

## Chapter 4

# Supply Chain Management, Logistics Changes and the Concept of Friction

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## Flows, Friction and Cities in a Global Economy

Within the globalization discourse, the concept of supply chain management has been actively investigated as it brings new challenges to the setting and organization of global freight flows (Leinbach and Capineri, 2007; Meixell and Gargeya, 2005; Waters, 2010). Every aspect of supply chain management, from product design, the sourcing of parts, the assembly and distribution has been impacted by outsourcing and a global division of production (Dicken, 2011). Longer and more complex supply chains are well understood outcomes, but several other changes are occurring in the organization and structure of material flows. To better understand this global distribution space the concept of distance is being expanded through the concept of logistics that requires the management of flows over four major components.

The first is *geographical* where each flow has an origin and a destination and consequently a degree of separation. Typically, flows with high degrees of separation tend to be more limited than flows with low degrees of separation. Paradoxically, however, globalization supported a higher degree of separation in conjunction with a growing intensity of flows between specific trade partners (WTO, 2008). The second is *physical* where each flow involves specific physical characteristics in terms of possible load units and the conditions in which they can be carried. The container has provided a convenient mean to standardize the physicality of flows (Levinson, 2006; Notteboom and Rodrigue, 2009). The third is *transactional* where the realization of each flow has to be negotiated between providers and users of transport services, such as booking a slot on a containership. Commonly, a flow is related to a monetary exchange between the provider of transportation and the user. Third party logistics providers

increasingly act as intermediary in the transactional processes behind supply chain management (Marasco, 2008). The fourth is *distributional* where flows are organized in sequences where the most complex are involving different modes and terminals. Many transport flows are scheduled and routed to minimize costs or maximize efficiency, often through intermediary locations. The notable growth of transshipment in maritime shipping is reflective of the growing importance of intermediate locations in the global system of maritime circulation (Notteboom and Rodrigue, 2010).

This chapter will discuss the dimensions over which the traditional concept of friction is being expanded by contemporary supply chain management practices and their related usage of transportation and distribution assets. A particular emphasis will be placed on the role and function of cities in the global system of freight flows. Although the concept of friction has always been a multidimensional one, supply management expands this concept further particularly with costs, time and reliability conditions that implies different levels of friction depending on the concerned supply chains.

The most salient changes provided by globalization on freight flows concern distribution. The more separated are the trading partners the more complex are the related supply chains and transport systems supporting them (Spens and Bask, 2002). Geographical theory has for long provided a rationale about the extent it is possible to overcome spatial constraints, notably the friction of distance (Huff and Jenks, 1968). A common theme is that improvements in transportation technology and infrastructure have been the most significant factors behind changes in the friction of distance, implying that a greater amount of space could be traded for a similar amount of time. Particularly, the concept of space - time convergence (Janelle, 1968; Knowles, 2006) has been influenced by freight distribution on issues related to speed, economies of scale, the expansion of transport infrastructures, the efficiency of transport terminals and the use of information technologies.

Yet, space / time convergence does not occur in an even manner. Over time, some locations gain more accessibility than others, particularly if they experience a higher level of accumulation of transport infrastructures. Accessibility often declines in relative terms, sometimes in absolute terms. After centuries of transport development, global accessibility illustrates a highly heterogeneous space that is reflected in freight distribution with a concentration around large manufacturing clusters, gateways and corridors. Cities have been the main beneficiaries of increasing accessibility as transport nexuses within the global space of flows. They are the convergence point of transportation infrastructure and services, they have an extensive concentration of transport terminals and have been equipped with a high capacity system of internal circulation through personal and collective mobility.

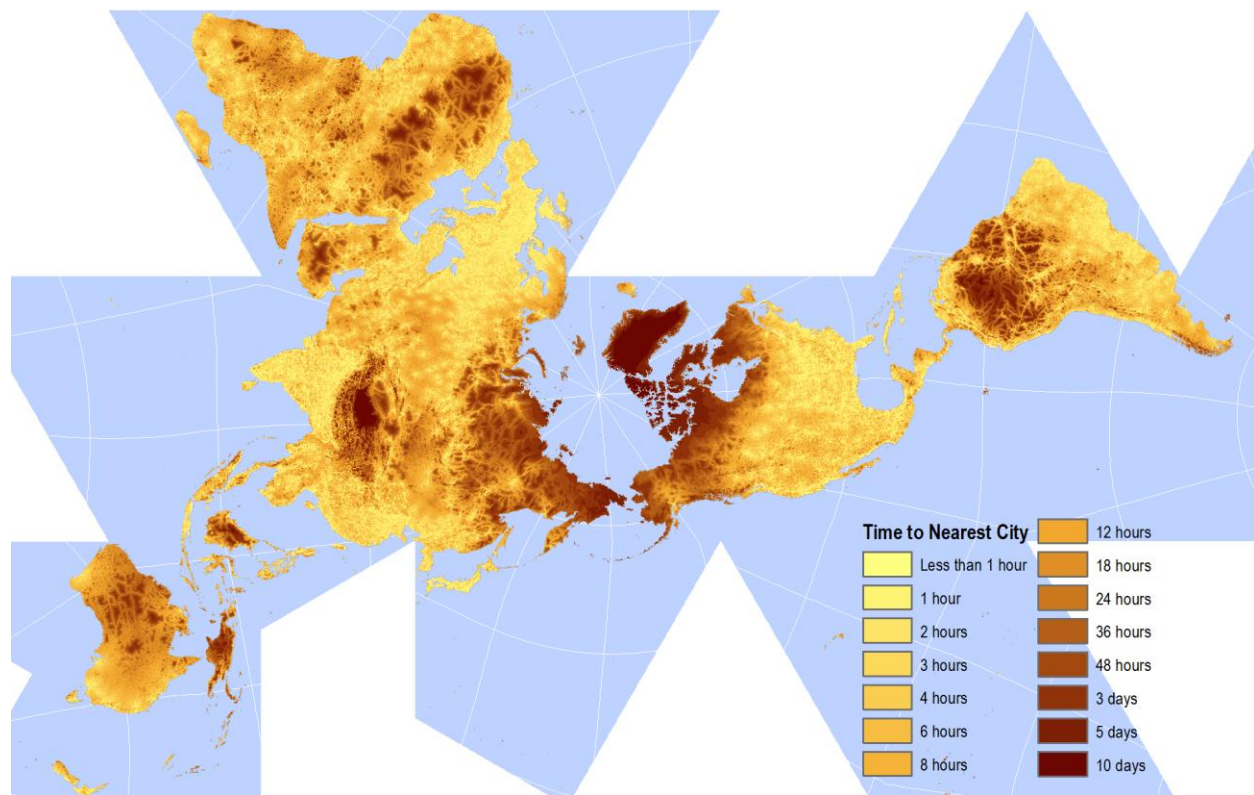


Figure 1 - Global Accessibility: Time to the Nearest Large City<sup>1</sup>

Space - time convergence is far from being a uniform process as differences in transport infrastructures and basic landscape constraints have a discriminatory effect on accessibility. Figure 1 represents travel time, from less than 1 hour to 10 days, to the nearest city of more than 50,000 people. It is the outcome of an overlay of several friction of distance factors, including the road and rail networks, navigable rivers, shipping lanes and land cover. It can be considered as a proxy for global accessibility with only 10% of the world's population being more than 48 hours away from a large city. While it depicts the general improvements in the ease of accessing urban markets, it does not depict well the effectiveness of particular freight flows. For instance, South Asia appears highly accessible because of the density of large cities; however, the quality and capacity of inland transport infrastructures is generally poor.

The global picture of accessibility must also be nuanced by the respective urban settings in which many flows are taking place, particularly those related to the “last mile”. City logistics is an emerging field dealing with the whole array of issues pertaining to urban freight flows and the unique friction conditions in large cities (Taniguchi and Thompson, 2008). As such, the concept of friction is evolving from a simple distance-based consideration to a more complex representation where a set of activities related to circulation, such as loading, unloading and transshipment, are considered. While this application of the concept of friction is more reflective of the intermodal reality in which freight distribution takes place, it does not fully addresses the reality of global supply chains.

<sup>1</sup> Source: adapted from Nelson, A. (2008) Estimated travel time to the nearest city of 50,000 or more people in year 2000. Global Environment Monitoring Unit - Joint Research Centre of the European Commission, Ispra Italy.

*Logistical friction* is a complex representation that encompasses all the tasks required so that a movement between two locations can take place. It thus includes flows, but also a set of activities necessary for the management of these flows (Hesse and Rodrigue, 2004). Among the most significant tasks for freight distribution are order processing, packing, sorting and inventory management. Geographical distance is less relevant in its assessment, but the interdependent factors of costs and time are very significant in light of the logistical requirements of having the right product in the right quantity at the right time in the right condition and at the right cost (Lee, 2004). Time not only involves the delay related to management and circulation, but also how it is used to service transport demand, namely the scheduling of pickups and deliveries.

## **Supply Chain Management and Material Flows**

### **Transport and Logistics Chains within Supply Chains**

The growing flows of freight have been a fundamental component of contemporary changes in economic systems at the global, regional and local scales. These changes are not merely quantitative with more freight in circulation, but are also structural and operational. Structural changes mainly involve manufacturing systems with their geographies of production; outsourcing has become a dominant paradigm (Jones and Kierzkowski, 2005). Operational changes mainly concern freight transportation with its geography of distribution, with intermodalism, the capability to use several transportation modes in a continuous sequence, being a dominant paradigm (Slack, 1998). The increasing level of control on physical flows has led to improvements in supply chains, namely over physical distribution and materials management; this is the realm of logistics. With improved logistics practices, timely deliveries can be made and lower inventory levels can be maintained, implying that a large share of the inventory is in constant circulation. The principle of uninterrupted flow is thus at the core of an effective use of logistics to support supply chain management (Figure 2).

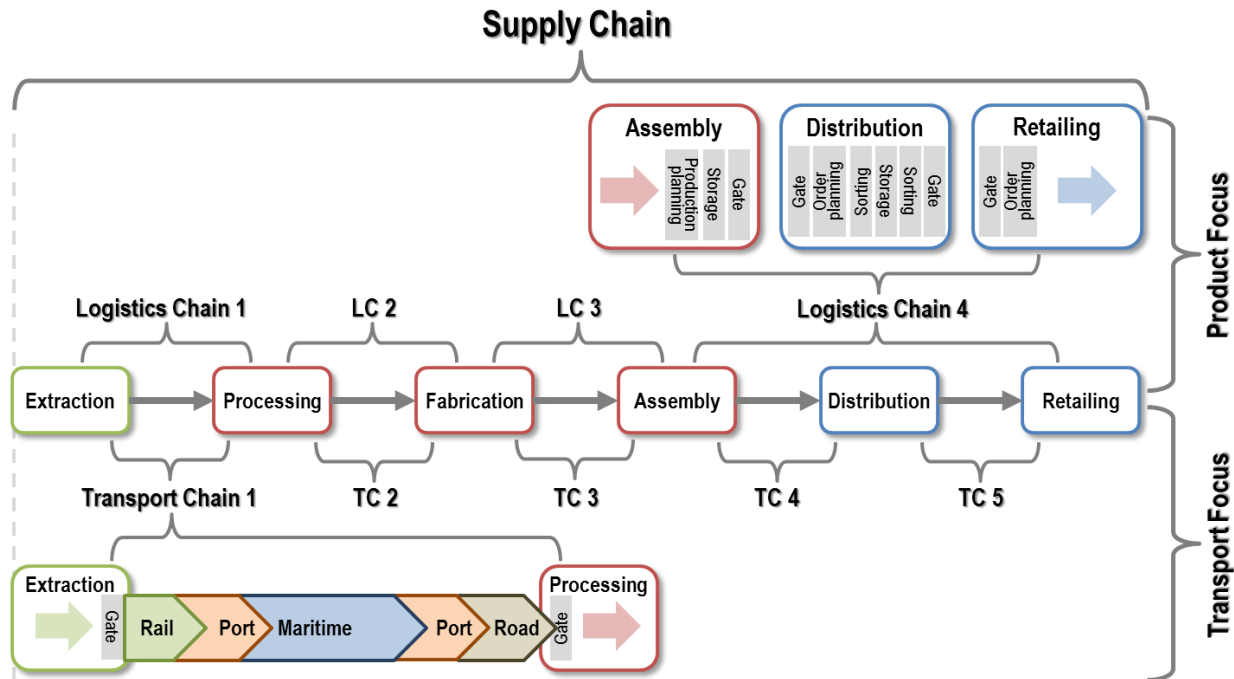


Figure 2 : The Scope of a Supply Chain, Logistics Chains and Transport Chains<sup>2</sup>

A supply chain focuses upon a product and extends back over the different actors, activities and resources required for making it available at the place of consumption. It encompasses a set of logistics and transport chains linking activities from basic extraction of raw materials to retailing (final consumption). It is rare that a whole supply chain will be managed by a single actor but it remains a functionally integrated entity. Flows at the supply chain level are organizational in nature, implying that they reflect a sequence of tasks required to make a product available, including where (division of production and distribution) and how (logistics) they are undertaken.

A logistics chain focuses upon an individual part (item) of an inventory and extends from when it is created (manufactured or received from a supplier) until it is dissolved (consumed, becoming a part of another item or being split into several items). For instance, a logistics chain could include a product that has been assembled into a final good, brought to a distribution center to be sorted and temporarily stored and delivered to a retail store. It is both a physical and managerial process. Flows at the logistics chain level are functional as they reflect concrete added value activities performed on a good.

A transport chain focuses upon a consignment and extends over movement, physical handling and activities directly related to transport such as dispatch, reception, transport planning and control. For long distance logistics chains, a transport chain can involve a sequence of modes and terminals. Containerization and intermodalism have helped improve the efficiency of transport chains and consequently of supply chains. Flows at the transport chain level are operational implying that they take a concrete form as a mobile unit within a transport system by using its modes and terminals.

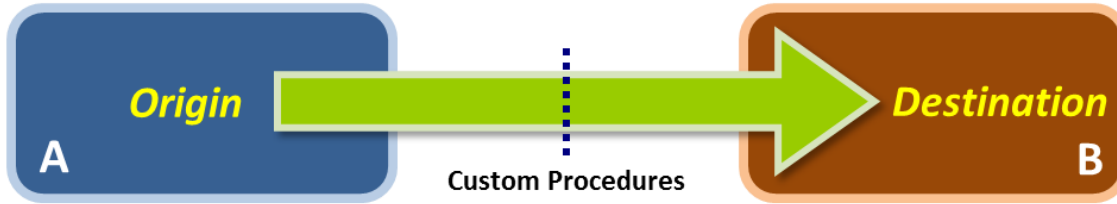
<sup>2</sup> Source: adapted from Woxenius, J. and J-P Rodrigue (2011) "Detours in Supply, Logistics and Freight Transport Chains", submitted for publication to the Journal of Transport Geography.

## Flows within Transport Chains

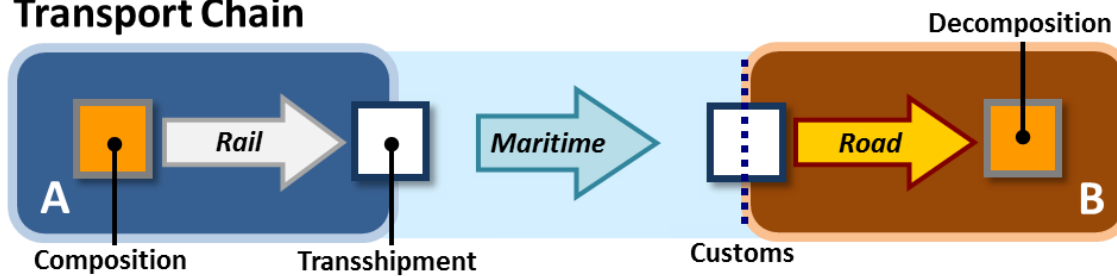
International trade focuses on what is being traded, the partners involved as well as the transactional environment in which trade takes place. Commonly, international trade is seen as a series of commercial transactions between trade partners that tracks the value of what is being traded as well as the nature of goods concerned (such as the standard international trade classification). Its extent, either in value or volume, is an abstract expression of the quantity of goods being exchanged as they do not represent the actual physical flows supporting trade. The physical realization of international trade requires a transport chain which is a series of logistical activities that organize modes and terminals, such as railway, maritime and road transportation systems, and thus the continuity along the supply chain through a set of stages, each having its specific friction factors (Figure 3).

The first stage in the transport chain is composition where loads are assembled at the origin, often on pallets and/or containers. Composition is an important process as it tries to achieve economies of scale over a transport chain by providing larger and easier to handle load units. The cargo being traded then moves along the transport chain using a transport mode, commonly rail or road to reach a terminal where it is transshipped to an international transport mode (at a port or airport depending on the nature of what is being transported). Additional economies of scale become possible as several load units can be consolidated into a single large shipment, such as a loaded containership. Once cargo enters another country through a gateway (point of entry) customs inspection takes place as the cargo is transshipped over the inland transport system. Custom procedures and delays are among the most constraining factors in global freight distribution (Arvis et al., 2010). The final stage of the transport chain, decomposition (the last mile), takes place in the proximity of the final destination. Loads are broken down into units corresponding to effective demand, such as store orders. If the demand concerns retail goods, urban freight distribution strategies may be required.

## International Trade



## Transport Chain



## Physical Flows

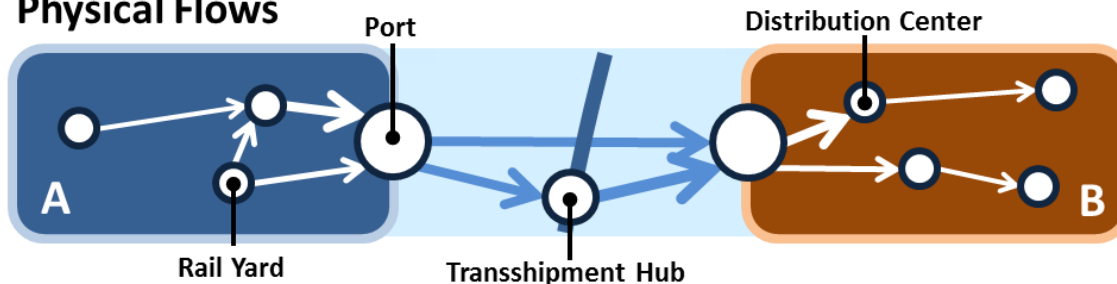


Figure 3 : International Trade, Transportation Chains and Flows

In the operational reality of modes and terminals, international trade is a series of physical flows that may not necessarily use the most direct path, but the path of least resistance. The existence of inland corridors which enjoy economies of scale, shapes the structure of freight flows and well as the selection of the port of entry or exit. On the maritime side, transshipment hubs have become strategic intermediary locations helping consolidate maritime flows and connecting different maritime systems of circulation (Notteboom and Rodrigue, 2010). In such a setting, the container has become the fundamental element facilitating transfers between modes and supporting international trade flows. Distribution centers also play an important role in physical flows since they can act as a buffer helping reconcile the temporal and spatial requirements of demand. Within the organizational and distributional complexity of contemporary international trade cities play a crucial role in logistics systems.

## Logistics: Shaping the Space of Flows in Cities

The development and provision of advanced logistics services varies from country to country. In most developing countries, the market for these services is small, which can be a major deterrent for companies wishing to establish a market presence. The first worldwide Logistics Performance Index (LPI) was developed to provide a better assessment about how respective countries rank in the managerial and physical effectiveness of their logistics (Arvis et al., 2010). At the global level, a gradual convergence

of the LPI is observed. It is mostly the outcome of the diffusion of transport infrastructures and services, a process favored by the growing presence of global freight carriers, such as maritime shipping companies, global terminal operators, air freight forwarders and even third party logistics providers.

The LPI is a composite index<sup>3</sup> based on proxy measures for transport and information infrastructure, supply chain management and trade facilitation capabilities, which are calculated based on a world survey of international freight forwarders and express carriers. The LPI rankings show that building the capacity to connect firms, suppliers and consumers, is key in a world where predictability and reliability are becoming even more important than costs. For instance, a difference of one point lower in the LPI is related to two to four additional days of port hinterland access and a 25% higher physical inspection rate at customs. High-income OECD countries lead in logistics performances, but developing countries are showing gradual and continuous improvements. They benefit from economies of scale and scope, innovation and technological change in logistics services. On average, the LPI is a good proxy for the involvement of each country in global value chains and the friction of freight flows.

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<sup>3</sup> The LPI is based on six underlying factors of logistics performance: (1) efficiency of the clearance process by customs and other border agencies; (2) quality of transport and information technology infrastructure for logistics; (3) ease and affordability of arranging international shipments; (4) competence and quality of logistics services; (5) ability to track and trace international shipments; and (6) timeliness of shipments in reaching destination.

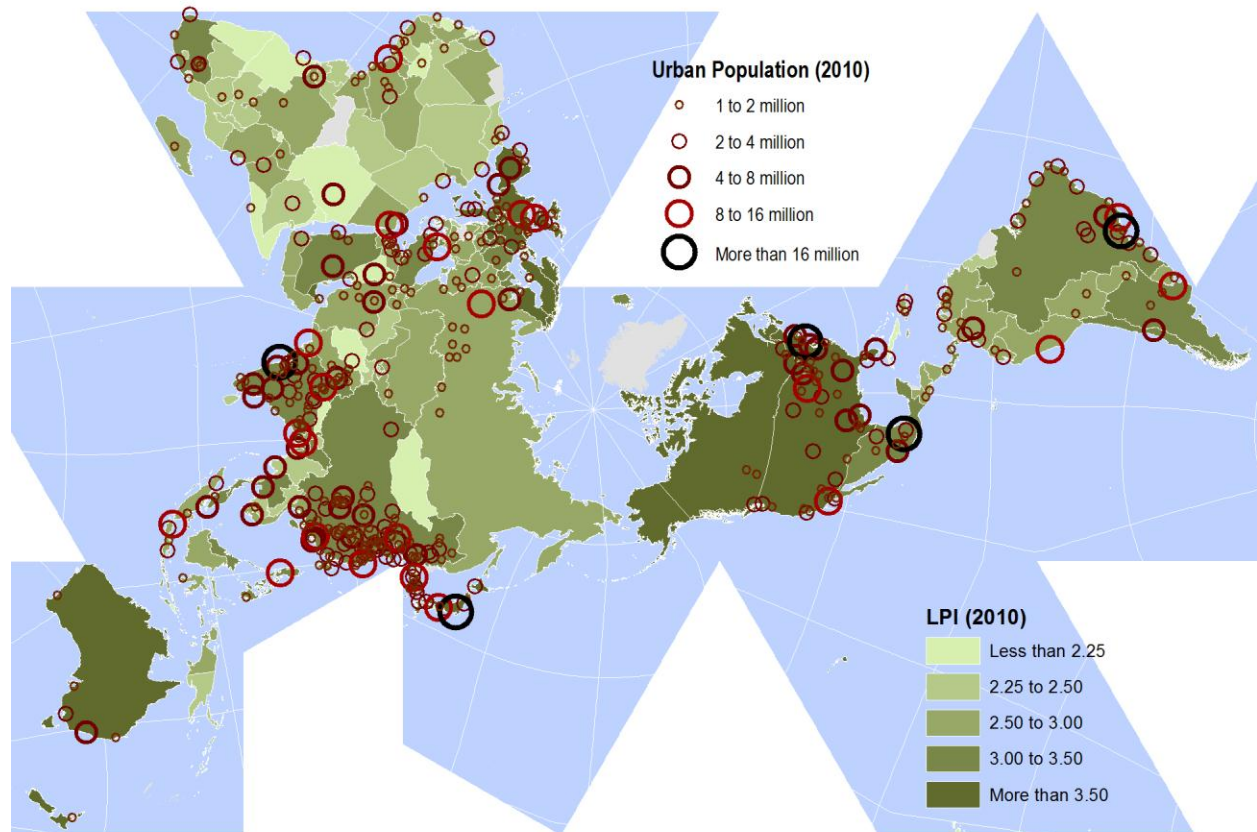


Figure 4 : Major Cities and the Logistics Performance Index, 2010<sup>4</sup>

While the LPI reflects global trade and supply chains, it can also be reflective of the logistical capabilities of cities (Figure 4). Of the world’s 435 cities of more than 1 million inhabitants, 27% of the population (336 million) lived in cities within countries with a low LPI (less than 3), and 47% of the population lived in cities with below average LPI conditions (between 3 and 3.5). Only 26% of the world’s large-city population lived in cities with good LPI conditions (more than 3.5). It can thus be inferred that more than half of the world’s urban population are living in cities where the logistical capabilities are deficient. Such an assessment should be interpreted with caution as significant national differences exist such as between coastal China, which has efficient export-oriented freight distribution systems, and its interior provinces where the quality of transport infrastructures is more lacking. Port and airport cities tend to have more capabilities for city logistics because of the availability of international trade infrastructures and a concentration of third party logistics service providers.

## The Multiplicity of Friction Factors

The multidimensional aspects of friction in light of contemporary supply chain management relate to several factors. Hesse and Rodrigue (2004) suggested that transport costs, the complexity of the supply

<sup>4</sup> LPI data from Word Bank. Urban population data from United Nations, World Urbanization Prospects: The 2007 Revision Population Database.

chain, the transactional environment and the physical environment were the most salient. Here, specific urban dimensions are examined, namely the divergence of production and distribution, intermodalism, logistics costs, transit time and reliability.

### **The Divergence of Production and Distribution**

The most evident friction from a geographical standpoint concerns the disconnection between production and distribution. Yet, in spite a growing level of separation between the components of supply chains, the level of embeddedness between production, distribution and market demand has improved (Coe, Dicken and Hess, 2008). The presence of an efficient distribution system supporting global commodity chains is linking (embedding) the elements of the supply chain in a cohesive system of suppliers and customers. A functional complementarity is then achieved through a set of supply/demand relationships, implying flows of freight, capital and information. It relies on distribution over vast territories where "just-in-time" and "door-to-door" strategies are relevant examples of interdependencies created by new freight management strategies, particularly since flows tend to be highly imbalanced. Intermodal activities create heavily used transshipment points and corridors between them, where logistical management is more efficient.

Extensive resource consumption in the global economy underlines a reliance on supply sources that are often distant, as for example crude oil and mineral products. The need to overcome space is fundamental to economic development and the development of modern transport systems have increased the level of integration of geographically separated regions with a better geographical complementarity. With improvements in transportation, geographical separation has become less problematic, as comparative advantages are exploited in terms of the distribution capacity of networks and production costs. Cities are the nexus of this divergence as the comparative specialization they reflect involves freight flows spanning the whole global urban system.

### **Intermodalism and the Velocity of Freight Flows**

The velocity of freight is more than simply the shipment speed, which refers to the rate at which it moves along modes. It also includes transshipment speed, which concerns the effectiveness of intermodal operations at port, airports and railyards. Many transportation modes, particularly maritime and rail, have not shown any significant speed improvements in recent decades, an indication that a speed barrier may have been reached. Intermodal operations have thus become one of the most important elements behind the increased velocity of freight and therefore of lower levels of friction. Containerization has been the fundamental factor behind such a radical change, as prior to containerization the shipment speed may have been adequate but acute delays linked with inefficient transshipment prevented many forms of effective operational time management of freight distribution. However, this undermines the local economic benefits that cities have enjoyed as a result of their role as points of transshipment

In many transport chains, the velocity of freight has reached a level where time based management of distribution becomes practical. This velocity must also be accompanied with a level of reliability in terms of schedule integrity. This enables a move from push (supply based) to pull (demand based) logistics where most of the inventory can be kept in circulation, minimizing warehousing. It is very likely that any

future improvements in the velocity of freight are going to be based on the function of transshipment, both from an intermodal and transmodal perspective. Still, the velocity of freight is being challenged. For instance, an increase in the amount of traffic eventually leads to congestion either along transport segments or at terminals, both having a negative impact on the velocity of freight. Maritime shipping companies have an important influence on the velocity of freight flows since they support the longest leg in international trade. Since the largest intermodal terminals are located within metropolitan areas, they are triggering new challenges for freight flows, particularly at their access gates. Indeed, these are often points of conflict over the externalities of freight movement. Large gateway cities need to reconcile flows that are simply transiting towards other destinations and well as flows originating or bound to the city.

## Logistics Costs

Total logistics costs consider the full array of costs to make products available to the final consumer, namely transport, warehousing and transshipment. Supply chain managers are particularly sensitive to the stability of the cost structure (consistent costs) implying that routes having cost fluctuations may be discarded in favor to routes of a higher cost, but with less volatility. The cheapest routing option is sought, as long as the cost structure remains stable, and supply chains are unlikely to be modified if a cost advantage is only temporary. The concept of cost is relative since its importance is in relation to the value of the cargo being carried. Cost considerations tend to concern more containerized goods that have a low value, such as commodities (e.g. paper) than high value goods (e.g. electronics).

Total logistic costs reveal much about the locational dynamics of logistics activities, particularly distribution centers (Figure 5). Transportation costs remain the dominant consideration as they account for about half of the logistic costs. Inventory carrying costs are also significant with a share of about one fifth of total costs. They include the costs of holding goods in inventory (capital costs, warehousing, depreciation, insurance, taxation, and obsolescence) and are commonly expressed as a share of the inventory value. Labor costs involve the physical handling of goods, including tasks such as packaging and labeling. Customer service encompasses receiving and processing orders from customers.

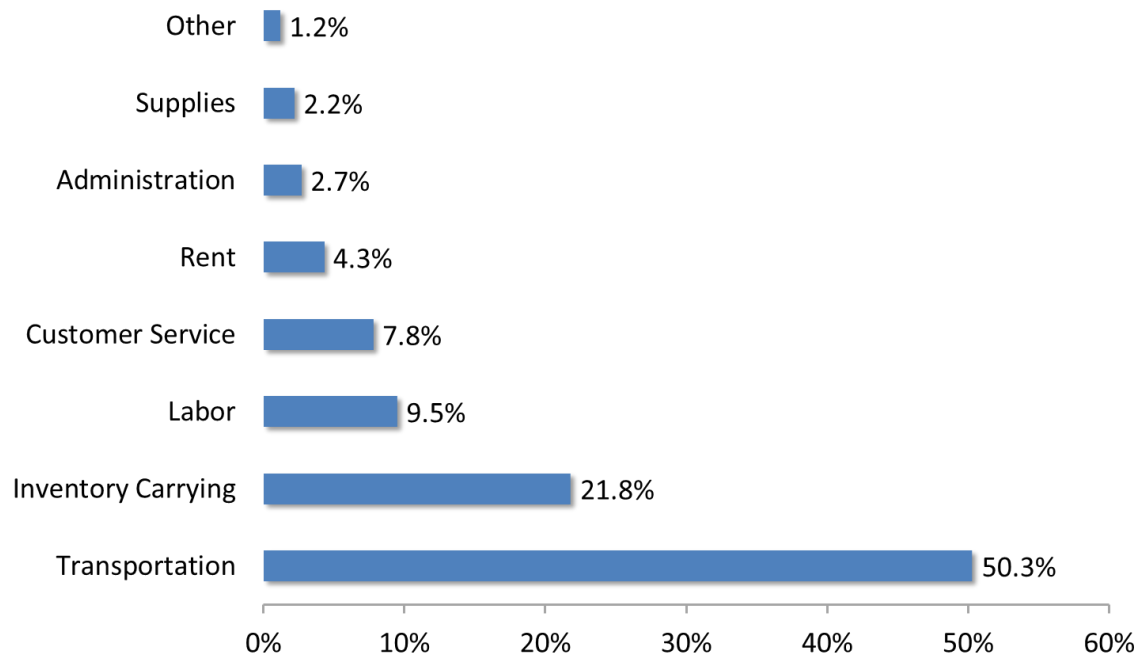


Figure 5 : Logistic Costs Breakdown<sup>5</sup>

Under such circumstances, distributors are willing to pay higher rents to take advantage of a logistics site that are in proximity to an intermodal terminal since this strategy enables them to reduce transportation costs, such as drayage, as well as improve their time responsiveness (lead time). Therefore, while transportation costs remains the most important element of logistics costs and its friction, components such as inventory carrying and labor costs, are significant. The urban setting has a notable impact of the logistics costs structure as congestion and higher rent values results in higher costs. Those higher costs are compensated by better economies of density such as the availability of labor, proximity to customers, higher concentration of consumption and lower lead times.

### Transit Time

Transit time is a factor that is increasingly being considered since it strongly influences inventory carrying costs and inventory cycle time in supply chain management. So, for cargo that has a higher value (clothing) or is perishable (reefers) the routing option that is the fastest and/or shortest will be preferred. Transit time is also an important dimension in the evaluation of transport costs, particularly since logistics concomitantly involves cost and time management. Cities have the advantage of being highly accessibly for global and regional freight flows and thus provide among the best long distance time performance. However, they are the most challenging environments for local freight distribution where congestion impairs, often in an unpredictable fashion, the timeliness of freight distribution.

The cold chain is a type of supply chain that has a high level of time friction since it transports goods that are temperature sensitive and perishable. Longer time periods are linked with the potential degradation

<sup>5</sup> Source: Establish, Inc. / HWD & Grubb & Ellis Global Logistics.

of the product or breaches in the temperature integrity. For food products such as fruits and vegetables, time has a direct impact on their shelf life and therefore on the potential revenue a consignment may generate. The efficiency and reliability of temperature controlled transportation has reached a point which allows the food industry to take advantage of global seasonable variations, meaning that during the winter the southern hemisphere can export perishable goods to the northern hemisphere while an opposite trade, generally of smaller scale, takes place during the northern hemisphere summer. Since cities are the main consumption markets of cold chains the timeliness of deliveries has direct commercial implications in terms of the shelf life of perishables.

## Reliability

Reliability relates to a factor that is mitigated by contemporary supply chain management practices. For several supply chains, transit time can be a secondary factor as long as shipments arrive at the distribution center within an expected time frame. If shipments are regular and reliable, it is possible to organize supply chains accordingly by having more inventory in transit. Therefore, the lack of reliability becomes a direct friction factor for supply chains. Freight distribution has a level of disorder (fragmentation), implying that the higher the level of disorder the more significant the efforts made to maintain its operational conditions. The functional and geographical integration of freight distribution are strategies to cope with uncertainties derived from spatial and organizational fragmentation (Rodrigue, 2006). The higher the uncertainty, the less reliable and the more costly freight distribution is. Among the most common sources of uncertainty are capacity constraints, congestion and energy prices.

## Cities as Supply Chain Bottlenecks

### Cities and Bottlenecks

Bottlenecks are locations in global freight distribution that are imposed by nodal capacity constraints. They are the main locations where logistical friction is taking place, commonly corresponding to large cities. Physical restrictions can form bottlenecks as traffic expands. Under-investment in infrastructure can produce chronic bottlenecks when rapid economic growth takes place, implying that capacity is insufficient to keep up with the demand. Temporary transportation bottlenecks can be caused by natural or market forces. Weather disruptions, such as a storm, are among the most prominent, as well as construction and accidents. These events are expected, but cannot be predicted. A surge in demand can also create a bottleneck as many freight distribution systems are designed to convey a constant level of service. Dis-investment, often through the lack of maintenance, can cause temporary bottlenecks that could become permanent. It is clear, as exemplified by the LPI (see Figure 4), that there are significant variations in the effectiveness of cities in facilitating freight flows as gateways or as points of final consumption.

Regulations that delay goods movements for security or safety inspections create bottlenecks as a direct consequence. Urban areas are particularly prone to regulatory constraints in terms of land use and freight operations (e.g. speed, vehicle size, parking, curfews, etc.). Even if the intention is not to convey delays, regulations inevitably cause delays and disruptions. Supply chain bottlenecks relate to specific tasks and procedures in supply chain management that trigger bottlenecks. For instance labor

availability, such as work shifts, may impose time dependent capacity shortages at terminals and distribution centers. Some firms may create bottlenecks on purpose as a rent seeking strategy since they control key elements of the supply chain. Technology can also be an issue as different information exchange protocols can create delays in information processing and therefore delays in shipments (or transshipments).

### Hubs and Transshipment: Disconnected Cities and Flows

With the growth of long distance containerized trade, intermediate hubs grew in importance in helping connect different systems of maritime circulation (Olivier, 2010). They tend to be located along the main circum-equatorial maritime route that goes through Panama, the Strait of Malacca, Suez and Gibraltar and that links the world's major production and consumption markets (Figure 6). Many also provide a relay function between the north-south and the east-west shipping lanes. The world's most important intermediate hub is Singapore where 85% of the traffic is transshipment, which accounted for more than 25.9 million TEUs in 2009.

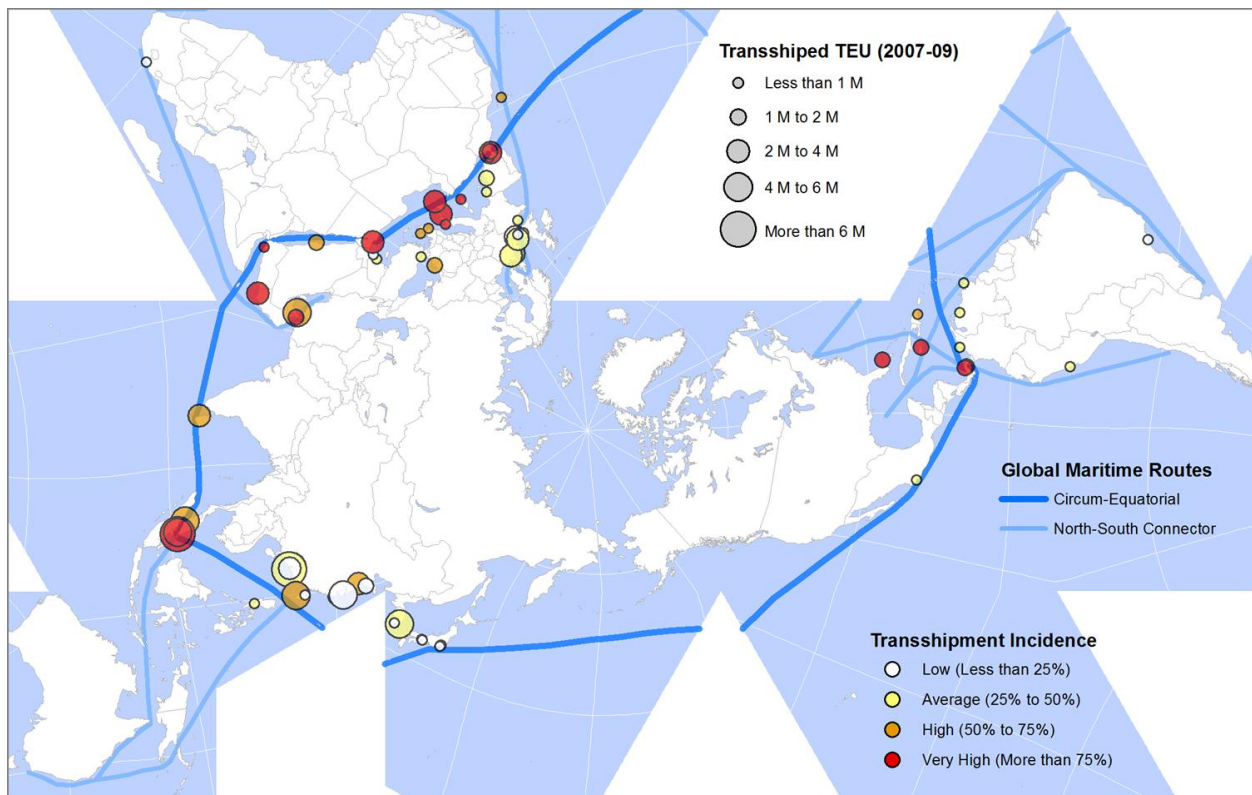


Figure 6 : World's Main Intermediate Hubs and Markets, 2009<sup>6</sup>

The emergence of major intermediate hubs favored a concentration of large vessels along long distance high capacity routes while lesser ports can be serviced with lower capacity ships. Economies of scale over long distances are thus reinforced. The emergence of intermediate hubs permitted liner services that would otherwise be economically unfeasible. However, there is a limit to the hub-and-spoke

<sup>6</sup> Source: Data from Drewry Shipping Consultants.

network configuration and consequently also to the size of the vessels being deployed on the trunk routes.

Transshipment incidence is the share of the total port throughput that is "ship to ship", implying that the final destination of the container is another port. The higher it is, the more a port can be considered as a transshipment hub and an incidence above 75% places the port as a "pure" transshipment hub. Geography plays an important role in the setting of a transshipment market, which is often at the crossroads of north / south shipping routes and where there is a bottleneck. Singapore is such a case where the major Asia - Europe shipping lanes are constrained to pass through the Strait of Malacca. The Mediterranean has only two points of entry, Suez and Gibraltar, both of which have significant transshipment activity (Port Said at Suez and Tangier Med at Gibraltar), as well as ports that are at the center of the basin (e.g. Marsalokk). Although the Caribbean has a large exposure on the Atlantic side, it has one outlet for the Pacific; the Panama Canal which has significant transshipment activities both on the Atlantic and Pacific sides. The North Sea and the Baltic are another transshipment market, but of lower incidence since the Baltic generates limited volumes of freight.

What is salient about the emergence of transshipment hubs, many concerning large terminal facilities having a significant imprint on the urban littoral, is that they relate to a different urban geography. While transshipment traffic can be significant, it does not interact much with its hinterland, which is effectively disconnecting terminal / city relations. This function creates a sense of "placelessness" in global freight flows since transshipment locations may be interchangeable.

### **City Logistics: Global Processes, Local Flows**

While cities are important producers and consumers of freight, much of these activities were taking place in proximity to major transport terminals, such as ports and railyards, with limited quantities of freight entering the city per se. The functional specialization of cities, the global division of production, containerization and intermodal terminals, the rise of service activities as well as increasing standards of living are all correlated with a higher demand for transport and logistics services in cities, a higher frequency of deliveries, and larger quantities of freight shipments coming from, bound to or transiting through urban areas. This challenges the sustainability of major gateway cities as they are coping with flows linked with processes well outside their jurisdiction (Hall, 2007). Still, the scale, intensity and complexity of urban goods movement have reached a point where in many cities additional forms of organization and flow management are required.

All urban freight distribution systems involve a wide array of supply chains, each of various salience depending on the urban setting and the level of development, but coming into two main functional classes (Dablanc, 2009). The first is related to *consumer-related distribution*. Independent retailing concerns a wide variety of retailing activities, often of small scale (single store) and which can also take the form of more informal activities such as street stalls. Chain retailing concerns larger stores (such as "Big box" stores) that tend to be located in suburban locations, enabling them to offer parking space for their customers as well as dedicated delivery bays accommodating larger trucks. Food deliveries concern specialized supply chains supplying outlets (grocery stores and restaurants) with goods that are often perishable. In developing countries, outdoor (or central) markets are particularly important as they

represent a dominant supply of fresh food for the urban population. Due to the significant growth of transactional activities (e.g. trade, finance) the movement of parcels has increased on par with the companies specialized in these freight distribution services (e.g. UPS, DHL, TNT, FedEx). Another emerging dimension concerns home deliveries, particularly with the growth of web-based retail transactions.

The second functional class of city logistics is related to *producer-related distribution*. The constant renewal and repair of urban infrastructures (e.g. housing, offices, roads) requires a supply of materials to construction sites. Waste collection and disposal concerns the collection and disposal of the variety of wastes generated by daily urban activities. It is a form of reverse logistics since the waste being discarded were previously goods being delivered. To this can be added recycling activities, all of which using specialized vehicles. Industrial activities and transportation terminals such as ports, airports and railyards generate a substantial amount of goods movements within cities. Gate access at intermodal terminals, particularly ports, can lead to congestion (queuing) and local disruptions. Logistics zones and industrial parks also generate substantial amounts of freight movements.

Reconciling the demands of the wide array of flows related to urban activity systems remains a challenging task. How effectively this is addressed at the metropolitan level will shape commercial, transport and industrial competitiveness and consequently future development opportunities.

## Conclusion

This chapter expanded the conventional concept of friction to better reflect contemporary supply chain management strategies and their underlying flows, particularly as it relates to large cities. It illustrates a distribution geography not necessarily coordinated by distance, but mainly by costs and time considerations and their respective applications along supply chains. The global structure of production, the impacts of intermodal transportation assets on the velocity of freight, a total logistics costs perspective, the dimensions of time in logistics, such as timing, punctuality and frequency, and distribution reliability were the main factors being considered. Paradoxically, the multidimensional perspective brought by supply chain management upon the concept of friction makes a quantitative assessment quite problematic, particularly over the value of time. Still, proxy measures, such as the Logistics Performance Index, have been developed and underline a wide array of logistical frictions around the world's cities.

Since global supply chains concern an extensive array of good flows, each friction factor spans differently. The common rule of the thumb is that high value goods tend to be more time sensitive than low value goods. Yet, supply chain managers are also able to effectively mitigate time with reliability, which implies that longer and cheaper routes can be used as long as some frequency and reliability criterion are met. Thus, what may be considered an important friction factor for one supply chain may be of much less impact for another. Additionally, risk and supply chain disruption considerations raise caution in terms of relying upon a single supplier or a transport chain and may incite the usage of transport chains having a higher degree of friction. Friction is therefore most relevant when looked at

the supply chain level instead of at the geographical level, even if supply chains have an effective geography.

Prospections about how the friction factors discussed may unfold remain speculative, particularly for urban areas. It can be assumed that higher energy prices will transcribe into higher transportation costs, but modal demand elasticity will impact elements of the transport chain to different extents (Hull, 2005). In such a context a distinct possibility concerning the creation of complementary supply chain flow channels, each with a different cost / time / reliability / risk balance, remains. Still, cities are the nexus of the global system of freight flows and as bottlenecks they will greatly shape the structure of global supply chains.

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