that they may represent your supply chain's USP (unique selling point). The distinct combination of partners and activities in your supply chain may give you an advantage in producing a product and/or delivering a service better than your competitors. Ultimately, then you will seek – in the words of Professor Christopher – to exploit the complexity which your customers value (and are in effect willing to pay for) and minimise the complexity which they do not value. And the best way to achieve this is via effective supply chain design – think back to our discussion in Chapter 3 on supply chain strategy, and, in particular, the case for adaptable and agile supply chains.

While complexity can certainly favour supply chain agility, it also increases the probability of risk occurrence. We will come back to supply chain risks and risk management in Chapter 15 when we discuss the increasingly important subject of vulnerability. For the time being, it is important to bear in mind that all eight types of complexity described by Christopher affect the visibility that supply chain managers may have throughout the different supply chain processes, thus limiting their ability to effectively manage any risk of disruption in the normal flow of materials, information and financial resources. In this context, strategies such as for example increasing collaboration with supply chain partners, and adopting digital technologies to generate and improve information sharing and implementing early warning systems, can all help organisations avoid the adverse impact of poor risk management.

The issue of supply chain complexity is a pervasive and important theme then in LSCM and one that is relevant to most chapter topics in this book. We will also return to it in the closing chapter on emerging supply chain designs. Having now had an insight into the wider systems within which supply chains operate and the behaviours and characteristics inherent in many supply chains, it is appropriate to next consider how the various nodes in supply chains can be connected and networks designed. This is relevant in both a supply chain context and also in the context of logistics and transport networks and is the focus of the remainder of this chapter.

CONNECTIVITY AND NETWORK DESIGN

Connectivity is a word that is increasingly being used among both practitioners and scholars in the LSCM field. Often it is used to refer to either (i) the degree to which supply chain nodes are connected by transport networks or (ii) the ability to share information among supply chain partners.[3] The latter type of connectivity is discussed in Chapter 13; in this chapter we will focus on the former, namely the networks emerging from transport infrastructure and services.

We saw in Chapter 1 that supply chains comprise nodes – such as factories and warehouses – and links between these nodes, typically transport services. Combinations of such links in effect form networks – we can distinguish networks operated by specific companies (e.g. the Maersk container shipping network, the Emirates air network) and more general (multioperator) networks (e.g. the Asia–Europe land network of road and rail linkages, the US overnight parcel network). As we saw above with systems, networks too can have specific features and characteristics.

Network design is one of the most important topics in LSCM, since it has strategic, economic and operational implications for firms. These include selecting the number, size and location of warehouses/distribution centres; assigning inventory to these nodes; and identifying best delivery options to provide a given level of service while minimising transportation costs. Network design implies balancing logistics costs (including warehousing, inventory holding and transportation) with customer's expectations in terms of meeting product demand at the right time, in the right place and with the least possible costs. A variety of optimisation and heuristic models, along with software solutions, are available to help supply chain managers identify the most adequate network design according to the goals they are willing to achieve. These require a large amount of data on supplier, warehouse and customer location; product type and demand, demand characteristics and customers' expectations; transport services characteristics and costs; warehouse capacity and costs; and administrative and regulatory constraints (for example, delivery time windows in urban settings). We will return to some of these models in Chapter 14 which focuses on management science applications in LSCM.

In the e-commerce era, network design is becoming even more relevant as a means to meet consumers' expectation of faster, cheaper and more convenient deliveries of products purchased online. The two major e-commerce players in the US market, Walmart and Amazon, have been leveraging their networks of warehouses across the country to enhance consumer satisfaction and increase online sales. Walmart is using its network of 4,700 stores, which are located within 10 miles of 90% of the US population, as small warehouses and fulfilment centres that facilitate reducing delivery times to less than two hours and easing product returns. Amazon is heavily investing on acquiring warehousing space near the biggest cities in the country's east and west coasts, so that it can reach faster the majority of its clients. Moreover, the acquisition by Amazon of the supermarket chain Whole Foods for US$13.7 billion in 2017 helps Amazon to get closer to customers and provide them with the convenience of picking up and returning products at any of these 400 stores.

Network effects

By being part of a supply chain, firms can get benefits in terms of value added, visibility, resilience and innovation. Indeed, there is a *network effect* by which as more firms join the supply chain, the value of being part of the network increases. Let's take the example of e-commerce companies such as Alibaba and Amazon. For these platforms, the higher the number of firms selling through them, the more value a customer will get from shopping through them. This will in turn lead to customers returning to the platform. With a higher number of customers using the platform, the more value firms will get from selling their products through the platform. Another example comes from the logistics area. If a logistics partner expands its operations to more regions or increases the number of transport units, for example, shippers will also benefit from these changes as the logistics operations may now provide higher value to them (e.g. greater geographical reach and higher transport capacity). The network effect is especially evident for online logistics marketplaces such as Uber Freight and Freightos, as they are trying to increase their customer base by raising the number of transportation companies that offer their services on these platforms and, at the same time, attracting big shippers as customers so that more transport companies join the platform.

Another important value related to network effects is the increased visibility and resilience a company can gain from being part of a wider supply chain. The more information shared with a higher number of supply chain partners, the higher the visibility a firm will have on the performance of the entire supply chain. As we will see in Chapters 13 and 15, this information is critical for improving planning and risk management. Finally, by being part of a wider supply chain, firms can benefit from partners' innovations. A recent study from the Inter-American Development Bank and the World Economic Forum showed that supply chains are the channels through which new digital technologies such as automation and digitisation are permeating the business environment in the context of the Fourth Industrial Revolution (4IR).[4] Prompted by competitive pressure and disruption risks, large companies are advancing in the adoption of 4IR technologies. As they do so, their Tier 1 suppliers and logistics providers face the competitive pressure to join the transformation process, resulting in an incentive they adopt such technologies. In doing so, they benefit from the network effect since in many cases large companies facilitate the investment, share the technology and collaborate tightly with their suppliers and logistics service providers to advance technology adoption.

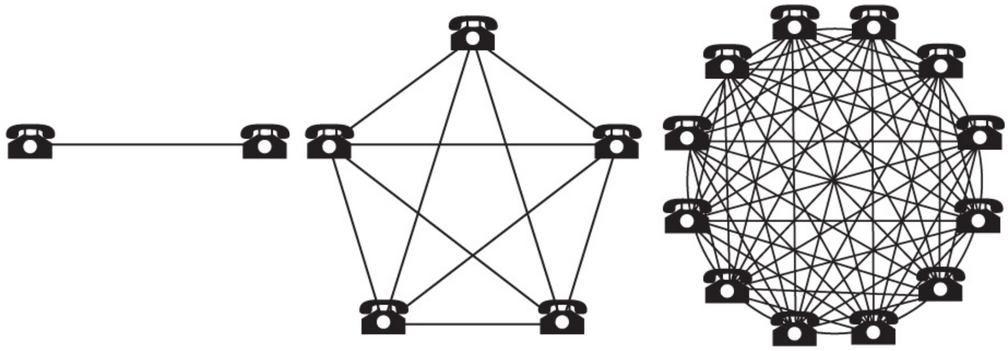
Graph theory in mathematics and related topics such as network theory are beyond the scope of this book. However, to understand the potential of networks, it is appropriate to briefly take the example of *Metcalfe's law* (Figure 5.2) which states that the effect of a telecommunications network is proportional to the square of the number of connected users of the system (n^2). There has been much debate concerning exactly how valid this relationship is, and we need to consider if, for example, all links in the network are of equal value; but this is why the biggest social networks, for example, with their hundreds of millions of users, are so valuable. The general principles of the law can be applied to other types of networks too. The general formula for calculating the maximum number of linkages in a complete network where each node is connected to every other node is given as[5]:

$$\frac{n(n-1)}{2}$$

where n is the number of nodes in the network. Thus if, for example, each of five airports had a flight connecting to every other airport in the network, then the number of linkages (connections between pairs of airports) is ten (we count both directions as a single link).

Transport networks

For global supply chains, network design often needs to consider the specific characteristics of maritime and air transport networks. Indeed, both liner shipping and air freight companies design their services in the form of networks whose goal is to maximise demand satisfaction in terms of customers' time and cost requirements and at the same time minimising operational costs. In many cases, networks tend to adopt a hub-and-spoke design, where the lowest cost for the entire network is achieved by indirect routing via hubs, the use of different types of vessels/aeroplanes in the network for optimal asset utilisation, and the amalgamation of flows to benefit from scale economies in transportation. As a result, the hub-and-spoke configuration creates a hierarchy among ports/airports with different functions in the network. Among these are ports/airports dedicated to transfer freight between transport routes, located in strategic geographical positions, which multiply shipping options and improve connectivity within the network through their pivotal role in regional hub-and-spoke networks.[6] Figure 5.3 shows, for example, how the liner shipping network is organised in the Americas (we will discuss liner shipping networks again in Chapter 7). As you will notice, ports in countries such as Panama, Colombia and the Dominican Republic take the role of hubs in the network, enabling transhipments between north and southbound routes. In turn, Figure 5.4 provides an example of the FedEx Express global airfreight network, which consists of 13 hub locations around the world that connect over 200 countries and territories using air routes supported by both FedEx Express and interline carriers. Other examples of key transport hubs are visible on the map of the global transport system at the start of the book – examples include the hub for air freight in Alaska and Singapore's role as a key liner hub. The key point to note is that in both cases (and in the other examples above) neither country has much local traffic to feed the hub – Alaska and Singapore are hubs on account of their strategic location in the context of the wider networks within which they sit.



Two telephones can make only 1 connection, five can make 10 connections, and twelve can make 66 connections.

Figure 5.2 Metcalfe's law

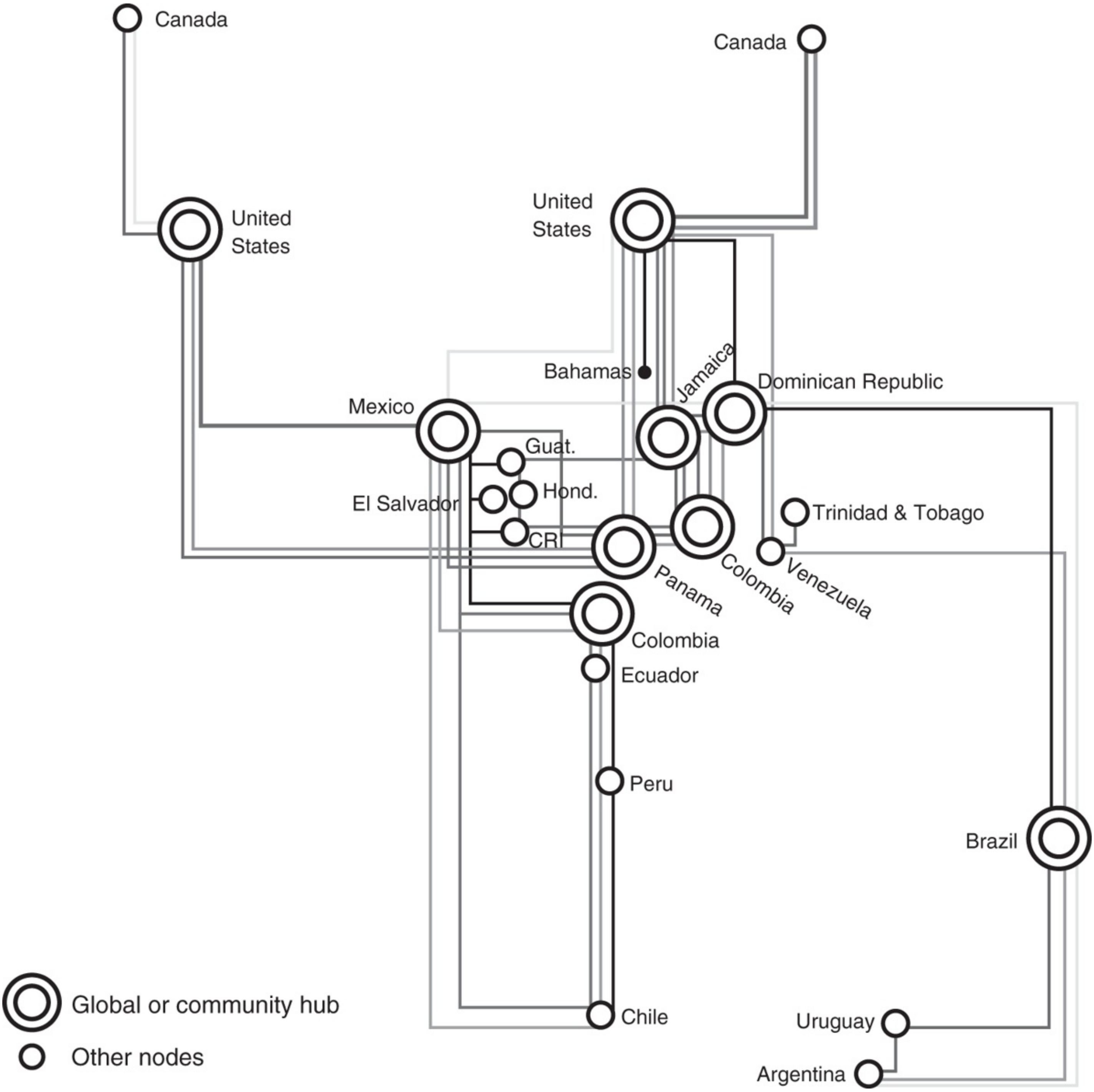


Figure 5.3 **Metro-like map of liner shipping network in the Americas**

(Source: Calatayud *et al.*, 2017; Reproduced with permission of Taylor and Francis.)

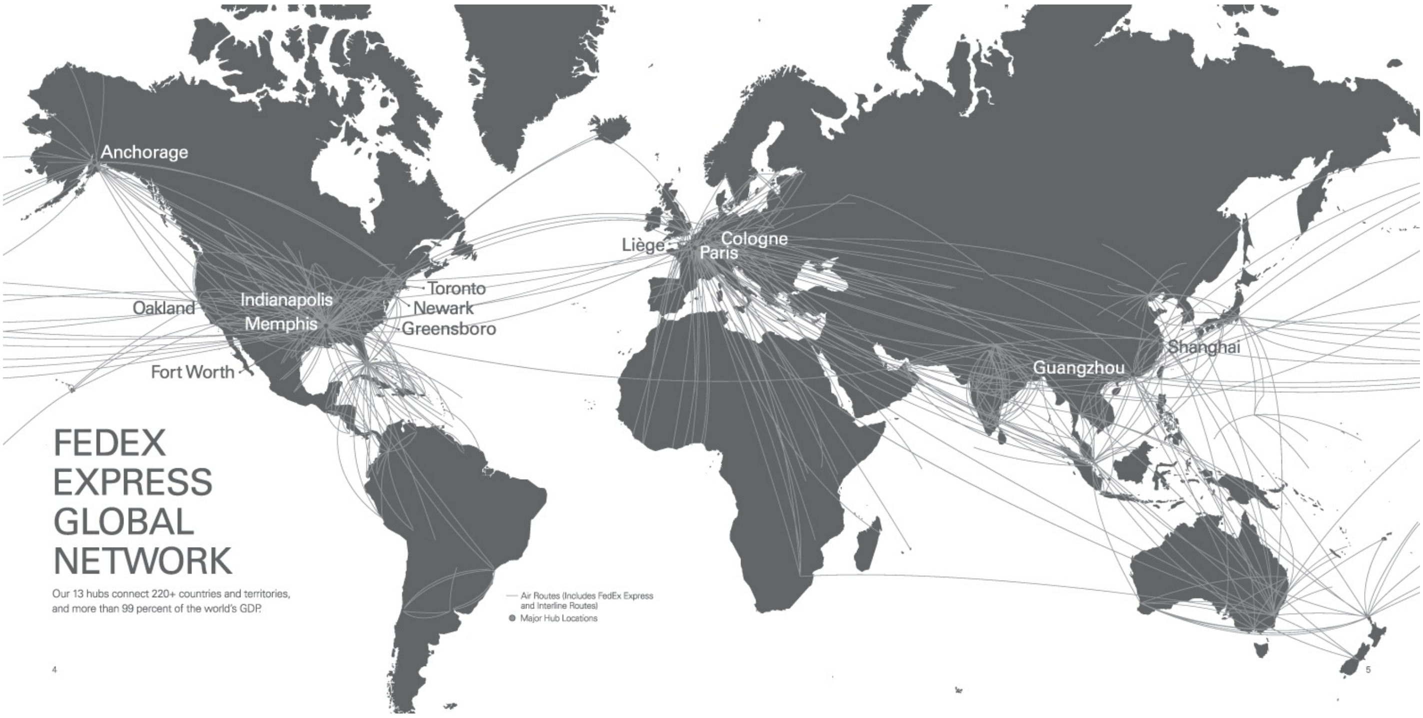


Figure 5.4 FedEx Express global airfreight network

(Source: https://newsroom.fedex.com/wp-content/uploads/2020/04/FedEx-CorpBrochure-2020.pdf.)

The configuration of transport networks brings benefits for those firms located near transport hubs, since they are served by a larger option of routes and a higher frequency of services, while firms located at the peripheries of the network have fewer transport options and often face longer transportation times due to the larger number of transhipments for their goods to arrive at destination. Think, for example, about a raw material sent from Chile to a production plant located on the East Coast of the US. It is highly likely that such a raw material will have to switch ships at a port in the Caribbean to reach its destination. In contrast, a raw material sent from a supplier located in Colombia will likely arrive to the US East Coast without changing ship. Therefore, from a supply chain perspective, network considerations are very important, since they influence for example:

- How we can connect with our supply chain partners
- How we can access our markets

Aside from the particular configuration of transport infrastructure and services, other obstacles may emerge along the network hindering the smooth flow of goods. Among these are port/airport performance (see the discussion later on transport infrastructure in Chapter 6), as well as customs duties and other international trade regulations (see the discussion on trade facilitation in Chapter 9). For example, to reduce manufacturing costs, a company may decide to locate its production plant in a country where labour costs are lower. However, such a company will also have to take into account how well the plant is connected to the country's international gateways (e.g. ports and airports), how efficient these gateways are and how well international trade controls work, so that all these do not increase the expected transit time and thereby raise total costs, and thus offset the expected benefits from reduced labour costs (we will return to all of these issues in Chapter 12).

CONNECTIVITY AND RELATED LOGISTICS PERFORMANCE INDICES

Several indices are available for decision makers to assess countries' connectivity and related logistics performance. Table 5.1 summarises the main indices currently available.

TABLE 5.1

Summary of connectivity and related logistics performance indices

Doing Business – DB (World Bank)	Goal	To provide a measure for regulations related to business activity in a given country. To provide a measure for cross-country comparison. Regulations are assessed on a scale from 1 (most friendly business regulation) to 0 (least friendly business regulation).
	Components	(1) Starting a business; (2) Dealing with construction permits; (3) Getting electricity; (4) Registering property; (5) Getting credit; (6) Protecting investors; (7) Paying taxes; (8) Trading across borders; (9) Enforcing contracts; (10) Resolving insolvency; (11) Employing workers.
	Usefulness to measure connectivity	The 'Trading across borders' component measures time and costs associated with fulfilling official procedures for importing and exporting standardised cargoes of goods by maritime transportation. This indicator provides a measure of how well trade facilitation procedures work in a country and their impact (time & costs) on accessing (connecting to) international markets.
Liner Shipping Connectivity Index - LSCI (UNCTAD)	Goal	To provide a measure for a country's level of integration into the existing liner shipping network. The LSCI can be considered a proxy for accessibility to global trade. The higher the index, the easier it is to access a high capacity and frequency global maritime freight transport system and thus effectively participate in international trade.
	Components	(1) Containership deployment; (2) Container carrying capacity; (3) Number of shipping companies, liner services and vessels servicing a country; (4) Available and maximum vessel size.
	Usefulness to measure connectivity	LSCI provides a measure for availability and capacity of maritime transport services connecting to international markets.
Global Enabling Trade Index – GETI (World Economic Forum)	Goal	To provide a measure for factors, policies and services that facilitate the trade in goods across borders and to destination.
	Components	(1) Market access; (2) Border administration; (3) Transport and communication infrastructure; (4) Business environment.
	Usefulness to measure connectivity	The 'Border administration' component provides a measure for assessing the performance of trade facilitation procedures and their burden on accessing international markets. The 'Transport and communication infrastructure' component provides a measure for assessing the performance of transport infrastructure and services and their contribution to accessing international markets.
Logistics Performance Index – LPI (World Bank)	Goal	To provide qualitative and quantitative measures of performance along the logistics chain within a country. To provide a measure for cross-country comparison.
	Components	(1) Efficiency of the clearance process by customs and other agencies; (2) Quality of transport and IT infrastructure for logistics; (3) Ease and affordability of arranging international shipments; (4) Competence of the local logistics industry; (5) Ability to track and trace international shipments; (6) Domestic logistics costs; (7) Timeliness of shipments reaching destination.
	Usefulness to measure connectivity	Taking into account the relationship between connectivity and logistics (more efficient logistics ensures better connectivity), the LPI provides a measure of logistics performance, including both infrastructure and logistics processes.
Air connectivity metrics (various academic sources)	Goal	To understand the level of connectivity of each airport within the air transportation network.
	Components	Subject to each metric. It may include the number of (direct and indirect) connections; aircraft capacity; the number of steps to reach any other airport in the network; the average waiting time between steps; the average travel time to reach any other airport.
	Usefulness to measure connectivity	These metrics provide a measure for availability and capacity of air transportation services connecting to international markets.

The various indices provide much useful information. For example, the 'Trading across borders' component of the World Bank's Doing Business index provides decision makers with a measure of how well trade facilitation procedures work in a country and their impact (time and costs) on accessing (connecting to) international markets. The LSCI is a measure for availability and capacity of maritime transport services connecting to international markets. The 'Border administration' component of GETI provides another measure for assessing the performance of trade facilitation procedures and their burden on accessing international markets, while the 'Transport and communication infrastructure' component provides a measure for assessing the performance of transport infrastructure and services and their contribution to accessing international markets. The LPI presents information on the quality and availability of logistics services in the domestic markets, as well as a general metric of logistics performance. Finally, there is the DHL Global Connectedness Index (see the box below), which also considers some factors not taken into account by other indices: (1) remoteness, in order to account for the influence of distance; (2) regional integration, to account for the ease of accessibility to international markets.

THE DHL GLOBAL CONNECTEDNESS INDEX[7]

There are a number of very useful and informative indices of globalisation and inter-country connectedness, one of which is the DHL Global Connectedness Index which is compiled every two years. Since 2001 it has tracked flows of trade, capital, information and people. Importantly, it measures both the breadth (geographical distribution of international flows) and the depth (international flows relative to domestic activity) of such flows. Countries with, for example, high scores on depth but low scores on breadth are connected only to a narrow set of partner countries. Table 5.2 ranks the top 20 countries in the index.

Key insights from the most recent index (2017 rankings) follow.[9] The Netherlands is the world's most globally connected country. Singapore leads on the size of its international flows relative to domestic activity, while the UK has the most global distribution of flows around the world. Europe is the world's most globally connected region, with 8 of the 10 most connected countries. Europe leads on trade and people flows, while North America is the top region for information and capital flows. The economies where international flows exceed expectations the most are Cambodia, Malaysia, Mozambique, Singapore and Vietnam. Emerging economies have much lower average levels of connectedness than advanced economies. The largest gap is found in information flows, into which advanced economies are nine times as deeply integrated. Global connectedness is still constrained by distance and cross-country differences. Roughly half of all international flows are between countries and their top three origins and destinations.

TABLE 5.2

DHL Global Connectedness Index for 2017

(Source: Altman *et al.*, 2019)[8]

Country	Depth Score	Breadth Score	Overall Score
1. Netherlands (0)	46	47	93
2. Singapore (0)	48	39	87
3. Switzerland (+1)	41	44	85
4. Belgium (+1)	46	38	84
5. United Arab Emirates (+2)	45	38	83
6. Ireland (0)	44	38	82
7. Luxembourg (−4)	45	36	82
8. Denmark (0)	36	42	78
9. United Kingdom (+2)	28	49	77
10. Germany (−1)	34	42	76
11. Norway (−1)	33	43	76
12. Malaysia (+1)	40	36	76
13. Sweden (−1)	34	41	75
14. Czechia (+4)	42	32	74
15. France (+2)	30	43	73
16. Korea (Republic of) (0)	28	45	72
17. Israel (−3)	28	44	72
18. Hong Kong SAR (China) (−3)	46	26	72
19. Austria (+2)	40	31	71
20. Hungary (0)	39	32	71

Note: figures in parentheses show rank changes from 2015 to 2017.

The report notes that most people believe the world is more globalised than it really is, and such misperceptions exacerbate fears of globalisation. As a 2019 update to the index notes, while the world is more connected than at almost any previous point in history, international flows are far smaller than most people presume. Most business still takes place within rather than across national borders.[10] Countries that integrate more deeply into international flows tend to enjoy faster economic growth, and even the top-ranked countries have untapped opportunities to strengthen their global connectedness. The future of globalisation depends on the choices of policymakers around the world. Because global connectedness remains limited, countries have more flexibility than many presume to shape their international flows and influence the distribution of their benefits.

LEARNING REVIEW

This chapter showed how logistics and supply chains fit into wider systems and how the characteristics and behaviours of such systems influence supply chains. We reviewed the bullwhip effect and discussed how it can be tamed. We also looked at the many different complexities that can be a feature of supply chains. The final parts of the chapter introduced the whole area of network design and connectivity indices. We looked at the key features and effects of networks and showed how many transport networks are designed (often as hub-and-spoke networks). The contribution of various connectivity indices to LSCM was also illustrated. This is the final chapter in the first part of our book which has set the context for LSCM. Part Two of the book now focuses on the key features and operational activities in transport and logistics – key enablers of any supply chain.

QUESTIONS

- What is the bullwhip effect?
- Describe the different types of supply chain complexity.
- Why do you think the Netherlands is the world's most globally connected country?
- Describe the key features of, and benefits from participating in, hub-and-spoke transport networks.

NOTES

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Part One Case Studies
Dell – Pioneers in Mass Customisation

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Dell Technologies is today one of the world's largest technology companies and comprises seven industry leading brands, namely Dell, Dell EMC, Pivotal, RSA, Secureworks, Virtustream and VMware.[1.] The combined organisation is active in a range of technology sectors from cloud computing to hardware manufacture. One of the organisation's most significant milestones was when Dell and EMC joined forces in September 2017 in one of the largest technology mergers in history. Our interest in this case, however, extends to much earlier than this and focuses in particular on its pioneering new way of manufacturing and delivering computers and related devices since the establishment of Dell in 1984 by a young medical student in Texas, Michael Dell. Today those products are manufactured in the Dell division/brand within Dell Technologies and comprise not only desktop computers but also laptops, 2-in-1s and thin clients, as well as monitors and other peripherals; services too are provided such as security solutions. Dell ascribed much of its success to its expertise in supply chain management and the velocity with which it is able to process and deliver orders – in the personal computer sector where competitors often take weeks to build and ship product, Dell's metrics are hours and days. Its successful production model has been imitated by many other companies both in the technology sector and other sectors too.

DIRECT TO CUSTOMER

Central to Dell's phenomenal success is its distribution strategy: since it started to build its own machines in 1985 (prior to this the company had focused on upgrading old IBM machines), it has sold direct to the customer, disintermediating any 'middlemen' and getting product faster to the customer. The computers themselves were viewed by some as not particularly remarkable from a technological perspective, so much so that in 1996 *The Economist* magazine described Dell as 'selling PCs like bananas'. The business market segment is highly important to Dell, and the company has invested in CRM in order to stay close to key customers, while also evaluating the cost-to-serve different customer segments and designing product offerings accordingly. Finished products are delivered by third-party logistics partners direct from the manufacturing plants to customers, often merging-in-transit with peripherals.

FULL VISIBILITY AND PARTNERSHIPS WITH SUPPLIERS

The Internet is central to Dell's strategy, allowing direct communication with customers and real-time visibility of purchasing patterns. Indeed, a key attribute of the Dell supply chain is full visibility along the chain with sales and production systems linked to suppliers who supply components just-in-time, usually direct to the production line and often with very short lead times (sometimes even as little as one hour!). Consequently, Dell needs limited warehouse space for inbound raw materials. These preferred suppliers and their expertise in vendor managed inventory (VMI) play a key role in Dell's success.

FOCUSED MANUFACTURING AND BUILDING TO ORDER

Dell pioneered the adoption of standardisation and postponed manufacturing (also known as mass customisation) in the electronics industry (Figure 1). This involves producing a small number of common platforms which are then customised according to customer demands (the customer generally recognises more so what is different among products, not what is the same!). Before standardisation (left side of Figure 1), there are multiple product lines at both the upstream and downstream ends, whereas after standardisation (right side of Figure 1) the number of different product lines upstream reduces considerably and products are only customised (i.e. configured into different products) at the downstream end (once customer orders are visible).

The benefits of this strategy are many and include sharing of common components across product lines, thus reducing the number of stock keeping units (SKUs) which have to be carried. This strategy is now increasingly also adopted across a range of other sectors including the automobile (e.g. Volkswagen Group) and fashion (e.g. Zara) sectors.

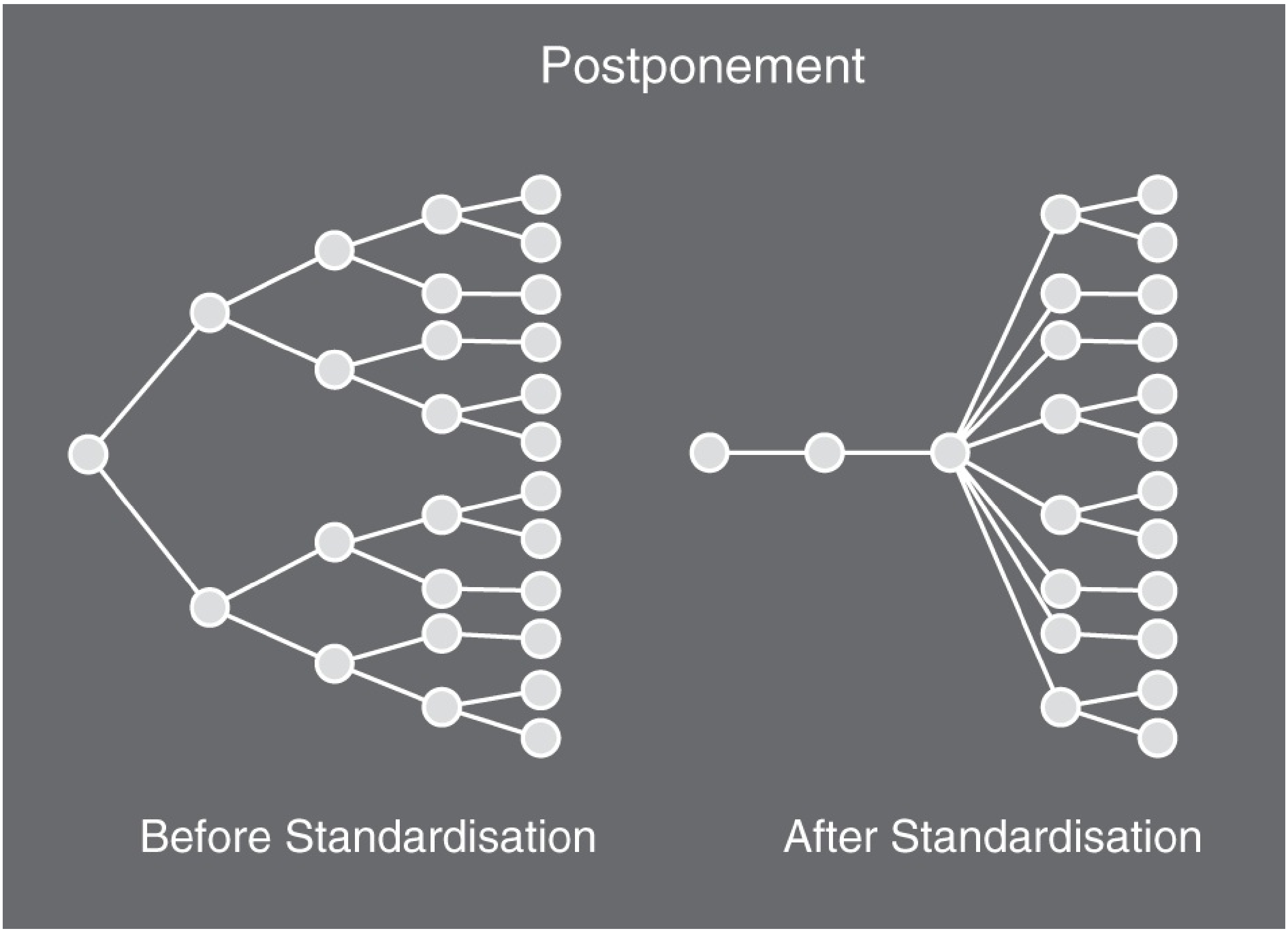

Figure 1 **The Principle of postponement**

Dell's 'manufacturing associates' can assemble desktop computers at a rate of 16 to 17 per day using 'single person build' rather than traditional assembly line techniques. This leads to both increased job satisfaction and product quality. Modular manufacturing using standardised components is employed to build the 'vanilla products' which are then customised for market.

Increasingly, Dell is moving into higher value offerings and markets. In their view, they sell solutions, not products. The company has not, however, been immune to problems. For example, difficulties in the past associated with faulty laptop batteries, which attracted a lot of negative publicity to the company, led to some product recalls. Intense competition combined with rapid changes in technology are ongoing challenges that characterise the sectors within which Dell now operates.

QUESTIONS

- What are the fundamental reasons for Dell's success in the personal computer market?
- What should Dell do next to maintain their competitive advantage in this market?
- Will configure-to-order and postponed production work in other sectors? If not, why not?

NOTE

1. https://corporate.delltechnologies.com/en-us/about-us/who-we-are.htm.

Jaguar Land Rover's Global Supply Chain: From Design to Execution

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INTRODUCTION

The automotive sector is in the midst of a major transition driven by four main trends, in addition to several other challenges such as trade wars and environmental pressures, most easily remembered by the acronym ACES: autonomous driving, connectivity, electrification and shared mobility (McKinsey Quarterly, 2019). In such a climate, putting global supply chains in motion requires exhaustive preparations and decision making at many different levels, from design to execution, that have a significant impact on a company's performance. This case study analyses the complexity of supply chain operations in the automotive industry and how Jaguar Land Rover, a UK-based Original Equipment Manufacturer (OEM), has managed to deal with this complexity and with the challenge of rapidly expanding their operations at a global scale.

BACKGROUND

Land Rover and Jaguar were founded in the late 1890s and the early 1920s respectively, by motorcycle enthusiasts, and have become two of the most iconic British brands. The two, then independent, companies gained much of their reputation and growth after the Second World War initially not only by producing cars with very high performance engines, but also by rolling out the first British all-terrain vehicle. Land Rover's bodies were lightweight and rustproof, and designed to be field-serviced, giving the vehicles a reputation for longevity in tough conditions. Later in the 1950s and in the 1960s, Jaguar became famous for producing a series of elegant sports cars and premium saloons including the Jaguar E-type. The two companies first came together as part of British Leyland[1] in 1968. Another landmark year was 1970 with the launch of the Range Rover. The years that followed were characterised by changes in the structure and ownership of the two companies from the split off of Jaguar from British Leyland in 1984 to its acquisition by Ford in 1989, and some years later to the acquisition of Land Rover by BMW (1994) and eventually the reunification of both companies by Ford (2000). The £1.1 billion takeover by Tata (India's largest automobile manufacturer) in 2008 created new opportunities for the company. The company experienced unprecedented growth rates for several years and at its peak it employed more than 40,000 people globally.

THE GEOGRAPHY OF JAGUAR LAND ROVER'S SUPPLY CHAIN

Manufacturing

The manufacturing base of the company is primarily in the UK and is currently split across six sites with three vehicle manufacturing plants (Castle Bromwich, Solihull and Halewood), two advanced design and engineering centres (Gaydon and Whitley), and one Engine Manufacturing Centre (EMC) near Wolverhampton. The £500m engine centre was opened in 2014 and is designed to manufacture a range of four-cylinder petrol and diesel engines. The facility contains the UK's largest solar panel array – 21,000 panels to power 30% of the plant (or 1,600 homes). Full production in EMC commenced in 2015 with a targeted capacity of 400,000 engines per year, one engine every 30 seconds. From 2020, EMC will begin the manufacture of Electric Drive Units (EDUs) used in electric cars. For a number of years due to the significant volume growth, the company often had to switch to a three shifts pattern (e.g. in Solihull and Halewood) in order to meet the increasing demand. A car will roll off the production line every 90 seconds. In addition, the company has grown and is constantly looking at expanding its manufacturing operations in other parts of the world (see Figure 1).

The company has developed a balanced global manufacturing footprint to remain competitive. For example, selected Jaguar Land Rover vehicles are assembled (using local assembly kit) globally in local assembly plants: Land Rover Defender in Kenya, Malaysia, Pakistan and Turkey, and Evoque, Freelander 2, Jaguar XF and XJ models in India (opened in 2011 in Pune). Local assembly kit is a set of parts necessary to assemble a certain vehicle. In local assembly operations, therefore, all parts necessary to manufacture a specific car are collected, packed and exported by the OEM to another region for final assembly. Jaguar Land Rover executes two types of local assembly operations, both by means of contract manufacturers that hold Jaguar Land Rover manufacturing license: Complete-Local Assembly (CLA) and Semi-Local Assembly (SLA). In CLA a vehicle is fully disassembled; in SLA certain parts of the vehicle may be assembled prior to shipment. Two part groups can be distinguished: Body In White (BIW) – the body of the vehicle assembled out of large metal pressed parts, and Trim And Final (TAF) – the internal parts of the vehicle.

The design of a car can have a direct impact on shipping operations. For example, the design of Land Rover Defender is very specific, as the vehicle possesses an internal frame – a skeleton of BIW – to which other BIW parts are attached (e.g. doors, bonnet). This allows for a CLA – all parts can be shipped separately. Operations in India are SLA, due to the fact that neither Land Rover Freelander nor Jaguar XF/XJ models possess an internal frame. This means the BIW parts that are manufactured by Jaguar Land Rover in the UK are assembled together to form the body of the vehicle prior to shipment. The body is also fully painted, thus after the arrival at a kit assembling plant, it is ready for the assembly of TAF parts.

In 2012 by means of a joint venture, Jaguar Land Rover extended its operations to China. The company has a partnership with a local Chinese firm Chery Automobile Company and established Chery Jaguar Land Rover (a 50:50 joint venture). In November 2014 the first model rolled off the line, a Range Rover Evoque. In 2016, the company opened a plant in Itatiaia, Brazil to build the Range Rover Evoque and Land Rover Discovery Sport and one year later, in 2017, it started contract manufacturing in Austria, where the I-Pace, the first ever battery-electric crossover SUV is built by contract manufacturer Magna Steyr in Graz. 2018 was a landmark year with the company opening a plant in Nitra, Slovakia. Plant Nitra, Jaguar Land Rover's first European plant outside the UK, is a 300,000 m² facility with an annual production capacity of 150,000 units.

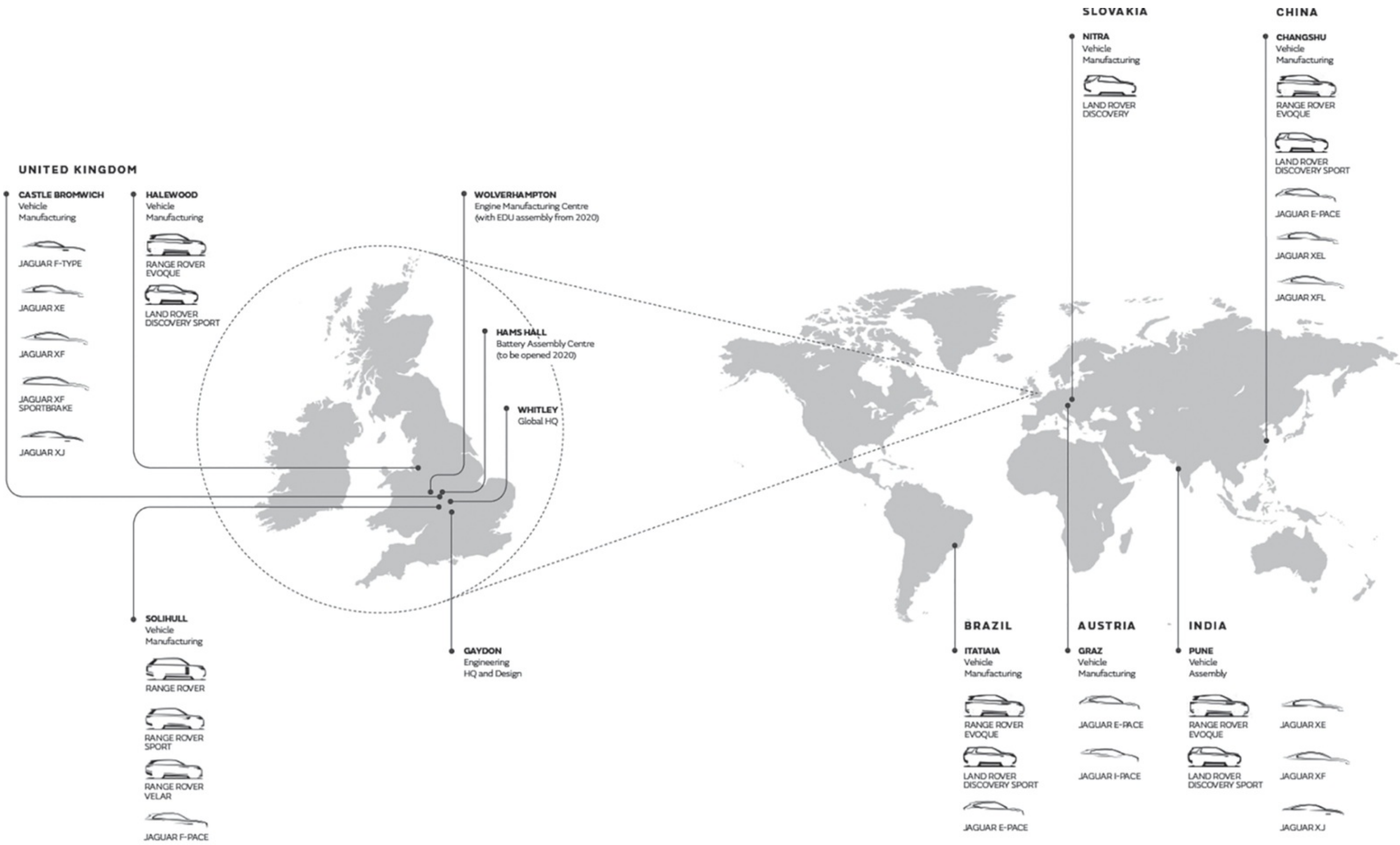

Figure 1 Current Jaguar Land Rover international operations

(Source: Jaguar Land Rover (2020). Annual Report 2018/19).

Suppliers

The car industry has been developed as an extended and complex network of different level tier suppliers. First-tier suppliers are delivering to OEMs either individual parts or large integrated systems that are assembled from parts delivered by second-tier suppliers. Jaguar Land Rover collects parts only from first-tier suppliers, mainly because of demand schedules that are sent only to first-tier suppliers. First-tier suppliers must therefore place separate demand schedules on second-tier suppliers.

Jaguar Land Rover has a base of approximately 900 suppliers that are located in continental Europe (50%), in the UK (45%) and the rest of the world (5%). Jaguar Land Rover seeks suppliers who deliver quality and reliability whilst being considerate of the total logistics cost. Other key factors to consider are location, transport time and cost, weights, sizes, duties and security of supply. Jaguar Land Rover holds close relationships with its suppliers, that is each supplier is provided with a mid-term demand forecast, furthermore certain confidential information is also shared to enable suppliers to plan their infrastructure and potential necessary investments to meet future demands. Furthermore, many Jaguar Land Rover contracts with service providers are fully open book. On the one hand, this allows Jaguar Land Rover to ensure the company is getting value for money, especially when international freight is involved; on the other hand, it demonstrates that Jaguar Land Rover recognises that their service providers not only have the necessary expertise in the field, but also a very good understanding of the market due to cooperation with other OEMs. This results in a better overview of, for instance, different transport routes, ports and operating rates that are available. The use of suppliers' extensive knowledge provides various opportunities (e.g. cost savings).

Demand and sales

Over the last five years the company has witnessed unprecedented success. Sales have almost doubled from 232,839 vehicles sold in 2010 to 557,706 in 2019. The company exports to more than 170 markets and had a revenue of over £24 billion in the financial year 2018/19. Figure 2 shows the development of the company's global retail sales volumes over the last two decades.

Changes in demand have taken place not only in terms of total absolute volumes, but also in terms of geography. For example, in the 2000s most of the sales would be generated in the UK and in Europe followed by the US. By the middle of the 2010s, China became the biggest market generating over a quarter of the sales overtaking the UK as Jaguar Land Rover's largest single market. More recently, sales in the UK and in the US are on the rise, while sales in China (after years of double-digit growth) and in Europe have weakened. With the exception of some markets, such as the US, where dealers usually order in stock, Jaguar Land Rover sells on a build-to-order basis. The challenge for Jaguar Land Rover is to provide reliable delivery dates that allow a high level of customer satisfaction to be maintained, while also efficiently managing inventory and cash flow in terms of wholesale and retail deliveries.

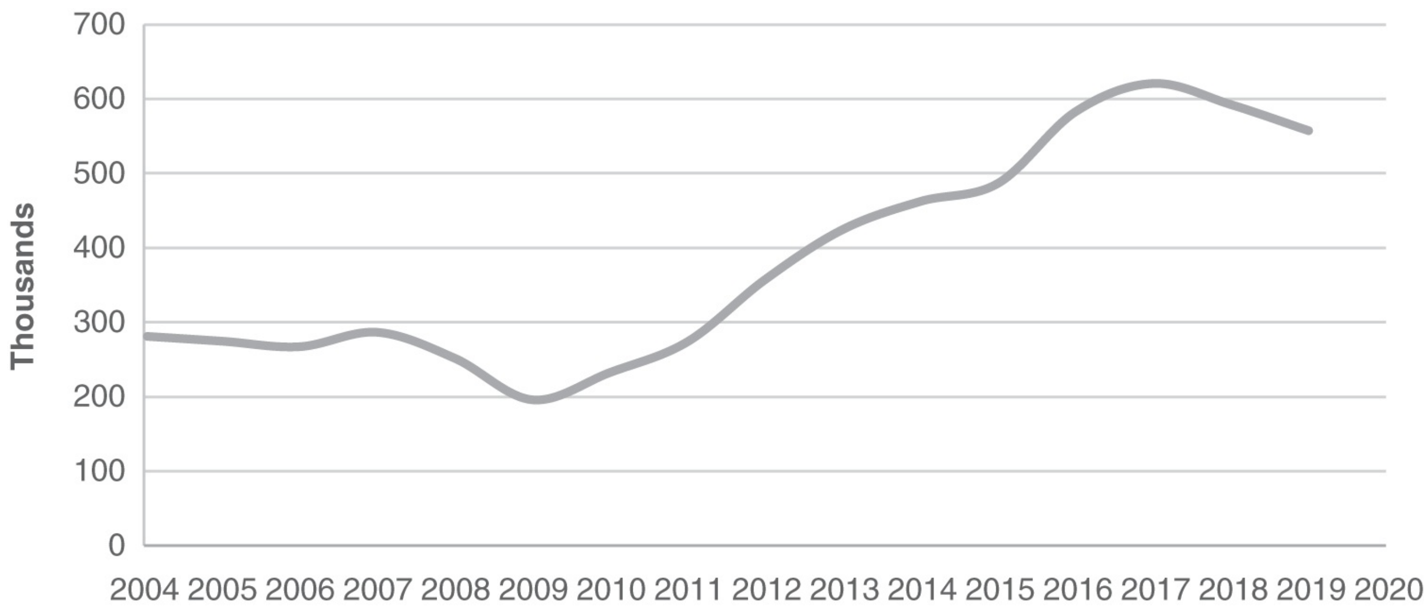

Figure 2 **Global retail sales volumes of Jaguar Land Rover**

(Source: Jaguar Land Rover Annual Reports 2004–2019)

LOGISTICS AT JAGUAR LAND ROVER

The speed and scale of growth enjoyed in recent years increases supply chain complexity and creates a need for new logistics solutions. The role of the Logistics function at Jaguar Land Rover is vital and this is evident by the early involvement of Logistics within the life cycle process of car development (e.g. as soon as the concept of a particular car is created the Logistics team contributes with an input into the approach and departure angles[2] of the vehicle as well as the lashing configurations[3]). A number of logistics activities take place throughout the complete supply chain to ensure vehicle production is lean, prompt and effective. One can enumerate the following main activities: inbound (collection and transport) and outbound (distribution of finished vehicles) freight, packaging design, warehouse and inventory management, and in-plant logistics (e.g. line feeding, stock handling). Logistics is also responsible for the operations strategy (i.e. line rates, shifts, volumes) and for the management of third-party contracts.

Moving freight: inbound, outbound and modes of transport

Upstream in the supply chain, Logistics is responsible for the collection and delivery of component materials to point of use for both production and prototypes, whilst downstream in the supply chain it is responsible for worldwide distribution of finished vehicles.

In total, inbound and outbound freight vehicles cover almost 60 million road miles per year, equivalent of going to the moon and back 125 times. More specifically, the inbound flow (from both within the UK and Continental Europe) includes the collection of 120,000 parts from approximately 800 suppliers across 20 countries, with over 5000 full- and partial-load collections to sites in Castle Bromwich, Solihull and Halewood, and to 9 more cross-dock centres in the UK and Europe on a weekly basis. Three types of road collections are used, in the order of preference: (i) Full Truck Load (FTL) – the most efficient collection type – a full truck is loaded at a specific supplier and parts are directly delivered to a destination plant, (ii) Milk run – milk runs are used to collect parts from various suppliers located in a close neighbourhood to achieve FTL, and (iii) Less than Full Truck Load (LTL) – used when low volume parts need to be collected from distant suppliers – the utilisation of truck capacity is suboptimal. To minimize the impact of LTL on total cost, consolidation centres located all over Europe are used, that is LTL trucks instead of delivering parts directly to plants they deliver to those consolidation centres. Different parts are consolidated, and FTL trucks are then sent to a destination plant.

Apart from road transport, Jaguar Land Rover also uses rail, sea freight and air freight. In the UK heavy investments in rail infrastructure at the Castle Bromwich and Halewood facilities took place to allow for 25% of finished vehicles to be distributed by rail to major ports. Rail freight is also used for inbound freight, where possible, currently for containerised parts ex-Halewood to India, China and Brazil. Only suppliers with high parts supply and good access to rail network are suitable. The main drawback of rail freight is the lack of flexibility, that is all shipments need to be pre-arranged with the rail network owner. When additional volumes of parts are requested or the delivery of parts to loading point is delayed, rail freight leaves little flexibility to accommodate it. As such, most of Jaguar Land Rover's inbound freight uses road transport. Even though air freight is the most time-efficient mode of transport, its high cost outweighs the benefit of short delivery time. This mode of transport is used only in emergency situations or for special moves of finished vehicles (e.g. vehicles destined for VIP customers or launch events).

The main challenge related to inbound operations is data integrity. To execute optimal collection of parts, Inbound Freight operations need to know what parts, in what volume and from which suppliers need to be collected. Given the current high diversity in Jaguar Land Rover's portfolio and a high number of parts on each vehicle's Bill Of Materials (BOM), maintaining 100% effective data integrity becomes a challenging task. This is also due to the high number of parts that are uplifted[4] every year and new models entering into the Jaguar Land Rover portfolio. Increased volumes provide new opportunities for more cost-efficient sourcing and this may also lead to changes in the current supplier base. Another aspect that introduces complexity to inbound freight is related to part characteristics (e.g. weight and type of goods). Legal requirements impose weight restrictions on vehicles. Furthermore, dangerous goods (e.g. chemicals) need to be transported in special conditions and with correctly trained drivers. Other aspects that Inbound Freight operations must take into consideration include bank holidays (which can differ across countries) and shut down periods of suppliers. Bank holidays in a specific country may impact transport in the country itself, and also in other countries on the same route. For instance, a bank holiday in France that is an entry point for road deliveries from Europe to the UK will affect also parts sourced from other European countries (e.g. Germany, Italy). In order to incorporate all enumerated factors, optimisation tools are used to provide optimal and feasible collection plans.

With about a fifth of the company's retail sales and about half of the suppliers coming from the EU region (in fiscal year 2018/19), Brexit is a significant source of uncertainty for all manufacturers with operations in the UK, particularly for the automotive sector which relies on free and frictionless trade. Any barriers (e.g. tariffs and border delays) could adversely impact the sector, which relies heavily on just-in-time deliveries with tens of millions of pounds of components being delivered daily to the UK just-in-time from the EU. It is not only the proportion of components that come from European suppliers, but also the fact that some of these parts may cross the Channel several times in a several thousand miles journey before the finished car rolls off the production line. This will not only put pressures on OEMs like Jaguar Land Rover which will have to ensure they hold additional days of resilience or buffer stock, but also on component suppliers who may face extreme pressures to deliver on a timely basis and to bear some of the additional inventory and transportation cost (e.g. customs charges for border crossings).

With over 80% of JLR's volume being exported out of the UK to either Europe or the Rest of the World and over £1bn of 'Inventory in Transit' managing outbound logistics becomes a critical part of the company's success. The global outbound distribution of finished vehicles makes use of 12 UK ports (Figure 3). Southampton and Portbury are key ports for deep sea and southern Europe respectively; significant volumes are also shipped via Immingham Port. Felixstowe port is also used, but for container transport only.

For international shipping Jaguar Land Rover primarily uses sea transport. Automobiles are shipped on either Roll-On/Roll-Off vessels (RORO) or Pure Car Carriers (PCC – specially designed deep sea vessels which can carry up to 6000 automobiles) and will often undertake voyages of up to 45 days. The company at the moment uses over 90 different global ports of entry (see Figure 4), of which 15 (see Figure 5) are located in Europe. For Importer markets, vehicles are handed over either at Ports of Entry or in land compounds. For larger markets, vehicles are delivered to multiple Ports of Entry allowing effective regional distribution. Once product arrives at the Port of Entry in each individual market the Importer takes responsibility for the vehicles and arranges the subsequent in market transport. The Material Planning & Logistics (MP&L) team will manage all shipping activities from forecasting, vessel booking, customs, as well as supplier and service level management. Almost 98% of the outbound volume is distributed via RORO and PCC, whilst for the remaining 2% containers are used.

Figure 3 UK Ports used for international car shipping

(Source: Based on Department for Transport, 2019)

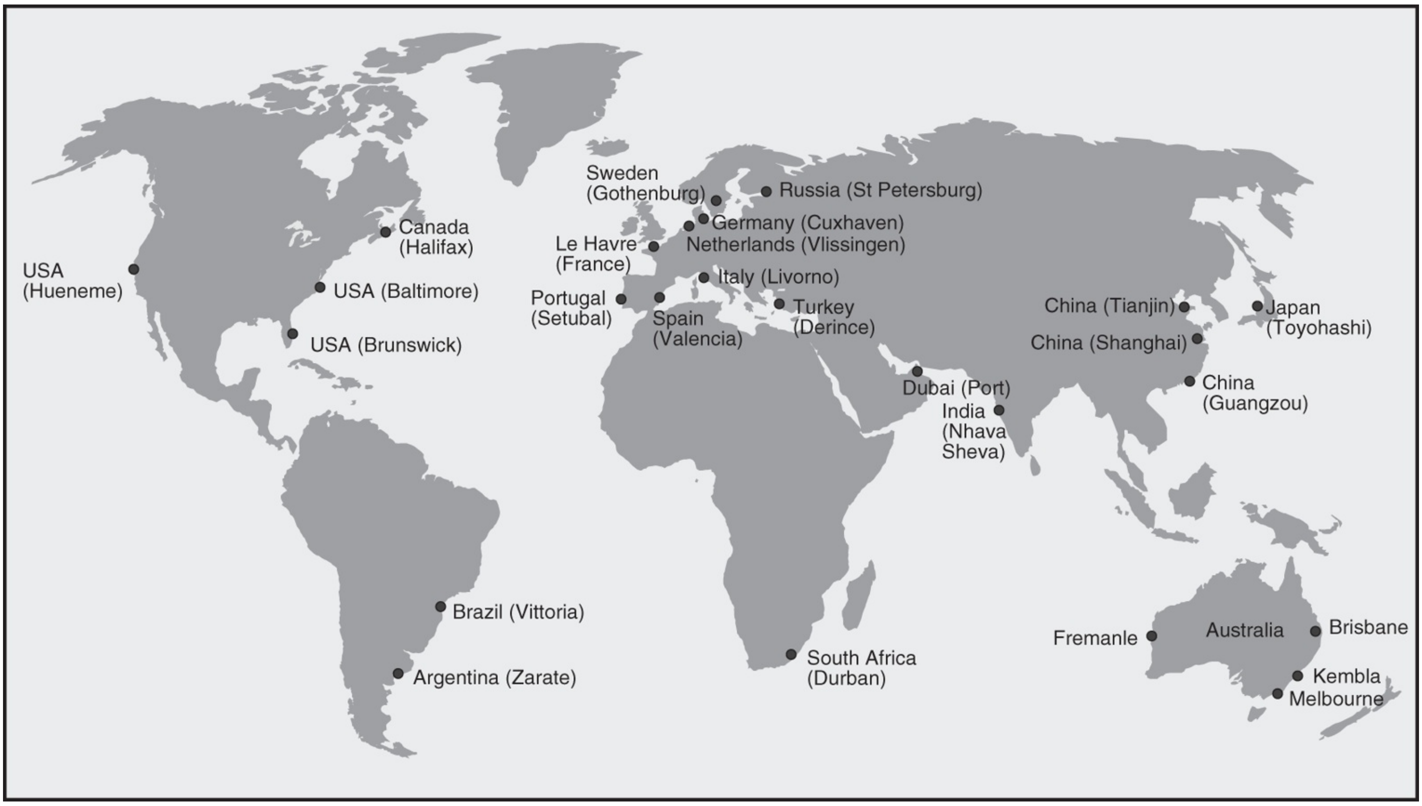

Figure 4 Ports of entry used by Jaguar Land Rover for international shipments

(Source: Jaguar Land Rover)

Figure 5 Ports of entry used by Jaguar Land Rover for European Distribution

(Source: Jaguar Land Rover, Autoshippers, 2018, Shipit, 2020)

The need for multi-modal transport ... and why it is not always applicable

Vehicles are distributed by several contracted Logistic Service Providers (LSPs), each of which is responsible for a specific part of the journey. For instance, one LSP may be responsible for the transport of vehicles from a plant's dispatch area to the port, and other LSPs would be responsible for sea freight and final delivery from the destination port to a dealer. The selection of LSPs is executed via a tendering process, during which a number of factors (e.g. experience, costs, travel time, quality) is assessed. Costs and time are influenced mainly by size and weight of vehicles, mode of transport chosen, travel distance and destination, and volumes shipped (which in turn will affect the frequency). Overall, for outbound freight, unlike for inbound, multi-modal transport is often the preferred option. This is due to the geographical spread of operations, the length of the supply chain and the need to reach many different customer locations. However, despite the advantages and the necessity for multi-modal transport, it may not always be applicable due to a number of factors such as: differences in types of components, terms of supply, incoterms-related issues, customs, import regulations, packaging needs and product complexity. The lack of appropriate infrastructure is another very important reason. Often, there are infrastructure limitations (e.g. some sites are not serviced via rail, or cannot support sailing schedules, or there may be capacity issues at the Port of Entry), or lack of connected infrastructure.

Jaguar Land Rover's growth in recent years allowed economies of scale in inbound as well as in finished vehicle distribution operations. Nevertheless, higher production requires also larger dispatch areas or shorter throughput times. The main challenges of outbound operations are the high level of quality that need to be maintained regardless of the destination country, the time constraint affecting customer service levels (weather conditions may affect chosen sea freight routes and thus transport duration), the size of some Jaguar Land Rover vehicles that is larger than the standard and therefore, not ideally sized to containers, governmental transport regulations that vary per country, and low environmental impact (e.g. minimum CO_2 emission).

Logistics Service Providers (LSPs)

As is the case with many other OEMs, LSPs play a key role in Jaguar Land Rover manufacturing. They are involved in various logistics activities throughout the supply chain, from the collection of parts and in-plant material flow management to distribution of finished vehicles. The company's LSPs also make a significant contribution in the global growth of Jaguar Land Rover, mainly in design and implementation of logistics outsourcing strategy. In order to ensure those inbound and outbound logistics challenges are dealt with in the most effective way, Jaguar Land Rover contracts LSPs with high levels of experience and expertise in specific regions (LSPs need to have knowledge of the local area – e.g. legal constraints, how weather conditions might impact transport). This allows high customer service levels to be maintained (e.g. intact quality of vehicles, timely delivery). Due to the fact that a number of different LSPs can be used to transport a specific vehicle shipment, scrupulous quality checks need to be executed every time an ownership of responsibilities is passed from one LSP to another.

The primary LSPs for Jaguar Land Rover include: Syncreon, DB Schenker, Priority Freight and DS Smith. Syncreon runs the UK Export Sales Centre (ESC) – cross-docks designed to receive, repack and consolidate the material into sea and air freight shipments. Furthermore, it also runs the in-plant logistics for the new Wolverhampton engine plant. Similar services are provided by DB Schenker, but only for prototype build parts destined for non-UK assembly plants. Additionally, DB Schenker is also responsible for collection and delivery of those parts to the Launch Shed (ESC for prototype parts). The LSP Priority Freight is used for emergency shipment of parts that can be caused by parts quality issues, stock losses or late part engineering changes.

In addition to the above, Jaguar Land Rover has established a more strategic relationship with a specific LSP (DHL) that plays a critical role in overall Jaguar Land Rover logistics operations. Its responsibilities encompass a much more expanded supply chain scope in contrast to other Jaguar Land Rover LSPs. This type of LSP is called a Lead Logistics Provider (LLP). DHL is responsible for coordinating Jaguar Land Rover's entire inbound network including transport management, stock handling and line feeding at three UK plants. DHL is responsible for around 85% of global inbound freight, including all of Europe and the UK, with a common service for plants through LTL and FTL shipments.

Managing the relationships with LLPs is critical as Jaguar Land Rover can achieve cost savings and increase operations flexibility. In doing so, relationships need to be built on openness (willingness to share often confidential information) and above all trust.

Packaging

Effective packaging is of critical importance for the car industry not only because it protects raw materials and finished vehicles, but also because it affects cost and logistics operations. It is estimated that a significant amount of capital is often locked in automotive parts packaging, which in the case of inbound parts may cost 2%–4% of the total part value (Deloitte, 2012). Logistics has therefore a key role to play in ensuring that packaging implications are also considered in the component design process to maximise density, minimise expendable packaging and protect quality. In fact, a packaging solution needs to be developed for every part and tailored to the specific transport mode in order to ensure the quality does not deteriorate during transport. Packaging in this sector falls mainly into two categories: returnable (e.g. pallet boxes, collapsible pallet boxes, containers, pallets and lids) and expendable (e.g. similar cargo units as above but made of cardboard, foam, plastic).

The automotive industry uses traditionally returnable packaging mainly for the benefit of cost, quality and operational efficiency. Nevertheless, returnable packaging comes also with some disadvantages (e.g. disruptions in the supply chain due to missing or damaged containers, re-design of special packaging for non-standard size parts in case parts specifications change or line feed space is decreased). The main downside of returnable containers is however their unsuitability – for reasons of cost – for long supply chains. The solution to this is the use of expendable packaging which is intended only for one-way transport operation. This practice is in place particularly in one-way automotive trading relationships (e.g. spare parts or for emerging markets) or when consolidation centres are involved. In the latter case, parts would be delivered to consolidation centres in returnable containers, repacked into expendable packaging and shipped to the destination location.

The global expansion of Jaguar Land Rover led to an increased use of expendable packaging. In fact, all parts necessary to build the Range Rover Evoque require a specifically designed expendable packaging. To support this process, Jaguar Land Rover established a close relationship with DS Smith, a leading British-based international packaging business. The involvement of this experienced packaging solution provider has allowed Jaguar Land Rover to achieve a high rate of undamaged parts deliveries. An example is a recently developed packaging solution called Bumper Outer Shipper. This is used for packing individual vehicle parts worldwide with the aim of optimising containers' use with an easy-to-assemble pack. The board protects parts and wraps around the contours of bumpers, allowing each pack to be nested and secured together with smart locking tabs. Vehicle bumpers are wrapped in a bubble-foil envelope bag to maximise protection (Packaging Gateway, 2017).

EPILOGUE

Jaguar Land Rover's product portfolio growth combined with plant expansions and growth in overseas markets have created numerous challenges across the supply chain, from supplier sourcing and managing inbound material flows to vehicle distribution and reverse logistics for returnable packaging. This case study has illustrated the sheer scale of supply chain operations that is happening 'behind the scenes' in the automotive industry and has also illustrated the importance of meticulous logistics design, planning and execution in order to deal with the challenges of global expansion and the associated complexity.

DISCUSSION

1. How does the design of a car impact logistics operations?
2. What are the advantages and the challenges of local assembly operations?
3. What are the issues that Jaguar Land Rover's supply chain needs to consider with regard to the ongoing increase in export volumes?
4. Why is Jaguar Land Rover using a mixed manufacturing strategy (e.g. joint ventures, contract manufacturing)?
5. a. What are the preferred modes of transport used by Jaguar Land Rover and why?
   b. Discuss the main advantages and disadvantages of multimodal transport in the case of Jaguar Land Rover?
6. How important is the role of LSPs in the automotive industry and why?
7. Compare open to closed book logistics services contracts.
8. What are the benefits of introducing returnable packaging instead of expendable packaging?
9. What do you think are the challenges related to packaging solutions that have emerged from Jaguar Land Rover's global expansion?

Note from the author

This is an updated version of the case study published in the previous edition of this book for which acknowledgements were given to the entire MP&L Group at Jaguar Land Rover for providing relevant data and information during numerous discussions. The new material used for this case was compiled from public sources and is intended to be used as a basis for class discussion rather than to illustrate either effective or ineffective practices.

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ACRONYMS

BOM	Bill Of Materials
BIW	Body In White
CLA	Complete Local Assembly
DC	Deconsolidation Centre
EDU	Electric Drive Units
EMC	Engine Manufacturing Centre
ESC	Export Sales Centre
FTL	Full Truck Load
LLP	Lead Logistics Provider
LSP	Logistics Service Provider
LTL	Less than Full Truck Load

MP&L	Material Planning and Logistics
OEM	Original Equipment Manufacturer
PCC	Pure Car Carriers
RORO	Roll-On/Roll-Off
SLA	Semi-Local Assembly
TAF	Trim And Final

NOTES

1. British Leyland was a UK government-owned holding company which controlled a number of well-known automotive engineering and manufacturing companies (including Jaguar and Land Rover) during late 1960s and 1970s.

2. The approach angle is the maximum angle of a ramp onto which a vehicle can climb from a horizontal plane without interference. Departure angle is its counterpart at the rear of the vehicle – the maximum ramp angle from which the car can descend without damage. Both are important for shipping purposes (to put the car on a ship or on a truck).

3. This refers to lashing chains/wires used in different ways to secure the cargo on board.

4. Uplifting refers to the issuing of new engineering specifications for a part due to the model year running out and/or new additions being introduced which results in a new BOM (e.g. the BOM of a vehicle of 2021 model year will differ from the BOM of 2020 model year).

Part Two
Transport and Logistics

6
Transport

LEARNING OBJECTIVES

- Understand the cost structures, operating characteristics and applications in logistics of the different transport modes.
- Illustrate freight shares by mode.
- Highlight key concepts and terms used in transport.
- Discuss the roles of distribution centres and highlight the concept of factory gate pricing.
- Consider the efficiency of freight transport services.
- Review the world's major transport networks.

INTRODUCTION

Freight transport is an integral part of LSCM, but traditionally it has been treated as a service that is easily available when required by suppliers and distributors. Also, transport is typically regarded as a non-value-adding activity in the supply chain, although we challenge this assumption on the basis that it plays an essential role in the supply chain and when managed properly can allow supply chains to work more efficiently and effectively. That said, transport is of course a **derived demand** in that the demand for transport is dependent upon someone wishing to move freight from one point to another.

There are essentially five modes of transport:

- Air
- Road
- Water
- Rail
- Pipeline

The Internet can also be regarded as a possible sixth mode of transport.

> All modes of transport have been heavily – and largely positively – impacted by various technology developments; we discuss these in more detail in other chapters and in particular in Chapter 4 (on-demand transport and Mobility as a Service (MaaS)), Chapter 11 (automation), Chapter 13 (digital) and Chapter 16 (decarbonisation, sustainability and energy sources). Intelligent Transport Systems (ITS) is a term used for all aspects of using information technology and telecommunications for transport applications such as analysis and control of networks to improve safety, mobility and efficiency. Widely known applications of ITS include transport telematics, which incorporates technologies such as GPS navigation systems.

Chapter 6 comprises four core sections:

- Characteristics of the different transport modes
- Transport operations, distribution centres and the role of factory gate pricing
- Efficiency of transport services
- International transport networks

CHARACTERISTICS OF THE DIFFERENT TRANSPORT MODES

Choosing which mode(s) to use for freight transportation will usually be a function of the volume and value of the freight, the distance to be travelled, the availability of different services, freight rates to be charged and so forth. Once the appropriate mode of transport has been chosen, it is usually the case that there is not a simple linear relationship between the freight rate charged and both the weight of the freight and the distance to be travelled (Figures 6.1 and 6.2). Regardless of how short the distance to be travelled, the logistics service provider (LSP) will still have to recover certain fixed costs (terminal charges and so forth) for transporting a consignment (Figure 6.1). For heavier shipments, the rate per kilo will typically decrease as the fixed costs can be spread over a larger shipment weight (Figure 6.2). For bulky or difficult-to-handle shipments, LSPs will typically apply what is known as **volumetric charging** based on the dimensions of the consignment. This is to compensate for lost capacity as a result of carrying the bulky shipment where applying a rate per kilo would not sufficiently cover the costs incurred. Think, for example, of a roll of carpet in an aircraft hold, by weight this shipment may be quite light, but because of its dimensions there may be a lot of lost space in the aircraft hold which cannot now be utilised. Chapter 12 will deal with costing and pricing in LSCM in more detail – however given that we have reviewed here the different types of basic freight rates (varying by weight, distance and volume), it is worth pointing out too that on some trades so-called special ‘commodity rates’ are charged which reflect the (usually lower) costs associated with carrying (usually larger volumes) of those commodities – examples include flows of fish, flowers and similar products which often flow in large volumes on certain routes.

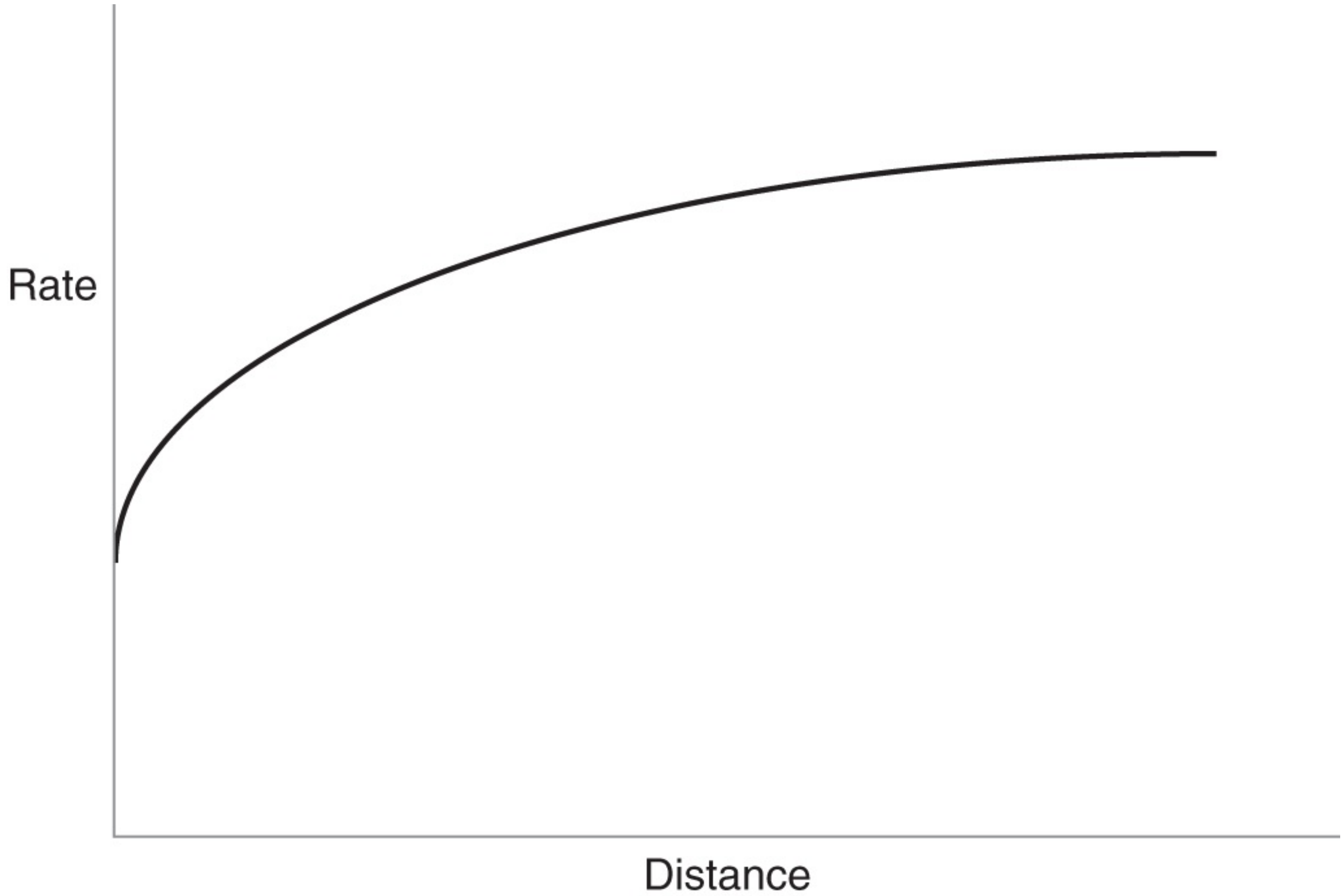

Figure 6.1 **Relationship between rate and distance**

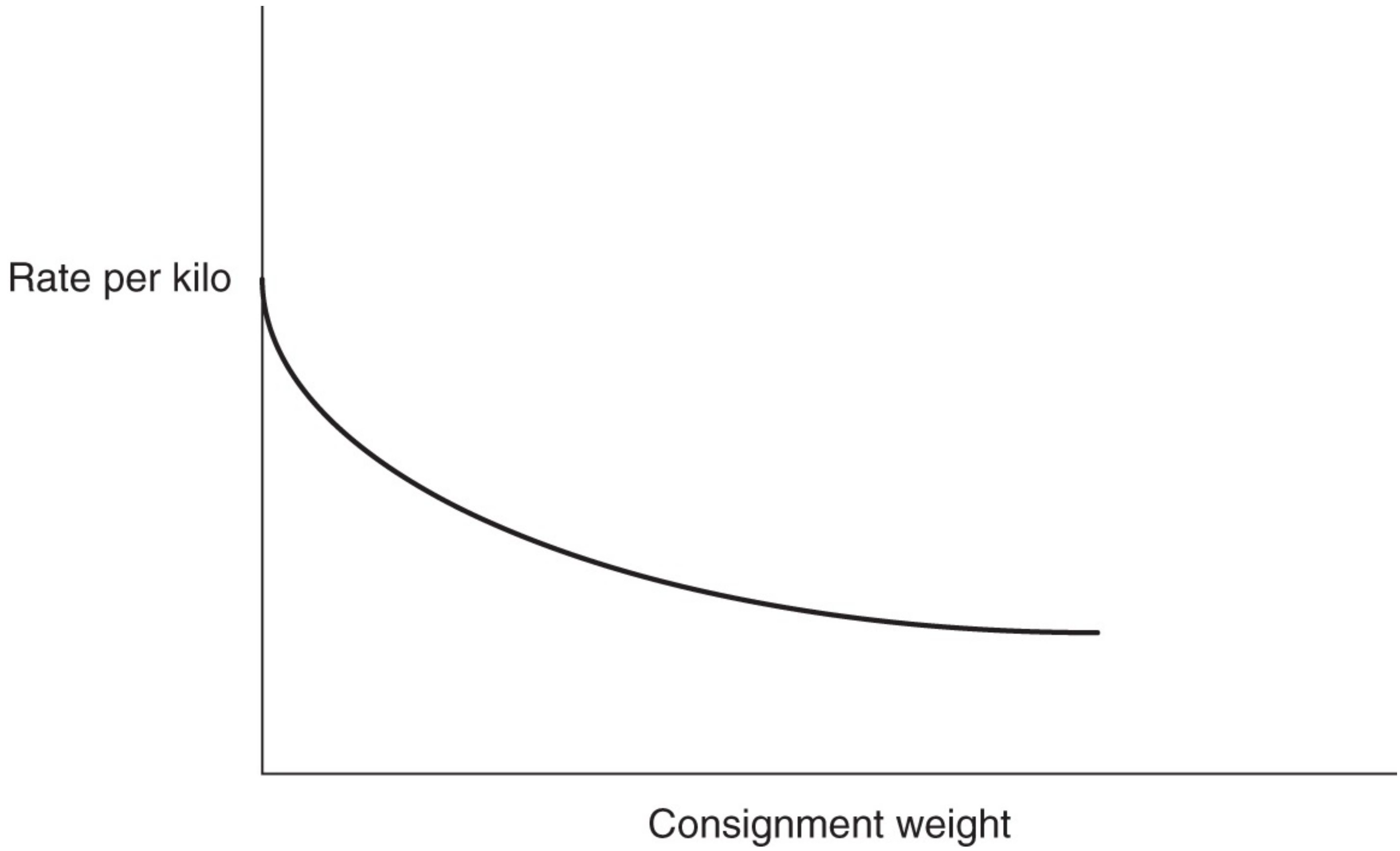

Figure 6.2 **Relationship between rate per kilo and consignment weight**

An interesting feature of logistics systems is that sometimes consignors do not know exactly which transport mode their freight travels on, leaving this decision to the LSP. For the LSP it is not a simple matter of trading off one mode against another; sometimes multiple transport modes are used in combination. Table 6.1 illustrates the cost structures and operating characteristics of the different transport modes, together with their uses in logistics. When reviewing this table, you will note that freight is often carried in standardised loading devices (such as containers in shipping and ULDs (see Table 6.1) in air transport) – such standardisation facilitates ease of handling, commonality of handling equipment and so forth and is an important attribute in the context of logistics system optimisation. We will return to this in Chapter 7 when we will look in detail at containerisation. Another interesting feature of many transport modes is that they can be used too for other purposes – for example running data cables along pipelines, attaching air pollution sensors to vehicles and even attaching cameras to refuse collection vehicles so that local authorities can monitor road surface conditions![1]

TABLE 6.1

A summary of costs, relative operating characteristics and uses of the different transport modes

Mode	Relative costs and operating characteristics by mode	Uses in logistics
Road	Fixed cost is low as the physical transport infrastructure such as motorways are in place through public funding; variable cost is medium in terms of rising fuel costs, maintenance and increasing use of road and congestion charges. In terms of operating characteristics, road as a mode of transport scores favourably on speed, availability, dependability and frequency, but not so good on capability due to limited capacity on weight and volume. Uniquely among transport modes, it can allow direct access to consignor and consignee sites.	Trucking. As a form of commuting, walking (and indeed also so-called 'run commuting') is becoming increasingly popular and as is the distribution of small/light freight shipments by foot and bicycle in congested cities.
Rail	Fixed cost is high and the variable cost is relatively low. Fixed costs are high due to expensive equipment requirements such as locomotives, wagons, tracks and facilities such as freight terminals. On relative operating characteristics, rail is considered good on speed, dependability and especially capability to move larger quantities of freight.	Rail freight. Use of urban metro networks for parcel distribution and stations as distribution/parcel pick-up hubs.
Air	Fixed cost is on the lower side but high variable cost that includes fuel, maintenance, security requirements etc. The main advantage of air is speed; it is however limited in uplift capacity; similarly other modes of transport are required to take freight to and from airports, thus air cannot directly link individual consignors and consignees.	Drones Air freight (both in the 'belly' of passenger aircraft and in dedicated freighter aircraft – in both instances it is generally carried in what are known as 'unit load devices' (ULDs) (sometimes also referred to as igloos)).[2] The case study on air cargo at the end of Part Two of the book describes this sector in more detail.
Water	Fixed cost is on the medium side including vessels, handling equipment and terminals. Variable cost is low due to the economies of scale that can be enjoyed from carrying large volumes of freight – this is the main advantage of the water mode, together with its capability to uplift large volumes of freight. Like air, it cannot offer direct consignor-to-consignee connectivity, and vessels are sometimes limited in terms of what ports they can use. It is also quite a slow mode.	Waterborne freight is generally categorised based on the means by which freight is loaded onto or off of the vessel: *Unitised*: lift-on/lift-off (Lo-Lo) and roll-on/roll-off (Ro-Ro) freight. Both are generally expressed in number of units (as opposed to shipment weight). Lo-Lo comprises containers lifted on to the ship by crane; RoRo comprises wheeled trailer units (accompanied – where the truck tractor also travels on the ship attached to the trailer, and unaccompanied where the trailer only is carried on the ship), note too that cars, coaches and vans are also classified as Ro-Ro. The other categories of waterborne freight are generally expressed in tonnage and comprise liquid bulk, dry bulk and other general cargo. The case study on port-centric logistics at the end of Part Two of the book describes the intersection between ports, shipping and logistics. A recent trend is that in many congested cities there is a re-emergence in the use of rivers for distributing freight and for commuting.
Pipeline	Fixed cost is high due to rights of way, construction and installation, but the variable cost is relatively low and generally just encompasses routine maintenance and ongoing inspection/security. On operational characteristics, the dependability is excellent but this mode can only be used in very limited situations.	Urban utilities (gas, sewage and water). Oil and gas extraction and distribution.

Modal split

The International Transport Forum (ITF) at the OECD is an intergovernmental organisation with 59 member countries. Its annual *Transport Outlook* provides a detailed and informative overview of trends and prospects for transport demand at a global level.[3] They estimate (Figure 6.3) that of the 108 trillion tonne kilometres of (domestic and international) freight transported worldwide in 2015, 70% travelled by sea, 18% by road, 9% by rail, 2% by inland waterway and less than 0.25% of global freight in tonne kilometres is transported by air. Figure 6.3 also shows the ITF's projections for freight transport demand by mode out to 2050. Note that the modal shares we are discussing here are by freight *weight* and not by freight *value* – in LSCM data for freight value is typically more difficult to find and compare. In any event, it can be difficult to adjudicate the actual value of a given freight shipment – recall our discussion in Chapter 2 on transfer pricing where the value of a consignment may be dictated by what taxes are applied and where those taxes are applied; more generally too some shipments will comprise materials that are inputs to further manufacturing processes and thus their value isn't fully realised as such until the final product is produced. Typically too loading units such as shipping containers and air freight ULDs will comprise a mix of products with different values. In freight transport then our focus tends to be on the weight of what we move – there is, of course, another very practical reason for this in that our infrastructure (trucks, cranes etc.) will have limits to the weight it can handle. Looking back then to the statistics for air freight tonne kilometres above (less than 0.25% share), the share for air freight by *value* would obviously be much higher as more valuable freight tends to travel by air. In fact, the International Air Transport Association (IATA) estimates that air cargo transports over US$6 trillion worth of goods, accounting for approximately 35% of world trade by value.[4] Within modes too there will be variations – in shipping, for example, higher value freight tends to be unitised.

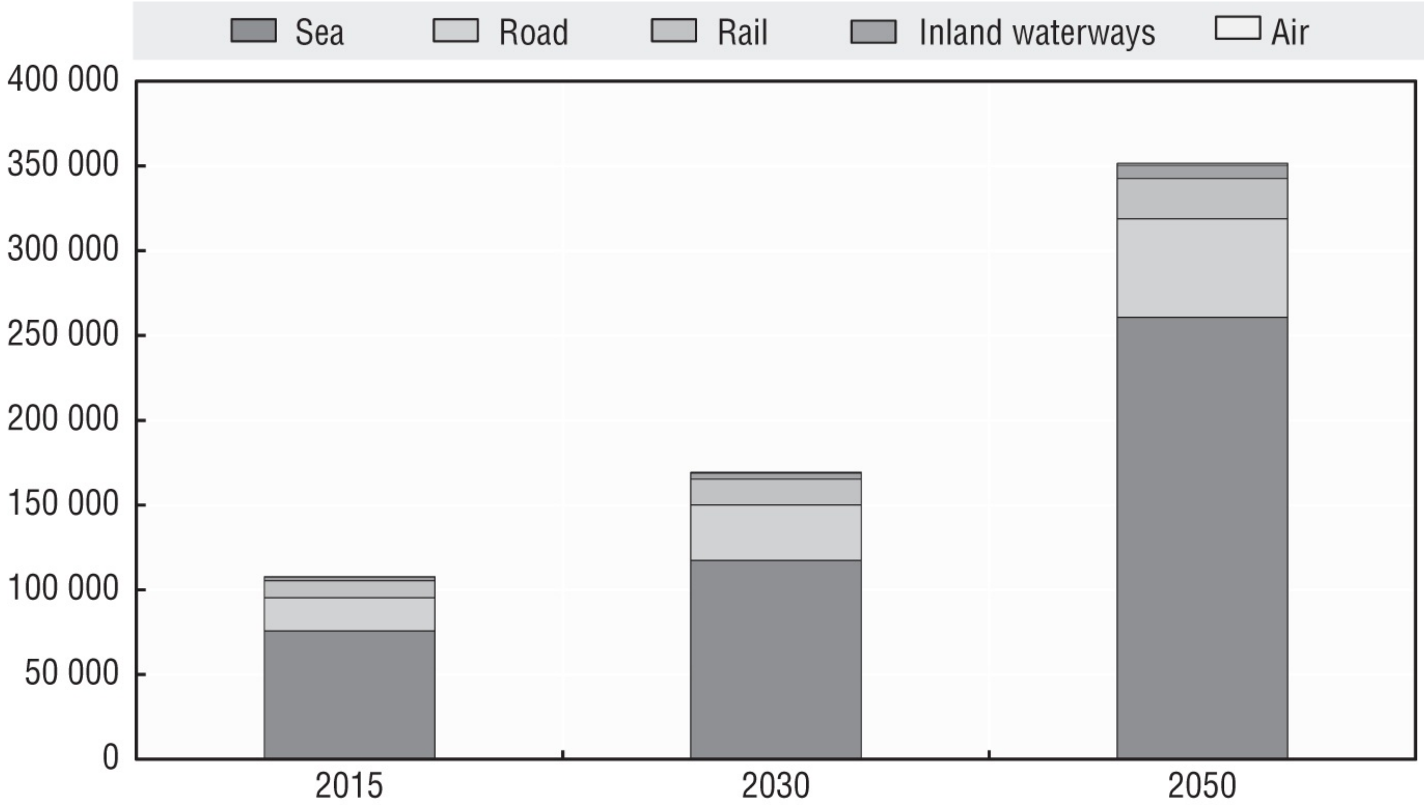

Figure 6.3 Modal split and projected freight transport demand by mode in billion tonne-kilometres

(Source: Based on ITF Transport Outlook, 2019)[5]

The split of freight among the different modes varies too by region and type of freight. Maritime transport is the dominant mode of transport for international freight transport movements. UNTCTAD's annual *Review of Maritime Transport* estimates that world maritime trade reached 11 billion tons in 2018.[6] Road transport is the dominant mode of transport for inland transport. Due mainly to the flexibility, directness and speed that the movement of freight by road offers, when compared to rail, inland waterway or sea transport, it has become the principal freight transport mode, carrying the majority of inland freight. It is, however, also the most environmentally damaging mode of transport, an issue we will return to in Chapter 16 which deals with sustainability. Policymakers are thus endeavouring to shift freight away from road to more environmentally friendly transport modes, in particular to rail and inland waterway. This is not an easy task, however, as many transport systems are predicated on extensive use of road transport.

The International Transport Forum website has a useful tool that allows countries to be compared across multiple transport-related parameters.[7] One such measure is what is known as *freight transport intensity,* which measures the ratio of tonne-kilometres to GDP and thus how dependent an economy is on freight transport (ideally, you would like the measure to be low – that economic output can be generated with low levels of freight volume and distance travelled). A range of other transport indicators are also available on the website (e.g. modal split, infrastructure investment, transport-related CO_2 emissions) and allow comparisons to be made between countries.

Macro volumes of freight are usually measured in **freight tonne-kilometres**[*] (FTKs), that is the volume of freight measured in tonnes multiplied by the distance the freight travels measured in kilometres. Macro volumes of passengers are usually measured in revenue passenger kilometres (RPKs), the *revenue* denotes that the passengers are fare paying (as opposed to positioning crew, staff travelling on concession etc.).

*Sometimes too the term tonne miles is used.

TRANSPORT OPERATIONS, DISTRIBUTION CENTRES AND THE ROLE OF FACTORY GATE PRICING

Chapter 10 will illustrate how inventory is stored at multiple points in supply chains. In this section we will consider the role of distribution centres and in particular a concept known as 'factory gate pricing'. Over the past 35 years, supply chain configurations have been changing to achieve higher levels of logistics performance and customer service. In the 1970s and 1980s, **distribution centres (DCs)** were introduced in the retail sector, with retailers taking over responsibility for deliveries to their stores (sometimes DCs are referred to as **RDCs – regional distribution centres**, and **NDCs – national distribution centres)**. A DC is a type of warehouse where a large number of products are delivered by different suppliers, preferably in full truck loads. Each DC services a number of retail stores in the regional area. In the 1990s, **consolidation centres (CCs)** were added and served to consolidate deliveries from multiple suppliers into full loads, which could be delivered onwards to the DCs (see Figure 6.4). A more recent development has been for the retailers to take control of the delivery of goods into their DCs and this is known as **factory gate pricing – FGP**. This gives a single point of control for the inbound logistics network and can be defined as: Factory gate pricing (FGP) is the use of an ex-works price for a product plus the organisation and optimisation of transport by the purchaser to the point of delivery.[8]

The case below on FGP highlights the savings for a retailer due to increased supply chain visibility and better management of transport leading to reduction in delays in their inbound logistics.

Figure 6.5 illustrates the evolution of grocery distribution over the past half century. In addition to the control of their inbound logistics using FGP, retailers are also looking at further improving their efficiency by increasing the backloading of store delivery vehicles and the consolidation of smaller loads into consolidation centres. In addition to the retail sector, FGP has been used in a number of other industry sectors.

The application of FGP within the grocery sector has complexities due to the large number of suppliers, huge number of products and the scale of distribution. With regard to the impact of FGP on transport, LSPs could feel that the retailers can use it as a lever to reduce haulage rates and thus their profit margins. Research by the ITeLS research team at Cardiff University suggests that there are numerous operational benefits that arise for the retailer from implementing FGP.[9] These include increased supply chain visibility provided to the retailer giving management greater insight into the behaviour of its replenishment processes in response to changes in demand; in addition, the research showed that the retailer benefits from higher delivery service levels. For the suppliers, FGP enables them to focus on their core competencies. In the grocery industry, this is pertinent as the retailers do not add value to the product through manufacturing, but do so through the efficient delivery of products. Therefore, distribution is one of their key strengths. Conversely, many suppliers outsource their distribution in order to focus upon the core competency of manufacturing.[11]

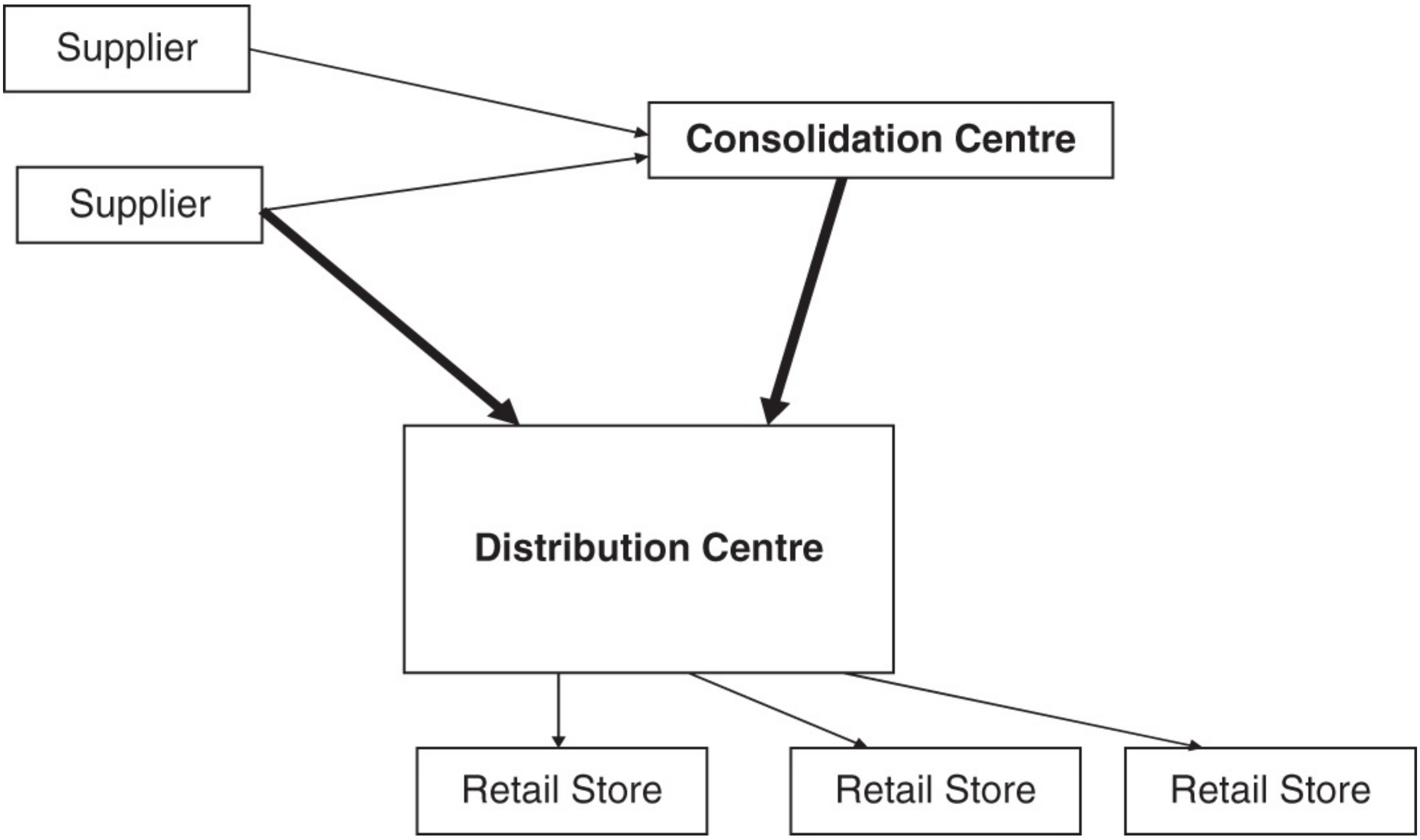

Figure 6.4 Inbound logistics in the retail sector

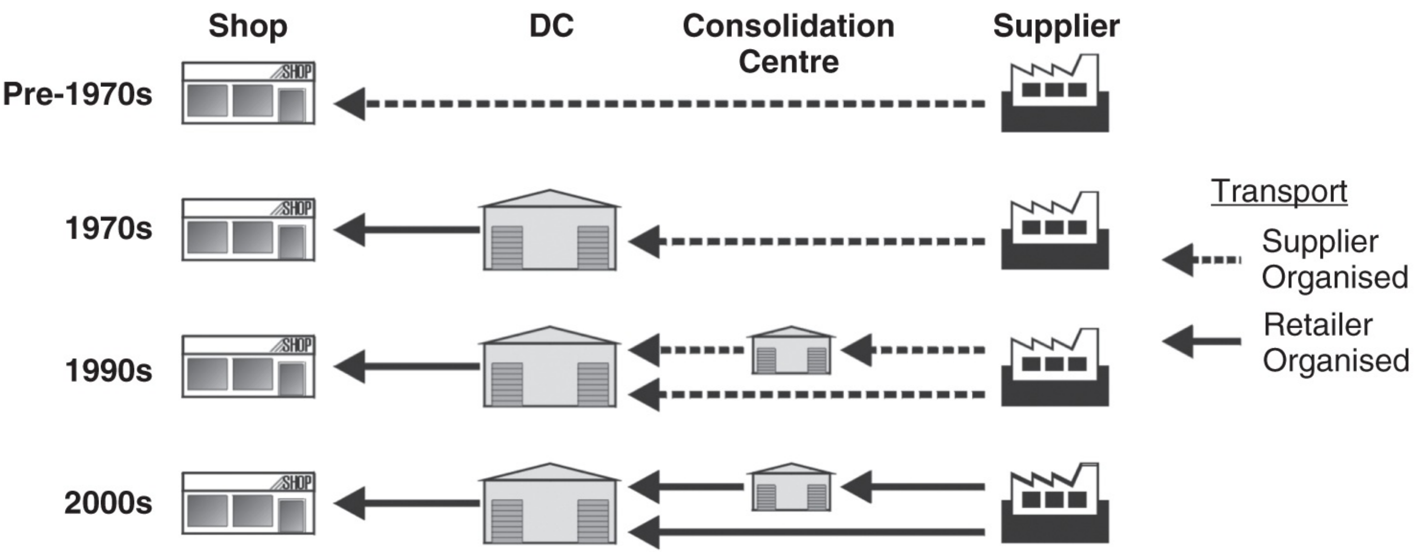

Figure 6.5 The evolution of grocery distribution

(Source: Potter *et al.*, 2003; Reproduced with permission of Emerald Publishing Limited.)[10]

For FGP implementation, a single point of control is required in the supply chain. With no overall single point of control, there will be additional costs such as in achieving collaboration between all parties for transport movements. In the grocery sector, the power of the retailers makes FGP suitable for managing the single point of control. However, this may not apply in all cases. The implementation of FGP heavily depends on the use of ICT, particularly for transport planning but also for communication with the LSPs.

The next section turns to the issue of minimising total transport cost within a transport network. Minimum total transport cost solutions could be arrived at by balancing the DC demands with suppliers' capacities in an existing transport network. In addition, where there is a possibility of redesigning the network, the total transport cost could be further minimised by optimising the location of consolidation centres and/or DCs in relation to the supplier network. One of the methods to do this is using what is known as the **transportation model** – this technique is discussed in Chapter 14.

AN EXAMPLE OF THE APPLICATION OF FGP[12]

This example illustrates that implementation of FGP could generate savings to justify the investment for its adoption in the retail sector. The case company is a leading UK grocery retailer with over 1750 stores in the UK and nearly 2000 own-brand primary suppliers in 98 countries. The example discussed here is based on the UK suppliers, UK DCs and UK CCs only.

The suppliers to the case company retailer could deliver products in full or less than full truck loads. Less than truckload suppliers are defined by the retailer as those supplying less than 18 pallets per day to a DC (a full vehicle can hold 24–26 pallets).

With less than truckload suppliers, the decision was taken by the retailer to consolidate these shipments through a new network of CCs so as to make deliveries to the DC in full vehicle loads.

In analysing the data collected from the retailer on flows of existing consolidated products, it was found in some cases that a supplier was transporting products across the UK to a CC, only for them to then be moved back along almost the same route for delivery to a DC. This obviously increased transport costs. Under FGP, products are routed more rationally, going from suppliers to the local CC for onward movement to the DCs. Where the supplier is close to the DC, direct deliveries to the DC continue to be the most cost-effective approach. With full truckload suppliers, the ability of the retailer to have visibility of its whole inbound distribution network also created opportunities for transport cost reduction.

While the application of FGP delivers reductions in transport miles and costs, the implementation has required the use of the latest developments in ICT. If the technology was not available, the efficiency of the process would be significantly reduced due to the number of people required to plan and manage the inbound distribution process. Through the acquisition of an effective transport management system, the retailer can control the whole inbound distribution network with a limited number of people working at any one time.

The ITeLS research team at Cardiff University carried out a mini project with the case company and made an attempt to quantify the transport benefits. In the context of the retailer's business, less than full truck load deliveries accounted for 18% of the total ambient volume, 57% of composite volume and 35% of total grocery volume. Composite distribution networks are the centres used for distributing multi-temperature controlled products (fresh, chilled and frozen). The data from the retailer was modelled in a network planning software package to determine the transport distance and cost benefits. The results for both ambient and composite networks are detailed in Table 6.2. There are a number of assumptions that should be kept in mind in interpreting the results. It is assumed that the demand is spread evenly over time, with 100% availability at the supplier. The decision on less than truckload suppliers was made strategically at the retailer, rather than incorporating all suppliers into the model. Costs were based on current charges incurred by the retailer and levied on a per mile basis for transport and per pallet basis for handling charges at the CCs. Finally, the figures only represent the movement of products from the supplier to the DC and do not take into account any costs in positioning the vehicle at the supplier. Because the retailer uses third-party logistics providers for the majority of their requirements, it has been assumed that any cost associated with this is included in the haulage cost.

By controlling the consolidation network from a single point through FGP, it is possible to reduce the total distance products travel between suppliers and stores by 23–25% (see Table 6.2). This results from reducing the number of suppliers that deliver directly to the DC, particularly for ambient products. The relative reduction in transport costs is less, being 13.9% and 17.2% for ambient and composite products, respectively. This is because there is cost associated with handling the pallets at the consolidation centre. The researchers estimate that, given the volume of products these savings are achieved on, it can be extrapolated that FGP will reduce the retailer's total distribution cost by approximately 5.7%. However, this value does not consider any gains from implementing the strategies for full vehicle loads or the potential for the retailer, as a large user of transport, to realise economies of scale for freight rates.

TABLE 6.2

The impact of the primary consolidation network with FGP

(Source: Potter et. al., (2007); Reproduced with permission of Emerald Publishing Limited.)

Product type	Scenario	Weekly transport miles (normalised)	Total weekly cost (normalised)	Volume	
				Direct	Consolidated
Ambient	As is	100	100	88.7%	11.3%
	FGP design	74.7	86.1	16.7%	83.3%
Composite	As is	100	100	39.0%	61.0%
	FGP design	77.0	82.8	12.8%	87.2%

In this example, the benefits of FGP in the retail sector have been highlighted, but it is important to comment upon potential issues that arise through its implementation. First of all it is likely that there will be additional costs for achieving collaboration between all parties for the transport movements if it is implemented using the consolidation centres. Second, there is the question of who manages the point of control. In the grocery sector, the power of the retailers makes FGP suitable. However, this may not apply in all instances. Finally, the implementation of FGP has been heavily dependent upon ICT, particularly for transport planning but also for communication with hauliers.

EFFICIENCY OF TRANSPORT SERVICES

A variety of issues impact the efficiency and effectiveness of transport services. These include congestion problems, waste including empty running of vehicles, carbon emissions, regulatory directives on maximum permitted working time, road user charges and skill shortages. These problems cause inefficiencies and waste such as excessive waiting time, poor turnaround time, low vehicle fill rates, poor asset utilisation, unnecessary administration and excessive inventory holding.

Poor asset utilisation for example is illustrated in Figure 6.6 that uses real-life data from the steel sector. It can be seen that the demand placed by corporate customers on the transport operator per day during a week can vary from 83 vehicles to 170 vehicles.

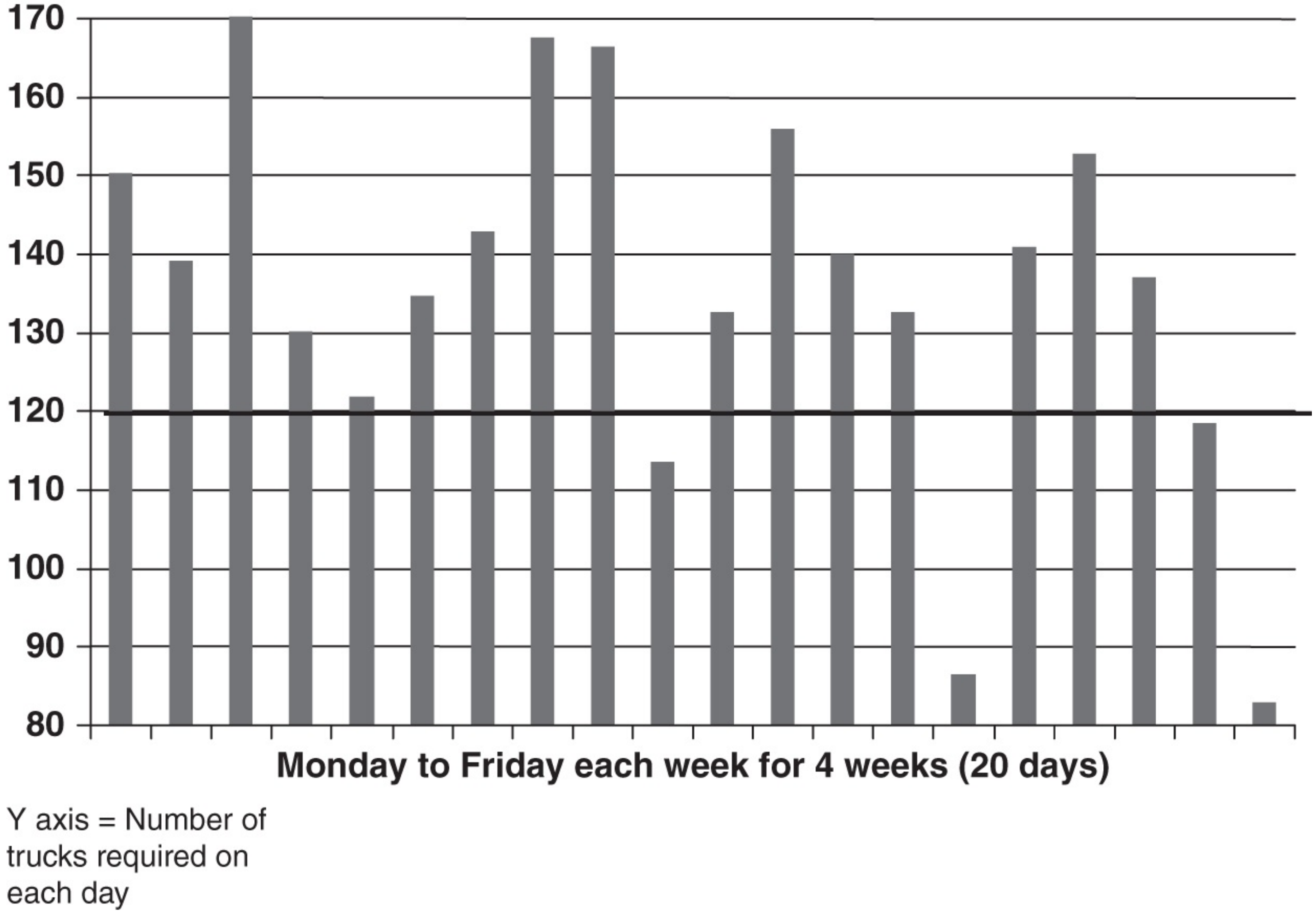

Figure 6.6 Poor asset utilisation in transport

(Source: Mason *et al.*, 2006; Reproduced with permission of Cardiff University.)[13]

The strategies pursued in a supply chain impact the efficiency of the transport services demanded. Pursuing a JIT strategy (see Chapter 3), for example, has many advantages, but one of its downsides is that it can lead to inefficient transport utilisation with frequent small loads. In fact from the LSP's perspective JIT can lead to: inconsistent fleet utilisation, reduced payload optimisation, reduced ability to effectively plan fleet operations, an image of expendable and infinitely flexible resource in the eyes of customers, etc.

Fuel consumption and emissions are also key parameters in the context of transport efficiency. In the US, for example, it is estimated that transport accounts for 28% of total energy use.[14] Petroleum products still accounted for about 92% of the total US transportation sector energy use in 2018, biofuels such as ethanol and biodiesel contributed about 5%, natural gas accounted for about 3% (most of which was used in natural gas pipeline compressors) and electricity only accounted for less than 1% of total transportation sector energy use and nearly all of that in mass transit systems.[15] As noted already above, we will return in Chapter 16 to the important topic of the environmental impact of transport on the environment and sustainability. The transport industry is expending significant effort to reduce its carbon footprint and impact on the environment, especially with regard to moving away from petroleum-based products to more environmentally friendly energy sources for propulsion (it should be noted too, of course, that the motivation here isn't solely concern on the part of the transport industry for the environment – cost (especially in the context of added carbon taxes/penalties) and availability of fuels are key concerns too). It has been reported that Amazon, for example, is creating a futuristic fleet of 100,000 electric delivery vans, with Alexa and routing software built-in.[16] As well as focusing on energy sources, much development work is also ongoing in the transport industry into both autonomous and high-capacity vehicles.

INTERNATIONAL TRANSPORT NETWORKS

The map at the start of the book illustrates the world's international shipping routes and top container ports. Other features of international transport networks are also highlighted, such as the Trans-Siberian Railway and the Northern Sea Route (which is now emerging because of the melting of Arctic ice). The map highlights the dominant role played in world trade by the large container ports, and in Asia in particular. As we saw in Chapter 5, the major shipping lines generally organise their services as hub-and-spoke networks with the hubs centred on the large container ports. Hub-and-spoke network designs are also used in other transport modes.

It can take many years to provide new transport infrastructure, so while there may be competition among service providers, in many respects international transport networks have quite fixed characteristics. Thus while a consignor may have a choice of carriers to choose from, in reality all carriers may transport the shipment along broadly similar routes. Another issue in international shipping is whether to transit the canals (Suez/Panama) or take longer sea routings via the Capes at the bottom of South Africa/South America. Costs obviously play a key role in these decisions with the canal operators setting their transit dues and other charges accordingly. The other issue to consider is the vessel size restrictions of the canals, although with expansion of both canals in recent years this is becoming less of an issue. New routing opportunities too are emerging (albeit as noted previously these can take many years to emerge from when they are first mooted to when they become operational); examples include the ongoing development of the China-led Belt and Road Initiative (BRI), the planned Nicaragua Canal and the aforementioned Northern Sea Route.

LEARNING REVIEW

This chapter focused on physical flows using transport in LSCM. The characteristics of the five principal transport modes and their uses in logistics were described, and considerations in determining freight rates were explained. We looked at modal split and the link between transport and sustainability – which we will return to in Chapter 16 – was an underpinning theme across the chapter. The role of distribution centres and in particular the concept of FGP were described. This led us to a discussion around the efficiency and effectiveness of transport services, and developments in international transport networks were also reviewed.

We noted at the outset to this chapter that transport is typically regarded as a non-value-adding activity in the supply chain. In conjunction with the understanding that will be gained from studying the next two chapters on containerisation and logistics service providers, and the contributions we will see in Chapter 16 that transport can make around issues concerning sustainability, it is evident that transport plays a vital role in ensuring that supply chains operate both efficiently and effectively.

QUESTIONS

- In your view does transport add value in the supply chain?
- What is volumetric charging?
- What are the key characteristics of the five principal modes of transport?
- Why do we say that transport is a derived demand?
- What is FGP?

TRANSPORT PERFORMANCE BY COUNTRY

Either for your own – or any other – country look at the data on the International Transport Forum website that allows countries to be compared across multiple transport-related parameters.[17] What is the modal split and freight transport intensity for your country? What are the reasons for this modal split and freight transport intensity? How does it compare with other countries and regions?

In view of increased awareness of environmental and related issues, is this modal split and freight transport intensity sustainable going forward? If it is not, what future changes in transport industry structure in your country do you envisage?

NOTES

1. See page 70 on *The Future of Mobility – A Time of Unprecedented Change in the Transport System*, UK Government Office for Science Foresight Programme, January 2019.
2. For the different types and sizes of igloos, see https://www.searates.com/reference/uld.
3. See https://read.oecd-ilibrary.org/transport/itf-transport-outlook-2019_transp_outlook-en-2019-en#page1.
4. See https://www.iata.org/en/programs/cargo/sustainability/benefits.
5. See https://read.oecd-ilibrary.org/transport/itf-transport-outlook-2019_transp_outlook-en-2019-en#page1.
6. UNCTAD, *Review of Maritime Transport 2019*.
7. See https://www.itf-oecd.org/compare-your-country-new-online-tool-visualise-key-transport-indicators.
8. Potter, A.T., Lalwani, C.S., Disney, S.M. & Velho, H. (2003) Modelling the impact of factory gate pricing on transport and logistics, *Proceedings of the 7th International Symposium on Logistics*, Seville, 6–8 July, pp. 625–630.
9. Lalwani, C.S., Mason, R.J., Potter, A.T. & Yang, B. (eds) (2004) *Transport in Supply Chains*, Logistics and Operations Management Section, Cardiff Business School, UK.
10. Potter *et al.* (2003), op. cit.
11. Rushton, A., Oxley, J. & Croucher, P. (2000) *Handbook of Logistics and Distribution Management*, 2nd edition, Kogan Page, London.
12. Potter, A., Mason, R. & Lalwani, C. (2007) Analysis of factory gate pricing in the UK grocery supply chain, *International Journal of Retail and Distribution Management*, 35(10), 821–834.
13. Mason, R.J., Lalwani, C.S. & Boughton, R. (2006) Alternative models for collaboration in transport optimisation management, *Supply Chain Management: An International Journal*, 12(3), 187–199.
14. See https://www.eia.gov/energyexplained/use-of-energy/transportation.php. Transport's share of total country CO_2 emissions

varies widely by country from over 60% down to – in the case of China – less than 10% (see again the ITF country comparison tool: see https://www.itf-oecd.org/compare-your-country-new-online-tool-visualise-key-transport-indicators).

15. Ibid.

16. See https://www.businessinsider.com/amazon-creating-fleet-of-electric-delivery-vehicles-rivian-2020-2?r=US&IR=T.

17. See https://www.itf-oecd.org/compare-your-country-new-online-tool-visualise-key-transport-indicators.

7
Containerisation

LEARNING OBJECTIVES

- Demonstrate the critical and dominant role played by containerisation in LSCM and global trade.
- Explain container-related terminology and practices.
- Discuss the role of ports in LSCM.
- Show why standardisation is so important in containerisation and the implications of this for LSCM.
- Review indices used to measure how well connected individual countries and ports are to liner shipping networks.

INTRODUCTION

We saw in the previous chapter that some 70% of the world's total freight tonne-kilometres are carried by sea. Maritime transport has for centuries played a key role in world development. You will recall from Table 6.1 the different categories of maritime freight: unitised, bulk (dry and liquid) and other general cargo. One of these categories – unitised freight – has played a pivotal role in the evolution of SCM (recall our discussion with regard to the key drivers behind the evolution of SCM in Chapter 1) and is now a key component of today's LSCM systems and is the focus of this chapter. Without unitised freight, global trade today would be both much less and quite different. You will recall from Table 6.1 that unitised freight comprises lift-on/lift-off (Lo-Lo) and roll-on/roll-off (Ro-Ro) freight. LoLo comprises containers (often simply referred to as boxes) lifted on to the ship by crane; RoRo comprises wheeled trailer units (accompanied – where the truck tractor also travels on the ship attached to the trailer, and unaccompanied where the trailer only is carried on the ship). There are various types of RoRo trailers such as flatbed/platform trailers where the cargo is placed on top of a flat trailer (particularly useful for awkward/large freight) and box trailers which are similar to LoLo containers except that they sit on top of wheeled axles. The advantage of RoRo is its flexibility – the tractor unit attaches to the trailer and it can drive away. While LoLo units have to be lifted by crane, their advantage is that the boxes can be stacked one on top of the other (whereas RoRo units cannot be stacked due to their underpinning axles). In general, it is cheaper to move freight by LoLo than RoRo. At the outset, it is useful to clarify some terminology:

- *Liner shipping* is the term commonly used to refer to the LoLo container shipping sector.
- *Containerisation* generally refers to LoLo only. While RoRo plays an important role in LSCM – for example carrying freight such as perishable food produce and flowers across short sea routes – LoLo carries a far greater share of global unitised traffic.
- The term *intermodal transport* is often used in transportation and refers to both types (RoRo, LoLo) of loading units. The premise behind intermodal transport is that the loading unit may move upon a number of different transport modes (ships, barges, trains, trucks), but the freight remains within the same unit at all times. The great advantage of intermodal transport is, of course, that it reduces the amount of time the freight within the container needs to be handled (we refer to these as 'freight touchpoints'), and this obviously then reduces the chance of damage or loss of freight. In intermodal transport, the loading unit is referred to as an **ITU – intermodal transport unit**. **Transhipment** is where the loading unit moves from one transport service to another (e.g. a box is lifted from a ship to a train (note that transhipment doesn't necessarily imply a modal shift – for example moving a box from one ship to another is also transhipment)); in transhipment, the loading unit remains sealed and the freight within is not touched.
- The term **FCL** is used in transport to refer to **full container loads**, while the term **LCL** is used to refer to **less than full container loads**. When carriers have a consignment that will not fill an entire loading unit, they will sometimes try to build a consolidated shipment (i.e. a mix of different consignments) to make up an FCL.

Before exploring the significant role played by containerisation in LSCM, trade and the global economy, it is important that we first understand how containerisation works in practice (both operationally and in terms of industry structure). This is the focus of the next section, which in turn is followed by a section on containerisation, trade and the global economy. We saw in Chapter 5 that many useful indices have been developed to assess countries' connectivity and related logistics performance – one of these is the liner shipping connectivity index (LSCI), which we will discuss in this chapter. Chapter 7 thus comprises three core sections:

- Standardisation
- Shipping containers and global trade: the humble hero
- The liner shipping connectivity index (LSCI)

STANDARDISATION

We saw in Chapter 1 that up to the mid-1950s most maritime freight was carried on bulk vessels. This began to change, however, when some ship owners started to carry freight containers. In 1956, an iconoclastic entrepreneur Malcom McLean put 58 aluminium truck bodies aboard an ageing tanker ship (called the *Ideal-X*) which set sail from Newark, NJ to Houston, TX in the US. This marked the start of containerised transport as we know it today.[1] The introduction and growth of containerisation led to huge changes in ports which previously were dominated by large workforces responsible for manual handling of bulk cargo. Containerisation also reduced the costs of transporting freight by maritime transport and significantly improved its efficiency. Today, containers are carried on ships, barges, trucks and trains. Their success lies in standardisation – instead of trying to handle a disparate range of loading unit sizes, the transport service providers can design their infrastructure and systems to accommodate the limited range of standard container sizes and types that are available. The key advantages of using standardised containers are ease/uniformity of handling and commonality of the equipment used to lift these containers. In some ports with the appropriate cranes and skilled labour, a single crane can lift a container every two minutes; some terminals are using automated cranes which can meet or even exceed this speed.

Some transport companies own their containers, others lease them and most often companies will operate a mix of owned and leased containers. Usually – but not exclusively – consignors do not have their own containers but instead use those provided to them by the LSPs. Because of the directional imbalances in trade that we saw in Chapter 2, much effort is expended in repositioning empty containers to where they are required. Table 7.1 shows the dimensions of the more common container types, and some of these are also illustrated in

Figure 7.1. Other container sizes also exist, for example 53-ft containers and wider 45-ft containers (the latter are able to accommodate a larger number of Euro-pallets (see Chapter 11 for pallet dimensions)) – these other container sizes are generally only used on particular trades. Container volumes are calculated in twenty-foot-equivalent measures (TEU); thus a 40-ft container is equivalent to 2 TEUs.

TABLE 7.1

Container dimensions

		Dimensions (ft)			
Size (ft)	**Type**	**Length**	**Width**	**Height**	**Maximum payload (kg)**
20	Standard	20	8	8.6	28,200
40	Standard	40	8	8.6	28,800
40	High	40	8	9.6	28,620
45	High	45	8	9.6	27,600

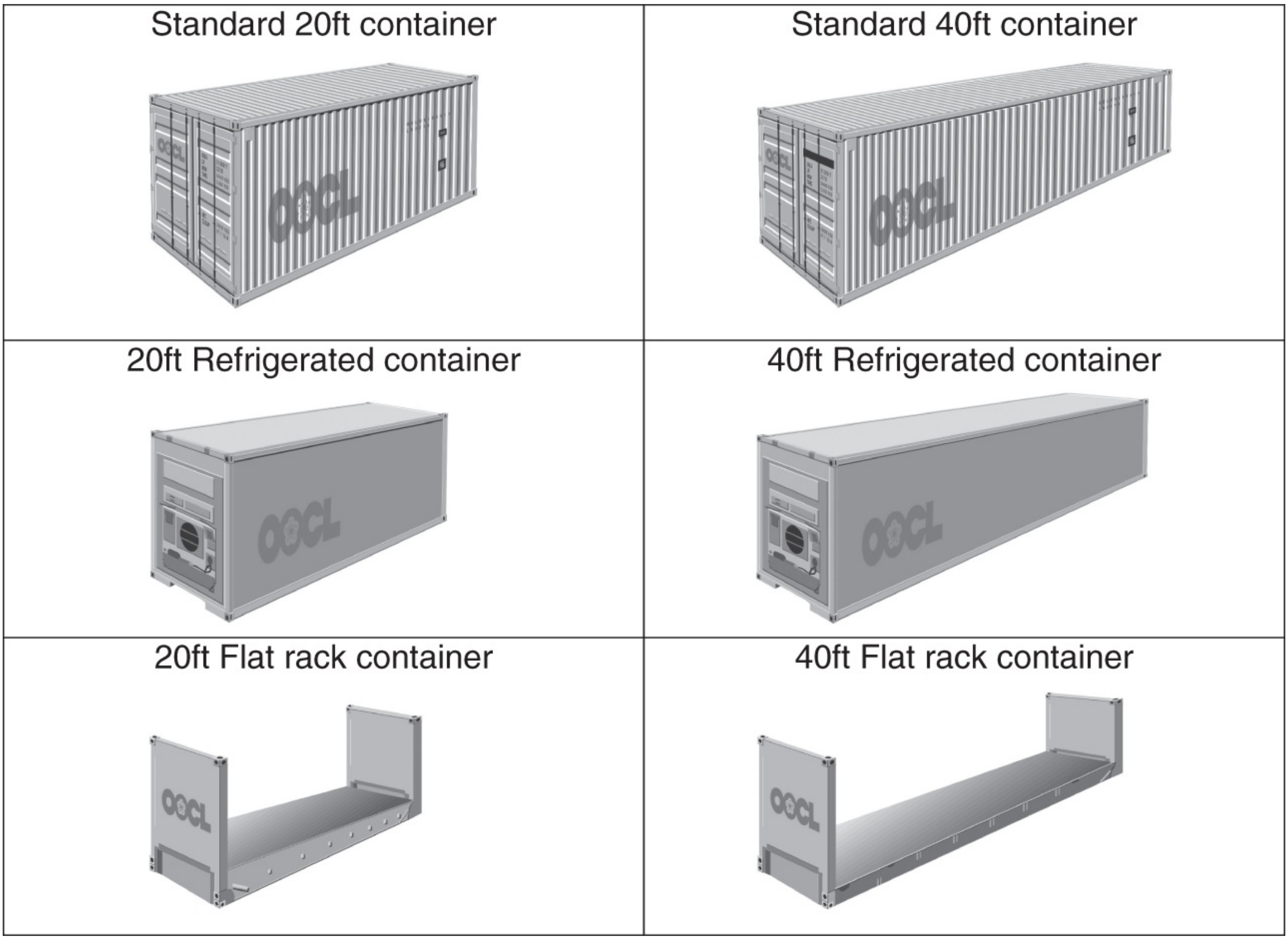

Figure 7.1 Container types

(Source: OOCL)

Containers vary not only in size and payload but also in their use. In addition to the standard dry containers, there are other types of containers (some of these terms are also used to describe RoRo units) such as refrigerated ('reefer'), open top, insulated, ventilated, side opening (often referred to as 'curtain-siders'), tank containers (where a tank is enclosed within a container shell), and 'swap bodies' which often have legs and flatbed/platform (these are without sides, ends and roof – so just comprise a base platform – and can be used for odd-sized freight which does not fit on or in any other type of container). Because of their structure/design, it is not possible to stack some of these other container types. While the standard 20-ft and 40-ft containers are used to transport all manner of commodities at ambient temperatures, refrigerated containers have revolutionised the transportation of temperature-sensitive goods such as fresh fruit and vegetables. When loaded onto a container vessel or parked in a port's container marshalling yard, a reefer container must be connected to a power supply to ensure that the correct internal temperature is maintained so that the freight does not spoil. For refrigerated containers, an important constraint is the availability of 'reefer points' on ships so that the container's refrigeration unit can connect to an electricity supply.

Other specialised containers include those used in the fashion and wine industries. The fashion industry has developed containers that are specially fitted out with clothes rails to allow for easy loading and unloading of hanging garments. The wine industry is increasingly transporting wine in bulk in 20-ft containers, also known as flexi tank containers, which contain a single-use inflatable bladder which can hold up to 24,000 litres of wine.

In the next chapter, we will look at the role played by the broad logistic service providers (LSPs) sector in LSCM. In the liner trades, we generally distinguish two categories of service providers:

- *Terminal operators (sometimes too referred to as global port operators):* these companies handle the LoLo containers at ports using large cranes to load them onto and off of ships, trains, barges and trucks. The companies with the largest market share in this sector include Cosco, PSA, Dubai Ports World (DPW), Hutchison and APM Terminals. Efficiency (container handling time) is a key metric for terminal operators, and there is a growing market for software solutions that track container movements, measure efficiency and costs, and integrate systems.
- *Container shipping lines:* in this sector consolidation is quite evident with a small number of alliances between the large lines dominating the market. The largest lines include Maersk, Cosco, MSC, CMA and Hapag-Lloyd.

Some companies – such as Cosco and Maersk – are active in both the liner and terminal markets. Increasingly too many endeavour to provide a wider range of logistics services beyond the handling/carriage of boxes. Hub-and-spoke network designs (as described in Chapter 5) are quite prevalent in the world's container shipping networks. Giant container vessels (more on these later in the chapter) ply between the major hub ports with smaller feeder vessels radiating out from those hubs to other ports. Directional imbalances (as described in Chapter 2) are a feature of many of the products typically moved by containers and thus the container shipping lines endeavour to optimize their network designs and port calls so as to minimise the impact of lower traffic volumes on certain routes. The container shipping lines often design their networks whereby a vessel will call to multiple ports on a continuing rotation – these are often referred to as 'strings'. A string could thus comprise port calls as follows:

Intercontinental string: Hub Port 1 – Hub Port 2 – Hub Port 3 – Hub Port 4 – Hub Port 5 – Hub Port 2 – Hub Port 1 – Hub Port 2 – Hub Port 3 …

Regional string: Feeder Port 1 – Feeder Port 2 – Feeder Port 3 – Hub Port 1 – Feeder Port 1 – Feeder Port 2 – Feeder Port 3 – Hub Port 1 …

Note how in both examples some ports had one and not two port calls. The container shipping lines have to carefully plan their allocations of containers to the various port pairs (e.g. how many containers to pick up at Hub Port 3 that need to be dropped off at Hub Port 2). Websites such as *marinetraffic.com* provide interesting real-time insights into worldwide ship movement patterns.

PORTS

Ports play an important role as key nodes in logistics and supply chain systems. There are a number of different models of port ownership and governance around the world – many operate as 'landlord ports' and award concessions to terminal operators to handle containers, some will even host competing terminals on their port estate. A question which arises for many ports is whether they should serve merely as transit nodes for freight or whether they can also provide value-adding logistics services (this is known as **port-centric logistics**). An important factor in this regard is port location – some ports are located for historical and geographical reasons close to urban areas where land is valuable, and the noise and congestion associated with port operations may be increasingly unwelcome. Some ports operate inland or so-called dry ports where freight is consolidated before being moved to the port by rail (or in some cases canal barge) or, in the case of imported freight, it first moves in bulk from the port to the inland port where it is then broken into individual shipments for onward distribution. In addition, many consignors and consignees operate inland distribution centres in strategic locations chosen to minimize their overall distribution costs across their networks; they will thus seek to move their freight as quickly as possible through the port to and from these distribution centres. All of these themes are explored in greater detail in the case study (Port-centric vs inland location decisions in Gothenburg, Sweden) by Jason Monios and Rickard Bergqvist at the end of Part Two of the book.

The most common shipping containers in use today are welded steel or aluminium boxes constructed of corrugated metal, which gives them their strength. They are generally enclosed except for a set of double doors at one end that are held shut by two sets of vertical steel tubes which twist to lock by levers that are themselves lockable by applying a container seal (the seal plays an important role especially with regard to customs and security to show whether or not the box has been opened). The **tare weight** of a container refers to the weight of the empty container, for example a standard 40-ft steel container weighs some 3700 kg. In shipping calculations, it is important not to forget to include tare weights in addition to the weight of the shipment itself. To avoid problems such as freight overflow or wastage of space, it is essential for shippers to have what is known as a 'stuffing plan' before freight is loaded into the container. Besides the consignment's measurements, the stuffing plan should also take the consignment weight into consideration. It is important to note that in many countries the permissible weight limits for road and rail transportation are lower than the maximum payload a container can take. Especially with bulky freight, containers can 'cube out' (think, for example, of a roll of carpet). This is where no further freight can be fitted into the container even though it has not yet reached its maximum permissible weight limit (hence volumetric charging – as explained in Chapter 6 – will need to apply). In practice, many containers are not at their weight limit: an analysis of average container weights at five of Europe's leading container ports, for example, showed that the average weight of a loaded TEU ranged from 9520 kg to 11,410 kg.[2]

After traversing the world's transport networks for many years, containers often find interesting uses once they are decommissioned, some even becoming offices and hotels with their standardized modular structure allowing them to be easily combined into larger structures.

Transloading

We discussed transhipment above – where the loading unit moves from one transport service to another. On some occasions, however, freight may need to be transferred from one type of loading unit to another. This is referred to as **transloading**. Table 7.2 illustrates some of the reasons why freight may need to be transloaded.

SHIPPING CONTAINERS AND GLOBAL TRADE: THE HUMBLE HERO

In Chapter 2 we looked at globalisation and the growth of world trade. In fact, it has been contended that containerisation has been *more* of a driver of globalisation than all trade agreements in the past 50 years taken together. An insightful article in the *Economist* quoted research which showed the beneficial impacts of a country connecting into global container networks.[4] These connections allow developing countries to simply join existing supply chains rather than build an entire industry from the ground up. The key contributions of containerisation have been the quicker, safer and more cost-effective movement of freight along the supply chain, rather than a reduction specifically in ocean shipping charges (which in any event has been only partially apparent). We will return to the important topic of having an understanding of the full end-to-end costs in the supply chain in Chapter 12. Another study explored the importance of containerisation for China's trade and economic growth, and concluded that it has contributed substantially to China's trade-induced economic growth.[5]

TABLE 7.2

Reasons for transloading[3]

Supply chain management	Combine smaller shipments from various consignors into one single load (this is referred to as **consolidated shipment** – another term sometimes used for this activity is **groupage**). Generally, we can distinguish two reasons for such consolidation: (i) to spread the carriage costs across a range of customers and (ii) to provide consignees with a range of shipments from different consignors (this often happens, for example, with retailers who prefer to receive a single load of different but related products, e.g. garden products).
	Perform value-adding activities such as packaging or palletising of products.
Compliance requirements	Transfer the contents of heavy containers into loads meeting national or regional road weight limits.
	Similarly, some containers may be too high for bridge clearance on certain road and rail networks.
Mode specific requirements	Transfer freight to a different loading device necessary for another mode of transportation.
Equipment availability	The loading unit may be needed for another shipment. In some cases, the equipment owner may levy certain charges if the loading unit is not returned by a certain time (these are referred to as **demurrage charges**).

The role of scale

One of the key benefits of containerisation is standardisation as described above and which in turn leads to improved *productivity*; the other key benefit is *scale*. By shipping containers on larger vessels, the unit cost per container moved reduces. Ever since the maiden voyage of the *Ideal-X* in 1956, container ships have grown larger and larger (Figure 7.2). At the time of writing, the largest container ships in operation can handle around 24,000 TEUs. It is hard to imagine the sheer size and scale of these vessels – you can find some fun videos online produced by Maersk and other shipping lines who operate these vessels showing just how much they can carry; in fact according to Maersk:

- If all the containers in the world were lined up, it would create a container wall with a length of 108,000 km: a third of the way to the moon!
- The volume of freight that can be held in one standard 40-ft container is quite significant: 200 dishwashers, 350 bicycles or 5000 pairs of jeans.
- The shipping cost per unit is thus quite low: Maersk estimates, for freight coming from Asia to Europe, it costs £9 per dishwasher, £5 per bicycle and just £0.35 per pair of jeans.

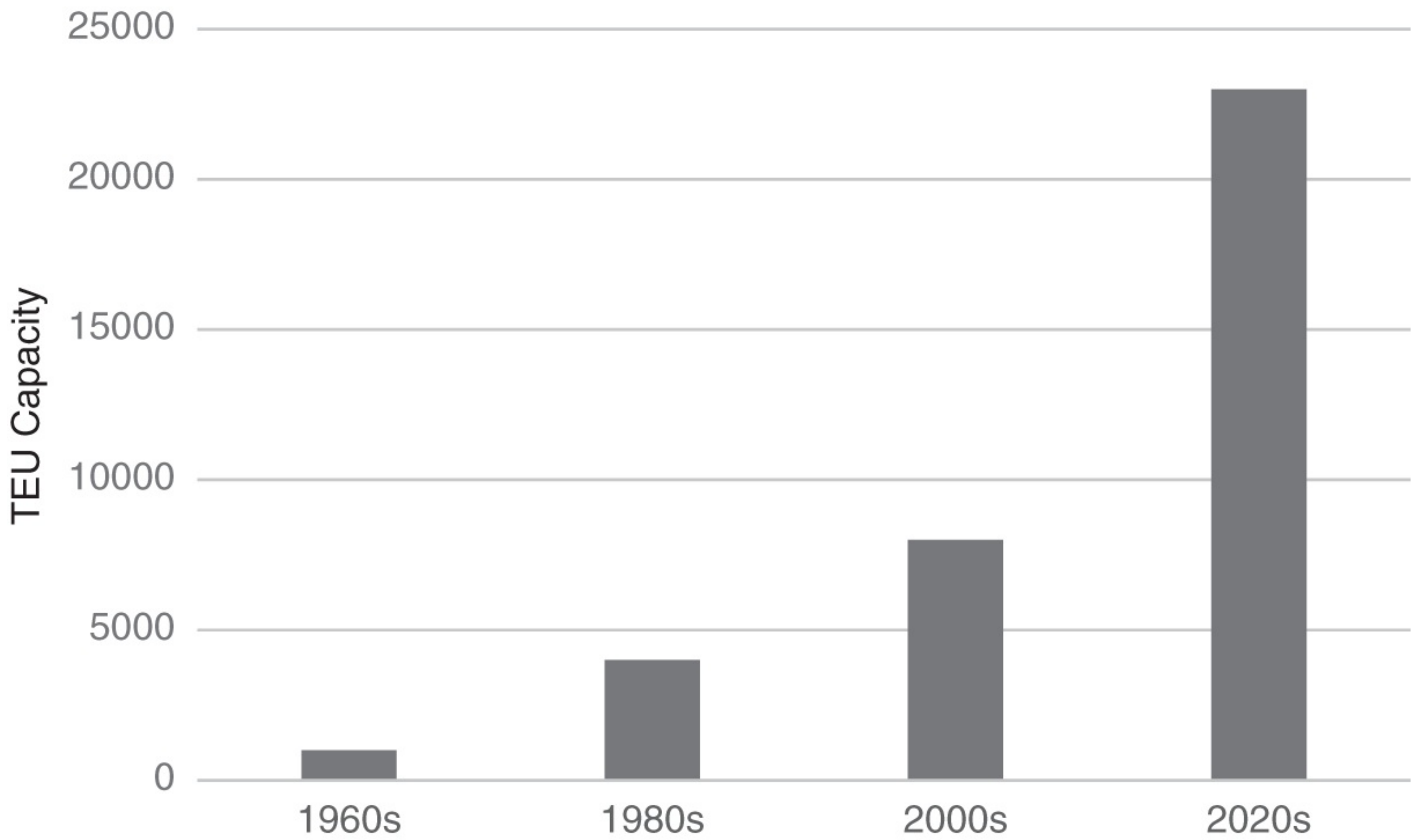

Figure 7.2 Growth in container ship size

Ever larger vessels are planned and there is much debate around what is the maximum feasible vessel size. Ships carrying up to 50,000 TEUs by 2050 are not unrealistic; however, we need to keep two constraints in mind[6]:

- *Technical/engineering challenges*: what ports will be able to accommodate such vessels and what technologies would we deploy to lift boxes on and off such wide vessels?
- *Commercial/economic challenges*: would such vessels be too large even for the densest hub-and-spoke networks? We have seen in the air transport sector, for example, a move away from the largest commercial aircraft such as the Airbus A380 to more medium-sized aircraft and a growth in popularity too of more point-to-point routes.

According to UNCTAD's *2019 Review of Maritime Transport,* an estimated 793 million TEUs were handled in container ports worldwide: Asia had the largest share (64%), followed by Europe (16%), North America (8%), Latin America and the Caribbean (7%), Africa (4%) and Oceania (2%). Table 7.3 details TEU shares by sector; bulkier and lower value products tend to be transported by the other maritime modes (dry bulk, liquid bulk, other general cargo). Because of increased efficiencies and falling costs, some products (e.g. fruit imports) that were traditionally transported by bulk shipping are now increasingly also being containerised.

TABLE 7.3

TEU shares by sector[7]

36%	Chemicals; basic metals; mineral-based products; wood products; paper and pulp; refined petroleum, coke, nuclear
19%	Rubber and plastic products; fabricated-metal products; food, beverages and tobacco; printing and publishing
16%	Motor vehicles, trailers, parts; electrical machinery; machinery, equipment and appliances
14%	Agriculture
13%	Textiles, apparel and leather; furniture, jewellery, toys, others
2%	Computers and office machinery; semiconductors and electronics; medical, precision and optical

THE LINER SHIPPING CONNECTIVITY INDEX (LSCI)

We noted above that there is a lot of interest in measuring container terminal efficiency. This is one among a number of other performance indicators that are used across the marine transport sector.[8] You will recall in Chapter 5 (Table 5.1) that we reviewed a number of connectivity and related logistics performance indices. One indicator of particular interest is that of how well connected individual countries and ports are to liner shipping networks as this is an important determinant of accessibility to global trade, trade costs and competitiveness. To provide an indicator for this connectivity, UNCTAD in 2004 developed the liner shipping connectivity index which aims to capture a country's level of integration into the global liner shipping networks by measuring liner shipping connectivity. In 2019, UNCTAD expanded the coverage of the index and introduced a new port liner shipping connectivity index for more than 900 ports. All of the data behind the index is freely available, and it may be of interest to see how your country and ports of interest fare.[9] Table 7.4 ranks the top 10 (of some 900) container ports in the port liner shipping connectivity index for 2019.

TABLE 7.4

Top 10 ports in the 2019 port liner shipping connectivity index

(Source: UNCTAD. Licensed under CC BY 3.0.)[10]

1	Shanghai
2	Singapore
3	Pusan
4	Ningbo
5	Hong Kong
6	Antwerp
7	Rotterdam
8	Qingdao
9	Port Klang
10	Kaohsiung

The liner shipping connectivity index can be considered a proxy for accessibility to global trade. The higher the level, the easier it is for a country to access the global maritime freight transport system, including in terms of capacity, transport options and frequency, and thus participate in international trade. Therefore, the index can be considered both as a measure of connectivity to maritime shipping and as a measure of competitiveness and trade facilitation. Analysis of the index shows a growing connectivity divide – an increasing difference between the most and least connected countries. This has significant implications for the economic wellbeing of the least connected countries and is something which policymakers seek to redress – in Chapter 9 we will return to this topic when we discuss trade facilitation. Figure 7.3 illustrates trends in individual components of the LSCI since 2006.

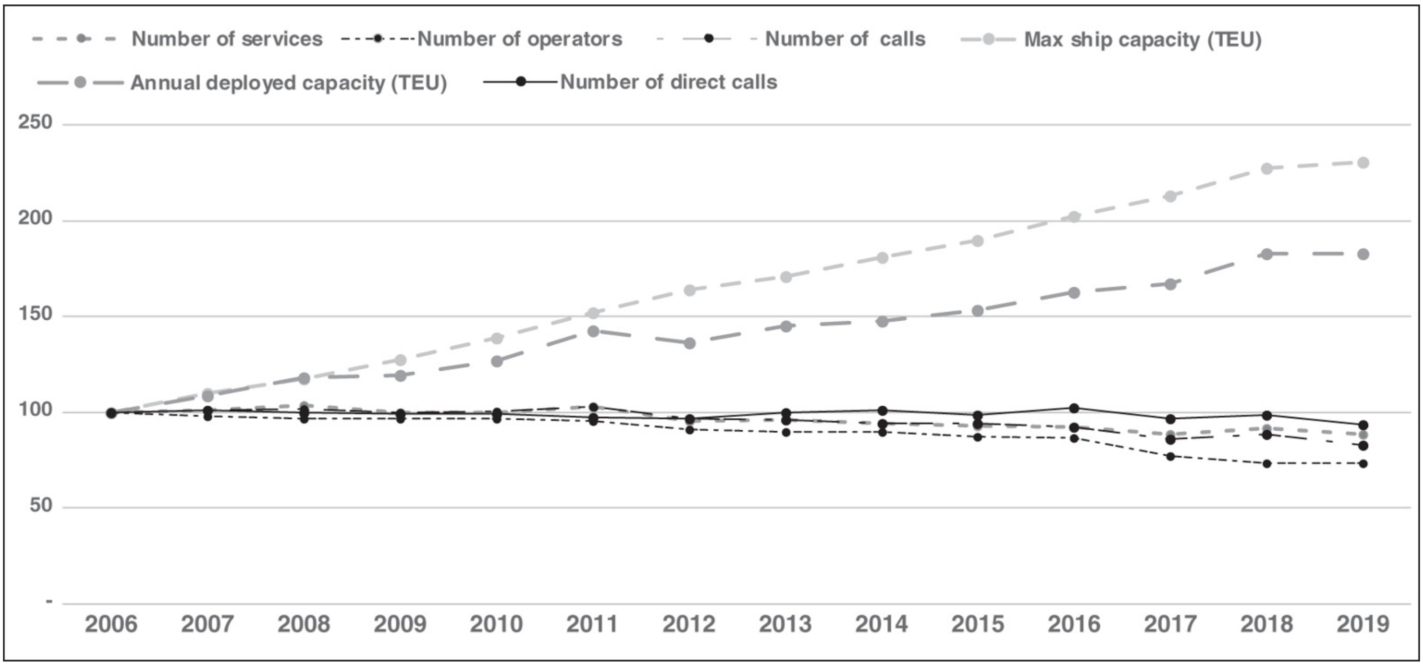

Figure 7.3 Trends in LSCI components (Source: Data from Transport Section/Trade Logistics Branch, Division on Technology and Logistics, UNCTAD)

LEARNING REVIEW

In this chapter, we showed the critical and dominant role that containerisation plays in LSCM and global trade. Key actors and practices were identified, and we endeavoured to explain a range of container-related terminology. We saw in particular how standardisation is so important in containerisation and the implications of this in turn for LSCM. We also reviewed the role played by ports in logistics systems. The final section in our chapter reviewed the range of interesting indices used to measure how well connected individual countries and ports are to liner shipping networks. In this chapter, we have introduced some key categories of logistics service providers (LSPs) – namely terminal operators and liner shipping companies. In the next chapter, we introduce other types of LSPs and review and differentiate the full range of providers and the services that they provide.

QUESTIONS

- Distinguish the roles played by liner shipping companies and terminal operators in LSCM.
- What is the difference between transhipment and transloading?
- How does RoRo differ from LoLo?
- What do you think is the optimum container ship size?
- What logistics services do you think ports should provide?

NOTES

1. As noted already in Chapter 1, for a fascinating insight into the growth of containerisation see: Levinson, P. (2006) *The Box*, Princeton University Press, Princeton, NJ. Another very useful reference source is the beautifully presented and meticulously researched history of Maersk Line in containerisation by Chis John Jephson and Henning Morgen: see *Creating Global Opportunities: Maersk Line in Containerisation 1973–2013*, Jephson and Morgen, Cambridge University Press, 2014.

2. See Leonardi, J. & Browne, M. (2010) A method for assessing the carbon footprint of maritime freight transport: European case study and results, *International Journal of Logistics: Research and Applications*, 13(5), 357.

3. Drawn in part from Waters, D. & Rinsler, S. (2014) *Global Logistics: New Directions in Supply Chain Management*, pp. 457–459. Waters and Rinsler provide a good, further discussion on transloading.

4. 'The Humble Hero', *The Economist*, 18 May 2013.

5. A leading trade nation: The role of container shipping and logistics in enhancing trade and economic growth in China, Technical Report produced by Maersk, February 2014.

6. Container shipping: The next 50 years, McKinsey and Company, October 2017.

7. Ibid.

8. See Chapter 3, Performance indicators in UNCTAD's *2019 Review of Maritime Transport*.

9. Go to UNCTAD's data centre at https://unctadstat.unctad.org/EN and search for 'liner shipping' – three data sets of interest will appear: liner shipping connectivity index, liner shipping bilateral connectivity index and port liner shipping connectivity index. The data sets are very comprehensive. You can search and rank by country/port and year. Clicking the information button ('i') gives a nice summary of what each index measures.

10. Port liner shipping connectivity index at https://unctadstat.unctad.org/EN.

8
Logistics Service Providers

LEARNING OBJECTIVES

- Describe, and differentiate, the various types of companies that provide logistics services.
- Discuss the role of fourth-party logistics.
- Examine the range of issues in, and the process employed for, selecting logistics service providers.

INTRODUCTION

In recent years providers of logistics services have grown both in scale and in terms of the services that they provide. Increasingly many companies no longer perform many of their own logistics activities. This chapter looks at the range of such logistics providers, and the various services that they provide, and in particular how organisations go about selecting such companies. Traditionally the only services provided were transport, warehousing and customs clearance. This, however, has expanded to encompass a raft of other activities, which we will explore later in the chapter.

Chapter 8 comprises four core sections:

- Classifying logistics companies
- Fourth-party logistics
- Carrier responsibilities
- Selecting logistics service providers and services

CLASSIFYING LOGISTICS COMPANIES

Many logistics companies started life by transporting freight using one mode of transport only. Generally speaking this worked quite well for people who wanted to have their freight moved. In fact one of the world's largest and most successful logistics companies (UPS) is reputed to have started life delivering parcels by bicycle in North America (indeed as we mentioned in Chapter 6this mode of transport is now popular again for distributing very light parcels in congested urban areas). As we saw in Chapter 1, in recent decades the fields of logistics and SCM grew both in popularity and complexity, spurred on by developments such as the proliferation of containerisation and advances in tracking technologies. For freight transport companies, there was an opportunity to do more than just simply move freight using a single mode of transport from A to B. We have also observed an increasing tendency, for a variety of reasons, of companies to outsource various activities, many of which they may regard as non-core, and focus on their core competencies. In recent years many companies have sought in particular to move away from **own-account transportation** to third-party transportation, and this has provided many opportunities for transport and logistics companies.

Own-account transportation is when a company provides its own transport services.

A dynamic and profitable new sector of activity has emerged in recent decades, and we can use the generic label of **logistics service providers (LSPs)** to describe companies that operate in this sector. In fact, myriad different types of companies operate in this sector, which we can broadly categorise as follows (see also Table 8.1):

- *Freight carriers* do just that: carry freight. Such carriers include hauliers or trucking companies; operators in the other modes also carry freight – train companies, airlines (with the exception in particular of many of the 'low-cost airlines' who do not generally carry freight) and shipping companies.
- *Freight forwarders* are just like high-street travel agents, except that they arrange transportation for freight, not people. Different types of freight forwarders have evolved in recent years.

A significant area of activity for many freight forwarders is in arranging customs clearance for freight that moves internationally (this is sometimes referred to as brokerage and encompasses not just dealing with customs agencies but also managing all documentation that should accompany freight). With the development of regional trade agreements (which we discussed in Chapter 2), increasingly freight can move freely within regions, thus obviating the need for customs clearance for that freight (customs clearance will of course still be required for freight moving *into* the region).

TABLE 8.1

Classifying logistics service providers

Type	Services typically provided
Freight carriers	Basic carriage of freight – by hauliers, trucking companies, train companies, airlines, shipping companies
Freight forwarders	Make transportation and other arrangements
Couriers	Urgent delivery of products
Integrators	Offer a seamless (i.e. integrated) end-to-end service from consignor to consignee
Agencies	Companies combine buying power to gain reduced freight transport rates, e.g. in the shipping sector companies come together and charter a vessel – this is known as an **NVOCC (non-vessel owning common carrier)**

Freight forwarders have thus broadened out their product portfolio to encompass many other activities. For example, some act as ships' agents for vessels that arrive into a port. Many other freight forwarders have evolved to a stage where they now operate their own vehicles and warehouses. Increasingly, too, many larger freight forwarders offer freight consolidation services (recall we introduced this concept in Chapter 7 and noted that it is also known as 'groupage'), where they combine smaller shipments from various consignors into one single load. They will then buy space from the transport provider, who will carry this combined load. Sometimes freight forwarders are called *freight agents* or *brokers*. Again there are minor distinctions between all of these terms, but there is no need to go into these here.

Couriers grew significantly, especially in the 1980s and 1990s, in response to a growing demand for immediate delivery of products. Many operate within and between large urban areas and service organisations who wish to move valuable documents quickly. Examples include financial and legal companies who wish to send hard copy documentation, deliveries of urgent drugs and other healthcare products, and parts for machines that have broken down. In many cases the relatively high cost of using a courier is offset by the lost production costs etc. The term 'onboard courier' is used to describe courier employees who travel with ultra-urgent shipments either as checked-in or hand luggage on a flight.

A final group of companies are those that have become known as *integrators*. Examples of integrators include FedEx, United Parcels Service (UPS) and DHL. These companies' unique sales proposition is that they offer a seamless (i.e. integrated) end-to-end service from consignor to consignee (i.e. responsibility for the consignment doesn't pass from, for example, a haulier to a freight forwarder to an airline and so forth). They have evolved into very substantial companies who provide a range of logistics services (see the case examples below). One of the difficulties which often arises in supply chains is that when freight gets lost or damaged it is usually at what are known as the 'touchpoints' (these are where freight is handled or transferred from one carrier to another). Integrators argue that the service they provide often circumvents these problems as they retain sole responsibility for freight from origin to destination, and they will usually 'track and trace' freight as it moves along their transport chains and thus have enhanced visibility of the product and any problems which may arise. A final organisation type, which doesn't fit easily into any of the above categories although is close to the NVOCC concept in shipping, is where individual companies come together to form an agency to arrange their freight movements and use their combined buying power to get capacity at reduced rates from carriers.

There is a considerable overlap between all of these categories. For example, a company that operates ships can also have its own freight forwarding operations. The classification above is given to illustrate the various activities and types of companies that operate across the sector. As freight companies provide a broader and more integrated range of services, many have come to be known as **third-party logistics companies (3PLs)**.

The evolution of 3PLs is evident in the 'FedEx and the Hub-and-Spoke System' case below. DHL (which can be described as an integrator and as a 3PL; in fact it also provides 4PL® services, an area discussed in the next section) started life as an air courier company, while Kuehne + Nagel's origins, for example, were more so as a traditional freight forwarder, but it is now a full-service 3PL.

> Distinguishing LSPs and 3PLs: as has already been noted, there is a considerable overlap between the pertinent terminology used to describe the various companies that provide logistics services. We regard all such companies as *logistics service providers (LSPs)*. Those LSPs that provide multiple logistics services, often in an integrated fashion, we refer to as *third-party logistics companies (3PLs)*.

Some of the many different services provided by 3PLs are outlined below. As the list illustrates, transportation/delivery is just one of the many services that 3PLs provide. The 3PL sector has now become quite sophisticated. In some instances consignors forge quite close links with their 3PLs who often will have people working within the consignors' logistics department.

- Transportation – often using multiple modes
- Warehousing – including providing capacity for seasonal and other fluctuations
- Pick and pack – for example picking multiple different SKUs and packing these into single units
- Light manufacturing – acting as contract manufacturers for OEMs (original equipment manufacturers, companies which own the brand – such as Nike and HP for example – but who may do little actual manufacturing themselves, we will discuss OEMs in more detail in Chapter 12.), this is quite prevalent in, for example, the electronics sector
- Vendor managed inventory
- Customs clearance – and associated regulatory requirements, such as hazardous goods clearances and food safety certificates
- Trade financing – for example mitigating currency exposure
- Managing reverse logistics – in some instances 3PLs manage the entire reverse logistics process for a client and manage all repairs and returns
- Parts distribution – with their extensive networks of warehouses, it is sometimes more economical and effective for 3PLs to take over the management of critical spare parts inventories. This is quite prevalent in sectors such as electronics, automotive spares and medical technologies
- Inventory management – management of inventory has considerable financial implications and we will explore these issues in detail in Chapter 10

Armstrong & Associates Inc. analyses and provides information on the 3PL market. Table 8.2 illustrates its rankings of the top global 3PLs (by revenue) in 2018.

TABLE 8.2

Top 20 global 3PLs (by revenue) in 2019

(Source: Data from Armstrong & Associates, 2019) [1]

1	DHL Supply Chain & Global Forwarding	27,302
2	Kuehne + Nagel	25,875
3	Nippon Express	19,953
4	DB Schenker	19,349
5	C.H. Robinson	14,630
6	DSV	14,355
7	XPO Logistics	12,144
8	Sinotrans	11,200
9	UPS Supply Chain Solutions	9,302
10	J.B. Hunt (JBI, DCS & ICS)	8,788
11	Expeditors	8,175
12	CJ Logistics	7,173
13	CEVA Logistics	7,124
14	Hitachi Transport System	6,472
15	DACHSER	6,408
16	GEODIS	6,379
17	Toll Group	6,260
18	Damco/Maersk Logistics	5,965
19	GEFCO	5,365
20	Kerry Logistics	5,274

FEDEX AND THE HUB-AND-SPOKE SYSTEM

FedEx (www.fedex.com) started life in the early 1970s and was founded by Frederick Smith. As a student at Yale, Smith had pondered the economics of the route systems then dominant in US airfreight markets. His deliberations were to lead to the pioneering introduction by FedEx of hub-and-spoke networks into air freight markets.

Rather than offer point-to-point services between all city pairs, hub-and-spoke networks operate on the simple, but highly effective, principle whereby freight is shipped from all origin points to a central hub, re-sorted and then shipped out to destination. Customers were initially sceptical of this concept in that if they were sending a parcel from, for example, Boston to Chicago, they got confused as to why its routing would take it to Memphis (the location of FedEx's central hub, and a place some distance away from both Boston and Chicago). The logic and economics of Smith's hub-and-spoke model, however, quickly won out and today all of the integrators have large hubs and associated networks across most continents.

FedEx itself has also grown considerably. Today it has one of the world's largest airfreight fleets. FedEx has a team of 450,000 people in more than 220 countries and enjoys annual revenues of approximately $69.7 billion (FedEx Annual Report, April 2019). The company also operates a diverse range of logistics-related FedEx branded companies under the core FedEx brand.

EXAMPLES OF LEADING LSPs

DHL (www.dhl.com)

DHL (standing for the initial letters of the surnames of the three company founders) started life in 1969. In fact it was one of the first air courier companies in that its original product was the delivery by air of ships' papers from San Francisco to Honolulu (allowing customs clearance of a ship in Honolulu before the ship actually arrived, thus dramatically reducing time spent waiting in the harbour). Today the company is 100% owned by Deutsche Post DHL Group, a global organisation with a group workforce of some 550,000 employees present in most of the world's countries and territories.

Kuehne + Nagel (www.kn-portal.com)

Kuehne + Nagel is one of the world's oldest logistics companies. It was founded in 1890 in Bremen, Germany, and today has more than 1000 locations in over 100 countries with 81,900 employees. It has evolved to become a full-service 3PL, active across all modes of transport.

A.P. Moller – Maersk Group (www.maersk.com)

The company is probably best known today for its deep-sea container vessels that traverse the world. It is, however, much more than a shipping company. Established in Denmark in 1904, today the group employs over 76,000 people and had US$39 billion in revenues in 2018. In the shipping sector, the group's subsidiaries operate more than 600 vessels (including some of the world's largest container vessels) and 64 ports and terminal facilities. As well as being involved in unitised (i.e. containerised) shipping, the group is also active in other shipping areas, such as crude oil transportation and supporting offshore oil and gas activities. It has also diversified extensively into other transport and non-transport areas such as shipyards, airfreight and even the retail supermarket sector.

FOURTH-PARTY LOGISTICS

In the preceding section we noted the shift from own-account transportation towards increased use of LSPs, with more companies outsourcing more logistics activity to 3PLs. Some companies of course still perform their own logistics activities, although the share of companies doing this is declining. The topic of outsourcing will be discussed further in Chapter 12. When companies do outsource, in many cases they will use more than one 3PL, either to ensure competitive rates are secured or because different 3PLs will have strengths in different markets or trades. In addition, the outsourcing company will still have to have a logistics department (even though all freight handling may be done by the 3PLs) in order to manage the 3PLs which it retains.

In recent years a concept known as **fourth-party logistics (4PL®)** has emerged. It sought to offer a radical solution that would offer companies total outsource supply chain solutions. It was invented and trademarked by Accenture in 1996, who originally defined it 'as a supply chain integrator that assembles and manages the resources, capabilities and technology of its own organisation, with those of complementary service providers, to deliver a comprehensive supply chain solution'.[2]

The concept has evolved since then with the Australian author John Gattorna in his insightful book *Living Supply Chains* noting that 'some of the essential elements that differentiate 3PL and 4PL® business models have been lost'.[3] While a number of genuine 4PL® solutions have emerged, in practice it is now more common for some 3PLs to offer 4PL® type solutions. This involves 3PLs in turn outsourcing, where it makes most sense for the final customer, certain activities to other 3PLs. We can thus envisage a 4PL® type concept today where individual 3PLs offer an overarching solution for an individual customer and which encompasses offerings from different (competitor) 3PLs. Some people use the description '4PL control towers' to refer to the role played by such 4PLs.

Digitisation of supply chains has helped in the rise of both 3PL and 4PL operations enhancing performance and reliability. Technologies used are applied to handle big data for real-time operations and management using data analytics, integrated IoT, blockchain and cloud-based computing. Indeed yet another label is emerging to describe a particular category of LSPs – 5PL (**fifth-party logistics**). Although still new and not clearly defined it refers to LSPs who use technology solutions across complex networks that incorporate multiple supply chains – it would thus appear to be most suited to LSPs serving e-commerce companies.[4] We will return to digitisation of the supply chain and its impact on logistics operations in Chapter 13.

CARRIER RESPONSIBILITIES

Once freight leaves a consignor, it is up to responsible LSPs to ensure that it reaches the consignee in the right condition, at the right time etc. (recall the eight 'rights' description of logistics in Chapter 1). Unlike passengers, freight cannot, of course, speak for itself (although we will see in Chapter 13, which deals with technology in the supply chain, that advances are being made in intelligent tracking systems at the individual item level). Documentation (either in physical or soft format) will need to accompany the freight so as to ensure that anyone who comes into contact with the freight will know where it comes from, what it comprises, where it is going and how it is going to get there. Customs and security agencies, who do not have time to physically check each consignment, will also want to know the various details about individual consignments that are moving over international borders. Chapter 9 will again consider carrier responsibilities and in particular review transit documentation and introduce Incoterms.

SELECTING LSPs AND SERVICES

Decision-making is an ongoing and important part of many logistics managers' jobs: for example, trying to decide which routing to use for a particular shipment, which carriers to use and how much inventory to hold. Different people, depending on their role in the supply chain, will have varying views on what the optimum decision is, and it is the job of the logistics manager to reconcile these conflicting views.

With regard to using LSPs, a strategy that is often used by logistics managers is to give a large share of their business to one carrier, and the remaining smaller share to a competitor carrier. This has two advantages: firstly if there are any problems (for example delays) with the preferred carrier, then they can, if necessary, switch traffic to the alternative carrier; secondly this dual approach has the advantage of keeping both carriers 'on their toes', because they know there is an alternative available if their performance starts to weaken.

More generally, companies also need to decide which 3PL(s) to use. The list below gives some of the many factors that have to be considered when selecting LSPs. Contracts with LSPs can often be worth large amounts of money and obviously cover an important area of a company's activities; therefore it is essential to choose the right partner(s).

- Services to be provided (geographical areas, volumes including fluctuations, time frame etc.)
- Costs and costing approach (open book, gain share, penalties, inflation/cost increases etc.)
- Terms of carriage, applicable Incoterms, insurance (responsibility for damage and shrinkage)
- Speed/transit time
- Performance metrics and service levels, reliability
- Information systems (especially with regard to systems integration), other technology issues (e.g. capability to 'track and trace' freight and requirement to use advanced technologies such as RFID) and documentation requirements
- Core versus value-adding services required (examples of the latter are discussed further in Chapter 11)
- Staffing issues (e.g. transfer of undertakings with respect to previous employees, legal responsibilities, company image and responsibility, union recognition, disruptions)
- Reverse logistics issues (packaging, returns – damaged and faulty goods, failed deliveries etc.)
- Implementation/termination/ability to alter conditions
- Details on the LSP's history, client references etc.
- Digitisation and transparency capability in the end-to-end supply chain

In Chapter 12 we will look more generally at the various stages in procuring products and services; the various steps outlined there can also be applied in the procurement of logistics services.

Chapter 10, which will deal with performance management, will discuss the role of service-level agreements in the ongoing management of LSPs. Obviously once the appropriate providers are selected, the next and important stage is to manage them effectively.

As well as deciding which LSP(s) to use, logistics managers also often need to decide which transport mode(s) to use. We say *often*, not *always*, because sometimes consignors do not know exactly which transport mode their freight travels on; they leave this decision to the 3PL. Furthermore, it is often not a simple matter of trading off one mode against another. Sometimes multiple transport modes are used in combination – in air transport, for example, the concept of **air trucking** is quite prevalent whereby freight is transported by road (sometimes over a relatively long distance) to a hub airport from where it travels onwards by air. Direct cost comparisons between alternative modes and services can be complex – this is the concept of **generalised costs**, which will be discussed further in Chapter 12. In addition, we will look at decision-making in logistics (e.g. how to choose a carrier or route) in Chapter 14.

LEARNING REVIEW

This chapter described the important role played in supply chains by logistics service providers (LSPs). We discussed the various, and overlapping, types of LSPs and noted in particular the growth of a category of LSPs called 3PLs; the latter we described as LSPs who generally offer multiple logistics services, often in an integrated fashion. We then considered the raft of different services which such 3PLs actually provide, with transportation/delivery being just one of the many services offered. The concept of fourth-party logistics was then explored and we noted the reality that in many instances it is actually 3PLs that often offer 4PL® type solutions.

The issue of LSP responsibilities was next explored and we also discussed how consignors go about selecting LSPs and services – topics we will return to in later chapters when we look at trade facilitation (Chapter 9), costs in the supply chain (Chapter 12) and logistics decision-making (Chapter 14).

QUESTIONS

- What is 'own-account' transportation?
- Describe the different types of LSPs.
- Describe the various factors that have to be considered when selecting LSPs. How in practice do you think consignors make decisions concerning choosing logistics services?
- What is fourth-party logistics (4PL®) and how has the concept evolved in recent years?
- How might we distinguish 3PLs from other LSPs?

‘ASSET UNENCUMBERED’ 3PLS

In recent years many 3PLs have grown in scale and become quite sophisticated. In this chapter we also saw how some 3PLs are in practice offering 4PL® type solutions. In fact some 3PLs have advanced to the point where they believe that their knowledge and systems, and not the physical capital which they own and operate (warehouses, transport etc.), are what give them critical, competitive advantage. Some commentators refer to such 3PLs as ‘asset unencumbered’ in that they increasingly divest themselves of physical assets, yet concomitantly grow their business via more effective use of people, knowledge and systems.

Search the web for examples of 3PLs becoming ‘asset unencumbered’. Is such a strategy sustainable in the long term, in your view?

NOTES

1. Armstrong & Associates (2019) A&A's top 50 global third-party logistics providers (3PLs) list, https://www.3plogistics.com/Top_50_Global_3PLs.htm, accessed 17 September 2020.
2. Quoted in Gattorna, J. (2006) *Living Supply Chains*, Pearson Education, Harlow, p. 204.
3. Ibid.
4. See for example: Giusti *et al.* (2019) Synchromodal logistics: An overview of critical success factors, enabling technologies, and open research issues, *Transportation Research E* (129), 92–110.

9
Facilitating International Freight Flows

LEARNING OBJECTIVES

- Explain how responsibility for freight is determined as it moves between consignors and consignees.
- Review the documentation that accompanies freight.
- Examine the efforts to ensure a more seamless, efficient movement of freight.
- Explain why trade facilitation is key for easing the movement of international freight.
- Review the opportunities that new technologies can provide for a smoother movement of freight.
- Introduce the port community systems and single window concepts.

INTRODUCTION

While in the previous chapters of Part Two we looked at transport and logistics services, in this chapter we will turn our attention to the concepts and processes associated with international trade. Supply chains are often stretched along multiple geographies, requiring raw materials, intermediate inputs and final products to be transported internationally. Ensuring clarity around who is responsible and accountable for the freight at the different stages along the supply chain is important, and we will detail how this is enabled via the use of Incoterms. Moreover, we will also discuss the documentation that typically accompanies in transit freight and the efforts underway to facilitate more efficient movement of freight internationally through the elimination of bureaucracy and other barriers.

Chapter 9 comprises three core sections:

- Incoterms
- Documents required in international trade
- Trade facilitation

INCOTERMS

International freight flows along global supply chains are not possible without the flow of information. This information is included in the documents used in international trade, which we summarise in the next section. Indeed, unlike passengers, freight cannot, of course, speak for itself and is thus dependent upon both tracking technologies and accompanying documentation. Such documentation (in either physical or soft format) will need to accompany the freight so as to ensure that anyone who comes into contact with it will know where it comes from, what it comprises and whether any special handling requirements apply, where it is going and how it is going to get there. Customs and security agencies, who do not have time to physically check each consignment, will also want to know the various details about individual consignments that are moving across their borders.

The document that typically contains all of this requisite information is known as a **bill of lading**, or in airfreight the more common term is an air waybill, or AWB for short. In the case of consolidated shipments, the entire shipment will be covered by a 'master waybill', with the individual shipments covered by documents known as 'house waybills'.

When freight moves from consignors to consignees, it is important to understand who has responsibility for it at the various stages of its journey. If something happens to the freight, for example it becomes damaged, who will be held responsible? Similarly, if charges for customs clearance are to be paid before the freight can be collected, who should pay such charges, the consignor or the consignee? Issues such as these are resolved by using what are called **Incoterms**, an abbreviation for 'international commercial terms', which were first published in 1936 by the International Chamber of Commerce (ICC) (www.iccwbo.org) and are now commonly accepted standards in global trade. Incoterms are periodically updated. The latest version entered into force on 1 January 2020. While Incoterms are very useful with regard to various cost and risk issues, they are not intended to replace legal agreements such as contracts of sale. There are, in fact, 11 Incoterms, divided into four groups, as illustrated in Table 9.1. Some Incoterms can be applied to any transport mode, these are: FCA, CPT, CIP and Groups E and D. In contrast, FAS, FOB, CFR and CIF are used in inland and waterway transport only.

As shown in Figure 9.1, the way both responsibilities and risks are allocated between seller and buyer varies according to the Incoterm selected. For example, with FOB, the seller is responsible for delivering the goods from their place of business, clearing customs and loading goods onto the vessel at the port of export. From that point, the buyer is responsible for covering all transport and insurance costs, as well as for clearing customs at the point of import. In contrast, if CIF is applied, the seller would be obliged to pay for international transport and insurance.

DOCUMENTS REQUIRED IN INTERNATIONAL TRADE

Documents accompanying international trade provide useful information to supply chain stakeholders, from manufacturers and LSPs to government authorities. Trade documents contain information on the international transaction taking place between the seller and the buyer and assign responsibilities between both parties. The information reported is defined by national and international regulatory requirements in areas such as health, consumer protection, safety, tax and revenue, trade policy, environment and security.[1] Such documents can take paper or electronic form. However, as we will discuss next, for the past 20 years, governments across the globe have made important progress into digitising information and documentation required for the international movement of freight. The United Nations Commission for Europe (UNECE) classifies trade documents into four categories as shown in Table 9.2.

TABLE 9.1

Incoterms
(Source: Derived from www.iccwbo.org and www.gov.uk/incoterms-international-commercial-terms/overview)

Incoterm	Details
Group E – Departure	The seller minimises their risk by only making the goods available at their premises
EXW (Ex-Works)	(... named place)
Group F – Main carriage not paid by seller	The seller usually arranges and pays for the pre-carriage in the country of export
FCA (Free Carrier)	(... named place)
FAS (Free alongside Ship)	(... named port of shipment)
FOB (Free on Board)	(... named port of shipment)
Group C – Main carriage paid by seller	The seller arranges and pays for the main carriage but without assuming the risk of the main carriage
CFR (Cost and Freight)	(... named port of destination)
CIF (Cost, Insurance and Freight)	(... named port of destination)
CPT (Carriage Paid To)	(... named place of destination)
CIP (Carriage and Insurance Paid To)	(... named place of destination)
Group D – Arrival	The seller's cost/risk is maximised because they must make the goods available upon arrival at the agreed destination
DAT (Delivered at Terminal)	(... named place of destination)
DPU (Delivered at Place Unloaded)	(... named place of destination)
DDP (Delivered Duty Paid)	(... named place of destination)

Figure 9.1 Parties' responsibilities according to Incoterms

(Source: Derived from https://www.kn-portal.com/incoterms_2020)

The bill of lading – also known as B/L or BOL – is one of the most important documents in an international transaction. It provides evidence of a contract between the carrier and the exporter to deliver the goods to the importer (the consignee) at a specific destination in the importer's country. The main features of the bill of lading are as follows:

- It is an acknowledgement that the carrier has received the goods to be delivered to the importer.
- It details the goods being transported, the name of the port where they were loaded and the destination port.
- It gives title of the goods to the importer, who can take possession of them once the goods reach his/her country.[2]

Let's see now how the different trade documents work together in a simple export transaction. Imagine that you work for a firm that exports shoes. An interested buyer may contact you to enquire about your product. She would like to buy 500 brown men's loafers, to be delivered in Spain in a period of 120 days. To do so, she will send you a *letter of enquiry*, including the terms of her interest and a request for a quote. If you decide to reply to the enquiry, you may send her a *proforma invoice*, which is a quote that looks like a commercial invoice and that can be used by the buyer to obtain finance for her purchase. If the buyer agrees with the offer, the next step is to sign the *sales contract*. Such a contract includes the terms of the sale – the Incoterms we discussed above – the payment terms, the means of transportation and the documents that each party must provide, among others. You will then receive a *purchase order* outlining the terms agreed on the contract.

TABLE 9.2

Trade documents

(Source: Derived from http://tfig.unece.org/contents/trade-documents.htm)

Category	Definition	Examples
Commercial transaction sector documents	Documents exchanged between partners in international trade for information to tender, exchanges between offeror and offeree and the conclusion of a contract	Offers and quotations, orders, pro-forma invoices and dispatch advice
Payment sector documents	Documents exchanged between partners in international trade and their banks, as well as between banks for payments related to commercial transactions	Commercial invoices, collection payment advice, documentary credit applications and bank guarantee
Transport and related sector documents	Documents exchanged between trading partners and carriers to specify the characteristics of e.g. freight forwarding, handling and insurance	Transport contracts (bills of lading, consignment notes), cargo freight manifests, freight invoices, arrival notices, insurance policies and warehouse receipts
Official control documents	Documents required for the control of goods conducted by various official bodies for the export, transit and import of goods	Goods declaration for customs purposes, sanitary and phytosanitary certificates, control and inspection certificates and dangerous goods declarations

Next you will need to prepare the goods and documents for export. This will include (1) the *commercial invoice* which replicates the terms agreed in the contract and the purchase order; (2) the *packing list* which provides the freight forwarder, carrier, customs and consignee with information about your shipment and the packing details; (3) a *shipper's letter of instruction* to have a written record of, for example, who received the shipping documents and whom to contact if needed; (4) *bills of lading* for inland and maritime transport and (5) the required *sanitary and phytosanitary certificates, control and inspection certificates*. Finally, in some cases, you will also need to include a *certificate of origin* of the goods – this is particularly relevant for customs duties purposes.

TRADE FACILITATION

While the information provided by trade documents is critical to ensure the rights of each party involved in an international transaction, as well as ensuring compliance with national and international regulations, cumbersome administrative procedures can harm international trade. Empirical evidence, for example, shows that each additional day freight spends in transit reduces the probability that a country will export to the US by 1%.[3] Given the importance of trade to economic development, there is increasing emphasis on **trade facilitation**. Each year the World Bank publishes its *Doing Business* report, which includes analysis of the ability to trade across borders (measured by way of the time and cost associated with exporting and importing a standardised cargo of goods by sea transport).[4] Trade facilitation is also a key focus of much of the work of UNCTAD's Transport and Trade Logistics Branch among developing countries.[5] Two main concerns of those advocating for trade facilitation are elimination of time as a trade barrier (poor international transport links increase time to market) and reducing bureaucracy caused by procedural, administrative and legal impediments. Indeed, UNCTAD estimates that around 40 documents are involved in the average customs transaction, with 70% of data needed to be rekeyed at least once.[6] The World Trade Organization (WTO) has reported that the cost of complying with customs formalities can even cancel the benefits brought by tariff reductions through international agreements.[7]

Trade facilitation refers to the simplification, harmonization and automation of international trade procedures, providing trade transactions with more transparency, predictability and efficiency.

In this context, the goal of trade facilitation is to make international trade transactions easier, quicker and less costly. In particular, trade facilitation refers to the simplification, harmonisation and automation of international trade procedures, providing trade transactions with more transparency, predictability and efficiency (Table 9.3).

Impact on international trade and supply chains

With the aim of fostering trade facilitation across the globe, the members of the World Trade Organization developed in 2013 the Trade Facilitation Agreement, which entered into force in 2017 after being ratified by two-thirds of its member countries. The agreement contains provisions for expediting the movement, release and clearance of goods, as well as for improving cooperation between customs and other agencies on trade facilitation and other customs compliance matters. The full implementation of the Trade Facilitation Agreement could reduce trade costs by more than 14% and increase global trade by up to US$1 trillion per year. For Asian countries, for example, it is estimated that further trade facilitation could generate gains of about 0.26% of Asia-Pacific Economic Cooperation (APEC) GDP, doubling the gains from tariff reductions.[8] Among the main beneficiaries of such gains are small and medium-sized enterprises, which in many economies account for more than 90% of businesses and employment creation. Administrative barriers and cumbersome procedures for firms that often trade in small quantities make access to international markets difficult and even too costly. Trade facilitation is also critical for exporters of time-sensitive products such as agricultural products and high-tech manufacturing components. Available evidence shows that a day's delay reduces the probability of exporting time-sensitive agricultural goods by as much as 6% and as we saw already above each additional day freight spends in transit reduces the probability that a country will export to the US by 1%.[9] Moreover, with the boom of e-commerce and the rising number of parcels travelling across borders, the need for trade facilitation is becoming more relevant. In 2018, 1.8 billion people globally purchased goods online, and 57% of online buyers purchase from foreign sellers.[10] Finally, simplifying trading procedures removes incentives and opportunities for corruption, therefore aiding good governance and transparency.

TABLE 9.3

Trade facilitation
(Source: Derived from http://tfig.unece.org/details.html)

Trade facilitation		
Simplification	**Harmonisation**	**Standardisation**
Eliminating unnecessary elements and duplications in trade formalities, processes and procedures	Aligning of national procedures, operations and documents with international conventions, standards and practices	Developing formats for documents and procedures internationally agreed by various parties

Trade facilitation has a direct impact on two critical variables for the performance of global supply chains: time and cost. Because production processes in global supply chains are fragmented across different latitudes, the delay of materials at any border crossing can create significant risks for production, particularly when just-in-time strategies are implemented. In such cases, manufacturers carry limited inventories of inputs and instead rely on their regular and timely delivery. This requires high reliability on when and how deliveries will take place. When reliability is lower due to uncertainties related to cross-border procedures, producers often opt for increasing their inventories, which in turn raises their financial costs. Moreover, each time that goods cross a border, they are subject to a variety of controls and administrative procedures, generating costs for trade partners. Additional costs may arise with delays in border clearance, for example requiring that importers pay for extra storage and security. Finally, the merchandise itself may lose value due to quality degradation, depreciation or technological obsolescence. This is why public and private sectors around the world are working on simplifying, harmonising and standardising international trade procedures.

Improving trade facilitation

At the international level, countries can track their progress in facilitating trade by looking at the aforementioned World Bank's annual *Doing Business* report. As noted above, *Doing Business* measures the time and costs (excluding tariffs) associated with documentary and border compliance for import and export processes. Table 9.4 shows the best performers in the 2020 edition of the report and the gap still present between best and worst global performers in trade facilitation.

TABLE 9.4

Trading across borders – Best performers 2020
(Source: Derived from https://openknowledge.worldbank.org/bitstream/handle/10986/32436/9781464814402.pdf. Licensed Under CC BY 3.0 IGO.)

	Country with best performance	Best regulatory performance	Worst regulatory performance
Time to export			
Documentary compliance (hours)	Canada, Poland, Spain	1	170
Border compliance (hours)	Austria, Belgium, Denmark	1	160
Cost to export			
Documentary compliance (US$)	Hungary, Luxembourg, Norway	0	400
Border compliance (US$)	France, the Netherlands, Portugal	0	1,060
Time to import			
Documentary compliance (hours)	Republic of Korea, Latvia, New Zealand	1	240
Border compliance (hours)	Estonia, France, Germany	1	280
Cost to import			
Documentary compliance (US$)	Iceland, Latvia, UK	0	700
Border compliance (US$)	Belgium, Denmark, Estonia	0	1,200

Countries with more efficient trade facilitation environments are characterised by a number of common features including:

- Electronic exchange of information between traders, customs and other control agencies, which we will discuss next.
- Reduced number of physical inspections of shipments by adopting a risk-based selectivity approach (meaning that cargo can go through green (no inspection), yellow (limited inspection) or red (physical and documentation inspection) channels according to its risk profile).
- International cooperation and agreements with other countries and regions in order to reduce the documents and processes needed to comply with border requirements.[11]

The ability to electronically exchange information is a key element to improve trade facilitation. Countries around the world are implementing web-based systems to allow traders to submit relevant documents and even pay duties remotely, thus saving them time and money and reducing the complexity of border requirements. Moreover, by limiting direct interactions between traders and government officials, opportunities for bribery can be significantly reduced. Other critical benefits from the electronic exchange of information include generating statistical data, improving the monitoring of processes and foreign trade transactions and combating fraud. Such web-based platforms are currently available in more than half of OECD high-income countries, where traders no longer need to visit government offices to complete certain procedures (e.g. the submission and clearance of export declarations). Another example is the International Goods in Transit (TIM) system that countries in Central America have put in place to simplify, harmonise and standardise previously cumbersome procedures in a single document to enable the smooth movement of goods across nine countries, thereby helping to progress regional integration initiatives.

Together with the deployment of information systems, trade facilitation requires that countries modify their regulatory frameworks to, for example, allow for electronic signatures and recognise the validity of electronic transactions in trade procedures. Moreover, before the deployment of information systems, process reengineering is needed to simplify the number of documents and processes required for international trade. Without the appropriate legislation and process reengineering in place, the implementation of a new system can lead to redundancy and delays. For example, the World Bank suggests that while many economies in Sub-Saharan Africa, Eastern Europe and Central Asia have electronic systems, they still require traders to submit hard copies of documents, thus reducing the impact of trade facilitation reforms.[12] Another challenge to implement new information systems is the cost that both governments and traders need to bear in terms of hardware, software and training to use such systems. This can delay adoption and the benefits associated with it.

Trade facilitation and information technology

A key initiative among those endeavouring to facilitate more efficient movement of freight is the creation of a 'single window' – an electronic portal through which all relevant transport, customs and other documentation can be lodged and to which all relevant stakeholders can have access. This saves duplication of effort and unnecessary delays, freight can even be cleared by customs before it reaches its destination and, equally, customs and security authorities can identify in-transit freight for screening upon arrival if necessary. Single windows increase the productivity of government offices to cope with the increasing volume of global trade. For example, in Singapore, border-related agencies are able to process trade permits in less than 10 minutes, for a total of up to 30,000 trade declarations per day.[13] Moreover, single windows generate important benefits for the economy. For example, before the implementation of a single window in 2010, traders in Costa Rica had to go to different government offices in person to submit trade permits, which were processed manually and separately by each agency involved. With the single window in place, traders now fill in a single form online, which the system then distributes automatically to the different agencies that need to issue permits according to the regulations. Trade-related paperwork is processed electronically by all agencies at the same time. Empirical analyses suggest that, without the single window system, aggregate Costa Rican exports would have been, on average, 2% lower than they were between 2008 and 2013, which is equivalent to approximately 0.5% of the country's total GDP.[14] Estimates from the Korean Customs Service also suggest positive results. The introduction of the single window in 2010 generated benefits to the economy of approximately US$18 million.[15]

Another initiative to facilitate information exchange among international freight stakeholders are Port Community Systems (PCS). The International Port Community Systems Association define a PCS as an electronic platform that connects the multiple systems operated by a variety of organisations that make up a seaport community.[16] The PCS is aimed at eliminating unnecessary paperwork and streamlining processes to improve efficiency at all the stages of cargo handling at port terminals (e.g. vessel discharge and loading, customs clearance, port health formalities and delivery in and out of the terminal). In general, it serves as a 'one-stop shop' for port stakeholders and offers the following services to their users:

- Information exchange among port stakeholders, such as shipping companies, trucking operators, shippers, terminal operators, customs, port and other authorities.
- Electronic exchange of customs declarations and customs responses and cargo releases between private parties and customs.
- Electronic handling of all information regarding import and export of containerised, general and bulk cargo for the port community.
- Processing of dangerous goods.
- Processing of maritime and other statistics.
- Status information and control, tracking and tracing goods through the whole logistics chain.[17]

Evidence from PCS implementations around the world shows that they can generate benefits for port stakeholders. The adoption of a PCS allowed, for example, the port of Los Angeles to reduce congestion at port gateways by 50% and increase container movements by 2000 units per day. It has been estimated that the PCS adopted in the port of Valencia, Spain, saves around €23 million each year across the whole port community. Similarly, Portnet, the PCS currently operating in Singapore, has reportedly generated savings of over $80 million over a three-year period.[18]

Beyond document digitisation, other new technologies such as blockchain and artificial intelligence can help further improve trade facilitation. Blockchain is a distributed ledger technology where all the information shared in the network is stored in each node, therefore making it easier to access and trace transaction history – we will review this technology further in Chapter 13. The features of blockchain technology are particularly relevant for streamlining cross-border procedures: through blockchain, information can be created and shared in an immediate, unalterable and transparent fashion among the actors taking part in an international trade transaction. This can help eliminate redundant processes for information sharing, accelerate customs procedures and customs clearance, and enhance coordination between the various agencies and stakeholders involved in cross-border procedures. Moreover, since any change to the information stored in the distributed ledger must be approved by consensus by all the nodes in the network, the risk of forgery and fraud in the information shared is virtually eliminated, therefore improving transparency. One expected benefit of blockchain relates to ensuring goods provenance and end-to-end product traceability, facilitating controls on, for example, rules of origin, authenticity and sanitary and phytosanitary requirements for imported goods. Various organisations such as the World Economic Forum, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and the World Customs Organization are researching the potential of blockchain technology to facilitate cross-border trade, and several proofs of concept and pilot projects have been developed. Preliminary findings on blockchain are promising; however, further work is needed to explore fully the potential of the technology and how it can be integrated with existing cross-border control systems. In turn, artificial intelligence is increasingly being used to analyse regulatory requirements, monitor any changes to cross-border regulations and help traders comply with them. Artificial intelligence algorithms can go through large amounts of data in a fraction of the time that it takes humans, reducing the probability of errors and saving money for traders.

LEARNING REVIEW

This chapter introduced Incoterms and explained how they allow for clarity around who is responsible and accountable for the freight at the different stages of the supply chain. In addition, we also discussed the documentation that typically accompanies freight and the efforts underway to facilitate more efficient trade flows through the elimination of bureaucracy and other barriers.

This now completes the second part of our book, which focused on transport and logistics, and, subsequent to the case studies that follow, we will move on to the third part of the book which will deal with managing supply chain operations.

QUESTIONS

- What are Incoterms?
- Why is the Bill of Lading an important document in freight transport?
- Identify the various documents that are typically associated with an international shipment.
- How can trade facilitation benefit global logistics?
- How can new technologies improve trade facilitation?

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Part Two Case Studies
Air Cargo

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Air cargo plays a significant role in modern-day supply chains. The majority of cargo is carried in the belly hold of aircraft, underneath the passenger cabin or by dedicated cargo airlines. Some purely provide air transport services for all types of freight (such as Cargolux), while integrated carriers like DHL provide door-to-door services for smaller-sized consignments. Finally, specialist cargo airlines operate aircraft capable of carrying oversize cargo. These airlines use aircraft such as the giant Antonov AN-124, which have large-volume cargo holds.

Airports provide a critical link between air and surface modes. Table 1 shows the major global air cargo hubs in 2018, ranked by cargo tonnage. Many of these hubs are located in Asia, reflecting the significant growth in trade in this region in recent decades. By contrast, Memphis and Louisville benefit from being the main US hubs for FedEx and UPS, respectively. Two airports benefit from their geographical location at the crossroads between major markets: Anchorage (Asia and North America) and Dubai (Asia and Europe).

TABLE 1

Top 10 airports for air cargo, 2018 [Source: Modified from ACI (2019)]

Airport	Air cargo volume (tonnes)
Hong Kong	5,121,029
Memphis	4,470,196
Shanghai Pudong	3,768,573
Seoul Incheon	2,952,123
Anchorage	2,806,743
Dubai	2,641,383
Louisville	2,623,019
Taipei	2,322,823
Tokyo Narita	2,261,008
Los Angeles	2,209,850

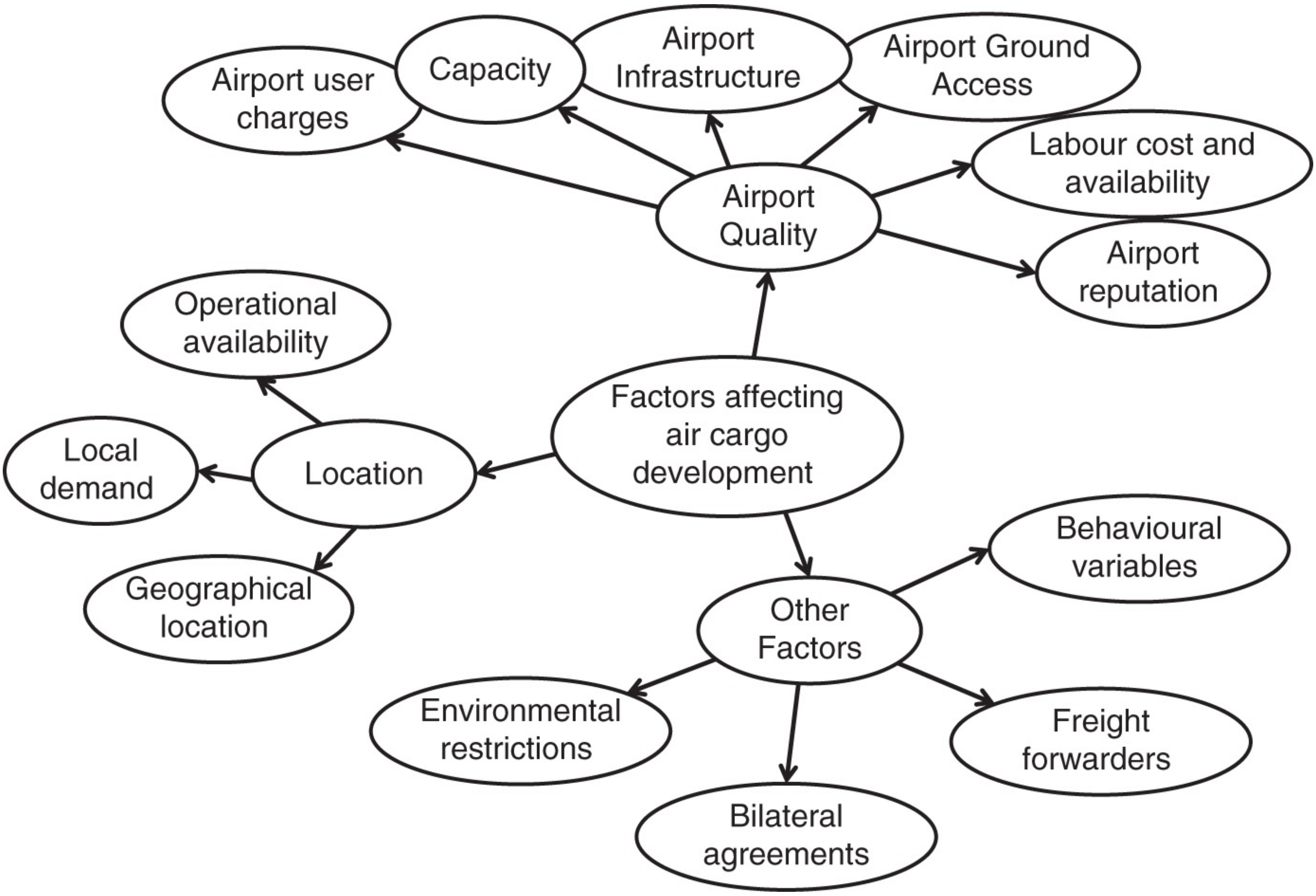

Figure 1 Factors affecting cargo development at airports

There are many factors that can affect the development of the air cargo volumes through a particular airport, as summarised in Figure 1. Location is a critical set of factors, where the physical location relative to key cargo markets is important. However, having local demand is also important to support air services, ideally for both imports and exports. Finally, the airport should not be constrained by operational factors such as the weather. However, influencing these factors often lies outside of the airport's control.

Airport-based factors, however, are something that can be more directly controlled. The infrastructure provided both on-site by the airport and for ground access to the market can also be significant in influencing an airline's choice of airport, these being different to the requirements for passengers. Capacity is an important aspect here, with sufficient capability to handle all aviation users of the airport. Linked to this, congestion can cause delays or a lack of availability of slots at appropriate times, while the level of airport charges and labour costs can have a significant impact on the viability of services. Beyond these tangible elements, the overall reputation of the airport in the air cargo market is important.

Finally, there are a range of other factors that can have an impact. Environmental concerns and government legislation may, for example, restrict operating hours. Despite a move towards 'open skies' deregulation, there are some markets that are still constrained by bilateral agreements. The presence of freight forwarders, who play an important role in organising air freight movements, is potentially one of the most important factors (Kupfer *et al.*, 2016). Finally, there will be underlying behavioural aspects that managers within air cargo airlines bring into their decision-making.

Despite the diversity of factors affecting the development of cargo operations at airports, it is possible to develop a categorisation of cargo airports (Mayer, 2016). Geography plays an important role but, beyond this, the categories are (Mayer, 2016) as follows:

- Cargo-dependent hubs – these are airports with a significant proportion of operations dependent upon air cargo. One such example is Anchorage, which has benefitted from its geographical position between North America and Asia to become a hub, with significant trans-shipment of freight between aircraft at the airport. More often than not, however, cargo-dependent hubs obtain this status through being a central part of parcel carrier networks. Airports such as Louisville and Leipzig see significant cargo volumes through being bases for UPS and DHL, respectively.
- International passenger hubs – here, the development of significant cargo volumes is largely dependent upon the sizeable number of passenger flights available at the airport. Much of the cargo is carried in the belly hold of these flights, supplemented by dedicated cargo flights. In many cases, there is a sizeable local demand for cargo too. In the case of Hong Kong, the surrounding markets generate a significant demand for air cargo, while it also acts as a trans-shipment point for Southeast Asia generally. Other examples include Amsterdam, where the movement of flowers is important, and Munich, where the automotive and electronics industries support services.
- Dual-base airports – in this case, the airports are bases for both cargo and passenger airlines, albeit often for smaller passenger airlines. For example, Luxembourg is the hub for both Luxair and Cargolux. Being located centrally offers good connectivity for freight movements throughout mainland Europe, and Cargolux has built a strong position as one of the largest air-cargo carrying airlines.
- Passenger-dominated airports – this final group represents airports that mainly focus on passenger operations but, because of the opportunities from belly hold cargo, are able to handle small volumes of cargo too. For example, Tianjin generates air freight to support its aerospace, automotive and petrochemical industries. While predominantly associated with international air cargo movements, both the US and China feature airports reliant on domestic cargo.

Within a country's airport network, there will be examples of the different types of airport, each filling particular roles in the system. To illustrate this, consider the UK airport network. Approximately 2.7 million tonnes of freight and mail was handled in 2019 (CAA, 2020). In weight terms, this represents a relatively small amount – by comparison, the volume through UK ports over a comparable period was 470 million tonnes (Department for Transport, 2019). However, the cargos carried by air are typically goods with a high value density, and therefore, by value, air freight accounts for around 40% of UK imports and exports (Airlines UK, 2018). Key export flows from the UK include jewellery, aerospace, medical instruments and pharmaceuticals. It has been estimated that the air freight industry supported 46,000 jobs directly, and 151,000 jobs once indirect and induced impacts are also considered (Airlines UK, 2018).

Table 2 shows the top 10 airports ranked by air cargo volumes in the UK. It is clear that the market is dominated by London airports, and particularly Heathrow. Much of the traffic through Heathrow is cargo carried in the belly hold of aircraft (typically under the passenger compartment). Where airlines use dedicated freighter services, they tended to operate to either Stansted or Luton. Both of these airports had spare capacity and 24-hour operating licences, enabling them to support the air cargo industry more effectively. By contrast, Heathrow is heavily slot constrained and can typically only accommodate dedicated freight services on weekends.

TABLE 2

Top 10 air cargo airports in the UK, 2019

[Source: Modified from CAA (2020)]

Airport	Freight (tonnes)	Mail (tonnes)	Total cargo (tonnes)
London Heathrow	1,587,486	85,423	1,672,910
East Midlands International	335,948	22,041	357,989
London Stansted	224,139	17,094	241,233
London Gatwick	110,358	7,640	117,998
Manchester	108,382	2,364	110,746
Edinburgh	19,410	22,968	42,378
Belfast International	25,095	11,538	36,633
London Luton	35,761	801	36,562
Birmingham	29,866	143	30,009
Doncaster Sheffield	17,647	0	17,647

Outside of London, East Midlands Airport plays an important role both for cargo and mail, ranking second behind Heathrow in both cases. The past 30 years has seen the airport take a strategic decision to emphasise air cargo given its central location in the UK and excellent access to the UK motorway network (Budd *et al.*, 2015). Consequently, there has been significant investment in air cargo facilities within the airport, leading to DHL and UPS establishing their UK hubs at the airport, as well as being an important destination for TNT. These cargo facilities receive flights from a range of international destinations, handling freight and mail coming to and from the UK. In addition, East Midlands is the hub for the Royal Mail air freight network. In 2014, this represented about 10% of the airport's volume (CAA, 2020). Mail is received by road from 34 sorting centres before being distributed by air to more distant locations in the UK, such as Aberdeen, Edinburgh, Belfast, Bournemouth and the Channel Islands (East Midlands Airport, 2015).

What the UK airport system shows is that, given the range of different air cargo services that exist, airports can position themselves to serve different niches. Furthermore, development of air cargo hubs does not necessarily align with passenger hubs.

QUESTIONS

1. For an airport you are familiar with, what are the main factors helping or restricting air cargo development?
2. Focusing on major air cargo hubs (such as Hong Kong, Anchorage or Dubai), compare and contrast the factors that have affected their growth.
3. With the increasing focus on sustainability, how will this impact on the development of air cargo hubs into the future?

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Port-Centric Versus Inland Location Decisions in Gothenburg, Sweden

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INTRODUCTION TO PORT-CENTRIC LOGISTICS

Port-centric logistics means locating a distribution facility at a port (Mangan *et al.*, 2008). In some cases (e.g. Teesport, UK), this means actually inside the port area, needing only a small shunt from the quayside to the distribution centre (DC). In other cases (e.g. Savannah, US), port-centric logistics means a large logistics area growing around the port. Sometimes, the term port-centric is used to refer simply to de-stuffing or transloading, e.g. from inbound container to pallets, or from inbound deep sea 40-ft containers to domestic 53-ft (US) or 45-ft (Europe) containers, enabling greater value from the inland transport costs. Such de-stuffing can be done in a container freight station inside the port or in other facilities outside the port. For example, many facilities perform this task in the areas surrounding the ports of Los Angeles/Long Beach. The choice of location for these tasks will depend on various factors such as timing, demurrage charges and local road haulage costs.

Whether a specific port is a good choice for port-centric logistics depends to a large degree on the local economy. An ex-industrial city with low employment will be looking to attract businesses, whereas a more prosperous city already experiencing congestion and not lacking jobs may find that wealthy residents form a strong lobby against such developments, preferring waterfront living and entertainment opportunities to noisy and dirty freight handling.

From a shipper perspective, whether port-centric logistics is appropriate depends chiefly on the balance of primary and secondary distribution as well as on the role of other costs such as land and labour. Centralisation of DCs is popular for a very good reason, and a coastal rather than inland location is not going to suit the majority of businesses. An inland location allows choice of port, choice of carrier, agglomeration economies and ease of secondary distribution to stores or customers. These very advantages, however, may produce high land and labour costs in the most desirable inland locations.

Ports logically want to anchor customers at a port, which will limit their opportunities to take their business elsewhere, in addition to providing a revenue stream from land rental. If a shipper wants to give up the advantage of port choice, it is essential that the coastal location matches their distribution patterns and they are confident of a continuation of a choice of carrier service options at that port in the future. They must also ensure to obtain significant savings on the land (and usually labour) costs to make it worth their while.

THE GOTHENBURG CASE

Background

The Port of Gothenburg is the largest port in Scandinavia and the only one with direct trans-ocean lines to Asia and America, handling over 800,000 TEUs per year. In the past, it has enjoyed dominance due to its location and has also benefited from the development of a strong hinterland rail network. Now it is facing challenges from several directions, partly from its city location which results in a lack of space, congestion and labour conflicts, but also due to emerging competition from other ports.

With recently privatised terminals, the port authority is seeking to redefine its role with its Swedish hinterland by growing the area of port land devoted to logistics activities. This could be considered a contrast to the last two decades which has seen a large focus on the rail network and inland terminals for transporting goods to the hinterland. Branded and marketed as 'Railport Scandinavia' by the port authority, the share of hinterland transport by rail has increased from around 20% in 2000 to around 45% in 2016. This is an outcome from the port authority's collaborative work (cf. Bergqvist 2009, 2013) with inland actors to stimulate more freight on rail through the development of rail shuttles but without taking a direct stake themselves. The network currently serves around 30 different destinations.

Port-centric developments

The city of Gothenburg is undergoing a transformation, a process that started several years ago when old industrial and terminal areas were converted into residential areas (Olsson *et al.*, 2016). For example, Norra Älvstranden (north bank of the river) has changed from a shipyard and industrial area into a cluster for high-tech companies, education and residential areas. As a consequence of the historically strong logistics position of the city, there is a conflict of interest between residential/commercial areas and some of the main transport routes. The port dominates the logistics developments in the city of Gothenburg, given that 85 of 135 freight terminals in the city are located close to the port area (Olsson & Larsson, 2015). Gothenburg is frequently ranked as the most attractive location to establish logistics facilities in Sweden (Intelligent Logistik, 2017). In the next 20 years, 5 million m^2 of logistics facilities are going to be developed there, of which more than 1 million m^2 will be developed by the port authority.

From a port-centric perspective, land availability inside the actual port is relatively low; however, there is great demand for further expansion of logistics facilities close to the port. A 1 million m^2 logistics platform is currently being developed near the port, led by the port authority in conjunction with four other companies: NCC, Prologis, Eklandia and Bockasjö. The logistics development is estimated to generate some 2000 jobs and is projected to be completed by 2025 (Port of Gothenburg, 2017a).

A recent study commissioned by the port authority arrived at the conclusion that a port-centric location in Gothenburg is a competitive location for DCs in Scandinavia (Port of Gothenburg, 2017b). The study compared costs for transport of import freight from the port, palletised distribution, warehousing, customs and land. This study would seem to conflict with the general trend of migration of port-related logistics activities to hinterland locations with a better centre of gravity in relation to market population compared to coastal locations at the outskirts of the market, supported by the growth of the ‘Railport’ system described earlier.

Analysis of port-centric versus inland location

A recent study (Monios *et al.*, 2018) comparing a port-centric (Gothenburg) versus inland (Falköping, located about 125 km from the port) location concluded that the inland location would be 4.8% cheaper per year. One of the biggest reasons behind the advantage of the inland location is that of land purchase, which is many times more expensive in the port-centric location (about 800 SEK per m^2 near the port and 50–200 SEK per m^2 inland). Successful port-centric development usually relies on cheap brownfield land that public authorities are highly motivated to develop, rather than on valuable city land with alternative uses. With high volumes and high-frequency intermodal connections, inbound transport by rail is efficient and competitive with road, but still represents a cost that the port-centric location avoids; nevertheless, the cost disadvantage of higher inbound cost is offset by the relative advantage with regard to cost of land.

In terms of outbound transport costs, the location of DCs is very dependent on the closeness to the centre of gravity in relation to the market it serves, which normally corresponds well with the centre of gravity of the population. Locating directly at the centre of gravity might seem an obvious choice but, in order to minimise the total cost, inbound transport cost needs to be considered as well, normally shifting the optimal location of the DC away from the population centre of gravity to the direction of the point of entry (e.g. border-crossing point for imports), which may make the port-centric location suitable for some flows.

It is also important to consider the relative proximity between the rail terminal and the warehousing at the inland location, allowing strategies such as using cheap storage at the terminal for stock buffering, which is not possible at a highly congested port terminal. In this case, it is a couple of kilometres from the port to the logistics zone, whereas in the Falköping example, it is a matter of a few hundred metres. Also at inland locations, they can often use private roads between the warehouse and the terminal, so they have more freedom to use tugmasters rather than registered road vehicles and also transport heavier loads than are allowed on public roads. A truly port-centric location, meaning within the port perimeter, would also allow these advantages, but many “port-centric” developments in reality mean locations a few kilometres from the port.

CONCLUSION

The case showed that in Gothenburg, Sweden, the port authority plans to turn ex-port land into warehousing, but the analysis revealed that this might not be the best solution in city ports where other options exist for such real estate. A city port like Gothenburg, Sweden, has higher land and labour costs than the Swedish hinterland, whereas an old industrial or greenfield port such as the Teesport, UK example can offer land at much cheaper rates than a high-demand agglomerated inland logistics zone like the golden triangle in the UK's Midlands. There is thus a potential contradiction here: a port-centric logistics development would obtain cheaper land and labour costs at a non-city port, but it would be closer to final customers in a city port (Monios *et al.*, 2018).

Location decisions have not changed over time, and remain based on the traditional cost factors such as land and labour, and particularly primary versus secondary transport costs. If the port has land available and a shipper has a distribution portfolio that suits a coastal location, then port-centric logistics can be a win–win solution. But if land or transport costs are high, then the shipper must calculate the trade-off and make a decision based on their distribution model, reflecting the fact that any location decision can only be made on a case-by-case basis.

QUESTIONS

1. Which type of goods or market segments do you think are most suitable for port-centric locations?
2. Can you think of reasons why companies and logistics activities would choose to be located port-centric even when the cost-related aspects favour inland locations?
3. How do you think port centric versus inland dynamics will change in the future? What trends might influence this and how (e.g. electric trucks and vans, autonomous vehicles)?

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Part Three
Managing Operations

10
Inventory Management, Planning and Control

LEARNING OBJECTIVES

- Explain the significance of inventory in LSCM.
- Describe the various costs associated with inventory management.
- Introduce common inventory control systems and strategies used to reduce inventory-related costs.
- Illustrate techniques used for supply chain planning and control and outline how performance metrics are established.

INTRODUCTION

Inventory is another name for materials and is any material that a firm holds in order to satisfy customer demand (and these customers may be internal and/or external to the firm). Inventory can thus be found at multiple locations along the supply chain – at the supplier, in the factory and at the customer's premises. The purpose of inventory management then is to strike a balance between the levels of inventory a firm holds to be able to satisfy customer demand in supply chains and the associated costs.

Companies hold inventory for a number of reasons including the following:

- To cope with fluctuations in demand and to provide choice for customers.
- On the supply side to cope with fluctuations in availability and the risk of upward price changes.
- Quantity discounts are often available for buying in bulk, but this can result in excess inventory being carried.
- We saw the importance of JIT in Chapter 3. Not every system, however, can operate on a fully JIT basis – invariably some inventory may need to build up before a production run can start or there is enough to comprise a full transport load.

Inventory is generally categorised into the following types:

- Raw material inventory is material purchased and waiting to be processed.
- Work in progress (WIP) inventory comprises material that is being processed along the production line.
- Finished goods inventory are the products awaiting shipment.

The costs associated with holding and managing inventory can be quite high. The **inventory holding costs** comprise:

- Fixed costs – warehouse space, insurance, security systems, monitoring and management etc.
- Variable costs – light/heat/refrigeration costs, costs associated with pilferage (sometimes called 'shrinkage') and damage, labour costs (these could also be categorised as fixed costs depending upon the staffing arrangements).
- Opportunity costs – money is tied up in inventory, someone had to pay for it, the opportunity cost then is the amount of money the firm would have earned if the money were invested elsewhere other than in inventory. Opportunity costs can be quite significant especially where large inventory holdings and high value inventory are concerned.
- Obsolescence costs – these costs arise if we hold too much inventory and it becomes out of date or no customers want it (for example, many technology products can have a very short lifespan before the next-generation model emerges).

Partners in supply chains want to reduce all of these costs but also want to ensure that they don't lose customers due to having no stock available for them. We will return to costing approaches and concepts in LSCM in Chapter 12.

Chapter 10 comprises five core sections:

- Inventory turnover and ABC classification
- The economic order quantity (EOQ) model
- Inventory control systems
- Inventory planning and control
- Managing logistics performance

INVENTORY TURNOVER AND ABC CLASSIFICATION

The inventory management performance of a firm can be measured using '**inventory turnover**'. The inventory turnover ratio is a useful indicator of how effective a firm is in managing its inventory. The ratio is calculated by dividing the cost of goods sold within a defined time period by the value of average inventory held throughout the same time period (the time period can be for whatever time period you chose, the important point to note is it must be the same for the numerator and the denominator in the following equation):

$$\text{Inventory turnover} = \frac{\text{Cost of all goods sold in a year}}{\text{Value of average inventory held throughout the year}}$$

PROBLEM 10.1A

Lamda Pharmaceuticals Limited has the following inventory performance:

Cost of goods sold in a year: $600,000

Value of inventory at the beginning of the year: $110,000

Value of the inventory at the end of the year: $130,000

What are its inventory turns?

Answer:

The value of average inventory held throughout the year = (110,000+130,000)/2 = $120,000

Inventory turnover = $600,000/$120,000 = 5 turns

PROBLEM 10.1B

Lamda Pharmaceuticals made efforts to increase the cost of goods sold for the following year to $950,000; however, the value of average inventory held for the year increased to $135,700. Has the company's inventory management performance improved?

Answer:

Inventory turnover = $950,000/$135,700 = 7 turns

So yes the company's inventory management performance has increased significantly, in fact by 40% from 5 to 7 turns per year.

Many firms achieve a turnover of about 10, while well-performing firms can achieve a turnover of 50 or more. A higher number of turns can imply that the firm is managing its inventory well, while a lower number can indicate the opposite. There can be some exceptions to this – a shop selling a wide range of specialist spices in small amounts, for example, could have annual inventory turnover of less than 1 (i.e. turning over its inventory very infrequently).

ABC classification

ABC analysis is used to establish policies for those firms that have many inventory items or stock-keeping units (SKUs). A SKU – as we saw in Chapter 3 – is a unique version in terms of size, packaging etc. of a particular product type. This method separates the most important and critical items that require more attention in inventory management compared to the many trivial ones. This analysis is based on the 'Pareto' or '80/20' rule of classifying items into groups – in the case of inventory management then we might be interested in grouping items according to their share of overall sales revenue. A useful measure in this regard is what is known as 'annual dollar volume' (ADV), which is calculated as annual demand multiplied by the price of the item.

ABC analysis divides the items into three categories, but the boundary between categories is not a hard and fast rule; the objective is to separate out the important few from the trivial many.

- **A items** can represent anywhere from 65% to 80% of the ADV, but only account for perhaps 15%–20% of the items.

TABLE 10.1

ABC analysis calculations based on ADV

Item stock number (SKU)	Annual volume	Unit cost	ADV	Percent of ADV	Cumulative % ADV	Cumulative % ADV	Category
1280	1000	$90.00	$90,000	38.78	38.78		A
1187	500	$154.00	$77,000	33.18	71.96		A
1420	1550	$17.00	$26,350	11.35		11.35	B
1472	350	$42.86	$15,001	6.46		17.81	B
1542	1000	$12.50	$12,500	5.39		23.20	B
1615	600	$14.17	$8,502	3.66	3.66		C
1767	2000	$0.60	$1,200	0.52	4.18		C
1877	100	$8.50	$850	0.37	4.55		C
1655	1200	$0.42	$504	0.22	4.77		C
1434	250	$0.60	$150	0.06	4.83		C
		Sum	$232,057				

- **B items** can represent 25%–30% of the ADV and typically account for 15%–25% of inventory items.
- **C items** can represent only about 0%–10% of ADV but may account for 60%–70% of items.

To carry out an ABC analysis, the ADV for each item is calculated and the items are then listed in descending order from highest to lowest as shown in the example given in Table 10.1. In this example – with calculations using Excel – the A category items constitute 20% of SKUs but account for 71.96% of the ADV; SKUs in the B category constitute 30% of the entire SKUs range and account for 23.20% of the ADV; 50% of all SKUs are in the C category and account for only 4.83% of the ADV. Again to reiterate the point made earlier: the boundary between categories A – B – C is not a hard and fast rule, the objective is to separate out the important few from the trivial many. Other criteria instead of ADV could be used to determine the ABC classification. For example, a firm could categorise inventory according to delivery problems, faults or complaints – a small proportion of all SKUs of washing machines delivered, for example, might account for the greatest share of customer complaints, thus we would separate out these A items (i.e. those few SKUs that generate a disproportionately large share of customer complaints) and try and identify what the problem with them is rather than focusing on the many other SKUs which generate fewer complaints.

THE ECONOMIC ORDER QUANTITY (EOQ) MODEL

In order to determine optimum order quantities, sometimes the EOQ model is used. There are different forms of EOQ models that can be used depending upon the characteristics of the inventory system, and these include a basic or simple EOQ model; an EOQ model with quantity discounts for when suppliers offer their goods at a discount if larger quantities are ordered; an EOQ model with production lots where supply rate is greater than usage rate, and an EOQ model for handling uncertainty in demand. Here we only present the simple EOQ model as the other models involve formation and solution of complex mathematical equations to cater for the specific characteristics of the inventory systems and situations under review. The simple EOQ model is only applicable for systems that exhibit the following characteristics:

- Lead time is known and constant.
- Demand is known and constant.
- Inventory holding cost is the only cost which is variable.
- There are no restrictions on the order quantity.
- Stock-out is avoidable.
- There is a set cost for placing an order.
- Quantity discounts for large quantity orders are not possible.

The following notation can be used:

D	Annual use of a particular item, in number of items per year
S	Order-processing cost, in $/order
p	Price per item, in $/unit
H	Inventory holding cost per unit per year, in $/unit/year
Q	Number of items ordered in one purchase order, in units
T	Time periods between purchase orders in fraction of a year
SS	Safety stock, in units
L	Lead time, in fraction of a year
l	Current inventory on hand, units
TAC	Total annual cost

Figure 10.1 is an idealised depiction of inventory levels of an item over time. The graphic shows initially the inventory level of an item dropping steadily because of usage of this item. When the inventory level is at a certain level, called the **reorder point (ROP)**, a purchase order is issued for the item. After the passage of a certain length of time, referred to as the **lead time**, this order is filled and the inventory level increases by the amount of the order, *Q*. This cycle of inventory depletion and order fulfilment repeats itself. Note also that in the diagram the inventory level is kept above a certain amount, called the **safety stock**. Various questions arise, such as what level of safety stock should be held, what should be the ROP, and what should the order quantity be. Let us look at the cost considerations of order quantity first.

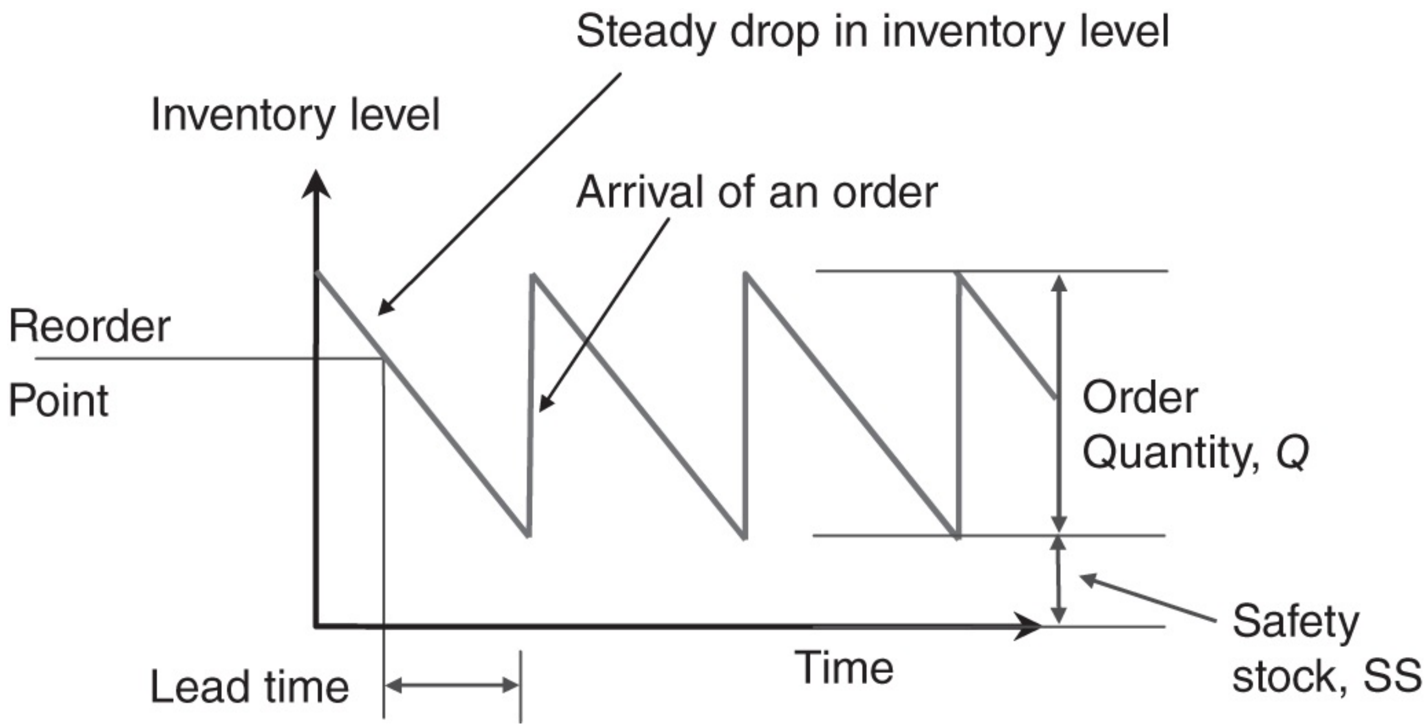

Figure 10.1 Inventory build-up and depletion

(Source: C. Basnet and P. Childerhouse (2016); Reproduced with permission of John Wiley & Sons.)[1]

Calculating the annual costs to buy this item is straightforward, since the usage per year is D units and the price per unit is p (\$).

$$\text{Purchase cost} = p \times D$$

Annual holding cost – which we defined in the Introduction section above – can be calculated based on the average inventory held. From Figure 10.1, the maximum inventory held is $SS + Q$, decreasing gradually to minimum inventory level, SS. Thus, the average inventory held is:

$$\begin{aligned}&\text{Average inventory level} = (SS + Q + SS)/2 = SS + Q/2\\&\text{And the annual holding cost} = (SS + Q/2)H\end{aligned}$$

Since D is the annual usage of the item, and each time an order is placed for this item the number of items purchased per order is Q, the number of orders placed over the whole year is D/Q. The annual order processing cost includes the cost of identifying the supplier, preparing a purchase order and receiving the item. If S is the order processing cost per order, we can calculate the annual order processing cost:

$$\text{Annual order processing cost} = (D/Q)S$$

Adding these three costs, the total annual inventory costs associated with this item are calculated below.

$$\begin{aligned}\text{Total annual cost } (TAC) &= \text{Purchase cost} + \text{Holding cost} + \text{Order processing cost}\\&= pD + (SS + Q/2)H + (D/Q)S\end{aligned}$$

How does the order quantity Q influence the total annual cost? The effect of changing the order quantity from small to large is illustrated in Figure 10.2. With a small order quantity, there is a large number of orders, but smaller average inventory holdings. When the order quantity increases, fewer orders are placed, with a consequent rise in average inventory holding.

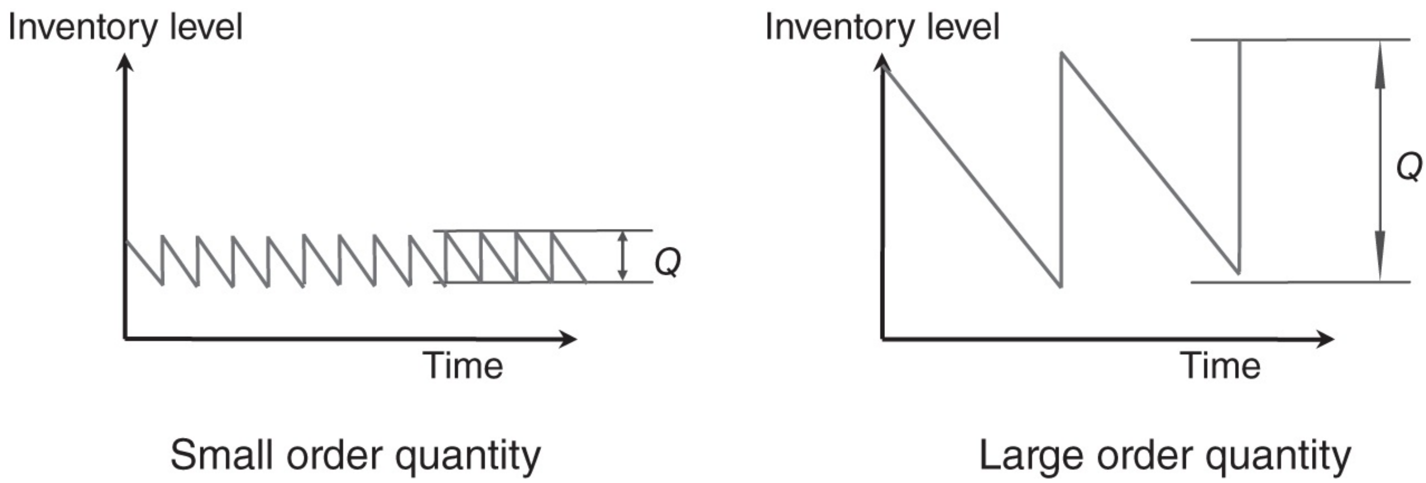

Figure 10.2 Small versus large order quantities

(Source: C. Basnet and P. Childerhouse (2016); Reproduced with permission of John Wiley & Sons.)[2]

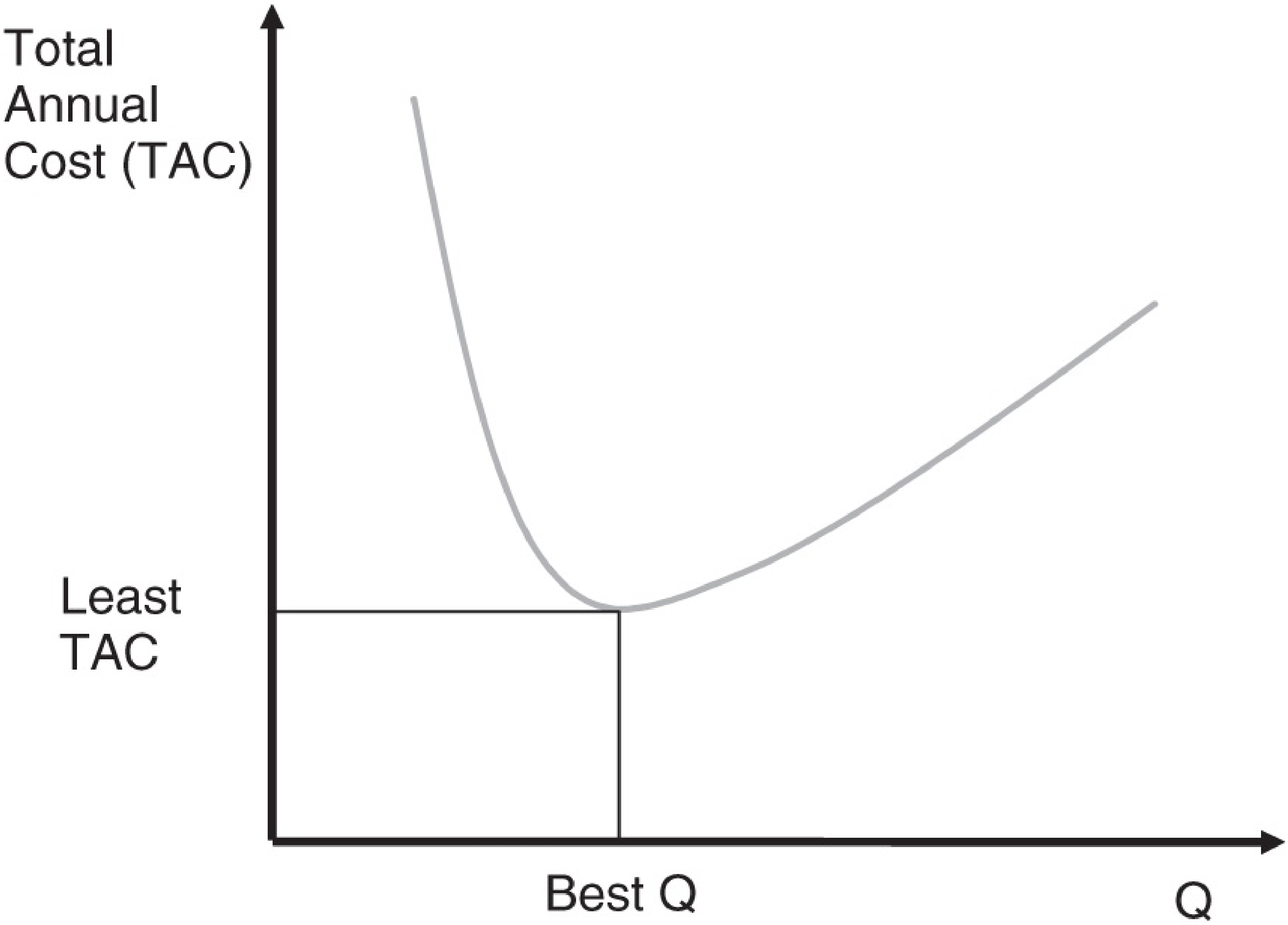

Figure 10.3 Order quantity versus total annual cost

(Source: C. Basnet and P. Childerhouse (2016); Reproduced with permission of John Wiley & Sons.)[3]

The variation of total annual cost with order quantity is shown in Figure 10.3. To minimise the total annual cost, there is a best order quantity, known as the **economic order quantity (EOQ)**, as depicted in the diagram. This represents a balance between order processing costs and inventory holding costs. With lower order quantities, there are too many orders; the order processing costs are high and dominate the total costs. With higher order quantities, the average inventory holding cost is high and dominates the total costs.

The order quantity that minimises the total annual cost is known as the EOQ and is given by (see the box below for an explanation as to how the EOQ is derived):

$$\text{EOQ} = \sqrt{\frac{2DS}{H}}$$

By ordering in lots of EOQ, the total annual cost is the lowest it can be.

It is relatively straightforward to derive the EOQ formula. Differentiating the expression for *TAC* and setting to zero for minimisation:

$$\frac{d(TAC)}{dQ} = 0$$

$$\Rightarrow \frac{d\left(p\times D+\left(SS+\frac{Q}{2}\right)H+\frac{DS}{Q}\right)}{dQ} = 0$$

$$\Rightarrow \frac{H}{2} - \frac{D\times S}{Q^2} = 0$$

We assume that the purchasing cost is constant (no quantity discounts). We also assume that the safety stock remains fixed as order quantity is changed:

$$\Rightarrow Q = \sqrt{\frac{2DS}{H}}$$

To confirm that this is indeed a minimal-cost order quantity (and not the maximal-cost one), we check that the double derivative is positive at this quantity and this confirms that the EOQ is the order quantity with the least total annual cost.

PROBLEM 10.2

Electronic Gadgets Company Beta sells laptop computers. Annual demand forecast for this product is 12,800 units. The order processing cost per order is $2500 and the inventory holding cost is $80 per unit per year. How many computers should the company order in one shipment? Also, calculate the number of orders per year and the expected time between the orders.

$$\begin{aligned} \text{EOQ} &= \sqrt{\tfrac{2DS}{H}} \\ &= \sqrt{\tfrac{2\times 12{,}800\times 2500}{80}} \\ &= 895 \end{aligned}$$

To minimise total inventory cost, Beta should request 895 laptops in each order.

$$\begin{aligned} \text{Total number of orders per year} &= \text{Annual demand /Number of laptops in each order} \\ &= 12{,}800\ /\ 895 \\ &= 14.3 \end{aligned}$$

$$\begin{aligned} \text{Expected time between the orders} &= 365\ \text{days}/14.3 \\ &= \mathbf{25.5\ days} \end{aligned}$$

In the case of a quantity discount given by a supplier, we may be tempted to order a larger amount and take advantage of the reduced product cost – but ordering in larger amounts increases the average inventory holding and associated costs. Hence a new trade-off needs to be considered. We need to express the cost of holding inventory in a way that incorporates the purchasing cost as a variable. To solve this requires a more advanced formulation of the standard EOQ model (which is beyond the scope of this book).

INVENTORY CONTROL SYSTEMS

Inventory control systems help inventory managers decide when to order inventory and in what quantities. Inventory control systems may be set up on the basis of the EOQ model discussed above. There are a number of important issues to consider in any inventory control system such as establishing a ROP, determining safety stock levels and ensuring in-transit inventory is captured, and these are now discussed in turn.

Reorder point

While the EOQ model helps to determine the order quantity, it is important too to know when to order. It becomes important when there is a lead time between placing the order and when the material is received by the company. The ROP can be calculated as follows:

$$\text{ROP} = \text{demand per day} \times \ \text{lead time for a new order to be received in stock} + \text{safety stock}$$

$$\text{ROP} = d \times L + SS, \text{where } SS \text{ is safety stock, } \ L \text{ is lead time and } d \text{ is demand per day (the last one can be calculated by dividing annual demand by the number of working days).}$$

If the company does not want to keep any safety stock, the ROP is $d \times L$.

Safety stock

Safety stock – also referred to as **buffer stock** – is the inventory held in the event that unforeseen issues lead to insufficient inventory being available to meet demand. It helps organisations to cope better with the variations of lead time, variations of production and variations of demand. How much safety stock a firm should keep is based on the service level the firm wants to provide to its customers (and these can be both internal and external customers). There is a trade-off between the cost of keeping excess stock and the cost associated with losing sales – and therefore customers – due to shortages or backlogs of unfulfilled orders.

In-transit inventory

In-transit inventory comprises those items that are in transit across a supply chain and includes both inventory being transported on ships, trains, trucks and so forth and also inventory that is being loaded and unloaded at ports, warehouses and other nodes along the supply chain. In some cases (e.g. the global distribution of newly assembled cars by deep sea ships), in-transit inventory can account for a large share of total inventory holding.

Most firms aim to reduce in-transit inventory. However, there can be exceptions to this. A key strategy of most organisations is to reduce the amount of inventory that they hold. In some instances, warehouses are eliminated altogether; this is especially the case when JIT is prevalent. One consequence of this is that sometimes companies use transport as a *mobile or rolling warehouse*. The mode of transport that they use may depend on how fast they want to get product to market. One industry professional describes this as the *gearbox approach* to inventory management: speeding up and slowing down the flow of inventory through the supply chain by using alternative transport modes. Indeed, technology is available to alter product conditions while in transit – the time it takes fruit to ripen, for example, can be increased or decreased depending upon the real-time demand profile downstream.

INVENTORY PLANNING AND CONTROL

A number of techniques, with associated software systems, have been developed to plan and control the movement and storage of inventory (and the related data and finance flows) along the supply chain. Note too that data are not the same as information: data aren't of much use unless we can interpret and use them (we will discuss this again in Chapter 13 which deals in depth with data and digitalisation). As these techniques have developed and evolved, they have facilitated enhanced visibility further upstream and downstream in the supply chain.

MRP, ERP and CPFR

A production planning technique known as **MRP – Materials Requirements Planning** – emerged in the decades following World War II. With advances in computing power and software capabilities, the reach and contribution of this technique increased. Today the modern derivative of MRP is **ERP – Enterprise Resource Planning** – which can span across multiple organisations both upstream and downstream in the supply chain.

The components of an MRP system are shown in Figure 10.4. Understanding how demand varies is a key aspect of MRP. Typically, we distinguish between products as having either **independent demand** or **dependent demand**. Products with independent demand are those that are ordered independently of any other products, whereas products with dependent demand are those whose ordering is dependent upon the demand for other related products. This concept can be explained using the example of a distribution centre (DC) that specialises in the storage and distribution of bicycles and bicycle components. Bicycles are delivered and stored as sub-assemblies, rather than as complete bicycles, so as to enable customisation to particular market requirements. The DC receives orders from wholesalers and retailers for either complete bicycles or bicycle spares (i.e. components). When customers order bicycle pedals as spares to be sold separately, this demand is 'independent' of demand for any other items. However, when complete bicycles are ordered, pedals are required to be picked from storage and fitted to (or packed with) the bicycles before shipping. Demand for these pedals is therefore 'dependent' on demand for the complete bicycles. Throughout a supply chain, any number and combination of various materials with either independent or dependent demand will be ordered. This creates myriad complexities for the various production plants, warehouses and DCs across the supply chain. MRP is the tool used for planning and controlling production and the associated orders and materials flows.

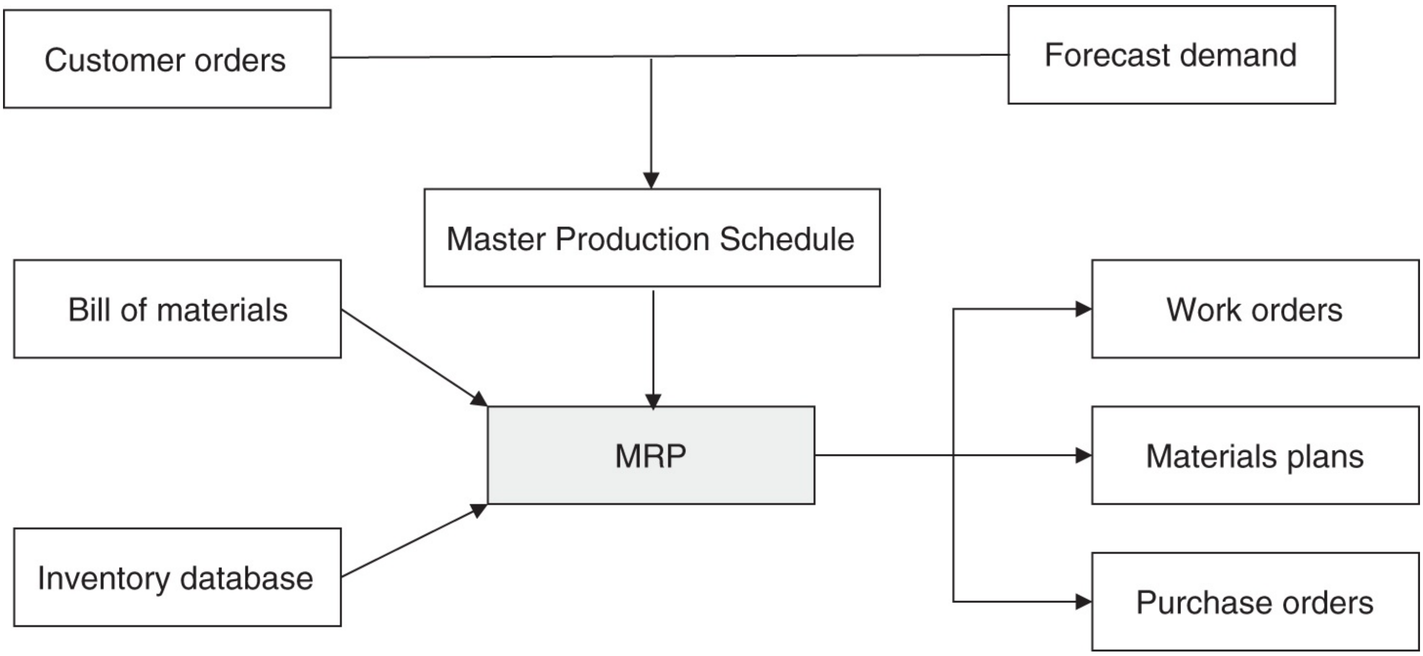

Figure 10.4 An MRP system

A combination of demand forecasts and customer orders are input into the master production schedule (MPS) (Figure 10.4), which informs the factory of what should be manufactured and/or assembled and when. The MPS drives the MRP process, it sets out the quantity and timing of the final products to be made. Production cannot, however, begin without the required materials, components and/or sub-assemblies. The MRP system therefore interrogates the bill of materials (the BOM – the list of materials and quantities required for each product (much like the recipe one might have for a cake)) to determine what is required and when. The inventory database is also interrogated to determine what materials are available on-site and what needs to be sourced from suppliers. Up to this point, no physical work has been done. The final stage is for the MRP system to generate work orders to trigger production and/or assembly, materials plans to call materials from in-house storage and purchase orders to be sent to suppliers.

As computing power and software capabilities have progressed, MRP systems have evolved and more advanced techniques have emerged – **MRPII**, known as **Manufacturing Resource Planning** – added other data sets to MRP such as financial and HR data. The next phase in the development of MRP systems has been to incorporate other firms beyond the manufacturer running the MRP such as upstream suppliers and downstream distributors and even customers – such systems are known as enterprise resource planning (ERP) systems. ERP systems require a substantial financial, resource and time investment at implementation and for ongoing maintenance and development. Many small and medium-sized enterprises (SMEs) cannot afford such an investment; however, scaled-down versions of ERPs are now also available from the major software vendors, allowing smaller firms too to apply some of the core functionality of ERP systems to their operations and wider supply chains. Some companies develop their own ERPs in-house; however, many purchase them from large vendors such as SAP and Oracle. A particular challenge in any supply chain is to ensure that smaller partners in the supply chain can 'plug into' the ERPs operated by the larger entities (such as big manufacturers and retailers) who dominate and take a lead role in the supply chain. Key features of ERPs include the following:

- Many comprise modules for different functions and processes (e.g. a module dealing with finance, a module dealing with customer orders and so forth).
- How these modules integrate is thus a key feature of the ERP's functionality. The various actors along the supply chain will have varying access to the different modules.
- Data format and standardisation, and systems interoperability, are thus central to the efficacy of ERPs – a supplier, for example, will need to ensure its IT systems can 'talk to' the retailer's ERP.

To ensure greater collaboration among all entities along the supply chain, a technique known as **CPFR – collaborative planning, forecasting and replenishment** – was developed and is particularly popular in the food and retail sectors. It is a supply chain–wide concept that seeks to ensure improvements in efficiency and integration through collaboration among supply chain partners and cooperative management of inventory, with a particular focus on information sharing and visibility. CPFR is more than just a software application bolt-on to ERP systems – it is a collaborative method of scheduling logistics between suppliers and customers. It is, however, dependent upon timely and accurate information sharing, visibility and transparency. Relationships then among supply chain partners are key. IT-enabled CPFR is essential in high-velocity supply chains such as those of the major supermarkets.

Vendor-managed inventory (VMI)

As with CPFR, VMI is more than just a software application. VMI is again self-explanatory. Simply put, customers, such as high-street retailers, outsource their inventory management to their suppliers. In some cases, although suppliers are accountable for the VMI system, they may elect to outsource it to a specialist third-party logistics company (3PL). Such collaborative arrangements are common in the fast-moving consumer goods (FMCG) sector. **Vendor-managed inventory** (VMI) can thus be described as the way the upstream stage of a supply chain takes responsibility for managing the inventories at the downstream stage (customer) based on previously agreed limits.[4] Dedicated VMI software solutions are available to manage the intricacies of such systems.

For VMI, a holistic view of inventory levels is taken throughout the supply chain with a single point of control for all inventory management. By enabling a vendor to manage stock replenishment at their facilities, a customer (such as a supermarket retailer) is effectively eliminating an echelon in the supply chain. In doing so, upstream demand visibility is improved to reduce the impact of demand fluctuations (i.e. the bullwhip effect as discussed in Chapter 5). Hence, VMI can enable supply to more accurately and precisely meet demand. VMI helps in shortening the lead time of replenishment and in reducing inventory costs.

Although VMI is today centred on an IT solution, the concept of a customer merely defining their requirements and their supplier being accountable for fulfilling them predates contemporary IT solutions.[5] A simplified VMI scenario is illustrated in Figure 10.5. As with ERP, the implementation of just a software application will not derive the full benefits of VMI. By essentially eliminating an echelon, certain logistics activities and information processes will either become redundant or be redesigned. Business process reengineering (BPR) is necessary to eliminate the non-value-adding activities created and to align the IT with the business processes. As with CPFR, significant investment in developing an appropriate collaborative relationship is a prerequisite to operating VMI.

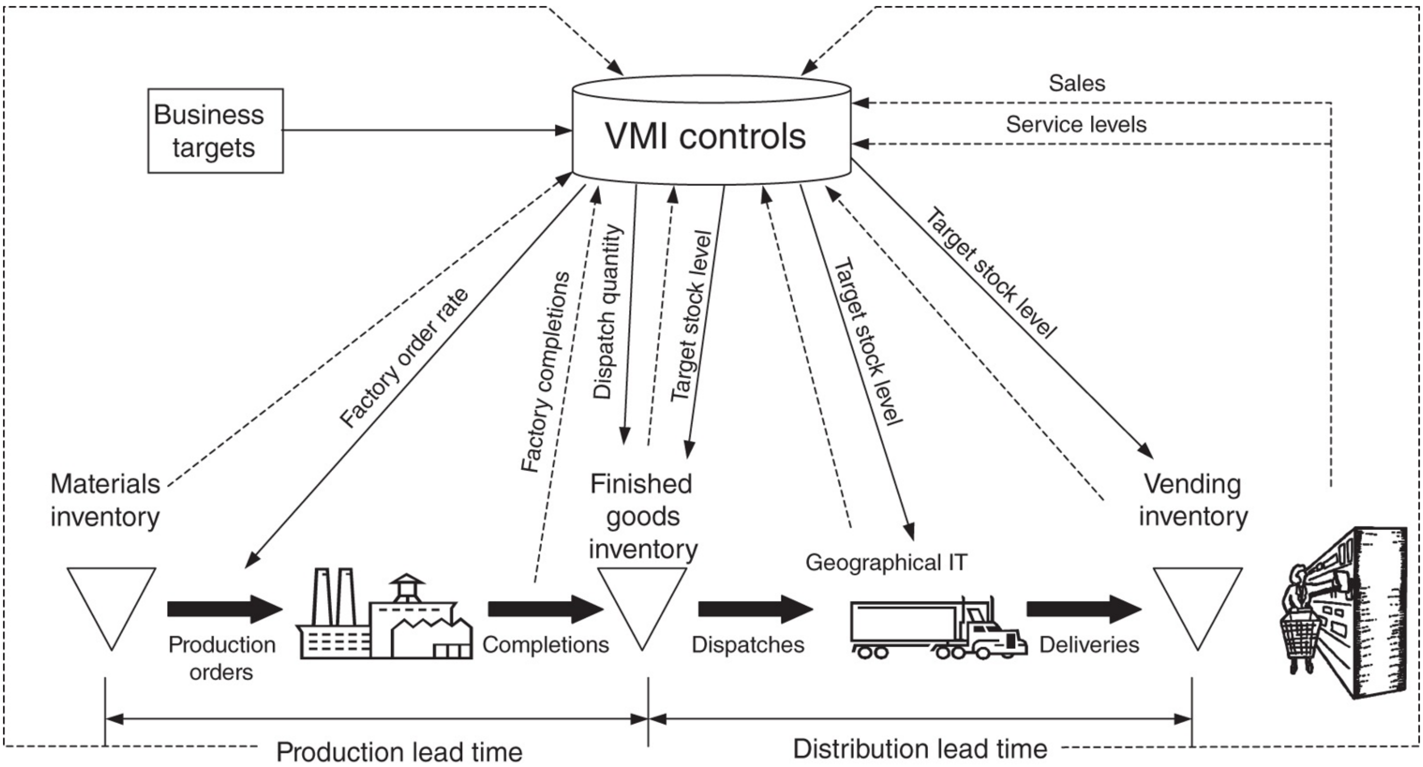

Figure 10.5 A simplified VMI scenario

(Source: Adapted from Matthias *et al.*, 2005)[6]

MANAGING LOGISTICS PERFORMANCE

Stakeholders in supply chains such as logistics service providers (LSPs) and contract manufacturers have to keep track of each transaction and ensure that they and their customers and partners can have access to information relating to this as and when it is required.

Measuring activities and collating data on these in the form of metrics is an important part of the work undertaken by these stakeholders. The software used by these companies and its ability to provide the requisite outputs and reports is key in this regard. The terms **metric** and **key performance indicators (KPIs)** are usually used interchangeably; however, while there may be many metrics, some will be more important than others and more accurate measures of important areas of performance, and are thus more correctly labelled as 'key performance indicators'. At least seven driving forces behind the increased use of performance measurement in an LSCM context can be identified:

- Increased reliance on contract manufacturers
- Strategic importance of LSPs to supply chain success
- Adoption of manufacturing management techniques, such as JIT and Six Sigma, has increased the demand for metric reporting
- Customer expectations
- A need for visibility around resource utilisation
- Information technology improvements
- Empowerment of employees – affording them the opportunity to have visibility of KPIs, and then using expectations of performance as a motivator

In the area of performance measurement, a useful maxim is to *measure results, not activities*. This is valuable advice, as it is all too easy to focus on simply assimilating data without necessarily understanding how these data may be used. When first trying to design a set of indicators, the focus should not as such be directed towards what data may be easily available, but rather towards what benefit one hopes to gain as a result of having these indicators in place. The majority of indicators should be focused on quantitative data. Although it is always good to add some qualitative measures to a set of KPIs, it is very important to stress that measures based on quantitative data can often be better for accurately comparing performance over time, and indeed for predicting future results. Also quantitative measures should in general be more reliable when comparing over time, as long as the data used to generate them can be replicated without error.

When deciding on which measures to use, a company should always ensure that benchmarking against other competing companies is not made impossible by its choice of metrics. Companies should always look to emulate best in class; however, without benchmarking, it can be very difficult to do this! Similarly, a company may wish to compare performance across several of its own sites, hence consistency in metrics use is important.

Evaluating the optimum number of measures is always a difficult task but is one that should be given some thought. Too many metrics will result in an unnecessarily large scorecard, with measures of lesser importance having the effect of just adding background noise while simultaneously making it an arduous task to actually identify the critical ones. The optimum scorecard will highlight the vital indicators needed to monitor the health of the organisation's key organs.

Choosing appropriate metrics

Deciding which metrics to track and report depends upon a number of factors, including relevance, ease of data reporting, customer requirements and appropriateness to the intended audience. It is important to differentiate the measures applicable to different levels within the organisation. KPIs that may be very important to the warehouse manager, for example, may not prove useful for senior management, and vice versa. When creating a set of metrics, it is generally useful to split the metrics into strategic/high-level metrics and more operational metrics. Table 10.2 details examples of both categories of metrics (note the distinction between both categories is not absolute and will obviously depend upon the context).

TABLE 10.2

Examples of strategic and operational KPIs in logistics and SCM

Strategic/high-level metrics	Asset utilisation (including labour – full-time equivalents (FTEs)) Inventory turnover Financial metrics – costs/profitability, return on capital, price fluctuations of key inputs such as oil Market share Carbon footprint
Operational metrics	Receiving and put-away Pick requests by unit/pallet etc. Order backlog Order lead time Failure/system downtime/dropped deliveries* Forecast accuracy Efficiency (in picking, delivery etc.) On-time delivery (OTD)/on-time in full (OTIF) Forward cover (amount of stock available) Aged stock on hand (obsolescence risk)

* A **dropped delivery** is a consignment that is not delivered for a variety of reasons (e.g. insufficient address details or consignee not present)

In practice many LSPs, for example, tend to have a generic set of metrics, and additional customer-specific metrics which would include measures relevant only to that customer. We will see too in Chapter 12 when we discuss outsourcing and related topics that companies generally put in place service-level agreements (SLAs) as part of a contractual agreement between a customer and a supplier to identify upfront the performance (i.e. service) levels expected.

Broader measures of logistics performance

Various tools and techniques have been developed to measure and improve organisation and wider supply chain performance. One such model is the Supply Chain Operations Reference (SCOR) model which was developed in the 1990s. It seeks to link business processes, performance metrics, practices and people skills into a unified structure; it is hierarchical in nature, interactive and interlinked.[7] The model provides a systematic framework for supply chain improvement and has been used in a variety of sectors including automotive, aviation and footwear.[8]

Of course, companies will also have other metrics that they track beyond the domain of LSCM. While financial metrics are obviously central, there is an awareness of a need to track, too, other non-financial metrics. This is the basis of other approaches such as the 'balanced scorecard approach' first introduced in 1992 by Kaplan and Norton.[9] It has become a very popular tool for measuring a firm's performance in the widest sense, and it has been used across a wide variety of sectors and firm types. It reviews performance across four different perspectives namely[10]: financial or stewardship, customer and stakeholder, internal process, and organisational capacity or learning and growth. It is, of course, possible to relate performance measures used in these four perspectives of the balanced scorecard with elements of LSCM performance.

LEARNING REVIEW

This chapter explained the significance of inventory in LSCM and described the costs associated with inventory management. Common inventory control systems and strategies used to reduce inventory-related costs were introduced and the EOQ model was described. Techniques and metrics used for supply chain planning and control were illustrated, and wider performance measurement and improvement tools – namely the SCOR model and the balanced scorecard – were also introduced.

Now that we know how to manage inventory and its associated costs, the next chapter will explain how to physically handle inventory and introduces related topics such as warehousing and handling automation.

QUESTIONS

- Explain how a reduction in lead time can help a supply chain reduce its inventory buffer without hurting customer service.
- Why are Internet retailers often able to provide a variety of different products for sale with less inventory than traditional 'bricks-and-mortar' retail stores?
- Why should a customer be concerned about transit inventory cost if they pay for the inventory only when the merchandise arrives at their premises?
- How do ERP systems differ from MRP systems?
- Discuss the factors that should be considered when choosing appropriate supply chain performance metrics.
- How does the balanced scorecard differ from the SCOR model?

NOTES

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11
Materials Handling and Warehousing

LEARNING OBJECTIVES

- Define the role of warehousing in supply chains.
- Explain how materials movements are planned and controlled.
- Describe materials handling processes within warehouses and distribution centres.
- Offer insights into how warehouses are managed, technology is employed and how work is organised.

INTRODUCTION

Chapter 10 introduced the theory and practice of inventory management. This chapter will focus on the logistics operations that store and handle those inventories. As well as needing to know how much inventory we have in our supply chains, we also need to know how and where to store it. In this chapter, we will also discuss the processes, technologies and people employed in warehousing and materials handling.

Chapter 11 comprises five core sections:

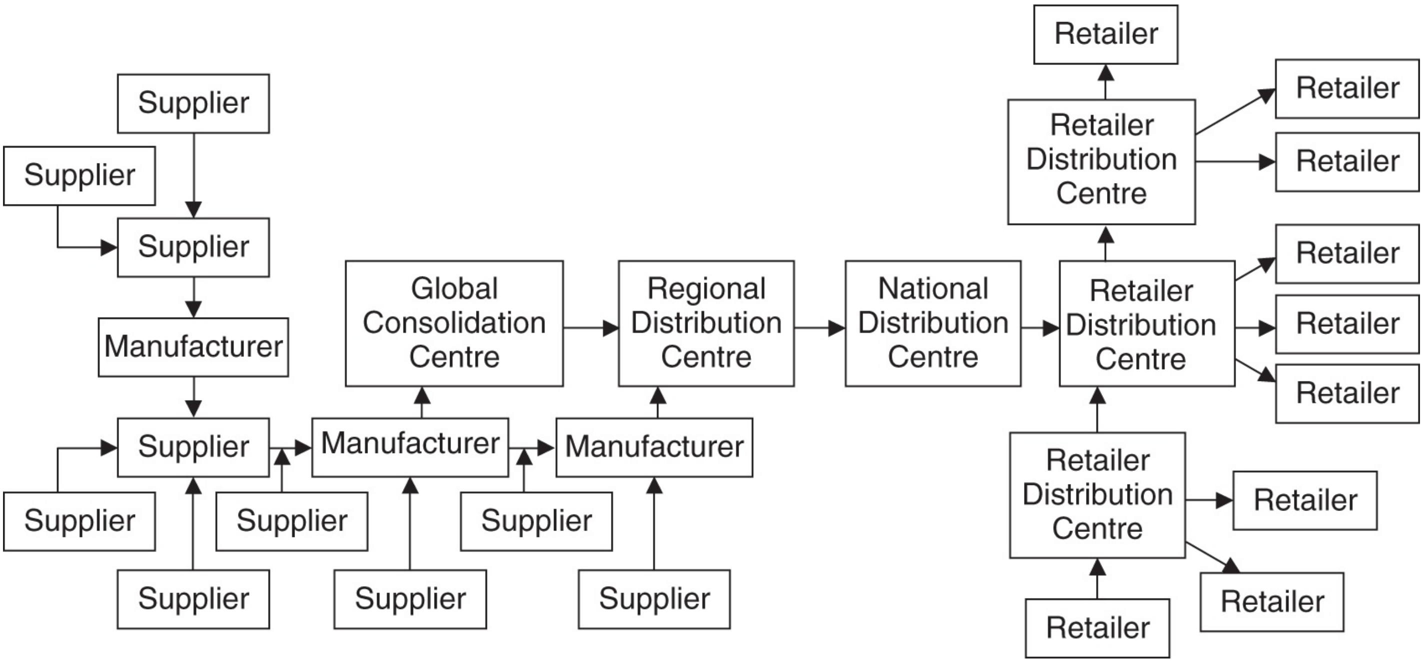
- Warehousing in global supply chains
- Warehouse layout and design
- Warehouse management systems
- Materials handling and storage
- Work organisation and job design

WAREHOUSING IN GLOBAL SUPPLY CHAINS

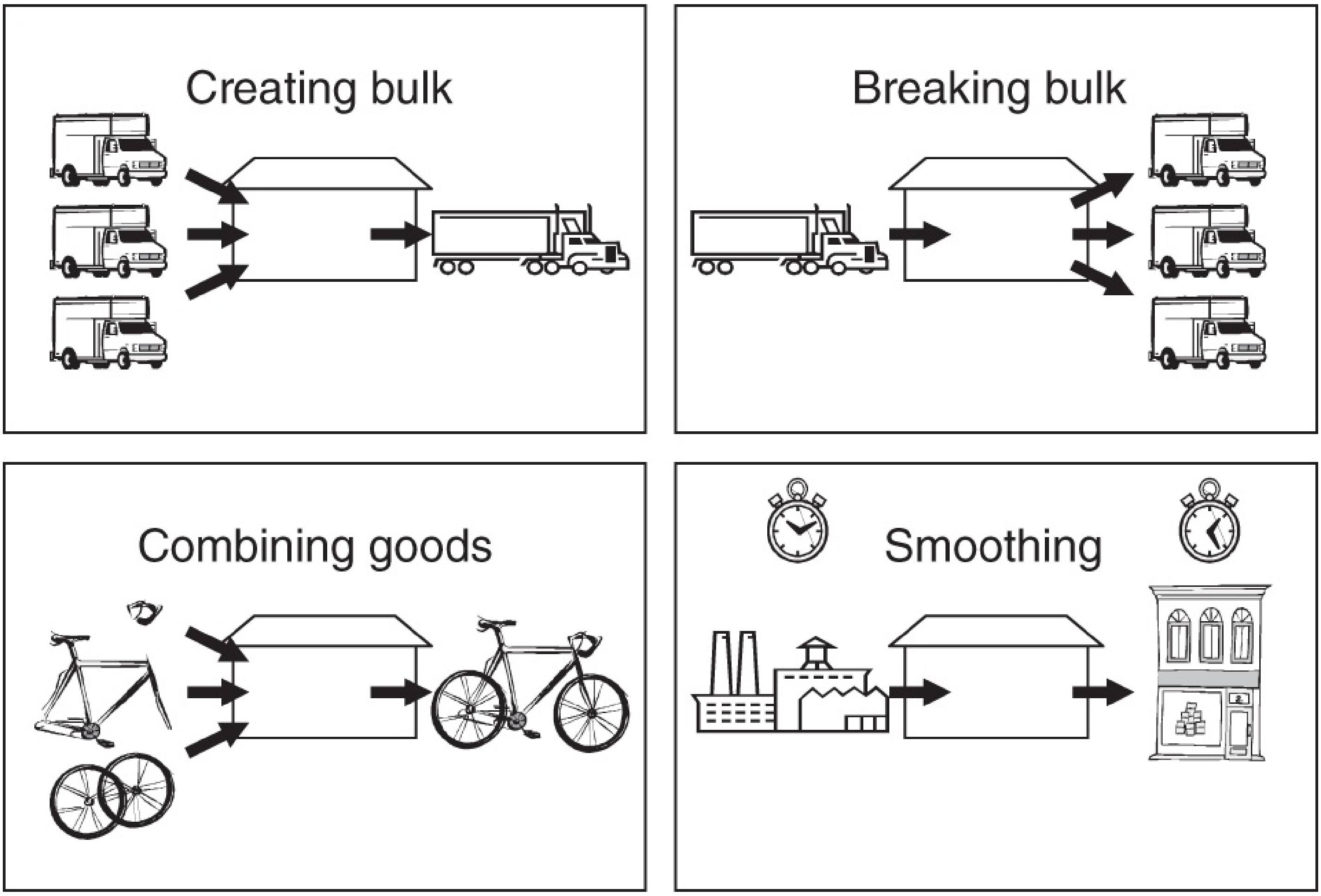
Global supply chains commonly comprise multiple echelons, spread across various international locations. As well as extended in-transit inventory travelling between disparate locations, supply chains also have inventory stored at multiple stages in various states of manufacture or assembly. Hence warehousing and materials handling systems have become highly sophisticated to maintain the flow of freight to the end customer. At each echelon, different types of warehouse perform different functions.

Many different networks of warehouses are possible ranging from a single global distribution centre to multiple depots within a single country. These are often combined as shown in Figure 11.1 with, for example, manufacturers having networks that feed products into retailer networks. It is often best to have a single inventory holding level within a supply chain, which can provide sufficient buffer stock to decouple lean production (normally based on forecasts) from an agile supply chain that serves volatile markets (based on specific customer orders). In some situations, this inventory holding level may be at a global distribution centre level (e.g. for high-value, low-volume products, such as silicon chips) or at the local level (e.g. for low-value, high-volume products that may be required on very short lead times, such as photocopy paper). Being able to achieve inventory holding at a single level often requires close collaboration between all parties in the supply chain involving open and rapid exchange of information.

As discussed in Chapter 10, inventory holding is a cost we would rather not have. A supply chain not only incurs the cost of the inventory itself, but also the fixed asset costs of warehouses and plant such as racks and forklifts and the associated costs of labour and administration. Hence, the conventional view of warehousing is of it being a costly necessity of an inefficient supply chain. Whilst it is true that we must seek to minimise inventory holding and handling, the paradox is that contemporary supply chains require inventory staging posts more than ever before. Material storage and handling systems therefore have two key objectives: to minimise cost *and* to add value. That is to say that if warehouses and distribution centres are essential to global supply chains, they should complement other supply chain activities to ensure effective and efficient delivery of freight to the end customer.



[Figure 11.1](#) **A typical map of warehousing operations in a global supply chain**



[Figure 11.2](#) **Using warehouses to add value**

(Source: Jessop & Morrison, 1994; Reproduced with permission of Pearson Education.)[2]

Value-adding activities are those supply chain activities that enhance products to increase the customer's perceptions of those products' benefits.[1] Customer value can be added to a product in warehousing by, for example, improving its quality during storage (e.g. maturing whiskey, wine, cheese or cured meats), by performing tasks such as packing and labelling, and by reducing lead time (e.g. cross docking – this will be explained later). Warehousing operations can achieve each of these objectives in various ways, such as for example:

- Creating bulk consignments
- Breaking bulk consignments
- Combining freight
- Smoothing supply to meet demand

These material related value-adding activities are illustrated in [Figure 11.2](#) and discussed further in the next section on warehouse layout and design. In addition, warehousing plays an increasingly important role in manufacturing and logistics postponement (recall our discussion on mass customisation in [Chapter 3](#)). With the recognised benefits of postponing final assembly and combining freight and/or packaging, downstream distribution centres today offer much more than just storage and handling. Hence such facilities include assembly and packaging processes to ensure that order fulfilment can occur as close to the end customer as possible, postponing stock handling until the order is confirmed. In this way, the number of product lines that need to be held only comprise those of the base components rather than all the varieties of the final products that could be demanded. This postponement concept can therefore be used to reduce inventory significantly, where appropriate.

Increasingly, global supply chains are as concerned with information flows as they are with material flows. Hence information-related value-adding activities such as product tracking and cycle counting are also essential warehousing functions that improve supply chain performance.

> Warehouses should aim to provide value-adding services as well as minimise operating costs.

This chapter will continue by explaining how modern warehouse operations are designed to not only maintain the flow of freight but also enhance its perceived value.

WAREHOUSE LAYOUT AND DESIGN

All activities within a warehouse can be associated with one of the four functions illustrated in Figure 11.3.

Warehouse layouts should be primarily designed to optimise the flow of freight through these four functions. However, warehouse designers should also aim to achieve optimal output, reduced costs, excellent customer service and sound working conditions.[3] At the freight receiving area, core activities include unloading, unpacking, quality control inspection and recording the receipt of freight. From here freight will follow one of two possible routes: either to 'put away' or directly to freight dispatch. This second option is referred to as 'cross-docking', which is discussed below. At 'put-away', freight is moved to a reserve storage location, either manually or via materials handling equipment (also discussed later).

When required, freight is moved from reserve storage locations to pick locations. This activity is known as replenishment, as this movement is normally triggered by the quantity at the pick locations falling below a predetermined level (the reorder point, as shown in Chapter 10) and therefore needing to be replenished. When orders from customers are received, a 'pick list' is created and items are 'picked' from the pick locations and 'packed' ready for 'dispatch'. During these two processes, freight will be either broken down from a bulk consignment, grouped into a bulk consignment, combined with other freight or simply held until required, thereby meeting one of the four objectives in Figure 11.3. At dispatch, freight and associated information are inspected against the original order and moved to the shipping area.

No matter what the scale of a warehouse is or its role in the supply chain, the four core functions in Figure 11.3 will be necessary. This may involve a number of processes. These processes must be designed to suit the freight and materials being handled and stored, and to minimise movements and handling. This can be achieved by minimising the distance that freight travels through the warehouse and/or through automated handling systems such as cranes, conveyors or AGVs (automated guided vehicles). In doing so, processes are standardised to reduce human error and therefore maintain the quality of the freight. Figure 11.4 illustrates three common warehouse layouts designed to reduce freight movement and handling.

Note that the boxes in Figure 11.4 labelled A, B or C refer to the ABC classification system described in Chapter 10 where freight classified A is frequently ordered, B less so and C is rarely ordered.

Cross-docking bypasses the storage areas in warehouses and distribution centres - in cross-docking inventory is not put into storage but instead moves from the receiving area to the dispatch area of the warehouse. Storage should be avoided unless the freight requires one of the four value-adding activities in Figure 11.2, otherwise storage is costly and non-value adding. 'Creating bulk' and 'breaking bulk' are normally associated with transport economies, while 'combining goods' is part of the production postponement principle. 'Smoothing' is associated with holding buffer stock to decouple lean production from the agile supply of goods to the market. As mentioned earlier, this is often at a single inventory holding level and freight is frequently cross-docked rapidly through the supply chain down to this level and then cross-docked again after that level through to the final customer. Cross-docking reduces cost and improves customer service by accelerating the processing of freight requiring reshipment. In bypassing put away, storage, picking and packing, the associated costs and non-value-adding functions are eliminated to enhance customer service. Cross-docking is typically employed for fast-moving freight with constant demand that spends less than 24 hours on-site.[5] This function is therefore a key enabler of quick response logistics as it will maintain the flow of freight and reduce lead time.

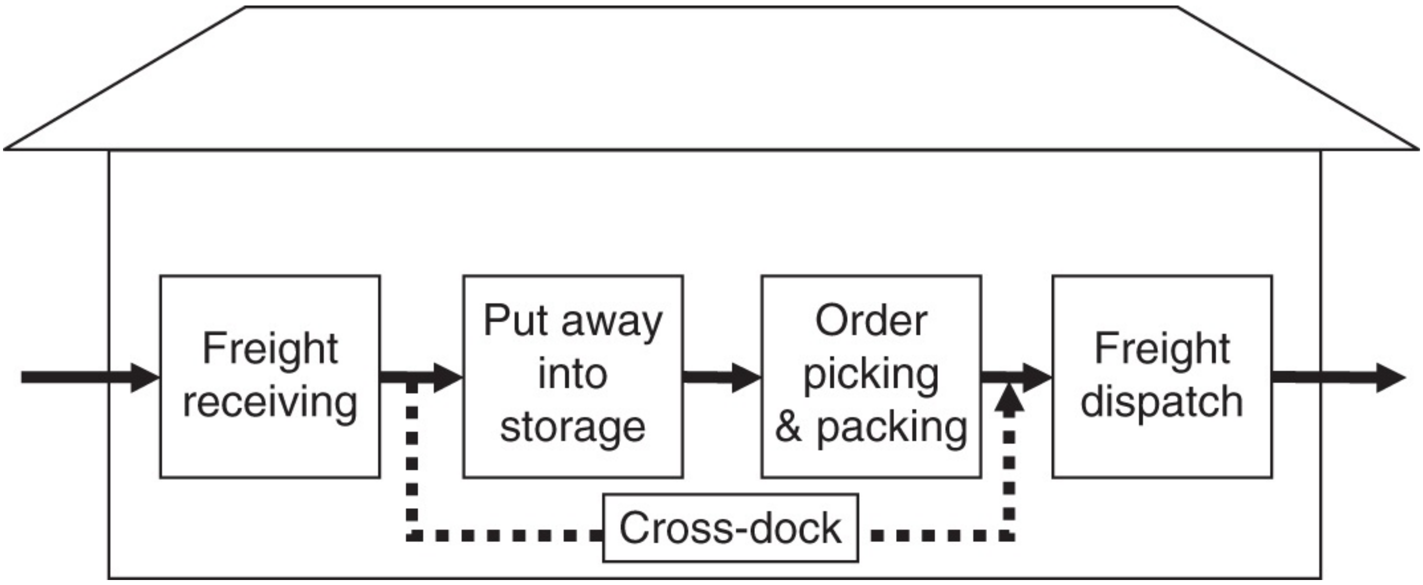


Figure 11.3 Generic warehouse functions

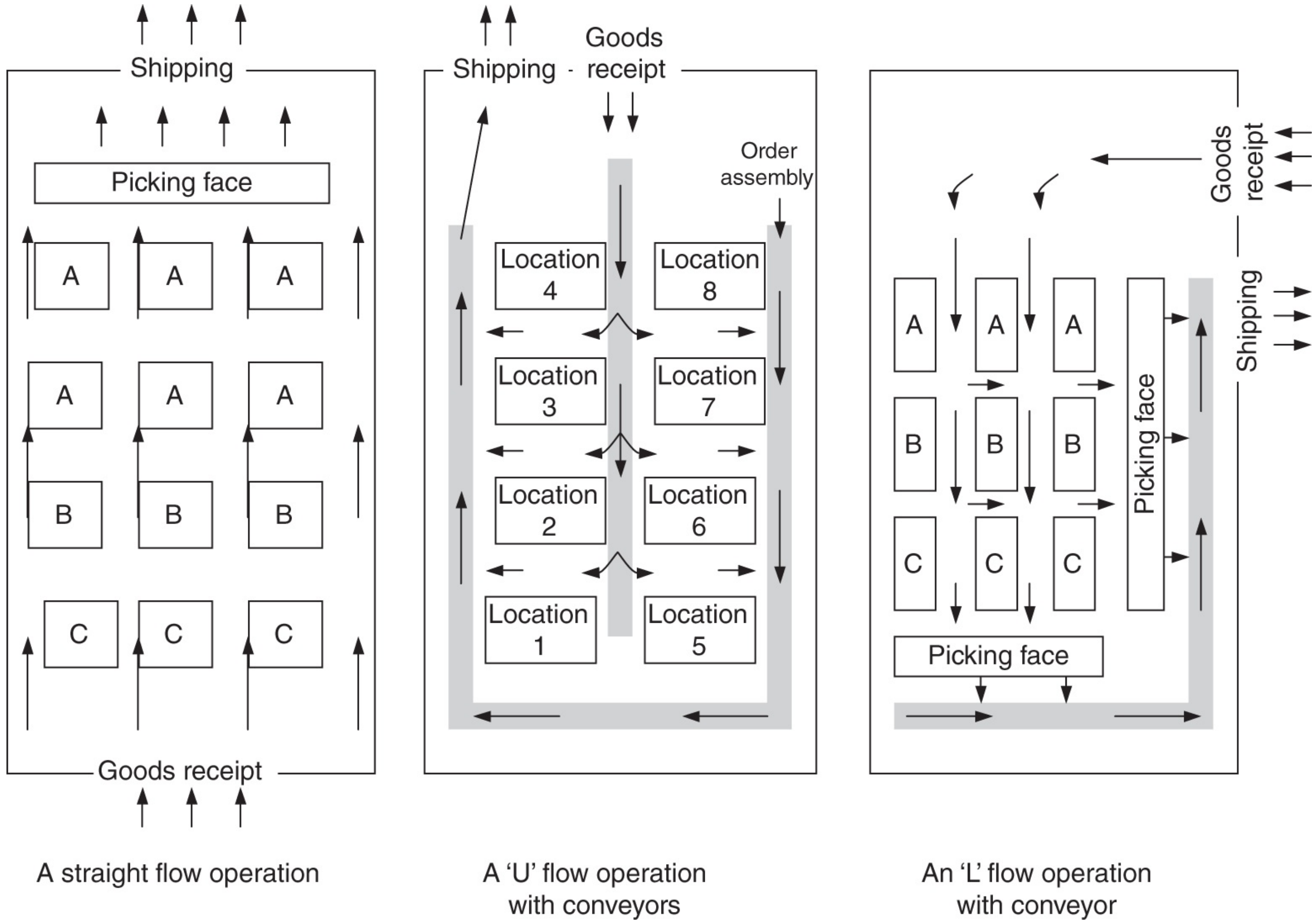


Figure 11.4 **Three warehouse layout examples**

(Source: Warman, 1971; Reproduced with permission of Pearson Education.)[4]

Besides the primary focus on freight flowing down the supply chain, contemporary logistics operations must also manage the reverse movement of freight in the form of defects and customer returns. The impact on warehousing is the requirement for additional processes to inspect, redirect and/or re-store such freight. Furthermore, concerns about the environmental impact of freight are driving legislation such as the EU's Waste Electrical and Electronic Equipment (WEEE) Directive to require producers to reduce, reuse and recycle. Such developments lead to increased interest in reverse logistics. Clearly, in global supply networks, warehouses and distribution centres play an important role in managing the upstream movement of freight that has reached the end of its usable life. Whilst distribution centres located downstream will store or redirect end-of-life freight, reverse logistics warehouses may employ processes to disassemble freight, and reuse or recycle their components. Chapter 16 will discuss reverse logistics in more detail.

WAREHOUSE MANAGEMENT SYSTEMS

A management information system such as an enterprise resource planning (ERP) system (discussed in Chapter 10) defines the material requirements that are transmitted to the warehouse or distribution centre for a **warehouse management system** (WMS) to manage the information processes within the warehouse. As alluded to previously, product proliferation in the supply chain creates complexity in the warehouse. A WMS manages this complexity to trigger the right work at the right time across the operation to meet demand, as illustrated in Figure 11.5.

> A warehouse management system comprises software that manages materials and freight movement throughout the warehouse. It may interact directly with automated handling equipment and / or provide work instructions for operatives. It will also interact with, or be a component of, a wider ERP system.

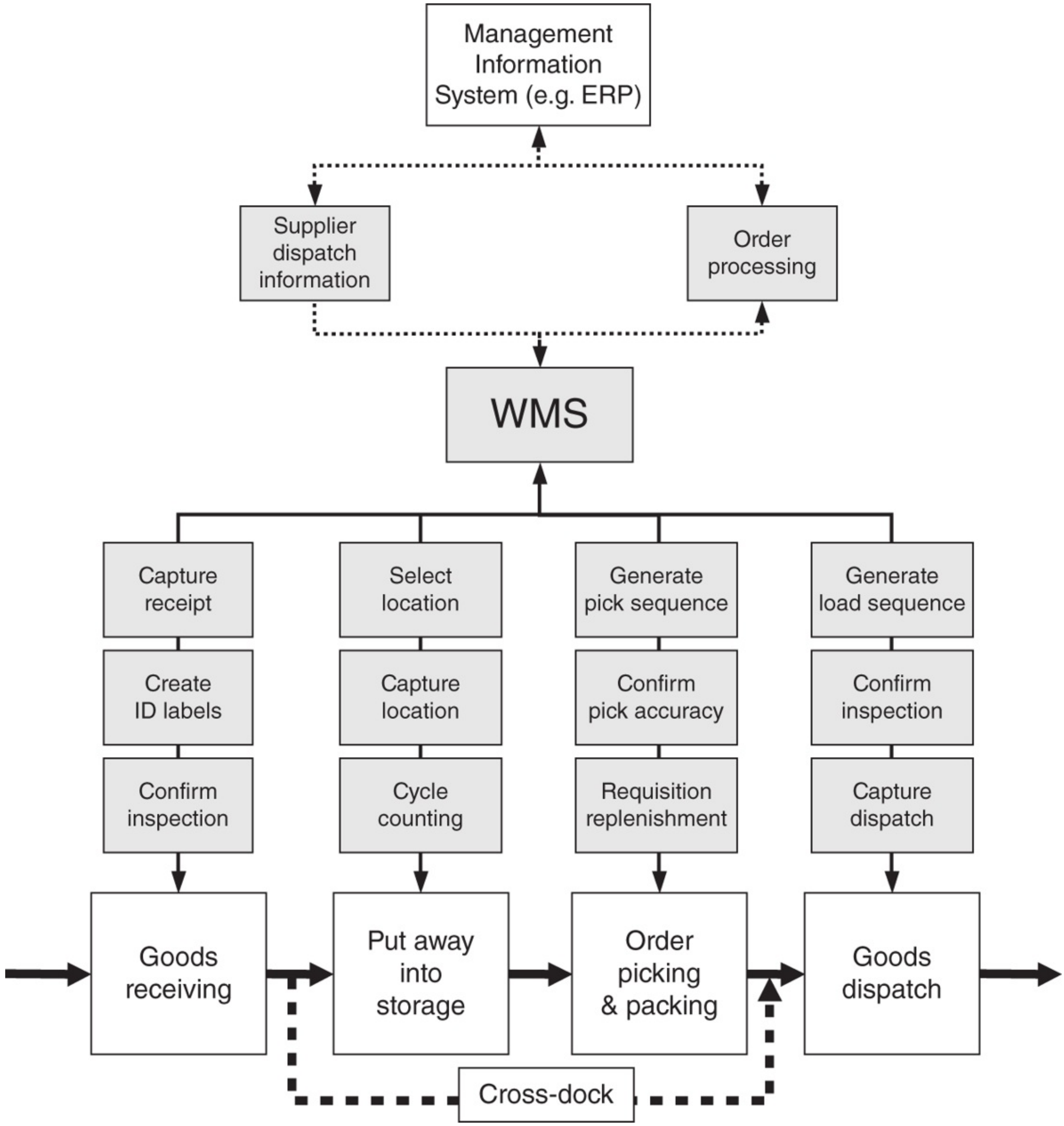


Figure 11.5 WMS information inputs and outputs

TABLE 11.1	
WMS data capture and transmission technologies	
WMS information task	**Technology used**
Capture receipt	Read bar code or RFID tag (via handheld or fully automated)
Create identification labels	Print bar code label or RFID tag (via PC/handheld or fully automated) (if required)
Confirm inspection	Read bar code or RFID tag (via PC/handheld)
Select location	Normally determined by WMS
Capture location	Read bar code or RFID tag (via handheld or fully automated)
Cycle counting	Assistance provided by WMS
Generate pick sequence	Determined by WMS
Confirm pick accuracy	Read bar code, RFID tag or verbal confirm (via handheld, fully automated or pick-to-voice)
Requisition replenishment	Determined by WMS
Generate load sequence	Determined by WMS/TMS (transport management system)
Confirm inspection	Read bar code, RFID tag or verbal confirm (via handheld, fully automated or pick-to-voice)
Capture dispatch	Read bar code, RFID tag or verbal confirm (via handheld, fully automated or pick-to-voice)

Information may be manually or automatically uploaded and downloaded to and from a WMS. Increasingly, electronic data capture is proving to be more effective and efficient than conventional paper-based systems, particularly at the shop floor. Warehouse operatives undertaking various information tasks are more likely to use handheld RF (radio frequency) or bar code readers, desktop and laptop computers, smartphones and tablets, label printers and pick-to-voice technologies. Each of these technologies aims to minimise human effort to reduce the time taken, errors and costs in information handling. Furthermore, processes are standardised to improve accuracy and repeatability. Meanwhile, some information tasks may be fully automated within the WMS by integrating radio-frequency identification (RFID) technologies.[6] Table 11.1 lists particular technologies for selected information tasks.

Chapter 13 will discuss in more detail the role and application of information technology in LSCM.

MATERIALS HANDLING AND STORAGE

The automation of shop-floor information tasks is a relatively recent development in warehousing, but materials handling mechanisation and automation are well established. Cranes, forklifts, reach trucks, pallet trucks, AGVs and conveyors are widely used to minimise human effort and intervention. The term **MHE – materials handling equipment** – is commonly used to describe the various types of equipment for handling freight. As in automated information tasks, automated materials handling improves and standardises warehouse performance by minimising human intervention. A further consequence is the optimisation of warehouse space. By employing mechanical and automated handling technologies, floor space between storage locations can be minimised and the locations themselves are able to occupy multiple levels. Increasingly, automated MHE is being used in warehouses to improve productivity – rather than a picker walking to a location to retrieve the freight, a robot can go and pick the freight and take it back to the picker for checking and packing.[7] There have been incredible advances – by companies such as Amazon – in robot technology for use in warehouses. Combining robots with some of the data analytics techniques we will describe in Chapter 13 is a powerful combination (e.g. giving robots artificial intelligence capabilities). Some companies too are engaging in 'frugal engineering' and developing simpler and cheaper robots that just follow set trajectories in the warehouse.[8] The Internet of things (IoT) – which refers to sensors and other types of instruments that can connect objects and machinery to computing systems – too is seeing increasing application in the warehousing context.[9] We will deal with IoT in more detail in Chapter 13.

Storage solutions vary depending on the volume, variety and throughput of freight in a warehouse or distribution centre. One or more of a variety of storage and picking systems may be used.

PALLET DIMENSIONS

OOCL, a global LSP, describes the two major types of pallets: Euro-pallets and standard pallets.[10] The size of a Euro-pallet is 800 mm × 1200 mm per piece while the size of a standard pallet is 1000 mm × 1200 mm per piece. A 20-ft container can hold 11 Euro-pallets in one tier or 9–10 standard pallets in one tier, while a 40-ft container can hold 23–24 Euro-pallets in one tier or 20–21 standard pallets in one tier.

Pallet storage

In the case of palletised storage, the alternatives may be classified into 'dense' storage systems and 'individual access' systems. The former are suitable where there are many pallets of a product line and where it is acceptable for any of these to be accessed. On the other hand, 'individual access' systems are suitable where there are few (i.e. one, two or three pallets per product line) or where it is important for an individual pallet to be accessed (e.g. as in the case of a master whisky blender requiring a particular cask to incorporate into blended whisky).

The simplest and cheapest form of 'dense' storage is block stacking, where boxed and palletised freight is stacked in blocks on the floor. This enables excellent use of floor space (i.e. high-density stacking), but has height restrictions based on the weight of the freight (i.e. load crushing may occur if stacked too high).

Drive-in racking offers a basic frame to support block stacking. The racking framework has horizontal flanges on which pallets can be positioned by a forklift truck. This solution prevents load crushing because palletised loads are not stacked directly on top of each other. It also enables high-density storage by enabling forklifts to drive through empty racking, putting away freight in columns.

Pushback racking also offers high-density storage by storing palletised freight in rows on each rack (normally up to about four pallets deep). Whilst being effective in storing multiple pallets, their accessibility is limited. That is to say that to reach a pallet at the back of a rack, those pallets in front of it must first be removed. Hence, it is normal for rows to be made up of the same products, and last-in-first-out (LIFO) retrieval employed (as with the previous two systems).

Pallet live storage employs racks equipped with rollers inclined at a gradient to enable palletised freight to be put away at the back of the rack and roll down towards the front where it is retrieved. This facilitates first-in-first-out (FIFO) retrieval, which is obviously preferable for lifed items (i.e. items with a specified lifespan) such as fresh foodstuffs.

Powered mobile racking offers racking that can be moved along tracks in the floor to offer access to specific rack locations whilst maintaining high-density storage. This is a high-cost solution that requires floor reinforcement. Although this solution offers both 'dense' storage and 'individual access', it can be slow to operate.

Adjustable pallet racking (APR) is the most common 'individual access' solution. This basic form of racking enables forklifts to load palletised and non-palletised freight onto free rack space. The racks are normally positioned back-to-back so that access can be gained from aisles on either side of the racks. It is an affordable and flexible solution, but floor space utilisation is poor. To improve floor space utilisation, double-deep racking can be used (i.e. with double racks placed back-to-back). This sacrifices 'individual access' for greater density of storage and is therefore used where there are more than about four pallets per product line.

Narrow aisle racking is similar to APR and, as the name suggests, the aisles are much narrower. Specialised MHE such as narrow aisle pallet trucks and combi trucks are required, and this greatly increases the equipment cost, although these trucks do have the advantage of reaching higher than conventional warehouse reach trucks. As this system provides individual access to pallets within a reasonable floor space, it is a common solution in large warehouses.

Automated storage and retrieval systems (AS/RS) are common when storing high volumes and high variety in high densities. They are commonly used for finished products warehouses, particularly in regions where land values and labour costs are high.

Non-pallet storage

Although wooden pallets are the most common unit loads stored in warehouses, freight may be stored in a variety of other formats too, for example in cartons, in plastic tote bins (you will often see these in supermarkets, for example, where items such as packaged fruit and vegetables are stacked in these plastic tote boxes which are placed directly onto the supermarket shelf or display frame), bundled together in long loads (e.g. wooden boards), as individual items (e.g. large pieces of machinery) or as hanging garments. An advantage of some of these storage systems is that the product can be delivered and displayed in a shop without being removed from the storage device (e.g. garments hanging on a rail or fruit in wheeled totes). Indeed, there are examples of products which have been designed/engineered so that they fit with a preferred storage and materials handling approach – one example is specially cultivated fruit and vegetables. For small items, metal shelving is very common, arranged in aisles so that operators can access the inventory easily. Mechanised solutions for small items include vertical carousels, which contain shelves that rotate vertically by means of an electric motor, and horizontal carousels, which are similar in concept but contain modules that hang from an overhead chain and are rotated horizontally. There are also 'miniload' systems that are similar to pallet AS/RS, except that they are designed to handle plastic tote bins or cartons.

Order picking

Picking solutions also vary depending on freight volume, variety and throughput. A WMS is commonly programmed to offer different pick sequences depending on requirements.

The simplest sequence is pick-to-order, where the generated pick list will direct the picker to retrieve freight from multiple locations along a pick face or in storage in the warehouse to fulfil an order. Pick-to-order is most effective in low-volume operations and in situations where a customer may order many products that would fill a unit load, such as a roll cage.

Batch picking is an alternative sequence whereby many orders are combined together by the WMS and the picker then retrieves all products for those orders at the same time. This is an effective pick method but does require the subsequent sortation of products to orders, either manually or by means of automated sorters. This sequence is suitable for large-scale operations, where there is a large product range and yet customers may only order very few product lines per order.

Pick-to-zero or pick-by-line sequences are most effective when cross-docking freight. That is to say that where an inbound shipment is deconsolidated at the receiving dock, individual product lines are moved to the dispatch dock for sorting to orders, reconfiguring and/or repacking until no freight remains at the receiving dock.

Zone picking is a method of dividing up the warehouse for picking purposes, with each zone containing the pick stock of particular groups of products and pickers allocated to each zone. Zones may be picked at the same time and the various products brought together at packing or marshalling. Alternatively, a container (such as a tote bin on a conveyor, or a roll cage) may be part filled in one zone and then passed to another zone for further order completion. This is referred to as 'pick-and-pass'. Zone picking is normally adopted in operations containing a wide product range and it may be combined with pick-to-order or batch picking.

Wave picking refers to how orders are released to the picking area. It is a sophisticated sequencing method suitable for the inherent complexities of warehouses storing high volumes and varieties of high-throughput freight being packed into multiple shipments (as in FMCG). Zones are picked in parallel and individual items are then sorted and packed into specific shipments. Waves of orders are released to the warehouse for picking. When a wave of picks is complete, the next wave will commence.

Besides these sequencing methods, the way in which the picking occurs can be classified as picker-to-product, product-to-picker or automated picking. Where the operation is small or pick density is high (i.e. a relatively high proportion of the different product lines in the pick face may be picked in a single sequence), then picker-to-product is most effective. In its simplest form, this is where pickers go into the storage racks and retrieve the items on their pick list. Often this may be mechanised with the pickers riding on, for example, low-level order-picking trucks or narrow aisle picking trucks. Product-to-picker, on the other hand, delivers the freight to the picker who will select items on their pick list. Product-to-picker solutions increase effectiveness where pick density is low. Equipment examples include vertical carousels, horizontal carousels and miniload cranes, as mentioned above. A combination of these two concepts occurs in the case of a 'dynamic pick face' where miniload equipment delivers only those product lines to a pick aisle that are needed for the next pick wave. This 'product-to-aisle' process is then followed by a 'picker-to-product' process for the actual picking. This may be effective where there is a very wide range of slow-moving products. Automated picking may be employed where high variety and throughput coexist. For example, A-frame dispensers are commonly used to quickly and precisely pick and sort items such as pharmaceuticals. A further example is that of automated layer pickers that are employed to pick layers of cases from pallets.

DROP BOX LOGISTICS

Drop box or locker box logistics is a recent development in materials storage and handling. One of the disadvantages of a traditional warehouse is that there can be time delays in both getting freight into a (large) warehouse and then also retrieving the correct freight from this warehouse when it is needed. Think, for example, of the many different products that would typically be delivered to a large hospital each day. Within this mix of products, however, there may be some products that are urgently required. In an effort to bypass the delays associated with large warehouse systems, deliveries can be made directly to a dedicated drop/locker box which the end user will have access to.[11] A similar strategy is being employed to replenish pharmaceutical company sales forces and other categories of employees (field service engineers for example) who spend a lot of time away from base serving customers and require frequent replenishment of different products.[12]

Storage and picking combinations

From this discussion it is clear that warehouse designers must select the appropriate balance between storage and picking, plus the most effective and efficient solutions depending on volume, variety and throughput of freight in a warehouse or distribution centre. Figure 11.6 summarises this from a very high-level viewpoint.

Despite the obvious benefits of automation, technologies must be fit-for-purpose. That is to say that different warehouses and distribution centres serve different purposes. As alluded to above, a warehouse storing 20-m steel girders will require very different handling and information technologies to a supermarket national distribution centre (NDC).

Packaging

Packaging plays an important role in LSCM. The Jaguar Land Rover case earlier in the book, for example, discussed the role of packaging in the car supply chain. A key concern is to ensure the reuse or recycling of packaging. For example, it has been reported that IKEA has started using compostable mushroom-based packaging for its products.[14] Indeed, there is much ongoing research in the whole area of packaging technology – for example making packaging 'intelligent' by incorporating sensors and using developments in materials science to allow packaging change colour etc.

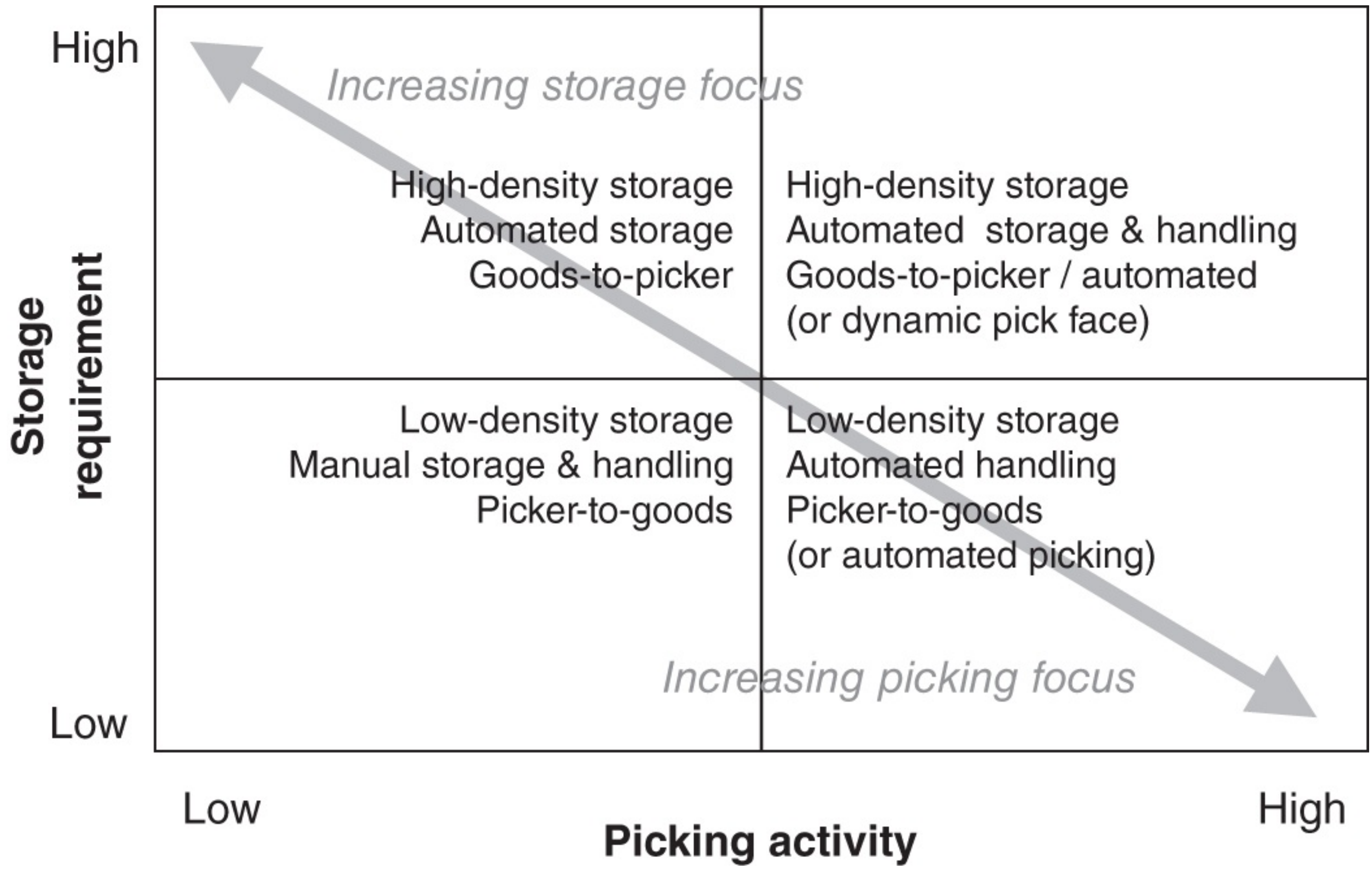


Figure 11.6 Prioritising storage versus picking

(Source: Strategos, 2010)[13]

While appropriate packaging is needed to ensure that product integrity is maintained, excessive packaging can lead to increased costs (larger/heavier products incurring higher transport and other costs). Packaging dimensions are often determined in turn by the dimensions of the pallets on which the products are to be carried – either to ensure that the product doesn't overhang the pallet or that small products do not shift while in transit on the pallet (in the latter case, you may use wrapping or ties to secure the product to the pallet or place slip barriers between products). Another consideration is whether the packaging can be used for marketing purposes or – in the case of high-value products – there may be a preference instead to use 'neutral packaging' so as to avoid shrinkage (i.e. theft).

WORK ORGANISATION AND JOB DESIGN

Another important consideration in implementing warehousing technologies is the impact of those technologies on the workforce. This is the focus of **socio-technical systems (STS) theory** (Figure 11.7). The fundamental principles of STS theory are as follows:

- Joint optimisation of the technical and social system
- Quality of work life
- Employee participation in system design
- Semi-autonomous work groups

Despite attempts in the 1980s to promote the vision of the 'lights-off factory', many automated factories and warehouses still remain dependent at least in part upon people. Labour remains the greatest cost in any operation, but in warehousing operators provide the dexterity, flexibility and adaptability to maintain high levels of performance. For example, it may be perceived to be more cost-efficient to replace a human picker with a robot, but it may not be cost-effective because the robot may not have the same dexterity or the ability to think laterally and multitask.

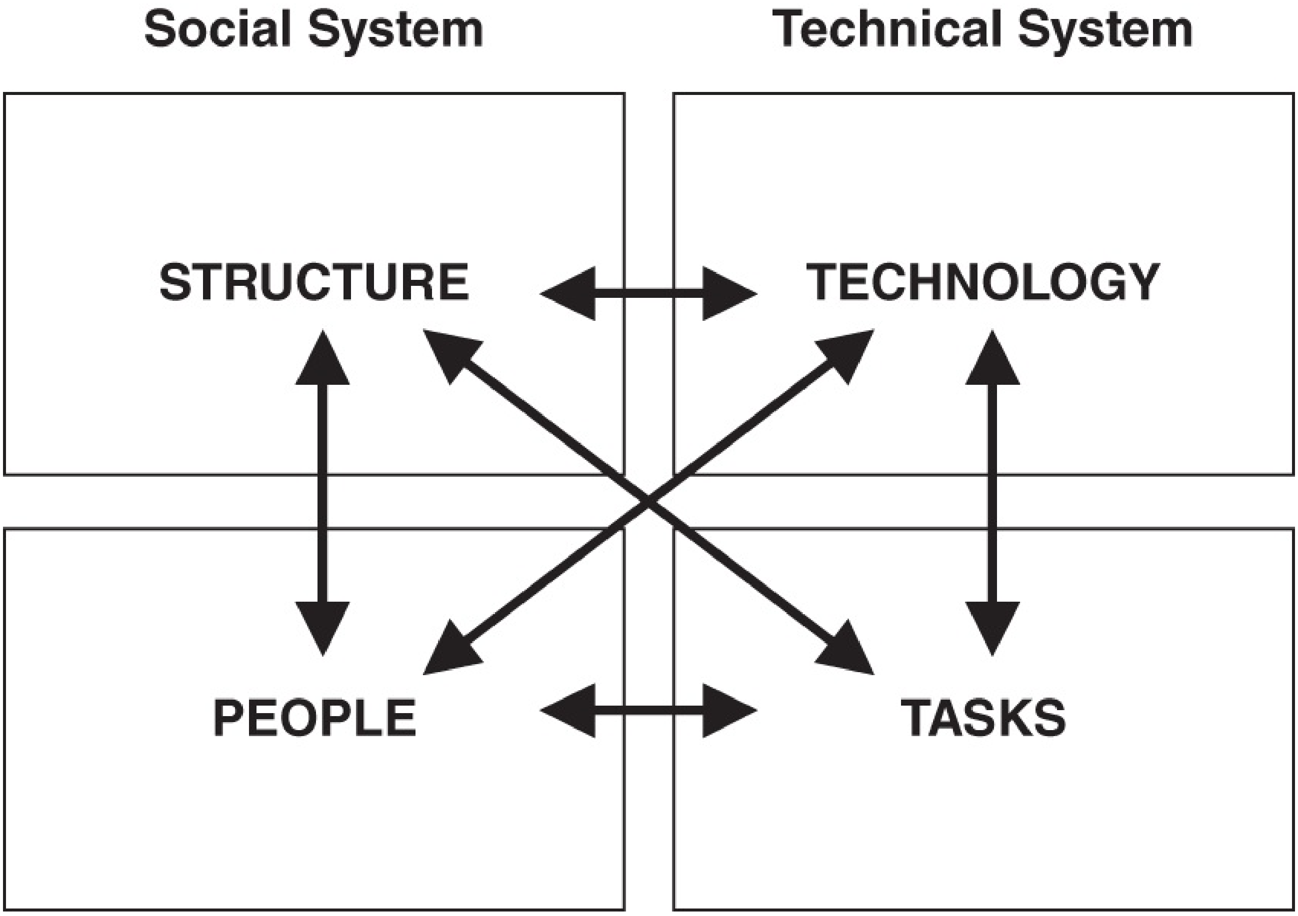


Figure 11.7 Socio-technical systems theory

(Source: Modified from Bostrom & Heinen, 1977)[15]

Addressing the four principles of STS theory, the capabilities of a social system (i.e. people) and a technical system should be balanced. There is no point in implementing high-tech solutions that operators cannot use. This also has a knock-on effect on workers' quality of work life. This will include human factors such as ergonomics (ensuring the workplace is designed such that employees can work safely, comfortably and efficiently). Unhappy workers are not effective workers. Indeed, this should be a key concern regarding the implementation of automation in warehousing. As discussed above, automated information systems and MHE have the potential to greatly reduce human input in warehouse operations. If STS principles are not adhered to, increased automation could result in reduced scope of work, reduced job satisfaction, demotivation and consequently reduced operational performance. The Liquor DC case below illustrates how maintaining quality of work life can result in improved performance.

LIQUOR DC, AUSTRALIA

A leading retailer in Australia operates two bespoke distribution centres (DCs) for the storage and supply of liquor products, one in Sydney, the other in Melbourne. Between them, these two DCs service the firm's retail outlets across Australia. Australian consumers buy liquor both in small quantities (i.e. as required) and in bulk (i.e. the monthly shopping trip). The major retail chains therefore operate two types of bespoke liquor stores: self-branded high-street outlets for the former and larger (often drive-through) superstores for the latter. Each sells similar products, but at different price points tailored to their respective markets.

This firm's Sydney liquor DC supplies New South Wales, Queensland and the Northern Territories. Besides liquor, it stores other products that liquor stores (i.e. bottle shops) stock, such as cigarettes. At 75% capacity, the value of the stock held is A$85 million. It is situated on the outskirts of the Sydney suburbs on an 11.2 hectare site. The floor space inside the DC is 53,000 square metres. The facility has 34,000 reserve locations and 4500 pick locations, and can handle between 1200 and 2000 pallets at the receiving bays per 10-hour shift, and 1600 pallets at the dispatch bays. The layout is designed for straight flow, with receiving on one side of the DC, and dispatch on the other. Between 300 and 400 staff are employed (depending on peak volume e.g. Christmas, Easter) across two shifts, there are 137 manual handling machines and 98 pick machines. The liquor DC currently carries 3500 SKUs.

The Sydney liquor DC employs a number of innovations that improve its effectiveness and efficiency. As employees enter the DC, they are greeted by a series of television screens. These provide a range of content through the day to communicate performance, achievements, health and safety information and general notices. Keeping their employees informed is a key motivator to identify with generation Y.

Other innovations include the following:

- An ‘info link’ system on all MHE that asks operators 12 health and safety questions before they can use that piece of equipment
- A one-way traffic system at the receiving doors to prevent collisions (‘in’ and ‘out’ doors with appropriate signage)
- Raised barriers at the pick face of gravity-fed racks for tall bottled products to prevent damage from overspills

Employee participation in system design is also important. The people who know how best to improve a process are often the people who work in it every day. Involvement encourages ownership and therefore improves motivation. Finally, ownership and motivation can also be promoted via semi-autonomous teams. Given sufficient autonomy, teams can self-manage and coordinate their work. Consequently, there is less of a burden on management through less referral of decisions.

Work organisation and structure are important considerations in contemporary warehousing. Market pressures drive down operational costs, but at the same time demand greater responsiveness, reliability and resilience. Supply chains cannot afford the time and cost associated with the complex hierarchical management structures of the past. Flat hierarchies and devolved decision-making via semi-autonomous teams goes part way to addressing this issue. Other considerations will include effective and efficient information and communication systems to facilitate improved management reporting and supply chain integration.

At the warehouse shop floor, the number and scope of individual job roles will be dependent upon the warehouse layout and design, types of products, processes and technologies employed. Nevertheless, typical job roles are focused around the four functions outlined in Figure 11.3 and include freight receipt, quality control, put away and replenishment, picking, packing and loading. Usually there are dedicated teams in each section. However, work in warehousing is generally regarded as standardised and unskilled, requiring minimal education and training. It is therefore realistic to expect operators in selected operations to rotate around different processes or even multitask (e.g. undertake put away, picking and packing) to maintain motivation. On any given day an operative could be working on any given task, or a number of different tasks. This promotes job enlargement (i.e. multitasking) and enrichment to maintain motivation and therefore employee retention.

Nevertheless, as previously discussed, increased automation is reducing the amount of manual handling and increasing the amount of information processing in warehousing. Job roles are changing. Warehouse operatives today interact more with information than they do with physical materials. This evolution has socio-technical implications. Conventionally, there has not been a requirement for unskilled warehouse operatives to read and write, or indeed to be fluent in a particular language. Within the EU, for example, workers are able to migrate across national borders for work. Hence, in EU-based warehouses, it is common to find employees from a number of countries, with differing levels of education and speaking in different languages. Thus written communication of information is not always the most effective mode of communication. Technologies such as pick-to-voice therefore play an important role in communicating instructions. Operatives receive verbal picking instructions via a headset in one of a number of preloaded languages. Operatives respond verbally either in the same language or another language, and normally confirm that they are at the correct pick location by speaking the location check digit into the microphone. They also confirm the number of items picked. In addition, this technology may be used with bar code scanning (or increasingly RFID), whereby the pickers also bar code scan the items to ensure that the correct products have been picked. The design of technologies appropriate to the capabilities of the workforce is therefore increasingly important.

> Automation and computerisation are reducing human intervention in the physical handling of freight, and increasing information interaction. This has implications for job design.

Finally, the reduction in physical handling tasks and increase in information tasks offers an opportunity for supply chains to engage their workforces in new and different tasks. With increased information, there is scope to use that information in new and innovative ways to further improve supply chain performance. Within warehouse semi-autonomous teams, opportunities are emerging for people to shift their focus from ‘doing’ tasks to ‘thinking’ tasks. Critical thinking, problem-solving and decision-making skills will therefore become important at the shop floor. Many warehouses now involve staff formally in continuous improvement programmes, for example, by displaying prominently key performance indicators, forming improvement teams and introducing improvement techniques such as six sigma.

THE DARK STORE

The growth of home shopping using the Internet to order groceries has affected the traditional supermarket sector. Initially, the retailers picked such Internet orders from existing stock on the shelves of their shops. More recently, however, dedicated warehouses – known as 'dark stores' – have been developed to service this growing market.[16] While they stock the same range of products as a typical store, they are dark in the sense that the customer is not present physically but is instead represented by a picking list.

LEARNING REVIEW

This chapter described the important role played in supply chains by warehouse operations and materials handling. We discussed the need to minimise the costs of warehousing and inventory holding, whilst maximising the value added in these essential operations. At different points in a supply chain, warehouses and distribution centres can perform different functions. Equally, different internal processes will be employed for handling different types of freight.

The role of the WMS was then discussed. The provision of such an information system enables precise management of freight as it moves through warehouses and distribution centres. We also discussed different storage and picking solutions that may be employed based on requirements. Nevertheless, the role of people should not be ignored. Hence the chapter continued with a discussion of the need to achieve equilibrium between people, processes and technology. We also introduced the various technologies that are being used to create smart warehouses. As warehouses become more high-tech, the important roles that people play must not however be neglected.

In this and the previous chapter we have shown how inventory is handled, managed and controlled and have detailed the associated considerations especially around cost. In the next chapter, we will consider how this inventory is procured and also look in detail at the important strategic considerations of outsourcing and offshoring.

QUESTIONS

- In the context of postponement, how might downstream distribution centres be viewed as value-adding?
- List the various information sources from across the supply chain that will improve order delivery and discuss how not having each would impact delivery.
- With the evolution of mobile communications (e.g. smartphones and tablet computers) and warehouse automation and MHE, consider what warehouse job roles and tasks will exist in the future. How will they differ from today?
- Discuss the role played by product packaging in logistics systems.

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12
Outsourcing, Offshoring and Procurement

LEARNING OBJECTIVES

- Introduce – and distinguish – both outsourcing and offshoring.
- Show how outsourcees are selected and how the relationship between outsourcer and outsourcee develops and is managed.
- Examine trends in offshoring such as rightshoring and also explore the role of corporate social responsibility in offshoring.
- Introduce the concept of landed costs.
- Show how integration and collaboration along the supply chain can be enabled.
- Explain what the procurement function comprises and review the important role played by both risk and value.
- Explain and differentiate the various LSCM costing approaches and concepts.

INTRODUCTION

In the previous two chapters, we have focused on managing and handling inventory as it flows along the supply chain. In this chapter, we will detail the strategies and techniques employed by the various partners along the supply chain which enable these inventory flows and also describe and differentiate the various associated costs.

Chapter 12 comprises seven core sections:

- Outsourcing
- Offshoring
- Selecting and managing outsourcees
- Landed costs
- Integration and collaboration
- Procurement
- LSCM costing approaches and concepts

OUTSOURCING

In Chapter 3 (Figure 3.3), we saw how production strategies have evolved. Today capabilities such as lean production are almost ubiquitous – and if you don't have such capabilities yourself, you can still leverage their advantages by outsourcing processes to providers who have those capabilities. **Outsourcing** can be defined as the transfer (from the outsourcer) to a third party (i.e. another company, referred to as the outsourcee) of the management and delivery of a process previously performed by the company itself. Sometimes, we use the acronym BPO – business process outsourcing – to refer to outsourcing. The opposite to outsourcing is insourcing – where the company performs the process itself. Outsourcing has increased significantly in recent decades for these and other reasons. Some companies outsource for *cost* reasons, as the outsource partner may be able to provide the service more cheaply than the outsourcing company can itself provide it for. Foreign exchange risk might be an important consideration in the context of costs. Increased *flexibility* is another reason to outsource, as the outsource partner may be more readily able to provide more or less of the service as required by the outsourcing company, and thus save it having to commit its own resources. A third reason often cited for outsourcing is more of a strategic one whereby a company decides to focus upon its *core competencies* – that is, the tasks it is good at or has advantages in – and outsource all other activities. Given the rapid advances everywhere in *technology*, companies may no longer always necessarily have the most up-to-date technology available to them and thus may outsource to partners who do have such technology. Indeed, some suppliers may have best in class capabilities and companies may wish to gain access to them. The company may learn from such suppliers and migrate that knowledge back in house. They may also wish to pre-empt their competitors and prevent them accessing such capabilities. There are many other, perhaps more subtle, reasons as to why companies outsource. For example, there may be tariff or other barriers in place that prevent the company – but not the outsource partner – operating in a particular region. Finally, outsourcing can be a popular way to spread risk and build alternative supply sources.

Obviously, these various reasons for outsourcing are neither mutually exclusive nor exhaustive, and a company may decide to outsource for any combination of reasons.

> Outsourcing can be defined as the transfer to a third party (i.e. another company) of the management and delivery of a process previously performed by the company itself.

There are a number of issues to be considered in outsourcing: first, how to go about selecting an outsource partner, and then how to effectively manage the chosen partner. In order to effectively manage the outsource arrangement, companies generally put in place a **service-level agreement (SLA)** and set various performance metrics (we looked at metrics in Chapter 10). An SLA is a key part of a contractual agreement between a customer and a supplier to identify upfront the performance (i.e. service) levels expected. Potential suppliers will have to first qualify by meeting those criteria and/or performance expectations defined in the SLA before they are given proper consideration. You will recall from Chapter 3 that we refer to these minimum requirements as order qualifiers, while the criteria that allow the supplier to actually be selected we refer to as order winners.

SERVICE-LEVEL AGREEMENTS (SLAs)

Companies need to ensure that a mutually agreed and understood agreement is in place between both the company buying the service and the company providing the service. The document that covers this area is commonly known as an SLA – a service-level agreement. It is typically within the SLA that the selected performance metrics are detailed and elaborated. Typically, SLAs will include details of

- Roll-out and duration of the service or process being purchased
- Scope of services
- Areas of responsibility
- Performance metrics

Ongoing monitoring of suppliers and managing the buyer–supplier relationship are also critical. Sometimes, the relationship can extend to **supplier development** where, in both parties' interests, improvement efforts are made, leading to, for example, new and better products and solutions being provided by suppliers. Such an approach 'inverts' the traditional approach that sought to squeeze suppliers as much as possible on price. Of course, price is still regarded as important, but it is now not the only criterion to be considered.

Many studies have shown that good supplier relationship management leads to better results and added benefits, especially when it is over an extended period of time, sharing risks and benefits.[1] Such collaborative partnerships help in improving quality, product development and logistics efficiency, as both parties are able to share information on forecasts, sales, supply requirements, production schedules and problem alerts in advance. Additional benefits such as higher quality, lower inventories and better planning can also be achieved.

Another important issue for any organisation to consider is exactly which activities to outsource and which activities to do itself, the classic 'make versus buy decision'. In fact, some organisations, especially many in the e-business sector, outsource almost everything. These organisations are referred to as **virtual organisations**. In contrast, other organisations, albeit more so in the past than today, outsource little or nothing. For example, the Ford Motor Company – which we met in Chapter 3 in the context of our discussion on mass production – was reputed in the first half of the 20th century to even own farm animals in order to guarantee a source of supply of fabric for its cars (it was noted in Chapter 1 that the technical term for this is vertical integration, a concept that implies ownership or at least control of upstream suppliers and downstream customers).

Virtual organisations are companies which outsource most, if not all, major functions.

In the last decade or so there has also been a shift in the way suppliers are arranged. Previously, many companies, especially in the manufacturing sector, had multiple suppliers. Indeed, it was not unknown for some large multinational companies to have thousands of suppliers, and this is still the case today for some companies. Managing so many suppliers can, of course, bring its own problems; similarly, with large numbers of suppliers it can be difficult to leverage other advantages from them such as sharing research and development and encouraging new product development (generally speaking, this is easier done with fewer, rather than many, suppliers). The response to much of this has been the organisation of suppliers into tiers.

If you think of a pyramid, the top tier is the manufacturer or client organisation. Below this are what are referred to as first-tier suppliers, below these the second-tier suppliers and so forth. Sometimes, the term **original equipment manufacturer (OEM)** is used to describe the top-tier organisation, i.e. the manufacturer/ultimate client organisation. Such OEMs are the producers of the final product that carries their brand. In some cases, such OEMs make little (for example they may just assemble the various supplied components) or no (as such they are virtual organisations as described above) physical modifications to the product, with the first-, second- and lower-tier suppliers doing most of the manufacturing (sometimes the term **contract manufacturer** is used to refer to such suppliers).

DESIGNING PRODUCTS THAT ARE EASY TO MAKE: DESIGN FOR MANUFACTURE (DFM)

Simchi-Levi *et al.*[2] describe the advent in the 1980s of **design for manufacture (DFM)** where designers and engineers moved from focusing solely on designing products to a focus on considering the actual manufacturing process when designing products, i.e. not only to design good products but also ones that can be manufactured cheaply and efficiently. For example, mass customisation, which we met in Chapter 3, can be enabled by designing postponement into the production process – this can be something straightforward such as delayed product differentiation enabled by downstream supply chain partners. Having suppliers organised into tiers is also a key enabler of DFM as it allows components to be produced by suppliers, which can in turn be assembled by the higher tiers. The OEMs then just need to combine the various 'modules' supplied by the first-tier suppliers.

OFFSHORING

Companies are always looking at ways in which to reduce their costs. One approach – which has been popular now for a number of decades – has been to move some processes to cheaper, often offshore locations. Offshoring and outsourcing are often confused, so first the term offshoring will be defined and then both terms will be differentiated.

Offshoring is not the same as outsourcing because outsourcing involves handing process ownership over to a third party, whereas with offshoring the company may still own and control the process itself in the lower cost location. Of course, one can both outsource and offshore a process at the same time – many OEMs, for example Apple, outsource processes to large, offshore contract manufacturers such as Foxconn. Figure 12.1 distinguishes the various terms.

Offshoring is the transfer of specific processes to lower cost locations in other countries.

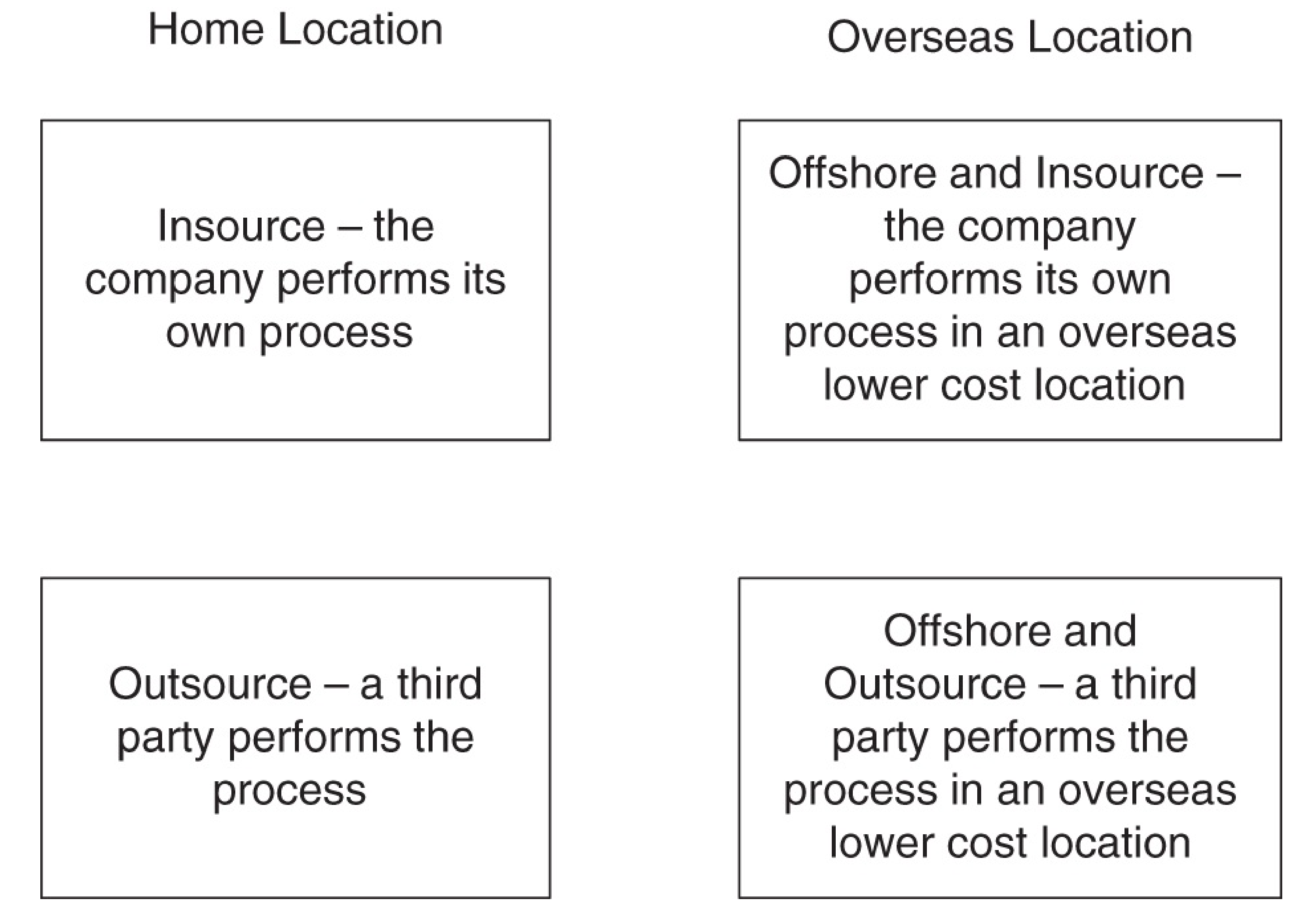

Figure 12.1 Outsourcing and offshoring

Some leading authors have noted that the lure of cost savings, largely due to fewer regulatory controls and significantly lower wages, has prompted the mass migration of manufacturing from the developed world to emerging economies in other regions.[3] They note that geopolitical events moving in step with technological developments and the deregulation of trade have made global sourcing and supply a reality. It is important to note that it is not just manufacturing processes that are offshored, but many service-based processes are often also offshored. Examples include call centres, transaction processing (e.g. typical accounts functions such as invoicing) and even aspects of human resource management. Table 12.1 outlines some of the reasons behind companies' decisions to offshore.

One of the questions which sometimes emerges with regard to offshoring is: can the cost savings enjoyed by offshoring be offset by other unforeseen costs? Examples of such costs include extra monitoring costs incurred as a result of the location of the offshore activities. The other main set of costs are extra transaction costs as a result of, for example, moving materials over greater distances. Ultimately, the challenge is to ensure that these extra monitoring and transaction costs are less than the savings enjoyed as a result of offshoring.

Rightshoring

As a result of the potential risks, delays and extra costs associated with moving products from a distant location, some companies are moving their offshored activities to countries closer to their home market, a practice called **nearshoring**. In some cases, companies will abandon offshoring (perhaps because of the aforementioned risks and delays, but usually also because of a new awareness of total costs issues) and move the activities back to the original home market, a practice called **backshoring** or **reshoring** or **reverse shoring**. Indeed, yet another term has entered into use – **rightshoring** – which is seeking to locate the activity at the 'right' location and which is what we really we should be doing anyway! Reshoring has become a hot political topic in some developed countries as politicians seek to assuage their electorate with the prospect of more jobs 'at home'.[4] Various tariff wars have ensued as countries have sought to enable domestic industries to become more competitive and similarly to respond to such actions by other countries. In reality, however, it can be difficult to translate such actions into more jobs 'at home' – where previously a process may have been offshored to a region with lower labour costs, today such low labour costs play a lesser role in ensuring competitiveness as many processes have become more automated. Thus while a process may reshore, it may not necessarily lead to the generation of many jobs.

TABLE 12.1

Some of the reasons why companies offshore
Lower costs in offshore regions
Less stringent regulatory controls in offshore regions
Deregulation of trade facilitates offshoring
Lower communication and IT costs
Clusters of specific activities (e.g. call centres) and capabilities exist in certain regions

A final term to mention is **omnishoring**, which has originated from work particularly in the fashion industry by two scholars, Professors Abecassis-Moedas and Moatti.[5] They describe it as a rich portfolio of sourcing destinations (close and far) and of institutional models (a firm's own facilities and subcontracted ones) that allow firms to manage different products, seasons, stages of product innovation and so forth.

SELECTING AND MANAGING OUTSOURCEES

Once the outsourcing decision has been made, the first step is to evaluate potential outsourcees. As shown in Figure 12.2, the first stage of the evaluation involves ascertaining if the outsourcee meets the qualifier parameters determined for the process under consideration. These parameters will vary depending on the product or service to be outsourced.

As we noted above, order qualifiers are those criteria and/or performance expectations that a company must meet for a customer to even consider it as a possible supplier. Vendors in the manufacturing sector, for example, usually need to get certification under the ISO 9000 series as in most cases it allows them to bid or be considered for an order as a potential supplier.

Some criteria that could be included as order qualifiers include the following:

- Reliability of delivery
- Quality certifications
- Conformance to agreed specifications
- Delivery lead time
- Financial capability
- Performance track record
- Price or cost reduction
- Senior management attitude
- Responsiveness to demand uncertainty
- Record of corporate social responsibility

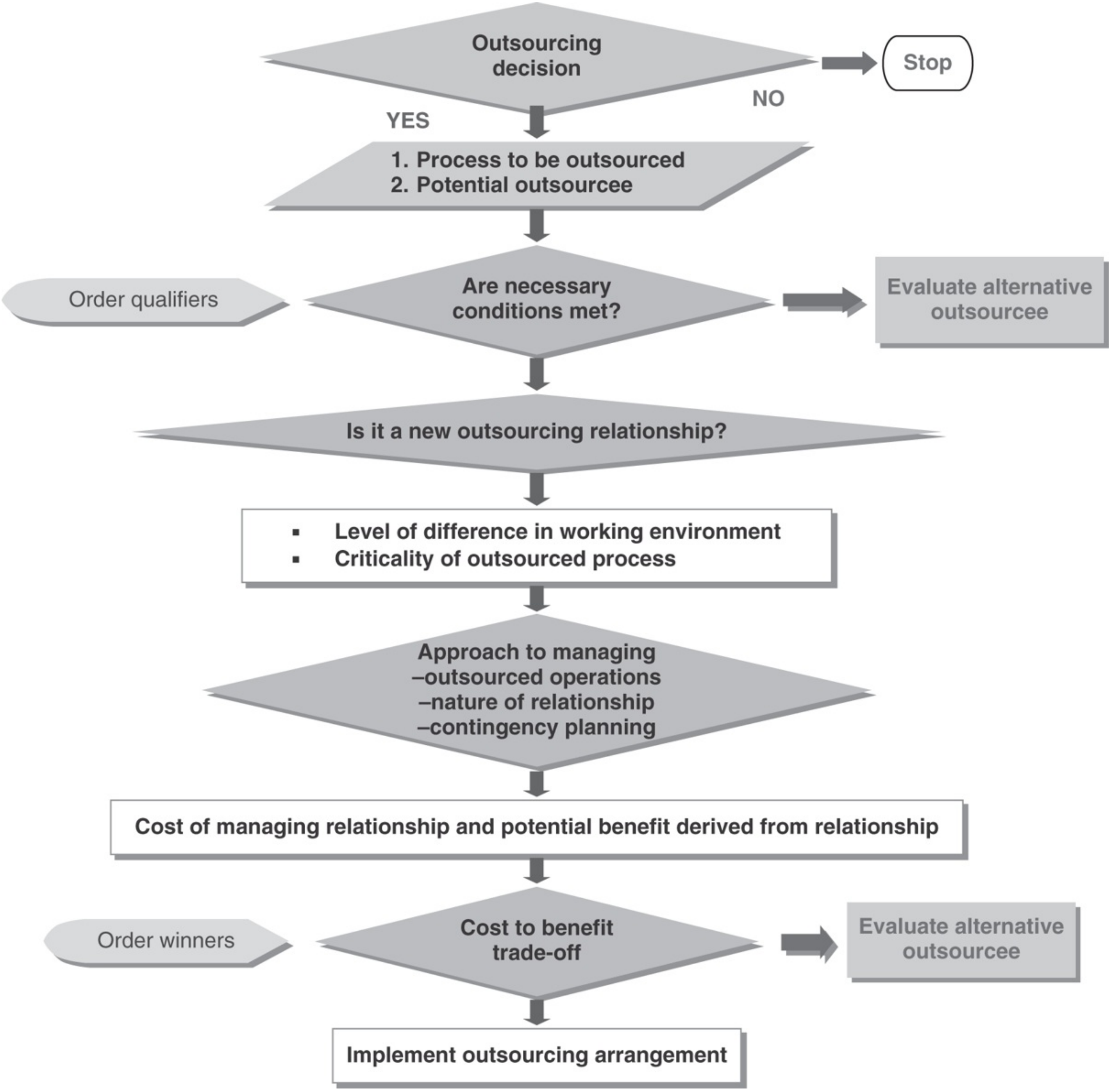

Figure 12.2 A framework for evaluating potential outsourcees

(Source: Based on Lalwani *et al.*, 2007; Reproduced with permission of University of Nottingham.)[6]

The issue of **corporate social responsibility (CSR)** is growing in importance in business. CSR covers a multitude of activities and issues, and in essence concerns how 'ethical' a company's activities are. In this regard, the external image of a company is very critical. In recent years, many companies for example have become embarrassed by revelations that they outsource upstream activities to suppliers with poor labour and safety records. CSR issues also have arisen downstream in the marketplace with concerns among consumers that some toys, largely produced by suppliers in low-cost locations, might comprise harmful components. This in turn raises the issue of how closely outsourcers need to monitor outsourcees. We will return to CSR issues in Chapter 17.

If the qualifier parameters are not met, then the outsourcer starts looking at alternative outsourcees. If the qualifier conditions are satisfied, but the outsourcer has no prior working experience with the outsourcee, then it is important to look at the level of difference between the working environments (the **environmental separation index**) of the outsourcer and outsourcee companies (or perhaps between the two countries). In addition, the outsourcer should consider how critical the outsourced product/process or service is to their core business. This will determine the management approach the outsourcer should use for supplier development, monitoring and supervision.

> The environmental separation index (ESI)[7] is used to assess the level of difference between the working environments of the outsourcer and outsourcee companies. A higher value of ESI indicates large differences in work practices, culture and perceptions. Once the outsourcee gains experience in working closely with the outsourcer and performs as per the expectations of each other, the ESI could reduce to a lower value.

As we noted above, price is not the only criterion to be considered when selecting an outsourcee. The outsourcer needs to consider the total cost of outsourcing, and this should include, as well as the basic cost of the product or service, the cost incurred by the outsourcer to manage the outsourcing arrangement. This is the cost of monitoring the outsourcee and the cost of setting up the relationship right from initiation through to operations and to termination. This cost should also reflect the risks involved in terms of transfer of technologies and intellectual property for example. In addition to the cost of coordination, there is also the cost of contingency planning to ensure delivery on time, for example by keeping higher inventory levels in the outsourcer country, or the need at times to deliver by air at premium costs due to not being able to meet the agreed schedule when using cheaper forms of transport. Related to the total cost of outsourcing is the concept of 'landed costs', which we will discuss in the next section.

Outsourcer and outsourcee relationship development

The relationship between the outsourcer and the outsourcee evolves over time. It is possible that the initial outsourcing arrangement could change as the outsourcer starts to have more confidence in the capability of the outsourcee. This could also mean that the level of monitoring carried out by the outsourcer with respect to the outsourcee's operations is likely to reduce. It may be that the outsourcer was involved in day-to-day operations management of the outsourced activity in the initial phases of the arrangement, however, as the relationship evolves the outsourcer would gradually reduce involvement in the outsourced activity. In fact, research has shown that outsourcer–outsourcee relationships can move across four stages[8]:

- *Master–servant stage*: in this conventional relationship, the outsourcer sets the expectations and the rules and the outsourcee delivers as per the stipulated norms. Low cost is the main driver of the outsourcing arrangement.
- *Consultative stage*: this stage is a type of a 'consultant–client' relationship. The outsourcer consults with the outsourcee on a regular basis. In addition to the cost, other factors such as quality, reliability and responsiveness are important for sustaining the outsourcing arrangement.
- *Peer-to-peer relationship stage*: this is considered to be the ideal stage where the outsourcer and the outsourcee share a peer-to-peer relationship. This stage of collaboration results in a more synergistic long-term relationship creating 'win–win' situations for both parties.
- *Competitive stage*: in this stage, the original outsourcee company takes the lead role and starts to compete with the outsourcing company in global markets.

We will return to this topic later in the chapter when we look at collaboration across the supply chain.

Outsourcing failures

It is important to note that just because outsourcing can at times be the right thing to do, it does not always follow that all outsourcing arrangements always run smoothly. In fact, the opposite can often be the case. Research shows that four out of five BPO contracts will need to be renegotiated within two years and that 20% of such contracts will collapse.[9] Table 12.2 lists some of the common issues that cause outsourcing arrangements to fail.

TABLE 12.2 **Some of the common issues that cause outsourcing arrangements to fail**
Erosion of standards over time
'Hidden' costs not originally envisaged begin to surface
Communication delays and breakdown
Differences in culture and understanding between the parties
Outsourcee becomes less dependent upon the outsourcer

In view of the issues that commonly lead to the failure of outsourcing, it is important to properly evaluate potential outsourcees before they are selected. In addition, a good outsourcer–outsourcee relationship development strategy can help to overcome a number of factors causing failure in outsourcing.

Before concluding this section, it is worth pointing out one final concern in outsourcing relationships and that is the risk of 'lock in'. Sometimes, an outsourcer may fear becoming too dependent upon an outsourcee and indeed over time may lack the ability to replace the outsourcee and/or their product. Similarly, the outsourcee may become too reliant on the outsourcer's business. All parties then need to keep a close watch on such concerns. Effective collaboration between the partners is key, and we will discuss this in the second next section.

LANDED COSTS

Landed costs incorporate the various costs associated with sourcing and receiving products from suppliers. Landed costs take into account the following costs:

- Supplier identification and management costs
- Product purchase costs
- Packaging costs
- Transportation charges
- Working capital employed/opportunity costs
- Costs associated with risk mitigation
- Broker fees
- Insurance costs
- Taxes and duties
- Reverse logistics costs

- Costs associated with currency risk

The concept of landed costs allows managers to make better decisions regarding sourcing, and rather than just going with the lowest possible product cost, companies can compare the overall financial impact from using different potential suppliers in different markets. Platts and Song (2010), for example, have shown that the cost savings from overseas sourcing may not be as great as expected.[10] Software tools are available that allow importers to compare landed costs. OOCL Logistics,[11] for example, has a software tool called 'Landed Cost' that allows such calculations to be made.

Costing materials on an 'ex-works' basis is not adequate to make a purchasing decision and so it is important that all related costs are considered and compared. For example:

- *Freight:* The further from the intended destination that raw materials are sourced, usually the greater the freight costs. Even if freight is planned to be moved via ocean, the greater distance will result in longer lead times, and the chance of moving at least some product via air will increase.
- *Carrying costs:* Longer transit time will often lead to higher inventory in the supply chain, which in turn will increase the working capital employed and the risk of obsolescence, damage and shrinkage.
- *Duty:* Local sourcing is often the only way to minimise potential import duty of raw materials. Although some countries offer certain duty avoidance measures for materials bought overseas, the risk of paying higher rates of duty and inbound taxes, along with charges for more complicated clearance processes, increases.
- *Packaging:* The longer a product is in transit, the better the packaging needs to be. Also the potential for using reusable packaging decreases. More generally, it is important too to recognise how a small change in a product's specification (e.g. extra packaging for marketing purposes) can aggregate up into increased landed costs (heavier or bulkier products, less now fitting into a storage unit etc.).
- *Warehousing:* Longer lead time for products may increase the need for buffer inventory storage locally.
- *Localisation costs:* Converting product for destination country use.

As freight costs can change dramatically over the short term, owing to changing fuel and security surcharges and differing demand patterns for cargo (seasonal induced variations for example) along with changing air and ocean timetables, it is important that companies continually review their landed costs by having metrics to measure these costs on an ongoing basis.

INTEGRATION AND COLLABORATION

It will be apparent from the preceding sections that in any given supply chain there will be a variety of actors with different types and degrees of inter-relationship. In this section, we will review how the various actors collaborate and integrate. **Supply chain integration** is a term that embodies various communication channels and linkages within a supply chain network. However, it should not be confused with **supply chain collaboration**, which refers to how the relationship between supply chain partners develops over time. While supply chain integration is the alignment and interlinking of business processes, collaboration is a relationship between supply chain partners developed over a period of time. Integration is possible without collaboration. For example, order processing via electronic data interchange (EDI, a technology we will meet in the next chapter) is an example of an integrated transaction, but it does not require the customer and supplier to operate collaboratively. Conversely, integration is an enabler of collaboration. Hence, the terms integration and collaboration should not be confused. There are four primary modes of integration within a supply chain (also illustrated in Figure 12.3):

- *Internal integration:* cross-functional integration within a selected organisation.
- *Backward integration:* integration with selected first-tier and increasingly second-tier suppliers.

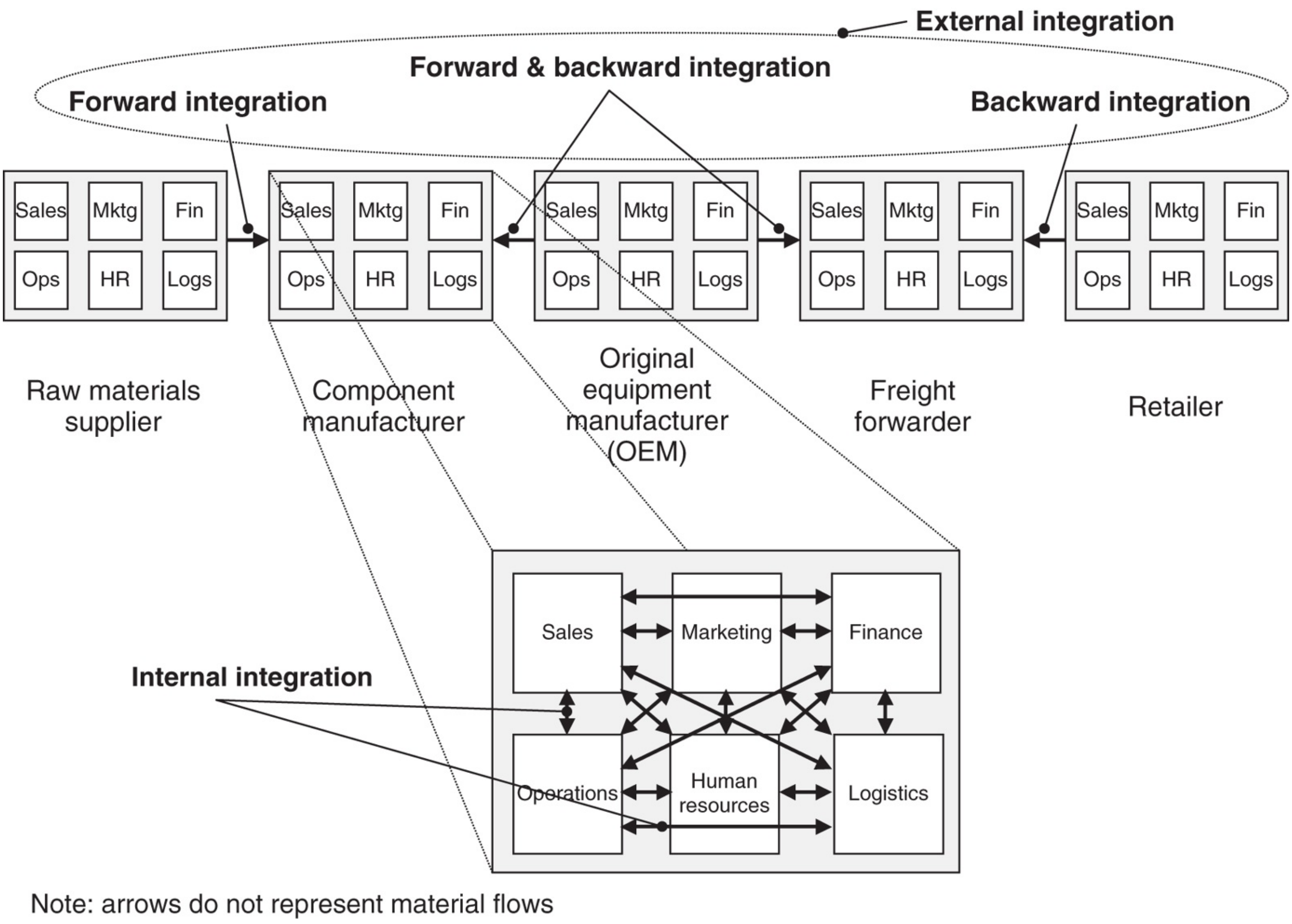

Figure 12.3 Distinctions between the primary modes of integration

(Source: Fawcett, S. & Magnan, G. (2002); Reproduced with permission of Emerald Publishing Limited.)[12]

- *Forward integration:* integration with selected first-tier customers or service providers (e.g. logistics service providers). Forward integration with second-tier customers is uncommon.
- *Forward and backward integration:* integration with suppliers and customers. This 'total' integration is rare but theoretically ideal.

The last three modes listed above can be classified as external integration (i.e. extending beyond the confines of a single organisation) as opposed to internal integration, which limits integration to within a particular organisation.

Focusing firstly on internal integration, the aim is to integrate communications and information systems so as to optimise their effectiveness and efficiency within the organisation. This can be achieved by structuring the organisation and the design and/or implementation of information systems for improved communication and information sharing. In doing so, non-value-adding activity is minimised (e.g. duplication of effort), costs are reduced (e.g. reduced error rectification), lead times are reduced (e.g. order processing) and service quality is improved (e.g. improved order tracking).

External integration can take one of three forms: backward, forward or a combination of the two. EDI is a key enabler of supply chain integration. The automated transfer of order data between supply chain partners streamlines information sharing and processing. However, effective and efficient organisational design is a prerequisite. Leading automotive manufacturers, for example, work closely with their first-tier suppliers to integrate manufacturing, logistics and information processes. This enables just-in-time line-side delivery at their assembly plants. Typically, the OEMs (e.g. Ford or Toyota) use consultants to work with their suppliers to design their work structures and processes to fit with those of the OEMs. By adopting the same practices, a seamless lean supply chain is created. That is, the processes up to line-side delivery at the assembly plant are part of one extended operation. To filter these same principles further upstream, the Japanese automotive OEMs typically adopt a *keiretsu* supply chain structure, where the OEMs support their first-tier suppliers, their first-tier suppliers in turn support the second tier and so on. *Keiretsu* was pioneered in Japanese banking and has since been adopted with great success in SCM. Thus, while information technologies are enablers of supply chain integration, optimal and uniform organisational structures are fundamental to integrating various parties across the supply chain. Nevertheless, the scale and complexity of global supply chains remains the key constraint to integration across multiple echelons.

> Whilst information technologies are enablers of supply chain integration, optimal and uniform organisational structures are fundamental to integrating actors in a supply chain.

As noted earlier, supply chain integration is an enabler of collaboration. Whilst integration is product and process oriented, collaboration is focused on relationships. Information sharing can be achieved by implementing integrated processes and applications, but may not be of benefit to all supply chain partners, possibly exposing suppliers to their competitors. For example, supermarket retail is intensely competitive, as are automotive sales. This drives down consumer prices at the supermarket shelves and car dealers' forecourts, which in turn causes them to 'squeeze' their suppliers to operate with lower profit margins and tighter delivery schedules whilst maintaining service quality. Consequently, suppliers are forced by these market conditions to behave competitively rather than collaboratively. Collaboration is dependent on the provision of mutual benefit. Clearly, in such supply chains, mutual benefit between suppliers is difficult to achieve. Hence, trust becomes an issue.

The prisoner's dilemma

The dynamics of trust and collaboration can be explained via the prisoner's dilemma, an example of Nash equilibrium game theory. Here is the analogy:

> *You and a partner are suspected of committing a crime and arrested. The police interview each of you separately. The police detective offers you a deal: your sentence will be reduced if you confess! Here are your options:*

- If you confess but your partner doesn't: your partner gets the full 10-year sentence for committing the crime, whilst you get a two-year sentence for collaborating.
- If you don't confess but you partner does: the tables are turned! You get the full 10-year sentence, whilst your partner gets the two-year sentence.
- If both of you confess: you each get a reduced sentence of five years.
- If neither of you confess: you are both free people.
- The dilemma you face is 'do you trust your partner to make the same decision as you?'

As we can see in Figure 12.4, the best strategy is based on trust and results in a win–win situation. Yet, if neither partner trusts each other, it is most likely that both will confess and spend time in prison.

Traditionally, business relationships have been built upon open-market negotiations (i.e. gaining the lowest priced products and/or services). From this common 'competitive' starting point, a trust-based win–win situation in a supply chain partnership takes time. Trust needs to be built up step by step. The journey towards a collaborative supply chain can be long and arduous. This is illustrated in Figure 12.5.

Collaboration has two dimensions: vertical collaboration between suppliers and customers and horizontal collaboration between competitors and other supply chain actors. As per our discussion thus far, vertical collaboration is more common and easier to implement than horizontal collaboration. However, supply networks that achieve both will gain significant business benefits. In the context, for example, of transport management, the combination of vertical and horizontal collaboration can achieve reduced inventory carrying costs, reduce unproductive waiting time, reduce overall transport costs, improve integration of the transportation network, reduce empty running times, and improve lead-time performance by adopting collaborative methods such as joint planning and technology sharing. Imagine, for example, the benefits of two major high-street retailers sharing transport capability in and out of a major city for their stores. This reiterates the prisoner's dilemma. Both retailers would benefit from improved logistics performance, but the fact that they compete directly for consumers' business is a significant barrier. Indeed, we will see in Chapter 16, which deals with sustainability, that retailers are in fact adopting solutions such as this.

		You: Confess	You: Don't confess
Your partner	Confess	5,5	2,10
	Don't confess	10,2	0,0

Figure 12.4 The prisoner's dilemma

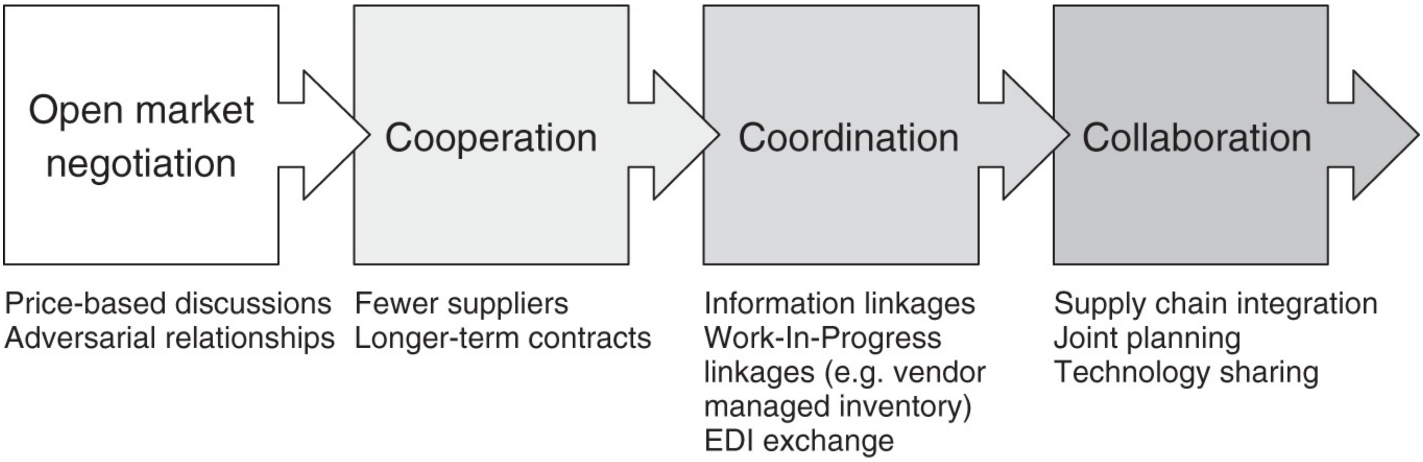

Figure 12.5 The journey from open-market negotiations to collaboration

(Source: Adapted from Spekman *et al.*, 1998)[13]

So far, the focus of our discussion has been in the business context. But what, for example, of the humanitarian logistics context (a topic we will return to in Chapter 17)? In a humanitarian disaster, competition between supply chain actors could have potentially devastating consequences. For example, two or more non-governmental organisations (NGOs) attempting to deliver the same aid to a particular location could overstock one area and understock another. In humanitarian logistics, vertical coordination and collaboration between representatives/governors of a disaster-struck region and actors from outside of that region, such as the national government or United Nations, is essential for preparation, immediate response and reconstruction. Whilst some NGOs may share warehouse facilities, this is not usual. Yet if they did it is possible that significant benefits could be gained.

Achieving integration and collaboration

Global supply network complexity is a major constraint of both integration and collaboration. In networks such as those of the major retailers and manufacturers, there are multiple echelons with many suppliers competing for the same business. Hence, **supply base rationalisation** is periodically a key focus of such organisations. Upstream in many supply chains it is not uncommon to find two companies with the same capabilities (e.g. engineering SMEs manufacturing cylindrical engine components) competing for the same orders handed down from their first-tier customer. This traditional competitive behaviour creates supply chain inefficiencies. If small-scale suppliers with limited resources are continually competing for business, they will inevitably drive down their prices, promise unrealistic lead times and lose their focus on product and service quality. Whilst we are conventionally led to believe that competition in business is good, in this case it can be destructive. From our discussion of *keiretsu* above, it is far easier for a company such as Nissan to work with a few selected suppliers than to work with many suppliers. Furthermore, from our discussion on horizontal collaboration, suppliers who are not directly competing against each other for individual orders are more likely to collaborate. Coupled then with the inevitable periodic supply base rationalisation should be supplier development activity (see our earlier discussion in this chapter on outsourcing). As discussed in the context of *keiretsu*, supplier development can enable improved integration and also collaboration. Rather than individual suppliers tendering for particular orders, specific suppliers are selected based on their capabilities. In the previous *competitive* environment, some suppliers would win orders whilst others would not. In the new *collaborative environment,* each supplier gains a share of the total orders based on their ability to deliver the order on time and to specification. Consequently, the overall supply base incrementally improves.

> Supply chain collaboration cannot be achieved through IT solutions alone. Substantial investment in building resilient, long-term relationships is a prerequisite.

PROCUREMENT

The final section in our chapter focuses on a specific business function that plays a key role in LSCM and that draws upon many of the issues discussed already in this chapter, namely the procurement function. **Procurement** is an 'umbrella term' that includes sourcing and purchasing and incorporates the activities involved in specifying requirements, identifying appropriate sources, evaluating options and then arranging the purchase of products and/or services from those sources that are fit for purpose, cost-effective and sustainable. Procurement is thus concerned with more than just purchasing, with the latter in effect just a transactional activity. And as we saw too in Chapter 4, often the line between products and services is blurred with companies sometimes purchasing solutions that comprise both (i.e. servitisation). In addition to many of the issues already discussed above – such as ethical sourcing and determining landed costs – a number of issues are worthy of special consideration in the case of procurement and these are now discussed

How much to buy? – as well as considering the actual landed costs to receive the product, there are also inventory carrying costs to consider once you have purchased the product: you may receive a discount for buying in bulk, but you are then faced with the inventory carrying costs associated with holding a large amount of inventory (see our discussion on inventory-related costs in Chapter 10). Other considerations include whether the consignor will manage the supply of the product on an 'as-needed' basis (i.e. vendor-managed inventory – see Chapter 10) and what will be the terms of purchase (see our discussion on Incoterms in Chapter 9) with regard to where in the chain ownership of the freight will pass to the buyer. The procurement manager also needs to consider do they buy from the supplier just one product (e.g. pens) or a range of products (e.g. all office stationery). In the latter case, a supplier(s) will be nominated to provide a range of products within the particular product category. **Category management** is the term used in procurement to describe the grouping of similar suppliers and/or product purchases.

Increasingly, there is a trend away from having many suppliers to fewer suppliers with whom the company can build closer relationships and leverage better prices; this too has the advantage of having lower transaction costs per item purchased overall. Particularly too when it comes to procurement by public bodies there is an increasing emphasis on ensuring value for money is attained. The next section considers attitude to risk in procurement – in this context then, while striving for fewer suppliers you need to balance this against the risk inherent in having just one supplier for your product. Many companies – in order not to have ‘all of their eggs in the one basket’ – will procure a large share (70% or 80%) of a product from one supplier, and thus enjoy procurement economies, and use an alternative supplier for the balance. They thus have a relationship with an alternative supplier which can be useful should problems arise with their main, preferred supplier. In fact, many logistics services are purchased in this fashion. An LSP, for example, will typically spread its purchase of container slots across two or more shipping lines if it can in order to spread risk (e.g. due to weather delays affecting one line more so than another).

What is the attitude to risk? – cost is not the only, or key, consideration in procurement. Risk is also an important parameter – how essential is the part or service being procured to my operation? In effect then we need to distinguish three terms: price (what you pay the supplier), cost (a wider consideration which takes account of other factors such as landed costs and total costs of ownership – see the next section on understanding logistics costs) and then value (and not just in monetary terms – what is this product or service actually *worth* to your organisation). For example, you may sell high-value pharmaceuticals, but these need to be placed in specific packaging and labelled appropriately – without such packaging and labels you cannot sell your products. Thus, a production input with a comparatively low price (packaging and labels) is actually of high value. This purchasing dilemma is eloquently described by the **Kraljic matrix** first put forward by Peter Kraljic in the *Harvard Business Review* in 1983 and which seeks to categorise products to be procured along two dimensions: risk of supply availability and the impact of the procured products on the company's profit potential (see Figure 12.6).

How to buy? – how will you identify potential suppliers for your product and select from among those? Some companies, for example, will specify a pre-qualification stage where potential suppliers must go through a process before they can be listed as a potential supplier (again refer back to Chapter 3 and our discussion there around order winners and order qualifiers). Many companies will issue a document which specifies their requirements either to pre-qualify potential suppliers and/or to select them. Such a document is typically referred to as an **RFI/RFT/RFP/RFQ** (request for information/tender/purchase/quote). In situations where price is the main purchase criterion, many companies now invite pre-qualified suppliers into an online reverse auction where they submit their bids and the lowest price wins. Transparency is an important element in any procurement process, and especially in the context of procurement by public bodies who, as we noted already above, need to ensure value for money is attained (it is in effect taxpayers money that they are using). They also need to show that they uphold the laws which they set – for example not procure from a body which does not uphold labour laws. A final point to note is that effective negotiation skills – especially when it comes to large/valuable purchases – are a key ingredient in any successful procurement process.

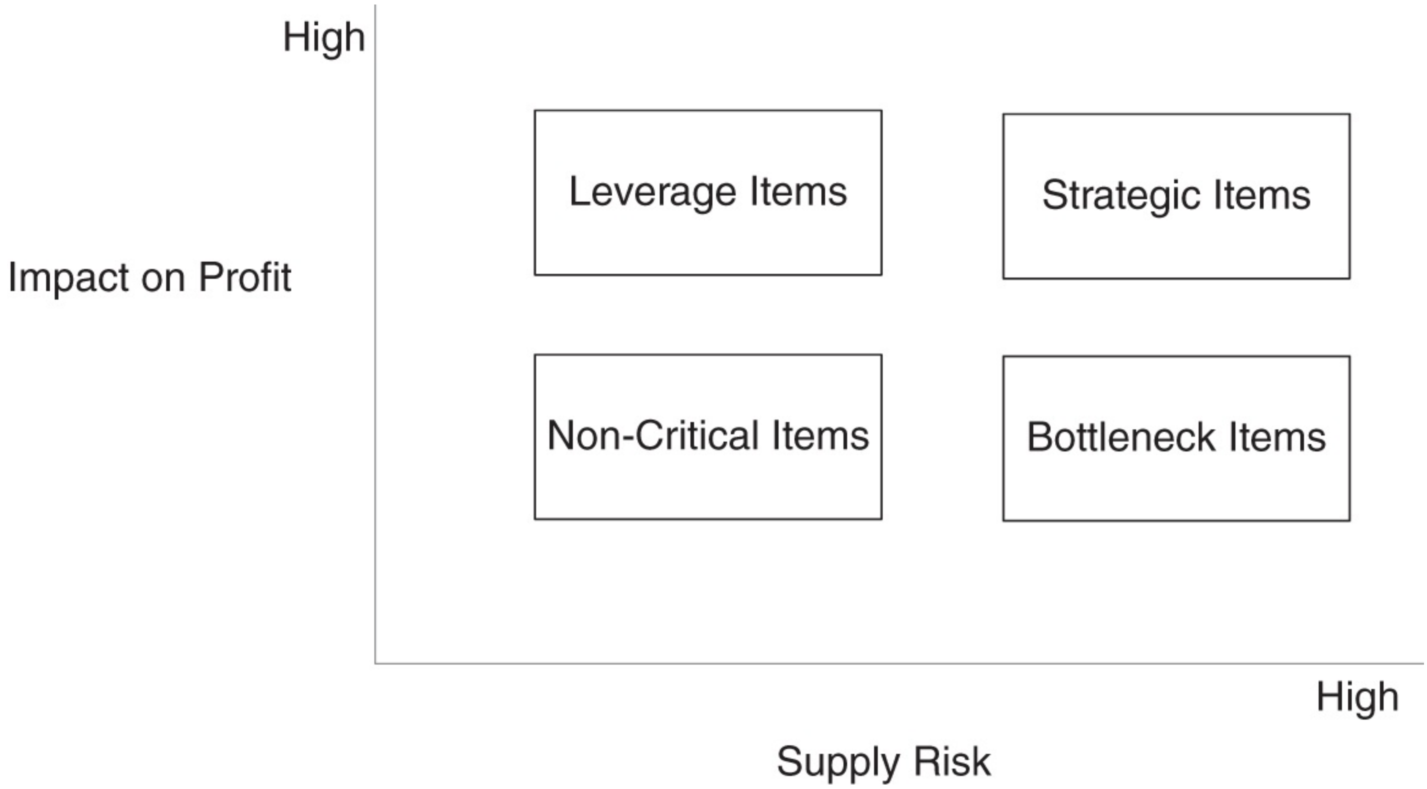

Figure 12.6 The Kraljic matrix[14]

LSCM COSTING APPROACHES AND CONCEPTS

While the subjects of accounting and finance are beyond the scope of this book, it is useful to review briefly a number of pertinent costing approaches and concepts which are particularly relevant in an LSCM context. It is estimated that the components of logistics costs are[15]:

- Transportation (44%)
- Inventory carrying (25%)
- Warehousing (24%)
- Customer service (4%)
- Administration (3%)

One of the key costs in LSCM is, of course, **opportunity costs** (Chapter 10) – can the money tied up in inventory be put to better use/make a better return elsewhere. And we introduced too earlier in this chapter the important concept of **landed costs** which incorporate the various costs associated with sourcing and receiving products from suppliers.

At a micro level, there is **activity-based costing**, which involves apportioning costs to a particular activity and calculating costs per unit, for example cost to pick an item from the warehouse. This is often also referred to as cost-to-serve. Apportioning costs can be difficult and involve subjective decisions, for example in Chapter 16 we will look at carbon footprinting and to take just one example: if freight is carried on a RoPax vessel (a vessel that carries both passengers and freight), then what share of the vessel's carbon footprint is attributable to the passengers and what share is attributable to the freight?

At a much broader level, there are **total costs of ownership**, also known as **through/full life costs**, for example the cost to purchase a truck, payments for ongoing maintenance and operations and then an allowance for any residual value. You may, for example, have come across companies offering a product for free (e.g. a printer) on the basis that you subsequently purchase all consumables for this product (in this case ink) from the same company – the company in this case makes its assessment of expected profits on the basis of full life costs (recall our discussion on servitisation in Chapter 4). Total costs of ownership will thus consider both *fixed costs* (overheads such as buildings and equipment) and *variable costs* (for example fuel used).

In transport (Chapter 6), we considered freight rates which can vary with distance/consignment weight/volume of capacity used. An important concept in LSCM – but which has its origins in economics – is that of **generalised costs**: consignors are usually concerned not simply with the financial costs of carriage but also with the speed, reliability, service schedule and so forth. The demand for transport is not, therefore, simply dependent on financial costs but rather on a wider interpretation of costs incurred. The generalised cost of a trip can thus be expressed as a single, usually monetary, measure combining, generally in linear form, most of the important but disparate costs that form the overall opportunity costs of the trip:

$$G = g(C_1,\, C_2,\, C_3, \ldots, C_n)$$

where G is generalised cost and C_1, C_2, C_3, … are the various time, money and other costs of travel such as insurance, packaging requirements dictated by the mode used etc. In essence, it is the total effect of these costs, in any particular set of circumstances, which determines the choice of transport mode. For example, taking a taxi – as opposed to a bus – to the airport might be more expensive but quicker and more comfortable. The concept of generalised transport costs is important in LSCM because it helps us to understand the importance of trade-offs in decision-making and how optimum decisions can be made. People engaged in marketing logistics services make use of this concept. For example, rates to ship freight by air are usually higher than by alternative, surface transport modes. If, however, we factor in other costs/savings, such as the fact that because the freight is in transit for a shorter period of time when transported by air and so the opportunity cost of capital is lower, the overall cost of air freight compared with surface freight may for some shipments actually be lower. Even though air freight rates are usually higher, air freight benefits then by usually having lower other costs associated with it over competing modes such as insurance and the aforementioned opportunity cost of capital.

Another example of the application of generalised costs is the international movement of fresh fruit. Containerisation is now being increasingly used, because of its cost advantages, for the transport of refrigerated products as well as ambient products. This obviously is competition for the dedicated refrigerated ships that carry bulk freight. The choice between container versus dedicated refrigerated ship will depend on a number of factors as well as the direct carriage costs – volume of freight to be moved (enough to charter a full ship?), transit time and perishability (this can often be managed on board the ship with chemicals and temperature variations used to alter product conditions/shelf life), and the routing to be taken (a dedicated ship can travel direct to destination while a routing using container lines may take longer because of the use of hub-and-spoke networks – it is estimated, for example, that kiwi fruit can be transported from New Zealand to Europe via dedicated refrigerated ship in 27 days, while it can take up to 52 days via the container lines).[16]

In addition to freight rates, other charges often apply when moving freight. For example, while a container line may just quote a port-to-port rate to move a container, other costs though will also accrue such as costs for handling the box at the container terminals (THCs – terminal handling charges), customs clearance costs, inland transport costs and so forth.

In Chapter 8, we looked at the various factors that have to be considered when selecting LSPs and their services. Once selected you then need to decide what costing and pricing approach to adopt:

- Transactional costing – where a set cost applies (e.g. set cost per container movement); discounts may apply with increased volume of business; in addition differential pricing could be applied such as applying a lower rate at less busy times.
- Costs plus margin – a set cost per activity plus a management fee as a percentage of total costs; a variation of this is 'open book' where the LSP provides full costs visibility to the customer and charges accordingly
- Gain share – where no direct charges are made; instead the LSP seeks to make savings on behalf of the client and accordingly charges a set percentage of those savings.
- Other issues to consider include what penalties if any may apply (e.g. if performance falls below a set level) and should any allowance be made for inflation/cost increases (e.g. fuel escalators).

CONCLUSION

In this chapter, we have reviewed the important role played by outsourcing and offshoring in extended supply chains, how such supply chains can be integrated and how partners along the supply chain can collaborate. We also described the procurement function and differentiated the various LSCM costing approaches and concepts. This is the final chapter in Part Three of the book which has focused on LSCM operations. In the next part of the book we will turn our attention from operations to data and analysis. The first chapter in Part Four looks at the role of data and digitalisation in the supply chain. We will then consider how various analytical techniques from management science can be used to analyse and improve various aspects of LSCM. The final chapter in Part Four looks at the area of risk and vulnerability in supply chains and considers how risk can be mitigated.

QUESTIONS

- Companies regularly review the locations where they offshore activities to and the associated costs. Some decide to reshore or nearshore. Referring to the world map at the start of the book, how do the various trends in offshoring impact the major logistics hubs in the world, and will there be a need for more and/or different hubs?
- Explain the distinction between outsourcing and offshoring.
- What are the most frequently reported problems in outsourcing?
- Explain what factors would typically be considered in contingency planning in outsourcing arrangements.
- Explain the distinction between integration and collaboration.
- Is procurement only concerned with purchasing?
- What issues will a procurement manager for a large multinational manufacturer consider in appointing an LSP (consider both the procurement related discussion in this chapter and also the discussion on selecting LSPs in Chapter 8).
- Describe and differentiate the various LSCM costing approaches and concepts.

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Part Three Case Studies
The Medical Devices Company

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MDC is a successful and innovative multinational company which manufactures and distributes a range of sophisticated medical devices used by surgeons in the operating room. Individual unit value for MDC's product range is high and begins at €2000 for some standard, widely used devices. Products for the European market are manufactured at two plants, one in Ireland and one in Poland. Other products and peripherals are also sold under the MDC brand, and these are shipped in the first instance to both of the European manufacturing plants, before being moved downstream in the MDC supply chain. From both manufacturing plants, the entire product range is then shipped to some 15 warehouses located across Europe. These 15 warehouses act as hubs and feed a further 40 warehouses, located mostly near the large urban centres across Europe. It is from these latter 40 warehouses that MDC's sales representatives and distribution agents draw their inventory.

MDC faces a range of challenges. Advances in medical technology and an expanded product range are driving business growth. Many customers (i.e. hospitals) want improved service solutions centred around increased product availability combined (paradoxically) with lower levels of stock holding. Indeed, many users are demanding a solution whereby a number of different variants of a particular device are readily available for immediate use, but whereby payment is only made for the particular variant actually used during the operation. Competition in the marketplace is increasing with some competitors beginning to offer such solutions. Inventory turnover is, however, problematic for MDC's European operation and has steadily fallen to five turns per year (the industry norm is around ten), resulting in increased inventory in the system, while issues with product obsolescence have also arisen on a number of occasions. Stock-outs at various stages along the chain are also becoming common (especially in the case of patients ready for surgery and requiring a specific device immediately in order for the surgery to go ahead) with the resulting need to expedite inventory direct to users from either manufacturing plant.

QUESTION

- Recommend a logistics strategy that could enable MDC in Europe to improve service to its customers and simultaneously reduce the total inventory in its European network.

Patient Safety and the Pharmaceutical Supply Chain

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PLS Pharma Ireland & UK

This case study focuses on patient safety in the context of the pharmaceutical supply chain, in particular in the European context. However, the lessons illustrated here are applicable in most other jurisdictions too.

OPERATION PANGEA

Shining a light on pharmaceutical crime and protecting consumers all over the world from counterfeit medical products.

Coordinated by INTERPOL, Operation Pangea, is a well-established international effort to disrupt the online sale of counterfeit and illicit health products. Just as importantly, Pangea works to raise awareness of the risks associated with buying medicines from unregulated websites. Since its launch in 2008, the Operation has removed more than 105 million units (pills, ampoules, sachets, bottles and so on) from circulation and made more than 3000 arrests. The combined efforts of police, customs, regulatory bodies and private sector companies have prevented potentially dangerous medicines from reaching unsuspecting consumers and have dismantled a number of illegal networks behind these crimes. Figure 1 highlights Operation Pangea successes since its establishment in 2008.

During the Pangea 2020 week of action (3–10 March 2020), authorities in participating INTERPOL countries saw a rise in fake medical products related to COVID-19. They inspected more than 326,000 packages, of which more than 48,000 were seized. The operation resulted in 121 arrests worldwide and the seizure of potentially dangerous pharmaceuticals worth more than US$14 million. The COVID-19 outbreak offered an opportunity for fast cash as criminals took advantage of the high market demand for personal protection and hygiene products. Law enforcement agencies taking part in Operation Pangea found 2000 online links advertising items related to COVID-19. Of these, counterfeit surgical masks were the medical device most commonly sold online, accounting for around 600 cases during the week of action. The seizure of more than 34,000 counterfeit and substandard masks, 'corona spray', 'coronavirus packages' or 'coronavirus medicine' reveals only the tip of the iceberg regarding this new trend in counterfeiting. 'Once again, Operation Pangea shows that criminals will stop at nothing to make a profit. The illicit trade in such counterfeit medical items during a public health crisis shows their total disregard for people's wellbeing, or their lives', said Jürgen Stock, INTERPOL's Secretary General.[2]

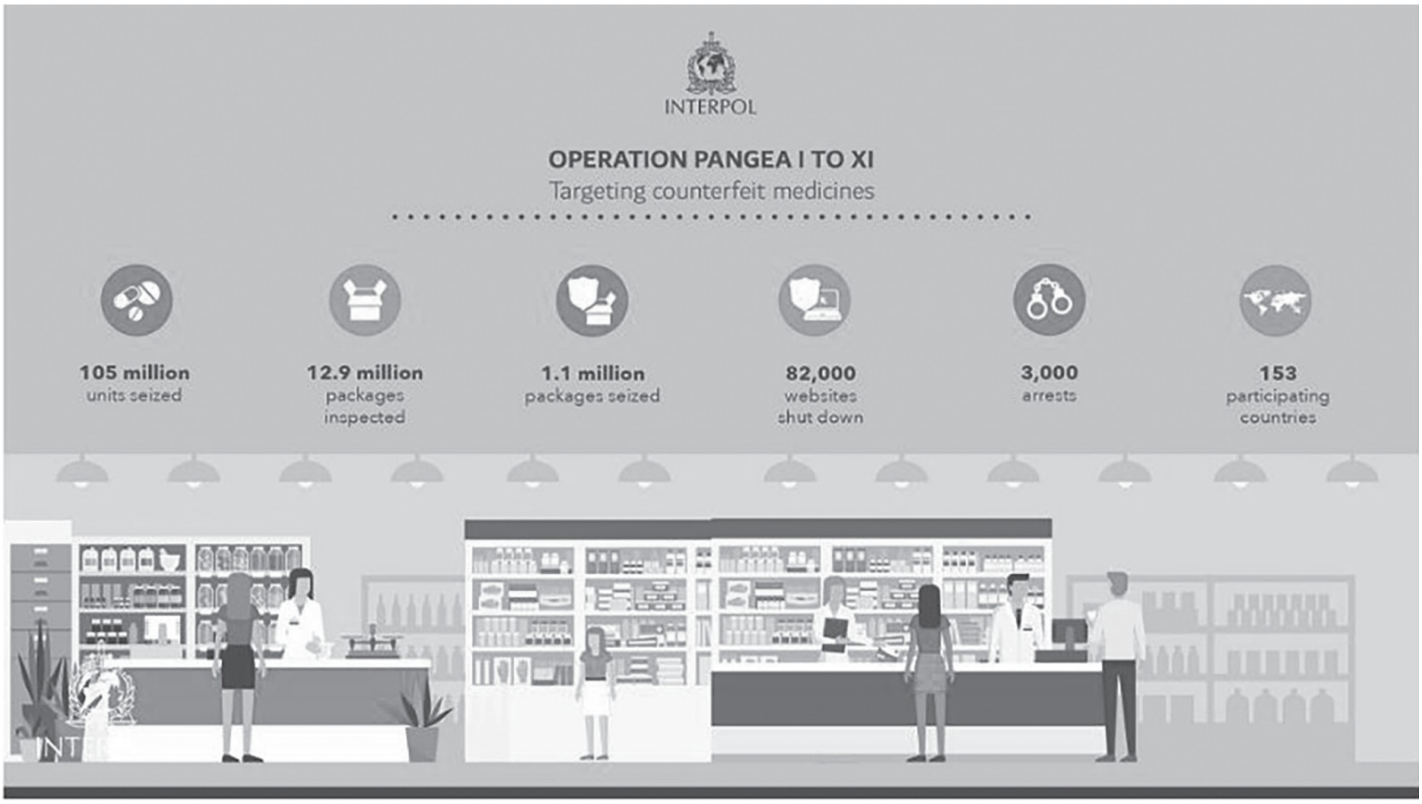

Figure 1 Operation Pangea

(Source: Reproduced with permission of INTERPOL[1])

The pharmaceutical industry has a vital role, and responsibility, to ensure the products it manufactures, distributes and delivers are fit for purpose and safe for the patient. Falsified/counterfeit medicines are a growing concern with the resilience of the pharmaceutical supply chain under constant pressure as economic conditions continue to pose significant challenges for business and consumers globally. Assuring supply chain integrity and patient safety is today more important than ever. All of us depend on safe medicines, medical devices, healthcare products and equipment including personal protective equipment (PPE) at various times in our lives. There is much better understanding of this following COVID-19. A risk-based approach should be used on a global and local basis to ensure continuity of supply. The pharmaceutical supply chain is somewhat unique in that compliance at every point along the supply chain is essential.

In the pharmaceutical industry, a manufacturer's responsibility begins at sourcing materials from approved suppliers, continues through manufacturing under **good manufacturing practice (GMP)** and on to delivery/distribution of the finished product to the final customer under **good distribution practice (GDP)**. The entire supply chain and the distribution network are focused on supplying a quality product that complies at every point with regulatory requirements. Any failings within the pharmaceutical supply chain can seriously compromise the quality of the product and patient safety.

The pharmaceutical supply chain extends well beyond the vehicles used to move bulk pharmaceutical materials, ingredients and components to the manufacturing facility and finished products from the manufacturing facility to distributors/wholesalers worldwide. It also must ensure compliant delivery to hospitals, pharmacies and even supermarkets, where the consumer can now purchase medicines. As patients, we would like to be guaranteed that the excellent quality under which medicines are produced, in the manufacturing facility, extends all along the legitimate distribution chain.

GMP ensures that products are manufactured batch upon batch, year upon year, to the appropriate and consistent quality standards and in accordance with regulatory requirements. Driving higher standards and compliance in the distribution chain is essential for continued success. As mergers within the pharmaceutical industry continue apace, and more blockbuster drugs come off patent, there is continued pressure on the industry, governments and patients worldwide. As a greater number of new products require cold chain distribution, temperature-controlled transportation will be the standard required throughout the supply chain for the majority of pharmaceutical products going forward.

WHAT IS GDP?

GDP together with GMP (sometimes called GMDP) should encompass the full supply chain that is necessary to make and sell pharmaceutical products (Figure 2). The critical need is to establish controls and manage risks at all points along the supply chain so that all partners handling and transporting pharmaceuticals do so within compliance. GDP can be defined as 'that part of quality assurance which ensures that the quality of medicinal products is maintained throughout all stages of the supply chain from the site of manufacture to the pharmacy or person authorised or entitled to supply medicinal products to the public'.[3]

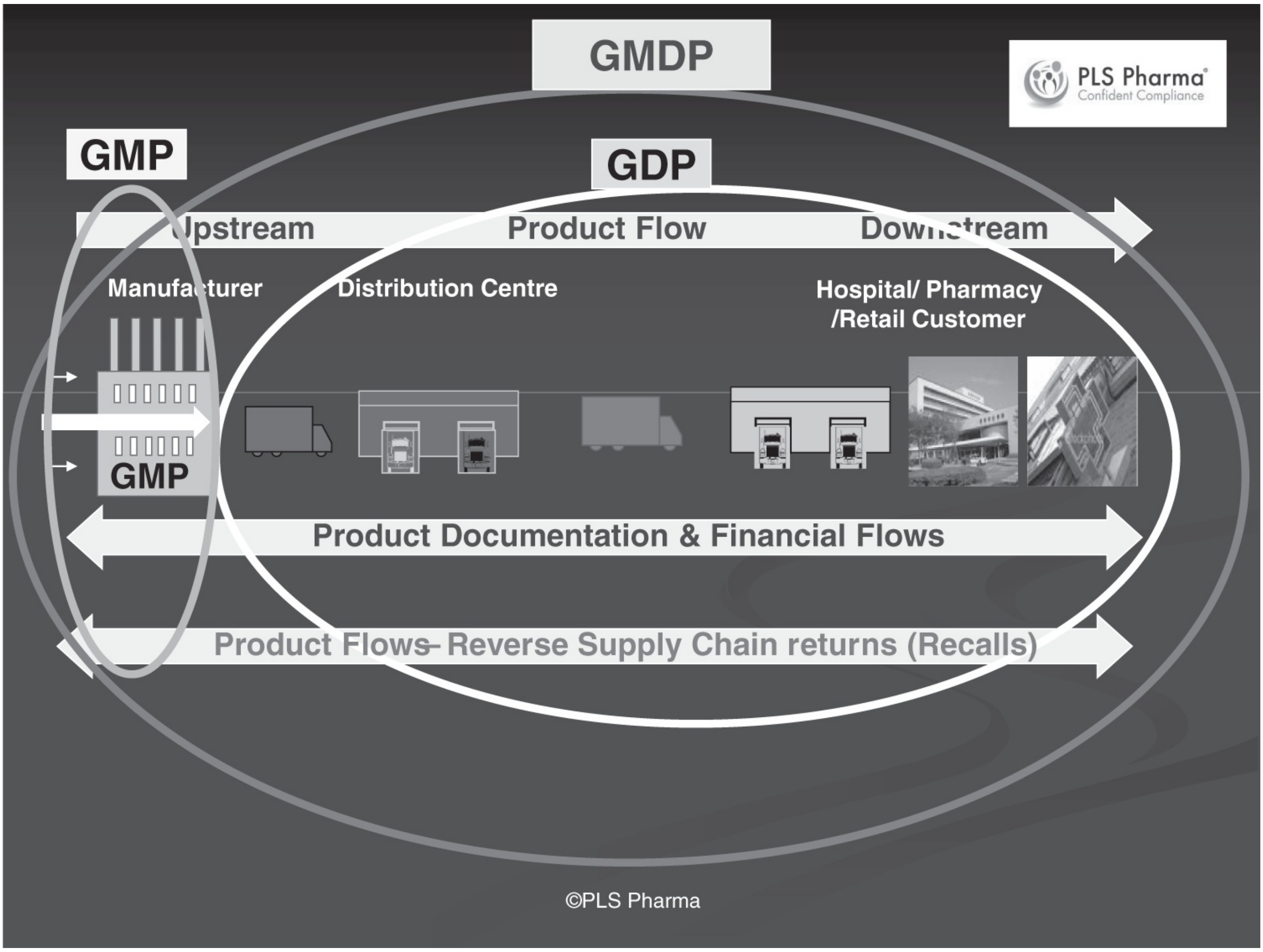

Figure 2 GMP and GDP (GMDP) in the pharma supply chain

(Source: Reproduced with permission of PLS Pharma[4])

The importance of GDP in Europe for example is clarified in the EU GDP Guideline 2013/C 343/01 (EU GDP Guideline) on GDP:

> The wholesale distribution of medicinal products is an important activity in integrated supply chain management. Today's distribution network for medicinal products is increasingly complex and involves many players. These Guidelines lay down appropriate tools to assist wholesale distributors in conducting their activities and to prevent falsified medicines from entering the legal supply chain. Compliance with these Guidelines will ensure control of the distribution chain and consequently maintain the quality and the integrity of medicinal products.

This EU GDP Guideline represents a substantial increase in standards as it raises the bar for all players in the pharmaceutical supply chain, including outsourced providers. For the first time, manufacturers performing GDP activities with their own products must also now comply with GDP.

Areas covered by the guidelines now include, for example, outsourcing, quality risk management, change control, CAPA (corrective and preventative actions), brokers, management responsibilities and more responsibilities for the ‘Responsible Person’ (RP); the RP or person responsible depending on national legislation is named on European WDA (Wholesale Distribution Authorisation) licences. These licences are issued by local regulators in the country of operation, and the role, responsibilities and qualification vary by country. The RP has legal and compliance responsibilities to ensure the licence is complied with as outlined in the EU Guidelines and local regulatory requirements.

Transportation is receiving increased regulatory focus at inspections. It is a complex area to manage with increasing challenges concerning security, temperature management and more requirements for track and trace technology. As many facilities and equipment are often used during distribution (including temporary storage facilities, unloading and reloading at hubs etc.), this presents greater complexity as products move across increasingly complex supply chains. Some European regulators have put limits on the number of hours products can remain in temporary facilities without a WDA and have defined when storage should occur in such facilities under a WDA licence to protect the quality of the products during transportation.[5]

DEFICIENCIES FOUND IN PHARMACEUTICAL SUPPLY CHAINS

Regulators continue to see deficiencies in pharmaceutical supply chains.[6] Some examples of deficiencies found include the following:

- Inadequate temperature management for warehouses/vehicles and temperature excursions in storage and transportation of pharmaceutical products.
- Lack of understanding of the pharmaceutical supply chain in GMP and GDP.
- All distribution activities were not clearly defined and systematically reviewed.
- The Quality Management System (QMS) did not set out the responsibilities, processes and risk management principles in relation to the activities conducted or controlled from the site.
- The QMS procedures were not following current compliance expectations.
- Adequate GDP training and re-certification was not taking place as per the QMS.
- The Licence Holder and Responsible Person had failed to meet their obligations to comply with the GDP Guidelines.
- Outsourcing partners (for example Transportation Providers) used were not carrying out GDP duties and responsibilities under signed agreements as documented under the QMS.
- Transportation standards of vehicles, equipment and GDP training falling short of current compliance requirements.
- Supply chains not demonstrating temperature compliance, no documented risk assessment and route qualification available for review.
- No proof from temperature devices used or vehicle printouts providing proof that product was distributed as per label claim for the duration of the shipment – including road, air and sea as well as temporary storage on route.
- Inadequate training of key staff, including management, in GDP.
- Bona fides of suppliers, customers and outsourced partners not established and maintained.
- No risk assessment had taken place to prevent the possible entry of falsified medicines into the legal supply chain.
- Validation of systems and equipment not documented.
- Management review and monitoring using KPIs not demonstrating RP oversight and how non-compliances are successfully reported and closed out on time to enhance changing compliance standards.
- Changes of activities in the business, physical, financial and product flows not clearly documented. Supply chain mapping not in keeping with current operations.

WHAT ARE FALSIFIED OR SUBSTANDARD MEDICINES?

A falsified medicine is defined by EU GDP Guidelines as any medicinal product with a false representation of: its *identity*, including its packaging and labelling, its name or its composition as regards any of the ingredients including excipients and the strength of those ingredients; its *source*, including its manufacturer, its country of manufacturing, its country of origin or its marketing authorisation holder or its *history*, including the records and documents relating to the distribution channels used. A falsified medicine could be a genuine product but with a falsified history, source or identity.

Falsified Herceptin 150 mg powder concentrate for solution

Falsified Herceptin units were identified as having been stolen from a hospital in Italy before being re-introduced in EU markets. It is understood that unauthorised wholesalers operating in Cyprus, Hungary, Latvia, Romania, the Slovak Republic and Slovenia supplied the stolen medicines to authorised Italian wholesalers who subsequently exported the falsified products to other EU markets.[7]

Toxic diet pills

A 21-year-old student from Shrewsbury in the UK died in hospital on 12 April 2015 after becoming unwell. Police said the tablets were believed to contain dinitrophenol, known as DNP, an industrial chemical. Two tablets were a lethal dose – but unfortunately the student had taken eight. DNP is highly toxic and is not intended for human consumption. An industrial chemical, it is sold illegally in diet pills as a fat-burning substance. Users experience a metabolism boost, leading to weight loss, but taking even a few tablets can be fatal.[8]

Untrained, unsuspecting consumers are vulnerable to the potentially lethal outcomes of buying medicines online. Increasing numbers of consumers are choosing to source their medicines this way, having stated cost, convenience and privacy as some of the key reasons they choose to purchase online. A global marketplace exists for falsified/counterfeit medicines, and organisations know where the maximum profits can be made through, especially illegal, websites.

The introduction of serialisation and safety features to medicinal products commenced on a phased basis in 2019. Following the introduction of the Falsified Medicines Directive (FMD) in 2011/EU/62, this Directive introduced harmonised European measures to fight medicine falsifications and ensure that medicines are safe and that the trade in medicines is rigorously controlled. The main provisions of the Falsified Medicines Directive are to introduce the following:

- A new obligatory authenticity feature (referred to as a safety feature) which must appear on the outer packaging of designated medicines
- More robust rules regarding the control on starting materials and inspection of producers of active substances and excipients contained in medicines
- More robust controls on the wholesale distribution of medicines, including introducing controls for the first time on entities involved in brokering medicines
- A common, EU-wide logo to identify legal online pharmacies and to establish a notification system for entities offering to supply medicines to the public over the Internet

Falsified medicines are fake medicines that pass themselves off as real, authorised medicines. The EU has a strong legal framework for the licencing, manufacturing and distribution of medicines, centred around the Directive on falsified medicines for human use, so that only licenced pharmacies and approved retailers are allowed to offer medicines for sale, including legitimate sale via the Internet. The European Medicines Agency is working closely with its partners on the implementation of these laws. This legislation will enhance visibility, improve patient safety and better manage and measure pharmaceutical supply chain performance where medicines are manufactured stored, transported and distributed. The introduction of serialisation will help to ensure a safe secure falsified free supply chain. Good Supply Chain Management, coupled with best-in-class good distribution and manufacturing practice, is a minimum requirement in helping to stem the flow of falsified/counterfeit products to protect the legal supply chain and patient safety on a local and global basis.[9]

NEW MANDATORY LOGO FOR SELLING MEDICINES ONLINE

Taking the UK as an example, anybody selling medicines online to the public needs to be registered with the MHRA (Medicines and Healthcare Products Regulatory Agency) and to be on the MHRA's list of UK-registered online retail sellers. They also need to display on every page of their website offering medicines for sale the new European Common Logo which is registered to the seller. The registered EU Common Logo will contain a hyperlink to their entry in the MHRA's list of registered online sellers.[10]

Anybody buying medicines online can check whether the website is legitimately registered and will be able to click on the logo which will take them through to a list of approved sellers. If the registered person retails a medicine through a third-party marketplace website, then the third-party marketplace service provider must display that registered person's EU Common Logo on every page of their website that offers the registered person's medicine for sale to the public from that service provider's site. Under the rules of the new scheme, the medicine being offered online must be licenced in the member state where the member of public who buys the medicine is based.

CONCLUSION: THE WAY FORWARD

If we are to deliver patient safety, there is a need for all stakeholders in the pharmaceutical industry to work in partnership to ensure supply chain integrity, quality and compliance. Regulators across the world are working with manufacturers, distributors and other stakeholders involved in pharmaceutical supply chains to embrace and drive higher compliance standards.

EU Guidelines and Directives, together with the introduction of serialisation and the EU Common Logo, will continue to raise standards in the management of the pharmaceutical supply chain. There will also be more focus following COVID-19 on medical devices healthcare and equipment suppliers including essential PPE supplies. The resilience of supply chains and availability to deliver continuity of supply will continue to bring challenges. The need to protect the legal supply chain and improve standards from sourcing to final delivery is essential if we are to keep our families safe.

The critical need to establish controls, review real risks in increasingly complex supply chains and understand where individual responsibilities start and finish is essential. Legislation and good practices oblige pharmaceutical manufacturers and distributors to exercise control over the distribution chain and ensure that the quality of medicines is maintained. Critical in this regard is control of the environmental conditions under which medicines are stored and transported. As global temperatures increase, the need to carefully transport all products within their specific temperature ranges will remain a significant challenge.

Optimising the pharmaceutical supply chain is a competitive necessity, but delivering patient safety should never be put at risk. Suppliers, manufacturers, distributors and outsource partners who transport and distribute products must ensure that the high level of product quality achieved by observing GMP is maintained throughout the distribution network as products are transported and delivered on a global and local basis.

While the regulators are doing all they can to heighten awareness, everyone working in this area must ensure that they act as part of the team delivering best practice and patient safety all along the supply chain. Now, more than ever, education, training and awareness are essential to maintain and continuously improve quality, integrity and supply chain performance and standards and to reduce risk. Operating without supply chain integrity and product authenticity will not deliver patient safety all day every day.

‘GET REAL, GET A PRESCRIPTION’[11]

A campaign in the UK to heighten awareness of the risks of buying counterfeit medicines using the Internet, ‘Get real get a prescription’, helped to educate consumers about the real dangers of buying counterfeit medicines online and that such a transaction could end in death.

NOTES

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2. https://www.interpol.int/en/News-and-Events/News/2020/Global-operation-sees-a-rise-in-fake-medical-products-related-to-COVID-19.
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5. For more on the role of transport in GDP, see Chapter 9 (Transportation) in *Guidance on the Interpretation and Implementation of European Good Distribution Practice*, European Compliance Academy and the Pharmaceutical Quality Group of the Chartered Quality Institute, October 2013.

6. See, for example, https://mhrainspectorate.blog.gov.uk/2019/05/08/what-does-qualification-of-suppliers-mean-to-you-risks-to-patients-and-to-your-business.

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8. BBC News (2015) *Mother's Plea After Eloise Parry 'Diet Pills' Death*, http://www.bbc.com/news/uk-england-shropshire-32391903.

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Part Four
Data and Analysis

13
Data Flows and Digitisation

LEARNING OBJECTIVES

- Examine how data flows through the supply chain.
- Identify technologies that enable data sharing.
- Show how new digital technologies can improve LSCM.
- Consider the future of supply chains in the context of increased connectivity and automation.

INTRODUCTION

Parts Two and Three of the book described the key components of LSCM operations such as LSPs, transportation, single windows, inventory management, materials handling, procurement, costing and outsourcing. In Part Four, we now focus on the analysis and control of these various entities. Key here is understanding and leveraging the data that flows through supply chains, and this is the focus of this chapter. A key issue to address is data visibility in the supply chain and barriers to it. We will also discuss how new technologies that are emerging in the context of the Fourth Industrial Revolution are radically increasing information sharing and visibility across the supply chain, and thus improving SCM. Before we proceed further, it is important to distinguish two terms which are often used interchangeably: data and information. Data can be raw, random, disorganised. When it is processed, organised and structured, it becomes (useful) information.

> ‘Digitisation will have the impact on supply chains that steam and electricity had on manufacturing’
>
> (Joe Terino, Bain).[1]

Chapter 13 comprises three core sections:

- Data flows in the supply chain
- The Fourth Industrial Revolution and the Internet of things
- Analysing supply chain data and the self-thinking supply chain

DATA FLOWS IN THE SUPPLY CHAIN

You will recall that in Chapter 1 in our diagram of the supply chain we illustrated three flows, namely material, resource and data flows. Material flows enable the delivery of freight and resource flows, such as finance, ensure that partners get paid. Data flows are more complex and multifaceted. Data is the key that unlocks supply chain responsiveness to demand. In this section we will look at the characteristics of data and the software systems and associated techniques that have been developed to manage information flows along the supply chain.

Matching supply with demand is essential to delivering freight at the right time, in the right quantity and to the customer's specification. But how do suppliers know when their freight is required, in what quantities or, indeed, what the customer's exact specification is? This is the role that demand-side information plays. Furthermore, how do downstream supply chain partners and customers know when freight will be delivered by suppliers, what quantities it will arrive in or to what specification? Supply-side information therefore plays a second essential role.

With today's global supply networks distributed across multiple, widely dispersed echelons, comes information complexity and proliferation on the supply side. On the demand side, ever more fickle consumers (many of whom are ‘always on’ with regard to personal communications technologies) expect the availability of high varieties and volumes of specific consignments in shortening time frames. This creates a need for accurate, high-velocity market information. So, contemporary supply chains are information intensive. *Information complexity*, *proliferation*, *diffusion*, *velocity* and *accuracy* are thus key drivers of developing increasingly sophisticated supply chain information technologies. Data management and synchronisation are therefore critical functions necessary to ensure the timely and accurate transmission and retrieval of a vast array of product and process data at any given time.

- *Information complexity:* data may be flowing in multiple directions and be interdependent (i.e. one set of data is reliant for its accuracy on another set of data).
- *Information proliferation:* how *wide* (upstream, downstream) does the data go.
- *Information diffusion:* how *deep* does the data go (i.e. can different layers of management drill down into the data to get greater insights).
- *Information velocity:* how fast does the data flow (e.g. when can upstream actors get data on downstream sales).
- *Information accuracy:* is the information that's captured sufficiently valid.

You will recall from Chapter 11, which dealt with materials handling and warehousing, that handling data is as important as handling inventory in the day-to-day activity of many people working in logistics and supply chain. It is not just the data itself that is important but also how we store, retrieve and use it.

Access to timely and accurate information is fundamental to effective SCM. Information must also be useful and usable. You will recall our discussion on the Internet of things (IoT) in Chapter 11 (we also deal further with this topic later in this chapter): networked desktop and mobile devices such as laptops and smartphones are now not only the toolkit of management but also used on the shop floor to access real-time information from upstream and downstream in the supply chain. This information accessibility not only supports the ability to plan and control supply chain activities but also, and arguably more importantly, provides 24/7 visibility of when things don't go to plan. For example, the availability of demand information from a range of high-street stores at a national distribution centre (NDC) will enable a particular consignment of freight to be rerouted to the stores where there is demand for it. Clearly, the more timely and accurate that information is, the greater the chances of meeting demand, thereby reducing the probability of overstocking some stores while understocking others. Imagine the benefits of having such information visibility across an entire supply network.

> Information complexity, proliferation, diffusion, velocity and accuracy are key drivers of developing increasingly sophisticated supply chain information technologies.

Information visibility is the ability to see information at the various points across the supply chain as and when required, which can help to manage the inherent complexity that exists in supply chains today. Visibility of information is highly desirable, but is difficult to achieve. The number of supply partners alone can be a major contributing factor, but it is also compounded by barriers to sharing information. In Chapter 12, we looked at the important topics of integration and collaboration along the supply chain – effective information visibility is facilitated not only by information technologies but also by integrated and collaborative relationships between supply chain partners. Without integrated information systems and collaborative, as opposed to competitive, relationships, information will not be shared effectively and efficiently. It is noteworthy that disparity between trading partners' capabilities and information security are commonly significant barriers to an IT-enabled supply chain.[2] *Cultural barriers* between supply chain partners should therefore be addressed before embarking on the implementation of supply-chain-wide information technology.

There are further barriers to gaining total visibility of information across a supply chain. The costs of implementing and maintaining supply chain spanning information technologies can be immense. These cost implications become *financial barriers* if the aforementioned disparities between trading partners exist. For example, it would be unreasonable for a major multinational supermarket to expect its small-scale third- or fourth-tier suppliers (e.g. market gardeners and small dairies) to implement cutting-edge information systems. In such supply chains, the further upstream a supplier is, the tighter the profit margins, and hence the fewer the resources available to invest in new technologies. For example, competitiveness between supermarkets drives down store prices, which in turn drives down the prices they are willing to pay their suppliers. In fact at the end of 2018, around 10,000 UK food suppliers were described as being in financial distress due to the pressure large supermarkets put on them to keep food prices low.[3]

Furthermore, the various information systems at each supply chain partner should either be the same or at least have the ability to 'talk' to each other. This issue does not end with the hardware and software. Supply chain partners must also agree on what data are required to be transmitted, when and to whom. Hence, there are myriad complex *technical barriers* to overcome before implementing information visibility solutions.[4]

Finally, *organisational barriers* to implementing supply chain spanning technologies can inevitably exist. Divergent processes can exist within single organisations, and to align the numerous disparate processes across multiple supply chain echelons, a highly complex programme of activities is required.

We can therefore classify the barriers to gaining information visibility and transparency as cultural, financial, technical and organisational. Each of these four types of barrier should be addressed to gain business benefits from supply chain spanning information technologies.[5] Nevertheless, such substantial effort is worthwhile, as the benefits are significant, and can include the following[6]:

- Customer-oriented operations
- Time compression
- Reduced schedule variability
- Shorter planning periods
- Consistent partnerships
- Supply chain synchronisation and coordination
- A single point of control
- Integrated information systems
- Customer relationship management (CRM)

Ultimately, a supply chain with information sharing, visibility and transparency can become customer focused and responsive to demand, thereby remaining competitive.

> Barriers to gaining information visibility and transparency can be classified as cultural, financial, technical and organisational, all of which should be addressed to gain business benefits from supply chain spanning information technologies.

Before concluding this section, it is worth noting that given the range and volume of data that now exists in supply chains, a challenge – yet also an opportunity – for supply chain managers and other stakeholders is how they can mine this 'big data' and leverage value from it. We will look, for example, at the opportunity presented by predictive analytics in the last section of this chapter.

THE FOURTH INDUSTRIAL REVOLUTION AND THE INTERNET OF THINGS

It is already widely accepted that we are now living in a new phase of economic history, the so-called Fourth Industrial Revolution (also referred to as Industry 4.0). This is characterised by an unprecedented advance in digital technology, which is blurring the lines between the physical, digital and biological spheres.[7] While the First Industrial Revolution used water and steam power to mechanise production, the Second used electric power to create mass production, the Third used electronics and IT to automate production, and now the Fourth Industrial Revolution is using the latest advances in digital technology. We illustrate this graphically in Figure 13.1. Among the breakthroughs that characterise the Fourth Industrial Revolution is the ability to collect and analyse massive amounts of data in an automated way, then use this data for decision-making and implement decisions in real time.[8] New technologies such as the Internet of things (IoT), artificial intelligence and blockchain are already bringing important benefits for supply chain visibility and management.

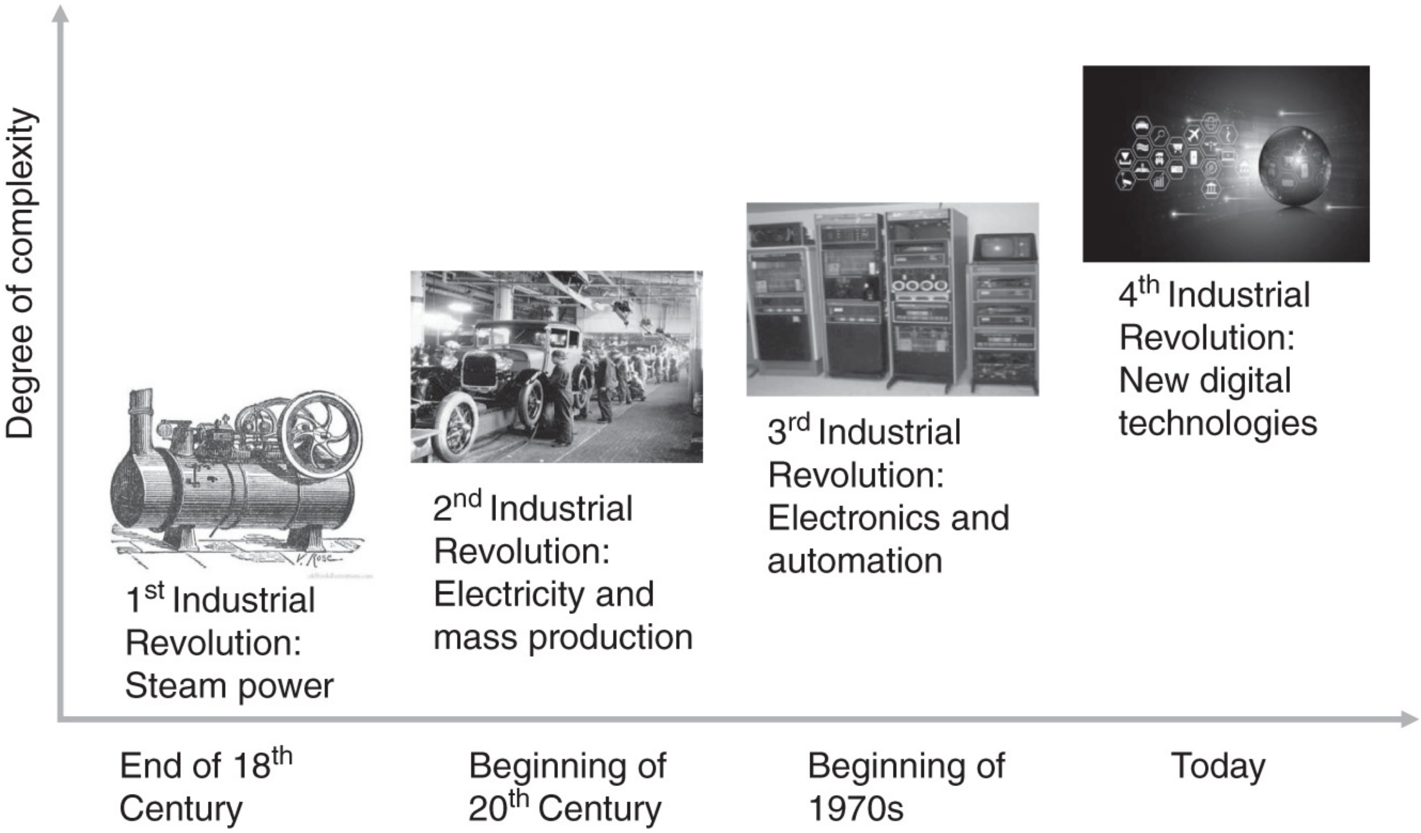

Figure 13.1 The Industrial Revolutions

(Source: Calatayud, 2017)[9]

Internet of things

As we saw in Chapter 11, the term **IoT** refers to a network of items including sensors and embedded systems which are connected to the Internet and enable physical objects to gather and exchange data. With the advent of IoT, Internet connections now extend to physical objects that are not computers in the classic sense and, in fact, have many other purposes. To light up such 'dark assets', IoT encompasses a diverse array of technologies, including wireless local networks (e.g. Bluetooth, RFID, Zigbee, Wi-Fi), mesh networks and wide area connections (e.g. 4G, LTE), as well as wired connections (Figure 13.2). With IoT, a connected bottle, for example, can send information about temperature, time and location throughout the bottle's entire journey across the supply chain, in-store and at the point of consumption. A connected forklift can alert a warehouse manager to a mechanical problem or safety risk, or be used to generate inventory data at the warehouse. A connected jet engine can send information about speed, fuel consumption, malfunctioning parts and other metrics that can be analysed to identify possible inefficiencies and prevent unnecessary downtime by spotting potential faults earlier (an example of servitisation as per our discussion in Chapter 4).[10]

Recent studies show that SCM can benefit significantly from IoT technologies.[12] With IoT, objects increase visibility throughout the supply chain by generating information in real time on the different supply chain processes.[13] For example, placing sensors on materials can enable a more precise and reliable monitoring of inventories that flow across the actors and processes involved in the supply chain, thus avoiding human errors, input shortages and the high cost of unnecessary inventory carrying. Moreover, they can enhance product end-to-end traceability, including quality control. Similar to the cases of the forklift and jet engine mentioned above, sensors capable of reporting on machinery performance and physical assets can indicate when maintenance is required and when machinery is likely to fail, thus avoiding damage and downtime. The big data produced by IoT technologies can be processed using data analytics to predict changes in consumer preferences and avoid the adverse effects of poor predictability, as well as inform probability-based risk assessments, early warning systems and simulation models. Smart sensors and metres can help improve energy efficiency and reduce water consumption in production processes, using resources in the most efficient way and ensuring the sustainability of the supply chain.[14] Experts suggest that companies that have invested in these technologies for their SCM have cut up to 30% of their inventory, increased the average fill rate by up to 7% and raised their revenue by up to 15%.[15] In addition, wider implementation of such technologies in supply chain operations management by 2025 could generate savings of approximately US$7 trillion globally.[16]

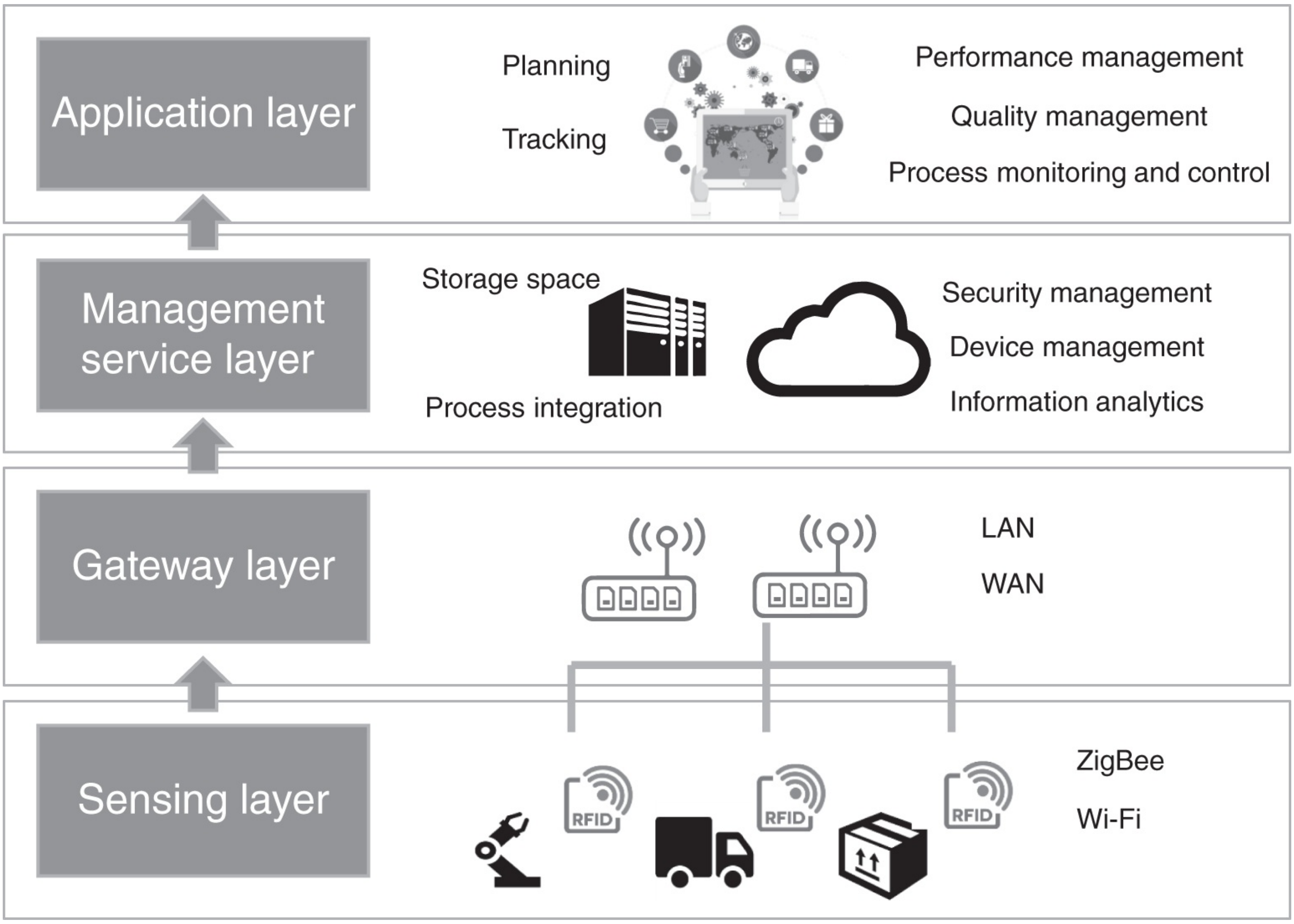

Figure 13.2 **Supply chain IoT architecture**

(Source: Calatayud *et al.*, 2019; Reproduced with permission of Emerald Publishing Limited.)[11]

IoT can also help increase integration between supply chain and infrastructure operations, thus creating a seamless transport system. Hamburg's smartPORT initiative is an example in this regard. The second busiest port in Europe, the Hamburg Port Authority, embarked on an ambitious project of modernising its IT infrastructure to coordinate all aspects of port operations, including ship, rail and road traffic. As part of this project, road and waterway sensors were installed to coordinate ship-road traffic and monitor infrastructure performance. The information gathered by sensors is used in a variety of ways, one of them being to send notifications to truck drivers on available parking spaces and bridge closures due to ship activities. This allows drivers to optimise route planning and reduce travel time. Indeed, when IoT sensors are placed on infrastructure and logistics assets, they become 'smart'. Billions of data can now be generated in real time and transmitted from transport, energy, water and telecommunication infrastructure. As in the case of the Hamburg smartPORT initiative, such data can be useful for decision-making on network and resources optimisation. Other examples include sensors placed on traffic lights to measure congestion levels and sending this information both to truck drivers for alternative routing and to public agencies for traffic management decisions. Likewise, sensors placed on parking spots at logistics and port facilities can generate information on available spots, the best route to reach them and the expected cost.

To store and manage the large amount of data generated by IoT technology, as well as provide useful information for decision-making, a number of platforms have emerged in recent years, creating a new business segment: the IoT platform market. Companies offering IoT platforms include software development leaders (e.g. IBM, Microsoft), e-commerce leaders (Amazon) and industrial leaders (General Electric). In the case of industrial leaders, their participation in this segment takes place within the trend in towards 'servitisation' (Chapter 4). Particularly relevant for business operations is the information that can be retrieved through raw data by using data analytics, which we discuss next.

ANALYSING SUPPLY CHAIN DATA AND THE SELF-THINKING SUPPLY CHAIN

Data analytics

Data analytics techniques can reveal trends and provide input to performance metrics that would otherwise be lost in the mass of data currently available along the supply chain through IoT and other digital technologies. This information can then be used to improve, for example, route planning and just-in-time inventory optimisation, as well as assist in trying to determine what may occur in the future. Indeed, forecasting is at the core of SCM and data analytics creates an unprecedented opportunity to enhance the accuracy of forecasting methods. Examples include the use of weather data to predict demand for seasonal products (e.g. a sudden improvement in weather conditions may lead to a rapid increase in the sale of barbeques), as well as the analysis of Internet search terms to help pharmaceutical manufacturers see that once people search for certain symptoms there will be a follow-on demand for their products.

Increasingly, too, there is a need to enhance information sharing across the supply chain to make the most out of data analytics. One way to do this is by allowing suppliers direct access to **electronic point-of-sale (EPOS) data,** thereby facilitating full visibility between them and retailers. By doing so, manufacturers can gain deeper insight into consumer preferences and be able to respond faster to any changes in demand. This can bring benefits for retailers too, drives more sales, minimising time-on-shelf and protecting them against out-of-stock or excessively overstocking.

Given the difficulties inherent in forecasting, and a reluctance among companies to be reliant on a single forecast that may well be wrong, many are now developing scenario forecasts of the future. The marine engine manufacturer Wärtsilä, for example, has developed three scenarios for the future global shipping sector, each dependent upon the dominant geopolitical context. The logistics company DHL provides a variety of forecasting solutions for logistics and supply chain processes, including DHL Resilience 360, a data-driven near real-time monitoring of shipment milestones across transport modes powered by advanced technologies to predict, assess and mitigate disruptions; and DHL Trade Barometer, a machine learning tool to predict air freight delays.

Artificial intelligence

The big data generated in supply chains by IoT and related technologies is ripe for the application of artificial intelligence (AI). AI is defined by the Oxford English Dictionary as 'the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages'. It is suggested that, in the near future, a variety of AI algorithms will be used to continuously monitor supply chain performance by analysing quintillion bytes of data generated by objects; forecast and identify risks; predict the future with minimum error and take actions to address any deviation from expected performance.[17] Often used interchangeably with the term AI, machine learning is actually an application of AI that provides systems with the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning is at the heart of chatbots, for example, which are increasingly being deployed in SCM for improved customer service. You may be familiar with Amazon's Alexa for example. Alexa uses machine learning to enhance the accuracy of its responses. Based on an agreement between Amazon and DHL, Alexa has been taught to answer questions about parcels, e.g. shipment details, location and so forth.

Among the many uses of AI in SCM, predicting demand is increasingly being used by firms in a wide array of sectors as a means to avoid the bullwhip effect described in Chapter 5, reduce inventory handling and increase customer satisfaction. For example, large e-commerce companies are using AI to analyse consumers' preferences and predict what products they will buy on their platforms. Based on these estimations, products are sent closer to consumers' location even before they place their orders, so that the products can be delivered faster, while customer satisfaction is increased. This is known as **anticipatory shipping**.

Ultimately, supply chain practitioners and researchers suggest that in the not-too-distant future, the supply chain will think by itself.[18] Driven by IoT, robotics and AI, the supply chain will be self-aware and require minimum, if any, human intervention. Information that was previously created by people will increasingly be machine-generated, while the entire supply chain will be connected. Based on these data, supply chains will be able to make decisions automatically and in real time, to optimise operations, handle incidents that require risk-mitigation actions, avoid disruptions and satisfy an increasingly volatile demand. The **self-thinking supply chain** will thus push supply chain flexibility and agility to limits yet to be discovered.[19]

Figure 13.3 illustrates the way a self-thinking supply chain will work. First, there will be a high degree of connectivity between cyber systems and physical objects through the use of IoT. Such IoT technology will be ubiquitous through the deployment of sensors, short- and long-range networks and Internet-enabled applications. Big data will be generated, stored and analysed through IoT and AI in real time. This will enable continuous monitoring of supply chain performance and early identification and management of potential risks. Increased connectivity among supply chain partners enabled by IoT, together with AI, will allow for more accurate demand forecasting, predictive maintenance and continuous optimisation. With AI, decision-making will be machine-generated and processes will be automated. Objects will be able to sense the environment (through IoT) and respond to it according to AI-made decisions. Changes will be made at the micro level (e.g. at individual nodes in the supply chain) in order to optimise supply-chain-wide performance. Efficient, accurate, fast and simultaneously orchestrated responses will thus improve supply chain performance in an increasingly complex and uncertain world. Using real-time data on both demand and available production and distribution capabilities, the gearbox approach (Box B in Figure 13.3 - recall we also mentioned this approach in Chapter 10) will be used to regulate (speed up/slow down) the flow of materials downstream in the supply chain.

> The self-thinking supply chain has autonomous and predictive capabilities.

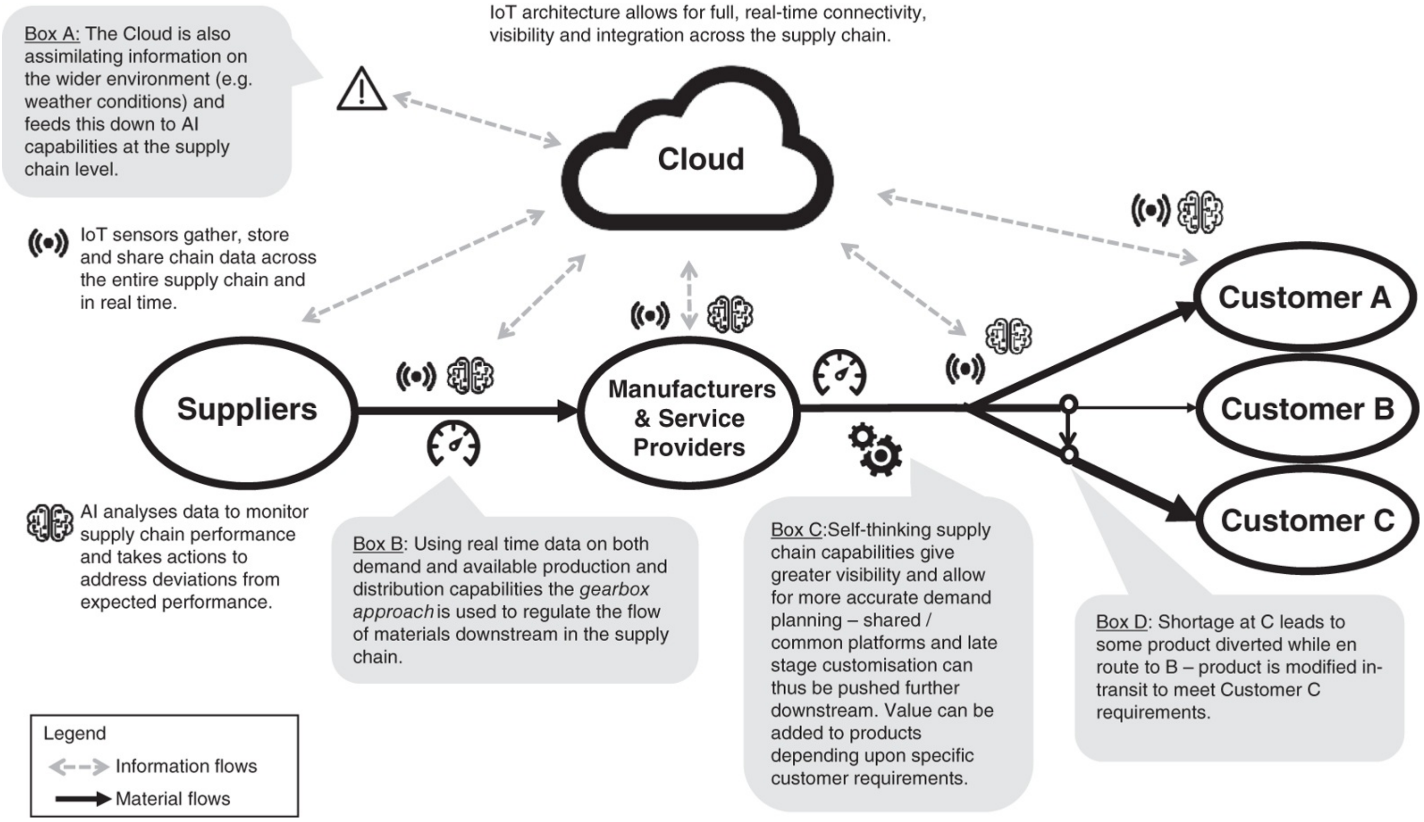

Figure 13.3 The self-thinking supply chain (Source: Calatayud *et al.* 2019; Reproduced with permission of Emerald Publishing Limited.)[20]

Blockchain technology

Another emerging technology that promises large benefits for supply chain risk management is blockchain. As we mentioned in Chapter 9 when discussing trade facilitation, this technology can help create and share information in an immediate, unalterable and transparent fashion throughout the supply chain, without the need to set up costly centralised information-sharing systems. It also decreases the need for third-party intervention and reduces the number of documents that have to be shared. By using distributed ledger technology, all the information shared in the network is stored in each node, making it easier to access and trace transaction history. Any change to the information stored in the distributed ledger must be approved by consensus by all the nodes in the network. Once the change is approved, the information is immediately stored in each node. This makes the system more resilient to failure or targeted attacks. In addition, since blockchain uses cryptography to guarantee the information stored in the distributed ledger, it makes it virtually impossible to alter the information already stored without having the consensus of the nodes in the network. This is an important feature to avoid forgery and fraud in the information shared. Finally, the decentralised feature of blockchain eliminates the need for third parties to validate the information shared, which in turn reduces transaction costs and increases transparency.

One expected benefit of blockchain relates to ensuring materials provenance and end-to-end product traceability. Together with the use of IoT and big data, real-time sensor-generated information can be encrypted, validated and shared among supply chain partners to ensure, for instance, that the temperature, humidity and quality conditions of materials and products have been unaltered in their flow through the supply chain.[21] Blockchain technology is currently being tested in different supply chains and industries. An interesting initiative is TradeLens, a platform developed by Maersk and IBM that is underpinned by blockchain with the aim to increase information sharing and collaboration among international trade partners – including port terminals, carriers, shippers and public agencies. It does so by simplifying and gathering in a single, secure data-sharing platform the flow of documents that accompanies every shipment (as described in Chapter 9). TradeLens started as a pilot project back in 2017 with the shipment of reefer containers from East Africa to Rotterdam. Such shipments could go through nearly 30 people and organisations, including more than 200 different interactions and communications among them. The pilot showed that the cost of paperwork (approximately US$300, or 15% of the cargo's value) could be significantly reduced while traceability increased for all parties.[22] At present, the platform handles 10 million events and more than 100,000 documents every week, from more than 100 organisations around the world.[23]

LEARNING REVIEW

This chapter looked at the characteristics of data in the supply chain, and how such data can be used to plan and control flows and activities along the supply chain. We also reviewed the barriers to full visibility of such data. We then turned our attention to how novel technologies such as IoT, AI and blockchain can improve visibility and SCM. We learnt that, in the context of the Fourth Industrial Revolution, SCM is expected to significantly improve through big data, real-time information sharing, enhanced predictive capabilities and even the automation of decision-making, with the supply chain of the future becoming 'self-thinking'.

QUESTIONS

- Describe the barriers to having full visibility of information across the supply chain.
- Information complexity, proliferation, diffusion, velocity and accuracy are key drivers of developing increasingly sophisticated supply chain information technologies. Describe each of these drivers in the context of logistics and SCM.
- How can new technologies improve supply chain management?
- What are the characteristics of a self-thinking supply chain?

NOTES

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21. Calatayud (2017), op. cit.

22. Forbes (2017) *IBM* and *Maersk Apply Blockchain to Container Shipping*, https://www.forbes.com/sites/tomgroenfeldt/2017/03/05/ibm-and-maersk-apply-blockchain-to-container-shipping/#3c627b273f05.

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14
Management Science Applications

LEARNING OBJECTIVES

- Summarise a range of management science applications in transport, logistics and SCM.
- Describe optimisation, simulation, decision-making and forecasting management science applications in the context of transport, logistics and SCM.

INTRODUCTION

Management science (MS), traditionally known as 'operations research' (OR), can be described as a discipline that attempts to aid managerial decision-making by applying a scientific approach to managerial problems that involve quantitative factors.[1] It is a highly developed field of study with many wide-ranging applications to everyday life, especially in the area of transport and, more recently, in LSCM as well. In this chapter, we will introduce some of the more widely used applications. It is beyond the scope of this book to go into significant depth concerning the detail of the tools described, but we hope this overview will provide an awareness of what tools are available to logistics and supply chain managers and what they can be used for.

Before we start to analyse logistics systems and supply chains, we need first to be very clear about the nature and characteristics of the systems that we are analysing, and this will be the focus of the first section. This is followed by a summary of the main MS applications in transport and LSCM, each of which will then be described in further detail in the following sections.

Chapter 14 comprises five core sections:

- System characteristics
- Management science applications in transport, logistics and SCM
- Optimisation
- Simulation
- Decision-making and forecasting

SYSTEM CHARACTERISTICS

As noted above, before we start to analyse logistics systems and supply chains, we need first to be very clear about the nature and characteristics of the system that we are analysing.

A key issue is the model inputs: are any of the input variables into our model random? **Stochastic models** have at least one random input variable, while **deterministic models** have no random input variables. Examples could be customer orders: might these be made at any time or would we know exactly what would be ordered and when? And if demand were random, you might wonder whether it could be forecasted with any accuracy (see the discussion on forecasting later in the chapter) and/or whether you could influence it in any way (e.g. use social media to do flash sales). Another dimension to our analysis is the passage of time and whether to account for it: **static models** do not allow for the passage of time (and thus just represent a snapshot of the system at that particular point in time), while **dynamic models** do. We can further divide dynamic models into two categories: discrete event models, where state changes only occur at discrete points in time (e.g. customers can only collect orders at a set time) and continuous models, where variables change continuously with respect to time (e.g. the temperature of a product may not be held stable during transit).

In any MS approach, the following key steps are recommended:

- Define the problem and gather data.
- Formulate a model (we can describe a model as a simplified representation of the real world) to represent the problem.
- Develop a computer-based procedure for deriving solutions to the problem from the model.
- Test the model and refine it if needed; we refer to this as 'sensitivity analysis'.
- Apply the model to analyse the problem and develop recommendations for management.
- Help with implementation as necessary.

Validity and reliability

Furthermore, once the model is complete, we recommend you 'sense check' your model: how valid are the results? By 'valid', we mean how true the results are. An example best explains: you may analyse alternative transport routings and decide an optimum solution in terms of transit time, cost etc. In some countries, however, truck movements are not allowed at certain times (night-time, weekends); therefore, no matter how good your solution is, if the freight has to travel at that time, then your solution won't work! A further issue to consider is to what extent you can 'fix' the system you are analysing. Perhaps your results indicate that no matter how much you attempt to fix a process the benefits accruing will only be marginal and not worth the investment. As an alternative recommendation, you may suggest that the process is reengineered completely: rather than make marginal changes (e.g. employ more staff to improve pick efficiency in your warehouse), you may decide that a completely different solution is required (outsource your warehousing requirements to a third party that may do it better). This is referred to as 'business process reengineering' (BPR), which is generally described as a fundamental rethinking and radical redesign of business processes to achieve dramatic improvements.

A further issue to consider is how reliable your results are. By 'reliable', we mean that if you repeat the analysis will you get the same results? If you don't, is that because your model is not correctly formulated or is the variability in the results an underlying feature of the scenario you are modelling?

Before progressing further with this chapter, you may wish to go back to Chapter 5 and refresh your understanding of systems thinking and related topics such as the bullwhip effect and supply chain complexity – these topics are all very relevant in the context of allowing us to first understand the nature and characteristics of the systems that we are going to analyse.

MS APPLICATIONS IN TRANSPORT, LOGISTICS AND SCM

Table 14.1 summarises some of the main MS applications in transport, logistics and SCM. As noted in the introduction, MS is a wide-ranging and well-developed field, so we are merely giving an insight here into how we can apply lessons learnt from MS to the analysis and improvement of transport and logistics systems and wider supply chains.

TABLE 14.1

MS applications in transport, logistics and SCM

Application	Example
Optimisation	Improving key performance metrics in a supply chain (e.g. getting the lowest possible item delivery cost within certain constraints, such as product integrity must be maintained and delivery cannot take more than *x* days)
Simulation	Seeing how a logistics system performs over time (e.g. you may have a network of trucks making regular deliveries, a simulation would illustrate to what extent irregular and/or random events may affect your schedule integrity)
Decision-making and forecasting	Logistics managers are always making decisions (some routine, e.g. how many pallets to put into a container, and some more strategic, e.g. which logistics service provider to enter a long-term agreement with) and various MS tools are available to help with such decision-making. Of course, it is impossible to predict the future but nonetheless there are MS tools that may at least assist us in looking at what could happen
Inventory models	Chapter 10 highlighted the key concerns in inventory management and the various tools that can be employed to analyse and operationalise inventory systems (e.g. setting reorder levels)
Other applications	There are many other MS applications in transport, logistics and SCM: examples include areas such as queueing models (e.g. how many truck bays or ship berths do we need), indices (e.g. many are used in shipping where they monitor trends over time – key issues are how indices are formulated, what data are used, how the different variables are weighted) and investment appraisal approaches (e.g. cost–benefit analysis)

The following sections will describe optimisation, simulation, decision-making and forecasting MS applications in the context of transport, logistics and SCM.

OPTIMISATION

Optimisation techniques can be used to analyse and help improve key performance metrics in a logistics system or supply chain (such as getting the lowest possible item delivery cost within certain constraints, e.g. product integrity must be maintained and delivery cannot take more than x days). In essence, these techniques help us to best allocate resources to various (often competing) activities in order to best meet organisational objectives. The output is typically to find the best mix of activities – which ones to pursue and at what levels. This may mean that certain compromises are necessary in order to optimise. In the example above (reducing delivery cost), you may not actually end up using the cheapest transport mode as it may be too slow and as a result the items may be in transit for too long, with associated opportunity costs, thus increasing the true total costs associated with delivery. The optimum solution then could be to use a slightly dearer, but faster, transport mode resulting in the lowest possible total costs (delivery, opportunity costs and so forth; indeed, your chosen mode of transport may even have different packaging requirements [airfreight often needs less packaging than sea freight] – so all costs need to be considered in the analysis).

THE TRUCKER AND THE PROFESSOR

‘One crisscrosses the country, hauling his cargo in an 18-wheeler. The other crunches the numbers and starts software companies – five at last count. Meet the twin engines driving the new math-based trucking industry.’

For further insights into optimisation applications, see this now somewhat old, but wonderfully insightful, article detailing the application of optimisation to truck routing and scheduling in the US: http://archive.wired.com/wired/archive/9.12/sheffi.html.

Optimisation techniques are widely used in transport and the remainder of this section now details their application in this domain.

One of the most commonly used models that seeks to work out a minimum total transport cost solution for the number of units of a single commodity that should be transported from given suppliers to a number of destinations is the **transportation model**. The input data required for this model include the number of units of the product required by the destination store/warehouse/distribution centre (destination) and the number of units available with each supplier (origin). In addition, the unit transport cost of the product from each origin to each destination is also required. When it is not possible to have the data on unit transport costs, it is common practice to use the actual travelling distance between each origin and each destination. The model application aims to determine the number of units that should be transported from each supplier to each destination such that total transport cost or total distance travelled is minimised.

There are a number of assumptions made in the application of the model (see any of the standard texts, for example: Taha, H. A. (2008) *Operations Research: An Introduction*, Prentice Hall). The main assumption is that there is a linear relationship between the transport cost and the number of units being transported (as we know from Chapter 6 this may not necessarily always be the case in practice). It is important that the units of supply and the demand (requirement) from destinations are consistent.

Let us assume that the amount of supply at origin i is s_i and demand at destination j is d_j and the unit cost between i and j is c_{ij}. Let x_{ij} be the amount or the number of units transported from origin i to destination j. The transportation problem using linear programming can be defined as follows:

$$\text{Minimise total transport cost } \mathbf{C} = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij} x_{ij} \tag{14.1}$$

subject to

$$\sum_{j=1}^{n} x_{ij} \leq s_i \text{ for } i = 1, 2, \ldots, m \tag{14.2}$$

$$\sum_{i=1}^{m} x_{ij} \leq d_j \text{ for } j = 1, 2, \ldots, n \tag{14.3}$$

$$x_{ij} \geq 0 \text{ for all } i \text{ and } j \tag{14.4}$$

Equation (14.2) suggests that the total of supply shipments from a supplier should be less than or equal to the available supply. Equation (14.3) means that the sum of shipments to a destination should be less than or equal to the demand/requirement at that destination. These constraints have to be satisfied with the objective of minimising total transport cost **C** given in equation (14.1). In addition to these constraints, the transport problem formulation must also satisfy equation (14.4) implying that the goods are only shipped from origins to the destinations, which means from suppliers to purchasers but not in the reverse direction. There is a special requirement of the basic transportation allocation problem that *the total plant capacity (origins) must equal the total warehouse (destinations) demand*. This helps in finding the solution of the problem.

Standard transportation model: A simple exercise

Alpha Limited manufactures washing machines in the UK with factories in Birmingham, Manchester and Glasgow. Its main UK distribution centres are located in Doncaster and Newcastle. The capacities of the three factories in the next month are, respectively, 300, 200 and 150 washing machines. The monthly demand for the washing machines from distribution centres are 400 (Doncaster) and 250 (Newcastle) washing machines. The transport cost per washing machine from factories to distribution centres are shown in Table 14.2.

Calculate the least total transport cost solution for delivery of the required washing machines by the two distribution centres.

The solution is worked out using equations as follows:

$$\text{Minimise transport cost } \mathbf{C} = 25x_{11} + 35x_{12} + 15x_{21} + 20x_{22} + 40x_{31} + 30x_{32}$$

TABLE 14.2

Transport cost per washing machine

	Doncaster (1)	Newcastle (2)
Birmingham (1)	£25	£35
Manchester (2)	£15	£20
Glasgow (3)	£40	£30

Subject to

$$\begin{aligned} x_{11} + x_{12} &= 300 \\ x_{21} + x_{22} &= 200 \\ x_{31} + x_{32} &= 150 \end{aligned}$$

and

$$\begin{aligned} x_{11} + x_{21} + x_{31} &= 400 \\ x_{12} + x_{22} + x_{32} &= 250 \end{aligned}$$

The final solution for this simple exercise is worked out solving the above equations for x_{ij} for i = 1, 2 and 3 and for j = 1 and 2. The exact solution is given in Table 14.3.

$$\begin{aligned} \text{Total cost for this solution is } &= 300 \times 25 + 100 \times 15 + 100 \times 20 + 150 \times 30 \\ &= £15,500 \end{aligned}$$

The above solution allocates the number of washing machines that should be transported from a specific factory to a specific warehouse to achieve minimum total transport cost, which is £15,500. Any variation in the allocation given in the above solution will increase the total transport cost. This is required for solving the transportation problem for allocation using the transportation model algorithm. In most practical applications, this will not be the case and this would require setting up a *dummy* plant or a dummy distribution centre as needed to make the two totals exactly match.

TABLE 14.3

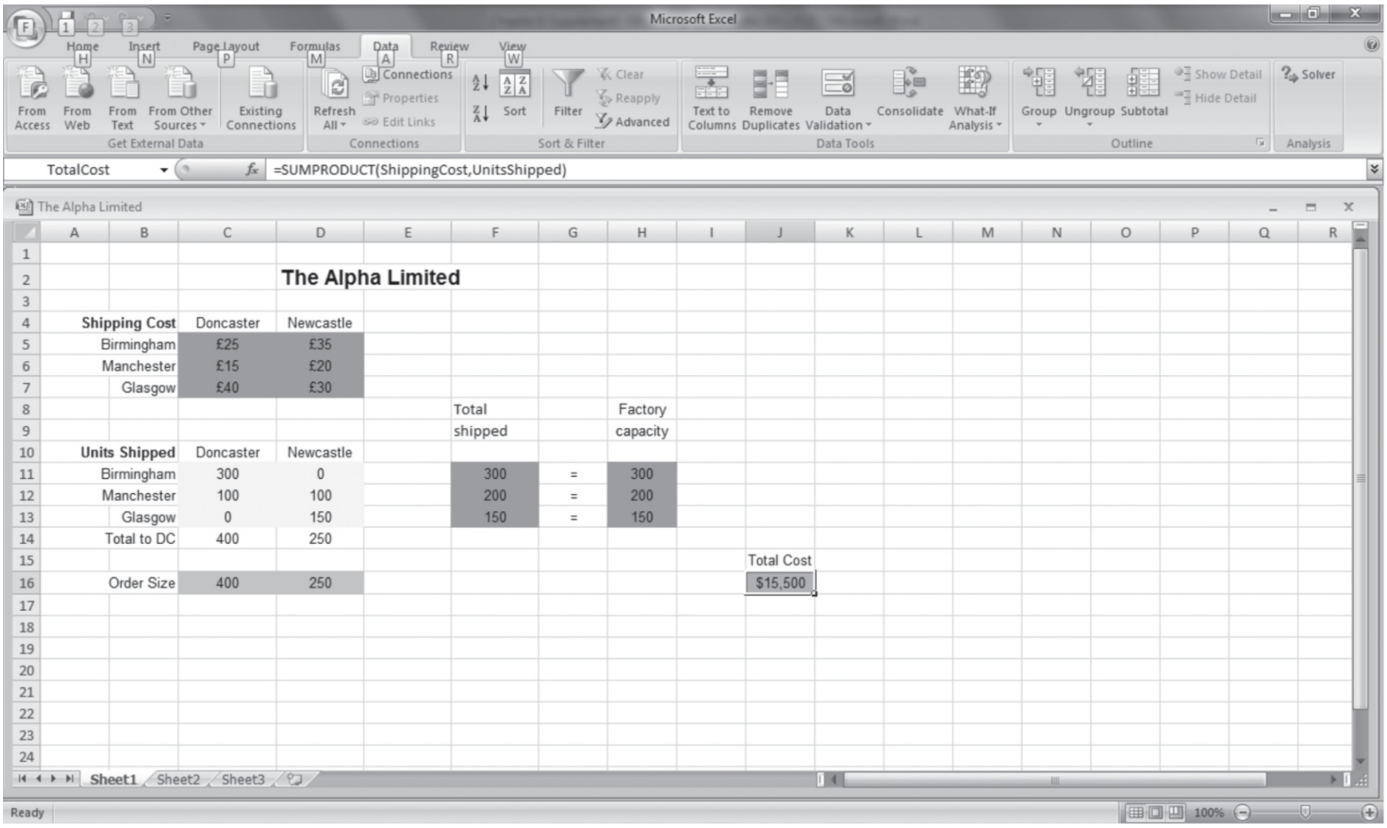
Optimum solution

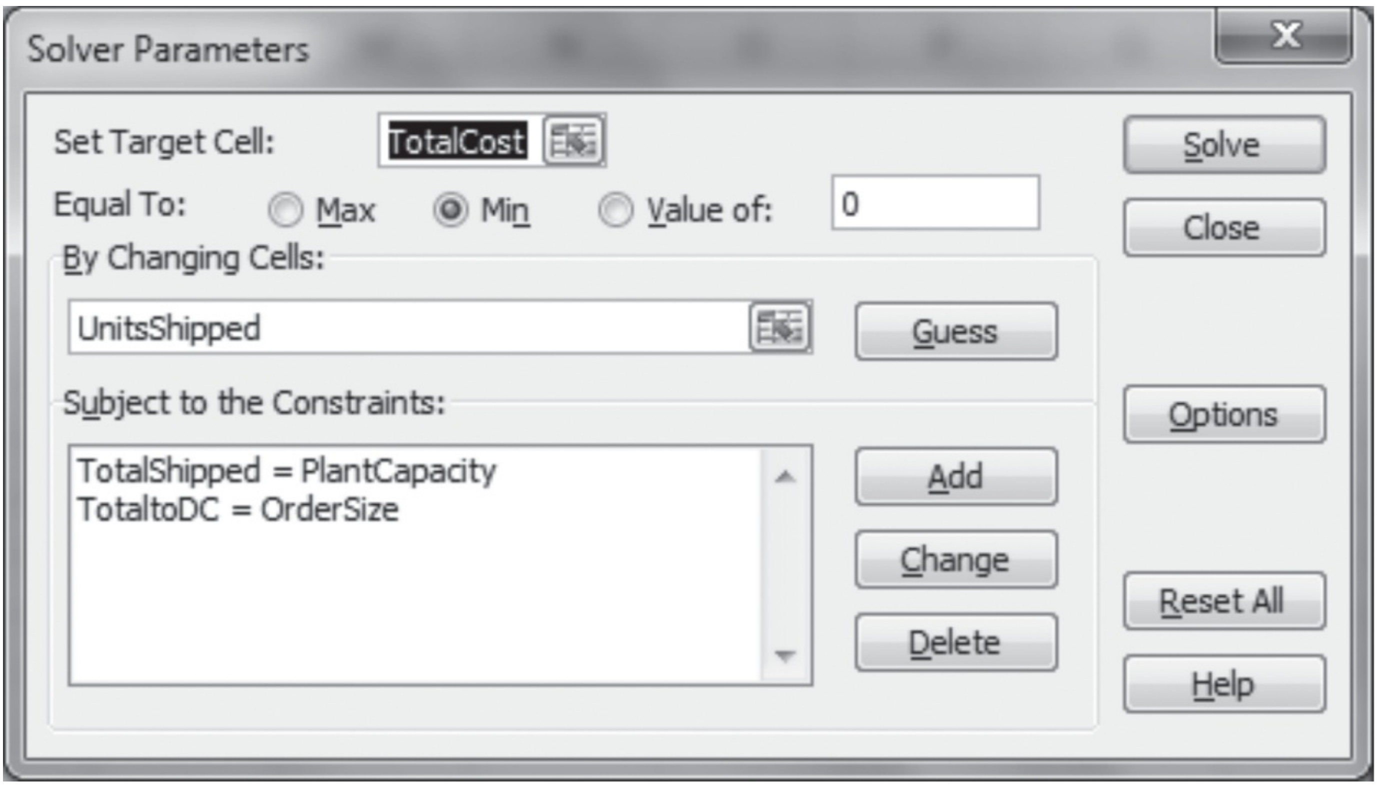
	Doncaster (1)	Newcastle (2)	Factory capacity
Birmingham (1)	300	0	300
Manchester (2)	100	100	200
Glasgow (3)	0	150	150
Distribution centre demand	400	250	

Note: It should be noted in the above example that the total of plant capacity is exactly the same as the total of the distribution centre demand, which is 650 as shown below:

$$300 + 200 + 150 = 400 + 250$$

Both specialist and off-the-shelf software packages are available for solving the transportation problem. In fact the 'Solver' function in Excel can easily be employed to solve many such problems. The 'screen grabs' below illustrate the solution to the above example using this function. Note that it is important in this case to click the Solver options 'assume linear model' and 'assume non-negative'.





SIMULATION

Simulation is useful for assessing how a logistics system performs over time. For example, you may have a network of trucks making regular deliveries, a simulation will illustrate to what extent irregular and/or random events may affect your schedule integrity. Simulation, then, is the process of building a model and experimenting with it (changing data inputs, conducting multiple runs) in order to develop insight into a system's behaviour based on a set of inputs. The output will help us to make decisions around system design. In the above example, then, it will help you to decide how many trucks you need in your network. Simulation can be particularly useful in a variety of situations:

- If there were process problems or bottlenecks, you could use it to experiment and see what would be the impact of process changes.
- Testing the behaviour/output/impact of major process or system changes.
- Comparing alternative process designs.

The key advantage of simulation is that it is relatively low cost – you can run the simulation on your computer – and thus you can investigate any questions you have (e.g. What will be the impact of a particular change?) before investing capital and disrupting operations. Specialised simulation software is available, and you can also run simulations on standard software programmes such as MS Excel. Speed of analysis and flexibility of data input are key advantages of simulation. An advantage of the specialised simulation programmes is their use of graphical interfaces which can show end users the simulation outputs (i.e. rather than seeing a set of numbers rolling through a spreadsheet, you see an animated representation of the actual system being simulated). Arena, for example, is one of the leading simulation software packages. It provides some very insightful example videos of simulations (at ports, warehouses etc.) on its website.[2]

DECISION-MAKING AND FORECASTING

Logistics managers are always making decisions (some routine, e.g. how many pallets to put into a container, and some more strategic, e.g. which LSP to enter into a long-term agreement with), and various MS tools are available to help with such decision-making. There is a lot of research available in this area, especially in the transport field around mode, route and carrier choice.

The structure of decision-making

A useful starting point in any analysis of decision-making is to first endeavour to understand how the requisite decision can be structured, what criteria should be considered and how they should be weighted and scored. One of the simplest approaches is to build a decision tree which represents the different possible outcomes and the probability of their occurrence; the decision then is made on the basis of selecting the outcome with the highest score (determined as the probability multiplied by the value associated with that particular outcome). More detailed approaches include the Analytic Hierarchy Process (AHP), a structured technique for organising and analysing complex decisions.[3]

Mode, route and LSP choice

In Chapter 8, we reviewed the variables that need to be considered when selecting LSPs. As well as identifying the relevant variables, it is important to understand how these variables interrelate in logistics decision-making. Although we would like to think that logistics decision makers always engage in objective analysis and decision-making, the reality is often different. In fact, many logistics decision makers often engage in what is known as 'satisficing' (as opposed to 'maximising') decision-making behaviour, that is, they select routes and services which they know are not optimum but with which they will nonetheless be largely content. This may be for a variety of reasons such as they do not have the time to appraise alternatives, ease and convenience of use, and a desire to avoid the risk of anything going wrong. In our experience, decision-making in logistics around choice of routes, modes and LSPs is complex, for the following reasons:

- The objectives of the process can conflict (e.g. to both maximise customer service and minimise costs).
- Full information is often not available because of the dynamic and uncertain environment.
- The evaluation of the potential options is based on multiple criteria.
- The evaluation can be dependent upon subjective judgements by the decision makers.
- The locus of the decision (Who? When?): several people are usually involved in the decision process.
- There are often a large number of alternatives to be evaluated in the process.

Forecasting, scenario building and data analytics

It is impossible to predict the future, but nonetheless there are MS insights and tools that can be employed to at least assist in looking at what may occur in the future. One of the easiest approaches is to examine historical patterns and simply extrapolate those into the future. Of course, just because something happened in the past is no guarantee that it will happen again in the future. There are variants of trend extrapolation, such as averaging and smoothing methods which endeavour to minimise the impact of outliers/spikes in the trend profile. When looking, then, at historical trends, it is important to also try to investigate causality. This is the basis for using regression models in forecasting. Various transport and logistics indices (we looked at some of these in Chapter 5) are often also used to track trends and thus hopefully get an insight into what may happen in the future (an example is the Baltic Dry Index, an economic indicator that tracks shipping rates). The methods considered thus far are all quantitatively based. In contrast, the Delphi technique is an iterative qualitative forecasting technique which employs a panel of experts to make forecasts on the basis of their shared insights and expertise.[4]

In the previous chapter we have seen how the volume of data in supply chains has increased significantly. Data analytics, artificial intelligence and machine learning can all help with forecasting in LSCM; as we saw in the previous chapter some supply chains are now becoming self-thinking and thus brining supply chain flexibility and agility to new limits and in effect reducing the dependence on forecasts.

Given the difficulties inherent in forecasting, and a reluctance among companies to be reliant on a single forecast that may well be wrong, many are now also developing scenario forecasts of the future. As we mentioned in the previous chapter the marine engine manufacturer Wärtsilä, for example, has developed three scenarios for the future global shipping sector, each dependent upon the dominant geopolitical context.[5]

LEARNING REVIEW

This chapter introduced the discipline of MS and illustrated applications to transport and LSCM. We noted how it is important before analysing logistics systems and supply chains to first understand the nature and characteristics of the systems that we are analysing. We looked at the application of optimisation tools and in particular at the transportation problem. Simulation, decision-making and forecasting approaches were also reviewed. The final chapter in Part Four of the book now turns to an increasingly important area in LSCM, that of vulnerability and related topics such as risk and security.

QUESTIONS

- Distinguish stochastic models from deterministic models.
- Identify the different approaches to forecasting – which in your view is the best approach?
- Distinguish validity from reliability.
- Why is it not always possible or feasible to select the 'best' route for a shipment?

NOTES

1. Hillier, S. & Hillier, M. S. (2014) *Introduction to Management Science*, 5th edition, McGraw-Hill, New York.
2. See www.arenasimulation.com.
3. AHP has had many applications to transport and logistics. See, for example, T.-C., Thanopoulou, H., Beynon, M. J. & Beresford, A. K. C. (2004) An application of AHP on transhipment port selection, *Maritime Economics and Logistics*, 6, 70–91.
4. See, for example, Dinwoodie, J., Tuck, S. & Rigot-Müller, P. (2013) Maritime oil freight flows to 2050: Delphi perceptions of maritime specialists, *Energy Policy*, 63, 553–561.
5. Wärtsilä (2012) *Shipping Scenarios 2030*, www.shippingscenarios.wartsila.com, accessed 25 October 2015.

15
Managing Vulnerability

LEARNING OBJECTIVES

- Explain why supply chain risk, vulnerability, robustness and resilience have emerged as important themes in LSCM.
- Identify the sources and types of supply chain risks.
- Illustrate potential impacts on supply chains.
- Show how various initiatives and technologies can be effectively used to mitigate risk.

INTRODUCTION

In the mid-1990s, the subject of supply chain risk or vulnerability would have been of little interest to anyone but professional logisticians and supply chain managers. Even then they would likely have interpreted 'risk' as simply the financial or competitive disadvantage resulting from a failure to implement 'best practice' SCM concepts. But times have changed. It is no longer unacceptable to acknowledge that bad practice may still flourish elsewhere in the network or that even well-managed operations can, and occasionally do, fail. This chapter provides an introduction to the complex, but fascinating, subject of supply chain risk and the related concepts of vulnerability, robustness and resilience.

Chapter 15 comprises four core sections:

- Some working definitions
- Changing times and an uncertain world
- Technology and supply chain risk management
- Security across the supply chain

SOME WORKING DEFINITIONS

Chapter 1 highlighted an enduring problem in LSCM – confusion over key terms, even amongst specialists and academics. This is especially pertinent with regard to supply chain risk, robustness and resilience, so our first objective must be to clearly define these key terms.

Risk

The main problem stems from multiple meanings of the term 'risk'. In decision theory, it is a probability or a measure of the range of possible outcomes from a single totally rational decision and their values, in terms of upside gains and downside losses. The concept tends to be illustrated by examples from gambling. Alternatively, 'risk' is sometimes used to refer to a particular type of hazard or threat, for example technological risk or political risk. Finally, 'risk' may describe the downside only consequences of a rational decision in terms of the resulting financial losses or number of casualties. The latter can be traced back to risk management disciplines, notably the safety and engineering literature.[1] The reasoning behind each of these interpretations and why they matter in a logistics or SCM context will be discussed later in this chapter.

Supply chain vulnerability

In the meantime we will use the term 'risk' as it relates to **vulnerability** as our point of embarkation; that is, '*at risk:* vulnerable; likely to be lost or damaged'. In Chapter 1, we adopted a definition of a supply chain as 'the network of organisations that are involved through upstream and downstream linkages in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer'.[2] Given that supply chains comprise many different elements and that SCM embraces many different functions, it is perhaps useful to ask the question 'What is it that is vulnerable, in other words *at risk?*' Is it a product or service, the performance of a process or specific activities, the well-being of an organisation, a trading relationship or the wider networks as a whole? Or is it the vulnerability of one or more of these to some external malevolent force that should be the focus of our consideration? In fact, the supply chain vulnerability field considers all of these issues and possibilities.

Ideally, we should strive to identify and manage known vulnerabilities by asking questions such as:

- What has disrupted operations in the past?
- What known weaknesses do we have?
- What 'near misses' have we experienced?

Recording near misses is something that all organisations should do. Unfortunately, it does not always happen. Sometimes no one was aware that a near miss took place, and often they go unreported because people feel that the incident might reflect badly on them or their department. The willingness to report events of this kind is often dependent on the culture of the department or wider organisation. Forward-thinking organisations recognise that near misses are often warnings of worse to come.

Taking a more proactive stance, a good supply chain manager should also be asking 'effects'- based questions, such as:

- What would be the effect of a shortage of a key material?
- What would be the effect of the loss of our distribution site?
- What would be the effect of the loss of a key supplier or customer?

Robust SCM

Whilst individual managers might focus on the effects of a range of eventualities, some argue that everyday SCM strategy also plays a part in supply chain vulnerability. In Chapter 3 reference was made to the work of Christopher Tang,[3] who identifies key elements of a **robust** SCM strategy. The dictionary definition of 'robust' is 'strong in constitution, hardy, or vigorous'.[4] Tang suggests that a robust strategy should enable a firm to manage regular fluctuations in demand efficiently under normal circumstances regardless of the occurrence of a major disruption. It might be supposed that any organisation would actively seek to ensure such a position. However, as Tang points out, for a variety of reasons, this is not always the case. What is more, even if your own organisation has implemented the tenets of best practice SCM, does this mean that your supply chain will not fail? Have other organisations in the supply chain all done the same? Even if they have, will that be enough to ensure operations continue? A robust strategy has much to commend it, but does not in itself make a resilient supply chain.

Resilience

The term **resilience** is used to mean 'the ability of a system to return to its original (or desired) state after being disturbed'. Based on a dictionary definition borrowed from the science of ecosystems,[5] this definition has been adopted in much of the research into supply chain vulnerability, risk and resilience.[6]

- It encourages a whole system perspective.
- It explicitly accepts that disturbances happen.
- It implies adaptability to changing circumstances.

If we are really to embrace the notion of global inter-organisational supply chains within a complex and dynamic environment, then this whole system-wide perspective is the position we should adopt when considering matters of supply chain risk or vulnerability.

Supply chain risk management (SCRM)

SCRM refers to the set of strategies used to identify and manage risks along the supply chain, with the goal of minimising vulnerability and improving supply chain resilience. Among such strategies are[7]:

- Increasing visibility with suppliers and clients through information sharing
- Increasing flexibility in the production process to respond to any external changes
- Postponement
- Multiple sourcing and flexible vendor contracts
- Building redundancy by adding external safety stocks (through e.g. VMI or CMI)
- Joint planning and coordination with supply chain partners

CHANGING TIMES AND AN UNCERTAIN WORLD

As we discussed in Chapter 5, modern industrial organisation is characterised by growing complexity. Trends such as outsourcing, offshoring, just-in-time production and consumer-driven production have increased complexity in supply chains and, consequently, the uncertainty and higher probability of risk occurrences. On the one hand, this is a result of (i) the levels of interconnection and interdependence between enterprises that are greater than they were previously and (ii) the fact that the competitiveness of a business no longer depends on itself, but on all the other firms with which it is connected within a supply chain.[8] On the other hand, the international expansion of supply chains generates greater complexity and makes them more susceptible to changing conditions in the business climate in each country that they operate in. For example, we will see below how extreme weather and social upheaval have affected the flow of materials throughout global supply chains, thus compromising their performance. In this context, risk management – defined as the ability to foresee and evaluate risks, and thereafter identify the actions necessary to avoid them or minimise their impact – has become critical for supply chain managers. In effect, in the modern economy, there is always a risk factor for SCM, either with regard to quality or security problems, biothreats (COVID-19 being the most obvious, but there have been many others too over the years), supply restrictions or disruptions, climate conditions and natural disasters, regulatory or political uncertainty or inadequate infrastructure, among others.

Supply chain risks

While there are different ways to classify risks, we hereby group them into five categories: (i) systemic, (ii) market, (iii) operational, (iv) credit and (v) liquidity risks (Table 15.1).[9] These are described in detail below. Generally speaking, these categories can be distinguished according to the level of risk which arises and where the consequences become evident. While systemic risks can emerge at the global level, independent of a particular industry or supply chain and affecting all industries and supply chains, market risks can affect a sector of economic activity. Operational and credit risks are manifested at the local level in the nodes of a supply chain or in the relationships between them. Finally, liquidity risks emerge at the level of a specific node or actor in a supply chain.

Systemic risks are those which affect the operation of the economy in general. The sources of these risks may be political, social, macroeconomic or environmental uncertainties. Political uncertainties may include, for example, situations of political instability, change in government policy, war, terrorism or military coups. Social uncertainties refer to changes in peoples' beliefs, values or attitudes.[10] In turn, macroeconomic uncertainties relate to the fluctuation of, for example, inflation rate, relative prices and exchange rates. Natural uncertainties include phenomena such as biothreats, floods, droughts, earthquakes or hurricanes, among others. Although the magnitude in which systemic risk may impact supply chains may differ, the common feature of this type of risks is that all supply chains will be affected in one way or another by them.

Market risks affect the operation of a specific sector of the economy. These risks include, among others, fluctuations in the levels of domestic and international prices for inputs and products, input availability, technological change, change in consumer preferences, availability of substitute products and quality standards in the sector. For example, rising oil prices between 2006 and 2008 significantly increased costs in energy-intensive supply chains. Technological change in the electronic and telecommunications industries, following the invention of MP3 players in the former case and mobile cell phones in the latter, altered customer preferences and reduced consumer demand for compact disc players and pagers, respectively. These changes required that supply chains in the electronics and telecommunications industries be redefined, so that they could provide consumers with the new products they desired.

Operational risks are those which affect the operation of a specific supply chain and which may arise at the level of a certain node or in the relationship between two or more nodes. This type of risk affects information or product flows throughout a supply chain. Among the sources of this type of risk are disruptions to production due to mechanical, technical or process failures; forecasting errors in input acquisition and in demand forecasting; failures in the power, communications and transport infrastructures; disruptions in the supply chain due to delays or failures in administrative procedures; disruptions in the supply chain due to failures in the quantity and/or quality of products provided by suppliers and failures in the quantity and/or quality of the products delivered to the consumer. An example of the effects of this type of risk often cited in the literature is the case of Toyota which, in 1997, was forced to close 18 plants for two weeks due to a production failure at its main brake valve supplier.[11]

TABLE 15.1

Type of supply chain risks (Source: Calatayud & Ketterer, 2016)[13]

Type of risk	Impact	Sources	Example
Systemic	On the general economy	Political uncertainties	Situations of political instability, changes in government policy, wars, terrorism, coups d'état, piracy
		Macroeconomic uncertainties	Fluctuations in levels of economic activity, or relative prices
		Social uncertainties	Changes in peoples' values, attitudes or beliefs
		Environmental uncertainties	Biothreats, floods, droughts, earthquakes, hurricanes
Market	On a specific sector of the economy	Market uncertainties	Fluctuations in price levels of inputs and products, technological changes, changes in consumer preferences, availability of alternative products
		Regulatory or institutional uncertainties	Quality standards and regulations, changes in the specific regulations of the sector
Operational	On a specific supply chain	Supply uncertainties	Delays in deliveries, failures in input quantity or quality
		Production uncertainties	Mechanical, technical or process failures, forecasting errors, infrastructure failures, failures in product quantity or quality
		Administrative uncertainties	Failures or delays in administrative procedures, such as for import and export, compliance with quality standards
Credit and liquidity	On a specific supply chain or its nodes	Uncertainty about the sector or the firm segment	Sectors in which there is greater information asymmetry, such as agriculture and the new technologies. Firm segments such as SMEs, in which there is greater information asymmetry and informality
		Uncertainty about the payment cycle	Non-compliance or extensions in the payment cycles that can cause delays in the firm's short-term commitments
		Uncertainty about the firm's financial health	Incomplete or out-of-date financial and accounting records, with low information quality

Credit and liquidity risks affect the financial stability of a supply chain or its nodes. Credit risks refer to problems arising from collecting payments from clients. The default of such payments can seriously affect the liquidity flow of a business and at the same time jeopardise payments to input and service suppliers, thereby generating a cycle of defaults that is difficult to resolve.[12] Liquidity risk is related to the problems that an enterprise might face when trying to meet its short-term obligations. Since the firms that participate in a supply chain do not all possess the same degree of financial stability, liquidity problems for one or more firms can have consequences for the financial stability of the entire supply chain.

Having endeavoured to identify all potential risks, organisations sometimes use risk heat maps as an aid in presenting the results of a risk assessment process visually and in a meaningful and concise way.

Negative impacts of supply chain risks

Various international studies indicate the importance that the different risk factors have for business and supply chain operation and sustainability. Practitioners highlight supply failure, natural disaster, political and regulatory uncertainty, failure in logistical processes, damage to product quality and delay in customs procedures among the most serious risk factors faced by a supply chain.[14] Due to the negative impact that these risks can have in a supply chain, some international surveys show that businesses now pay more attention to risk management with regard to their supply chains. A survey of supply chain leaders in 600 large international enterprises showed that 71% of them considered risk management among their top-of-mind issues in decision-making and 64% acknowledged that they had a specific risk management strategy for their supply chain.[15]

There are a large number of examples where the materialisation of risks led to significant supply chain losses. Let's focus on systemic risks now, such as the earthquake in Japan in March 2011, and the strike by port workers on the West Coast of the US in 2011. The earthquake of 8.9 degrees on the Richter scale that hit Japan in 2011 had consequences that spread out on a global level, given that hundreds of companies – among them Boeing, Honda and General Motors – whose suppliers were located in Japan, were forced to reduce their production levels drastically (for example General Motors' production at its US plants fell by half) and they experienced massive disruptions, which were felt up to the end of that year, causing losses estimated at US$240 billion. In 2011, labor disputes that led to the closure of the ports on the West Coast of the US for almost two weeks interrupted normal supply chain operations and generated costs for the country's economy of approximately US$19 billion. In the literature, there are plenty of examples regarding operational risks. We present here three of the most illustrative cases. In 1997, to save US$0.75 per unit, Whirlpool outsourced the production of the water seal of its dishwashers. This represented a yearly saving of US$2 million. The supplier, however, unexpectedly changed its own rubber provider. The new rubber leaked water in dry climates, causing a 10% failure rate. By the time Whirlpool had discovered the issue, more than 2 million dishwashers had been manufactured with two months' worth of inventory in transit. This quality failure cost the company millions of dollars, far above the saving generated by the initial outsourcing. Another case occurred in March 2000 when a lightning strike caused a power surge in the electricity network of Albuquerque, New Mexico, causing a fire at one of Philips' microchip plants. The plant supplied Ericsson which, at the time, applied an exclusive supplier policy. The blaze caused a disruption to Ericsson's production for months, resulting in a sales loss of US$400 million. Finally, in 2007, Mattel was forced to recall 19 million toys from the market because suppliers had used paint containing lead during production – a potential health hazard to consumers.

One should be aware though that, in a complex inter-organisational supply chain, it may, of course, be difficult if not impossible for anyone to identify every possible hazard or point of vulnerability. Moreover, it must be remembered that 'known' problems are only part of the picture. Indeed, in the words of former US Secretary for Defense Donald Rumsfeld,[16] there are 'known unknowns', 'knowable unknowns' and 'unknowable unknowns':

> Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know. And if one looks throughout the history of our country and other free countries, it is the latter category that tends to be the difficult ones (Donald Rumsfeld, 12 February 2002)

These are useful touchstones to bear in mind when considering the wider subject of supply chain vulnerability, risk and resilience. To illustrate this, we will turn to the creeping crises that affected the UK economy in 2000 and 2001. In September 2000, a small number of protestors blockaded some of the country's oil refineries, causing chaos at the petrol pumps. The protests were an outpouring of simmering resentment among farmers and transport operators over rising fuel costs, driven in part by the government's 'fuel price escalator'. The escalator increased prices annually by 6% over and above the general rate of inflation. Within days the fuel crises escalated, resulting in serious disruptions to the operations of countless companies and to the national economy as a whole. The outbreak of foot and mouth disease in British livestock herds in February 2001 again resulted in damage to whole sectors of the economy.

What made these events so memorable was that even those who were aware of threats did not anticipate the scale of their impact across the UK economy. A survey undertaken by Cranfield University[17] in 2002, involving 137 senior managers from both public and private sector companies, found that 82% of the organisations represented had been affected by the fuel protests, with 49% experiencing some impact from foot and mouth. Both these events could arguably be said to have been caused by 'knowable unknowns'. There were clear warnings that farmers and transport companies were aggrieved over fuel duties and that some form of protest was a real possibility. Foot and mouth was a known threat to livestock, albeit one that had not been seen in the UK for a generation.

The impact of livestock diseases is something that might reasonably be expected to be included in the supplier monitoring activities of companies engaged in the production and distribution of food. But what about car manufacturers or high-fashion apparel companies? The shortage of high-quality leather following the foot and mouth outbreak affected automotive manufacturers and fashion houses across Europe. The disease also had a catastrophic effect on the British tourism industry.

The scale and extent of the disruptions prompted the UK government to seek a better understanding of what are now sometimes referred to in emergency planning circles as **creeping crises**. During the fuel protests and the foot and mouth outbreak, it was industry and government – not the usual 'blue light' emergency services – that found themselves in the unfamiliar role of 'first responders'. These 'creeping crises' were remarkable in one other respect – they represented *systemic supply chain disruptions*. As such, they prompted the most extensive review of UK national emergency planning policy since World War II.

SOURCES OF EXTERNAL SHOCKS TO THE SUPPLY CHAIN

In this chapter, we have given various examples of shocks to the supply chain. These and yet other examples are summarised below. Can you think of others?

- Weather and other extreme events – for example the 2011 earthquake in Japan.
- Protests, blockades, strikes – for example the strikes at LA ports in 2011.
- Shortages of key supplies – these could be caused by supplier failure such as the case of Whirlpool mentioned above.
- Terrorism and other security threats such as piracy and kidnapping.
- Corporate accounting scandals, fraud.
- Biothreats – for example the foot and mouth livestock crisis in the UK; other more recent examples include the crisis caused by the discovery of horsemeat in the beef (cattle) supply chain in Europe and the COVID-19 virus which spread quickly in early 2020.
- Actions by upstream suppliers tarnishing the consignee's image – examples include the collapse of a garment factory in Bangladesh in 2013 with the loss of over 1000 lives and protests in Asia about labour conditions at contract manufacturers who service technology supply chains.
- Uncertainty caused by shifts in technology – the classic examples of the MP3 players and cell phones discussed earlier.

VUCA

This acronym emerged in the military in the 1990s and has since attracted interest in other sectors too as a way of helping people and organisations deal with risk and uncertainty:

- From **V**olatility to Vision
- From **U**ncertainty to Understanding
- From **C**omplexity to Clarity
- From **A**mbiguity to Agility

GATE GOURMET

Gate Gourmet was the sole supplier of in-flight catering services to British Airways (BA). Many of the staff had been BA workers until a cost reduction programme prompted the airline to outsource the activity in 1997 to Swiss-owned company Gate Gourmet. The move had been financially beneficial to BA, which, in a competitive environment, had continued to pursue further cost reductions through its supply chain. The pressure to continually cut costs was in turn cited by some as the root cause of the Gate Gourmet dispute.

In the post-9/11 climate of fear, demand for transatlantic air travel dropped and oil prices rose. These were hard times for the airline industry and its suppliers. The catering business went into loss. In 2002, Gate Gourmet was sold on to US-based private equity firm Texas Pacific Group (TPG). At this point, BA exercised an option within the original outsourcing agreement to renegotiate the contract for more favourable terms. The new owners improved productivity and increased management pay, but continued to lose money on the BA contract. In 2005, the new owners sought to cut its costs with redundancies amongst catering staff, and by imposing less generous terms and conditions on those who remained. At the same time, the company took on 130 seasonal workers on lower rates of pay. The resulting dispute and 670 sackings – involving mostly women drawn from the local Asian community – did not on the face of it represent a significant threat to BA. The airline could operate its core business without in-flight meals. However, when about 1000 BA ground staff – many of them with family ties to the sacked catering workers – decided to walk out in sympathy, the consequences for BA were unavoidable. The four-day strike halted BA flights out of its Heathrow hub, damaging the airline's reputation, and costing BA (and its shareholders) an estimated £40 million in cancelled flights and the cost of food and accommodation for 70,000 stranded passengers.[18]

With bankers threatening to move against TPG and TPG threatening to take Gate Gourmet into administration, BA was forced to intervene. The airline agreed to renegotiate its catering contract, and to donate about £7 million towards the cost of enhanced redundancy packages, but did so on the condition that Gate Gourmet settled its own labour dispute. On 27 September 2005, an agreement was reached between the trade unions and Gate Gourmet. About 700 catering staff volunteered to accept the new redundancy offer, slightly over the number required. In March 2007, TPG sold its holding in Gate Gourmet to bankers Merrill Lynch.

TECHNOLOGY AND SCRM

As discussed in Chapter 13, sharing information among supply chain partners is key to improving SCRM. Specifically, information sharing can help manage risks in three ways.[19] First, it helps identifying possible vulnerabilities along the supply chain, thus informing the design of risk management plans. Second, it helps prevent the occurrence of events that could become risks if no action is taken. Third, it enables rapid implementation of risk management measures, minimising the risk of disruptions. Empirical evidence shows that the more information is shared along the supply chain, the better the risk management and the financial performance of the supply chain.[20] It is not surprising that about 80% of large companies cite lack of information sharing as their top concern, especially in a context of increased complexity and uncertainty, which requires improved flexibility and responsiveness.[21] For example, a common supply risk that can be reduced by increasing information sharing is the 'bullwhip effect' we discussed in Chapter 5, which occurs when information about the final customer's demand becomes increasingly distorted as it moves upstream in the supply chain, distorting in turn decisions on inventory, production and delivery planning.[22] Indeed, sharing information with supply chain partners can improve the accuracy of information on demand and demand forecasting. Some practices frequently used with this goal are mentioned in other chapters, particularly vendor-managed inventory (VMI), continuous replenishment programs (CRPs) and collaborative planning, forecasting and replenishment (CPFR). These can reduce the operational and financial risks of flawed demand forecasts.

The growing trend of digitising processes by using new technologies such as IoT can significantly improve SCRM. In Chapter 13, we showed how objects can now generate information in real time on the status of different supply chain processes. For example, placing sensors on products in the supply chain can enable a more precise and reliable monitoring of inventories that flow across the actors and processes involved in the supply chain. Analysing this data with artificial intelligence can provide useful information to avoid human errors, input shortages and the high cost of unnecessary inventory carrying. Likewise, sensors capable of reporting on machinery performance and physical assets can indicate when maintenance is required and when machinery is likely to fail, thus avoiding damage and downtime. Finally, the big data produced by IoT technologies can be used to predict changes in consumer preferences and avoid the adverse effects of poor predictability. Indeed, a study has shown that companies that invested in these technologies for their SCM have cut up to 30% out of inventory, increased the average fill rate by up to 7% and raised their revenue by up to 15%.[23]

SECURITY ACROSS THE SUPPLY CHAIN

Security across the supply chain has become a major focus in LSCM, especially since the 9/11 attacks in New York in 2001. As we saw above that context gave rise to Donald Rumsfeld's 'known knowns' observation. Various initiatives have been introduced and technologies employed to mitigate security risks. Examples of such technologies include the following:

- Access control systems. Some may use biometric technologies – for example scanning your passport or eye retina. Others may be less technologically sophisticated – but equally effective – such as alarms, while at sea sometimes sonic and other devices are used to deter pirates boarding ships.
- Tracking and tracing systems.
- Detection systems (for example using drones, cameras or movements sensors).

In addition, various transport security initiatives have been developed by governments and other international bodies – examples are as follows:

- The International Maritime Organization's (IMO) International Ship and Port Security (ISPS) code.
- The US has a number of initiatives including Customs Trade Partnership Against Terrorism (CTPAT), Container Security Initiative (CSI) and Air Cargo Advance Screening (ACAS).
- The European Union Authorised Economic Operator (AEO).
- ISO 28000: Supply chain security.

Two points are worth noting with regard to these initiatives. Firstly, the span of control: for example the ISPS code is mostly concerned with ports and terminals and not the wider supply chain; in contrast, CTPAT involves multiple partners along the supply chain. The second point to note is that invariably security standards can vary across the world, a useful feature of some initiatives is, however, that they can enhance security standards globally. The US, for example, has some of the world's highest security standards, so if a country wishes to trade with the US, it will have to ensure that its export security protocols meet the high standards of the receiving country for the freight.

MEASURING RISK EXPOSURE AND TIME TO RECOVERY

Given the multiplicity of sources of shocks to the supply chain, a key focus now of supply chain managers is gauging how exposed the supply chain is and how long it will take to recover from any disruptions. With this in mind, Professor David Simchi-Levi and colleagues at MIT have developed a model for determining the impact a disruption of each node in a company's supply chain would have, regardless of its cause or likelihood.[24]

THE IMPACTS OF CREEPING CRISES

We discussed above the role of creeping crises in today's uncertain and changing world. Can you think of other creeping crises in addition to the ones mentioned in this chapter?

Taking either your own examples or the ones described in this chapter, outline the impacts these crises had on economies and societies.

USING TECHNOLOGY TO ENHANCE SECURITY AND REGULATORY COMPLIANCE

We saw in Chapter 13 how IoT enables a wide array of objects to be ‘switched on’, therefore increasing visibility throughout the supply chain by generating information in real time on the different supply chain processes. With thousands or even millions of sensors generating data from former ‘dark assets’, risk management can be greatly improved. Placing sensors on materials can enable a more precise and reliable monitoring of inventories that flow across the supply chain. This can help reduce human errors and input shortages and lower the cost associated with unnecessary inventory carrying. Security too can be enhanced. Irish company Netwatch,[25] for example, uses high-tech remote video monitoring and motion sensors to protect legalised cannabis grow farms across the US. As well as the obvious security benefits in deterring criminal activity, the supply chain data automatically generated can be used too to guarantee regulatory compliance

LEARNING REVIEW

This chapter provided an introduction to the complex, but fascinating subject of supply chain risk, and the related concepts of vulnerability, SCRM, robustness and resilience. The different types and sources of risk along the supply chain were detailed, as were the costs and other implications. We also considered how various initiatives and technologies can be effectively used to mitigate risk.

This is the final chapter in Part Four of our book. In the next and final section of the book, we will look to the future and see how LSCM can become more environmentally and socially responsible and also examine emerging supply chain designs.

QUESTIONS

- What is meant by supply chain vulnerability?
- Identify the different sources and types of risks along the supply chain.
- How can technology improve SCRM?

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Part Four Case Studies
Contamination in the Bulk Agri-Commodity Logistics Chain

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TRADING RELATIONS BETWEEN WESTERN AUSTRALIA AND JAPAN

Japan imports 5–6 million tonnes of bulk wheat each year to manufacture products such as udon noodles, bread, cake, Chinese noodles, white salted noodles, spaghetti, instant noodles and beer. Each year, Western Australia ships about 1 million tonnes of bulk wheat to Japan, with the income from wheat for noodle production alone estimated to have a value of A$150 million to the local economy. While Japan buys a significant amount of wheat from Western Australia, it is also the largest market for other bulk agri-commodities, such as barley, oats, canola and cereal hay, thereby indicating the importance of the trade relationship between the two nations. The Japanese market for Australian wheat is relatively stable, although Australia only supplies Japan with about a fifth of its demand (Figure 1), so market competition with suppliers such as Canada and the US is a key concern for Australia. As a consequence, a great deal of care is needed for managing and maintaining this high-value commodity supply chain. To add to this, market relations in the Japanese context are largely based on trust, honour and long-term relationships between supply chain actors, which makes establishing and maintaining markets a delicate and complex task.

AN OVERVIEW OF THE WESTERN AUSTRALIAN EXPORT GRAIN INDUSTRY

From 1933 to the beginning of the new millennium, Western Australian's grain export industry, which accounts for 95% of the state's annual harvest, was highly regulated with each sector of the supply chain operating as a government statutory authority. The ports, railways, quarantine services, grain traders and grain handlers all operated as statutory monopolies with specific charters to service one another's needs. Information was exchanged freely between the firms and all collaborated with a unified mission: to optimise market returns for grain producers by selling and transporting export grain at peak efficiencies. Most of the time, the exporting of bulk grain from Western Australia's ports at Geraldton, Fremantle, Albany and Esperance was very successful. To this day, the logistics and quality control systems for moving grain from regional grain depots to ports, onto ships and then to the destination port are highly efficient but, on two occasions in March 2002, this world-class system failed and cost the industry approximately A$5 million, with untold damage to the collaborative relationships in the international wheat supply chain.

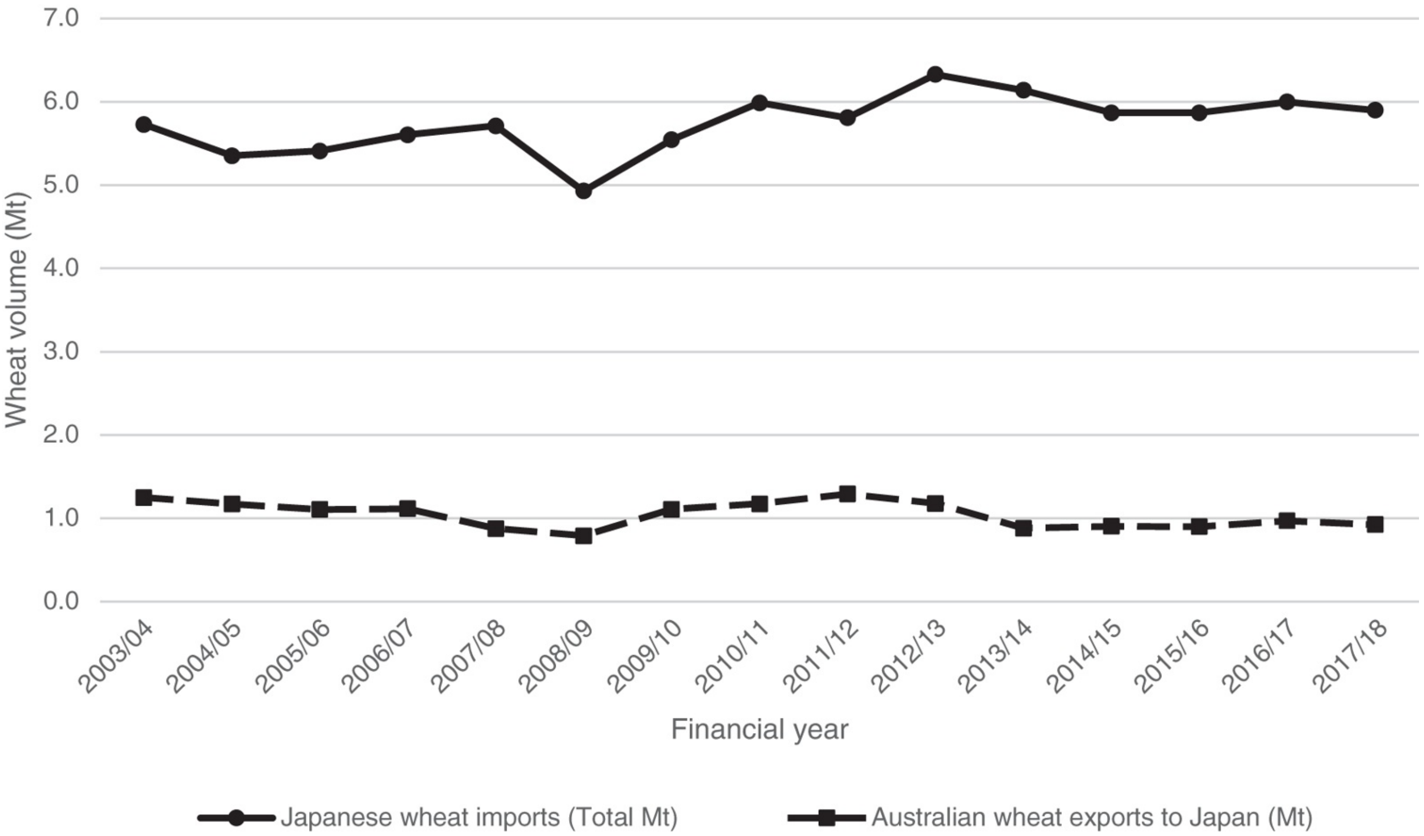

Figure 1 Annual wheat trading activity: Japan 2003/04 – 2017/18

(Source: Data from ABARES, Agricultural Commodity Statistics, 2019)[1]

OBJECTIONABLE CONTAMINANTS IN EXPORT GRAIN

The problem started when loading a vessel of barley destined for Saudi Arabia from the port at Fremantle. For this shipment, all quality control checks had been undertaken and showed that all standards for shipping barley to Saudi Arabia had been met, including a particular additive to the cargo, namely carmoisine. Carmoisine is a red food dye that is often used in the red meat industry to certify carcass grading. The Saudi Arabian market demands that about 1% of all imported grain is coloured with carmoisine in an attempt to minimise black market grain trading. The colouring process is carried out at the time of loading bulk grain onto the ship destined for Saudi Arabia. The liquid food dye is slowly dripped onto the conveyor belt that is loading the grain onto the ship to ensure that a tiny quantity of grains appear red in colour to certify their authenticity.

After the shipment of barley left for Saudi Arabia, the next ship to be loaded at the port of Fremantle was high-value noodle wheat bound for Japan. As per standard practice, all quality checks were undertaken, the vessel was loaded and set sail. Once the vessel reached its destination in Japan in early March 2002, unloading commenced and local authorities began their stringent import checks, during which they identified an 'objectionable contaminant' in the cargo – this is one of the most serious claims that can be made about a cargo of food. Western Australia's most important Japanese customers were horrified by this finding and contacted the grain marketing agent immediately to express their outrage about the unacceptable condition of the cargo. Upon rigorous testing of the grain samples, it was found that the objectionable contaminant was traces of grain that had been treated with carmoisine. Unloading the vessel was ceased and the ship was to be berthed until the problem was resolved.

The allegation of the carmoisine-contaminated cargo had the Western Australia grain industry in turmoil: valuable customers had been disappointed, an entire cargo of premium-quality wheat was split between the ship and port storage, the Japanese port had suspended operations, thereby preventing other vessels from berthing, extraordinary demurrage costs were being incurred from the ship being left idle and there was a threat of the customers demanding monetary compensation for loss of earnings. Western Australian grain marketers found it perplexing that their Japanese customers should find miniscule traces of a food dye so unacceptable, particularly because it was an additive that another customer (Saudi Arabia) demanded as a standard treatment. After identifying the immediate problem, substantial cracks started to appear in the seemingly robust supply chain.

OBJECTIONABLE CONTAMINANT: CARMOISINE

Objectionable contaminants in bulk grain commodities are usually traces of poisonous or dangerous substances such as pesticides, traces of herbicides used in crop management, traces of fertiliser from previous handling equipment, rust or paint flakes from inside the hold of a vessel, small pieces of metal from handling machinery, bird or rodent droppings from unclean storage facilities, poisonous gases from antiquated storage facilities or fungal mycotoxins produced during the growth or storage of wheat crops. International food standards specify a nil tolerance of generic objectionable contaminants (such as those listed above), but individual markets also specify particular substances as objectionable. In Japan, Canada, the US, Norway and Sweden, carmoisine is banned,[2] based on evidence that it is linked to hyperactivity in children[3] and hence is regarded as an objectionable contaminant in food importing.

The confirmation that the objectionable contaminant found in the wheat cargo was carmoisine resulted in the declaration of a 'distressed cargo': the entire cargo being rejected by Japan. This left the cargo of high-quality grain split between the port and the vessel, and without an owner taking responsibility for the cargo. The grain marketer eventually found a new buyer for the cargo at an enormous financial cost, but the most significant operational cost was finding a way to return the part-unloaded cargo onto the ship. Japan is principally an importing nation, so its port infrastructure has world-class facilities for unloading bulk cargo ships but very few, if any, facilities for loading bulk cargo ships. So reloading a bulk commodity onto a bulk vessel proved extremely costly in terms of emergency engineering and demurrage expenses. The reverse is true for Western Australia's bulk commodity ports, which are principally for exporting cargo, so returning the cargo to its home port was out of the question, hence the need for the grain marketer to make a quick sale of the redundant cargo.

When the matter was closed, the grain marketer responsible for selling the wheat and the bulk handler responsible for assembling and loading the cargo realised how dependent they were on each other to work collaboratively in protecting Japan as a valued customer and also how vulnerable the supply chain is because of conflicting international food standards. Relations between the two firms had been pushed to the limit with both blaming each other for the losses suffered: the grain marketer being blamed for not clearly communicating the fine detail of the exporting contract and the bulk handler being blamed for being so careless with assembling and loading the cargo (essentially not ensuring that all traces of carmoisine had been cleaned from the port's conveyor systems). Nevertheless, the relationship was recovered for the benefit of maintaining the important trade between Western Australia and its Japanese customer. The relationship with the Japanese customers had also been severely tested over this incident, and the Japanese still had a sceptical view of Western Australia, even after relations had appeared to be mended. However, this situation was to worsen. Despite root-cause analysis having been conducted and loading equipment being fully cleaned and serviced, within a matter of weeks, the media was informed on 22 March 2002 that another 20,000 Mt cargo of noodle wheat had been rejected by Japan owing to contamination with carmoisine. This was the second cargo to be rejected within a month for the same reason and from the same loading port. This second incident was almost too much for the Japanese to bear as the fragile trading relationship had already been so badly damaged earlier in the month. They were furious that the promises that had been made regarding ship and handling hygiene had not been taken seriously. They considered that trust had been abused and that they had been dishonoured. As a consequence, two vital aspects of conducting business with Japan had been neglected – twice. At this point, grain producer lobby groups had become involved with concerns about the breakdown of relations with Japan as a major buyer of their wheat.

Fortunately, the Japanese were savvy enough to have not unloaded the second cargo before testing it for traces of carmoisine, so the operational losses experienced when the first cargo was rejected were not re-experienced to the same extent. Nevertheless, significant demurrage costs were incurred while a new buyer was sought for the second contaminated cargo.

IMPORT REFUSALS AROUND THE WORLD

Incidents of import refusals, like those two cargoes rejected by the Japanese noodle wheat market in March, 2002, are costly in terms of financial losses (tangible) and damaged supply chain relationships (intangible). Figure 2 illustrates the tangible and intangible losses experienced at each tier of the supply chain as a result of an import refusal.

Published research on the frequency of cargo rejections from Australia and elsewhere is extremely sparse as data of this kind can be commercially sensitive and are often only collected internally by marketing and handling organisations as performance metrics.[4] This type of information is also very difficult to collect simply based on how to define a cargo rejection or import refusal. It is rare for a cargo to be rejected outright, like the Japanese noodle wheat cargo. It is much more common for 'near misses' to occur. This is when a mistake is corrected before any operational losses are incurred or financial losses are experienced (as a result of compensation claims from cargoes that are accepted but fall short of some quality standard).

Despite the difficulty of measuring cargo rejections, the US Food and Drug Administration (FDA) has been collecting high-quality data on food import refusals since 2002. Figure 3 illustrates the turbulent nature of wheat-product quality with 2013 being a particularly bad year for wheat refusals and 2010 being a particularly bad year for refusals all-round. While the FDA's data show that US import refusals of whole grain, milled grain products and starch are extremely low compared to total import refusals, researchers who have analysed the data agree that refusals of any imported products have a negative impact on trade relations.[5] In the case of Japan's refusal of contaminated Western Australian noodle wheat, the trade ramifications were significant. The trusted relationship between Australia's largest grain-producing state and a long-term, high-value customer was damaged, not to mention the animosity caused between the various members of the grain supply chain within Western Australia. Essentially, the harmony within a long-established supply chain was temporarily damaged.

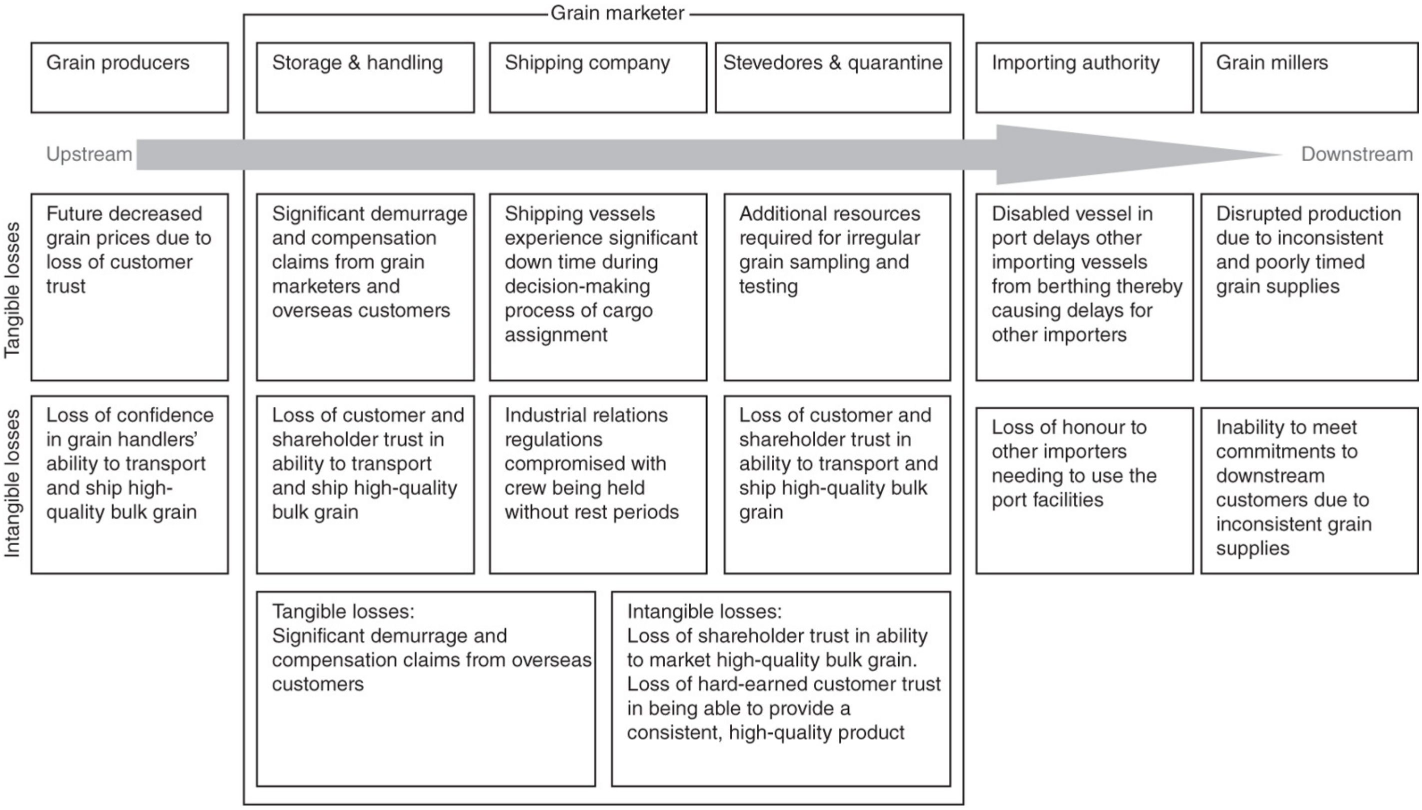

Figure 2 Tangible and intangible losses in the Australian wheat supply chain from an import refusal

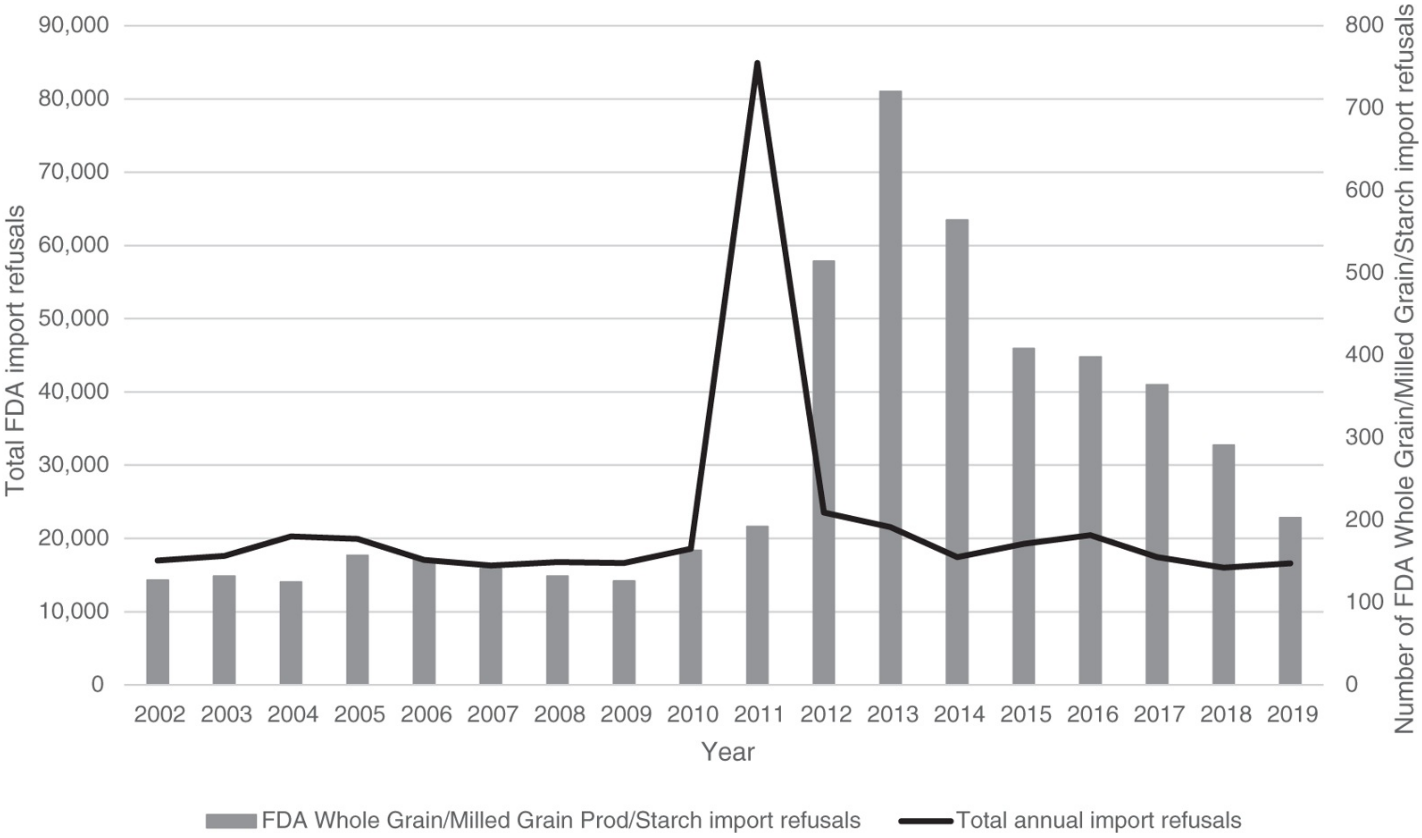

Figure 3 FDA total import refusals and whole grain/milled grain prod/starch import refusals (2002–2019)

(Source: Chart compiled from: https://www.accessdata.fda.gov/scripts/importrefusals)

CONCLUSION

In March 2002, the Western Australian grain supply chain suffered a debilitating shock to its system with two consecutive cargoes of noodle wheat being rejected by Japan because of contamination from the food dye carmoisine. Relationships between actors in the supply chain were stretched to the limit. The Japanese demanded answers about the quality of the cargoes, and supply chain actors were looking for compensation for the loss of income they experienced. At the same time, further upstream, grain producers were worried about losing a valuable downstream customer. It was not only relationships that were tested; this case also provides an interesting insight into how sophisticated port infrastructures have become rigid in terms of optimising efficiency whereby irregular occurrences such as these turn out to be unmanageable. The outcomes of these incidents were that the Western Australian grain industry had suffered a substantial economic loss and relations between numerous members of the grain supply chain and some of its customers had been severely damaged – damage that only hard, collaborative work could repair.

This case provides a real-life example of supply chain vulnerability and sheds light on the importance of port efficiencies and demonstrated that, despite the complexity of the global grain supply chain, relations between supply chain actors are at the heart of successfully managing such chains. The fact remains that the trade of agricultural commodities fluctuates as a consequence of numerous factors, such as global seasonal conditions, erratic currency markets and changes to government import/export regulations. Japan's Ministry of Agriculture, Forestry and Fisheries has a highly regulated method of buying wheat for the nation's milling industry, which facilitates competition between suppliers. So while Figure 1 suggests that the Japanese market is reasonably stable, it does not reflect the ill-will Japanese grain buyers had for Western Australia, nor does it show the colossal effort the Western Australia grain industry had to put into re-establishing the trust of one of its key customers.

QUESTIONS

Using the actors illustrated in Figure 2, what factors led to the breakdown of relations between members of the noodle wheat supply chain?

What SCM processes could have been put in place to ensure the second contamination of carmoisine did not occur?

Discuss the importance of collaboration in the development and maintenance of an international agri-food market.

Provide justification for the idea that the Western Australian export grain supply chain, as described in this case study, had robust qualities.

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Supply Chains Become Self-Thinking

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Technology is transforming supply chain capabilities. The self-thinking supply chain harnesses Internet of things, artificial intelligence and other technologies to continuously monitor performance, identify and manage risks, and more accurately forecast demand. It acts quickly and autonomously and presents many opportunities.

Many supply chains are now quicker and more nimble than ever before. Technology is truly transforming supply chain capabilities. What we have labelled the 'self-thinking supply chain'[1] is helping companies as diverse as Amazon and Zume Pizza to engage in 'anticipatory shipping' where product is moved closer to likely customer demand. Yet today's supply chains are also becoming increasingly complex due to the many interdependencies among supply chain partners. Many too are stretched over long distances connecting suppliers, producers and consumers across multiple geographies. These capabilities though bring challenges. In our connected world, problems in one region can quickly spread downstream and hit customer supplies many thousands of miles away. The collapse of the South Korean shipping line Hanjin in late 2016, for example, quickly led to shortages in retail stock for companies such as Nike right across the US – unfortunately coinciding with the annual Thanksgiving retail rush. Hurricanes in Puerto Rico in 2017 caused devastating damage – and led to fears of drug shortages in the US as some pharmaceutical companies have offshore factories there. Other supply chain challenges include the need to trace products – and check the condition that they are in – as they flow along the supply chain. Identifying and eliminating any slavery upstream in the supply chain is also a growing concern – companies don't want to be associated with dubious suppliers and poor work practices. On the other hand, some companies are using the many complexities of their long supply chains to hide nefarious practices such as dodging regulatory rules and building in obsolescence to their products.

EVOLUTION AND REVOLUTION

Supply chains have evolved significantly since the term first entered use in the 1980s. The Fourth Industrial Revolution – and its promise of a world of connected digital technologies, the so-called Internet of things (IoT) – brings with it the ability to manage and counter many of the supply chain challenges we mentioned above. When we think of developments in supply chain technologies, the first things that usually come to mind are physical applications such as drones for faster deliveries and the hyperloop for faster transportation. There are, however, many other developments in RFID, software and digital which are transforming supply chains, examples abound: IBM are pioneering the application of blockchain technology which allows greater transparency right along the supply chain (think of how a world of counterfeit drugs could quickly be eliminated) while much of Amazon's success is built around the clever algorithms it has developed to optimise its supply chains. Artificial intelligence (AI) and predictive analytics are allowing supply chains to respond much more quickly than ever before; increasingly such supply chains have growing levels of autonomy. Where previously we waited eagerly for our favourite artist's latest CD to be released, now content providers such as Spotify will deliver the latest songs to our playlists immediately they are released, and will also point us to other music we haven't even heard of but which might – given our browsing and listening profile – also appeal to us. Other technologies transforming traditional supply chains include devices that can interpret and act on voice commands.[2] Technology is truly transforming supply chain capabilities. In our work together over the past decade investigating supply chain developments, we have identified an emerging supply chain model: the self-thinking supply chain (see Chapter 13 for a detailed illustration of the self-thinking supply chain (Figure 13.4)).

THE SELF-THINKING SUPPLY CHAIN

Efficient, accurate, fast and simultaneously orchestrated responses can improve supply chain performance in an increasingly complex and uncertain world. We can now easily regulate the speed with which products flow downstream in the supply chain to accord with changes in real-time demand. This is the 'anticipatory shipping' strategy employed by Amazon and Zume Pizza we mentioned above where products are pushed further downstream in the supply chain closer to the point of anticipated demand. In the self-thinking supply chain, there is a high degree of connectivity between cyber systems and physical objects through the use of IoT. Huge amounts of data are generated, stored and analysed through IoT and AI in real time. This enables continuous monitoring of supply chain performance and early identification and management of potential risks. Increased connectivity among supply chain partners enabled by IoT, together with AI, allows for more accurate demand forecasting, predictive maintenance and continuous optimization. With AI, decision-making is machine-generated and processes are automated. Objects can sense the environment and respond to it according to AI-made decisions. To fully harness the potential of supply chain analytics companies need to reduce even further the time it takes to act on the insights those analytics generate.[3]

A LAND OF (SUPPLY CHAIN) OPPORTUNITY

The self-thinking supply chain presents many opportunities. It allows for greater agility, adaptability, flexibility and responsiveness through its ability to act quickly and autonomously. This complements strategies such as mass customisation and applications of technologies such as additive manufacturing (3D printing) and even auto configuration where products ranging from medical devices to road surfaces can change features according to their environment and/or prompts from the cloud. The self-thinking supply chain can also help to mitigate supply chain risk management concerns given its ability to help supply chains 'sense and respond' more quickly. IoT enables a wide array of objects to be 'switched on', therefore increasing visibility throughout the supply chain by generating information in real time on the different supply chain processes. With thousands or even millions of sensors generating data from former 'dark assets', risk management can be greatly improved. Placing sensors on materials can enable a more precise and reliable monitoring of inventories that flow across the supply chain. This can help reduce human errors and input shortages, and lower the cost associated with unnecessary inventory carrying. Security too can be enhanced – Irish company Netwatch, for example, is enjoying significant revenue growth from its remote monitoring services. Much of its recent revenue growth is from an unlikely niche sector: as cannabis growth and use is deregulated across the US, there is a demand for monitoring services to ensure that grow farms are secure and product is not interfered with. As well as the obvious security benefits, the supply chain data automatically generated can be used too to guarantee regulatory compliance. In other sectors, companies such as Rolls-Royce are using sensors capable of reporting on engine performance to indicate when maintenance is required and when machinery is likely to fail, thus avoiding damage and downtime. With this 'servitisation' many heretofore manufacturing companies are leveraging supply chain data and technology capabilities to sell not just products but solutions to their customers. The big data produced by IoT technologies can be used to predict changes in consumer preferences and avoid the adverse effects of poor predictability; it can also inform probability-based risk assessments, early warning systems and simulation models.

QUESTION

- A brave new world of digitally enabled, autonomous self-thinking supply chains is emerging. We are excited by this – but there are also pitfalls that companies need to be aware of while embracing self-thinking supply chain capabilities. Identify and discuss these pitfalls.

NOTES

* The views and opinions expressed in this case study are those of the author and do not necessarily represent the views of the Inter-American Development Bank.

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Part Five
Supply Chain Design and Improvement

16
Sustainability in Logistics and Supply Chain Management

LEARNING OBJECTIVES

- Gain an appreciation for what sustainability involves in the context of LSCM.
- Understand terms used in sustainability such as carbon footprints and food miles.
- Illustrate best practice examples of attempts to reduce carbon footprints.
- Introduce environmental supply chain performance measurement (ESCPM).
- Explain reverse logistics and the circular economy.

INTRODUCTION

In earlier chapters, we looked at globalisation and international trade and showed how both shape today's logistics systems. We also saw that in particular increased outsourcing and offshoring to lower cost locations have generated huge flows of international freight. Many of the preceding chapters in this book have given various insights into how effective and efficient LSCM can influence the success of organisations. Success, however, has different interpretations which go past consideration of only economic success. The purpose of this chapter is to look beyond how LSCM can influence organisational success and to consider the issue of sustainability as it applies to LSCM.

> Sustainable logistics is concerned with reducing the environmental and other disbenefits associated with the movement of freight. Sustainability seeks to ensure that decisions made today do not have an adverse impact upon future generations. Sustainable supply chains seek to reduce these disbenefits by *inter alia* redesigning sourcing and distribution systems so as to eliminate any inefficiencies and unnecessary freight movements.

Often, people regard sustainability as just referring to 'green' issues. This, however, is just one (albeit very important) dimension, and in this chapter we will also consider the issue of economic sustainability, i.e. how can the firm itself survive and grow in a sustainable manner without having adverse impacts on future generations, and specifically what is the role of LSCM in this context. Kleindorfer *et al.*,[1] for example, use the term sustainability to include 'environmental management, closed-loop supply chains and a broad perspective on triple-bottom-line (3BL) thinking, integrating profit, people and the planet into the culture, strategy and operations of companies.'

In Chapter 7 we saw the role of scale (i.e. ship size) in global container shipping, this goes to the heart of the sustainability debate: some argue that such scale is the only way to ensure that global trade can continue by helping to further reduce unit transport costs, others argue that scale is not the solution and that the answer must lie in local sourcing and production. It is important to also note that the movement of freight is not responsible for all of the environmental disbenefits associated with transportation (we use the term 'externalities' to refer to these disbenefits): the movement of people also creates disbenefits and some logisticians argue that freight takes an unfair share of the blame! In our discussion in this chapter, we will draw upon examples from maritime transport, air transport and road haulage to highlight issues of sustainability.

The last part of this chapter will focus on the management of the reverse flow of materials from end customers to the original suppliers, either for reprocessing or disposal. On the one hand, environmental-related legislation is forcing companies to be responsible for their waste; on the other hand, waste disposal costs (via both landfill and incineration) are increasing rapidly. In this evolving business environment, many companies have realised that reverse logistics practices can be used to gain competitive advantage. These initiatives have not only reduced waste and its adverse effects on the environment, but also lowered operating costs and improved the public image of these companies. Finally, we will discuss the concept of the circular economy and what it means for LSCM.

Chapter 16 comprises four core sections:

- Carbon footprinting and supply chain redesign
- Efficiency solutions
- Environmental supply chain performance measurement
- Reverse logistics and the circular economy

CARBON FOOTPRINTING AND SUPPLY CHAIN REDESIGN

Recent years have seen a dramatic increase in what have come to be known as 'green' issues, which can generally be regarded as encompassing respect for the world's natural environment (including its atmosphere) so as to ensure that actions taken today do not hinder future generations. Figure 16.1 summarises the key drivers behind the increased emphasis on green issues.

A key concern centres in particular around the use of fossil fuels for power generation and the resultant carbon emissions. The international Kyoto Protocol called for a 60% reduction in carbon emissions by 2050. 'Emissions trading' has now come into fashion whereby companies and countries engage in environmentally positive activities (for example planting trees) in order to offset the deleterious effects of carbon emissions. Various initiatives have been taken in the transportation sector to reduce emissions. For example, since 1 January 2020 the limit for sulphur in fuel oil used on board ships has been reduced from 3.5% to 0.50% m/m (mass by mass).

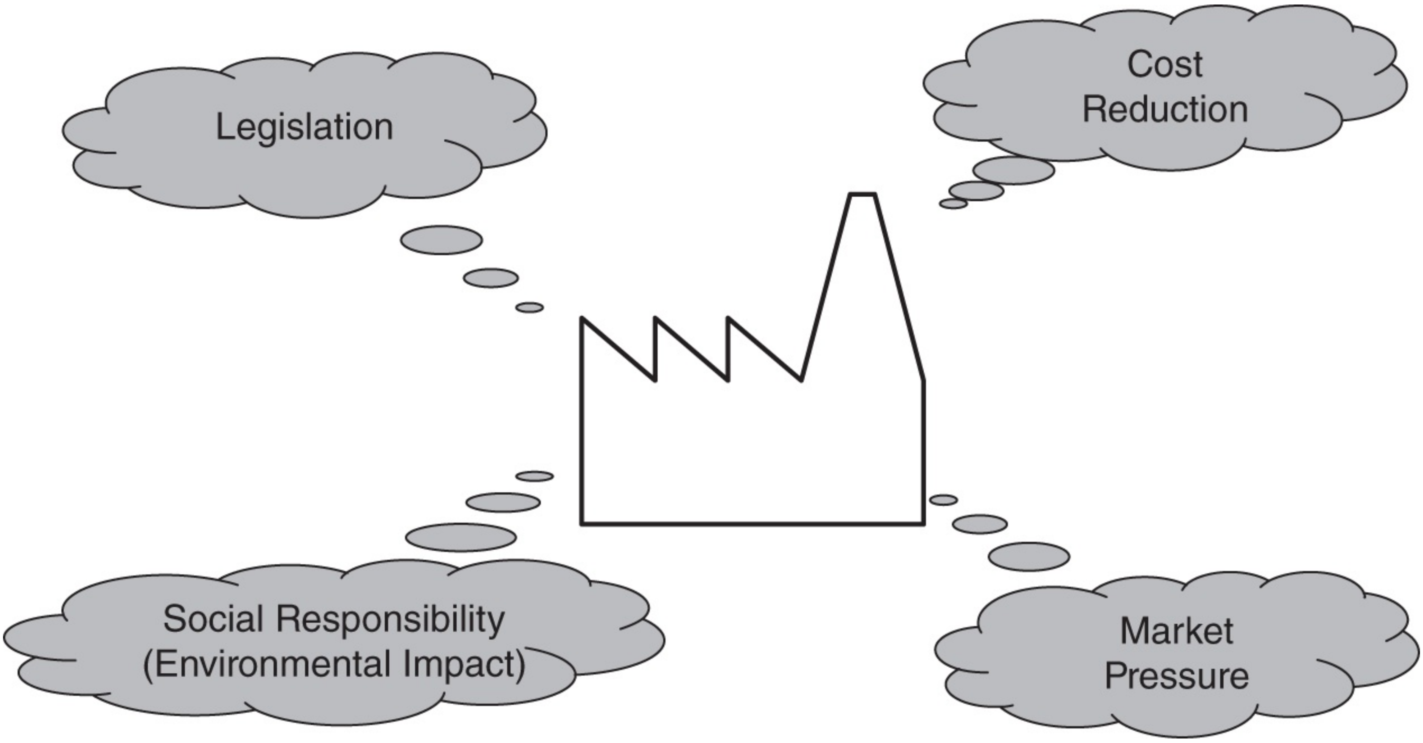

Figure 16.1 The drivers behind the increased emphasis on green issues

(Source: Kevin Ord, The University of Hull)

The term **carbon footprint** has come into use to describe the environmental disbenefits associated with economic activities such as manufacturing and the movement of freight. Another term that has come to be increasingly used is **food miles**: this refers to the distance over which the various components of a particular food item have to travel before final consumption. In time it may be the case that ingredients labels on foodstuffs will also include such food miles data.

MEASURING THE CARBON FOOTPRINT

Greenhouse gas (GHG) emissions are those that contribute to climate change, with most (approximately 95%) being in the form of carbon dioxide (CO_2), which results from, among other activities, the burning of fossil fuels. Various entities have developed guidelines on how to measure and report GHG emissions. The UK Government, for example, publishes detailed environmental reporting guidelines; each year they also produce a new set of detailed conversion factors to support those guidelines so that users can convert 'activity data' such as distance travelled, litres of fuel used or tonnes of waste disposed into carbon emissions.[2]

Many carbon footprint calculations measure emissions in the form of volumes of equivalent carbon dioxide emissions. The carbon footprint of fuel emissions would thus be calculated as follows:

$$\text{Fuel used} \times \text{the appropriate emission factor for the type of fuel used in kg } CO_2\text{eq}$$

where 'eq' refers to 'equivalent' as this also captures other gases such as methane and nitrous oxide.

Emissions are generally classified as Scope 1, 2 or 3 according to the GHG Protocol Corporate Standard: Scope 1 emissions are direct emissions from owned or controlled sources, Scope 2 emissions are indirect emissions from the generation of purchased energy and Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.[3]

Figure 16.2 illustrates carbon footprint data for a real-life study of container movements from the Middle East to the UK. Three route options were available, two involving deep-sea transport to Continental Europe and then transhipment via Antwerp (Lo-Lo) or Zeebrugge (Ro-Ro), plus a direct deep-sea transport option to the UK. The diagram illustrates the carbon footprint for the different transport-related activities in the end-to-end chain. What is striking from the data is the relatively large carbon footprint incurred by the relatively short feeder journeys between Continental Europe and the UK (the shaded boxes with black surrounds towards the top of the first two bars (there is no such feeder journey in the third bar as the deep-sea service goes direct to the UK)). In fact, in this study it was shown that end-to-end logistics-related carbon emissions could be reduced by 16%–21% through direct delivery to the UK as opposed to trans-shipment via a Continental European port.

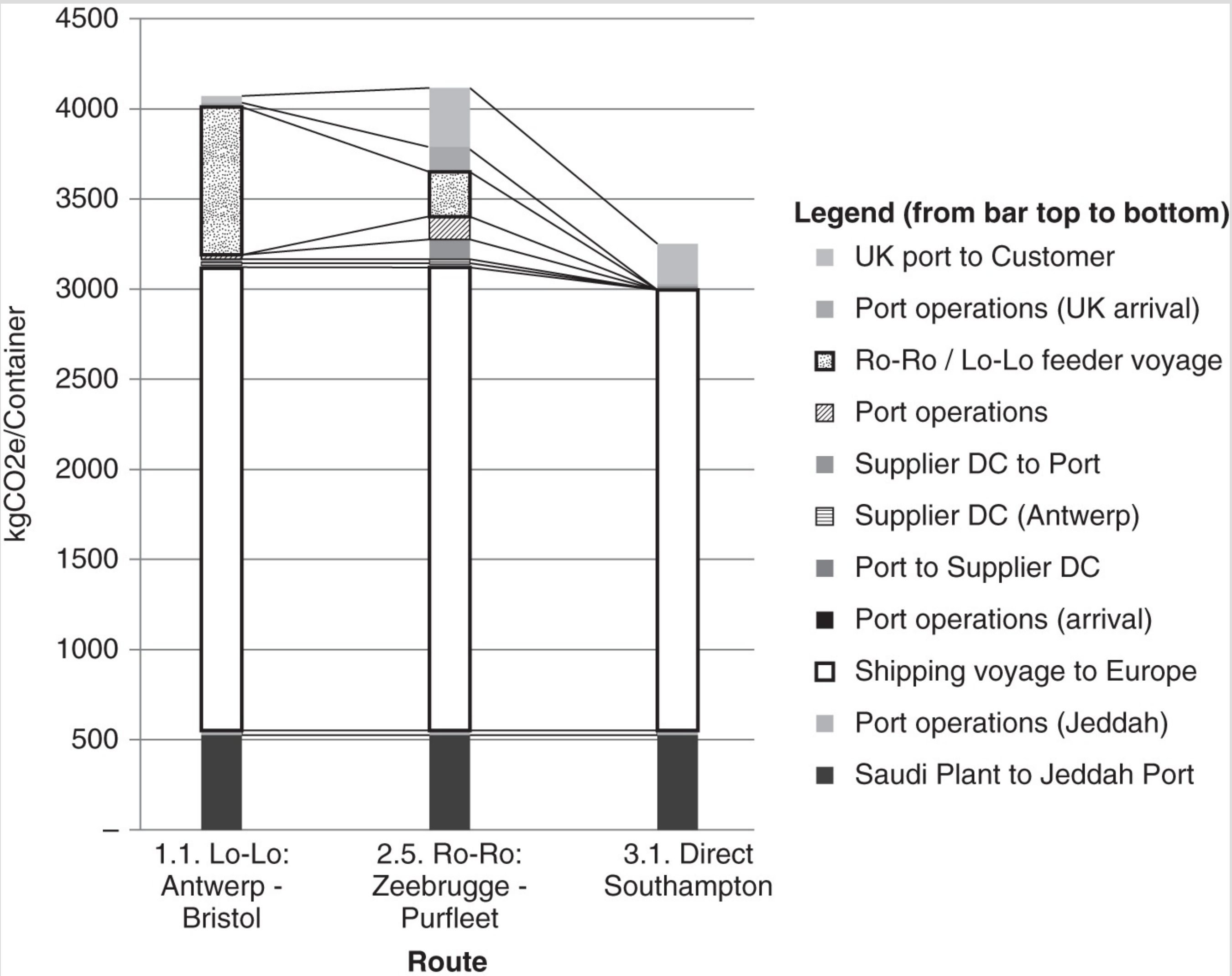

Figure 16.2 Carbon footprint for a container journey (three alternative routings)

(Source: Adapted from Rigot-Muller *et al.*, 2013)[4]

It is now generally accepted that greening a supply chain is largely about forward planning, with some commentators noting that over 80% of carbon savings are only achievable at the supply chain design stage.[5] While various initiatives such as, for example, switching to electric vehicles are obviously welcome, and generate publicity benefits for companies, it is the (often unnoticed in the public eye) *supply chain design* decisions, such as deciding where to locate warehouses and distribution centres and which transport modes to use, that have the greatest impact on the total carbon footprint. In this context, short-sea shipping – where freight is increasingly moved over short sea routes (a more environmentally friendly mode of transport) rather than along congested (and environmentally more harmful) roads – is becoming increasingly popular.

Other examples of sustainable supply chain redesigns include reconfiguring distribution networks so as to replace small deliveries direct to all end customers with centralised deliveries to a hub from where end customers can retrieve their orders. Many large airports, for example, now have a retail consolidation centre adjacent to the airport which receives deliveries on behalf of the various retailers within the airport. Deliveries from different suppliers for these retailers can then be grouped together and delivered on to the retailers. The key principle at play here is that it is, other things being equal, more environmentally sustainable when freight moves *in bulk* as far downstream as possible; conversely we can envisage a delivery truck with a small consignment going to a single customer as having relatively high environmental costs. It is important to add that other benefits can also accrue with such an initiative; for example, in the airport environment freight could be security checked and rendered safe to be delivered 'airside' once it passes through the hub, thus cutting down on the need for other security checks. We will return to the topic of supply (re)design again in the next and final chapter in the book which deals with the whole area of emerging supply chain designs. In particular, we will introduce a concept known as 'Design for Supply Chain Efficiency' (DSCE) which addresses the sustainability concerns flagged in this chapter.

Oglethorpe and Heron, for example, noted that many commentators believe the solution to environmental sustainability and social responsibility issues lies in the 'downscaling, decentralising and deconsolidating of supply chains and logistics systems'.[6] However, they challenge this and, using research on the food supply chain, suggest that 'environmental burden actually decreases across increasing logistical scale and supply chain sophistication'.

Many businesses have profit as their primary objective – the key then is to ensure that they see the business (as well as social) benefits of environmentally sustainable activities, which may include, for example, reduced energy bills and enhanced consumer loyalty (although we know that there is a limit to how much more customers will be willing to pay for products with a low carbon footprint).

LOCAL VERSUS OVERSEAS SOURCING

In Chapter 12 we looked at offshoring to lower cost locations and explained the concept of landed costs which reflect the true costs of sourcing products from overseas. As well as considering such costs, we need to consider the carbon footprint associated with such overseas sourcing. As consumers – and indeed wider society – become increasingly informed about the impact of economic activity on the environment, local sourcing (sometimes referred to as 'local for local') is often presented as the ideal solution for lowering a product's carbon footprint. This assumes, of course, that the local production and distribution is done in a manner that produces fewer emissions than production and distribution from overseas. Taking fruit and vegetables as an example – these may grow naturally in an overseas country but growing them in the country where they are to be consumed may necessitate artificial inputs (light, fertilisers and so forth) with a resulting carbon penalty. But can this penalty be offset by the fact that locally grown produce now requires transport over a much shorter distance to market? This depends on the specifics of the transport that is employed: products transported in a large, efficient deep-sea container ship over a long distance may have a lower carbon footprint per *unit of product carried* than is the case with products transported as part of smaller loads over shorter distances (recall our discussion in Chapter 7 on economies of scale in containerisation).

The key consideration then in deciding whether to source locally or overseas is to ensure that if products are sourced overseas, that this is done in an environmentally sustainable manner and takes account of both all relevant costs and the carbon footprint associated with both production and distribution. Risk and vulnerability too – as we saw in Chapter 15 – are also very important considerations, especially in the context of extended supply chains.

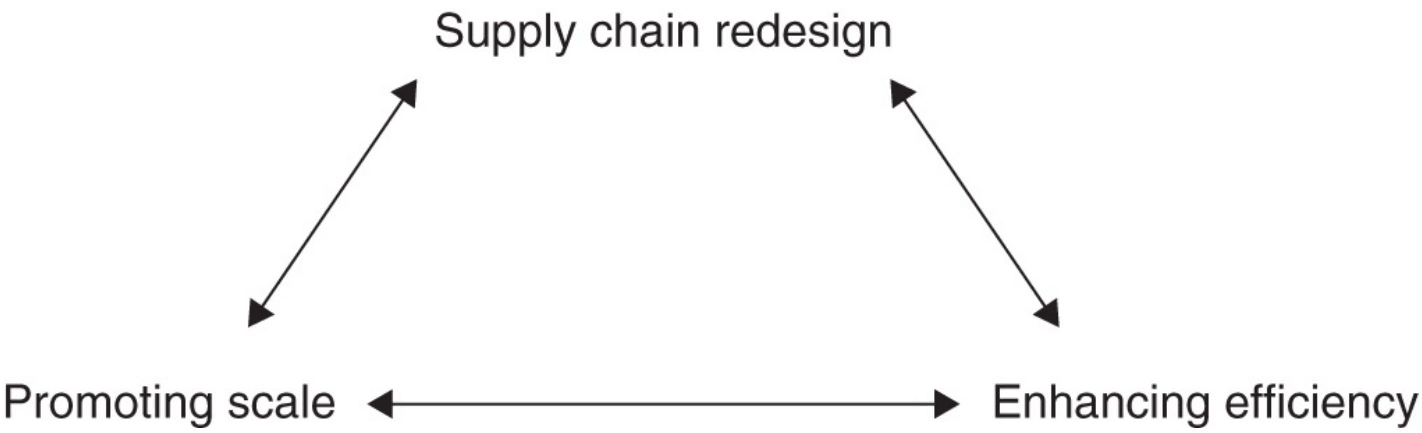

Figure 16.3 Sustainable logistics and SCM

It is our view that there are in effect three ways in which to improve the sustainability of logistics and supply chain systems (Figure 16.3):

- Redesigning supply chains (i.e. DSCE)
- Using *scale* to reduce the negative environmental effects of logistics activities (i.e. by moving freight in larger single loads, thus cutting down on both unit costs and environmental disbenefits per unit carried)
- Similarly promoting various *efficiency* solutions (by transporting and handling freight more effectively and efficiently – we will discuss this in the next section)

It is important to note that these three solutions are not mutually exclusive: a smart, environmentally sensitive supply chain will combine all three.

EFFICIENCY SOLUTIONS

As well as pursuing economies of scale, many logistics systems also continuously strive to become more efficient. We saw, for example, in

Chapter 2 the reality of directional imbalances in global trade – this then leads to many shipping containers and other load devices that are not full (by volume or weight as appropriate) moving around the world. It is sometimes said for example that Europe's largest export commodity in shipping containers is 'fresh air'! A core objective of LSPs then is to ensure that the utilisation of capacity under their control is maximised. In Chapters 3 and 10 we noted the role played by JIT in LSCM: from a sustainability perspective, however, a downside of some JIT systems is that they can lead to some resource inefficiency (e.g. smaller, frequent deliveries in less than full trucks).

As well as looking to increased scale, many LSPs are also seeking efficiencies with how they move and store freight so as to reduce the environmental impact of their activities. Table 16.1, for example, takes the case of road haulage and lists some of the many ways in which logistics efficiencies can be generated, and simultaneous environmental penalties reduced.

TABLE 16.1

Improving road haulage logistics efficiency and reducing environmental penalties[7]
• Reducing empty running, pooling and sharing capacity, obtaining 'backhaul' loads (a number of websites have been developed which match carriers who have available capacity with shippers seeking capacity – see the caselet later in the chapter on electronic logistics markets)
• Increasing vehicle payload capacity (by weight and/or by cubic volume) – double deck and higher trailers, single tractor unit and multiple trailer combinations etc.
• Improved vehicle routing using GPS and other systems
• More efficient use of packaging and loading of containers
• Improved vehicle driving (in-cab computer monitoring of driving style, even examining the benefits of air conditioning versus open windows!)
• Enhancing vehicle operating efficiency (for example using hybrid fuels, ensuring correct wheel alignment and enhanced aerodynamic styling of trucks)

Transport and fuel use

We saw in Chapter 6 the dominance of petroleum products in fuelling transport. The negative impact of burning fossil fuels on the environment is well documented, and this is a special challenge for transport that relies heavily on such fuels. In addition, as reserves run down, the price of many fuels is increasing. A further complication is the interdependencies that exist between the prices of different fuels – more availability of shale gas, for example, has obviously reduced its price, and this in turn has encouraged more use of this fuel with a knock-on effect of reducing demand for some other fuels. The challenge then for transport is to:

- Reduce the harmful effects of the fuel it does use (e.g. initiatives for ships to burn fuel with lower sulphur composition)
- Convert to using other energy sources (e.g. electric vehicles, LNG and, while it may initially sound rather farfetched, ships using sails and wind power)
- Developing engines with ever-greater fuel efficiency, thus ensuring that less fuel is used per kilometre travelled

Much work is being done in this area, spurred on by governmental regulations and pressure from various stakeholders to reduce the environmental impact of transport. We will discuss this topic in more detail in the next section on environmental supply chain performance measurement. Many of the leading LSPs and large transport companies now routinely produce annual sustainability statements, which are worth looking at. In addition, much technological research and development is ongoing with regard to this topic both in academia and in industry.[8]

In transportation, it is not just the road haulage sector that is seeking to reduce its environmental footprint. With the growth of air travel, spurred on in particular by rapid growth in the so-called low fares category of air travel, many commentators are looking towards the air transport sector to reduce its impact on the environment. The leading aircraft manufacturers are all moving towards aircraft designs that use lighter materials and are more fuel efficient. Similar developments are taking place in shipping, both in terms of vessel hull design and propulsion technologies.

Figure 16.4 depicts baseline freight flows and related CO_2 emissions for 13 freight corridors, and projections for 2050 under two scenarios (current ambition and high ambition), developed by the International Transport Forum (ITF). The high-ambition scenario incorporates potentially disruptive developments in the transport sector and ambitious deployment of mitigation measures.[9] Many observations and inferences can be taken from this analysis. See, for example, the relatively lower global shares of CO_2 for corridors where shipping dominates. Freight volumes are destined to grow and the measures associated with the high-ambition scenario will be essential to at least keep CO_2 emissions to levels broadly in line with today's (already too high) levels.

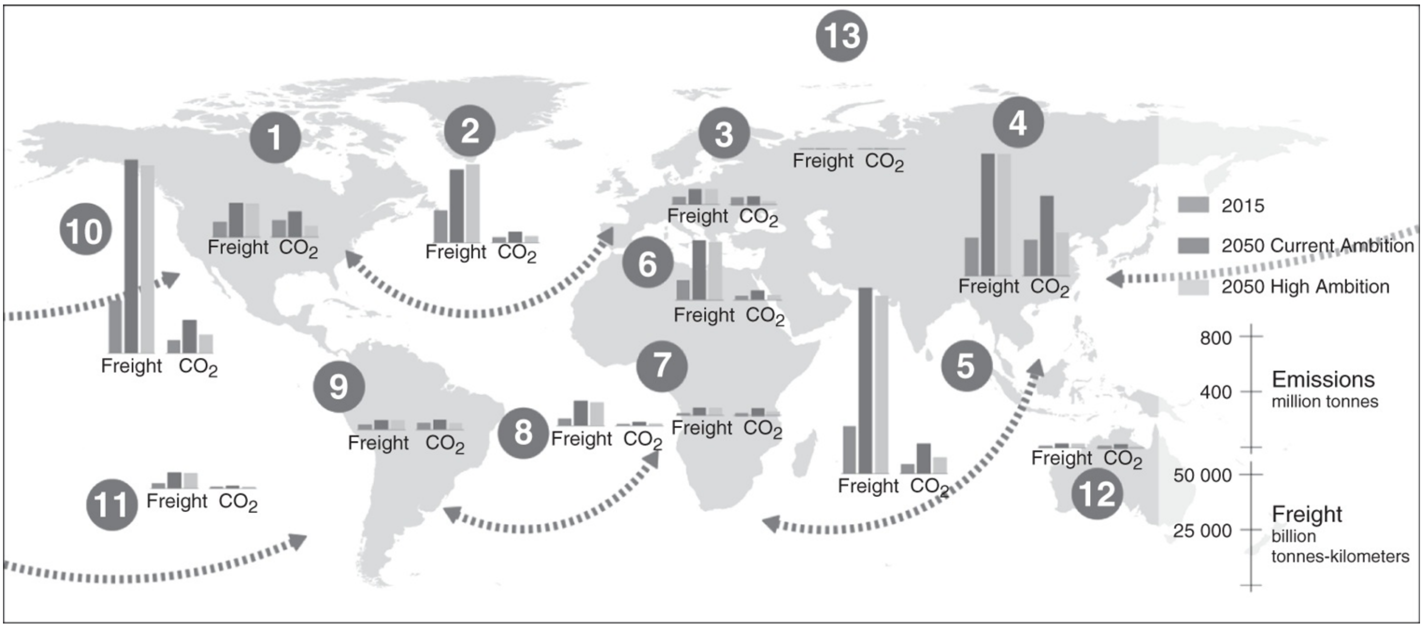

Figure 16.4 2019 Projected international freight flows and related CO_2 emissions

(Source: ITF Transport Outlook 2019)[10]

Note: 1. North America; 2. North Atlantic; 3. Europe; 4. Asia; 5. Indian Ocean; 6. Mediterranean and Caspian seas; 7. Africa; 8. South Atlantic; 9. Latin America; 10. North Pacific; 11. South Pacific; 12. Oceania; 13. Northern Sea Route.

In logistics, efficiency solutions are not just restricted to transportation. The area of green warehouse design is also growing in popularity. Many warehouses are vast structures, and their environmental footprints can be reduced by, for example, more efficient lighting and heating/refrigeration systems.

ELECTRONIC LOGISTICS MARKETPLACES[11]

As we noted in Table 16.1 a number of websites have been developed that match LSPs who have available capacity with shippers seeking capacity. These electronic logistics marketplaces (ELMs) provide opportunities both for the LSPs and for those companies using them: the LSPs can offer excess capacity within its fleet to a greater potential client base, thus maximising its loaded miles and leading to an ability to reduce freight charges; for shippers, ELMs enable them to increase the number of LSPs, and their concomitant services, that they can reach. Various ELMs provide services ranging from matching of one-off backhaul loads through to managing complex tendering processes for consignors.

DHL GOGREEN SOLUTIONS[12]

DHL offer a number of service options for minimising and/or avoiding logistics-related emissions, waste and other environmental impacts along the supply chain. These include tools to measure carbon footprint and efficiency, more environmentally friendly transport solutions (e.g. Sea-Air as opposed to using air freight for the entire end-to-end journey) and products to offset carbon emissions.

ENVIRONMENTAL SUPPLY CHAIN PERFORMANCE MEASUREMENT (ESCPM)

Emissions – and the resulting carbon footprint – are not the only externality associated with logistics activity. Other externalities can also arise – for example waste from packaging, noise from transport and so forth. Measuring environmental impact across the supply chain has grown in popularity in recent years because of climate change, diminishing raw materials, cleaner production, excess waste from production, increasing levels of pollution, globalisation, and because it is seen as a source of competitive advantage. Thus, 'what' environmental measures and 'how' to measure them have led to the emergence of environmental supply chain performance measurement (ESCPM).[13] Various initiatives have been developed – some mandatory and imposed by regulators, others voluntary and industry led – and in turn this has led to a requirement to measure their impact. Some of the top enablers for ESCPM include the following:

- Desire to reduce cost
- Improving operational efficiency
- Government regulation/legislation
- Reducing energy consumption
- A genuine care for the environment

Inhibitors to ESCPM, however, include the following:

- Cost
- The complexity of the supply chain
- Obtaining data

- Too many disparate governing bodies and regulations
- Lack of reporting/measurement tools

Notwithstanding these inhibitors, many benefits can accrue from ESCPM, which include helping companies to innovate, reduce waste and become more efficient, give them an improved image and reputation with a reduced risk of consumer/public criticism and help to reduce costs. Figure 16.5 – using the example of the shipping industry – illustrates both a plethora of environmental-related initiatives across the sector and the weightings which they accord to various environmental impacts of shipping (in fact, some 16 different impacts are identified).

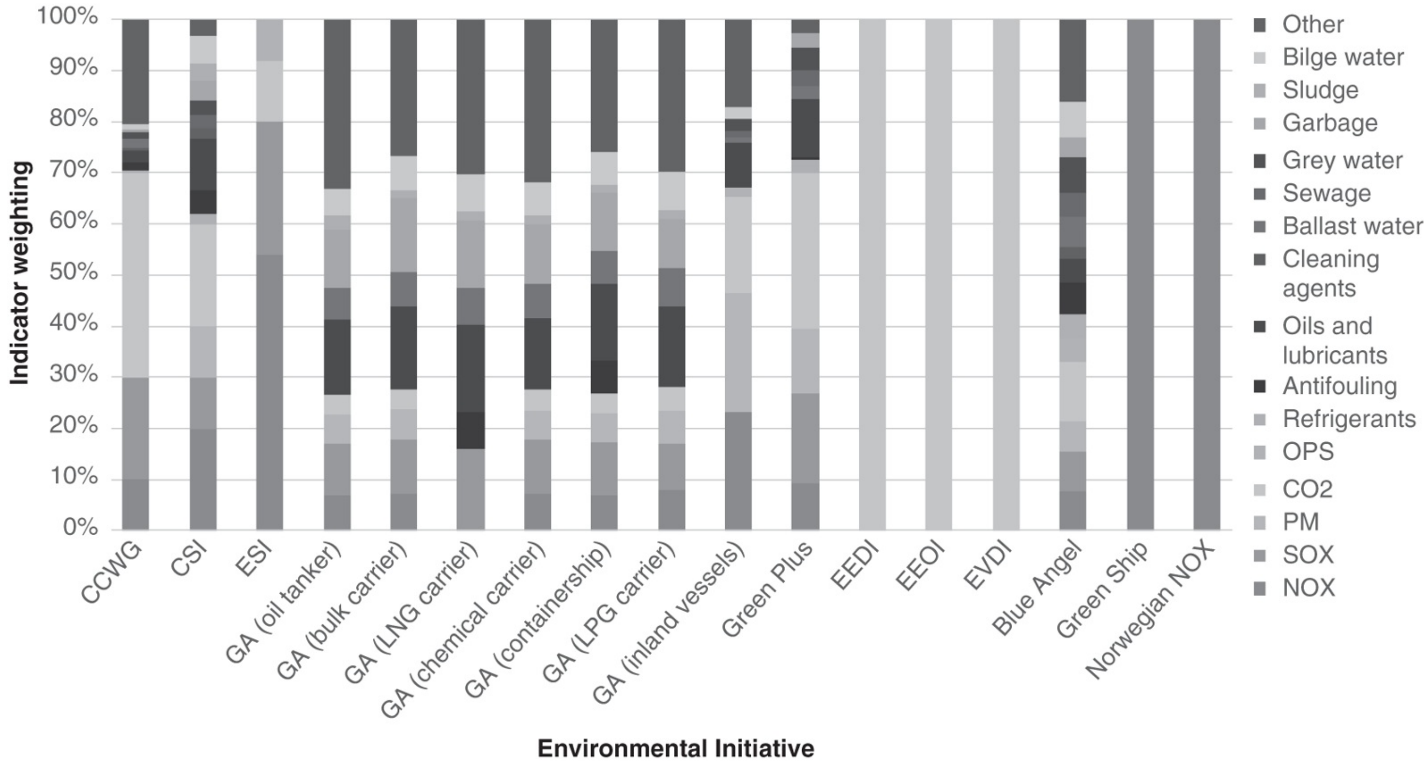

Figure 16.5 Environmental initiatives in shipping

(Source: Gibson et al 2019; Reproduced with permission of ELSEVIER.)[14]

REVERSE LOGISTICS AND THE CIRCULAR ECONOMY

One method for achieving sustainable growth is to increase the amount of materials recovered from the world's waste stream by using **reverse logistics**. Logistics management focuses primarily on the movement of material from the point of origin to the point of consumption, whereas reverse logistics concentrates on the flow of material from the point of consumption towards the point of origin (i.e. back upstream in the supply chain). Rogers and Tibben-Lembke (p. 4) defined reverse logistics as

> The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal.[15]

Reverse logistics can present companies with great opportunities, particularly when it comes to customers' loyalty. Surveys suggest that 85% of customers want to shop at a store with convenient return policies and that a customer's positive experience with returning items will likely lead to new purchases.[16]

Through reverse logistics, freight is moved from the customer to the seller for the purpose of:

- Reuse: the recovered product is used again for a purpose similar to the one for which it was originally designed.
- Repair: the defective product is fixed and put back in stock (in LSCM sometimes the acronym 'RMA – return material authorisation' (or similar variants) is used to denote products for refund/replacement/repair).
- Remanufacture: the recovered product is dismantled, and its parts used in the assembly of new products (so-called 'repurposing').
- Recycling: the recovered product is dismantled, its parts are classified into different categories and then processed into recycled materials.

As shown in Figure 16.6, a hierarchy among recovery options can be obtained by looking at the value they add to the supply chain. A firm should attempt to maximise value from the recovery options and thus first concentrate on the option that will provide maximum value. 'Resource reduction', which refers to the 'minimisation of materials used in products and minimisation of waste and energy achieved through the design of more environmentally efficient products',[17] should be the main objective of any supply chain. Development and utilisation of the resource reduction option would help firms minimise flows of materials both in the forward and reverse directions of supply chains. The next option to be considered in the hierarchy is reuse, followed by remanufacturing and recycling. Remanufacturing focuses on higher value-added recovery, compared with recycling, which concentrates just on materials recovery. Disposal, with and without energy recovery, should be the last option to be considered.

> Reverse logistics concerns materials flows from the point of consumption towards the point of origin (i.e. back upstream in the supply chain) for the purpose of reuse/repair/remanufacture/recycling.

Various factors are behind the growth of interest in reverse logistics:

- Government policy and legislation (for example concerning packaging, what to do with end-of-life products, etc.).
- Economic considerations (such as rising waste disposal costs, the opportunity to extract value from recycled products, etc.).
- Customer demand (there is an increasing customer demand for green products and for organisations to engage in environmental supply chain practices by, for example local sourcing (assuming of course that this reduces the carbon footprint – see our textbox above on local versus overseas sourcing).
- Environmental considerations (often driven by corporate social responsibility (CSR) policies and the need to both project and protect a company's image).

The circular economy

As opposed to the linear economy – where products are manufactured, used and disposed – the circular economy aims to eliminate waste by designing and optimising products for a cycle of disassembly and reuse.[20] Indeed, the circular economy is characterised by the '3Rs'[21]:

- Reduce the use of resources
- Reuse products and components
- Recycle products and components

For LSCM, the circular economy means that a holistic management approach is needed for materials and products, ensuring that the use of raw materials is minimised, products are designed to be durable and have a long lifespan (e.g. the possibility for product upgrades is built into the initial product design), and reverse logistics processes are in place to enable 'closing the supply chain loop' (the flow of materials and products back into the supply chain (and assuming, of course, that this does not have an adverse impact of increasing overall carbon footprint)). In the circular economy, the whole supply chain endeavours to be fuelled by renewable energy, thereby reducing its environmental impact. An overarching aim then is to reduce adverse impacts of resource use on the world's 'natural capital'.

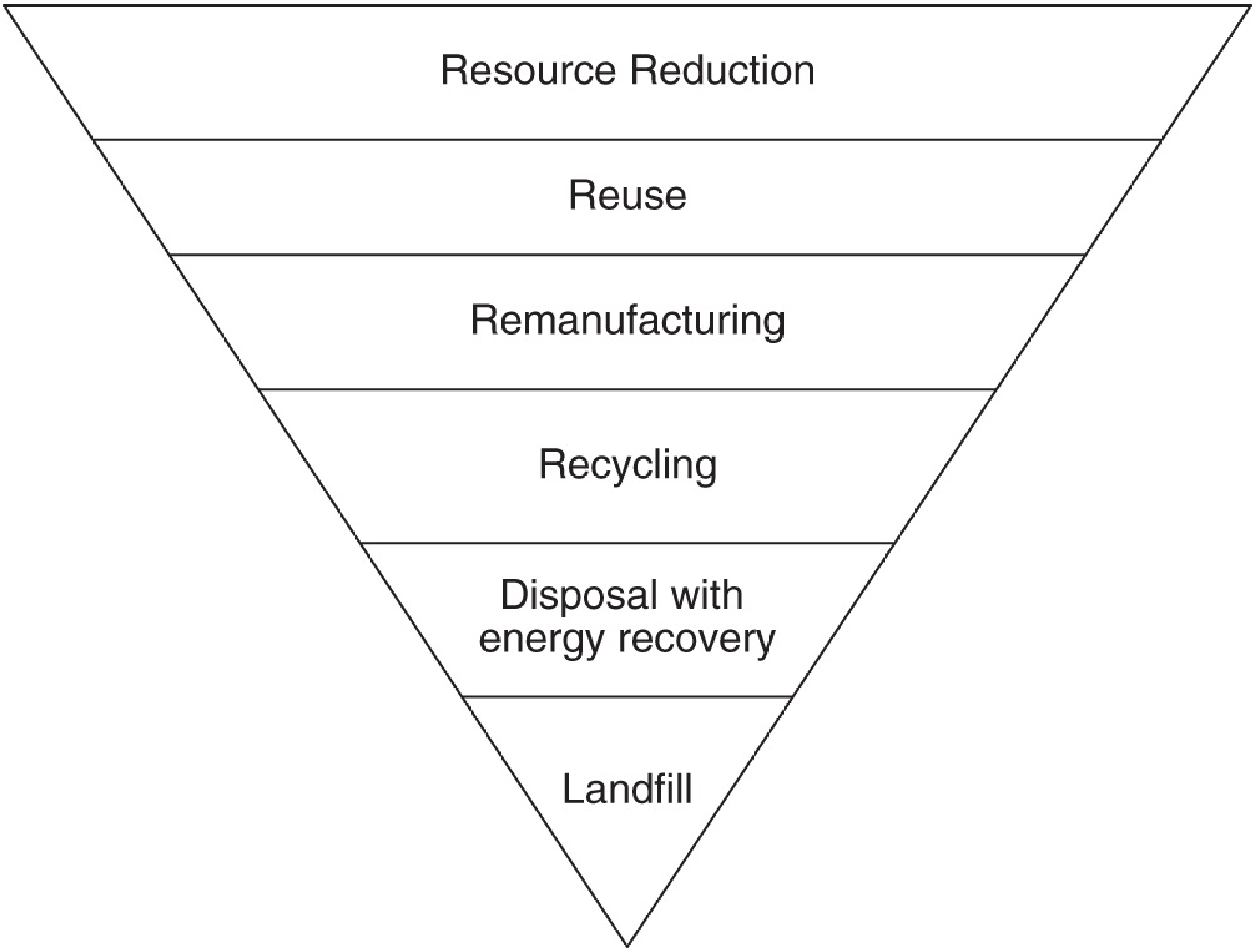

Figure 16.6 A recovery options hierarchys

(Source: Carter, C.R. & Ellram, L.M. (1998); Reproduced with permission of John Wiley & Sons.)[18]

GREENPEACE'S GUIDE TO GREENER ELECTRONICS

The Guide to Greener Electronics (published by Greenpeace USA) provides an analysis of what 17 of the world's leading consumer electronics companies are doing to address their environmental impacts, and where Greenpeace thinks work still needs to be done. From 2006 to 2012, Greenpeace published the Guide with regularity, and as a result saw steady progress from companies to eliminate hazardous materials from products and make them more energy efficient. Since 2017 the methodology expanded beyond the concerns of hazardous e-waste, now taking into account the following factors: (1) energy (reduction of GHGs through efficiency and renewable energy); (2) resource consumption (sustainable design and use of recycled materials) and (3) chemicals (elimination of hazardous chemicals from both the product itself and manufacturing). Within each impact area, companies are graded on transparency, commitment, performance and advocacy efforts. Among the results of the 2017 Guide, Greenpeace highlights that while some IT companies have incorporated recycled plastics in their products for several years, very little progress has been made in sourcing other secondary materials into new products. Fairphone incorporates recycled tungsten, and Dell has shown success in using closed-loop plastic collected from its take-back channel. Apple recently committed to 'closing the loop' for its materials, starting with tin and aluminium.[19]

CLOSING THE COFFEE POD LOOP

In order to reduce waste from coffee pods, Nespresso uses aluminium – a recyclable material – on its single-use coffee pods and provides its customers with prepaid return bags that they can drop off at any UPS store. The partnership between Nespresso and UPS allows the company to retrieve the used pods and use them again in new products, while coffee grounds are composted into high-quality soil amendments that go to landscapers, garden centres, municipalities and homeowners.[22]

LEARNING REVIEW

This chapter sought to investigate the important, and rapidly growing, area of sustainable LSCM. We first looked at the growth of interest in environmental and sustainability issues, the so-called 'green revolution' and carbon footprint measurement. Some commentators argue that the solution to reduce the environmental impact of current logistics systems is to source more freight locally, as opposed to overseas, but we saw that the issues surrounding this are more complex than they first appear. We also touched upon the impact of prevalent JIT systems and whether these are sustainable from an environmental perspective going forward.

We then reviewed the three key (and not mutually exclusive) ways in which the environmental footprint of LSCM can be reduced: by redesigning supply chains, by exploiting the benefits of scale (for example using larger ships) and by seeking out efficiencies in terms of how we move freight. We also looked at the growth of interest in ESCPM. The prevention of waste products through reverse logistics activities such as reuse, remanufacturing and recycling avoids many environmental costs. We discussed what motivates a firm to initiate reverse logistics activities. We next discussed different recovery processes and the key factors for the successful implementation of reverse logistics. Finally, we presented the concept of the circular economy, a system designed to reduce waste. The final chapter in our book will now bring together all that we have discussed thus far and look in particular to the future and emerging supply chain designs.

QUESTIONS

- What are the pertinent sustainability issues in the context of LSCM?
- What are the different ways by which the environmental footprint of LSCM can be reduced?
- Why might some JIT inventory management approaches not be sustainable from an environmental perspective?
- What is meant by the term 'carbon footprint'?
- How can environmental supply chain performance be measured?
- If you were designing and implementing a reverse logistics process for your firm, what are the key factors you would consider for implementation, and why?
- How does the circular economy relate to LSCM?

REVISTING THE QUESTION OF LOCAL VERSUS OVERSEAS SOURCING

Some commentators argue that the solution to reduce the environmental impact of current logistics systems is to source more products locally, as opposed to overseas (read again the textbox on Local versus Overseas Sourcing earlier in the chapter).

In your view what factors militate against this? It may be helpful to consider specific products and markets, and to consider the *price elasticity* of demand for those products (i.e. how will demand for the product change as the market price for the product changes?).

NOTES

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2. See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/850130/Env-reporting-guidance:inc_SECR_31March.pdf and https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting. Another informative website is that of the Carbon Trust at https://www.carbontrust.com/what-we-do.

3. See https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf.

4. Rigot-Muller, P., Lalwani, C., Mangan, J., Gregory, O. & Gibbs, D. (2013) Optimizing end-to-end maritime supply chains: A carbon footprint perspective. *International Journal of Logistics Management*, 24(3), 407–425.

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6. Oglethorpe, D. & Heron, G. (2010) Sensible operational choices for the climate change agenda, *International Journal of Logistics Management*, 21(3), 538–577.

7. Many of the ideas in this table have been elicited from www.freightbestpractice.org.uk.

8. See, for example, in the case of shipping, a very insightful report by the Royal Academy of Engineering in the UK: *Future Ship Powering Options: Exploring Alternative Methods of Ship Propulsion*, July 2013.

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16. See https://www.ups.com/us/en/services/knowledge-center/article.page?kid=aa38e992.

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18. Ibid.

19. See https://www.greenpeace.org/usa/reports/greener-electronics-2017.

20. See https://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/from-linear-to-circular-accelerating-a-proven-concept.

21. See https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy.

22. See https://www.uschamberfoundation.org/logistics-circular-economy.

17
Emerging Supply Chain Designs

LEARNING OBJECTIVES

- Review the many strategies and practices employed in logistics and SCM today.
- Appreciate the emerging, challenging and changing context within which logistics and SCM operates.
- Consider the rise of humanitarian logistics and opportunities for the creation of shared value.
- Examine the growing demand for more transparency in supply chains and see how sufficiency might impact LSCM.
- Understand the need to synchronise the design of supply chains with the design of products.
- Detail the skills and knowledge areas required of logistics and supply chain managers in the future.

INTRODUCTION

This concluding chapter of the book endeavours to bring together many of the key issues discussed in the preceding 16 chapters. The particular focus of this chapter is to summarise how various trends and challenges are shaping LSCM and in turn how supply chains can be best designed to meet these challenges, and what skills logistics and supply chain managers will need in the future. As we noted in Chapter 1, and reiterated throughout the book, increasingly it is supply chains that compete more so than individual firms and products. A company can have the best and most sophisticated product in the world, but if it doesn't have a good supply chain behind it, then it will likely not be able to compete, especially in terms of cost and speed, and indeed many other attributes also. The design of effective supply chains is thus a critically important factor for many organisations today.

Chapter 17 comprises three core sections:

- Supply chain strategies and the ever-changing context
- Synchronising product design and supply chain design
- The supply chain manager of the future

SUPPLY CHAIN STRATEGIES AND THE EVER-CHANGING CONTEXT

Figure 17.1 shows how in LSCM the initial focus was on lean, this has been of great benefit in many industries and sectors and led to significant cost reduction. While this is good, it is not enough to survive and prosper today. For many organisations, responsiveness is now a key capability that they wish to enhance. In Chapter 3, we discussed the wide and important area of strategy, and in particular the role of logistics/supply chain strategy, and we noted the current focus on adopting strategies based around lean and agile principles, and various combinations of both. A particular focus in this regard was on choosing strategies appropriate to various demand and lead-time characteristics. We noted how many experts agree that a ‘one-size-fits-all’ approach will not work and that companies need to continually assess their product range and market characteristics so that changing scenarios may be identified and appropriate supply chain designs configured. The supply chain, properly configured, can be a tremendous source of competitive advantage. It too can allow value to be created that heretofore didn't previously exist (e.g. new ways of manufacturing and delivering products thus opening up new market opportunities).

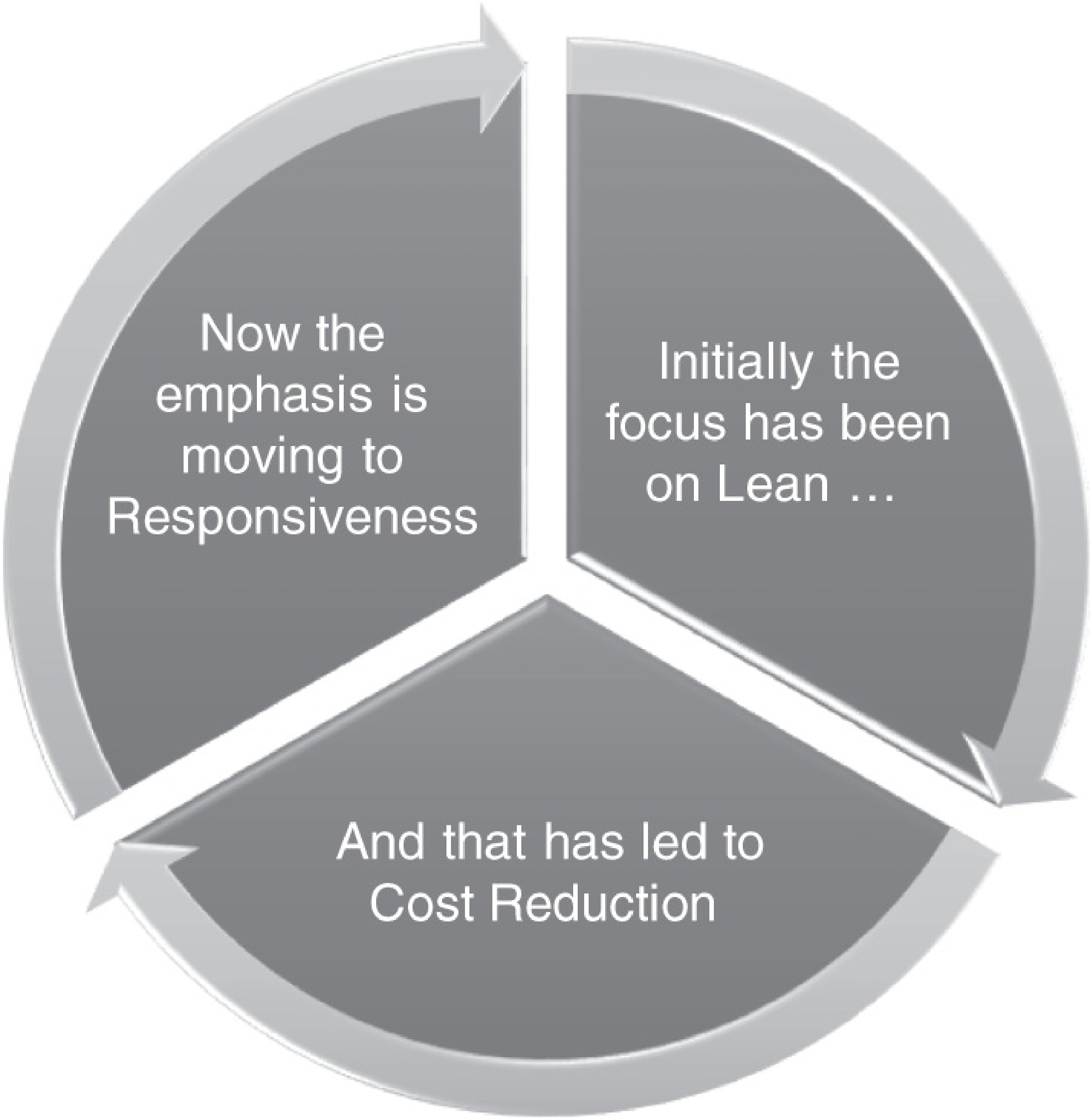

Figure 17.1 Lean and responsive

We have described a variety of different strategies and practices throughout the book (don't forget that brief explanations of each are also given in the glossary). Many of the common strategies and practices that logistics and supply chain managers engage in are listed below. The extensive list illustrates the diverse and multifaceted areas of activity that logistics and supply chain managers are involved in. This in turn requires a particular skills mix, a topic we will discuss further below.

COMMON LOGISTICS/SUPPLY CHAIN STRATEGIES AND PRACTICES

- Designing and optimising networks; understanding network characteristics, behaviours and complexities
- Pursuit of strategies based around lean and agile principles and varying combinations of both
- Mass customisation/postponement/additive manufacturing
- Time compression – faster order-to-delivery cycles and elimination of non-value-adding time
- Developing value-adding logistics activities
- Managing reverse logistics flows
- Moving from linear to circular economy business models
- Coordinating and managing transport flows and directional imbalances; selecting modes and routes
- Operating in a more sustainable fashion, especially by exploiting scale and seeking out greater efficiencies, carbon footprinting
- Operating 'own-account' transport versus using LSPs – and with regard to the latter identifying and selecting LSPs, and determining whether to employ a 4PL approach
- Use of electronic logistics marketplaces
- Integration of systems, business processes, etc.
- Capture and transmission of supply chain data
- Increasing visibility and information enrichment in supply chains
- Use of WMS and ERP systems
- Selecting tracking and materials handling technologies
- Collaboration with supply chain partners, use of strategies such as CPFR and VMI
- Managing distribution centres and cross-docking facilities
- Consolidating freight; applying factory gate pricing
- Managing outsource and offshore activities
- Procurement (sourcing and purchasing) – addressing ethical sourcing concerns – ensuring compliance with corporate social responsibility (CSR) and transparency requirements
- Supplier selection and development, supply base rationalisation
- Determining how much inventory to hold, in what location(s) to hold it and what inventory control system to use
- Selecting appropriate packaging and product handling techniques
- Determining costs – activity-based costs, through life costs and total cost of ownership, opportunity costs, generalised costs and landed costs
- Identifying and tracking appropriate metrics, ensuring compliance with SLAs
- Coordinating and managing upstream and downstream materials flows
- Maximising capacity utilisation and efficiency
- Assessing risks and complying with security, customs, food safety and other requirements
- Business continuity planning
- Completing appropriate documentation, selecting Incoterms
- Data analysis, forecasting of activity

Figure 17.2 illustrates many of the key trends in LCSM today. Following on from our wide-ranging discussion in the preceding chapters, and the insights we have gained, Figure 17.3 illustrates the key challenges (yet these can also be opportunities) for logistics and supply chain managers today. As well as sustainability concerns, the ethical dimension in LSCM, and its role in society, is likely to grow in importance with a need for supply chains to become more transparent. So too will managing 'last mile' delivery driven especially by the growth of online shopping (the supply chain challenge here is, of course, small lot sizes, often delivery of just one item).[1] Just as solutions such as Uber and Airbnb have grown in other sectors, crowdsourcing and sharing economy solutions may also become more prevalent in logistics (e.g. Walmart's Spark Delivery grocery delivery solution).[2] Complexity and vulnerability remain key concerns in LSCM - COVID-19 had a dramatic and significant impact on all sectors including LSCM with a new label entering the lexicon namely *the stressed supply chain*.

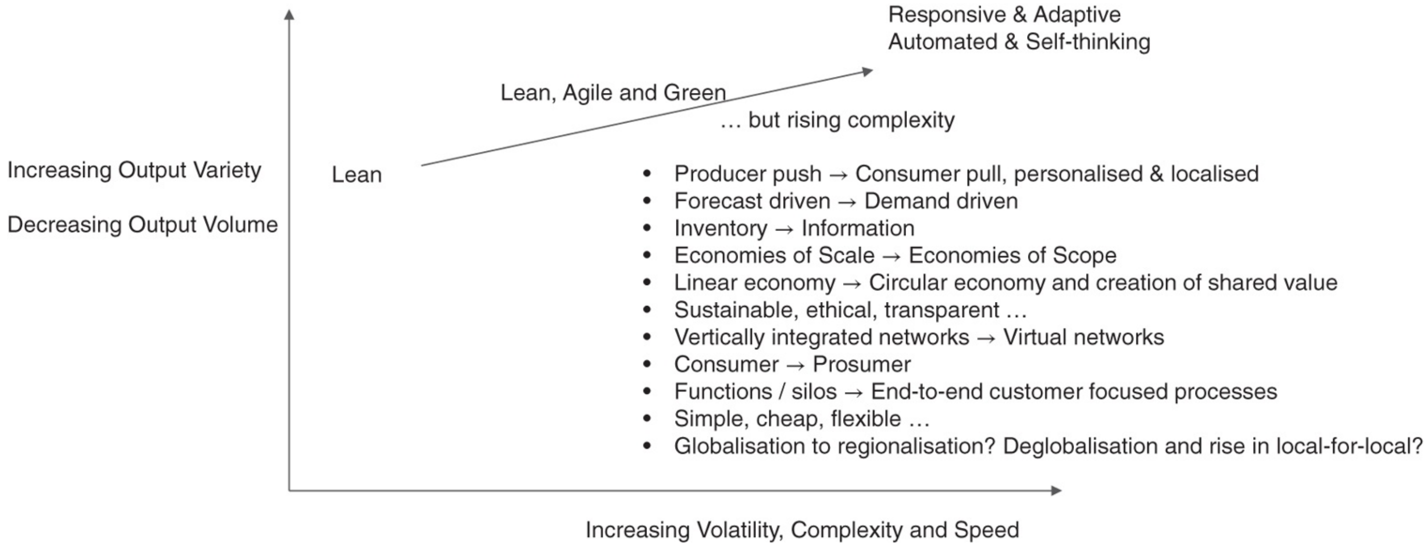

Figure 17.2 Trends in LSCM today

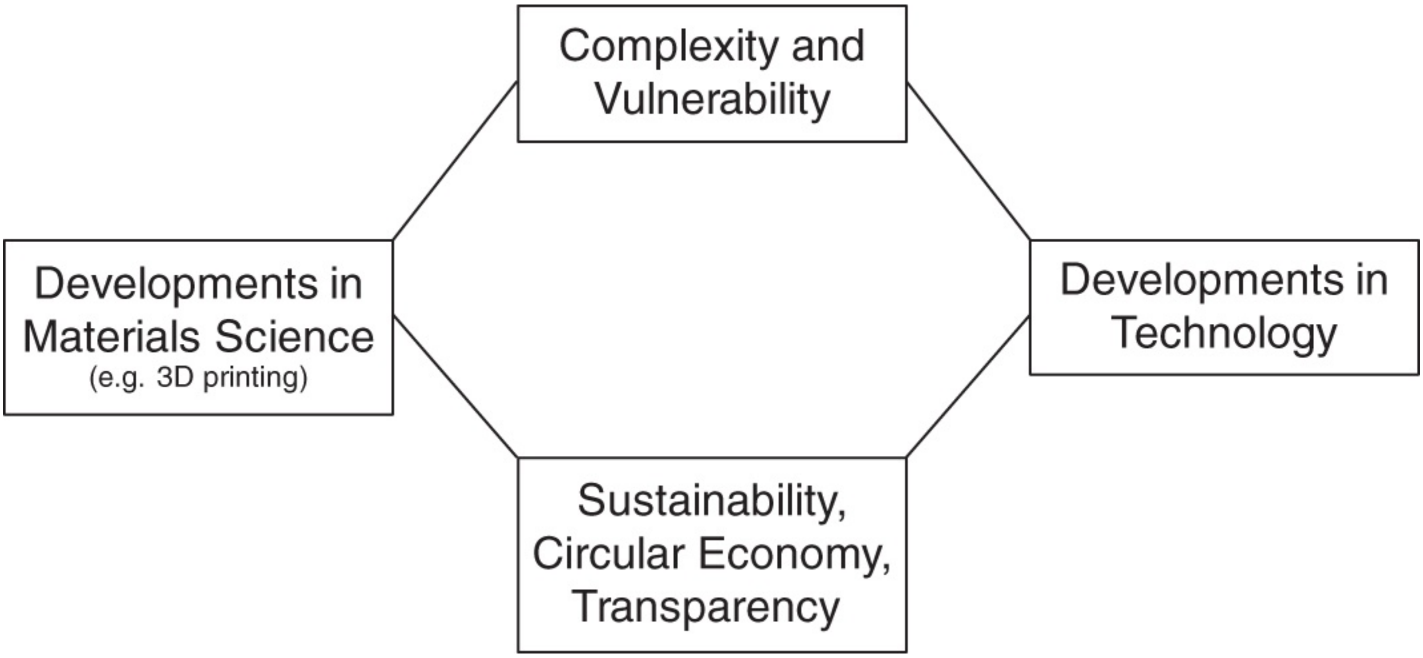

Figure 17.3 Key supply chain challenges and opportunities

A SPOTLIGHT ON SUPPLY CHAINS: THE NEED FOR MORE TRANSPARENCY

As companies become more interested in CSR matters, and as customers and wider society demand more ethical behaviours, transparency in supply chains is likely to become an increasingly important topic.[3] The UK's *Guardian* newspaper, for example, ran a special investigation on the seafood supply chain where it noted how in the fishing industry murder and slavery have become endemic in some areas.[4] Although not as serious in terms of harm to life, but nevertheless significant, another example of the importance of transparency in the supply chain concerns Amazon who came in for a lot of criticism when it was discovered that they were routinely destroying unsold and unwanted inventory; in response, the company launched a new programme to donate unsold products.[5] We saw too in Chapter 15 how (unethical) actions by upstream suppliers can cause shocks to the supply chain. Improvements in data and visibility across the supply chain will help consumers and other stakeholders become more aware of issues such as these.

Interest is growing too in a related issue which will have an impact on supply chain transparency and this concerns *sufficiency*: are we consuming too much?[6] Such overconsumption in the fast fashion sector, for example, is the focus of a very informative book by Dana Thomas where she looks at the price of fast fashion and the future of clothes.[7] The fast fashion supply chain is often held up as a paragon of supply chain excellence (see companies such as Zara); it will likely have to evolve considerably in the future if the issues and concerns discussed here come to the fore.

THE RISE OF HUMANITARIAN LOGISTICS & CREATION OF SHARED VALUE

It is estimated that today some 1.8 billion people across the world are living in poverty with 14 million people displaced by disasters such as earthquakes, tsunamis, floods and cyclones; many too are fleeing wars and conflicts.[8] A specialist branch of logistics – **humanitarian logistics** (or HumLog) – has grown in significance in recent years.[9] This encapsulates capabilities for providing logistics services in austere environments, contingency planning for emergencies, and also affords an opportunity for organisations across both the public and private sectors to share expertise.

Indeed, it is notable that while (the mostly private sector) actors can achieve CSR benefits from contributing to and participating in HumLog activities, they can also learn new skills from the (mostly public sector) logisticians who work in this challenging space. This is a good example of *shared value* as articulated by Porter and Kramer in a significant *Harvard Business Review* article in 2011; shared value is where policies and operating practices that enhance the competitiveness of a company can simultaneously advance the economic and social conditions in their communities.[10] Indeed, creating shared value in logistics does not need to be restricted to HumLog, such shared value can be created in other domains too e.g. circular economy solutions for diverting wasted food to those who need it.

SYNCHRONISING PRODUCT DESIGN AND SUPPLY CHAIN DESIGN

In design and manufacturing environments, variants of the acronym *Dfx* are common e.g. designing products that are easy to manufacture (DFM - as discussed in Chapter 12), easy to assemble (DFA), easy to manufacture and assemble (DFMA) and so forth. Simchi-Levi *et al.* noted that there's been a similar transformation in SCM whereby managers have started to realise that 'by taking supply chain concerns into account in the product and process design phase, it becomes possible to operate a much more efficient supply chain'.[11] Mass customisation, for example, can be enabled by designing postponement into the production process. This can be something straightforward, such as delayed product differentiation enabled by downstream supply chain partners.

Notwithstanding all of this, it is, of course, important to note that no matter how well designed a supply chain is it cannot overly compensate for poor products. You will recall that in Chapter 3, in the context of our discussion on supply chain strategy, we quoted Christopher *et al.* who state that 'responsive supply chains … cannot overcome poor design and buying decisions which fail to introduce attractive products in the first place'.[12]

Synchronising product design and supply chain design is, as we saw in Chapter 16, especially important from a sustainability perspective. We noted then that greening a supply chain is largely about forward planning, with some commentators noting that over 80% of carbon savings are only achievable at the supply chain design stage.[13]

We also noted that while various initiatives, such as switching to hybrid fuel vehicles, are obviously welcome and generate publicity benefits for companies, it is the (often unnoticed in the public eye) *supply chain design* decisions, such as deciding where to locate warehouses and distribution centres and deciding which transport modes to use, that have the greatest impact. This holistic approach has come to be known as **design for supply chain efficiency (DSCE)**.

Design for supply chain efficiency: by taking supply chain concerns into account in the product and process design phase, it becomes possible to operate a much more efficient supply chain.

From a societal perspective, supply chain design is not just concerned with sustainability issues. Sustainability is one part of a wider framework of CSR. Increasingly, ethical shareholders, regulators and customers are using their power to ensure organisations act responsibly and transparently, and the implications of this need to be considered at the supply chain design stage too.

It is often the case that a new supply chain is not designed by a lead company and then operationalised; often an extant supply chain is already in place, but may need for a variety of reasons to be modified or redesigned. A good example of this is in many countries the supply chain for blood transfusion products, which needed to be redesigned following on from some very significant concerns in terms of product traceability and integrity (many countries have witnessed in recent years awful scandals around the issue of contaminated blood products infecting already ill people).

THE SUPPLY CHAIN MANAGER OF THE FUTURE

In Chapter 1, we noted that the supply chain encompasses three flows – material, data and resources – and we considered different aspects of each in this book. To again note what was pointed out in Chapter 1: no single flow is more important, and all are interdependent. The challenge then for the logistics/supply chain manager is to operate within such complexity and competing demands.

Professor Martin Christopher has identified a set of wide-ranging and challenging skills that logistics and supply chain managers require[14]:

- Market understanding, customer insight
- Management of complexity and change
- Information systems and information technology expertise
- Ability to define, measure and manage service requirements by market segment
- Understanding of the 'cost to serve' and time-based performance indicators
- Specific functional excellence with cross-functional understanding
- Team working capabilities
- Relationship management

As you will now realise, the aim of SCM is to take a cross-functional, process perspective as distinct to a functional or silo-based perspective. The implication of this re-orientation is that the supply chain manager of the future will require a 'T-shaped' skills profile

(Figure 17.4).

The idea is that as well as bringing specific logistics management skills to the job (the vertical bar) supply chain managers need to have a wide understanding of related areas such as business process engineering, asset management and activity-based costing (the horizontal bar). Research into the development of future logistics and supply chain managers has identified the pertinent knowledge areas and competencies/skills outlined in Table 17.1.

People, with the right skills and knowledge, are thus critical to effective SCM. As Professor John Gattorna has noted: ‘It is people who drive the supply chain, both inside and outside your business, not hard assets or technology.’[16] We also note the views of Quinn, who stated that to achieve any measure of supply chain success three critical elements (people, process and technology) need to be kept in balance.[17] He added that there is no single answer as to which of these three is the most important to supply chain success, although in his view ‘you can't do *anything* without the right people’.

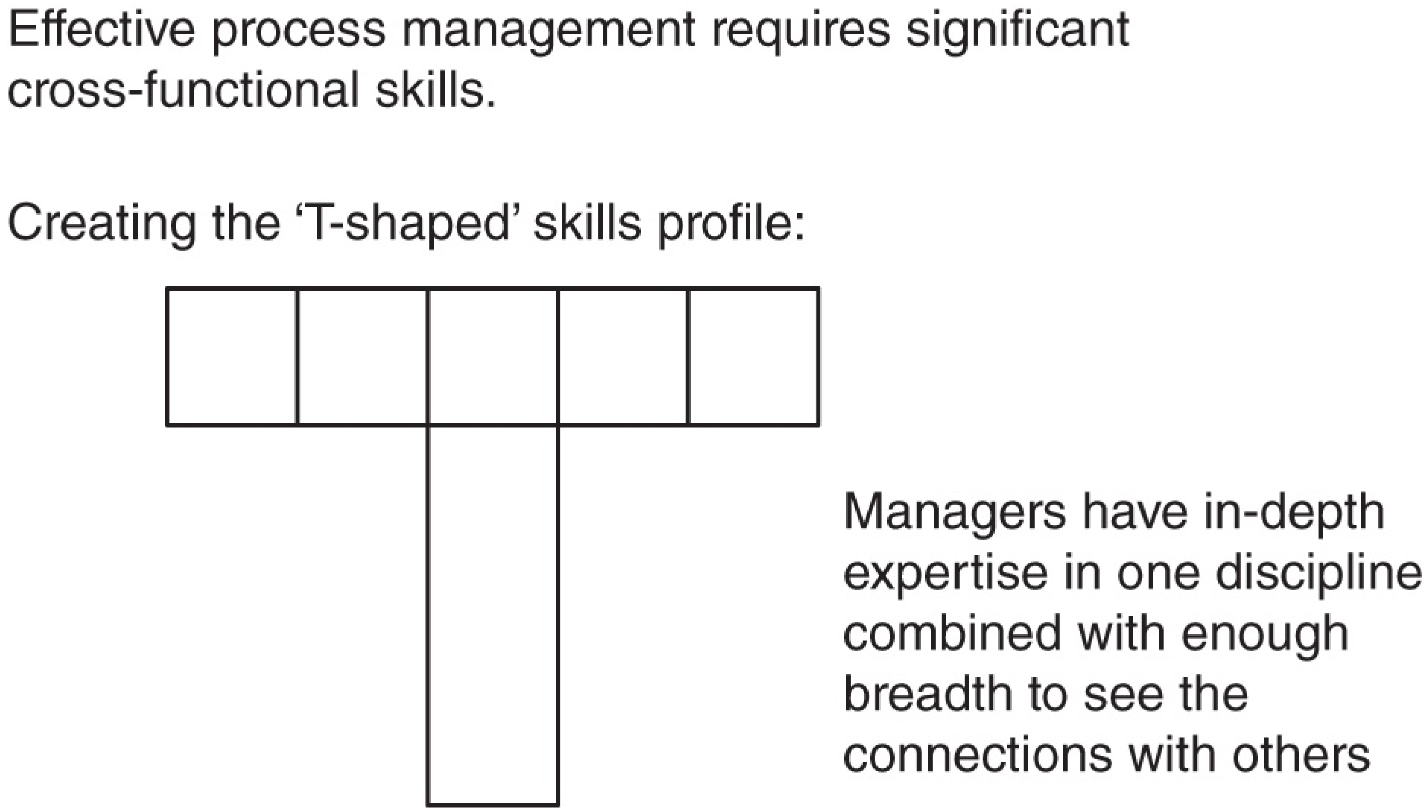

Figure 17.4 Supply chain manager skills profile

(Source: Mangan, J. & Christopher, M. (2005); Reproduced with permission of Emerald Publishing Limited.)[15]

TABLE 17.1

Key knowledge areas and competencies/skills required by logistics and supply chain managers [18]

General knowledge areas	Finance
	IT
	Management/strategy
Logistics/SCM specific knowledge areas	Operations/SCM
	Focus on processes/flows
	Legal, security and international trade
	Multimodal logistics
	Logistics in emerging markets
Competencies/skills	Analytical
	Interpersonal
	Leadership
	Change management
	Project management

This is an appropriate topic on which to conclude the book: essentially, supply chains are all about people. As a student of this fascinating subject, by equipping yourself with the appropriate knowledge and skills, an interesting and rewarding career hopefully awaits you. We hope this book will be of help to you on your journey and we wish you health, happiness and success in your career, and also that you will make a contribution through this important area of activity to make the world a better place.

SO WHO HAS THE BEST SUPPLY CHAIN?

Gartner (www.gartner.com) each year produces a list of the top 25 supply chains, which is generated from an analysis that uses various input metrics. The top 25 for 2020 – and for comparison we also show the top 25 in 2010 – are listed below:

In 2015 Gartner introduced the supply chain master category – companies that have attained top-five composite scores for at least seven out of the last ten years.

	2020	**2010**
Supply chain master	Apple	n/a
Supply chain master	Amazon	n/a
Supply chain master	McDonald's	n/a
Supply chain master	Proctor & Gamble	n/a
Supply chain master	Unilever	n/a
1.	Cisco	Apple
2.	Colgate-Palmolive	Procter & Gamble
3.	Johnson & Johnson	Cisco Systems
4.	Schneider Electric	Walmart Stores
5.	Nestlé	Dell
6.	PepsiCo	PepsiCo
7.	Alibaba	Samsung
8.	Intel	IBM
9.	Inditex	Research in Motion
10.	L'Oréal	Amazon
11.	Walmart	McDonald's
12.	HP Inc.	Microsoft
13.	Coca Cola Company	The Coca-Cola Company
14.	Diageo	Johnson & Johnson
15.	Lenovo	Hewlett-Packard
16.	Nike	Nike
17.	AbbVie	Colgate-Palmolive
18.	BMW	Intel
19.	Starbucks	Nokia
20.	H&M	Tesco
21.	British American Tobacco	Unilever
22.	3M	Lockheed Martin
23.	Reckitt Benckiser	Inditex (Zara)
24.	Biogen	Best Buy
25.	Kimberly-Clark	Schlumberger

https://www.gartner.com/en/newsroom/press-releases/2020-05-20-gartner-announces-rankings-of-the-2020-supply-chain-top-25

LEARNING REVIEW

This chapter brought together key points developed across the preceding 16 chapters. The many strategies and practices employed in LSCM today were detailed and illustrated the wide-ranging demands on logistics and supply chain managers. We also identified appropriate trends and challenges, and the emerging, changing and challenging context within which LSCM operates. It was noted that it is important, when designing supply chains, to endeavour to synchronise the design of supply chains with the design of products. The chapter concluded with a discussion on the skills and knowledge areas required of logistics and supply chain managers in the future. Logistics and SCM are ever-changing and demanding disciplines, but provide interesting and rewarding opportunities to people who wish to work in these areas.

QUESTIONS

- The Common Logistics/Supply Chain Strategies and Practices box earlier in this chapter listed many logistics/supply chain strategies and practices. In your view, are all of these carried out regularly by all organisations, or are some of them specific to certain types of organisations?
- Why is it important to synchronise product design and supply chain design? What are the implications of this from an environmental perspective?
- To what extent do you believe a supply chain can be redesigned to compensate for poor product design or poor product quality?
- Why do you think logistics and supply chain managers require a 'T-shaped' skills profile?
- Review some of the companies from the list of the top 25 supply chains. What in your view makes these supply chains so good?

THE EVER-CHANGING CONTEXT AND SKILLS REQUIRED OF LOGISTICS AND SUPPLY CHAIN MANAGERS

Look at the general business literature and try to identify various pertinent trends (in addition to those detailed in this chapter) which you believe are shaping the areas of logistics and SCM today. What are the implications of these trends in terms of skills requirements? You could, for example, review online job advertisements for the logistics and related sectors and try to identify skills requirements. If you can look at past advertisements, you will be able to observe various trends, such as an increased requirement for skilled logisticians; in addition, it should be apparent that logistics and supply chain managers are increasingly being appointed at higher levels within organisations.

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Part Five Case Studies
Why Supply Chains Should Be Involved in Product Design

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INTRODUCTION

Poor choices of material or supplier in the design process can have a significant impact on a company's performance. The case study below illustrates a scenario where both of these factors were simultaneously at play.

Supply chain considerations in design need to include inventory, logistics, transportation efficiencies, customs and duties, customer responsiveness and flexibility. The challenge for many organisations is that those involved in design tend to have little involvement once a product is launched, so they may not get to experience that supply chain in action or, indeed, live with the consequences of their decisions. Bringing that supply chain execution experience to the design table provides organisations with a great opportunity to design out potential inefficiencies and design in customer responsiveness. The term 'DFx' (design for x, where 'x' can mean a variety of things such as C = cost, M = manufacturability) is sometimes used as an all-encompassing term to flag the need for multiple perspectives in the design process.

CASE STUDY

Background to the design chain

The case company (TechCo) is a high-tech electronics manufacturer supplying products to original equipment manufacturers (OEMs), who bundle these products with other products and services for end-customer supply. Given the structure of this industry, there are very few very large OEMs. We typically refer to this type of supplier (TechCo) as a 'tier 1 supplier'.

TechCo had a significant engineering team who were responsible for product design. Engineering worked closely with these OEM customers in product design and qualification and also with tier 2 and tier 3 suppliers upstream, who manufactured various components or parts and sub-assemblies that made up the product. Initial prototypes were made in the engineering laboratories with materials procured by Engineering. The next stage was small-scale production managed by a new product introduction (NPI) group within Operations. There were a number of resources in this NPI team, mainly Project Management and Buying. The NPI group was responsible for ensuring the product could be produced in volume and produced initial volumes for OEM customers. The process of getting information from Engineering was difficult – one of those scenarios where the 'paperwork' lagged behind the activity of design and supply. Different information systems used by each team did not help since Engineering used 'Agile' as their system of record; this held detailed specifications, but Operations needed the information on its Oracle Enterprise Resource Planning (ERP) system in order to drive demand through the supply chain.

Thus, product design (i.e. new product development; NPD) was largely the remit of Engineering, and product launch (i.e. NPI) was largely the remit of the NPI team in Operations. Operations had established Advanced Manufacturing Operations (AMO) to introduce new products. This unit had a capacity to assemble about 50 units/day. Once customer demand ramped up, manufacture was then transferred to the large-scale production organisation (capacity to assemble hundreds of units/day).

Background to the supply chain

TechCo employed a mix of own-production and contract manufacturing in supplying the products to its customers. Parts or components were supplied by what could be considered as tier 3 suppliers. Some of these parts went to tier 2 suppliers for sub-assembly – either printed circuit board assembly (PCBA) or mechanical sub-assembly – and others directly to TechCo for finished products assembly. Hence, a problem with one part would have a domino effect throughout a rather interdependent and thus complicated supply chain. A simplified schematic of TechCo's supply chain is presented in Figure 1.

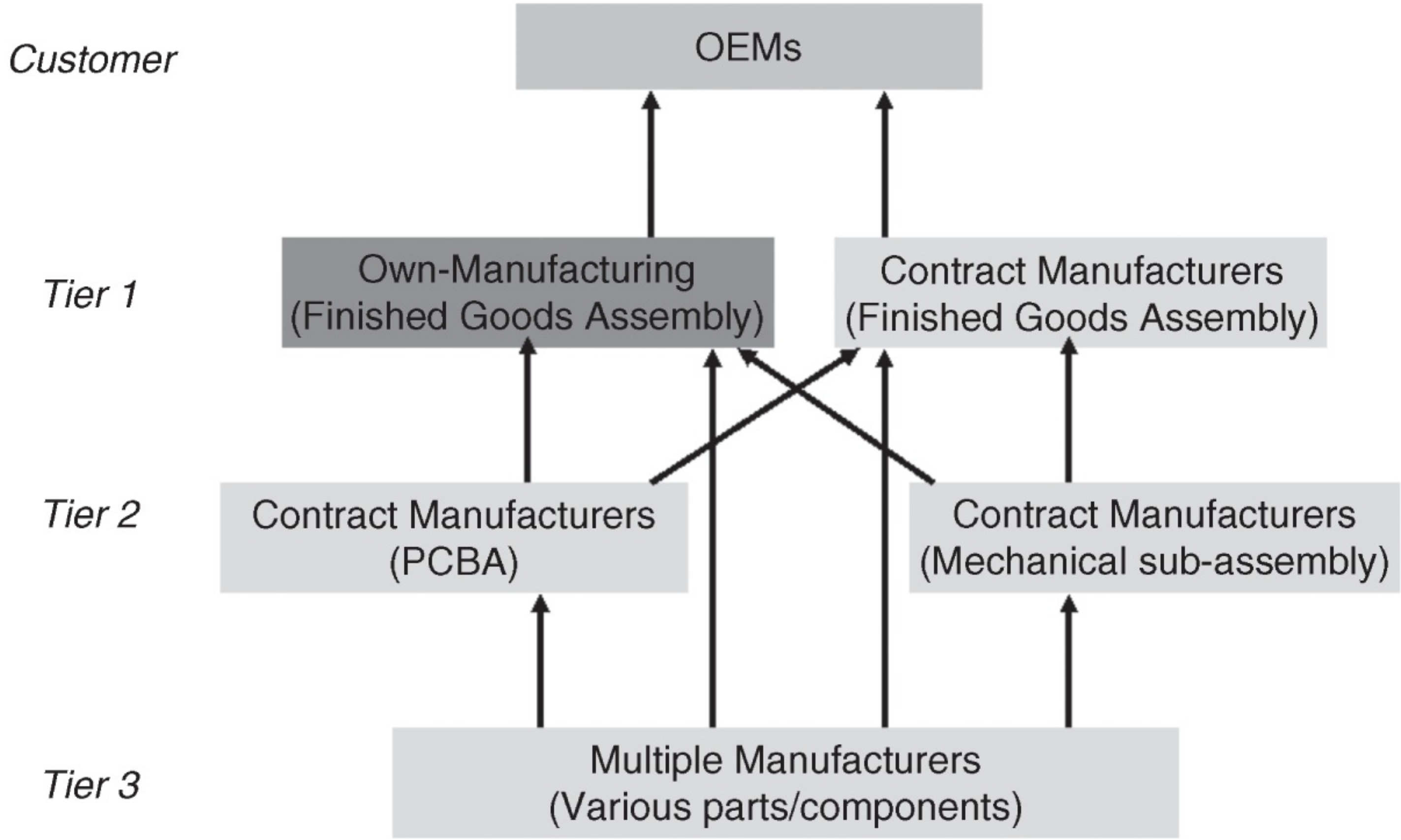

Figure 1 Simplified supply chain

New part, supplier, technology and problems

TechCo discovered the importance of supply chain involvement in product design when a problem arose that significantly threatened current and future revenues for the company. The design of a $3 part from a tier 3 supplier (supplying mechanical sub-assembly contract manufacturer) using new technology (thixomoulding) went somewhat unnoticed in the product design process. The difficulty of getting a high volume of parts became apparent when problems arose with the initial supplier and the product volumes began to ramp from Engineering to Production volumes (i.e. from producing about 50 units/day to 100s/day). This $3 part, in a product sold for $2000 upwards, limited sales revenue for the company for a four-month period. More significantly, there was a huge risk that customers identified for the product would move to a competitor's technology and the product would fail in the market. This was avoided only by massive management attention on recovering the situation.

The designers of the part were looking for a material with greater hardness that would have less vibration than current designs. They sourced injection moulded magnesium (thixomoulded) parts from a supplier to the automotive industry. The design of the part was more detailed than parts produced in this process for automotive applications, but this was not considered further once initial parts were produced to meet specification. Through all these stages, there was no SCM involvement, just design engineers making the best design decisions for product performance in the lab.

SCM became involved as the product moved from Engineering to Production in the product management process. Initial involvement was in determining the commercial aspects of supply since the tooling and initial parts had already been approved by Engineering. Shortly after this transition, the supplier went into liquidation and this galvanised numerous activities to secure future supply at this critical stage in the product lifecycle. As this part was customised for TechCo, the tooling used to manufacture it also needed to be customised. This customised tool was owned by TechCo.

Once it was determined that the current supplier would not be a viable option for the future, the identification of alternative suppliers began and so too did the SCM function's learning curve on the detailed technology used in the production of this part. Choices of alternative sources were limited to three in the whole of North America. Initial repair of the tool by the new supplier suggested that the previous supplier had not maintained the tool correctly. Subsequently, it was discovered that the design of the part made it difficult to produce using this technology and one of the side effects was a build-up of material on the tool, which led to significant downtime for cleaning and a high potential for tool damage.

The planned production of new tools to support higher volumes was slowed down through this learning period since it was unclear whether further changes to tooling should be made to address the issues arising in production. After two months at a new supplier, it became obvious that the output expected from each tool for the part was much lower than initial expectations. TechCo had to increase its plan for five customised tools to eight tools within the first six months of product life.

QUESTIONS

- Identify and discuss the fundamental issues that this case highlights.
- What actions would you take to address these issues? Consider both short-term actions and long-term learning and reconfiguration of product design and supply processes.

Oman: One of the World's Next Great Logistics Hubs?*

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INTRODUCTION

Oman has a long history of trade being strategically located between Africa, India and the Far East at the entrance of the Arabian Peninsula. The discovery of oil in 1964 turned Oman's economy from purely rural, agricultural and fishing to one dependent largely on petroleum with the sector accounting for over 30% of the country's gross domestic product (GDP) (Central Bank of Oman, 2020). With oil prices tumbling over the last decade, boosting non-oil economic activities and non-petroleum sectors remain pivotal to reduce dependence on the petroleum sector and to ensure sustainable growth over the medium to long run. Logistics along with manufacturing and tourism are amongst the sectors identified as central to Oman's post-oil future, and this is also reflected in Oman's 2040 vision initiative (Oman 2040, 2020).

Key facts

Oman has a population of about 5 million people (of which approximately 45% are expats). It is strategically placed at the mouth of the Gulf at the south-east corner of the Arabian Peninsula (Figure 1) and, in the 19th century, vied with Portugal and Britain for influence in the Gulf and Indian Ocean (BBC, 2020).

The country borders Saudi Arabia, Yemen to the south and the UAE to the west (Figure 2). Oman's close proximity to a market of 2.5 billion people and its location on two major international shipping routes, which are within two weeks journey time of some of the world's major ports, and the country's reputation as a stable, peaceful nation that maintains good relations with its neighbours make it an attractive entry point to the Arabian Peninsula for global freight.

Figure 1 Location map of Oman

(Source: Maps of the World, 2020. Licenced under CC-BY-SA-3.0.)

Figure 2 Oman's strategic location and neighbouring countries

(Source: Google Maps, 2020.)

SOLS 2040: A plan for moving logistics forward

Whilst logistics is already a significant contributor to Oman's economy after petroleum, contributing US$2.8 billion to its GDP in 2018, the goal is to make the logistics sector the country's second largest source of GDP (reaching up to 14% by 2040), and a global logistics hub (Oman 2040, 2020). The sector has already shown its potential (with the highest growth rate of 33% among some of the Gulf countries such as Saudi Arabia, Kuwait, the UAE, Qatar and Bahrain), but the country is still a long way from establishing itself as a regional powerhouse. Its share of total logistics activity in the region has remained low at about 2% (DHL, 2019). The Sultanate of Oman Logistics Strategy 2040, known as SOLS 2040, was initiated by the Supreme Council of Planning, under the auspices of the Ministry of Transport, with the purpose of establishing the country as a global logistics hub. The implementation of SOLS 2040 draws on four main pillars: trade facilitation, market segmentation, human capital and technology.

Current logistics network and activities

Oman has a good logistics infrastructure network and has seen many improvements in the field, but there are still a lot of development projects underway.

Roads

Oman has announced plans to expand and modernise its main and secondary road networks in order to link rural areas with urban centres in the Sultanate. In 2018, the length of paved roads in Oman's road network was about 15,000 km, and currently several projects are underway or close to completion, of which a new Muscat–Salalah road and the construction of a parallel highway to the one currently linking Muscat to Dubai. In January 2020, the Al Batinah Expressway opened to the public that connects Muscat with Sohar and the UAE border (leading to Dubai). The 191-km motorway (approximately US$250 million budget) stretches from the Wilayat of Bidbid to the Wilayat Al Kamil Wa Al Wafi (Ministry of Transport, 2018).

Ports

There are three main commercial ports in Oman (Figure 3), which together run approximately 200 weekly maritime services to 86 commercial ports across more than 40 countries (see Appendix) providing a vast network for clients (ASYAD, 2020). Sea transport accounts for more than 80% of freight (Ithraa, 2016). The competition from ports around the area is already fierce, so each of the ports has its own key development focus and are meant more to supplement each other than compete directly.

For example, Sohar Port is located in the North of the country, outside the congested Strait of Hormuz, and was set up as a 50:50 joint venture with the Port of Rotterdam in 2001. It is Oman's largest industrial port and free zone and one of the few global ports equipped with deep-water jetties, which makes it capable of handling the world's largest ships and a wide variety of dry, break and liquid bulk, as well as container shipping. It handles almost 60 million tonnes of cargo, over 800,000 twenty-foot equivalent units (TEUs) per annum with planned capacity to reach 7 million TEUs per annum, and it is structured around the following clusters: hydrocarbons, petrochemicals and plastics; iron and steel; aluminium, food and automotive distribution. It has good connectivity with other countries and direct road connections to Saudi Arabia and UAE (Sohar Port, 2020).

Figure 3 Key commercial ports in Oman

(Source: Google Maps, 2020.)

Duqm Port, central-eastern of Oman, is a joint venture with the Port of Antwerp. The port has a quay depth of 18 m and length of 2.2 km. Its container terminal has a throughput capacity of 3.5 million TEUs per annum and a general cargo terminal with capacity of 5 million tons of commodities (e.g. dolomite and limestone, silica sand, clay/shale) per annum (Port of Duqm, 2020). In addition, it specialises on oil and gas and its Liquids and Oil Terminal serves major refinery and planned petrochemicals complexes. In addition, it is a hub for international military and naval logistics, and South Korea's Daewoo Shipbuilding and Marine Engineering has been operating a dry dock at the port, where ships and tankers can also be repaired, since 2012 (CNN, 2018). Its economic zone is the largest in the Middle East and North Africa (MENA) region.

Salalah Port in the South of the country provides almost zero deviation from the major trade lanes of Asia–Europe, Indian Subcontinent–Europe and Middle East–Europe providing considerably better transit times (approximately 30%) than other competing ports in the Gulf. It is one of the most important container and cargo terminals in the region handling per annum close to 4 million TEUs and over 70 million tons of cargo (wet, dry and bulk). The port can serve any size or type of vessel be it container, cargo, crude carriers or even cruise ships (Port of Salalah, 2020). It has also an 18 square kilometre free zone adjacent to it. The port is structured around the following clusters: manufacturing, warehousing, logistics and distribution, office facilities, retail outlets, resort and residential developments (Port of Salalah, 2020). The nearby airport provides air cargo connectivity, which will further be strengthened by the Gulf Cooperation Council (GCC) rail network that will make Salalah the fastest connection point between the GCC market and the rest of the world.

In many cases, ports in Oman are adjacent to freeport zones, which offer some key advantages such as 0% corporate tax for a specific period, low operating costs, 0% import and re-export duties, 0% personal income tax for employees and dedicated sector-specific zones and clusters which result in knowledge spill overs. Often, there are specific bilateral agreements in place which offer additional benefits. For example, in the case of the Port of Salalah, the Oman–US Free Trade Agreement guarantees exporters duty-free access to the US market provided at least 35%

of their value is generated in Oman.

There are additional development plans to further increase the port infrastructure and improve connectivity. For example, Oman's South Al Batinah land port to commence in 2019–2020. This inland dry port is designed to serve as a midway point to facilitate the transport of containers from the Port of Sohar and other ports, but also to upgrade the overall transport capacity, expedite the clearance process and reduce the total cost for the traders (Logistics Middle East, 2019)

Airports

The two biggest airports (Muscat International Airport and Salalah Airport) have been rebuilt and expanded. Salalah expanded airport opened in 2015, and the new Muscat International Airport opened in 2018 and handled over 15 million passengers and 200,000 tons of freight in its first year. This could increase eventually up to 75 million passengers a year. Four other airports, Sohar and Adam (in the North), Ras Al Hadd (East) and Ad Duqm (East South), have also opened recently (Oman Airports, 2020).

Rail

Oman Rail Company was founded in 2014 to develop a 2135-km railway network, which also forms part of a wider proposed trans-Gulf rail network connecting all six GCC states (i.e. Oman, UAE, Saudi Arabia, Bahrain, Qatar and Kuwait). When complete, it will connect Oman's three deep-sea ports to the rapidly growing national and GCC-wide industrial, commercial and population areas (Times of Oman, 2018; ASYAD, 2020).

Logistics service providers and human capital

Logistics infrastructure is of paramount importance to develop competitive and modern services, but the existence of a sufficient number of competent companies, along with qualified personnel, could influence significantly any strategic plan. Oman has seen the emergence of a wide network of Omani and foreign logistics service providers being actively involved in the country. For example, there are about 20 international and local shipping agents currently operating in Oman's ports. In addition, there are currently some 15 logistics, transport, cargo operations, aviation and international trade–related programmes offered by 11 colleges and universities around the country. Three logistics-related programmes are also offered at the master's level. Lately, effort has been put into developing the vocational education and training sector in order to make training available for the vast amount of opportunities given at the vocational level. A competency-based skills framework is underway, while regulated qualifications and apprenticeships are also currently under development. This is important due to the significant growth of the workforce in the sector, which is expected to increase from around 85,000 in 2020 to 200,000 in 2030 and up to 300,000 in 2040.

Epilogue

The logistics sector in Oman has vast opportunities for development. Significant infrastructural developments have been initiated to position Oman as a world-class logistics hub. These range from the Duqm Port and the surrounding industrial areas that are bound to serve different clusters, to the highway connecting Oman to Saudi Arabia, and to the most recent large projects underway, such as the Khazaen Economic City development just outside of Muscat. These are only some of the developmental projects pending completion. Having the physical infrastructure in place is critical, but the importance of progress in other areas such as government regulations, international trade agreements, financial systems, logistics-related education and training along with research should not be underestimated.

QUESTIONS

- What factors have led to the growing potential of the logistics sector in Oman?
- What are the possible advantages and disadvantages for international businesses to establish presence in Oman's freeport zones?

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APPENDIX

Direct port connections

(Source: Reproduced with permission of ASYAD, 2020)

	Direct lines to Sohar Port (per week)
From East Asia and China	China: 3 Times from Ningbo and Shanghai, 2 Times from Yantian and Xiamen, 1 Time from Qingdao, Shekou and Nansha Singapore: 2 Times from Singapore Port Malaysia: 2 Times from Port Klang South Korea: 1 Time from Busan and Gwangyang
From GCC and Middle East	UAE: 14 Times from Jebel Ali, 5 times from Khalifa Port, 4 Times from Sharjah, 3 times from Ras Al Khaimah, 2 Times from Ajman, 1 time from Khor Fakkan Qatar: 5 Times from Hamed, 1 time from Mesaieed KSA – Kingdom of Saudi Arabia: 3 Times from Dammam Kuwait: 1 Time from Shuaiba Iraq: 1 Time from Umm Qasr
From Indian Subcontinent	India: 5 Times from Mundra, 3 times from Nhava Sheva Pakistan: 2 Times from Karachi, 1 time from Qasim
	Direct lines to Salalah port (per week)
From Africa	Djibouti: 3 Times from Djibouti Tanzania: 3 Times from Dar Salam Kenya: 2 Times from Mombasa Morocco: 2 Times from Tangier Sudan: 1 Time from Port Sudan Somalia: 1 Time from Mogadishu Madagascar: 1 Time from Toamasina
From North America	US: 3 Times from Newark and Norfolk, 2 times from Savannah, 1 Time from North Charleston, Houston, Savannah, Freeport, Los Angeles, Baltimore Canada: 1 Time from Vancouver
From East Asia and China	China: 4 Times from Ningbo, Shanghai and Yantian, 3 Times from Xiamen South Korea: 1 Time from Busan Japan: 1 Time from Yokohama Singapore: 2 Times from Singapore Port
From Europe and Russia	The Netherlands: 3 Times from Rotterdam Germany: 2 Times from Hamburg, Bremerhaven, 1 time from Wihelmshaven Belgium: 2 Times from Antwerp Italy: 2 Times from Genoa, 1 time from La Spezia UK: 2 Times from London Gateway and Felixstowe Spain: 2 Times from Algeciras and Valencia, 1 time from Barcelona France: 2 Times from Fos, 1 time from Le Havre Russia: 1 Time from Novorossiysk Ukraine: 1 Time from Chornomorsk and Yuzhnyy Romania: 1 Time from Constanța Malta: 1 Time from Marsaxlokk
From Indian Subcontinent	India: 4 Times from Nhava Sheva, 3 times from Pipavav, 2 Times from Mundra, 1 time from Hazira, Krishnapatnam, Kattupalli Sri Lanka: 4 Times from Colombo Pakistan: 2 Times from Karachi
From GCC and Middle East	UAE: 8 Times from Jebel Ali, 3 times from Khalifah KSA: 4 Times from Jeddah, 3 times from Dammam, 2 Times from King Abdullah Port Egypt: 3 Times from Port Said, Damietta Turkey: 1 Time from Izmit Korfezi, Ambarli, Iskenderun Lebanon: 1 Time from Beirut

NOTES

* The material used for this case was compiled from public sources and is intended to be used as a basis for class discussion rather than to illustrate either effective or ineffective planning.

Glossary

Chapter	Term	Definition
10	ABC analysis	An inventory management system that separates out the most important inventory items so that more attention can be focused on those items
12	Activity-based costing	Apportioning costs to a particular activity and calculating costs per unit, for example cost to pick an item from the warehouse
3	Agile	Ability to cope with volatility in demand
8	Air trucking	Moving freight, which will be carried by air at some stage on its journey, by road (often air freight rates will be applied for the full journey)
13	Anticipatory shipping	Products are sent closer to potential consumers' location even before they place their orders
12	Backshoring (also known as reshoring or reverse shoring)	Where a company abandons offshoring and moves the activities back to the original home market
10	Balanced scorecard (BSC)	A tool which seeks to include other factors, and not just financial factors, in measuring organisation performance
9	Bill of lading	A document that contains all of the key information in relation to a consignment being transported (referred to as an air waybill in air transport)
10	Buffer stock	Also known as safety stock, it is inventory held in the event that unforeseen issues lead to insufficient inventory being available to meet demand
5	Bullwhip effect	The distortion of orders along the supply chain, where small fluctuations in end customer demand result in amplification of demand upstream
16	Carbon footprint	A term that has come into use to describe the environmental disbenefits associated with economic activities such as the movement of freight
12	Category management	Category management is the term used in procurement to describe the grouping of similar suppliers and/or product purchases
10	Collaborative planning, forecasting and replenishment (CPFR)	Collaborative planning, forecasting and replenishment (CPFR) is a supply-chain-wide concept that seeks to ensure improvements in efficiency and integration through collaboration among supply chain partners and cooperative management of inventory, with a particular focus on information sharing and visibility
1	Consignee	Recipient of a consignment
1	Consignment	A shipment of freight which is passed on, usually to some type of logistics service provider, from a manufacturer or other source
1	Consignor	Originator of a consignment
7	Consolidated shipment	Where smaller shipments from various consignees are grouped into one single, full load
12	Contract manufacturer	Suppliers who manufacture products for OEMs
12 & 17	Corporate social responsibility (CSR)	A term used to refer to a multitude of activities and issues, and in essence concerns how ‘ethical’ a company's activities are
15	Creeping crises	Systemic supply chain disruptions that arise usually from unexpected sources and with widespread consequences
11	Cross-docking	Inventory is not put into storage but instead moves from the receiving area to the dispatch area of the warehouse
3	Decoupling point	The point in the production process at which the base product is customised to become the end product
7	Demurrage charge	The charge levied by the owner of equipment that is not returned by a certain time
10	Dependent demand	Products with dependent demand are those whose ordering is dependent upon the demand for other related products
1	Deregulation	Reduction/removal of various government-imposed barriers that hinder competition in markets
6	Derived demand	The fact that people or freight do not travel for the sake of making a journey, they travel for some other reason
12	Design for manufacture (DFM)	Designing products that can be assembled or manufactured cheaply and efficiently
17	Design for supply chain efficiency (DSCE)	By taking supply chain concerns into account in the product and process design phase, it becomes possible to operate a much more efficient supply chain
14	Deterministic models	Simulation models that have no random input variables
2	Directional imbalances	Mismatches in the volumes or types of freight moving in opposite directions in a freight market (leading to different freight rates being charged in opposite directions)
6	Distribution centre (DC)/regional distribution centre (RDC)/national distribution	Terms used to describe different types of warehouses depending upon their particular role and geographic coverage

	centre (NDC)/consolidation centre (CC)	
1	Downstream	Customer end of the supply chain
10	Dropped delivery	A consignment that is not delivered for any of a variety of reasons (e.g. insufficient address details or consignee not present)
14	Dynamic models	Simulation models that include the passage of time and represent systems as they change over time
10	Economic order quantity (EOQ)	That order quantity which seeks to balance two important sets of costs associated with inventory: the costs associated with ordering and receiving freight, and the costs associated with actually holding the freight
13	Electronic point-of-sale (EPOS) data	Electronically available data that capture, usually real time, sales to customers
10	Enterprise resource planning (ERP)	An enterprise-wide planning and control software system which plans and controls all resources required from receipt of an order to delivery of freight
12	Environmental separation index (ESI)	An index that measures the difference between the working environments of outsourcer and outsourcee companies
2	Ethnocentricity	Thinking only in terms of the home country environment
6	Factory gate pricing (FGP)	The use of an ex-works price for a product plus the organisation and optimisation of transport by the purchaser to the point of delivery
7	FCL	Full container load
8	Fifth-party logistics	LSPs who use technology solutions across complex networks that incorporate multiple supply chains
16	Food miles	Term used to refer to the distance over which the various components of a particular food item have to travel before final consumption
2	Foreign direct investment (FDI)	Financial flows from a company in one country to invest (e.g. in a factory) in another country
8	Fourth-party logistics (4PL®)	Invented and trademarked by Accenture in 1996, who originally defined it 'as a supply chain integrator that assembles and manages the resources, capabilities and technology of its own organisation, with those of complementary service providers, to deliver a comprehensive supply chain solution'
6	Freight tonne-kilometre (FTK)	Volume of freight measured in tonnes multiplied by the distance the freight travels measured in kilometres
8 and 12	Generalised costs	A single, usually monetary, measure combining, generally in linear form, most of the important but disparate costs which form the overall opportunity costs of a trip
2	Geocentricity	Acting completely independent of geography and adopting a global perspective
2	Globalisation	An umbrella term for a complex series of economic, social, technological, cultural and political changes which continue to take place throughout the world
2	Glocalisation	Thinking on a global, world market scale, but adapting to local wants as appropriate
Patient Safety (Case Study)	Good distribution practice (GDP)	Part of quality assurance which ensures that the quality of medicinal products is maintained throughout all stages of the supply chain from the site of manufacture to the public
Patient Safety (Case Study)	Good manufacturing practice (GMP)	Ensures products are manufactured to the appropriate and consistent quality standards and in accordance with regulatory requirements
7	Groupage	The provision of freight transport using consolidated shipments
17	Humanitarian logistics	Encapsulates capabilities for providing logistics services in austere environments, contingency planning for emergencies, and also affords an opportunity for organisations across both the public and private sectors to share expertise
9	Incoterms	Abbreviation for international commercial terms that are now commonly accepted standards in global trade
10	Independent demand	Products with independent demand are those that are ordered independently of any other products
13	Information visibility	The ability to see information at the various points across the supply chain as and when required
7	Intermodal transport	Where freight moves within a loading unit (known as an ITU – intermodal transport unit), this unit may move upon a number of different transport modes, but the freight remains within the unit at all times
1	Intersectionist view	Suggests that there is overlap between parts of both logistics and SCM, but also that each has parts that are separate and distinct
10	Inventory	Any material that a firm holds in order to satisfy customer demand (and these customers

		may be internal and/or external to the firm)
10	Inventory holding costs	The costs associated with holding and managing inventory and include fixed costs, variable costs, opportunity costs and obsolescence costs
10	Inventory turnover	A measure of a firm's performance in inventory management, which compares the annual sales a firm achieves with the amount of average inventory held throughout the year
13	Internet of things (IoT)	A network of items including sensors and embedded systems which are connected to the Internet and enable physical objects to gather and exchange data
3	Just-in-time (JIT) inventory replenishment	A production philosophy and set of techniques which has many components and principles, but at its core is the idea of making do with the minimum possible level of inventory holding. Inventory is thus kept to a minimum and replenished only as it is used
10	Key performance indicators (KPIs)	Specific metrics used to monitor performance on an ongoing basis
12	Kraljic matrix	A simple but powerful tool to understand and quantify relative value and procurement risk issues for any business or organisation
12	Landed costs	Landed costs incorporate the various costs associated with sourcing products – as well as vendor (i.e. material) costs other costs such as working capital, transport, insurance and so forth are also included
7	LCL	Less than full container load
10	Lead time	The time between placing an order and receiving inventory
3	Leagile supply chain	A supply chain that combines both lean and agile logistics philosophies; sometimes referred to as a 'hybrid strategy'
3	Lean	Elimination of waste and 'doing more with less'
1	Logistics	The process of planning, implementing and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements
8	Logistics service providers (LSPs)	The various types of companies (hauliers, freight forwarders etc.) that provide logistics services
1	LSCM	Logistics and Supply Chain Management
3	Make-to-order (MTO)	Producing product only to meet actual customer demand
3	Make-to-stock (MTS)	Producing product which is subsequently put into storage
10	Manufacturing resource planning (MRPII)	A planning and control software system which plans and controls all manufacturing resources required to source, manufacture and deliver products
4	Mobility as a Service (MaaS)	Multimodal travel solutions available through a single digital platform accessible on demand
3	Mass customisation	Customisation into various different finished products of what are often largely mass produced products
1	Material substitution	Replacement of physical product by virtual product
11	Materials handling equipment (MHE)	A term used to describe the various types of equipment for handling inventory
10	Materials requirements planning (MRP)	A planning and control software system which plans and controls the manufacture and assembly of products
10	Metrics	A measurement of an activity; specific important metrics are usually referred to as 'key performance indicators' (KPIs)
2	Multinational companies (MNCs)	Companies with operations in areas beyond their home country
12	Nearshoring	Where companies move their offshored activities to countries closer to their home market as a result of the potential risks, delays and extra costs associated with moving products from a distant location
8	Non-vessel-owning common carrier (NVOCC)	Refers to companies who consolidate smaller shipments from various consignees into full container loads which the NVOCC then takes responsibility for
12	Offshoring	Offshoring is the transfer of specific processes to lower cost locations in other countries
12	Omnishoring	Having a rich portfolio of sourcing destinations (close and far) and of institutional models (a firm's own facilities and subcontracted ones) that allow firms to manage different products, seasons, stages of product innovation and so forth
12	Opportunity cost	In the case of inventory management, this is the amount of money the firm would have earned if the money were invested elsewhere other than in inventory
3	Order qualifiers	Those criteria and/or performance expectations that a company must meet for a customer to even consider it as a possible supplier
3	Order winners	One or more criteria that lead to the selection of a particular outsourcee by an outsourcing company
12	Original equipment	Companies that produce final, branded products (with the components often produced by

	manufacturer (OEM)	Contract Manufacturers)
12	Outsourcing	Outsourcing involves the transfer to a third party of the management and delivery of a process previously performed by the company itself
8	Own-account transportation	Where a company does not use an LSP to transport its freight, but instead transports the freight using its own vehicles
2	Polycentricity	Adopting the host country perspective
7	Port-centric logistics	The co-location of various logistics activities at a sea port rather than at inland locations
3	Principle of postponement	The reconfiguration of product and process design so as to allow postponement of final product customisation as far downstream as possible. Other names for this approach are simply ‘delayed product configuration’, ‘delayed product differentiation’ and ‘late stage customisation’
12	Procurement	Procurement is an ‘umbrella term’ that includes sourcing and purchasing and incorporates the activities involved in specifying requirements, identifying appropriate sources, evaluating options and then arranging the purchase of products and/or services from those sources that are fit for purpose, cost-effective and sustainable
3	Pull	Materials are only produced and moved when they are required
3	Push	Materials are produced according to a planned forecast (which may or may not be accurate) and moved to the next stage of the supply chain
2	Regional trade agreements	Agreements between neighbouring countries that allow free trade between those countries
1	Re-labelling view	Contends that logistics has been re-labelled by the more recent term SCM
10	Reorder point	The inventory level at which an order for more inventory is placed
15	Resilience	The ability of a system to return to its original (or desired) state after being disturbed
12	Reshoring (also known as Reverse Shoring or Backshoring)	Where a company abandons offshoring and moves the activities back to the original home market
16	Reverse logistics	Material flows from the point of consumption towards the point of origin (i.e. back upstream in the supply chain) for the purpose of reuse/repair/remanufacture/recycling
12	RFI/RFT/RFP/RFQ	Request for information/tender/purchase/quote
12	Rightshoring	Seeking to locate an activity at the ‘right’ location
15	Robust	Used in a supply chain context to imply a strong or vigorous capability to for example manage regular fluctuations in demand
10	Safety stock	See buffer stock
13	Self-thinking supply chain	A supply chain with autonomous and predictive capabilities
4	Service supply chain	The network of suppliers, service providers, consumers and other supporting units that performs the functions of transaction of resources required to produce services; transformation of these resources into supporting and core services; and the delivery of these services to customers
12	Service-level agreement (SLA)	A mutually agreed and understood binding agreement between a customer and a supplier identifying service areas and performance levels expected
4	Servitisation	Manufacturers offering services with their products
3	Silo	A term used to describe teams or business functions operating in isolation to others
14	Simulation	The process of building a model and experimenting with it in order to develop insight into a system's behaviour based on a specific set of inputs and assist in decision-making processes
11	Socio-technical systems (STS)	A management philosophy that promotes joint optimisation of the technical and social system; quality of work life; employee participation in system design and semi-autonomous work groups
14	Static models	Simulation models that do not include the passage of time and represent the system at a particular point of time
14	Stochastic models	Simulation models that have at least one input variable that is random
3	Stock-keeping unit (SKU)	A unique version in terms of size, packaging etc. of a particular product type
12	Supplier development	Activities led by buyers which seek to assist their suppliers in improving the services or products which their suppliers provide to them
12	Supply base rationalisation	The process of reducing or rationalising the number of suppliers in a supply network, typically to reduce complexity and therefore cost
1	Supply chain	The supply chain is the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer
12	Supply chain collaboration	A relationship between supply chain partners developed over a period of time
12	Supply chain collaboration	Refers to how the relationship between supply chain partners develops over time
12	Supply chain integration	The alignment and interlinking of business processes across the supply chain

1	Supply chain management (SCM)	Supply chain management (SCM) is the management, across and within a network of upstream and downstream organisations, of both relationships and flows of material, information and resources. The purposes of SCM are to create value, enhance efficiency and satisfy customers
7	Tare weight	The weight of an empty container
8	Third-party logistics companies (3PLs)	LSPs that provide multiple logistics services, often in an integrated fashion
12	Through/full life costs	Take account of not just the initial landed costs of the product, but all costs incurred throughout the products lifespan such as repairs and recycling the end-of-life product
12	Total costs of ownership	See 'Through/full life costs'
3	Toyota Production System (TPS)	A production system designed by Toyota to eliminate waste in seven key areas
9	Trade facilitation	Refers to the simplification, harmonization and automation of international trade procedures, providing trade transactions with more transparency, predictability and efficiency
1	Traditionalist view	Regards SCM as a subset of logistics, as if it were an add-on to logistics
2	Transfer price	The value attributed to goods or services when they are transferred between divisions of the same company
7	Transhipment	The loading unit moves from one transport service to another
7	Transloading	Transferring freight from one type of loading unit to another
2	Transnational corporations (TNCs)	Companies that trade across many borders, with operations in multiple countries
1	Transport cost sensitivity	The relationship of transport costs to freight value: high sensitivity implies minor changes in transport rates will have a major impact on transport choice decisions
6 and 14	Transportation model	A model used to work out a minimum total transport cost solution for the number of units of a single commodity that should be transported from given suppliers to a number of destinations
1	Unionist view	Logistics is seen as part of a wider entity, SCM
1	Upstream	Supplier end of the supply chain
11	Value-adding activities	Supply chain activities that enhance products to increase the customer's perceptions of those products' benefits
10	Vendor-managed inventory	The supplier/vendor manages the inventory, sometimes at or near the customer's site and is responsible for replenishment
1	Vertical integration	Ownership, or at least control, of upstream suppliers and downstream customers
12	Virtual organisations	Companies which outsource most, if not all, major functions
6	Volumetric charging	Charging for freight based on the dimensions of the consignment
15	Vulnerability	The likelihood of a supply chain or logistics system being exposed to damage, disruption or failure
11	Warehouse management system (WMS)	Software that manages materials and freight movement throughout the warehouse. This may interact directly with automated handling equipment and/or provide work instructions for operatives. It will also interact with, or be a component of, a wider ERP system

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