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| UNIT – IV | **9 hours** |
| **Synchronous supply chain**- extended enterprise and the virtual supply chain- role of information- ‘Quick response’ logistics- Production strategies for quick response- Logistics systems dynamics  **Sustainable supply chain** - The triple bottom line- Greenhouse gases and the supply chain- Reducing the transport-intensity of supply chains – Carbon footprint and supply chain-Reduce, reuse, recycle | |

Perhaps one of the biggest issues to rise to prominence across every aspect of business and society in the opening years of the twenty-first century has been ‘**sustainability**’. The growing concern with the environment, in particular the possibility of climate change through global warming, has led to a focus on how human and economic activity has the potential to adversely impact the long-term sustainability of the planet.

The definition of sustainability that is most widely used originates from the United Nations Brundtland Commission, which reported in 1987. Sustainability, the Commission suggested, was about

***meeting the needs of the present without compromising the ability of future generations to meet their own needs.***

# **The triple bottom line**

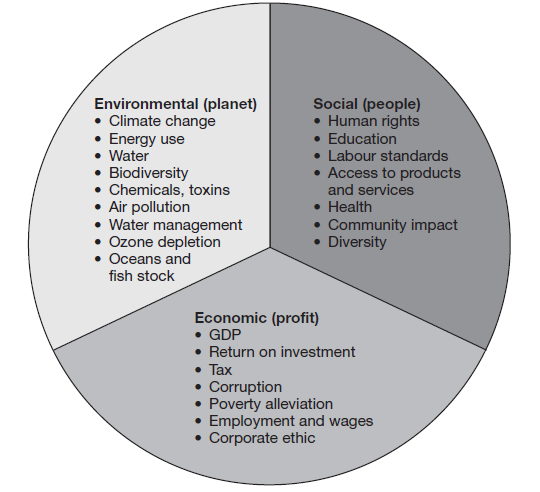
This definition can be further augmented by adopting the parallel idea of the ‘triple bottom line’.The triple bottom line concept emphasises the importance of examining the impact of business decisions on three key arenas:

Environment (e.g. pollution; climate change; the depletion of scarce resources, etc.)

Economy (e.g. effect on people’s livelihoods and financial security; profitability of the business, etc.)

Society (e.g. poverty reduction; improvement of working and living conditions, etc.)

These three elements – the 3Ps of **people, profit and planet** – are inevitably inter- twined and they serve to remind us that for a business to be truly sustainable, it must pay regard to the wider impact of the activities it undertakes if it seeks to remain viable and profitable (see Figure 1).

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**Figure 1 The triple bottom line: planet, people, profit (Source Accenture)**

In the context of supply chains we can build on the triple bottom line philosophy to compass the wider idea that sustainability is concerned with **ensuring the long- term viability** and continuity of the business as well as contributing to the **future well-being of society**. Indeed, it can be argued that **these two goals are mutually supportive, i.e. supply chain strategies that benefit the wider environment are likely also to involve the business in less cost in the long term as the result of a better use of resources.** For example, one element in a ‘**green’** supply chain might involve utilizing transport capacity more efficiently through better routing and scheduling. In so doing, not only is the environmental impact of transport reduced, but also the cost to the company.

Because the **supply chain underpins the efficient and effective running of the business it can provide a useful framework for exploring opportunities for improving sustainability.** If we adopt the philosophy that the supply chain ‘begins on the drawing board’, i.e. that product design decisions impact subsequent supply chain costs, it makes sense to look at sustainability across the entire product life cycle. In other words, we need to understand the impact on sustainability of everything we do from product design through to end- of-life disposal.

**Greenhouse gases and the supply chain**

Recent years have seen a considerable growth of awareness of the potential harm to the environment that can be caused by so-called ‘**greenhouse gases’**. These gases include carbon dioxide, methane and nitrous oxide and various fluorocarbons. Generically these emissions as they relate to an activity are often referred to as its ‘**carbon footprint’**. As a result of increased economic activity around the world, the level of these greenhouse gases has risen significantly over the years. It is estimated that current levels are around 430 parts per million compared to 280 parts per million before the Industrial Revolution.

A view that is held by many, although not all, commentators is that this increase in greenhouse gas levels has been, and is, a **major cause of climate change**. A number of influential reports have brought these issues to the attention of governments, industry and the wider public on a global scale. **Even though it has proved difficult to get universal agreement on the best means for reducing greenhouse gas emissions, there is a widespread acknowledgement that action is required.**

For supply chain managers this is a particular call to action since **some of the major causes of greenhouse gases arise from industrial activities such as manufacturing, energy production and transportation.** In the specific case of freight transport, for example, it is acknowledged that as a result of the globalisation of supply chains we are now moving products greater distances than ever before with a consequent impact on the carbon footprint. The example of the laptop used by Thomas Friedland, the author of *The World is Flat*, is a case in point. He estimated that the approximately 400 different components in his Dell computer had travelled hundreds of thousands of miles from all their different sources and through the assembly and distribution process to reach him.

In recent years there has been a **growing awareness amongst consumers of the issue of ‘food miles’ – in other words how far food travels from its origin to the point of final consumption** – and what the impact of this might be on carbon emissions. The item highlighted below is indicative of this growing concern.

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| **12,000-mile round trip to have seafood shelled**  A seafood firm was accused of ‘environmental madness’ ~~yesterday~~ for choosing to send langoustines on a 12,000-mile round trip to Thailand to have their shells removed.  Langoustines look like **large prawns** but are actually more closely related to a **lobster**. Also often known as Dublin Bay prawns, Nephrops and Norwegian lobster, langoustine (Nephrops norvegicus) look like large prawns but are actually part of the lobster family and can grow up to 250g in weight.  After the shellfish are caught in Scottish waters they will be frozen and shipped to the Far East where they will be peeled by hand and sent back to be sold as scampi. The move by Young’s Seafood is costing 120 jobs at a plant in Annan, south-west Scotland, where the langoustines have been peeled mechanically.  The firm claims that removing the shells by hand enhances the taste, but UK wage costs – **at £6 an hour, compared with about 25p an hour in Thailand** – are prohibitive.  Friends of the Earth Scotland said the move was ‘madness and would add to global warming’.  *SourcE*: CRAmB, A., ‘12,000-mIlE  RoUND TRIP To HAvE SEAFooD SHEllED’, *Daily TElEgraph*, 16 NovEmBER 2006 |

Whilst at the moment the environmental costs incurred as a result of commercial activity are not generally borne by the companies that cause them, this will **almost certainty change as a result of carbon taxes, emission trading schemes and regulatory change**. Hence the need for supply chain managers to think hard about alternative strategies.

**Reducing the transport-intensity of supply chains**

As global economic growth continues, so too does international trade increase and hence transport. The **continued upward trend in global sourcing has inevitably led to products travelling greater distances.** The end result is an increase in what might be termed the *transport-intensity* of the supply chain. Transport intensity can be measured in a number of ways, but at its simplest it is a reflection of the miles/ kilometres travelled per unit of product shipped. Since the transport of raw material and finished goods globally is estimated to consume 15 million barrels of oil each day – almost one fifth of the world’s daily production – there is clearly a correlation between transport intensity and a supply chain’s carbon footprint. Not only is there an economic benefit to be gained by improving transport intensity but also a potential positive environmental impact – this is the concept of *eco-efficiency*, which is now rapidly becoming a major issue in global commerce.

**What practical steps can organisations take to improve the transport-intensity of their supply chains?**

***review product design and bill of materials***

Product design can impact transport-intensity through the physical characteristics of the product, its density, the choice of materials (including packaging materials), the ease of recycling, reuse and end-of-life disposal.

***review sourcing strategy***

As we have previously noted, many sourcing decisions have led to a migration to low-cost country locations. This often has led to products being moved greater distances. Global sourcing decisions will increasingly need to factor the carbon footprint into the total cost of ownership.

***review transport options***

Clearly different transport modes have different impacts on carbon and other emissions. The design of vehicles and vessels is also increasingly influenced by the need to improve fuel efficiency. There are also arguments for increasing the size of vehicle or the vessel to achieve lower transport intensity per unit. For example, new-generation container ships such as the *Emma Maersk.*

***Improve transport utilisation***

Research has highlighted that vehicle capacity is often poorly utilised. It is suggested that empty running because of the lack of return loads means that up to a third of the trucks on the roads of Europe are running empty! More use of shared distribution, better vehicle routing and scheduling, and better loading can also dramatically improve transport-intensity.

***Use postponement strategies***

If standard, generic products can be shipped in bulk from their point of origin and then assembled, customised or configured for local requirements nearer the point of use, there may be an opportunity to reduce overall transport-intensity.

A further incentive to reduce the transport-intensity arises from the continued upward pressure on oil-based fuel costs, which will only intensify as oil reserves become depleted.

**Consider a number of transportation strategies that can be used by management to help reduce costs.**

**Fewer Carriers**

In the same way that the purchasing department streamlines vendors to gain better prices with higher volume, the transportation manager should adopt the same strategy when it comes to the number of carriers used.

A transport manager spends time finding the best carrier at the best price, but sometimes that leads to a large number of carriers being used, albeit giving excellent service. The multiple carrier approach occurs when the transport manager has negotiated the best deal for each route but has not looked at the big picture.

By reducing the number of carriers, the amount of work offered to the remaining carriers will increase. By offering vendors a larger volume of work, the carrier should be able to offer lower rates across all routes. It may be the case that on some routes the rate is not as good as was negotiated with another carrier, but overall the rates across all routes should be lower.

As carriers are offered more work, theoretically the negotiated rates should fall even more as the carrier wants to retain the routes they have and increase the volume of work they are receiving.

Of course, with any strategy, there is also a downside. The risk associated with only using a small number of carriers is that a company can become very dependent on those carriers.

If a company uses five carriers fairly equally and one of those carriers goes out of business, the company would quickly have to find carriers to allocate those routes. Otherwise, delivery delays could cause financial consequences with customers not receiving their deliveries and a drop in customer satisfaction which could lead to fewer orders in the future.

**Consolidating Shipments**

If a company uses carriers for its deliveries, the rate it pays is negotiated by trip based on weight, distance, and other variables.

One strategy that can be used by transportation managers is to consolidate shipments so that fewer trips are made, and the company reaps the benefit of lower rates based on larger shipments.

Consolidating shipments means that transportation managers will be moving away from less than truckload (LTL) shipments to truckload (TL) shipments. This is not always possible, but given that discounts for larger shipments are almost always available, the transportation manager should be looking at this strategy to reduce costs.

**Single Sourcing**

Some companies believe the best-negotiated prices can be achieved when they use a single source for all their transportation. This is fairly common for purchasing departments to use a single source for a range of products that a single vendor can provide.

The same can be achieved for transportation. By offering all transportation out to bid, via a request for quotation (RFQ), a company can provide carriers with a detailed explanation of what it requires, which may fall outside of what is normally provided by a common carrier.

If it wanted to use a single source, a company would have to thoroughly evaluate a bidder’s ability to provide the service and whether the carrier has the stability not fall into bankruptcy within the timeline of the contract. If the winning bidder fulfills the needs of the company and has been fully evaluated, a company could gain significant transportation savings using a single carrier.

**Peak oil**

**The concept of ‘peak oil’ originated as far back as 1956 when Dr marion King Hubbert, a geologist at Shell, first coined the phrase.** What he recognised was that all oil production, whether from an individual field, a country or the entire world, follows a normal distribution, i.e. a bell-shaped curve. All the current indications are that we have reached the top of that curve, or that we shortly will. Even with new discoveries, the total amount of oil reserves will still be in decline once the peak has passed.

At the moment the world demand for oil is approximately 85 million barrels a day, which by chance is about the current daily output of all the working fields. However, whilst output will inevitably decline as ‘peak oil’ is passed, world demand is likely to grow – particularly fuelled by economic growth in countries such as India and China. **The gap between demand and supply will get larger by the day.**

Some commentators have suggested that the gap between the demand and supply for oil will be filled by the **discovery of new oil fields or the development of new fuels** (e.g. bio-fuels). However, such is the likely deficit that it is estimated that we would need to find new reserves of oil (or create alternative fuels) equivalent to five Saudi Arabias over the next 20 years. Simple economics tells us that the only way that the gap will actually be closed is by the price mechanism. In other words, the cost of oil will increase dramatically to reflect the shortfall in supply.

Today’s supply chains are more energy intensive than before because they are more transport intensive than they used to be. There are a number of reasons for this including:

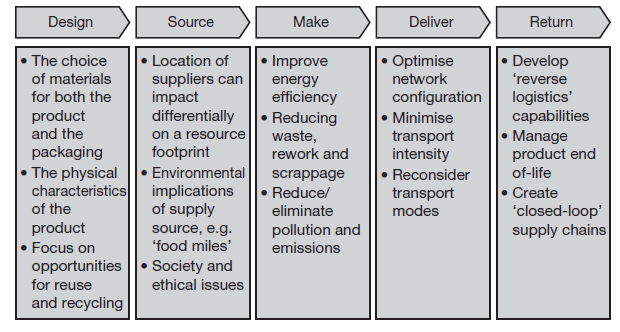
* **Focused factories and centralised distribution** – as a result of rationalising production and distribution, many companies are now having to serve customers at a greater distance.
* **Global sourcing and offshore manufacturing** – the well-established trend to low-cost country sourcing and manufacturing has meant that supply chains are significantly extended and products travel much further.
* **Just-in-time deliveries** – as more customers demand just-in-time deliveries from their suppliers, it is inevitable that shipment sizes reduce whilst delivery frequencies increase.

When many of today’s supply chains were originally designed, the cost of oil was a fraction of what it is today. For example, in December 1998 a barrel of crude oil sold for about US$9.64; in July 2008 – ten years later – it rose to an all-time high of $147.27.

It is quite possible that if oil prices continue to rise over time, current supply chain arrangements will prove to be too expensive. There is clearly a need for supply chain strategists to review their network configurations and to ask ‘what if’ questions based upon worst-case scenarios of transport costs.

**Beyond the carbon footprint**

Whilst there is an understandable concern that the supply chain’s **carbon footprint should be minimised,** it must also be recognised that supply chain decisions have a **wider impact on resources generally.** Rather than limiting the focus of attention to reducing greenhouse gas emissions, it is important to **recognise the effect of economic activity on the use of scarce resources across the value chain as a whole.** Decisions that are taken at every stage in a company’s value chain can have significant implications for resource requirements and for the wider environment. Figure 2 highlights some of the potential linkages.



**Figure 2 Supply chain decisions impact the resource footprint**

Because so many natural resources are being depleted at an increasing rate, it is important that businesses understand these linkages. Some examples of the resource implications of supply chain decisions are described below.

***Design***

We have previously argued that the supply chain **‘starts on the drawing board’**, meaning that decisions that are taken regarding the design of the product can have a significant impact across the supply chain. This is particularly true when considering the supply chain’s **‘resource footprint’**. More and more companies are actively seeking to reduce the amount of packaging material that is used, for example, but there can be other, less obvious ways to improve resource sustainability. If those managers responsible for new product development are not aware of the resource implications of their design decisions, this may lead to the launch of products with a bigger than desirable resource footprint. For example, many high- tech products rely for their functionality on scarce materials such as the so-called **‘rare earth metals’** (e.g. dysprosium and neodymium) whose future availability may increasingly be limited.

***Source***

**‘Sustainable sourcing’** is emerging as a fundamental element of best practice procurement. one reason for this is that it is estimated that for a manufacturer somewhere between 40 and 60 per cent of their total carbon footprint lies upstream of their operations, whilst for retailers it can be as high as 80 per cent. Depending on where and how those upstream materials and products are sourced and made, there can be major differences in resource consumption.

For example, SAB miller, one of the world’s biggest beer producers, compared its ‘**water footprint’** in two different countries – South Africa and the Czech Republic. It found that the water used in crop production accounted for the vast majority of the total water footprint, but the South African footprint was greater than the Czech footprint because of a greater reliance on irrigation and higher levels of evaporation required to grow the crops used in South Africa. **It actually required 155 litres of water to produce a litre of beer in South Africa against 45 litres of water required to produce a litre of beer in the Czech Republic**.

***Make***

**Manufacturing processes affect the resource footprint primarily through their use of energy,** their relative efficiency and the creation and disposal of waste and toxic materials/effluents. In this age of outsourcing and offshore manufacturing it may not always be apparent to the customer what impact manufacturing strategy decisions can have on supply chain sustainability. However, it is evident that there are big differences in the energy efficiency of different factories and also in the waste they generate and how they dispose of it. Even the source of energy has sustainability implications.

For example a study conducted by the UK Carbon Trust looked at the different footprints created by a **UK national daily newspaper** when it used newsprint produced in Sweden compared to newsprint made in the UK. Because newsprint production is a highly energy-intensive manufacturing process and since most electricity generated in Sweden is from **renewable hydro sources**– unlike in the UK where **most electricity is generated from coal or gas –** the most sustainable manufacturing source was Sweden, not the UK!

***Deliver***

**Clearly decisions on the mode of transport will affect the carbon footprint of a supply chain as will the extent to which transport capacity is efficiently used.** However, the nature of the delivery network (i.e. the number, location and design of distribution centres, the use of hub and spoke arrangements, the extent of cross-docking, etc.) can have a wider impact on supply chain sustainability.

Many companies have used network optimisation models to help determine the shape of their distribution arrangements. However, **these models tend to optimise on a narrow definition of cost rather than taking into account the wider resource footprint that is created by the network. A new generation of network optimisation tools is now emerging which take account of the carbon footprint as well as the more conventional costs.**

***Return***

**‘Reverse logistics’ is the term usually used to describe the process of bringing products back, normally at the end-of-life, but also for recall and repair**. In the past, little attention was paid to the challenge of reverse logistics, often resulting in extremely high costs being incurred. Now, partly driven by increasingly stringent regulations – particularly on product disposal and reuse/recycling requirements – the issue has moved much higher up the agenda.

**Essentially the challenge today is to create ‘closed-loop’ supply chains that will enable a much higher level of reuse and recycling.** Clearly products must be designed with their end-of-life in mind, but also the logistics network employed must minimise the use of resources. Reverse logistics provides a major opportunity for companies to impact both their costs and their carbon footprint and should be viewed as an opportunity rather than a threat. Xerox is a good example of a company that actively seeks to design products and supply chain processes that enable a sustainable end-of-life recovery programme to be achieved.

**Reduce, reuse, recycle**

The 3Rs of sustainable supply chain management – **reduce, reuse and recycle** – are now starting to receive much more attention in most companies today. There is a growing realisation that not only is a strategy focused on improving the environmental impact of economic activity good for all who live on this planet, but because such strategies consume fewer resources the overall profitability of the business should also improve.

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| **Water: The next oil?** As the world’s population continues to increase and as climate change impacts on rainfall, there is an increasing mis-match between supply and demand for water. Supply chains are big consumers of water when all the different production and manufacturing processes involved from start to finish are considered. Already many organisations are actively measuring their ‘water footprint’ across the supply chain and are seeking alternative solutions to enable a reduction in the amount of water that is required to bring products to market. Water may indeed become the ‘next oil’ as shortages start to impact across a much wider arena.  Some examples of the water footprint of different products and commodities are shown below.  How much water does it take …  To make a cup of coffee? 140 litres  To make a litre of milk? 1,000 litres  To make a hamburger? 2,400 litres  To make a t-shirt? 2,500 litres  To make a pair of jeans? 10,850 litres  To produce a kilogram of beef? 16,000 litres  **Source: WWW.WATERFooTPRINT.oRG** |

**Many companies are now actively seeking to create marketing strategies that emphasise the ‘greenness’ of their supply chains.** Whilst the more cynical observers may dismiss these moves as opportunism – what some have dubbed ‘greenwash’ – there can be no question that customers and consumers in markets around the world are starting to demand that suppliers reduce their various footprints.

**Strong evidence is emerging that consumers are increasingly basing their purchasing behaviour on ethical and environmental criteria.**

In some instances major retailers such as Wal-mart and Tesco are seeking to improve their supply chain footprints and are demanding action from their suppliers to improve their performance on the 3Rs, i.e. to demonstrate how they are reducing the use of materials such as packaging and how they are designing products that can be reused or recycled. Both Wal-mart and Tesco (and other retailers too) intend to provide information on the labels of the products they sell detailing the overall environmental impact of those items. To do this they are working closely with their suppliers to ensure that their supply chain arrangements are sustainable and that they continue to seek innovative ways to improve the end-to- end environmental footprint.

For example, **Tesco recognised that glass bottles, because of their weight, add significantly to transport intensity and overall carbon emission.** By working with suppliers to create lighter weight wine bottles, Tesco reduced its annual glass usage from one single supplier by 2,600 tonnes – a 15 per cent saving. Further savings were achieved by importing wines into the UK from Australia in bulk and then bottling them in lightweight glass in the UK.

**Further pressure on businesses to reduce their environmental footprints is coming from government regulation,** often in the form of Emission Trading Schemes (ETS) or so-called ‘Cap and Trade’ legislation. For example, the European Union’s Emissions Trading Scheme has recently been extended to cover a greater range of industries and is based on the principle that companies have a **basic allowance for carbon emissions** – if they go beyond that level they have to buy additional allowance from other companies who do not fully use their own allowance. Similar schemes are currently contemplated by governments around the world and in time their impact is likely to be significant.

**Since, as we have noted, most of a typical business’s total environmental foot- print lies in its wider supply chain, particularly upstream of its own operations,** the need for supply chain managers to become more involved in managing this footprint becomes apparent. Unless upstream suppliers are able to reduce their own footprint the additional costs that they will incur will inevitably end up in their cost of goods sold – and ultimately in the price of the products in the final marketplace.

**The impact of congestion**

**One of the key issues when considering sustainable supply chain solutions is traffic congestion and the related infrastructure issues**. In probably the majority of countries, developed and developing, the creation of logistics infrastructure has not kept pace with the level of economic activity. This is true for all types of infrastructure, including roads, ports and railways. Gridlock on motorways, container vessels waiting to unload at ports and bottlenecks on the railways are common occurrences in many countries and add to carbon emissions as well as adding cost to suppliers and customers alike.

There have been a number of causes of this problem, including increased global trade, lack of investment in capacity and the widespread adoption of just-in- time practices:

***increased global trade***

**With the growth in offshore manufacturing and the emergence of new markets, alongside the removal of trade barriers, the flow of products across borders has increased dramatically.** At the same time the size of many container vessels has increased significantly – the new generation of container ships can carry upwards of 10,000 TEUs (20 foot equivalent), which if laid end-to-end would stretch for 60 kilometres or 37 miles! When unloaded each of these containers may need to be stacked on the dockside before being loaded out to trains or trucks, further adding to congestion. Furthermore, in recent years the increase in container security requirements has led to additional delays at both the points of origin and destination.

***lack of capacity***

**Paradoxically in some developed countries environmental concerns have led to unwillingness to build more infrastructure such as new motorways or port extensions.** Also, there has been resistance in countries such as the UK to introduce bigger trucks which might actually reduce congestion, since fewer would be required. **Equally in developing countries the sheer scale of the investment required to meet the demand is daunting.** India is a good case in point where because of a lack of previous investment there is an overwhelming shortage of capacity on the roads, railways and at the ports – particularly in the face of burgeoning demand.

***Just-in-time practices***

**Over the last 50 years there has been a significant uptake across all sectors and supply chains of the philosophy and practice of just-in-time (JIT).** Essentially this has led to smaller but more frequent movements of products and materials. Even though many of those who have adopted JIT have attempted to mitigate its effects through **aggregation and consolidation there can be no doubting that it has contributed to an increase in shipments and movements.**

In the past it could be argued that the saving in inventory holding costs more than covered the additional transport cost. However, now **that concern with environmental issues has become much more prevalent,** JIT in its crudest form will increasingly be questioned. The challenge for supply chain managers is to find a solution that enables the benefits of JIT to be gained without incurring the potential environmental disadvantages.

While congestion will probably continue to affect logistics management for many years to come, particularly as economic growth and development continue, **there is likely to be some alleviation as a result of the application of what might be termed ‘smart logistics’ and ‘intelligent transport’.** The idea here is to combine the opportunities that exist for greater partnership and collaboration, both vertically and horizontally, in the supply chain with advanced information and communication technology.

Smart logistics works by aggregating and combining individual shipments into consolidated loads for final delivery. ‘Cross docking’ is an example of this idea whereby different suppliers ship complete truck loads to a distribution centre, typically with each pallet bar-coded or RFID-tagged with product and destination details, for resortment and consolidation with other shipments to the same final destination. The same principle can be used utilising ‘logistics platforms’ on the edge of large cities or conurbations to reduce individual deliveries to congested locations.

When **advanced IT solutions such as dynamic vehicle routing and scheduling and intelligent agent modelling** are used alongside these collaborative strategies, many things become possible – particularly enabling the better management of constrained capacity against a backdrop of uncertain demand.

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