5 Transport in Supply Chains

LEARNING OBJECTIVES

- Understand the cost structures and operating characteristics of the different transport modes, and the relationships between freight rates and consignment weight, dimensions and distance to be travelled.
- Highlight key terms used in transport.
- Outline the different types of load devices used in international transportation.
- Discuss the roles of distribution centres and highlight the concept of factory gate pricing.
- Identify some of the many issues (including the effect of supply chain strategies) that can impact the efficiency of transport services.
- Review the world's major transport networks.

INTRODUCTION

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

There are essentially five modes of transport:

- air
- road
- water
- rail
- pipeline

The 'information superhighway' can also be regarded as a possible sixth mode of transport.

Chapter 5 comprises five core sections:

- Characteristics of the different transport modes
- Transport operations, distribution centres and the role of factory gate pricing
- Load devices used in international transportation
- Efficiency of transport services
- International transport networks

CHARACTERISTICS OF THE DIFFERENT TRANSPORT MODES

Choosing which mode(s) to use for freight transportation will usually be a function of the volume and value of the freight, the distance to be travelled, the availability of different services, freight rates to be charged and so forth. Once the appropriate mode of transport has been chosen, it is usually the case that there is not a simple linear relationship between the freight rate charged and both the weight of the freight and the distance to be travelled (Figures 5.1 and 5.2). Regardless of how short the distance to be travelled, the logistics service provider (LSP) will still have to recover certain fixed costs for transporting a consignment (Figure 5.1). For heavier shipments, the rate per kilo will typically decrease as the fixed costs can be spread over a larger weight (Figure 5.2). For bulky or difficult to handle shipments, LSPs will typically apply what is known as **volumetric charging** based on the dimensions of the consignment. This is to compensate for lost capacity as a result of carrying the bulky shipment where applying a rate per kilo would not sufficiently cover the costs incurred from the carrying of this shipment. Think for example of a roll of carpet in an aircraft hold, by weight this shipment may be quite light, but because of its dimensions there may be a lot of lost space in the aircraft hold which cannot now be utilised.

An interesting feature of logistics systems is that sometimes consignors do not know exactly which transport mode their freight travels on, leaving this decision to the LSP. For the LSP it is not a simple matter of trading off one mode against another; sometimes

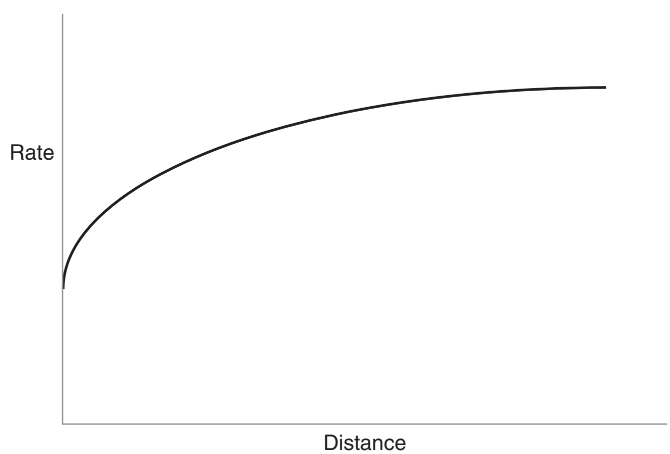

Figure 5.1 Relationship between rate and distance

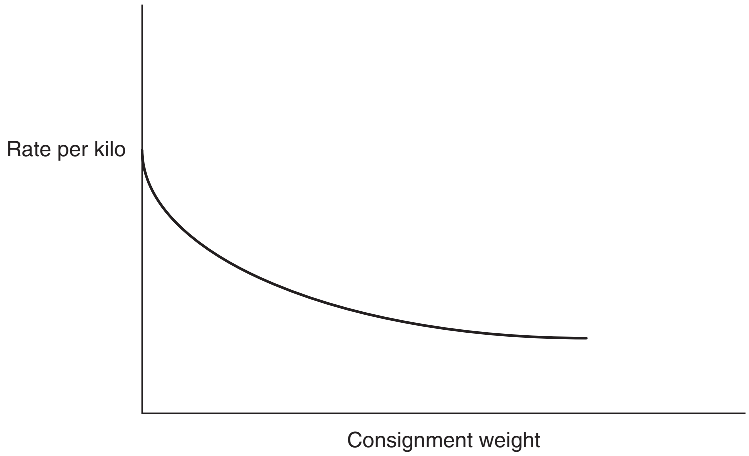

Figure 5.2 Relationship between rate per kilo and consignment weight

multiple transport modes are used in combination. Table 5.1 illustrates the cost structures and operating characteristics of the different transport modes.

Table 5.1 A summary of costs and relative operating characteristics of the different transport modes

Mode	Relative costs and operating characteristics by mode
Road	Fixed cost is low as the physical transport infrastructure such as motorways are in place through public funding; variable cost is medium in terms of rising fuel costs, maintenance and increasing use of road and congestion charges. In terms of operating characteristics, road as a mode of transport scores favourably on speed, availability, dependability and frequency, but not so good on capability due to limited capacity on weight and volume. Uniquely among transport modes, it can allow direct access to consignor and consignee sites
Rail	Fixed cost is high and the variable cost is relatively low. Fixed costs are high due to expensive equipment requirements such as locomotives, wagons, tracks and facilities such as freight terminals. On relative operating characteristics, rail is considered good on speed, dependability and especially capability to move larger quantities of freight
Air	Fixed cost is on the lower side but high variable cost that includes fuel, maintenance, security requirements, etc. The main advantage of air is speed; it is however limited in uplift capacity, similarly other modes of transport are required to take freight to and from airports, thus air cannot directly link individual consignors and consignees
Water	Fixed cost is on the medium side including vessels, handling equipment and terminals. Variable cost is low due to the economies of scale that can be enjoyed from carrying large volumes of freight – this is the main advantage of the water mode, together with its capability to uplift large volumes of freight. Like air, it cannot offer direct consignor-to-consignee connectivity, and vessels are sometimes limited in terms of what ports they can use. It is also quite a slow mode
Pipeline	Fixed cost is high due to rights of way, construction and installation, but the variable cost is relatively low and generally just encompasses routine maintenance and ongoing inspection/security. On operational characteristics, the dependability is excellent but this mode can only be used in very limited situations

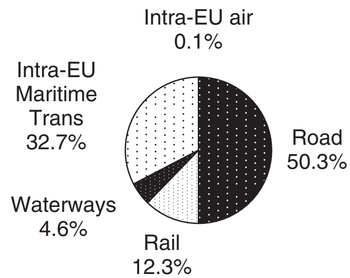

Figure 5.3 Freight transport in the EU-28: Modal split based on five transport modes (% of total tonne-kilometres) (Source: Eurostat)[1]

The split of freight among different modes varies by region and type of freight. Figure 5.3 for example shows the modal split within the European Union. (Note that this does not include transport activities between the EU and the rest of the world).

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

Maritime transport is the dominant mode of transport for international transport movements. According to the United Nations Conference on Trade and Development (UNCTAD), the volume of international seaborne trade in 2013 was estimated at nearly 9.6 billion tonnes (of which 30% was oil and gas).[2] Road transport is the dominant mode of transport for inland transport. Due mainly to the flexibility, directness and speed that the movement of freight by road offers, when compared to rail, inland waterway or sea transport, it has become the principal freight transport mode, carrying the majority of inland freight.[3] It is, however, also the most environmentally damaging mode of transport, an issue we will return to in Chapter 14 which deals with sustainability. Policy makers are thus endeavouring to shift freight from road to more environmentally friendly transport modes, in particular to rail and inland waterway. This is not an easy task, however, as many transport systems are predicated on extensive use of road transport.

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

Chapter 9 will illustrate how inventory is stored at multiple points in supply chains. In this section we will consider the role of distribution centres and in particular a concept known as ‘factory gate pricing’. Over the past 30 years, supply chain configurations have been changing to achieve higher levels of logistics performance and customer

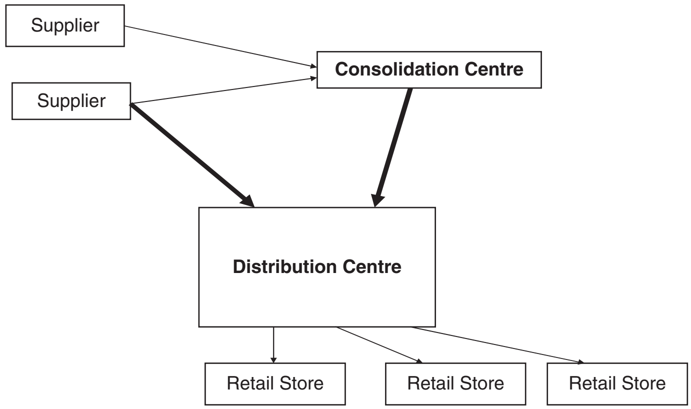

Figure 5.4 Inbound logistics in the retail sector

service. In the 1970s and 1980s **distribution centres** (DCs) were introduced in the retail sector, with retailers taking over responsibility for deliveries to their stores (sometimes DCs are referred to as **RDCs – regional distribution centres**, and **NDCs – national distribution centres)**. A distribution centre is a type of warehouse where a large number of products are delivered by different suppliers, preferably in full truck loads. Each distribution centre services a number of retail stores in the regional area. In the 1990s, **consolidation centres (CCs)** were added and served to consolidate deliveries from multiple suppliers into full loads, which could be delivered onwards to the DCs (see Figure 5.4). A recent development has been for the retailers to take control of the delivery of goods into their DCs and this is known as **factory gate pricing – FGP**. This gives a single point of control for the inbound logistics network and can be defined as:

> Factory Gate Pricing (FGP) is the use of an ex-works price for a product plus the organisation and optimisation of transport by the purchaser to the point of delivery.[4]

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

Figure 5.5 illustrates the evolution of grocery distribution over the past half century. In addition to the control of their inbound logistics using FGP, retailers are also looking at further improving their efficiency by increasing the backloading of store delivery vehicles and the consolidation of smaller loads into consolidation centres. In the grocery sector in the UK, Tesco was the first to move towards FGP in 2001, and subsequently other retailers applied the concept. In addition to the retail sector, FGP has also been used in a number of other industry sectors.

The application of FGP within the grocery sector has complexities due to the large number of suppliers, huge number of products and the scale of distribution. With regard to

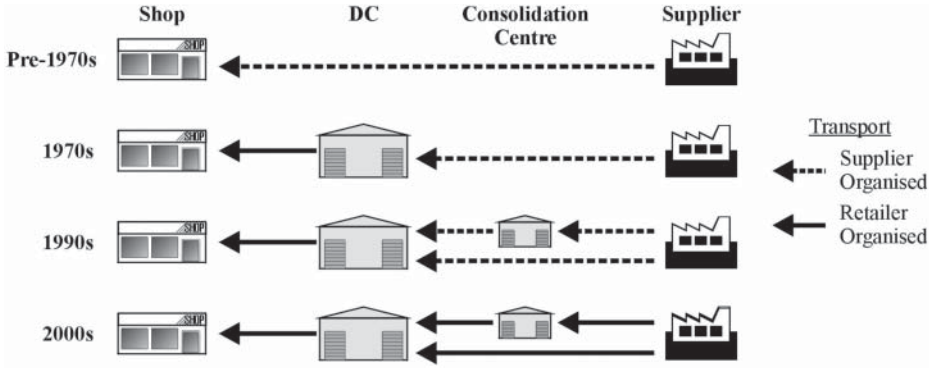

Figure 5.5 The evolution of grocery distribution (Source: Potter *et al.*, 2003)[6]

the impact of FGP on transport, LSPs could feel that the retailers can use it as a lever to reduce haulage rates and reduce their profit margins. Research by the ITeLS research team at Cardiff University suggests that there are numerous operational benefits that arise for the retailer from implementing FGP.[5] These include increased supply chain visibility provided to the retailer giving management greater insight into the behaviour of its replenishment processes in response to changes in demand; in addition the research showed that the retailer benefits from higher delivery service levels. For the suppliers, FGP enables them to focus on their core competencies. In the grocery industry, this is pertinent as the retailers do not add value to the product through manufacturing, but do so through the efficient delivery of products. Therefore, distribution is one of their key strengths. Conversely, many suppliers outsource their distribution in order to focus upon the core competency of manufacturing.[7]

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

The next section turns to the issue of minimising total transport cost within a transport network. Minimum total transport cost solutions could be arrived at by balancing the distribution centre demands with suppliers' capacities in an existing transport network. In addition, where there is a possibility of redesigning the network, the total transport cost could be further minimised by optimising the location of consolidation centres and/or distribution centres in relation to the supplier network. One of the methods to do this is using what is known as the **transportation model** – this technique is discussed in Chapter 17.

AN EXAMPLE OF THE APPLICATION OF FACTORY GATE PRICING (FGP)[8]

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

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

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

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

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

In 2004, the ITeLS research team at Cardiff University carried out a mini-project with the case company and made an attempt to quantify the transport benefits. In the context of the retailer's business, less than full truck load deliveries accounted for 18% of the total ambient volume, 57% of composite volume and 35% of total grocery volume. Composite distribution networks are the centres used for distributing multi-temperature controlled products (fresh, chilled and frozen). The data from the retailer was modelled in a network planning software package to determine the transport distance and cost benefits. The results for both ambient and composite networks are detailed in Table 5.2. There are a number of assumptions that should be kept in mind in interpreting the results. It is assumed that the demand is spread evenly over time, with 100% availability at the supplier. The decision on less than truckload suppliers was made strategically at the retailer, rather than incorporating all suppliers into the model. Costs were based on current charges incurred by the retailer and levied on a per mile basis for transport and per pallet basis for handling charges at the CCs. Finally, the figures only represent the movement of products from the supplier to the DC and do not take into account any costs in positioning the vehicle at the supplier. Because the retailer uses third-party logistics providers for the majority of their requirements, it has been assumed that any cost associated with this is included in the haulage cost.

Table 5.2 The impact of the primary consolidation network with FGP[9]

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

By controlling the consolidation network from a single point through FGP, it is possible to reduce the total distance products travel between suppliers and stores by 23–25% (see Table 5.2). This results from reducing the number of suppliers that deliver directly to the DC, particularly for ambient products. The relative reduction in transport costs is less, being 13.9% and 17.2% for ambient and composite products, respectively. This is because there is cost associated with handling the pallets at the consolidation centre. The researchers estimate that, given the volume of products these savings are achieved on, it can be extrapolated that FGP will reduce the retailer's total distribution cost by approximately 5.7%. However, this value does not consider any gains from implementing the strategies for full vehicle loads or the potential for the retailer, as a large user of transport, to realise economies of scale for freight rates.

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

LOAD DEVICES USED IN INTERNATIONAL TRANSPORTATION[10]

The term **intermodal transport** is often used in transportation. This is where freight moves within a loading unit (known as an ITU – intermodal transport unit). This loading unit may move upon a number of different transport modes, but the freight remains within the unit at all times. The great advantage of intermodal transport is that it reduces the amount of time the freight within the container needs to be handled (we refer to these as 'freight touchpoints') and this obviously then reduces the chance of damage or loss of freight.

The term **FCL** is used in transport to refer to *full container loads* while the term **LCL** is used to refer to *less than full container loads*. When carriers have a consignment that will not fill an entire loading unit they will sometimes try to build a consolidated shipment to make up a FCL.

Table 5.3 Container dimensions (Source: Maersk Line)[13]

		Dimensions (ft)			
Size (ft)	**Type**	**Length**	**Width**	**Height**	**Maximum Payload (kg)**
20	Standard	20	8	8.5	28,200
40	Standard	40	8	8.5	28,800
40	High	40	8	9.5	28,620
45	High	45	8	9.5	27,600

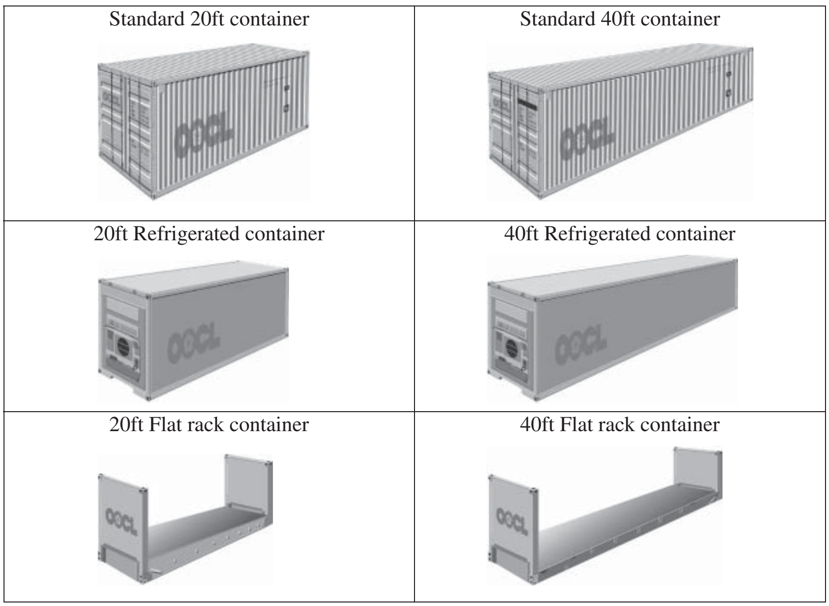

Figure 5.6 Container types (Source: Orient Overseas Container Line, http://www.oocl.com/eng/Pages/default.aspx)[14]

There are many different types of ITUs, perhaps the most common being the standard shipping container (we already introduced containerisation in Chapter 2[11]). The key advantages of using standardised containers are ease/uniformity of handling and commonality of the equipment used to lift these containers. In some ports with the appropriate cranes and skilled labour, a single crane can lift a container every two minutes; there are increasing moves to use automated cranes which can meet or even exceed this speed.[12] The most common shipping container dimensions are detailed and illustrated in Table 5.3 and Figure 5.6. Other container sizes also exist, for example 53ft high cube containers, but these are generally not used in international shipping but for storage and in road and rail transportation.

The most common shipping containers in use today are welded steel or aluminium boxes constructed of corrugated metal, which gives them their strength. They are generally enclosed except for a set of double doors at one end that are held shut by two sets of vertical steel tubes which twist to lock by levers that are themselves lockable by applying a container seal. The **tare weight** of a container refers to the weight of the empty container, for example a standard 40ft steel container weighs some 3700kg. In shipping calculations it is important not to forget to include tare weights in addition to the weight of the shipment itself. To avoid problems such as cargo overflow or wastage of space, it is essential for shippers to have what is known as a 'stuffing plan' before cargo is loaded into the container. Besides the cargo's measurements, the stuffing plan should also take the weight into consideration. It is important to note that in many countries the permissible weight limits for road and rail transportation are lower than the maximum payload a container can afford.[15] Especially with bulky freight, containers can 'cube out' (think, for example, of a roll of carpet). This is where no further freight can be fitted into the container even though it has not yet reached its maximum permissible weight limit (and note, too, the earlier discussion concerning the need to apply volumetric charging in this case). In practice, many containers are not at their weight limit: an analysis of average container weights at five of Europe's leading container ports, for example, showed that the average weight of a loaded TEU ranged from 9520kg to 11,410kg.[16]

Container volumes are calculated in twenty-foot-equivalent measures (TEU), which means that a 40ft container is equivalent to 2 TEU. Containers vary not only in size and payload but also in their use. In addition to the standard dry containers, there are other types of containers, such as refrigerated ('reefer'), open top/flat rack, insulated, ventilated, side opening (often referred to as 'curtain-siders'), tank containers (where a tank is enclosed within a container shell) and platform (these are without sides, ends and roof – so just comprise a base platform – and are used for odd-sized cargo which does not fit on or in any other type of container). While the standard 20ft and 40ft containers are used to transport all manner of commodities at ambient temperatures, refrigerated containers have revolutionised the transportation of temperature sensitive goods such as fresh fruit and vegetables. When loaded onto a container vessel or parked in a port's container marshalling yard, a reefer container must be connected to a power supply to ensure that the correct internal temperature is maintained so that the cargo does not spoil. Equally, it is important to know how many 'reefer points' are available onboard a vessel to ensure the reefer containers can be connected to a power supply.

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

Of course, there are many other types of loading units apart from shipping containers. In airfreight, for example, various different types of 'igloo' containers are used and many are shaped to fit easily into the holds of larger passenger aircraft.

Transloading

On many occasions, however, freight may need to be transferred from one type of loading unit to another. This is referred to as **transloading** (the concept is discussed again in the 'Port Logistics City' case study at the end of Part Two). Table 5.4 illustrates some of the reasons why freight may need to be transloaded.

Table 5.4 Reasons for transloading[17]

Supply chain management	Combine smaller shipments from various consignors into one single load (this is referred to as **consolidated shipment** – another term sometimes used for this activity is **groupage**) Perform value-adding activities such as packaging or palletizing of products
Compliance requirements	Transfer the contents of heavy containers into loads meeting national or regional road weight limits Similarly, some containers may be too high for bridge clearance on certain road and rail networks
Mode specific requirements	Transfer freight to a different loading device necessary for another mode of transportation
Equipment availability	The loading unit may be needed for another shipment. In some cases the equipment owner may levy certain charges if the loading unit is not returned by a certain time (these are referred to as **demurrage charges**)

EFFICIENCY OF TRANSPORT SERVICES

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

Poor asset utilisation for example is illustrated in Figure 5.7 that uses real-life data from the steel sector. It can be seen that the demand placed by corporate customers

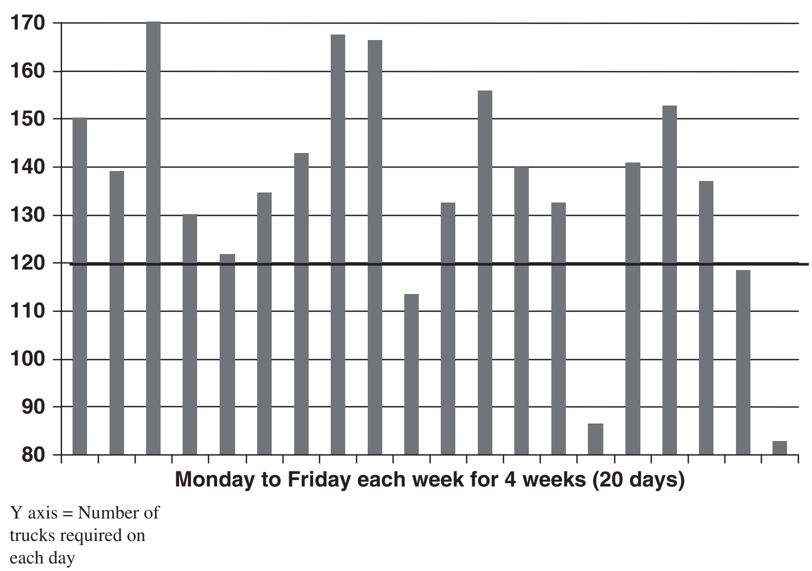

Figure 5.7 Poor asset utilisation in transport (Source: Mason, Lalwani & Boughton, 2006)[18]

on the transport operator per day during a week can vary from 83 vehicles to 170 vehicles.

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

INTERNATIONAL TRANSPORT NETWORKS

The map at the start of the book illustrates the world's international shipping routes and top 20 container ports. Other features of international transport networks are also highlighted, such as the Trans-Siberian Railway and the Northern Sea Route (which is now emerging because of the melting of Arctic ice). The map highlights the dominant role played in world trade by the large container ports, and in Asia in particular. The major shipping lines generally organise their services as hub and spoke networks with the hubs centred on the large container ports. Hub and spoke network designs are also used in other transport modes – Chapter 7 will describe the use of hub and spoke networks by logistics service providers, while the case study on air cargo at the end of Part Two of the book will illustrate the world's top air cargo hubs.

It can take many years to provide new transport infrastructure, so while there may be competition among service providers, in many respects international transport networks have many quite fixed characteristics. Thus while a consignor may have a choice of carriers to choose from, in reality all carriers may transport the shipment along broadly similar routes. Another issue in international shipping is whether to transit the canals (Suez/Panama) or take longer sea routings via the capes at the bottom of South Africa/South America. Costs obviously play a key role in these decisions with the canal operators setting their transit dues and other charges accordingly. The other issue to consider is the vessel size restrictions of the canals. In August 2015 Egypt opened a major expansion of the Suez Canal and at the time of writing the Panama Canal is being expanded to allow more and larger ships to transit; such largescale transport infrastructure developments will lead to significant changes in the way freight routes around the world.[19] New routing opportunities too are emerging (albeit as noted previously these can take many years to emerge from when they are first mooted to when they become operational); examples include the planned Nicaragua Canal and the aforementioned Northern Sea Route.

It would be remiss of us to conclude this chapter on transport without mentioning what is perhaps the key issue affecting the cost of transport services today: the cost and availability of fossil fuels upon which most transport services depend. We will return to this topic in Chapter 14, which deals with sustainability.

LEARNING REVIEW

This chapter focused on physical flows using transport in supply chains. The characteristics of the five principal transport modes were described and issues in determining freight rates were reviewed, and we also described the various types of loading devices used in international transportation. The role of distribution centres and in particular the concept of factory gate pricing were described. This led us to a discussion around the efficiency and effectiveness of transport services, and developments in international transport networks were also reviewed.

We noted at the outset to this chapter that transport is typically regarded as a non-value-adding activity in the supply chain. In conjunction with the understanding that will be gained from studying Chapter 7 on the key roles played by LSPs, and the contributions we will see in Chapter 14 that transport can make around issues concerning sustainability, it is evident that transport plays a vital role in ensuring that supply chains operate both efficiently and effectively.

The next chapter will continue the discussion on transport in the supply chain and will focus upon the critically important topic of security. Chapter 7 will describe and distinguish the various types of logistics service providers and clarify the terminology commonly used.

QUESTIONS

- In your view does transport add value in the supply chain?
- What is volumetric charging?
- What is the tare weight of a container?
- Outline some of the reasons why freight may need to be transloaded.
- What are the key characteristics of the five principal modes of transport?
- Why do we say that transport is a derived demand?
- What is factory gate pricing?

MODAL SPLIT BY COUNTRY

Try to determine what the modal split is for freight in your country. You will usually be able to find this in government transport statistics. What are the reasons for this modal split and how does it compare with other countries and regions?

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