Performance measurement in freight transport:

Its contribution to the design, implementation and monitoring of public policy

Prepared for the Roundtable on
Logistics Development Strategies and their Performance Measurements
(9-10-March 2015, Queretaro)

Alan MCKINNON
Kuehne Logistics University, Hamburg, Germany

February 2015

TABLE OF CONTENTS

INTRODUCTION

Freight transport is usually characterised as being the life-blood of a country and vital for its economic development, but political acknowledgement of its importance often does not extend as far as the statistics bureau. As a result, little or no data gets collected to establish the nature and scale of the freight task and how it is changing. Evidence-based policy-making is clearly impossible within a statistical vacuum, leaving officials to rely on anecdotes, intuition and lessons learned from other countries. Regrettably, this is the situation in much of the developing world, where the macro-level study of freight transport has to start from a clean slate.

At the other extreme are some developed countries with a long tradition of collecting freight data, where a range of parameters are carefully tracked on the basis of sample sizes that are large enough to make reasonably accurate assessments of patterns and trends. Even there, however, the statistical base is never complete. No country collects all the freight data that policy-makers and their analysts require to model, let alone understand, the detailed workings of the freight transport system. With the advent of Big Data there will potentially be a step-change in the availability of freight data, allowing many of the existing gaps to be plugged and permitting the macro-level analysis of freight flows and operations at a higher degree of granularity. This remains to be seen.

For many countries, the immediate objective is to collect enough freight data to answer four key public policy questions about freight transport:

1. How much freight is being moved?

The amount of freight movement can be a good barometer of the level of economic activity. There has traditionally been a close correlation between freight tonne-kms and GDP, though the ratio of these variables can decline as an economy develops and services increase their share of total output. Knowing how much freight is being moved also indicates the related transport demands for infrastructural capacity, fuel, labour and vehicles. It can also shed light on the aggregate level of freight-related externalities.

2. Where is the freight going?

Knowledge of the spatial pattern of freight flow is critical for infrastructure planning, the development of regional development strategies and the management of port and airport hinterlands. In an ideal world, statisticians would be able to track freight consignments across multi-link supply chains from initial origin to final destination, revealing the structure of logistics networks and product routing (McKinnon and Leonardi, 2009). Regrettably, the real world of freight statistics is a long way from this ideal.

3. What is the relative use of different transport modes?

Few governments are satisfied with the existing freight modal split. Most aim to alter the allocation of freight between modes to relieve congestion on one or more infrastructures, reduce the environmental impact of freight movement and / or correct what is deemed to be a market failure. In the absence of freight data disaggregated by mode it is not possible to assess the scale of the problem and the potential for effecting a modal shift.

4. How efficiently is freight being transported?

Where freight transport costs are higher as a result of inefficient operation, prices throughout the economy are inflated and business competitiveness impaired. Structural processes likely to promote economic development, such as the expansion of market areas and centralisation of production and inventory, are inhibited. Inefficient transport operations also tend to be more environmentally-damaging. So the level of efficiency needs to measured and the main causes of inefficiency identified and corrected.

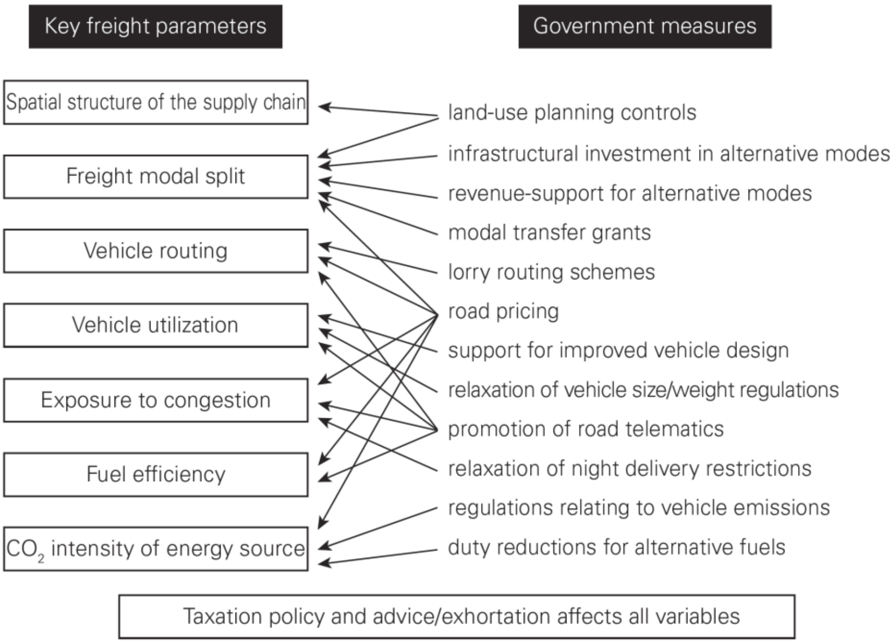
These are the basic questions that need to be answered to start the process of freight policy formulation. The paucity of freight data in many countries suggests that these questions are not even being asked. As the NCFRP (2011: 38) observe, 'the lack of national freight system programs, performance goals, or targets partially explains the lack of freight system performance data'. The early stages of policy-making must be underpinned by basic statistical knowledge of the freight transport system. One can get into a 'chicken and egg' argument over the sequencing of data collection and strategy formulation thereafter. As policy evolves, as new objectives arise and as a broader range of policy instruments are deployed, causing the freight data requirements multiply. NCFRP (2011) suggest that one needs 'clarity regarding strategy and desired outcomes' before going on to develop 'metrics to gauge the strategy's effectiveness'.

Figure 1 lists some of the main freight transport parameters that are often influenced by government intervention and gives of policy measures that affect them. Evidence-based decision-making on this range of interventions is inevitably very 'data hungry'. These data demands expand as freight policies are formulated at regional and urban levels by lower tiers of government. Normally regional and municipal authorities will be responsible for their own data collection though can benefit from the spatial disaggregation of national statistics where sample sizes are large enough.

At all levels of freight policy-making, the main goal must be to improve the performance of the freight transport system. The term 'performance' can be defined in different ways in this context. In this paper, we will examine six performance criteria, all of which are inter-related

1. Transport intensity
2. Modal split
3. Market diversity
4. Operational efficiency
5. Service quality
6. Environmental impact

Figure 1. **Range of freight transport parameters influenced by government intervention**



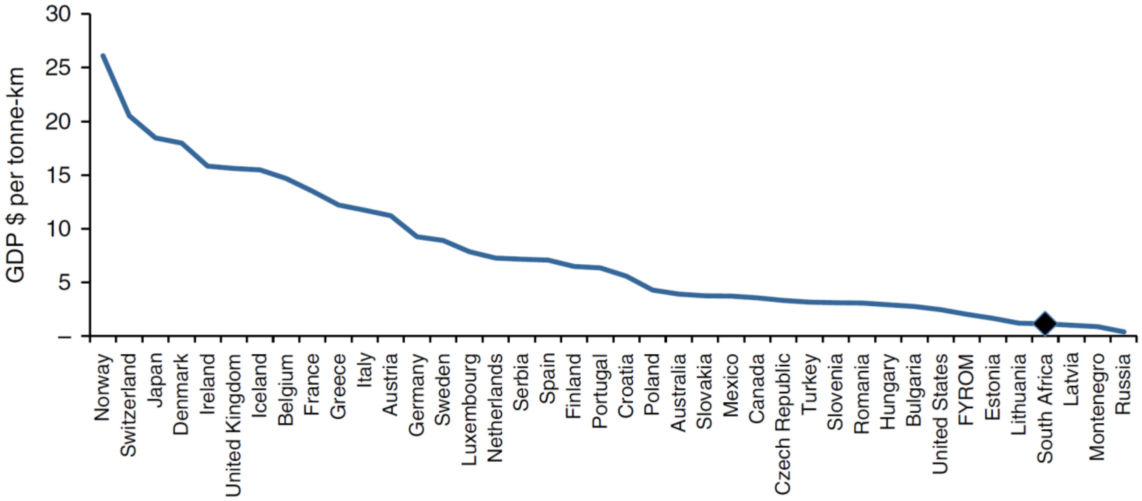
Source: McKinnon, 2015a

The paper will explain why these performance criteria are significant and discuss the indices commonly used to use to measure them. It will refer to freight policy and data issues in different parts of the world though many of the examples of good practice that it cites are drawn from Europe and North America.

1. FREIGHT TRANSPORT INTENSITY

This is usually defined as the ratio of freight tonne-kms to an economic output measure such as GDP. It is an important indicator of an economy's dependence on freight transport. Havenga and Simpson (2014) have shown that there are very wide international variations in the amount of GDP generated for each tonne-km of freight movement (Figure 1). For example, Norway earns approximately thirteen times more GDP per tonne-km than South Africa, mainly reflecting differences in the structure of these countries' economies and the average value density (i.e. $ per tonne) of the freight. Countries at an earlier stage in their development are usually more dependent on the production and export of low-value primary products that have to be moved in large quantities relative to national income. As they develop, industrialisation, movement up the global value chain and growth of the service sector tend to depress the level of freight transport intensity. OECD / ITF (2015) indicate how freight intensity is a function of both per capita income in a country and the service sector share of GDP. It can also be affected by other factors, however, as illustrated by the diversity of freight intensity trends exhibited by EU member states, even between countries at similar levels of economic development and service penetration. Several studies have explored the observed decoupling of GDP and tonne-km trends in countries such as the UK (McKinnon, 2005), Finland (Tapio, 2005) and the Spain (Alises et al, 2014).

Figure 2. **Freight Transport Intensity: amount of GDP generated per tonne-km**



Source: Havenga and Simpson, 2014

Freight transport intensity is a performance metric that few governments have tried to manipulate. Broader economic policy affects the GDP denominator in the intensity ratio, but governments seldom try to influence total tonne-kms as an explicit policy objective. The exceptions are those countries for which logistics accounts for a large share of GDP. For example, the 'logistics and supply chain sector' represented around 14% of the UEA's GDP in 2013 (Geronimo, 2014). Such global logistics hubs have a strong vested interest in maximising tonne-km throughput. At the other extreme, there have been a few examples of public policies designed to rationalise the pattern of freight movement and thereby reduce tonne-kms relative to economic activity mainly to ease environmental and congestion pressures. The Dutch government, for example, had a 'transport prevention' scheme advising companies on ways economising on their use of freight transport, while within the EU's Marco Polo II programme companies could receive funding for 'transport avoidance actions'. This could involve cutting the journey distance, increasing loads, reducing the number of empty runs or reducing the amount of waste' but not 'at the expense of jobs or total output' (European Commission, 2012). As discussed later, most governments' environmental policies towards freight transport aim to decouple freight-related emissions rather than tonne-kms from the level of economic activity.

Although freight transport intensity is normally measured with respect to GDP, it is not the ideal metric for this purpose. For some types of analysis and policy formulation, it is preferable to have a physical rather than monetary measure as the denominator in the intensity fraction. The tonne-km, after all, is a physical measure. In some countries the physical mass of economic inputs and / or outputs are measured in weight terms to assess the overall 'material intensity' of the economy. For example, Eurostat (2014) publishes domestic material consumption (DMC) statistics measuring 'the total amount of materials directly used by an economy ... defined as the annual quantity of raw materials extracted from the domestic territory, plus all physical imports minus all physical exports'.

In compiling the tonne-km statistic, national freight surveys estimate the total tonnes-lifted. This an aggregate measure of the amounts of freight loaded onto vehicles at the start of a journey. As each unit of freight is loaded onto vehicles several times as it moves through multi-link supply chains, the tonnes-lifted statistic is subject to multiple counting. Dividing the tonnes-lifted by a measure of the mass of goods in the economy, such as DMC, indicates the degree of multiple counting. The resulting index (known as the 'handling factor') can serve as a crude indicator of the average number of links in the supply chain. There have been several attempts in European countries to conduct this type of analysis (e.g. Fosgerau and Kveiborg, 2004)), though few countries elsewhere in the world compile 'material flow accounts' that would permit similar calculations. Where sufficient data exist, this analysis can reveal the changing structure of supply chains and hence the underlying process of freight traffic growth.

2. FREIGHT MODAL SPLIT

In most national freight markets, rail, and to a lesser extent waterborne transport, are losing market share to road while one of the main freight policy priorities is to arrest and, if possible, reverse this trend. The modal shift to trucks is partly a response to improvements in road infrastructure but also to changes in companies' logistical requirements which favour road because of its greater speed and flexibility. In countries, such as India, where this trend is pronounced a process of 'logistical lock-in' is underway whereby new production and warehousing capacity is gravitating to points of high accessibility in the highway network often distant from the nearest railway line. Once production and distribution systems are aligned to the road network, shifting freight back to rail or water can be very difficult. In European countries, where this process is at an advanced stage, a range of freight modal split policy initiatives deployed over many years have had limited success in winning goods traffic back to rail or water (Savy, 2010).

The formulation, implementation and monitoring of these policies requires detailed data on the allocation of freight between modes. Superficially this may seem straightforward, but in practice it raises a series of complicating issues:

2.1 Choice of metric

Most countries that publish freight modal split data express it in terms of tonne-kilometres (often referred to, quietly misleadingly, as 'transport performance') and / or tonnes-lifted. Using the former measure gives rail and waterborne transport a higher share as these are essentially long-haul models whose comparative advantage over road increases with the length of haul. Targets for altering the modal split can also be defined in terms of tonne-kms or tonnes lifted. For example, in a report for the Indian government, McKinsey recommends a target of raising rail's share of the surface freight market from 36% of tonne-km in 2010 to 46% by 2020. The European Commission (2011), on the other hand, in its last transport White Paper, set a target of getting 30% of freight tonnage moving over distances greater than 300 km onto to rail or water by 2030.

All weight-based measures of modal split are deficient, however, in the sense that they take no account of the average density of the products carried. Rail and waterborne services generally move heavier primary products, like coal, steel and chemicals, which have a higher average density than the mix of products typically transported by road. This means that 'weight-based measurement of modal split intrinsically favours modes carrying denser product. If it were expressed in terms of the cubic metres of freight moved, road would account for a significantly larger share of the market' (McKinnon, 2010: p.7) To our knowledge, no attempts have been made to calculate freight modal split on a volumetric basis.

It is, nevertheless, important to bear in mind the differing product density profiles of the freight modes when considering the feasibility of modal shift targets defined by tonnage or tonne-kms. Much of the freight diverted from road would be likely to have a lower density than the average for rail or water. As Woodburn (2007) notes for the UK 'a coal train operating over the same distance is likely to have a tonne kilometres weighting around four or five times that of a premium logistics service. It would therefore be far easier to achieve a target growth volume through new coal flows rather than premium logistics ones' (p.64). He challenges the validity of a weight-based modal split target for rail as it 'appears contrary to the likelihood that the majority of potential rail freight growth will come from relatively low weight sectors rather than traditional heavy products'.

2.4 Directness of the routeing:

Measuring the modal split by tonne-km can also give a distorted view of the freight market because of differences in the relative density of the road, rail and waterway networks. As the latter two networks are invariably much less dense that the road network, routeing of the freight flows tends to be less direct. Simply comparing the total length of a country's road and rail infrastructure can also result in under-estimation of differences in the degree of circuity in freight routeing. Sometimes, freight is confined to particular lines. In the UK, for example, Woodburn (2007) found examples of freight trains travelling 9% further to release capacity for passenger trains on trunk lines and 15% further because of loading gauge constraints on particular routes. Wagons may also have to be routed via marshalling yards or train depots, causing them to deviate further from the more direct route that the freight would normally travel on the road network. For example, in the case of one specimen haul between Rotterdam and Prague, the rail distance was 13% longer than the road journey (McKinnon, 2010). This 'route distance' bias can be corrected by comparing the lengths of a large sample of hauls between pairs of locations across the different modal networks and deriving a set of scaling factors.

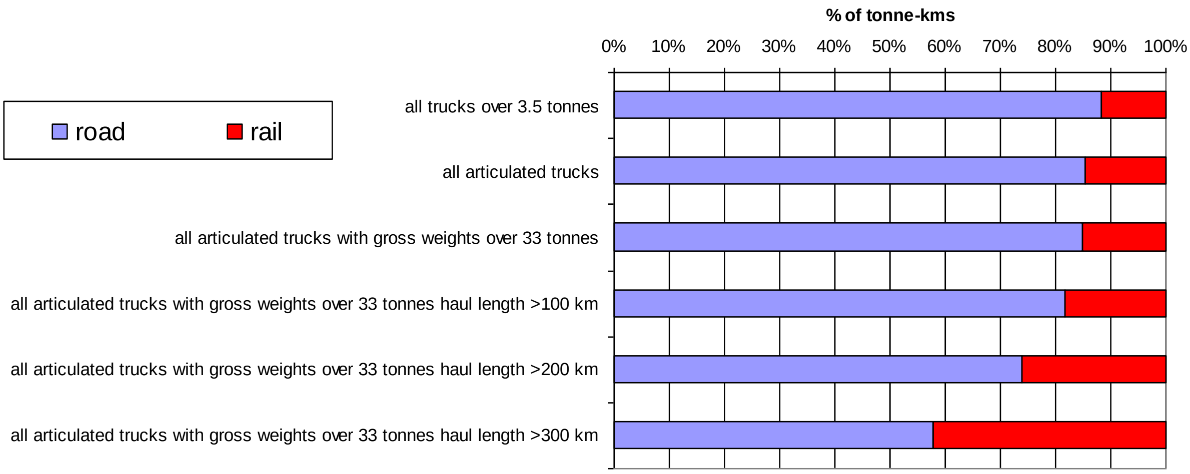
2.3 Intermodal freight movements:

Where the origins and destinations of freight consignments are not directly connected to the rail or waterway networks, road feeder movements are required to provide a door-to-door service. Most government transport statistics do not separately identify these 'inter-modal' movements, though this data can sometimes be obtained from trade associations representing intermodal operators, such as IURR in Europe. In many European countries and the US, intermodal services are projected to be the main source of future railfreight growth providing rail access to traffic moving between non-rail-connected premises. Most currently available freight data, however, do not adequately measure the net effect of a switch from road to intermodal services. This is partly because insufficient allowance is made for the road feeder traffic, but also because the routeing of freight on an intermodal service is more circuitous than the direct road movement, generating more tonne-kms. Across a sample of eight trans-European routes, door-to-door intermodal routes were on average 8% longer than the equivalent direct road journey (McKinnon, 2010). The magnitude of the deviation from the direct route depends on the numbers, locations and catchment areas of the intermodal terminals and can be significant even in regions with relatively mature intermodal markets. Although greater circuity can partly offset differences cost, energy use and emissions per tonne-km between road and rail, the net economic and environmental benefits of a modal shift can still be substantial.

2.4 Contestability of the freight market

Statistical evidence of a large modal imbalance may give the impression that there is huge potential to switch freight between modes. In practice, however, modes may only compete for a relatively small proportion of the total freight market. For example, as mentioned earlier, rail and water are generally only competitive over longer distances, except where freight volumes are large, regular and moving between rail-connected premises. These alternative modes are also ill-suited to low density, high value products moving in variable quantities on a just-in-time basis. Figure uses UK data to illustrate how rail's share of the road-rail freight market can vary depending on the definition of the combined market (Department for Transport, 2008a and 2008b). Using a broad definition with all freight moved in trucks with a gross weight in excess of 3.5 tonnes included, rail's share was only 12%. Within a much more narrowly-defined market excluding freight not carried in heavier articulated trucks over distances greater than 300km rail's share rose to 42%. To be able to measure the size of the contestable market and hence assess the true potential for freight modal shift, one requires a disaggregation of modal freight data by variables such as length of haul, commodity type and truck class and weight.

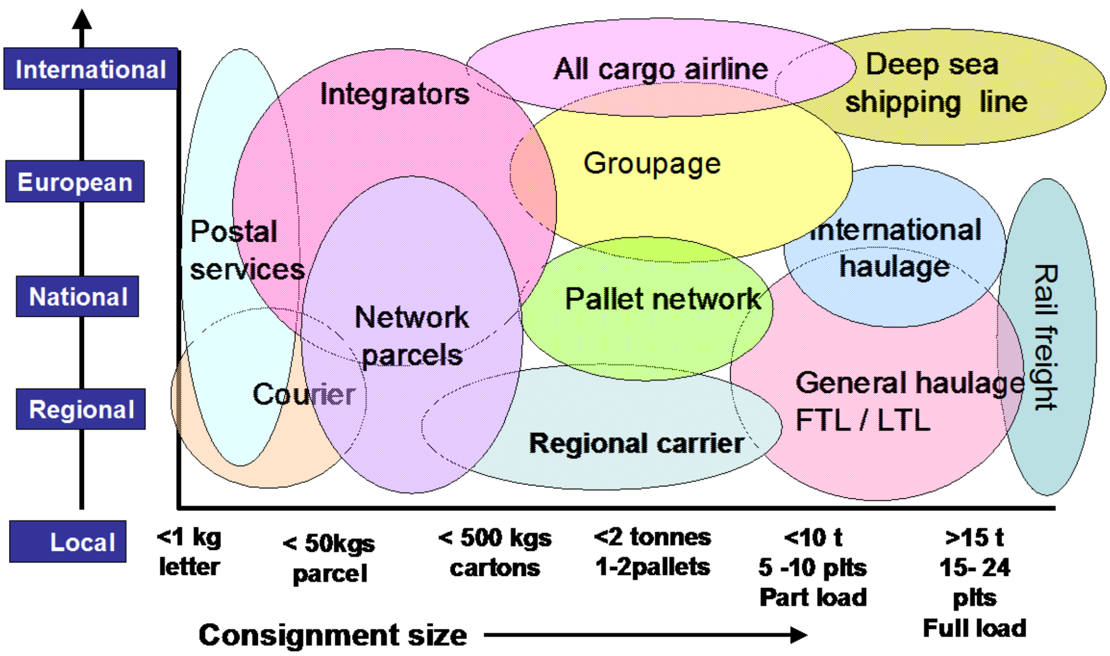
Figure 3. **Effects of Market Definition on the Road Rail Modal Shift UK 2007**



3. MARKET DIVERSITY

In the transport economics literature, the structure of national freight markets was traditionally assessed solely in modal terms, reflecting the deep concern of public policy makers that the modal split was unbalanced because of market failures. Viewed from a shipper's perspective, however, market structure is a good deal more complex than the road versus rail debate would suggest. Within each transport mode there is a broad range of service offerings. There are now many variants of intermodal service, combining modes in different ways. Carriers vary in the size and type of consignment they handle, the speed with which they deliver and the geographical extent of their coverage. Some operate only a basic transport service, while others integrate transport within a logistics package comprising storage, inventory management, order picking and, possibly, a range of other value-adding services, qualifying for the title logistics service provider (LSP). As economies develop, so the spectrum of logistics services expands to cater for the varying needs of the new types of business that emerge. Annual surveys of the global third party logistics market have found demand for a broader portfolio of 'value-adding' logistics services steadily increasing (Cap Gemini et al, 2015). In a mature logistics market one would expect to find the range of services shown in Figure 4, differentiated by two criteria, consignment weight and distance range. Were third and fourth axes to be added to this graph they would be calibrated with respect to the range of logistics services offered and speed of delivery.

Figure 4. **Portfolio of freight transport services classified by consignment size and geographical extent**.



So in judging the logistics capability of a country one must consider the diversity of logistics services on offer and the competitiveness of their respective markets. These are factors that affect not only the performance of other business sectors within the country but also its attractiveness to inward investment, particularly in activities that demand a mix of logistical services.

Few countries systematically monitor the state of the national freight / logistics market in the manner described above. Some compile data on the numbers of registered trucking companies and their fleet sizes, permitting an analysis of the changing degree of market concentration. Depending on the nature of the licensing system, it can also be possible to differentiate companies operating vehicles on an own account as opposed to hire-and-reward basis and to distinguish carriers engaging in domestic and/or cross border work. Such statistics, however, offer very limited insight into the structure and dynamics of this complex sector. To gain a deeper insight one normally has to turn to the reports of market research firms which scan company annual reports and trade directories to build up a detailed picture of the freight / logistics market in particular countries and regions, often supplementing their databases with original survey work. Their supply-side view of the market can be compared with the results of the demand-side surveys of companies regularly buying freight services, of which the Logistics Performance Indicator survey is by far the largest and most authoritative (World Bank, 2014).

Although governments tend not to routinely monitor the freight market themselves, relevant data is sometimes available from other sources and should certainly be incorporated into the logistics policy-making process, as was done in the UK (Department for Transport, 2010).

4. OPERATIONAL EFFICIENCY

Central to most, if not all, government freight transport policies is a desire to improve efficiency. This used to be justified purely on economic grounds, but it is now recognized that it yields environmental co-benefits and so is considered more sustainable in the 'green-gold' sense of the word. Given the importance attached to this policy objective, it is surprising that so little effort is made to collect the data required to monitor freight transport efficiency at a national level. There is even uncertainty about the choice of metrics that should be used for this purpose. In this section, we will focus on the efficiency with which vehicle capacity and fuel are used in the freight sector.

4.1 Vehicle Loading

In a seminal paper on performance measurement in logistics, Caplice and Sheffi (1994) distinguished two types of operational measure widely encountered in the freight sector:

Productivity: defined as the ratio of outputs (such as tonne-kms or vehicle-kms) to inputs (such as fuel, vehicles or labour). They described this as 'transformational efficiency' as it measures the efficiency with which a resource is converted into an activity.

Utilisation: the ratio of the capacity actually used to the total capacity available (such as the amount of space in a container actually occupied by a load).

Both types of efficiency can be measured in several different ways, giving differing impressions of just how well a transport operation is performing. For example, tonne-kms per truck per annum is a productivity index that generally presents the haulage industry in a favourable light, as in the UK between the 1953 and the late 1990s (Figure 5). In most countries it has risen steeply in recent decades because trucks have increased in size, weight and power rating, road infrastructure has been upgraded and the move to 24:7 operation has allowed vehicles to be double- or treble-shifted. A similar productivity trend has been observed among US Class 1 railroads (Figure 6). Higher productivity does not necessarily mean, however, that the trucks and wagons are on average running any fuller than before. When the maximum permitted weight of a truck goes up, the average payload weight typically increases (inflating the productivity index) but not raising it enough to increase the average 'lading factor' (defined as the actual tonne-kms carried to the maximum that could have been carried if the vehicle had been running at maximum weight). Indeed, following increases in the maximum truck weight, lading factors can actually decline as it takes time for companies' ordering and replenishment systems to adjust to the new vehicle weight regulations (McKinnon, 2005). This example demonstrates the need for a separate set of utilization metrics to show how much of the available carrying capacity in vehicles is actually being used.

Figure 5. **Increase in the productivity of UK road freight: 1953-2002**

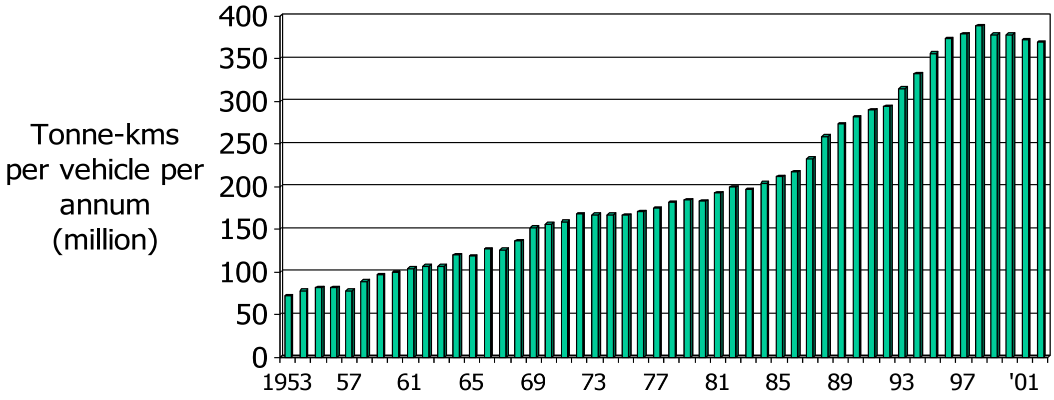
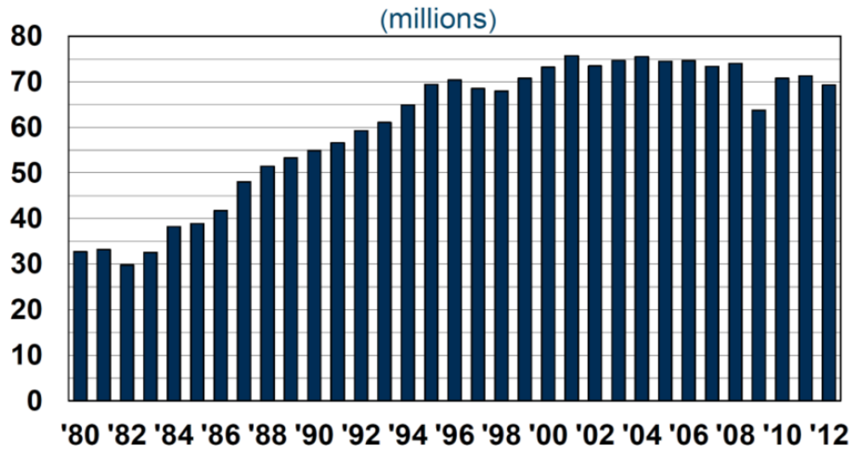


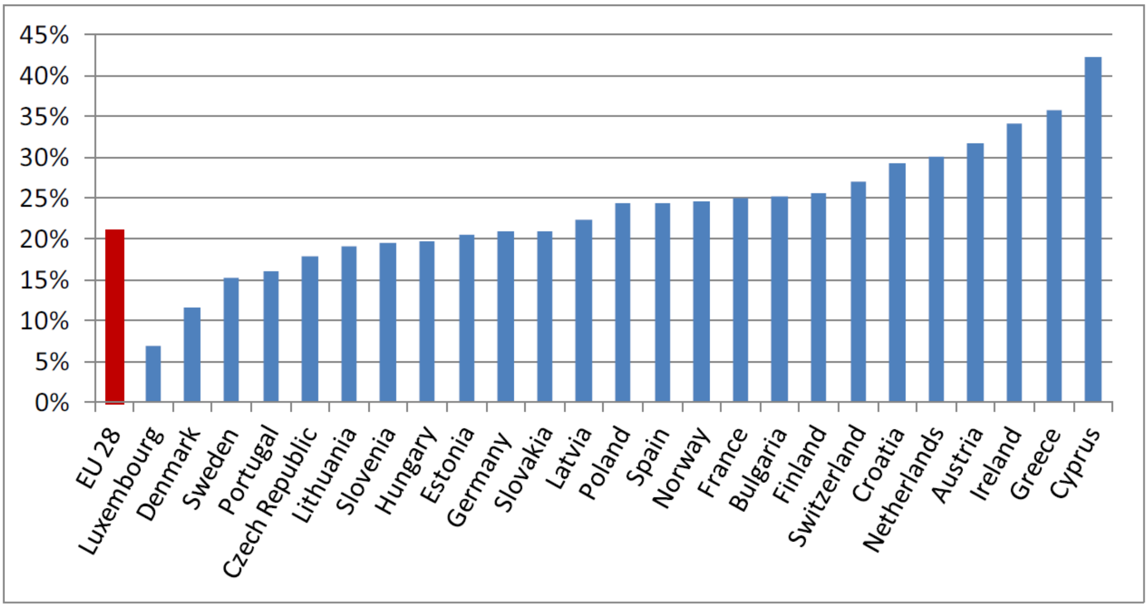
Figure 6. **Increase in the productivity of US Class 1 railroads: 1980-2012 ton-miles per locomotive per annum**



Source: Association of American Railroads

Very few countries routinely collect utilization statistics. EU statistical directives relating to road freight make the collection of only one utilization metric mandatory for member states, the % of truck-kms run empty (European Commission, 2012). As a result the EU's statistical agency, Eurostat, has by far the most comprehensive set of truck empty running statistics in the world, expressed in terms of distance travelled and trip numbers and split by type of operator (own account and hire and reward) and between domestic and cross-border movements. This European data set reveals wide international variations in empty running ranging from 38% of truck-kms in Greece to 15% in Denmark (Figure 7). No attempts have so far been made to explain these variations or assess their sensitive to differences in government freight transport policy. In the US, the Federal Government's Vehicle Inventory and Use Surveys (VIUS) of 1997 and 2002, despite their name did not collect data on either empty running or load factors. The empty (or tare) weight of the surveyed vehicles was recorded but not the distance they travelled empty. Regular surveys of Motor Vehicle Use by the Australian Bureau of Statistics (2014) classify vehicle-kms travelled by rigid and articulated trucks as either 'laden' and 'unladen'. Across the developing world, truck empty running data is sparse. A joint initiative of the World Bank and DFID (called Transport Research Support (2009)) compiled a set of truck empty running estimates for 12 developing countries (6 for Africa and 3 each for Latin America and Asia), which were mostly in the range 30-35%, not much higher than the mean for around half EU member states.

Figure 7. **Proportion of truck-kms run empty in EU member states (2012)**



Source: Eurostat

Empty running can be considered clear evidence of the under-utilisation of transport capacity, leaving carriers exposed to the criticism that they are not using their assets efficiently. This, however, would be a misinterpretation of much of the available empty running data. Several studies have shown that there are often good reasons for empty running, including geographical imbalances in freight traffic flows, short lengths of haul, tight delivery scheduling and vehicle compatibility issues. When allowance is made for all these operational constraints the proportion of feasible, let alone commercially-viable, backloads available to be collected by a returning empty vehicles can be drastically reduced (McKinnon and Ge, 2005). This is not to deny that some empty running is the result of market failures, where, for example, carriers simply lack knowledge of the available backloads or where the silo structure in many businesses prevent logistics and procurement departments from jointly exploring back loading opportunities. There is a limited role for government, however, in trying to correct these failures. The commercial pressures on vehicle operators to backload their vehicles are already very strong and, in many countries, a broad array of online load matching services have been developed by the private sector to facilitate the search for suitable backloads. Arguably the main way in which governments can reduce empty running is by removing legal restrictions on carriers' ability to pick-up backloads, possibly as part of a more general deregulation of the freight transport system.

Operational efficiency is also compromised when vehicles are only partially-loaded. Measuring the degree of under-loading, however, is fraught with difficulty. This is mainly because the maximum available carrying capacity on a vehicle has to be defined in different ways for different categories of freight. For dense commodities the vehicle weight limit is critical. For low density products with high 'stackability' the main constraint is cubic capacity, while for those with low 'stackability' it is the available floor area (or 'load length'). As all countries' freight comprises a mix of these three categories of commodity, no single metric can provide an accurate measure of average capacity utilisation. The UK government, for example, uses data from its annual survey of road freight movement to calculate average 'lading factor' values for different vehicle classes. For the entire truck fleet this average dropped from

60% in 2000 to 57% in 2009, suggesting a decline in vehicle loading (Department for Transport, 2010b). As the lading factor is an entirely weight-based measure, however, it gives no indication of any changes in the average density of road freight over this ten year period. The same surveys also enquired about the proportion of loads subject to a weight and / or volume constraint (in either 2 or 3 dimensions). This revealed that the proportion of loads solely or partly constrained by volume approximately doubled between 2000 and 2010, suggesting that trucks were not necessarily less full in 2010 than in 2000 but just more likely to 'cube or floor out' than to 'weigh out'. This highlights the danger of relying only on weigh-based measures of utilisation when assessing the operational efficiency of a freight transport system.

Very few surveys of freight transport efficiency have attempted to compile volumetric data mainly because it is difficult to collect on a consistent basis given differences in the nature of the handling equipment and in the ways companies record consignment data. Between 1997 and 2009 a series of transport KPI surveys, sponsored by the UK government, collected weight-based and volumetric utilisation data to benchmark the operational efficiency of carriers in several industrial sectors, such as food, drink, non-food retailing, parcels and building materials (McKinnon, 2009). These surveys were labour-intensive and required a high level of company engagement. They may be difficult to replicate in other countries.

In much of the developing world, efficiency is impaired more by the overloading of vehicles than by their under-loading. This has been identified as chronic problem in countries such as India and Indonesia (Asian Development Bank, 2012) where weight restrictions are often poorly enforced and penalties low. The immediate adverse effect of overloading is a substantial loss of fuel efficiency. The longer term damage to road infrastructure further reduces the efficiency of trucking operations because of the unevenness of the road surface and the delays caused by the additional maintenance that is subsequently required.

One controversial area of government freight policy-making that requires both weight and volumetric utilisation data is the regulation of maximum vehicle size and weight. Numerous studies have been conducted on the costs and benefits of relaxing size and weight limits to permit the use of high capacity vehicles, typically with lengths in excess of 20 metres and gross weights above 45 tonnes (e.g. OECD / International Transport Forum, 2010; Steer Davies Gleave, 2013). In modelling the impact of this regulatory change, researchers have to estimate the proportion of loads likely to migrate to longer and heavier vehicles and this can be done more accurately where data are available on the proportions of loads cubing and weighing out within the existing vehicle fleet.

As in the case of empty running, under-utilisation of laden vehicles is often justified and not necessarily evidence of inefficiency. Governments must therefore exercise caution in using utilisation data as a freight performance measure. The demand for freight transport services can fluctuate widely across daily, weekly and monthly cycles, making it difficult for carriers to match the supply of vehicle capacity with freight volumes in a way that ensures high average utilisation. Companies under-loading their vehicles may also be 'making perfectly rational trade-offs between transport efficiency and other corporate goals, such as minimizing inventory, optimizing the use of warehouse space or maximizing staff productivity at the loading bay. As a result total logistics costs may be minimized' (McKinnon, 2015b: 248). Much depends therefore on where the boundary is drawn around the operational efficiency calculation. If it is drawn tightly around the freight transport system the efficiency may appear much lower that if it encloses an entire logistics system. Clearly, from the standpoint of national economic competitiveness, it is preferable to adopt this broader logistical perspective.

A final observation under this heading is that, in most countries, very little is known about the utilisation of rail freight capacity. This can be measured at a wagon, train, terminal or route level. While many railfreight operators are likely to compile this data, very little of it is divulged for public scrutiny or research purposes. In competitive, privatised railfreight markets, operators have a legitimate claim to confidentiality, though their data could be aggregated and anonymised to provide industry-wide statistics comparable to those for the road freight sector. In many countries, rail freight is moved by state monopolies which could provide greater transparency of their internal efficiency.

4.2 Fuel Efficiency

Fuel accounts for a large share of operating costs in the freight transport sector and is the source of virtually all freight-related emissions. Policy-makers therefore need little convincing of the importance of fuel efficiency as a performance metric. The metric itself is a productivity measure showing the efficiency with which energy is converted into the movement of freight. This can either be done with respect to vehicle-kms (fuel efficiency) or to a denominator that takes account of the weight or volume of goods transported (often called 'energy intensity').

Macro-level analysis of energy efficiency trends in freight transport has been quite a fertile field of research in recent years, particularly in the trucking sector. Kamakate and Schipper (2009), Eom et al (2012) and Liimantainen et al (2014), for example, have undertaken multi-country reviews of these trends while other studies have focused on individual countries: e.g. United States (Langer, 2004), UK (Sorrell *et al*, 2009), Spain (Pérez-Martinez, 2009), Finland (Liimatainen and Pollanen, 2010) and China (Li et al, 2013) . Most of the latter studies suggest that the energy efficiency of the road freight sector is improving relative to both trucks-kms and tonne-kms. Eom et al (2012), however, found wide variations in both the average energy intensity of trucking across the eleven developed countries they examined and 'their overall trends ... mixed'. In much of the developing world, data are too limited to make similar assessments. Clean Air Asia (2012), however, were able to compile average fuel efficiency data for light- and heavy-commercial vehicles in thirteen Far Eastern countries. Statistics are also available on the average energy intensity of railfreight operations in many countries. The most recent set of figures assembled by IEA / CER (2012) suggest that the average energy intensity of moving freight by rail declined by 19% between 1990 and 2009 from 234 kilojoules per tonne-km to 191.

Compiling data on the fuel used by trucks can be challenging. In many countries no records are kept of the proportions of diesel fuel going into different types of vehicle at the point of sale. Splitting this fuel by trucks, vans, cars and buses must therefore be done by other means. This usually entails measuring vehicle-kms travelled by these vehicles and multiplying this by an average fuel efficiency measure (litres per 100km) derived from operator surveys or drive cycle testing. Research has found, however, that there can be significant discrepancies in government estimates of both truck-kms and average fuel efficiency derived in different ways (McKinnon and Piecyk, 2010). One must therefore exercise caution in interpreting national level fuel economy data.

5. SERVICE QUALITY

There is a substantial academic literature on the measurement of logistics service quality at a company level (e.g. Gunasekaran and Kobu 2007), but little discussion of the metrics that should be used at a national level to assess the quality of a freight transport system. This may be because the basic criteria are essentially the same at the micro- and macro-scales, comprising average transit time, reliability (i.e. variance around the average) and the condition of goods on arrival. In this section we will focus on the former two which top most companies ranking of service criteria. Quantifying these variables in a meaningful way at a national level is very difficult. This is partly because the speed and reliability for freight services varies enormously by mode, carrier, route, consignment size and commodity type making it very hard to calculate average values. Carriers are also naturally reluctant to divulge information about as sensitive a competitive variable as service quality.

In the case of timetabled services it is possible to access publicly-available data on service frequency and transit times to produce composite measures of average speed of delivery and punctuality. Several studies have examined the range of metrics that can be used to measure the quality of railfreight services either across a complete network or on particular corridors (Rail Net Europe, 2012). Some rail performance data enters the public domain, as, for example, on the website of the American Association of Railroads (AAR).

Measures of the quality of freight transport services have to be compared with some norm or benchmarked against similar data for other countries. Service quality is after all a relative concept. Supply-side metrics used to assess the quality of a country's freight transport system need to be accompanied by surveys of the perceptions companies using it. It is the perceptions of large samples of freight forwarders and shippers which the World Bank (2014) effectively captures and synthesises in its bi-annual LPI survey. Freight transport variables, such as timeliness, track-and-trace and infrastructure feature very prominently in this survey as they clearly have a strong influence on managers' rating of a country's overall logistics capability. The DHL Global Connectedness Index provides another perspective on a country's networking into the global economy (Ghemawat and Altman, 2014). It is based on actual trade flows rather than logistical and infrastructural capabilities. The authors justify this approach on the grounds that, 'while connectivity or the technical potential for connectedness has improved a great deal thanks to changes in transportation and communication technologies, actual levels of flows significantly lag that potential. This focus also allows the index to be based solely on hard data…' (p.75). The trade flow data used, however, is monetary rather than weight- or volume-based and the levels of trade are clearly influenced by many factors other than the quality of a country's international transport links.

Nevertheless, where a country scores poorly in these international rankings it is naturally keen to diagnose where the problems lie and that is when some of the supply-side metrics become relevant. For example, low ratings for timeliness and infrastructure quality are often found to be correlated and congestion blamed for much of the delay. Highway engineers can measure the level of traffic congestion reasonably objectively in various ways, such as calculating average time lost per truck-km, a congestion index used in the UK. Using value of time data for vehicles and freight, it is possible to monetise these estimates (e.g. Significance et al, 2012). A national infrastructure policy can set targets for reducing average time loss and / or congestion costs for different categories of traffic on different classes of road. Such a policy requires several qualifications, however.

First, the impact of congestion on logistics performance is not so much a function of the average delay as of the variability around this average. Where congestion is regular, stable and reasonably predictable, companies can build extra slack into their delivery schedules to maintain service standards, admittedly at a significant resource cost. Where a highway network is nearing full capacity, however, the vehicle flow becomes unstable and much more vulnerable to accidents, breakdowns, roadworks and bad weather. The resulting loss of delivery reliability not only increases the direct, on-the-road cost of traffic congestion; it also imposes indirect disruption costs on production and logistical activities at the destination and possibly several other downstream links in the supply chain. Few attempts have been made to quantify these 'consequential costs' of traffic congestion.

Second, it should be recognised that traffic congestion if only one of several causes of unreliability in companies' logistics systems. This was demonstrated by the UK Transport KPI surveys, which analysed the causes of 'deviations from schedule' across a sample of 55,820 truck movements in seven sectors (McKinnon et al 2009). It found that 26% of these deliveries were delayed, but only 35% of the delays were due primarily to traffic congestion. The average duration of the delay due to traffic congestion was also relatively short averaging 24 minutes, 17 minutes less than the unweighted average for all delays. There is often a complex interaction between congestion and other causes of disruption occurring at points of origin or destination or on the road. Sankaran et al (2005) noted that congestion was '*often an amplifier of delays and costs*' caused by these other factors. The main message from research on this topic is that efforts to improve reliability should not concentrate solely on infrastructural deficiencies but be based on a more holistic analysis of variability in transit time and logistical cycle time.

Although demonstrating a point, the delays recorded in the UK road freight system appear miniscule by comparison with the many days of delay experienced by, for example, trucks in India (Transport Corporation of India, 2012) (Table) or the average container vessel turnaround time in the ports of some African countries, which exceed five days against a global average of 1.4 days in 2011 (Ducruet et al, 2014). The excessive dwell times for consignments at ports, airports and international frontiers have been the subject of several studies of the contribution of improved logistics to trade facilitation. That conducted by the World Economic Forum (WEF) and Bain & Company (2013) was one of the few to quantify the potential uplift in global GDP (by 5%) and international trade volumes (by 15%) 'if every country improved just two key supply chain barriers – border administration and transport and communications infrastructure and related services – even halfway to the world's best practices' (p. 4). This report contains a wealth of case study data to show how the movement of trade is obstructed by a host of 'supply chain barriers' encountered at international frontiers. The World Bank's LPI survey and Global Enabling Trade report of the World Economic Forum (2012) allow countries to benchmark their 'cross-border' performance, but many of those that seriously under-perform in these rankings could do more to analyse where they are deficient. Although such analyses often reveal that the main barriers are administrative and customs-related, shortcomings in freight transport are also a major inhibitor and need careful monitoring. Holloway (2010) reviews the various transport and non-transport metrics that can be used for this purpose.

6. ENVIRONMENTAL IMPACT

Freight accounts for a high proportion-transport related emissions of noxious and greenhouse gases. Clean Air Asia (2012), for example, estimated that in 2010 freight vehicles accounted for only 9% of all road vehicles in Asia but 54% of total emissions. Much of the environmental impact of freight transport is associated with energy consumption and hence correlated with the metrics discussed in section 5.2. Carbon dioxide emissions are a direct function of the amount of fossil fuel burned, with specific emission factors for the different grades of fuel. On the other hand, emissions of noxious gases per litre of fuel consumed vary with the quality of the fuel and the emission standard of the vehicle engine and exhaust system and so must be measured separately. This is normally done by measuring the proportions of vehicles in the national truck fleet meeting particular emission standards. As tightening standards are introduced on specific dates, knowing the age profile of the fleet provides a crude indication of its emission performance. This information is deficient in several respects, however. First, it needs to be supplemented with data on the distances travelled / fuel consumed by trucks of varying age. Second, the emission performance of vehicles generally deteriorates with age and not at a constant rate. Distances travelled, driver behaviour and maintenance levels all shape the emission profile over time. Third, the impact of vehicle-related pollution varies with the environmental sensitivity of the area through which the freight is moved and is at its highest in urban areas. It is desirable, therefore, to have statistics on the emission performance of vehicles in particular areas and corridors. Estimates can also be made of the health effects of freight-related emissions at a country, regional or city level, taking account of freight's share of total emissions and preferably using established methodologies such as the Impact Pathway Approach (Bickel and Friedrich, 2005).

Another major freight externality is the involvement of trucks in traffic accidents. It is not known what proportion of the 1.25 million people killed in road accidents annually at a global level are involved in collisions with freight vehicles. In the EU24 in 2010 17% of road fatalities were in accidents involving trucks, though the incidence of truck-related fatalities varied widely (European Road Safety Observatory, 2012). For example, the probability of being killed in an accident involving a truck was eight times higher in Poland than in Ireland. The European trend in truck-related fatalities has been strongly downward, however, dropping 42% in the EU19 between 2000 and 2010. In the US, trucks account for 8% of vehicles but 11% of road fatalities (Dong et al, 2013). While driving standards among truck drivers are generally higher than those for the driving population as a whole, the greater momentum of freight vehicles increases the risk of accidents being fatal or causing serious injury. The compilation of accurate accident statistics disaggregated by vehicle type is essential for the development and monitoring of national road safety policies and campaigns.

As one of the first countries to develop a sustainable logistics policy, the UK undertook much of the early work on the measurement of freight transport externalities (Department of Transport, 1999 and 2008c). The SmartWay program, set up by the US Environmental Protection Agency in 2004, now sets the standard for the collection and benchmarking of energy and emission data from freight carriers (US EPA, 2014). It has proved the inspiration and model for numerous green freight initiatives that have been launched in Europe, China, India and elsewhere in recent years.

7. CONCLUSION

This paper has reviewed the main areas of freight transport policy-making and discussed the related data requirements. Several general points have emerged from the discussion:

1. *In most countries the amount of freight data available is insufficient to support evidence-based decision-making across the full spectrum of freight / logistics issues*. In some countries, government officials are essentially working in the 'statistical dark' unsure about the nature and scale of the problems they are trying to manage and the effects of any initiatives they apply.
2. *Different metrics can give differing impressions of freight transport performance*: This is well illustrated by the alternative use of productivity or utilization measures. A high score on one criterion can sometimes be achieved at the expense of a low score in another, making it important to keep freight performance measurement multi-dimensional. It should also be recognized that in the interests of maximizing logistical and overall corporate performance the efficiency of freight transport may have to be compromised.

3. *Poor choice of metrics can induce the wrong behavioural response*: For example, pre-occupation with maximizing the lading factor on a multiple drop round can encourage carriers to deliver the largest and heaviest loads last (Arvidsson, 2013) increasing overall fuel consumption and emissions. Again, a combination of KPIs may be required to correct anomalies and drive optimal behaviour.
4. *The nature and quantity of freight performance data varies substantially between modes.* This makes it difficult to compare modes on a consistent basis and to integrate data into multi-modal overviews of the freight transport system.
5. *There is a serious dearth of volumetric data*. This results in an over-reliance weight-based performance measures. This may be acceptable for dense commodities that typically 'weigh-out' but puts companies moving low density products at a disadvantage when comparing load factors, energy intensity and carbon efficiency.
6. *Data relate to individual freight journeys and generally lack of a supply chain perspective:* The unit of freight data collection is almost invariably the journey leg, spanning only one link in the supply chain. It is not possible to reconstitute links into end-to-end supply chains to plot the path that products follow. This frustrates efforts to give freight transport policy-making a supply chain dimension.
7. *Insufficient attention is paid to performance measurement during the freight policy-making process.* As a consequence the impact of policy initiatives is not properly assessed and the policy 'learning process' constrained.
8. *Isolating and evaluating the effects of individual freight policy initiatives is difficult.* This is because several initiatives can running in parallel, their impact can be felt over differing time-scales and they can interact in complex ways. The analytical challenge is great enough when confined to the freight policy arena. When this arena is broadened to include the full panoply of government policy measures that can have an indirect effect on freight transport, the data and methodological requirements move onto a higher plane, well beyond the reach of most countries.

References

Alises, A., Vassallo, J.M. and Guzman, A.F. (2014) 'Road freight transport decoupling: A comparative analysis between the United Kingdom and Spain.' Transport Policy, 32, 186-192.

Arvidsson, N (2013) 'The milk run revisited: A load factor paradox with economic and environmental implications for urban freight transport' Transportation Research part A, 51, pp. 56-62.

Asian Development Bank (2012) 'Indonesia: Transport Sector Assessment, Strategy and Road Map' Manila.

Australian Bureau of Statistics (2014) 'Motor User Survey' Canberra.

Bickel, P and Friedrich, R (2005) 'ExternE: Externalities of Energy-Metholodology 2005 Update', European Commission, Brussels

Cap Gemini, Penn State University, Penske and Korn Ferry (2015) ‘2015 Third Party Logistics Study: Findings and Results of the 19th Annual Survey’ Chicago.

Caplice, C. and Sheffi, Y. (1994), “A review and evaluation of logistics metrics”, International Journal of Logistics Management, Vol. 5 No. 2, pp. 11-28.

Clean Air Asia (2012) Accessing Asia. Clean Air Asia, Manila.

Department for Transport (2008a) Transport Statistics Great Britain. London

Department for Transport (2008b) Road Freight Statistics. London.

Department for Transport (2008c) Delivery a Sustainable Transport System: The logistics perspective, London

Department for Transport (2010) Logistics Growth Review: Connecting People with Goods’ London.

DETR (1999) Sustainable Development: A strategy, DETR, London

Dong, C., Richards,S.H., Huang,B. and Jiang,X (2013) ‘Identifying the factors contributing to the severity of truck-involved crashes.’ International Journal of Injury Control and Safety Promotion.

Ducruet, C, Itoh, H and Merk, O (2014) ‘Time Efficiency at World Container Ports’ Discussion Paper 8, International Transport Forum, Paris.

Eom, J., Schipper, L. and Thompson, L. (2012) We keep on truckin’: trends in freight energy use and carbon emissions in 11 countries. Energy Policy, 45,327–341

European Commission (2011) White Paper: Roadmap to a Single European Transport Area – Towards a Competitive and Resource-efficient Transport System, Brussels

European Commission (2012) ‘Regulation (EU) No. 70/2012 of the European Parliament and of the Council on 18th January 2012 on statistical returns in respect of the carriage of goods by road.’ Brussels.

European Commission (2012) [Online] http://ec.europa.eu/transport/marcopolo/in-action/traffic-avoidance/index_en.htm

European Road Safety Observatory (2012) Traffic Safety Basic Facts: Heavy Goods Vehicles and Buses. DaCoTa, DG Mobility and Transport, European Commission, Brussels.

Eurostat (2014) Direct Material Consumption. http://ec.europa.eu/eurostat/statistics-explained/index.php/Material_flow_accounts_-_flows_in_raw_material_equivalents

Fosgerau, M. and Kveiborg, O. (2004) A review of some critical assumptions in the relationship between economic activity and freight transport, International Journal of Transport Economics, 31, 2, 247–261

Geronimo, A. (2014) ‘Right on track – Dubai’s growing logistics sector’ Middle East Trade and Export, 14th September.

Ghemawat, P. And Altman, S.A. (2014) 'DHL Global Connectedness Index 2014: analysing global flows and their power to increase prosperity' Deutsche Post AG, Bonn.

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, 45, 12, 2819-2840

Havenga, J. and Simpson, Z. (2014) 'Reducing national freight logistics costs risk in a high-oil-price environment : A South African case study' International Journal of Logistics Management, 25, 1, 35 – 53.

Holloway, S (2011) ' Measuring the effectiveness of border management: designing KPIs for outcomes' World Customs Journal, 4, 2, 37-54.

IEA / IUC (2014) 'Railway Handbook 2014: Energy Consumption and CO2 Emissions' International Energy Agency, Paris.

Kamakate, F and Schipper, L (2009) Trends in truck freight energy use and carbon emissions in selected OECD countries from 1973 to 2005, Energy Policy, 37 (10), 3743–51

Li, H., Lu, Y, Zhang, J. and Wanga, T. (2013) 'Trends in road freight transportation carbon dioxide emissions and policies in China.' Energy Policy, 57, 99–106

Liimatainen, H and Pollanen, M (2010) Trends in energy efficiency in Finnish road freight transport, 1995–2009 and forecast to 2016, Energy Policy, 38, 12, 7676–86

Liimatainen, H., Nykänen, L,, Arvidsson, N, Hovi, I.B., Jensen, T.C., Østli,V. (2014) Energy efficiency of road freight hauliers—A Nordic comparison, Energy Policy, 67, 378–387

McKinnon, AC (2005) 'The economic and environmental benefits of increasing maximum truck weight: the British experience', Transportation Research Part D, 10, 77–95.

McKinnon, A.C. (2007) 'The Decoupling of Road Freight Transport and Economic Growth Trends in the UK: An Exploratory Analysis' Transport Reviews, 27, 1, 37-64.

McKinnon, AC (2009) Benchmarking road freight transport: review of a government-sponsored programme, Benchmarking: An International Journal, 16, 5, 640-656.

McKinnon, A.C. (2010) 'European Freight Transport Statistics: Limitations, Misinterpretations and Aspirations' ACEA, Brussels

McKinnon, A.C. (2015a) 'The Role of Government in Influencing Green Logistics' in McKinnon, A.C., Browne, M., Piecyk, M. and Whiteing, A. (eds) 'Green Logistics' 3rd ed. Kogan Page, London.

McKinnon, A.C. (2015b) 'Opportunities for Improving Vehicle Utilisation' in McKinnon, A.C., Browne, M., Piecyk, M. and Whiteing, A. (eds) 'Green Logistics' 3rd ed. Kogan Page, London.

McKinnon, A.C., Edwards, J.B., Piecyk,M.I. and Palmer, A. (2009) 'Traffic Congestion, Reliability and Logistical Performance: A Multi-Sectoral Assessment' International Journal of Logistics: Research and Applications, 12, 3, 331-345.

McKinnon, AC and Ge, Y (2006) The potential for reducing empty running by trucks: a retrospective analysis, International Journal of Physical Distribution & Logistics Management, 36, 5, 391–410

McKinnon, A.C. and Leonardi, J. (2009) 'The Collection of Long Distance Road Freight Data in Europe' in Bonnel, P., M. Lee-Gosselin, J. Zmud and J.-L. Madre (eds) 'Transport Survey Methods: Keeping up with a Changing World, Emerald, Bingley. pp 295-310.

McKinnon, A.C. and Piecyk, M.I. (2009) 'Measurement of CO2 emissions from road freight transport: A review of UK experience' Energy Policy, 37, 3733-3742.

McKinsey & Company (2010) 'Building India:Transforming the nation's logistics infrastructure'

National Co-operative Freight Research Program (2011) 'Performance Measures for Freight Transportation' Report 10, Transportation Research Board, Washington DC.

OECD / International Transport Forum (2010) Moving Freight with Better Trucks. OECD, Paris.

OECD / International Transport Forum (2015) 'Transport Outlook 2015' Paris.

Pérez-Martinez, PJ (2009) The vehicle approach for freight road transport energy and environmental analysis in Spain, European Transport Research Review, 1, 2, 75–85.

Rail Net Europe (2012) 'Guidelines for Freight Corridor Punctuality Monitoring' RNE, Vienna.

Sankaran, J., Gore, A. and Coldwell, B., 2005. The impact of road traffic congestion on supply chains: insights from Auckland, New Zealand, International Journal of Logistics: Research and Applications 8 (2), 159-180 .

Savy, M. (2010) 'Freight Transport Modes: Competition, Co-operation or Areas of Advantage' ACEA, Brussels.

Significance, VU University, John Bates Services et al (2012) ' Values of time and reliability in passenger and freight transport in The Netherlands' Report for the Ministry of Infrastructure and the Environment

Sorrell, S, Lehtonen, M, Stapleton, LM et al (2009) Decomposing road freight energy use in the United Kingdom, Energy Policy, 37 (8), pp 3115–29

Steer Davies Gleave (2013) The Impact of Megatrucks. Directorate General for Internal Policies, European Parliament, Brussels

Tapio, P. (2005) Towards a theory of decoupling: degrees of decoupling in the EU and the case of road traffic in Finland between 1970 and 2001, Transport Policy, 12, 137-151.

Transport Research Support (2009) 'Freight transport for development toolkit: road freight' World Bank / DFID http://www.ppiaf.org/freighttoolkit/sites/default/files/pdfs/road.pdf

US EPA (2014) SmartWay Program Highlights
http://www.epa.gov/smartway/about/documents/basics/420f14003.pdf

Woodburn, A. (2007) 'Appropriate indicators of rail freight activity and market share: A review of UK practice and recommendations for change' Transport Policy, vol. 14, pp. 59-69.

World Bank (2014) 'Connecting to Compete: Trade Logistics in the Global Economy' Washington DC

World Economic Forum (2012) 'Global Enabling Trade Report: Reducing Supply Chain Barriers' Geneva.

World Economic Forum, Bain & Company and the World Bank (2013) 'Enabling Trade: Valuing Growth Opportunities' Geneva.