International Journal of Productivity and Performance Management

Performance measurement systems in supply chains: A framework for contextual analysis

Richard Cuthbertson, Wojciech Piotrowicz,

The current issue and full text archive of this journal is available at
www.emeraldinsight.com/1741-0401.htm

Performance measurement systems in supply chains

A framework for contextual analysis

Richard Cuthbertson and Wojciech Piotrowicz
Saïd Business School, University of Oxford, Oxford, UK

Received April 2010
Revised December 2010, January 2011
Accepted January 2011

Abstract

Purpose – The purpose of this article is to propose a common framework for the empirical analysis of supply chain performance measurement systems used in different supply chain contexts.

Design/methodology/approach – This is a conceptual paper, which includes an extensive literature review and an illustrative case study. The content, context, process framework is applied to structure the body of knowledge and the case study.

Findings – Supply chain performance measurement is a context-dependent process, tailored to specific supply chain requirements. To understand how a performance measurement system in a supply chain has developed and is used there is a need to capture its context, process and content.

Research limitations/implications – The framework is illustrated by a single case study. Further empirical research is required to fully appreciate the breadth of application of this framework.

Practical implications – The proposed framework can help to develop performance measurement systems that are suitable for certain organisational and supply chain contexts in which a company operates, as well as to compare different systems used across different supply chains.

Originality/value – The paper demonstrates an approach for analysing existing supply chain performance measurement systems that can be applied across different supply chains and sectors. This will create an opportunity to use a consistent data collection process across a variety of supply chain situations and thus generate data for further theory development.

Keywords Supply chain management, Logistics, Performance measurement (quality), Performance management systems, Metrics, United Kingdom

Paper type Conceptual paper

Introduction

The aim of this paper is to propose a framework to analyse the supply chain performance management systems (SCPMS) implemented in different supply chains (SC). While past literature has concentrated on developing and proposing frameworks to measure supply chain performance, this paper concentrates on the framework to analyse performance management systems used by organisations to capture supply chain performance. The framework chosen to analyse the literature and to look at SCPMS is based on the content, context, process (CCP) design (Pettigrew, 1985) and modified to reflect the complexity of the performance measurement systems used within supply chains. The proposed framework considers contextual aspects of performance measurement in supply chains, beyond just metrics sets, tools and methods. The work is supported by the literature review, which is structured according to the CCP framework. The framework application is illustrated by the single case study of the global automotive supply chain of Jaguar spare parts, run by Unipart. This is a timely and important piece of research because since 2007 research related to

International Journal of Productivity and Performance Management
Vol. 60 No. 6, 2011
pp. 583-602

1741-0401
DOI 10.1108/17410401111150760

SCPMS has moved from being dominated by the conceptual to the empirical. However, there is a lack of a standardised approach or common framework to empirically analyse SCPMS. As the empirical studies have been performed without common structure, it is hard to draw common conclusions and develop further theories. This creates a need for a common data-set collected in a structured way across various supply chains, SC models, industries and geographical regions. The availability of a common framework will enable the search for common themes and will help to develop theories related to the SCPMS field. The framework will help to capture and report differences and similarities among performance measurement systems used across different supply chains. It will help to determine how to develop performance measurement in supply chains, whilst acknowledging that different organisations need different SC designs, strategies and relevant performance measures (Beamon and Balcik, 2008). This paper is structured as follows: first academic literature related to the topic is overviewed; then a detailed review is structured according to the CCP framework; next each element of the framework is illustrated by the findings from the case study; and links demonstrated between performance measurement system, supply chain context and measures.

Methodology

The framework for analysis selected by the authors is the content, context, process (CCP) framework developed in the strategic management field (Pettigrew, 1985). The framework has been used to look at information systems evaluation and performance measurement (e.g. Stockdale *et al.*, 2006; Symons, 1991) and is able to capture the context in which measurement takes place, including performance measurement methods and metrics, as well as considering dynamic changes in the context. Application of the framework was supported by an analysis of the SCPMS-related literature. The literature review is limited to peer-reviewed academic papers and includes papers published to the end of 2009. To select papers for the literature review the authors included leading journals from the operational research, operations management and logistics disciplines, as well as cross-disciplinary papers from related fields, such as supply chain management, and performance management and measurement. The authors searched abstracts based on the keywords "supply chain" together with "measurement", "benchmarking", "evaluation", "measure" and "metrics". A single illustrative case study of a SCPMS was completed to demonstrate how the framework could be applied to analyse an existing performance system. This case was selected as it covers a long supply chain involving more than one organisation (Unipart and Jaguar) with over 15 years history, so there was time to develop a mature SCPMS system. Case study data were collected at the main distribution centre for Jaguar parts in Baginton, near Coventry, and in Unipart HQ in Cowley, Oxford, UK. Data were collected via semi-structured face-to-face interviews with six staff members from both managerial and operational levels directly involved in Jaguar/Unipart work, plus an additional three interviews with other Unipart members involved in automotive manufacturing, consulting and warehousing. The interview questionnaire covered the aspects identified within the framework (Figure 1). Interviews were transcribed and data were then assigned into framework categories. In addition, company documents were reviewed, and company sites were visited (five visits in four locations) to observe how the supply chain performance metrics are collected and presented. Findings were

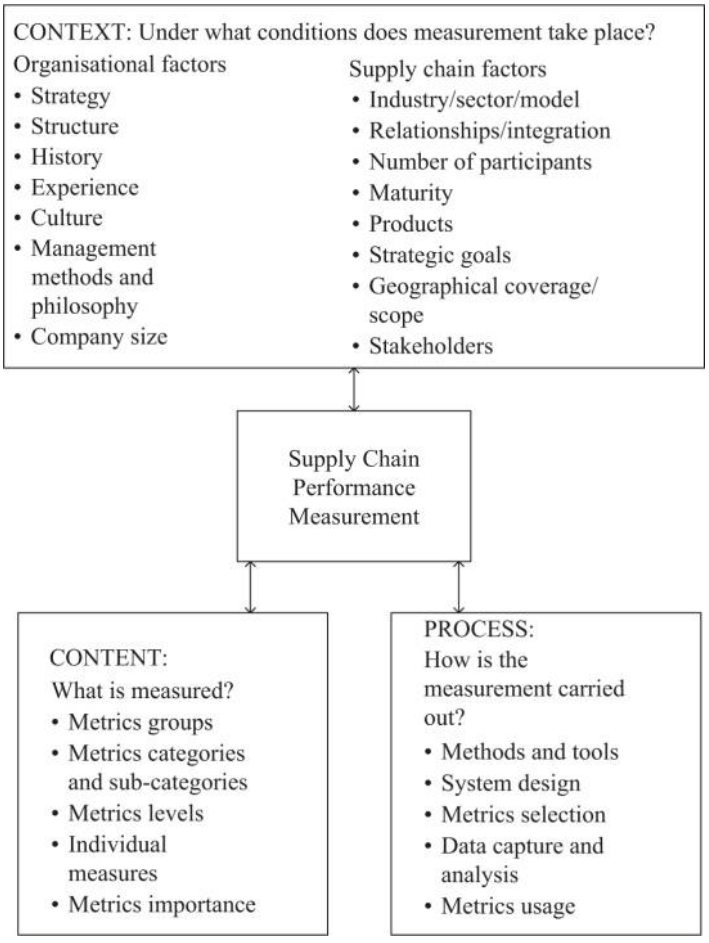

Figure 1.
Framework to analyse supply chain performance measurement system and literature classification

compared with publicly available documents developed by Unipart and third-parties (Friedlos, 2006; Green, 2008; Hrycyk, 2006; McNeill *et al.*, 2007; Powell, 2007; SAP, 2008; Unipart Group, 2009; Varnom, 2004, 2008; Vitasek, 2008). The case findings were reviewed by Unipart personnel and approved. The research findings have some limitations: they are specific to the case organisation and the supply chain analysed, in addition the interviews were performed within UK-based Unipart locations and do not include views of the other SC members.

Literature review

This section summarises research related to performance measurement in supply chains at the supply chain, not at the individual company, level. The authors identify 45 academic papers that cover the area of performance measurement in supply chains (Table I). The papers reviewed are related to measurement systems designed to measure an end-to-end supply chain. Individual groups of measures, such as quality,

Paper type	Paper (authors, year)
Research (empirical data are used)	(Angerhofer and Angelides, 2006; Aramyan *et al.*, 2007; Bhagwat and Sharma, 2007a; 2007b; Cai *et al.*, 2009; Charan *et al.*, 2008; Chia *et al.*, 2009; Clift, 2003; Cuthbertson and Piotrowicz, 2008; Gunasekaran *et al.*, 2004; Hervani and Helms, 2005; Hofmann and Locker, 2009; Holmberg, 2000; Lai *et al.*, 2002; Lockamy and McCormack, 2004; Lohman *et al.*, 2004; Morgan, 2004; Muratoglu, 2008; Park *et al.*, 2005; Saad et al., 2006; Sharif *et al.*, 2007; Thakkar *et al.*, 2009; Wickramatillake *et al.*, 2007)
Conceptual (some papers include examples)	(Beamon and Balcik, 2008; Beamon, 1999; Brewer and Speh, 2000; 2001; Bullinger *et al.*, 2002; Chae, 2009; Chan and Qi, 2003a; 2003b; Chan *et al.*, 2003c; Farris II et al., 2002; Gunasekaran *et al.*, 2001; Kleijnen and Smits, 2003; Lambert and Pohlen, 2001; Morgan, 2007; Otto et al., 2003; Sharma and Bhagwat, 2007; van Hoek, 1998)
Literature review	(Akyuz et al., 2009; Chan *et al.*, 2006; Gunasekaran and Kobu, 2007; Shepherd and Gunter, 2006)

Table I.
Publications related to SC performance measurement – by type

supplier evaluation, or other single-dimension supply chain metrics were excluded from this review. Papers which concentrated on the extended enterprise, such as (Bititci *et al.*, 2006; Saiz *et al.*, 2007) were not incorporated, as extended enterprise is taken to be a wider concept; similarly papers are excluded (Yilmaz *et al.*, 2006) which applied SC models such as SCOR into different sectors.

Less than half of the papers are conceptual or literature-based (18 out of 45). However, this proportion looks very different over time. In 2007 there was a noticeable shift in the papers related to SCPMS, as more empirical papers were published compared to conceptual works (Figure 2). This movement could have been stimulated by three literature reviews published in 2006/2007 (Chan *et al.*, 2006; Gunasekaran and Kobu, 2007; Shepherd and Gunter, 2006), and a further review related to the main approaches in SCPM (Akyuz *et al.*, 2009). There was also a shift in the conceptual work, from being mainly generic, to more specific, such as humanitarian-relief chains (Beamon and Balcik, 2008), green supply chains (Hervani and Helms, 2005),

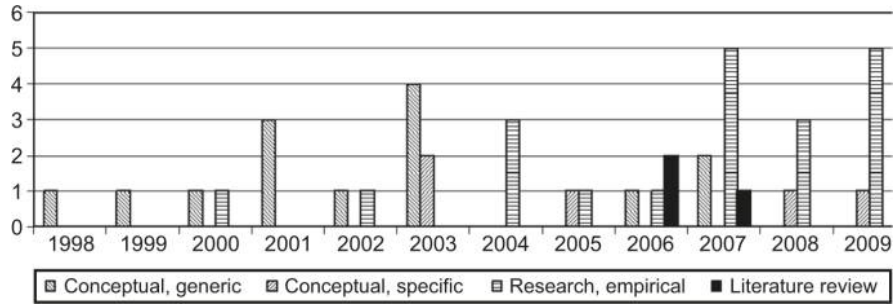

Figure 2.
SC performance measurement literature development (number of publications per year)

built-to-order SC (Sharif *et al.*, 2007), packaging (Hofmann and Locker, 2009) or the food industry (Aramyan *et al.*, 2007). There was a change in the literature focus from single performance measures in the supply chain, i.e. measures, which cover one dimension only, to a focus on the performance measurement system (see Saiz *et al.*, 2007).

Content, context, process framework for the SC performance measurement analysis

The CCP framework, after minor modification, was used to classify the SCPMS literature and then used for the analysis of the SCPMS as illustrated in the case study. The framework (Figure 1) incorporates elements such as:

(1) Context (under what conditions does the measurement take place?) – factors that impact supply chain performance measurement were separated into two groups:
   - organisational context – inner-organisational factors; and
   - supply chain context – factors specific for the supply chain environment.

(2) Process (how is the performance measurement carried out?). This covered tools, methods and frameworks to measure supply chain performance; the way that data are captured, presented and used; as well as the development of the measurement system.

(3) Content (what is measured?) – including metrics, their levels, categories and dimensions.

In the next sections the literature is reviewed, while details related to context, process and content are summarised in Appendices 1 to 3. Every section is illustrated in the case study by the findings from Unipart.

Performance measurement in context

The contextual analysis is related to questions such as:

- Under what conditions is the measurement system implemented and used?
- What factors impact on the supply chain measurement system?

The context is separated into two overlapping sections, the first section relates to the organisational factors that influence and determine the SC measurement, while the second part deals with supply chain specific issues.

Supply chain context – factors specific for the supply chain environment

In the reviewed literature there is limited discussion of the aspects related to the contextual factors that influence the selection of suitable methods and metrics at the supply chain level. Concentration on the metrics and methods used to measure supply chains without consideration of the specific organisational and supply chain setting makes it difficult to compare metrics and measurement systems used in different chains. To fully understand how a performance measurement regime was developed and how it is used we should know how it is influenced by factors such as: supply chain model, industry, relationships, integration and differences between SCM members, SC strategy and strategic goals, structure, complexity and processes, stakeholders, demand and product characteristics, the degree of regulation, SC scope,

globalisation and geographical coverage, the number of SC participants, technology, culture and attitude (see Appendix 1). Other factors include infrastructure, operating knowledge, corporate governance, social climate, innovation (Burgess and Singh, 2006). It is also important to note that within one supply chain there could be differences in the process maturity between SC partners or between geographical areas, so the same process can be designed differently at different locations within one chain (Manrodt and Vitasek, 2004).

The creation and use of performance measurement systems at the supply chain level is influenced by the organisation concerned, such as structure, culture, processes and company size (see Appendix 1). In the following section the supply chain and organisational context, which influence performance measurement in the case company are presented.

Context in the Unipart/Jaguar supply chain

Organisational context – The Unipart Group

The case company, Unipart Group, in 2008 employed over 8,000 people in total, had a turnover of over £1 billion, and operations in 140 countries. Unipart is one of the leading European providers in aftermarket logistics and distribution. Unipart de-merged from British Leyland in 1987 as a management buy out; the company was privatised and trade unions de-recognised. Unipart Group includes Unipart Logistics, Unipart Manufacturing, Unipart International, Rail and Unipart Automotive. Unipart serves automotive sector customers such as LTI, Mobis, Ford, Rover, Toyota, Lotus, Saab, Daimler-Chrysler and Jaguar. Unipart Logistics employed 3,377 people in 2008. Logistic services are offered in four sectors: consumer (Halfords, Homebase, Waterstones, Sainsbury, Habitat, RSPB, Jessops), technology (Vodafone, Sky), aerospace and defence (Airbus and Thales) and finally automotive. Unipart also manufactures original equipment car–parts and has a network of around 200 branches which distribute car parts to the automotive service and repair industry. Due to its origins in the automotive sector and wide cooperation with the automotive companies, Unipart have both experience and knowledge related to this industry.

Unipart management, strategy and processes are influenced by the Toyota lean managerial philosophy, which has been implemented not long after the company creation, learning from business partners such as Honda. The aim was to integrate people, processes, data and technology. A set of principles, guidelines and tools has been developed over time and is collectively called "The Unipart Way" (see: Unipart Group, 2009). A key principle states "The Group seeks to differentiate itself from its competitors by offering superior level of quality, service and availability to its customers" (Unipart Group, 2008). The management philosophy aims at constant improvement and waste elimination; which influences the design and performance measures selection for the whole corporation where the same metrics are used to measure internal performance at different Unipart companies regardless of industry and function. However, there are differences in measurement across the different supply chains outsourced to Unipart.

Supply chain context

The study of the Jaguar supply chain run by Unipart suggests that the performance measurement system is influenced by the supply chain characteristics and

organisational factors. This includes the influence of the SC structure (Appendix 1) whereby the SC is outsourced by Jaguar to Unipart. The case confirms the impact of stakeholders (Aramyan *et al.*, 2007; Beamon and Balcik, 2008; Hervani and Helms, 2005), with the strongest influence being the impact of Jaguar, as Unipart's customer. Cooperation between Unipart and Jaguar has continued over a long period of time (over 15 years), and so there has been time to create a mature SC (see Manrodt and Vitasek, 2004) and develop a consistent strategy. Although the contract is a commercial arrangement running over a period of years with each side able to withdraw at relevant times, Unipart has succeeding in retaining the Jaguar contract, despite changes in the ownership of Jaguar. This is a reflection of how closely Unipart adheres to the objectives of the Jaguar supply chain. However, during this period there have been significant changes, including a major change in the delivery cycle from weekly to daily in the UK.

The impact of the demand characteristics (Beamon and Balcik, 2008; Sharif *et al.*, 2007) and the supply chain model (Angerhofer and Angelides, 2006; Chan and Qi, 2003a; Morgan, 2007; Sharif *et al.*, 2007) are confirmed. The Jaguar parts chain is relatively stable over time both in terms of demand and structure. The SC is demand-driven without major demand fluctuations. Also, both in terms of the customer (Jaguar dealer) and the supplier (part manufacturer), the number of companies involved do not change dramatically. Changes in supply chain design and structure are not rapid. While companies (parts suppliers) have moved between countries, the supply chain configuration has not changed rapidly, but has grown steadily as new markets are added in to the global network (in 2008 new markets included South Africa and China, in 2007 – North America). Unipart control is expanding as new dealers are incorporated into the vendor management inventory system.

Unipart manages the outsourcing of the global supply chain for Jaguar automotive parts, and is responsible for the end-to-end flow. The Jaguar/Unipart SC can be described as a "lean" SC, which concentrates on waste elimination through a long-term stable partnership, work standardisation and stable long-term planning (Harrison *et al.*, 2005; Morgan, 2007). The contract between Unipart and Jaguar applies the Performance-Based Logistics (PBL) model which was characterised by Vitasek (2008) as based on long-term relationships, stable funding, top-level performance support outcomes, limited number of outcome metrics at the top level and aligned strategy focus and top-level performance. Application of the PBL model helps to change from product-centricity to performance-centricity The performance level is agreed, monitored and should be achieved (McNeill *et al.*, 2007). Unipart manage the whole of Jaguar's supply chain for spare parts – including links with the part manufacturers and Jaguar dealers. Over 1,200 suppliers from various countries produce spare parts that are delivered by Unipart to 850 Jaguar dealers worldwide (in 64 countries). The supply chain is based on a four-stage process: inbound- which includes scheduling inventory and vendor management; outbound – storage, picking and packing, despatching; customer-related processes – order entry, processing, availability check, arrival time estimation

The last stage is an end-to-end finance process (Hrycyk, 2006). This four-stage process determined the metrics categories presented in the following sections of this paper.

The inventory includes all parts and components for all the Jaguar models ever made (which is around 128,000 part numbers or SKU's, with 7 million items processed per annum). The parts are owned by Unipart. Parts, when their inventory level is low, are ordered from manufacturers (Tier 1 suppliers) in batches, to be sure that sufficient stock is always available; in some cases Unipart also contacts Tier 2 suppliers or manufactures some of the components internally. Distribution is based at a number of centres. In the UK two centres are used, one in Baginton, near Coventry (the main distribution centre), the second, for larger parts in Honeybourne, Worcestershire. Additionally, there are regional centres in the USA (two centres), Japan, Australia, Germany, South Africa, Russia, Spain and China. All together 14 distribution centres are in use; the number of regional DC allows decentralisation and increased flexibility. Parts are delivered to non-European distribution centres by ship, except for urgent orders required to repair "vehicles off the road" (VOR) which are delivered by air. Typically, a part should be available from a local dealer; if not, it should be delivered the next day to any place in the world for any Jaguar model. The supply chain measurement system is designed around this key principle. The impact of strategic goals (Beamon and Balcik, 2008) is also confirmed. The SCPMS is primarily designed to fulfil one main strategic goal – to achieve a required level of parts availability for all Jaguar customers. The most important issue is parts availability, so that vehicles can be repaired in the shortest possible time, and the Unipart commercial contract with Jaguar reflects this. The whole supply chain is designed to increase parts availability at every stage and geographical location.

Process

Process includes the methods and tools used to measure supply chain performance. It should be noted that some of the methods, frameworks and approaches to measure supply chain performance are based on existing methods, which were originally designed to be used at an organisational level then extended into supply chain. The most commonly proposed and analysed frameworks are those based on the scorecard approach (Bhagwat and Sharma, 2007a, 2007b; Brewer and Speh, 2000, 2001; Chia *et al.*, 2009; Lohman *et al.*, 2004; Park *et al.*, 2005), including integration of the SCOR model and Balanced Scorecard (Bullinger *et al.*, 2002; Thakkar *et al.*, 2009). The methods and frameworks proposed to measure SC performance are listed in Appendix 2. The process also includes the design of the system, metrics selection, data capture, analysis, presentation and usage. Apart from the measurement, which includes reporting and performance management, actions taken based on the information provided, should be considered (Radnor *et al.*, 2007). In the following part we present the way that performance is measured, reported and what technologies are used to capture data in the case company.

Process - how is the measurement carried out?

The measurement system for the Jaguar parts supply chain was developed from scratch by Unipart over a 15-year period. As the Unipart supply chain is evolving, the performance metrics are reviewed and revised as necessary. Data relating to performance across the whole supply chain are collected via a SAP ERP system, while performance measures on the individual, team and site are collected manually by the relevant communication cells, aggregated and compared against targets set for the

unit. In the warehouses bar codes and code readers are in use. The cargo carried by US sea transport is additionally monitored (location, cargo security and condition) by RFID at various points of the journey (warehouses, UK and US ports). In addition, data related to customer-relationship quality are collected using customer surveys or visits to receive feedback related to quality of service. Surveys include: annual global survey of parts managers, local surveys on specific aspects of service, and management reviews by region (Unipart Group, 2008).

Performance of the whole chain is pulled together in one place, processes are transparent and all performance metrics are made clearly visible. The system is designed to highlight all the potential problems at every stage of the chain – and then to solve them. Performance measures are available to all staff members. Every distribution centre and the head office have a whole wall that is covered by boards with graphs and tables where the current performance indicators are displayed and updated regularly, so that all employees at all sites are able to see the current performance across the whole supply chain compared against defined goals. Data are identical in every location across the global SC. Every performance measure can be analysed to find the root causes of any failure. All the contributing factors are captured and, if necessary, reviewed. Weekly phone conferences allow performance to be discussed along every part of the process. The usage of simple "smiling face" symbols allows anyone to see quickly whether a target performance is being achieved or not. Apart from the performance of the whole supply chain, every team has access to performance measures at their level, again presented in a visual form and communicated daily at the team (communication cell) meeting. During the meeting performance targets for the team are set. Performance of an individual employee is also reviewed and when targets are not achieved, performance interviews are completed. Supplier performance is monitored and communicated to suppliers, who can access the online system as part of the supplier development programme.

It is important to note that while most of the empirical work related to SCPMS is based on variants of the Balanced Scorecard (Sharif *et al.*, 2007), in Unipart this is not the case. Even though the performance measurement system used by Unipart was developed internally by the company, it is similar to the concept of supply chain measurement created by Holmberg (2000), which is based on systems thinking. Instead of treating the performance measurement system of each organisation separately, Holmberg (2000) proposes one system that covers the whole supply chain. Performance measurement needs to be treated as one inter-organisational system, not as fragmented and split between each organisation. Such a system was achieved; not by Jaguar linking distributors, suppliers, and dealers, but by outsourcing the logistics. Performance-related data are used to search for causes and improvements; this is in line with the managerial philosophy embedded in the company culture and structure. Even though lean SC performance metrics should concentrate mainly on costs and productivity (Harrison *et al.*, 2005; Morgan, 2007), in the case study the main metric was availability, which is a more common characteristic for agile SC (Harrison *et al.*, 2005; Morgan, 2007).

Technology and enabling technology- process automation and data collection

Unipart's supply chain is supported by SAP-based information technology, which is used to automate processes and communication, and allows collecting, storing,

analysing and sharing performance-related data and reports. The IT solution includes an online Unipart Parts Replenishment System, which helps to manage regional DC's and dealer's inventory and replenish stock. SAP Parts Planning for Logistics Service Providers, which integrates planning and forecasting, as well as SAP Extended Warehouse Management are in use. Initial SAP ERP R/3 implementation was completed in 2001 (implementation was begun in 1999) and over time an integrated Unipart Logistics System (ULS) was created. Also, internally made inventory management algorithms were incorporated into SAP. For the communication with dealers and suppliers SAP NetWeaver platform is in use. Dealers have access to the online Electronic Parts Catalogue and multilingual Unidial Parts Communication. Dealers are able to order parts online and track orders in real time. In 2006 RFID, provided by Savi Technology, was implemented and integrated with SAP (for the USA sea distribution), while in 2007 a GPS-based tracking trial was initiated, allowing cargo monitoring. Vehicle tracking and driver performance analysis are based on Logi-Track solution. Since 2006, when mySAP was implemented, IT infrastructure has been outsourced and managed by Computacenter in South Africa. Collection of environmental and social data by online systems is still under development: data are collected manually from an increasing number of Unipart sites.

Content

This section considers "what" to measure in the supply chain. This also includes metrics, groups, categories and classifications (Appendix 3). Performance metrics are covered in detail in reviews (Gunasekaran *et al.*, 2001; Shepherd and Gunter, 2006). There are a number of approaches that group together supply chain metrics. Some of them (Brewer and Speh, 2000, 2001; Kleijnen and Smits, 2003) are based on the balanced scorecard dimensions (Kaplan *et al.*, 1992): customer, financial, business processes, growth and learning. The second identified approach to measuring supply chain performance is based on process, where the metrics are classified into: resource, output and flexibility (Angerhofer and Angelides, 2006; Beamon and Balcik, 2008; Beamon, 1999; Cai *et al.*, 2009). Usage of single metrics, such as cash-to-cash, as a reflection of supply chain performance was proposed by Farris II *et al.* (2002). There are also some documented attempts to use the commercial SCOR model in academic papers as a form of metrics classification (Gunasekaran *et al.*, 2001; Shepherd and Gunter, 2006) as well as to link SCOR with supply chain performance (Lockamy and McCormack, 2004). Chan *et al.* (2003c) separate metrics into two major categories, qualitative and quantitative. The process of metrics selection is presented by Cai *et al.* (2009), who not only identify metrics but also highlight their relationships.

Content - what is measured at Unipart/Jaguar?

Chan and Qi (2003a) proposed a process-based measurement approach, decomposing a process into sub-processes and activities, next assigning to each of them metrics related to cost, time and outcome. There are similarities between such a concept and the Unipart metrics structure. Availability is the key measure, and is decomposed into availability measures at every stage of the SC and for every sub-process (planning, procurement, packing, transportation), which contributes to final availability. Every point between suppliers and customers where final availability can be reduced, is monitored. In addition, cost and time are measured for every sub-process. However, the

distinction between processes and structure in the Unipart case are not clear, as a mixed approach to group metrics is employed.

At Unipart performance is measured at various supply chain points, which contribute to the final outcome. The main performance criterion is the availability of spare parts to the customer (a Jaguar dealer). Availability, as a customer satisfaction measure, is the result of availability at every stage of the supply chain. To measure final availability all factors that contribute to it are monitored. If targets to meet availability at various supply chain stages are achieved, the final target is also met. Availability is the key performance indicator (KPI) used across the whole Unipart Group, not only in the Jaguar SC and logistics. Availability is listed in the Unipart Annual Report (2008) as the first performance indicator used to monitor progress; however the value is not given as it is determined by the individual client's requirements and is commercially sensitive information. Availability and inventory turn are the operational metrics used at the group level, others are financial one such as: daily sales, return on sales, debtors day and creditors day.

In the Jaguar SC, availability is reflected by interrelated metrics: availability (per cent) and availability loss (per site, daily, weekly, by country, by market, by region). Weekly availability loss is also compared against the forecast. The level of availability of parts for dealers (final customers) was agreed between Unipart and Jaguar as part of their Performance Based Logistics contract – it is set at between 96.6 per cent and 98 per cent. Unipart aims to achieve the 98 per cent availability.

The second important metric is backorder. If parts are not available at any point of the supply chain, they should be ordered from the relevant suppliers. At the distribution centre, this reflects the number of days required to restock the parts, while for "control and planning" the percentage of parts on backorder is monitored. Backorder is separately calculated for "Vehicle Off Road" parts, and for each country. The lead time is calculated for each part of supply chain.

Availability, lead time and backorder are measured across the supply chain as they have an impact on the final and most important measure – parts availability for the dealers. Apart from availability, any discrepancy is also monitored, both outbound (to dealers) and inbound (from suppliers). On-time deliveries are also measured, again both outbound and inbound. For the top 50 to 60 suppliers that deliver 40-50 per cent of products by value, a supplier development performance rating (SDPR) score system is used.

Apart from common metrics for the whole supply chain, there are metrics specific to selected points, such as:

- US pipeline (USA market) – lead time (time to arrive to the US by ship, every section of the transport route is monitored using RFID technology), stock level/inventory.
- Regional Distribution Centre – lead time, non-stock level, schedule fill.
- Prime Distribution Centre – delivery, receive to bin (parts delivered physically, but not added into the IT system), hours outstanding for picking (actual versus planned).
- Packers and primers performance (by distribution centre) – performance targets set for non-stock items, that should be packed in one day, number of items outstanding for picking.
- Suppliers – per cent of schedule fill, target fill and time.

Every team and site is also measured using three groups of measures standardised across the Unipart Group:

(1) cost;
(2) quality; and
(3) delivery.

Measures are specific to teams, their roles and responsibilities, but are always grouped into these three categories.

Processes are used as a key to group metrics, with measures of control and planning, forecasting and scheduling, packer and primer. At the same time metrics reflect the SC structure and geographical/national coverage, with metric groups for prime and regional distribution centres, the US pipeline, and suppliers.

Product characteristic influences measures selection (Aramyan *et al.*, 2007; Chan and Qi, 2003a; Park *et al.*, 2005). Jaguar parts have a long lifecycle, high value, and can be stored for long periods without value reduction (i.e. non-perishable). This eliminates the need to use metrics relevant to products and their lifetime, which are necessary in other sectors, such as the food industry, (see Aramyan *et al.*, 2007) where perishability is an important driver of SC decision making. The metrics structure used at Unipart is similar to the approaches presented by Gunasekaran *et al.* (2007, 2004, 2001). However, instead of a three-tier structure (operational, tactical, strategic), six levels of measures are used: individual employee, team (communication cell), site, divisional, business and group. Such a division of metrics reflects the organisational structure, not the processes as proposed by Chan and Qi (2003a), or functions, processes and SC as advocated by Bullinger *et al.* (2002).

Social and environmental measures

Corporate social responsibility (CSR) measures include four categories: community, workplace, marketplace and environment. At the site level, health and safety, and environmental metrics are monitored. health and safety metrics include:

- number of accidents;
- type of accident;
- near misses; and
- reasons for accident.

Environmental metrics include:

- landfill waste;
- waste types;
- gas, water and electricity usage;
- per cent of energy from renewable resources;
- fuel efficiency;
- per cent of fuel efficient vehicles;
- miles/year travelled;
- per cent of ISO 14001 certified suppliers; and
- airfreight level.

Increase in vehicle utilisation was also measured as the way to reduce fuel and CO2 emission. As a social responsibility measure amount of donations per annum is measured and reported, donations are separated into charitable and political. Also, the per cent of people trained as "lean practitioners" within the organisation is monitored as well as their competency level. CO2 emission is also controlled according to DEFRA reporting standards (CO2 monitoring does not include the whole of the SC). Carbon emission goals are set annually. Also, human rights and environmental performance targets were added into supplier evaluation (Unipart Group, 2008).

Conclusions and directions for future research

The case findings suggest that the analysis of the metrics without understanding how the supply chain operates will bring little value alone. It is important to understand what are the priorities, how were they developed, and how are they used. Otherwise, the output would be just another list of metrics. Thus, the analysis of the context is necessary, not only to understand the metrics selection and performance achieved, but also to consider opportunities for the application of similar metrics in supply chains with similar key characteristics.

Supply chain performance measurement should not be considered as a generic context-independent process, but as a system tailored to specific supply chain requirements. The Jaguar/Unipart case study confirms that the organisational and supply chain contexts have an important influence on metrics selection and usage. The authors recommend that performance measurement be viewed as a context-dependent process, tailored to specific supply chain requirements. Concentration on the metrics and methods used to measure supply chains without consideration of the specific organisational and supply chain setting makes it difficult to compare metrics and their values; so benchmarking between supply chains, supply chain members and their performance is difficult to justify without considering the context and context dynamics. To analyse a supply chain, existing frameworks can be applied, such as the approach created by Cooper *et al.* (1997) and Lambert *et al.* (1998), where the SC is composed of: structure, processes and management components; this framework was further developed by Croxton *et al.* (2001) and Spens and Bask (2002) as well as discussed in relation to SC metrics (Lambert and Pohlen, 2001).

The relatively low, but growing, number of empirical papers provides many opportunities for further research, both qualitative and quantitative. Applying case study design (see Seuring, 2008), there is an opportunity to analyse how selected companies within supply chains measure their performance. A cross-industrial, comparative multi-case study would be particularly valuable as it may help determine what sets of metrics and methods are used in various supply chains (or supply chain models) and how the contextual factors impact the metrics and methods. Alternatively, the selection of one industry or sector and analysis of the organisations involved could uncover characteristics of performance measures used in a similar context. An in-depth single case study of selected inter-organisational relationships could result in discoveries around how specific metrics and methods are selected and implemented, how such information is used, both within an organisation, as well as those shared between supply chain partners. There is also an additional opportunity to study third party logistics providers (3PL) to determine what metrics are most commonly used in Service Level Agreements between 3PLs and their customers, especially in the

Performance Based Logistics (PBL) model. The application of survey-based research is also possible. A large–scale survey of companies could determine the current "state of the art" – what groups of methods and metrics dominate certain companies, between various industries, transport modes, company sizes and regions.

References

Akyuz, G.K. and Erkan, T.E. (2009), "Supply chain performance measurement: a literature review", *International Journal of Production Research*, Vol. 11, pp. 1-19.

Angerhofer, B.J. and Angelides, M.C. (2006), "A model and a performance measurement system for collaborative supply chains", *Decision Support Systems*, Vol. 42 No. 1, pp. 283-301.

Aramyan, L.H., Lansink, A., van der Vorst, J. and van Kooten, O. (2007), "Performance measurement in agri-food supply chains: a case study", *Supply Chain Management: An International Journal*, Vol. 12 No. 4, pp. 304-15.

Beamon, B.M. (1999), "Measuring supply chain performance", *International Journal of Operations & Production Management*, Vol. 19 Nos 3-4, pp. 275-92.

Beamon, B.M. and Balcik, B. (2008), "Performance measurement in humanitarian relief chains", *International Journal of Public Sector Management*, Vol. 21 No. 1, pp. 4-25.

Bhagwat, R. and Sharma, M.K. (2007a), "Performance measurement of supply chain management using the analytical hierarchy process", *Production Planning & Control*, Vol. 18 No. 8, pp. 666-80.

Bhagwat, R. and Sharma, M.K. (2007b), "Performance measurement of supply chain management: a balanced scorecard approach", *Computers & Industrial Engineering*, Vol. 53 No. 1, pp. 43-62.

Bititci, U., Mendibil, K., Martinez, V. and Albores, P. (2006), "Measuring and managing extended enterprises", *International Journal of Operations & Production Management*, Vol. 25 No. 4, pp. 333-53.

Brewer, P.C. and Speh, T.W. (2000), "Using the balanced scorecard to measure supply chain performance", *Journal of Business Logistics*, Vol. 21 No. 1, pp. 75-93.

Brewer, P.C. and Speh, T.W. (2001), "Adapting the balanced scorecard to supply chain management", *Supply Chain Management Review*, Vol. 5 No. 2, pp. 48-56.

Bullinger, H.-J., Kuhner, M. and van Hoff, A. (2002), "Analysing supply chain performance using a balanced measurement method", *International Journal of Production Research*, Vol. 40 No. 15, pp. 3533-43.

Burgess, K. and Singh, P.J. (2006), "A proposed integrated framework for analysing supply chains", *Supply Chain Management: An International Journal*, Vol. 11 No. 4, pp. 337-44.

Cai, J., Liu, X., Xiao, Z. and Liu, J. (2009), "Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment", *Decision Support Systems*, Vol. 46 No. 2, pp. 512-21.

Chae, B. (2009), "Developing key performance indicators for supply chain: an industry perspective", *Supply Chain Management: An International Journal*, Vol. 14 No. 6, p. 422.

Chan, F.T.S. and Qi, H.J. (2003a), "Feasibility of performance measurement systems for supply chain: a process-based approach and measures", *Integrated Manufacturing Systems*, Vol. 14 No. 3, pp. 179-90.

Chan, F.T.S. and Qi, H.J. (2003b), "An innovative performance measurement method for supply chain management", *Supply Chain Management: An International Journal*, Vol. 8 No. 3, pp. 209-23.

Chan, F.T.S., Chan, H.K. and Qi, H.J. (2006), "A review of performance measurement systems for supply chain management", *International Journal of Business Performance Management*, Vol. 8 Nos 2/3, pp. 110-31.

Chan, F.T.S., Qi, H.J., Chan, H.K., Lau, H.C.W. and Ip, R.W.L. (2003c), "A conceptual model of performance measurement for supply chains", *Management Decision*, Vol. 41 No. 7, pp. 635-42.

Charan, P., Shankar, R. and Baisya, R. (2008), "Analysis of interactions among the variables of supply chain performance measurement systems", *Business Process Management Journal*, Vol. 14 No. 4, pp. 512-29.

Chia, A., Goh, M. and Hum, S.-H. (2009), "Performance measurement in supply chain: balanced scorecard perspective", *Benchmarking: An International Journal*, Vol. 16 No. 5, p. 605.

Clift, R. (2003), "Metrics for supply chain sustainability", *Clean Technologies and Environmental Policy*, Vol. 5 Nos 3-4, pp. 240-7.

Cooper, M., Lambert, D. and Pagh, J. (1997), "Supply chain management: more than new name for logistics", *International Journal of Logistics Management*, Vol. 8 No. 1, pp. 1-14.

Croxton, K.L., Garcia-Dastuge, S.J., Lambert, D.M. and Rogers, D.S. (2001), "The supply chain management process", *International Journal of Logistics Management*, Vol. 1 No. 2, pp. 13-36.

Cuthbertson, R. and Piotrowicz, W. (2008), "Supply chain best practices – identification and categorisation of measures and benefits", *International Journal of Productivity and Performance Management*, Vol. 57 No. 5, pp. 389-404.

Farris, M.T. II and Hutchison, P.D. (2002), "Cash-to-cash: the new supply chain management metric", *International Journal of Physical Distribution & Logistics Management*, Vol. 32 No. 4, p. 2002.

Friedlos, D. (2006), "RFID tracks Jaguar car parts", available at: http://s0.2mdn.net/1829324/ctgwelcomepage.html?rfp=http://www.computing.co.uk/computing/news/2165657/rfid-tracks-jaguar-car-parts

Green, M. (2008), "Unipart: continuous improvement and Lean principles in logistics – the Unipart way", *Proceedings of the The bestLog Conference, 3 December, Prague*.

Gunasekaran, A. and Kobu, B. (2007), "Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications", *International Journal of Production Research*, Vol. 45 No. 12, pp. 2819-40.

Gunasekaran, A., Patel, C. and McGaughey, R.E. (2004), "A framework for supply chain performance measurement", *International Journal of Production Economics*, Vol. 87 No. 3, pp. 333-47.

Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001), "Performance measures and metrics in a supply chain environment", *International Journal of Operations & Production Management*, Vol. 21 Nos 1-2, pp. 71-87.

Harrison, A. and Van Hoek, R.I. (2005), *Logistics Management and Strategy*, FT Prentice Hall, Harlow.

Hervani, A.A. and Helms, M.M. (2005), "Performance measurement for green supply chain management", *Benchmarking: An International Journal*, Vol. 12 No. 4, pp. 330-53.

Hofmann, E. and Locker, A. (2009), "Value-based performance measurement in supply chains: a case study from the packaging industry", *Production Planning & Control*, Vol. 20 No. 1, pp. 68-81.

Holmberg, S. (2000), "A system perspective on supply chain measurement", *International Journal of Physical Distribution & Logistics Management*, Vol. 30 No. 10, pp. 847-68.

Hrycyk, M. (2006), "What's behind a slick supply chain?", *Manufacturing Computer Solutions*, May, pp. 34-5.

Kaplan, R.S. and Norton, D.P. (1992), "The balanced scorecard – measures that drive performance", *Harvard Business Review*, Vol. 70 No. 1, pp. 71-9.

Kleijnen, J.P.C. and Smits, M.T. (2003), "Performance metrics in supply chain management", *Journal of Operational Research Society*, Vol. 54 No. 5, pp. 507-14.

Lai, K.-h., Ngai, E.W.T. and Cheng, T.C.E. (2002), "Measures for evaluating supply chain performance in transport logistics", *Transportation Research E: Logistics & Transportation Review*, Vol. 38, pp. 439-56.

Lambert, D. and Pohlen, T. (2001), "Supply chain metrics", *International Journal of Logistics Management*, Vol. 12 No. 1, pp. 1-19.

Lambert, D., Cooper, M. and Pagh, J. (1998), "Supply chain management: implementation issues and research opportunities", *International Journal of Logistics Management*, Vol. 9 No. 2, pp. 1-19.

Lockamy, A. III and McCormack, K. (2004), "Linking SCOR planning practices to supply chain performance: an exploratory study", *International Journal of Operations & Production Management*, Vol. 24 Nos 11/12, pp. 1192-218.

Lohman, C., Fortuin, L. and Wouters, M. (2004), "Designing a performance measurement system: a case study", *European Journal of Operational Research*, Vol. 156 No. 2, pp. 267-86.

McNeill, W., Fontanella, J. and Ruggles, K. (2007), "Service parts planning and optimisation landscape: saving millions through inventory reductions and increased sale", AMR Service Parts Planning and Optimisation Landscape, November.

Manrodt, K.B. and Vitasek, K. (2004), "Global process standardization: a case study", *Journal of Business Logistics*, Vol. 25 No. 1, pp. 1-23.

Morgan, C. (2004), "Structure, speed and salience: performance measurement in the supply chain", *Business Process Management Journal*, Vol. 10 No. 5, pp. 522-36.

Morgan, C. (2007), "Supply network performance measurement: future challenges?", *International Journal of Logistics Management*, Vol. 18 No. 2, pp. 255-73.

Muratoglu, K. (2008), "Performance measurement of supply chain via balanced scorecard: the case of a brewing group", *The Business Review*, Vol. 10 No. 1, pp. 330-7.

Otto, A. and Kotzab, H. (2003), "Does supply chain management really pay? Six perspectives to measure the performance of managing a supply chain", *European Journal of Operational Research*, Vol. 144, pp. 306-20.

Park, J.H., Lee, J.K. and Yoo, J.S. (2005), "A framework for designing the balanced supply chain scorecard", *European Journal of Information Systems*, Vol. 14 No. 4, pp. 335-46.

Pettigrew, A. (1985), *The Awakening Giant, Continuity and Change in ICI*, Blackwell, Oxford.

Powell, C. (2007), *Supply Chain Excellence in the Global Automotive Market*, Sapphire, Vienna.

Radnor, Z.J. and Barnes, D. (2007), "Historical analysis of performance measurement and management in operations management", *International Journal of Productivity and Performance Management*, Vol. 56 Nos 5/6, pp. 384-96.

Saad, M. and Patel, B. (2006), "An investigation of supply chain performance measurement in the Indian automotive sector", *Benchmarking: An International Journal*, Vol. 13 Nos 1-2, pp. 36-53.

Saiz, J.J.A., Bas, A.O. and Rodriguez, R.R. (2007), "Performance measurement system for enterprise networks", *International Journal of Productivity and Performance Management*, Vol. 56 No. 4, pp. 305-34.

SAP (2008), *SAP Customer Success Story, Travel and Logistics Services*, available at: www.sap.com/uk/about/success/casestudies/Unipart_Logistics_Success_Story(A4).pdf

Seuring, S. (2008), "Assessing the rigor of case study research in supply chain management", *Supply Chain Management: An International Journal*, Vol. 13 No. 2, pp. 128-37.

Sharif, A.M. (2002), "Benchmarking performance management systems", *Benchmarking: An International Journal*, Vol. 9 No. 1, pp. 62-85.

Sharif, A.M., Irani, Z. and Lloyd, D. (2007), "Information technology and performance management for build-to-order supply chains", *International Journal of Operations & Production Management*, Vol. 1235, p. 1253.

Sharma, M.K. and Bhagwat, R. (2007), "An integrated BSC-AHP approach for supply chain management evaluation", *Measuring Business Excellence*, Vol. 11 No. 3, pp. 57-68.

Shepherd, C. and Gunter, H. (2006), "Measuring supply chain: current research and future directions", *International Journal of Productivity and Performance Management*, Vol. 55 Nos 3/4, pp. 242-58.

Spens, K. and Bask, A. (2002), "Developing a framework for supply chain management", *International Journal of Logistics Management*, Vol. 13 No. 1, pp. 73-88.

Stockdale, R. and Standing, C. (2006), "An interpretive approach to evaluating information systems: a content, context, process framework", *European Journal of Operational Research*, Vol. 173 No. 3, pp. 1090-102.

Symons, V.J. (1991), "A review of information systems evaluation: content, context and process", *Journal of the Operational Research Society*, Vol. 1 No. 3, pp. 205-12.

Thakkar, J., Kanda, A. and Deshemukh, S. (2009), "Supply chain performance measurement framework for small and medium scale enterprises", *Benchmarking: An International Journal*, Vol. 16 No. 5, p. 702.

Unipart Group (2008), *Corporate Responsibility, The Unipart Way – CSR Report*, available at: www.unipart.co.uk/wps/wcm/connect/6cd40f004fb48387aa0bef93deecefb0/Unipart+CSR+Report+2008+v9c+Final+Version.pdf?MOD=AJPERES&CACHEID=6cd40f004fb48387aa0bef93deecefb0

Unipart Group (2009), *Conducting Business. The Unipart Way*, available at: www.unipartrail.com/WebPDF/StockPDF/Conducting%20Business%20the%20Unipart%20Way.pdf

van Hoek, R.I. (1998), "Measuring the unmeasurable – measuring and improving performance in the supply chain", *Supply Chain Management: An International Journal*, Vol. 3 No. 4, pp. 187-92.

Varnom, M. (2004), "Supplier performance management", *Unipart Logistics*, available at: www.smmt.co.uk/businessimprovement/2004%20seminar/unipart.pdf

Varnom, M. (2008), "The Unipart Group Lean transformation", *Unipart Logistics*, available at: http://video.wch.org.au/qi/intranet/Lean_Thinking_in_Manufacturing_and_Service_2008/Mike_Varnom2.pdf

Vitasek, K. (2008), "Next in outsourcing: performance-based logistics", *Proceedings of the Material Handling& Logistics Conference, Park City, UT*.

Wickramatillake, C.D., Koh, S.C.L. and Gunasekaran, A. (2007), "Measuring performance within the supply chain of a large-scale project", *Supply Chain Management: An International Journal*, Vol. 12 No. 1, pp. 52-9.

Yilmaz, Y. and Bititci, U. (2006), "Performance measurement in the value chain: manufacturing v. tourism", *International Journal of Productivity and Performance Management*, Vol. 55 No. 5, pp. 371-89.

Appendix 1. Supply chain performance measurement – context

(1) Supply chain factors:

- Relationships and differences between SCM members (Brewer and Speh, 2001; Hofmann and Locker, 2009; Holmberg, 2000; Lambert and Pohlen, 2001; Morgan, 2004).
- Strategic goals (Beamon and Balcik, 2008).
- Industry/sector (Aramyan *et al.*, 2007; Charan *et al.*, 2008; Hofmann and Locker, 2009; Lai *et al.*, 2002; Lockamy and McCormack, 2004; Muratoglu, 2008; Saad et al., 2006).
- Scope, globalisation, geography (Aramyan *et al.*, 2007; Saad et al., 2006).
- Supply chain model (Angerhofer and Angelides, 2006; Chan and Qi, 2003a; Morgan, 2007; Sharif *et al.*, 2007).
- Demand characteristic (Beamon and Balcik, 2008).
- Level of regulations (Saad et al., 2006).
- Stakeholders (Angerhofer and Angelides, 2006; Beamon and Balcik, 2008; Hervani and Helms, 2005).
- Performance measurement system design, implementation and usage (Brewer and Speh, 2001; Gunasekaran and Kobu, 2007; Morgan, 2004; Morgan, 2007; Sharif *et al.*, 2007).
- Level of integration, collaboration and relationships (Angerhofer and Angelides, 2006; Bullinger *et al.*, 2002; Saad et al., 2006).
- Number of SC participants (Saad et al., 2006).
- Structure (Aramyan *et al.*, 2007; Beamon, 1999; Bullinger *et al.*, 2002; Chan and Qi, 2003a; Lambert and Pohlen, 2001; Morgan, 2007).
- Processes (Angerhofer and Angelides, 2006; Beamon and Balcik, 2008; Bullinger *et al.*, 2002; Chan et al., 2003a; 2003b; Lambert and Pohlen, 2001; Lockamy and McCormack, 2004).
- Products (Aramyan *et al.*, 2007; Chan et al., 2003a).
- Technology and enabling technology (Angerhofer and Angelides, 2006; Sharif *et al.*, 2007).
- Culture and attitude (Chan et al., 2003a; Sharif *et al.*, 2007).

(2) Organisational factors:

- Links between metrics, strategy and SCM (Bullinger *et al.*, 2002; Chan *et al.*, 2003c; Gunasekaran *et al.*, 2001; Holmberg, 2000; Lambert and Pohlen, 2001; Morgan, 2004)
- Organisational strategy and goals (Beamon and Balcik, 2008; Bullinger *et al.*, 2002)
- Organisational processes (Morgan, 2004)
- Stakeholders (Beamon and Balcik, 2008)
- Organisational structure (Chan et al., 2003a)
- Company size (Morgan, 2004; Park *et al.*, 2005)
- Management methods (Chan et al., 2003a)
- Revenue source (Beamon and Balcik, 2008)

Appendix 2. How is the measurement carried out?

(1) Frameworks and tools:

- SCM measurement system (Holmberg, 2000).
- SCM performance measurement framework (Beamon and Balcik, 2008; Beamon, 1999; Gunasekaran and Kobu, 2007).
- Scorecard based and its modifications (Bhagwat and Sharma, 2007a; 2007b; Brewer and Speh, 2000, 2001; Chia *et al.*, 2009; Lohman *et al.*, 2004; Park *et al.*, 2005; Bullinger *et al.*, 2002; Thakkar *et al.*, 2009).
- Economic value added (Bullinger *et al.*, 2002; Lambert and Pohlen, 2001; Saad et al., 2006; Sharif, 2002; Sharif *et al.*, 2007; Sharma and Bhagwat, 2007; Thakkar *et al.*, 2009).
- Process-based measurement (Chan et al., 2003a; Gunasekaran *et al.*, 2004; Gunasekaran *et al.*, 2001; Lockamy and McCormack, 2004.
- Fuzzy-set approach (Chan and Qi, 2003b; Chan *et al.*, 2003c).
- SCOR model (Lockamy and McCormack, 2004; Thakkar *et al.*, 2009).

Appendix 3. What is measured?

(1) Metrics levels:

- Strategic/tactical/operational (Gunasekaran and Kobu, 2007; Gunasekaran *et al.*, 2004; Gunasekaran *et al.*, 2001).
- Function/process/SC (Bullinger *et al.*, 2002).

(2) Metrics categories and sub-categories:

- Based on SCOR model (Morgan, 2004; Saad et al., 2006; Shepherd and Gunter, 2006).
- Based on Balanced Scorecard (Bhagwat and Sharma, 2007a; 2007b; Brewer and Speh, 2000; 2001; Chia *et al.*, 2009; Lohman *et al.*, 2004; Park *et al.*, 2005).
- Qualitative/quantitative (Angerhofer and Angelides, 2006; Bullinger *et al.*, 2002; Chan *et al.*, 2003c; Saad et al., 2006; Shepherd and Gunter, 2006).
- Tangible/intangible (Park *et al.*, 2005; Saad et al., 2006).
- Resources/output/flexibility (Beamon and Balcik, 2008; Beamon, 1999; Sharif *et al.*, 2007).
- Financial/non-financial (Beamon and Balcik, 2008; Gunasekaran *et al.*, 2004; Gunasekaran *et al.*, 2001).
- Cost/customer/responsiveness/productivity (Chan *et al.*, 2003c).
- Transportation/time/buyer-supplier relation management/information management/ customer satisfaction/manufacturing and inventory/financial efficiency (Angerhofer and Angelides, 2006; Bullinger *et al.*, 2002; Saad et al., 2006).
- Sustainability/green (Chan and Qi, 2003a; Clift, 2003; Hervani and Helms, 2005).
- Cash-to-cash (Farris II et al., 2002).
- Social/economic/environmental (Cuthbertson and Piotrowicz, 2008).

About the authors

Richard Cuthbertson is a Senior Research Fellow at the Saïd Business School, University of Oxford. He focuses on developing effective value chains through the strategic use of information, performance measurement and benchmarking. He has worked with leading European and international companies. He is a member of the Global Commerce Initiative Scorecard committee.

Wojciech Piotrowicz is a Research Fellow at the Saïd Business School, University of Oxford. His research specialisation and expertise are in the areas of performance measurement and evaluation of supply chains and information systems, including sustainability-related measures. He is also interested in historical development of performance measurement and quality control. He teaches technology and operations management at Oxford University. Wojciech Piotrowicz is the corresponding author and can be contacted at: wojciech.piotrowicz@ sbs.ox.ac.uk

This article has been cited by:

1. Liliana Avelar-Sosa, Jorge Luis García-Alcaraz, Aidé Aracely Maldonado-Macías. Supply Chain Performance Factors in the Manufacturing Industry 91-128. [Crossref]
2. Liliana Avelar-Sosa, Jorge Luis García-Alcaraz, Aidé Aracely Maldonado-Macías. Conceptualization of Supply Chain Performance 69-89. [Crossref]
3. Ardian Qorri, Zlatan Mujkić, Andrzej Kraslawski. 2018. A conceptual framework for measuring sustainability performance of supply chains. *Journal of Cleaner Production* **189**, 570-584. [Crossref]
4. Z. Chorfi, L. Benabbou, A. Berrado. 2018. An integrated performance measurement framework for enhancing public health care supply chains. *Supply Chain Forum: An International Journal* **5**, 1-13. [Crossref]
5. Tero Rantala, Juhani Ukko. 2018. Performance measurement in university–industry innovation networks: implementation practices and challenges of industrial organisations. *Journal of Education and Work* **4**, 1-15. [Crossref]
6. Ali Ziaee Bigdeli, Tim Baines, Andreas Schroeder, Steve Brown, Eleanor Musson, Victor Guang Shi, Armando Calabrese. 2018. Measuring servitization progress and outcome: the case of 'advanced services'. *Production Planning & Control* **29**:4, 315-332. [Crossref]
7. MahindrooAnkit, Ankit Mahindroo, SamaliaHarsh Vardhan, Harsh Vardhan Samalia, VermaPiyush, Piyush Verma. 2018. Moderated influence of return frequency and resource commitment on information systems and reverse logistics strategic performance. *International Journal of Productivity and Performance Management* **67**:3, 550-570. [Abstract] [Full Text] [PDF]
8. BirhanuDagne, Dagne Birhanu, KrishnanandL., L. Krishnanand, RaoA. Neelakanteswara, A. Neelakanteswara Rao. 2018. Supply chain strategies of manufacturers in Ethiopia. *International Journal of Productivity and Performance Management* **67**:2, 318-340. [Abstract] [Full Text] [PDF]
9. Ratapol Wudhikarn, Nopasit Chakpitak, Gilles Neubert. 2018. A literature review on performance measures of logistics management: an intellectual capital perspective. *International Journal of Production Research* **19**, 1-31. [Crossref]
10. Francisco Rodrigues Lima-Junior, Luiz Cesar Ribeiro Carpinetti. 2017. Quantitative models for supply chain performance evaluation: A literature review. *Computers & Industrial Engineering* **113**, 333-346. [Crossref]
11. Kannan Govindan, Sachin Kumar Mangla, Sunil Luthra. 2017. Prioritising indicators in improving supply chain performance using fuzzy AHP: insights from the case example of four Indian manufacturing companies. *Production Planning & Control* **28**:6-8, 552-573. [Crossref]
12. SaunilaMinna, Minna Saunila, RantalaTero, Tero Rantala, UkkoJuhani, Juhani Ukko, PekkolaSanna, Sanna Pekkola. 2017. Gaining insights into the measurement of value in industrial service network. *International Journal of Quality & Reliability Management* **34**:4, 478-493. [Abstract] [Full Text] [PDF]
13. Andrés Muñoz-Villamizar, Jairo R. Montoya-Torres, Javier Faulin. 2017. Impact of the use of electric vehicles in collaborative urban transport networks: A case study. *Transportation Research Part D: Transport and Environment* **50**, 40-54. [Crossref]
14. Vieri Maestrini, Davide Luzzini, Paolo Maccarrone, Federico Caniato. 2017. Supply chain performance measurement systems: A systematic review and research agenda. *International Journal of Production Economics* **183**, 299-315. [Crossref]

15. Tuangyot Supeekit, Tuanjai Somboonwiwat, Duangpun Kritchanchai. 2016. DEMATEL-modified ANP to evaluate internal hospital supply chain performance. *Computers & Industrial Engineering* **102**, 318-330. [Crossref]
16. PekkolaSanna, Sanna Pekkola, UkkoJuhani, Juhani Ukko. 2016. Designing a performance measurement system for collaborative network. *International Journal of Operations & Production Management* **36**:11, 1410-1434. [Abstract] [Full Text] [PDF]
17. Hasan Balfaqih, Zulkifli Mohd. Nopiah, Nizaroyani Saibani, Malak T. Al-Nory. 2016. Review of supply chain performance measurement systems: 1998–2015. *Computers in Industry* **82**, 135-150. [Crossref]
18. Dotun Adebanjo, Tritos Laosirihongthong, Premaratne Samaranayake. 2016. Prioritizing lean supply chain management initiatives in healthcare service operations: a fuzzy AHP approach. *Production Planning & Control* **27**:12, 953-966. [Crossref]
19. Sanna Pekkola, Minna Saunila, Juhani Ukko, Tero Rantala. 2016. The role of performance measurement in developing industrial services. *Journal of Quality in Maintenance Engineering* **22**:3, 264-276. [Abstract] [Full Text] [PDF]
20. Kamel A. Fantazy, Mohamed Salem. 2016. The value of strategy and flexibility in new product development. *Journal of Enterprise Information Management* **29**:4, 525-548. [Abstract] [Full Text] [PDF]
21. Francisco Rodrigues Lima, Luiz Cesar Ribeiro Carpinetti. Evaluating supply chain performance based on SCOR ® model and fuzzy-TOPSIS 2075-2082. [Crossref]
22. Michael C.B. Cheng, James J. Wang. 2016. An integrative approach in measuring hub-port supply chain performance: Potential contributions of a logistics and transport data exchange platform. *Case Studies on Transport Policy* **4**:2, 150-160. [Crossref]
23. Job A.C. De Haan, Macarena Sacristán-Díaz. 2016. Measuring performance at the supply chain level: the role of the chain director. *WPOM-Working Papers on Operations Management* **7**:1, 1. [Crossref]
24. Jairo R. Montoya-Torres, Andrés Muñoz-Villamizar, Carlos A. Vega-Mejía. 2016. On the impact of collaborative strategies for goods delivery in city logistics. *Production Planning & Control* **27**:6, 443-455. [Crossref]
25. Cory Searcy. 2016. Measuring Enterprise Sustainability. *Business Strategy and the Environment* **25**:2, 120-133. [Crossref]
26. Leila L. Goedhals-Gerber. 2016. The composite supply chain efficiency model: A case study of the Sishen-Saldanha supply chain. *Journal of Transport and Supply Chain Management* **10**:1. . [Crossref]
27. Wojciech Piotrowicz, Richard Cuthbertson. 2015. Performance measurement and metrics in supply chains: an exploratory study. *International Journal of Productivity and Performance Management* **64**:8, 1068-1091. [Abstract] [Full Text] [PDF]
28. Samir K Srivastava, Atanu Chaudhuri, Rajiv K. Srivastava. 2015. Propagation of risks and their impact on performance in fresh food retail. *The International Journal of Logistics Management* **26**:3, 568-602. [Abstract] [Full Text] [PDF]
29. Yertai Tanai, Alfred L. Guiffrida. 2015. Reducing the cost of untimely supply chain delivery performance for asymmetric Laplace distributed delivery. *Applied Mathematical Modelling* **39**:13, 3758-3770. [Crossref]
30. Po-Hsing Tseng, Chun-Hsiung Liao. 2015. Supply chain integration, information technology, market orientation and firm performance in container shipping firms. *The International Journal of Logistics Management* **26**:1, 82-106. [Abstract] [Full Text] [PDF]
31. Jairo R. Montoya-Torres. Designing sustainable supply chains based on the Triple Bottom Line approach 1-6. [Crossref]

32. Payman Ahi, Cory Searcy. 2015. An analysis of metrics used to measure performance in green and sustainable supply chains. *Journal of Cleaner Production* **86**, 360-377. [Crossref]
33. Christos S. Tsanos, Konstantinos G. Zografos, Alan Harrison. 2014. Developing a conceptual model for examining the supply chain relationships between behavioural antecedents of collaboration, integration and performance. *The International Journal of Logistics Management* **25**:3, 418-462. [Abstract] [Full Text] [PDF]
34. Sarah Schiffling, Maja Piecyk. 2014. Performance measurement in humanitarian logistics: a customer-oriented approach. *Journal of Humanitarian Logistics and Supply Chain Management* **4**:2, 198-221. [Abstract] [Full Text] [PDF]
35. ManMohan S. Sodhi, Ekaterina Yatskovskaya. 2014. Developing a sustainability index for companies' efforts on responsible use of water. *International Journal of Productivity and Performance Management* **63**:7, 800-821. [Abstract] [Full Text] [PDF]
36. Kazi Arif-Uz-Zaman, A.M.M. Nazmul Ahsan. 2014. Lean supply chain performance measurement. *International Journal of Productivity and Performance Management* **63**:5, 588-612. [Abstract] [Full Text] [PDF]
37. Anoop Kumar Sahu, Saurav Datta, Siba Sankar Mahapatra. 2014. Supply chain performance benchmarking using grey-MOORA approach. *Grey Systems: Theory and Application* **4**:1, 24-55. [Abstract] [Full Text] [PDF]
38. Elisa Kusrini, Subagyo, Nur Aini Masruroh. 2014. Good Criteria for Supply Chain Performance Measurement. *International Journal of Engineering Business Management* **6**, 9. [Crossref]
39. Laosirihongthong Tritos, Samaranayake Premaratne, Adebanjo Dotun. Prioritizing lean supply chain management initiatives in healthcare service operations: A Fuzzy-AHP approach 236-242. [Crossref]
40. Daniel Maucher, Erik Hofmann. 2013. Savings measurement for capital equipment purchasing: challenges and conceptual model. *International Journal of Productivity and Performance Management* **62**:5, 490-513. [Abstract] [Full Text] [PDF]
41. Wan Nurul K. Wan Ahmad, Jafar Rezaei. Influence of external forces on supply chain sustainability goals and decisions in the oil and gas industry 1-9. [Crossref]
42. Susana Azevedo, Helena Carvalho, V. Cruz-Machado. 2013. Using interpretive structural modelling to identify and rank performance measures. *Baltic Journal of Management* **8**:2, 208-230. [Abstract] [Full Text] [PDF]
43. Omkarprasad Vaidya, Manoj Hudnurkar. 2013. Multi-criteria supply chain performance evaluation. *International Journal of Productivity and Performance Management* **62**:3, 293-316. [Abstract] [Full Text] [PDF]
44. Sajal Kabiraj, Dwarika Prasad Uniyal. 2012. A Coevolutionary Model as a Collaborative Mechanism for the Business Exchange in the High-technology Industrial Value Chain. *Jindal Journal of Business Research* **1**:2, 193-207. [Crossref]
45. Normalini, Md. Kassim, T. Ramayah, Sherah Kurnia. 2012. Antecedents and outcomes of human resource information system (HRIS) use. *International Journal of Productivity and Performance Management* **61**:6, 603-623. [Abstract] [Full Text] [PDF]
46. P.R.C. Gopal, Jitesh Thakkar. 2012. A review on supply chain performance measures and metrics: 2000-2011. *International Journal of Productivity and Performance Management* **61**:5, 518-547. [Abstract] [Full Text] [PDF]

47. Alfred L. Guiffrida, Kelly O. Weeks, Lihua Chen. Improving Supply Chain Delivery Performance Using Lean Six Sigma 958-980. [Crossref]
48. Alfred L. Guiffrida, Kelly O. Weeks, Lihua Chen. Improving Supply Chain Delivery Performance Using Lean Six Sigma 89-117. [Crossref]