Emerging global logistics networks: Some consequences for transport system analysis and design

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17TH SYMPOSIUM – BENEFITING FROM GLOBALISATION – ISBN 978-92-821-0168-1 – © OECD/ITF 2008

SUMMARY

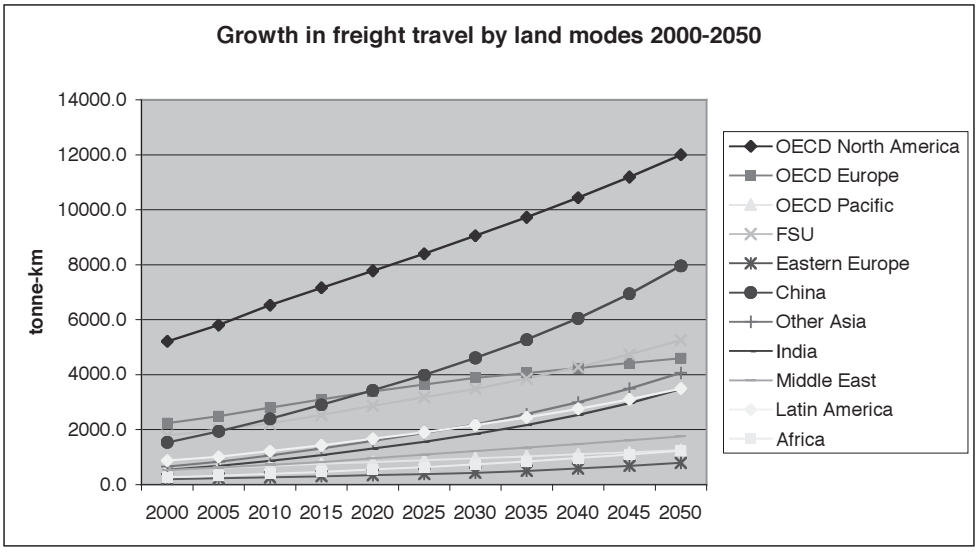
Delft, June 2006

1. INTRODUCTION

The internationalisation of freight flows is a mega-trend, stimulated by a large number of underlying developments. The way in which individual trends manifest themselves varies according to the geographical scale at which companies and markets are operating. Complex global trading networks have evolved, primarily, to exploit labour cost differences and the availability of raw materials in particular countries. Their development has also been facilitated by major regulatory and technological trends. Trade liberalisation, particularly within trading blocks such as the EU and NAFTA, has removed constraints on cross-border movement and has reduced related "barrier costs".

For the coming decades, we expect a continued growth of global freight flows. Some sources predict a doubling of present flows within half a century (WBCSD, 2004). Although this growth will be most visible in the emerging Asian economies (especially China and India), flows are expected to increase steadily in all regions of the world.

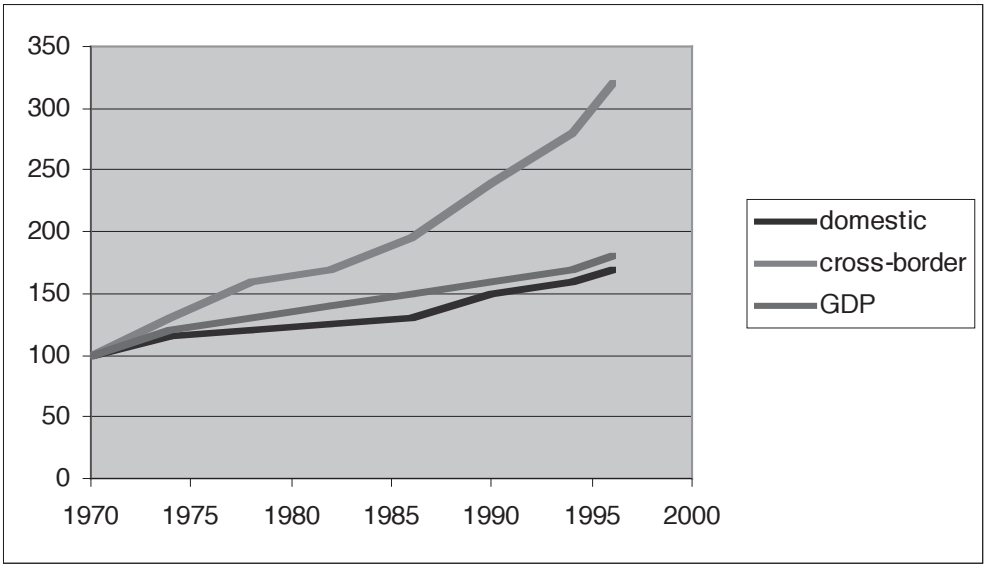
Figure 1. **World trade forecasts**



Source: WBCSD.

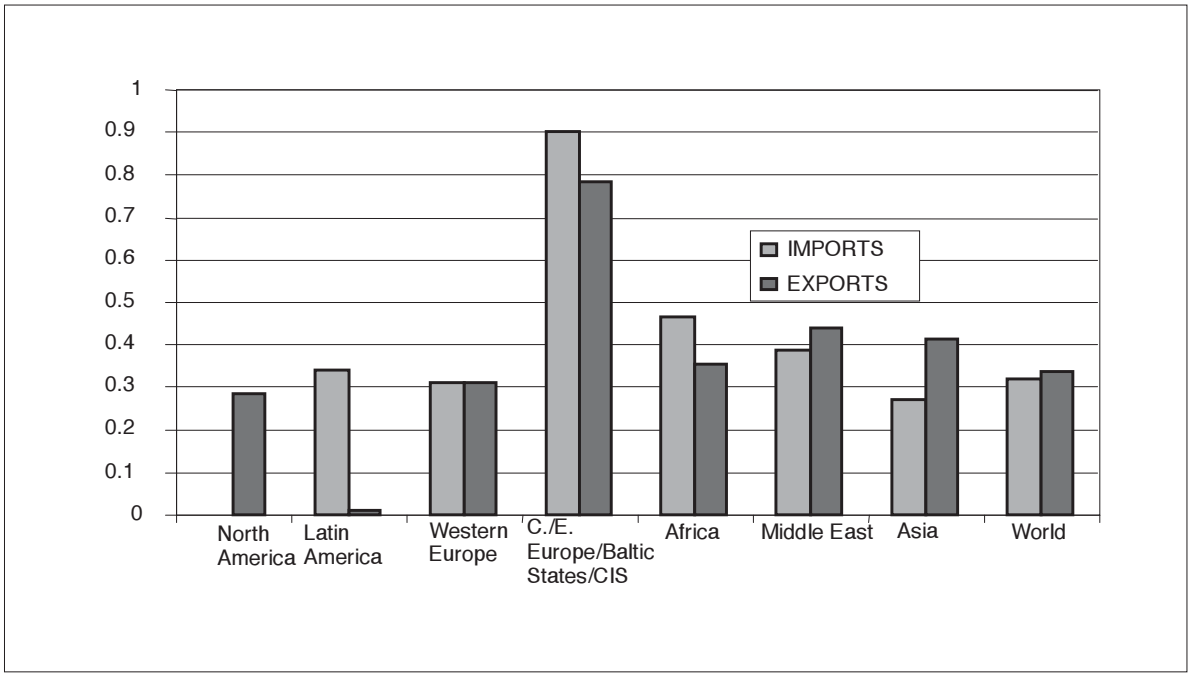
Within the EU, freight transport has doubled within a period of thirty years and forecasts are still equally strong (Kernohan, 2005). Apart from economic growth, this growth of freight travel is also explained also by changes in intercontinental trade and a decrease of barriers within the European continent. In the past decades, growth in cross-border flows, and in particular East-West, is twice as high as the growth in domestic transport, and surpasses GDP growth by far (Figure 2). The decrease of trading impediments has been the most rapid between East and West Europe, leading to almost a doubling of trade in this period (see Figure 3).

Figure 2. **Growth of freight transport within the EU**



Source: European Commission.

Figure 3. **Growth of trade with Western Europe, 1999-2003**



Source: WTO.

International trade goes hand in hand with technological and logistical innovations. Advances in telecommunications and information technology have given companies the means to manage the physical movement of product over long, often circuitous, routes. Many carriers have invested heavily in "track and trace" systems, to be able to establish the location of any consignment at any time,

thus improving the visibility of the global supply chain to shippers and their customers (see, e.g., HIDC, 1998). The consequences for the spatial patterns of settlements of production and logistics sites and the resulting freight movement are potentially huge. A compilation of a large number of logistics surveys (Sangam, 2005) reveals high expectations for the immediate future of the global logistics industry, which all point to a strongly dynamic market, where global trade and logistics are in positive interaction:

- Growth figures of around 10% per annum in the logistics outsourcing industry in the US and the EU; 15% per year in the Asia Pacific region;
- A warehousing market in Europe growing from €18.5 billion (2003) to €25.4 billion (2012);
- An expected 150% increase in revenues for logistics service providers in eastern Europe in the period 2003-2006.

This paper explores the logistics dimension of these changes, and develops some thinking around the possible consequences for transport systems: what new requirements will these emerging logistics networks place on our intermodal transport systems? What do we need in order to build new scenarios for strategic decision-making in the public sector that take these developments into account?

The paper is organised as follows. In the next section we discuss the logistics trends that are key to a globalising economy. Section 3 treats the implications of these trends on the spatial configurations of logistics networks. In Section 4 we describe the requirements that these new network forms impose upon intermodal transport systems. Section 5 records the consequences for methods of modelling and simulation, as a means to inform decision-makers. We conclude our paper with a brief summary of the key findings and some recommendations in Section 6.

2. HIGH-QUALITY LOGISTICS NETWORKS ARE KEY TO A GLOBALISING ECONOMY

The evolution of logistics networks during the last decades can be characterised by a strong rationalisation of business processes. Companies have become more aware of the impact that their logistics organisation can have on the costs of doing business and on the degree of satisfaction of their customers. Facilitated by the advent of information and communications technology and the lowering of trade barriers, companies have sought to optimise their logistic processes by continuously restructuring distribution networks and logistics partnerships. Logistics costs have fallen world-wide by 20-40% in the last fifteen years (ELA, 2002). Companies have found that one of the instruments to save resources and improve performance is to outsource logistics tasks to specialised service providers. Over a longer term, we can see that companies have been withdrawing to their core business by sourcing transport services (the so-called 3PL) and wider logistics services (4PL) from outside. At the same time, many external drivers have steered the development of logistics services. The series of production steps of goods is increasing, as the firms that produce goods tend to become more and more specialised, searching to reap economies of scale. The so-called “focused factories”

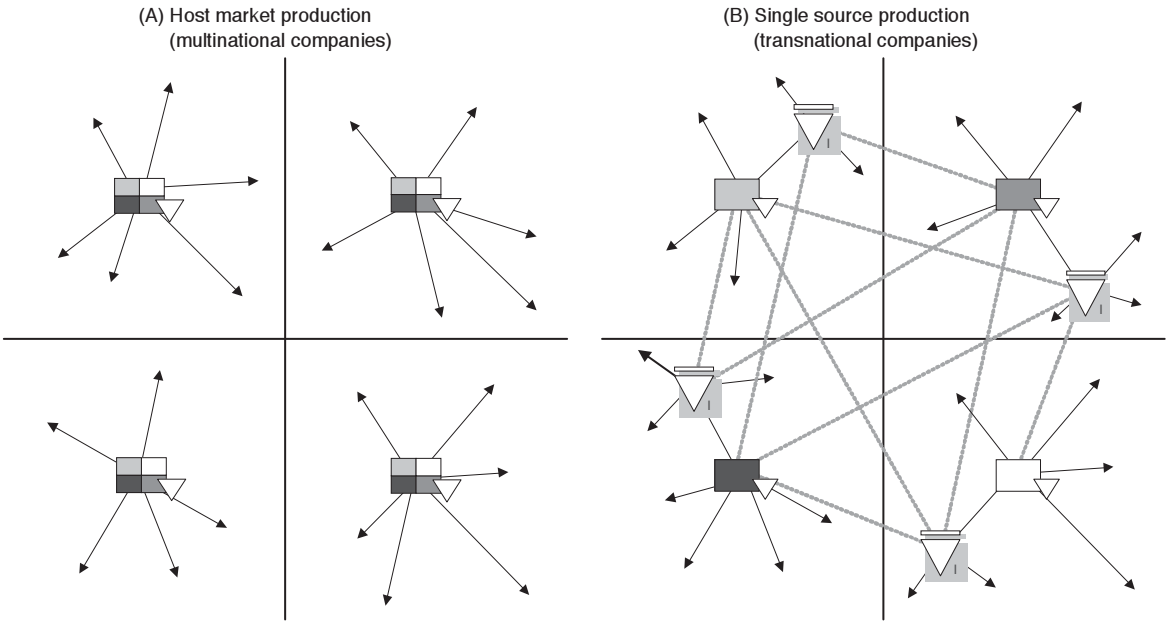
(producing only one specific, specialised item) are an extreme example of this. The increased technological possibilities to offer highly customised goods and to deliver these at short notice to markets worldwide are much appreciated by the consumer, and firms now compete to surpass each other in the area of logistics performance, instead of competing on product prices or physical product quality alone.

Over the past years there has been a sustained trend towards the globalisation of business. Ohmae (1985), for example, points to the trend of several life-style preferences around the world which creates ever-wider markets for products. Upstream in the market, there are also several important factors which drive the process of globalisation. Increasingly, it is too expensive to duplicate best manufacturing practice in each of an organisation's major markets. Manufacturing facilities have therefore become more focused, both by product specialisation and geographical location. Inevitably, as the process of globalisation continues, the character of companies must change.

The multinational and transnational or global corporations are not the same thing. The multinational corporation operates in a number of countries and adjusts its products and prices in each country - at high relative costs. The global corporation operates with resolute certainty - at low relative costs - as if the world (or major regions of it) were a single entity; it tries to sell the same products in the same way (Levitt, 1983).

Achieving economies of scale in business has been an important parallel development, in line with the changes in globalisation and manufacturing. If economies of scale exist that extend beyond the size of national markets, then there is a potential cost advantage to companies through centralised production (Lee, 1986). In other words, it will be worthwhile manufacturing in one location, to serve a number of markets, rather than to have national manufacturing units. This has been the strategy of companies such as Procter & Gamble, Kimberly-Clark and Unilever. A vital point about single sourcing of production is that it distances many final customers from production, as shown in Figure 4.

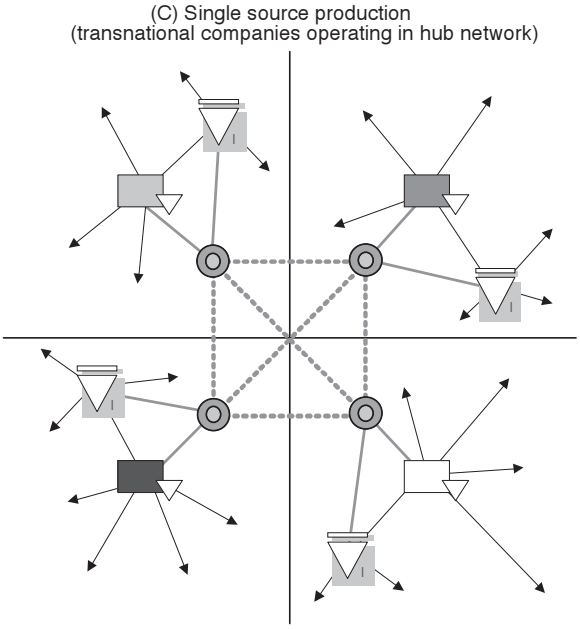
Figure 4. **Host-market production versus single source production**



Source: Adapted from Dicken, 1986.

For the multinational company operating a host-market production strategy, customers and production are in close proximity. As Figure 5 shows, this is less true for a global or transnational company practising single-source production; it follows that there are major implications for logistics management in this transition from multinational to global operations, leading to a growing fragmentation of flows and increased transport distances.

Figure 5. **Single source production operating in a hub network**

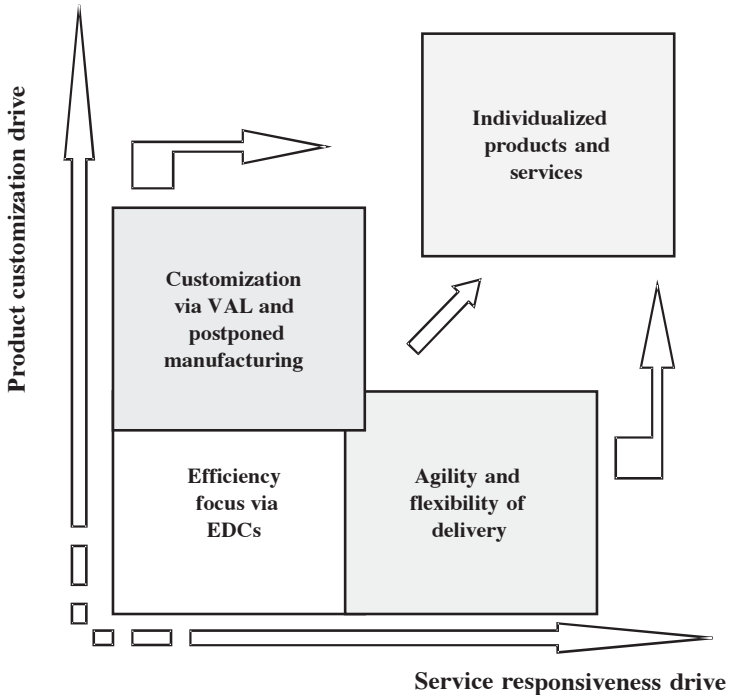


The above trends have introduced an important dilemma into logistics thinking – weighing logistics costs against logistics service quality. The supply chain management discipline embodies this strive to balance these two sides of the equation in order to raise profits, shareholder values and market shares. Especially when considering which changes in logistics networks are yet to come, this dilemma involves a tension between increasingly complex consumer demands and logistic costs. More specifically, on the one hand, the firm is faced with a fragmentation of flows because of smaller, customised shipments in higher frequencies; on the other hand, the need to maintain control over cost levels through benefits of scale in the logistic process is as high as ever. Typically, companies are now turning outside the boundaries of the firm and are seeking horizontal co-operation to bundle flows and save costs. Before we look at these co-operation issues, we first describe the spatial changes in logistics networks that accompany these globalised flows.

3. THE EVOLUTION OF LOGISTICS NETWORKS RESULTS IN NEW SPATIAL INTERACTIONS

Figure 6 shows how, from a consumer perspective, the two main "megatrends" in terms of the evolution of logistics networks, namely "customisation" and "responsiveness", are melting together to form new structures which satisfy the above demands.

Figure 6. **Market drivers for new logistics concepts**



Source: Vermunt *et al*., 2000.

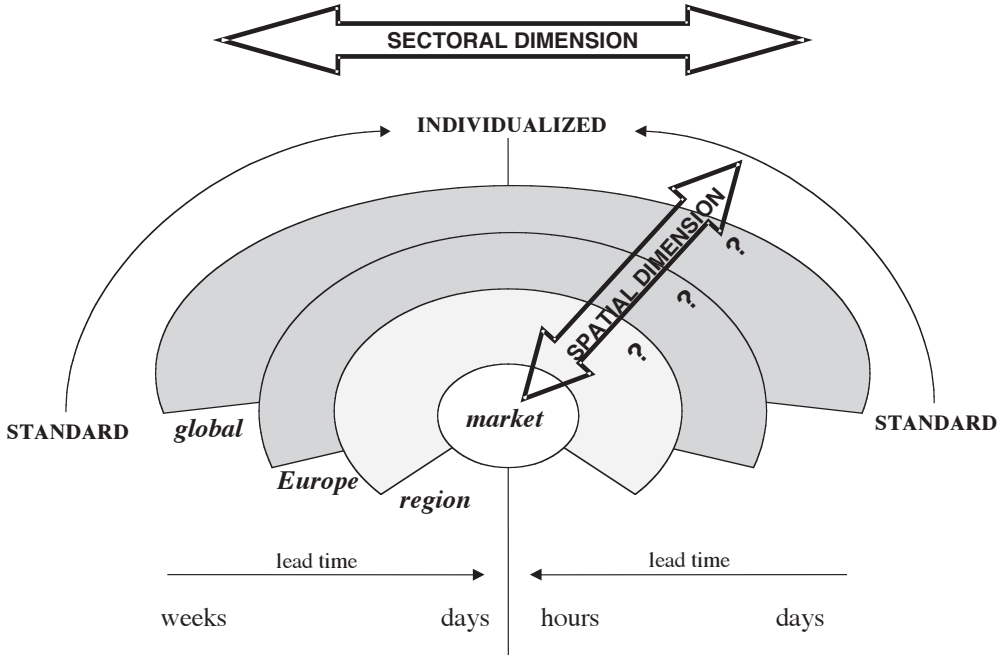
We see an increase in product variety, up to the level of individualised products and services. Eventually, this will go hand in hand with an improvement of lead times to the extent that customised products have the same responsiveness as standardised products have now. Note that the two main axes for development, "service responsiveness" and "customisation", can be operationalised using practical performance criteria like lead time or reliability, shipment size or frequency.

The question that needs to be answered is how these trends in logistics concepts are related to the global spatial economy. These relations are bi-directional, i.e. logistics structures depend on spatial economic structures and also influence them. We have two perspectives from which we observe these relationships:

1. *The sectoral perspective*: which logistics structures will evolve as a result of the above trends? We describe these changes in the remainder of this section.

2. *The spatial perspective:* what is the implication of long-term changes in logistical structures upon economic growth and economic development at various spatial levels (local, regional, continental and global)? (Figure 7).

Figure 7. **Interrelationships between logistics structures and spatial economic structures**

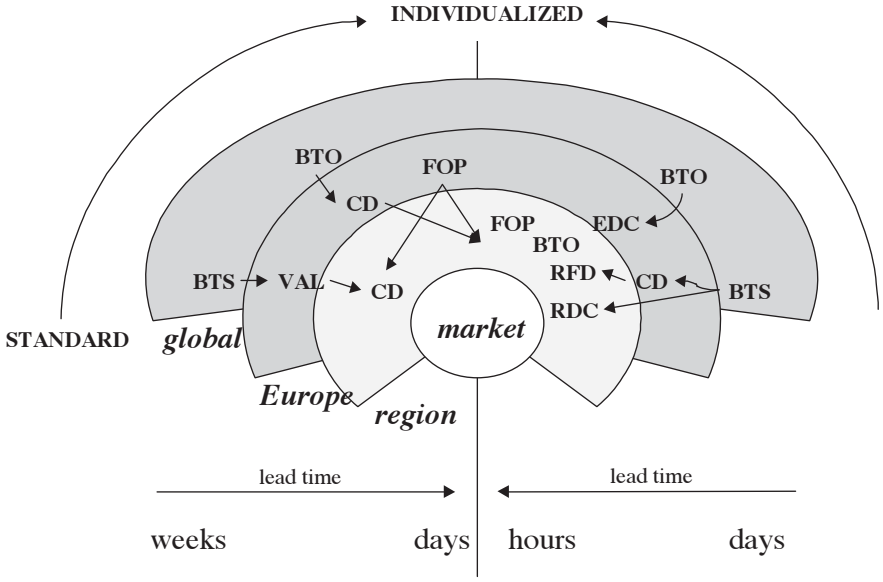


Source: Adapted from Vermunt *et al*., 2000.

The horizontal, i.e. sectoral, dimension in the figure combines the two trends of responsiveness (translated into order lead time) and customisation. The higher the degree of both responsiveness and customisation and the higher the importance of individualised products and services, the nearer we are to the central axis of the figure. The spatial dimension is built up as concentric rings around the central area of consumption, the market. Figure 8 shows how different production and distribution concepts result in this spatial layout, from the global scale towards the local market.

These network structures vary according to the degree of customisation and the degree of responsiveness required. Typical trends are the moves from European distribution, based on production to stock, towards production to order, where delivery takes place directly or through cross-docking. Also new concepts like rapid fulfilment depots (for low-demand but urgent products) and flexible order production (allowing fast switching in batch size and end-product specifications) are being introduced to allow for better responsiveness. The changing of distribution concepts is accelerated by wide-reaching, Internet-based planning and management systems. These do not only include the new business-to-business and business-to-consumer applications, but business-internal applications as well. The Cisco spare-part delivery network guarantees fulfilment of any order anywhere in the world within two hours; this is only possible through a seamless connection between external linkages and the internal logistics processes.

Figure 8. **Logistics structures by demand segment**



Legend

short	Detail
FOP	flexible order production
BTS	built to stock
BTO	built to order
RDC	regional distribution center
EDC	European distribution center
CD	cross-docking
RFD	rapid fulfillment depot

Source: Adapted from Vermunt *et al.*, 2000.

This is a mere illustration of the state-of-the-art transport requirements for products with a high degree of customisation, short lead time and small shipments. In the next section we will describe in some more detail these requirements of increasingly global logistics networks upon the management of transport systems.

4. GLOBAL NETWORK MANAGEMENT: NEW DEMANDS UPON TRANSPORT SYSTEMS

The management of the intricate networks (in terms of planning and operations) described in the previous chapter, places high demands on the freight service industry. The expanding worldwide economy helped the Top 25 Global Logistics Service Providers (LSPs) towards strong double-digit growth in 2004. In turn, the large LSPs are prosperous enough to invest in high-quality systems, processes and logistics networks that have allowed the world's largest companies to implement efficient supply chains stretching from Asia to North America and Europe. This synergy between the major LSPs and their customers has been highly beneficial to both sides and is likely to continue. Continuation of this trend towards concentration is anticipated. "*The big Third-party Logistics Providers are expected to continue to get the big opportunities* (Foster *et al.*, 2005)."

The present situation on the supply side of the market for logistic services, however, is still characterised by fragmentation, both in terms of market share and in terms of specialisation. The top-25 LSPs in the world only have a limited market share, and usually generate most of their turnover in specific markets. These market specialisations of LSPs may concern a specific product or mode of transport (e.g. ocean shipping, express delivery) or geographical coverage.

On a global level, the big LSPs are by definition intermodal companies. For intercontinental transport, intermodal transport, especially container-based intermodal transport, is the only way. On a European continental level, however, intermodal transport is of only limited importance for the big LSPs. Only a few LSPs have integrated intermodal transport into their intra-European service offerings. Examples of LSPs that do make use of intermodal transport on a substantial scale include Stinnes (part of Deutsche Bahn) and P&O Nedlloyd/Maersk Sealand (operating the ERS rail shuttle). Most of the LSPs, however, are very much road oriented.

As a result of the increasing sophistication required for logistics systems to fulfill the growing demands from their users (or clients of these users), there is an increasing need for flexible logistics structures that aim towards:

- Cost and asset efficiency;
- Responsiveness towards changing customer requirements;
- Obtaining marketing advantage.

The first objective is driven even more by the last two, because only if logistic structures are efficient can they offer feasible solutions in today's ever more competitive environment. Consolidation and Collaboration (horizontal as well as vertical co-operation between chain partners) are the most logical ways to generate lower costs per unit of freight. Through consolidation of flows, larger vehicles can be used and the loading efficiency is optimised. Also through collaboration, the planning of logistic activities is synchronised, which results not only in a much smoother, seamless flow of goods through the logistic system, and therefore higher utilisation, but also in the possibility of using cheaper and slower modes of transport, thus avoiding the need for safety stock (Groothedde, 2005).

The high level of responsiveness required could possibly conflict with the above-mentioned need for slower and smoother flows of goods, but avoiding this possible conflict is one of the biggest challenges in the design of logistic networks. The set-up of hybrid networks (which create different possibilities for flows to reach their final destination) for production, warehousing and transportation, creates the flexibility required. Some of the production, with a demand pattern that can be predicted well in advance, comes from far-away locations using low-cost labour. The remainder is postponed to the last possible moment in locations close to the customer.

Valuable products with a very low demand frequency (C-goods) are stocked centrally and can be shipped quickly over long distances if the reduction in inventory costs outweighs the additional transport cost of small lot sizes using express transport. The utilisation of cheap and slow modes in combination with faster means of transport can sometimes be much more advantageous than that of high-speed, expensive transport modes, especially for products with a low value density and a high level of demand certainty. As such, hybrid networks can combine the advantages of both network alternatives, and thus create higher levels of efficiency and flexibility.

Note that in such a network the Logistic Service Provider (LSP or 3PL) plays a crucial role. This party has to make sure that the commercial contracts of the producers that have created a consortium to deliver their products in a synchronised way to their customers (the retailers) are performed according to the service level agreements they have agreed. This means that in order to work efficiently and effectively the LSP has to know what specific logistic agreements exist between all parties concerned, and has to know the orders and production plans timely in advance. Also he has to make sure that the utilisation of the resources is optimised and that pro-active action is taken

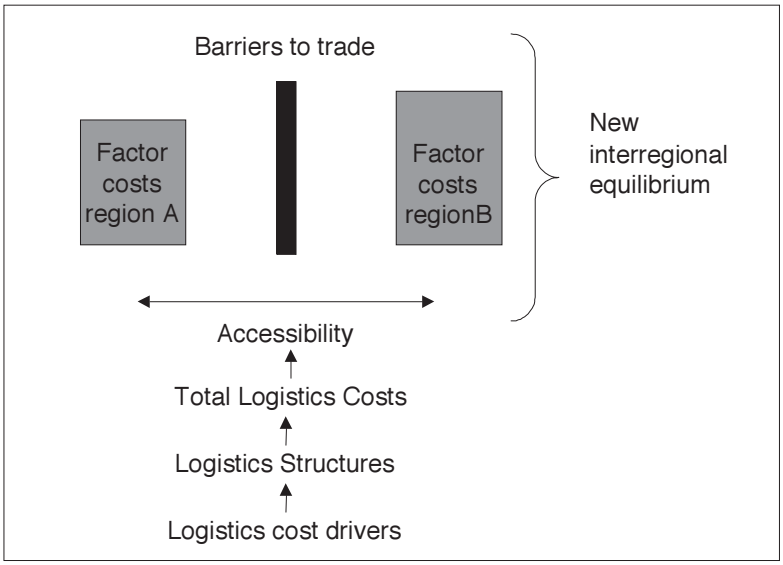
if unplanned actions occur that obstruct the current plan. It is clear that such a hybrid network asks for a good coordination and synchronisation of the actions of each of the partners in the logistics network.

5. EXTENDING THE BOUNDARIES OF FORECASTING AND MODELLING

Clearly the above will have repercussions for the way in which we prepare our strategic information base to support the policy making process. When preparing scenarios for globalised transport and forecasting the consequences of policy measures, we need to take into account the interrelations between transport, logistics and trade. We need to progress from a way of thinking which is mostly focused on transport to one that includes the advance logistic network forms discussed in this paper. In this section we discuss some consequences for our approach towards analysing this integrated transport-logistics-trade system.

The development of international trade is influenced by differences in factor costs in the respective regions as well as by the barriers to trade, both regulatory and generated through the distance between these regions. From this perspective, neoclassical equilibrium theory is an excellent starting point to forecast globalising transport patterns. Considering what has been said earlier in this paper, the only extension with this theory is that, instead of distance and transportation costs being used as measures of resistance between regions, one introduces the concept of total logistics costs (Figure 9).

Figure 9. **Conceptual model linking logistics and trade**



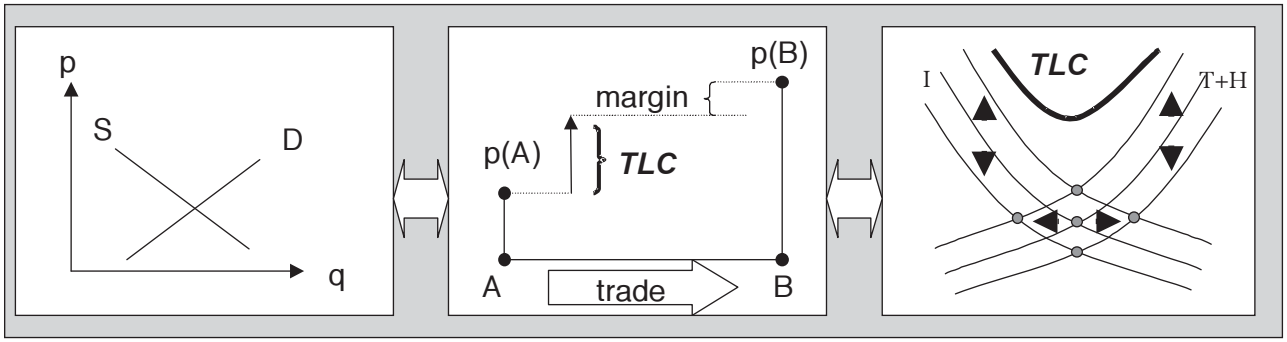
These costs reflect not only transport-related elements but also all relevant logistics costs which include storage, handling and inventory costs. In a situation where travel costs decrease and differences in factor costs remain high, globalisation can be expected to continue. Should production

costs differences diminish and transport costs increase, however, the opposite would be likely.

The relationship between logistics and transport is explained by the logistics costs function, which is defined by the trade-off between transport, inventory and handling costs. Structures with many depots and small but frequent shipments will emerge when firms are primarily service-oriented, and will generally be preferred when transport rates are high. While the decrease in transport costs has placed increasing pressure on firms to centralise their inventories, the increasing emphasis placed by firms on quality of service is leading to growing pressure to decentralise operations.

GCE modelling, already used before and more so since its development by Venables and Gasiorek (1996), is now available as a means of predicting the welfare effects of transport investment and policies. Despite the research problems which remain to be solved (see Lakshmanan *et al.,* 2002 and Tavasszy *et al.,* 2002), progress continues to be made in integrating transport models and CGE approaches into more comprehensive tools for assessment. In order to sharpen our insights into future logistics structures and their relationship with economic development, we propose to include total logistics costs into the CGE framework, thus giving a wider interpretation to what is now – in CGE terms – referred to as 'transport costs'. Logistics structures can be modelled along the lines of the SMILE model (Tavasszy *et al.,* 1998) which provides a picture of how logistics structures are affected by regional and product characteristics. Figure 10 provides a rough outline of the components of this multiregional spatial logistics model.

Figure 10. **Rough outline of a spatial logistics equilibrium model**



At the network level, more detail will be required in terms of the logistics demands of goods. The models described above only provide a crude picture of networks in that they only include intermediate warehouses (continental or national distribution centres). The optimisation models from Groothedde (2005) were developed to design hybrid, collaborative networks. They produce more sophisticated network forms and thus also create information sufficiently detailed to develop a multimodal micro-simulation of flows based on dynamic shipment, vehicle and client characteristics and routing requirements. As these optimisation models are valid for very specific sectors or markets, the next challenge will be to aggregate and generalise these behavioural rules towards a picture that is representative of all flows using the European transport network.

6. CONCLUDING REMARKS

In this paper we provide an overview of the changes in supply chains and networks that occur as a result of globalisation of production, trade and services. While logistics costs have dropped dramatically in the last decades, flows have grown twice as strongly internationally as they have within national borders. Together with the growing capability of firms to individualise their products and services, this has created new network architectures that can span the entire globe. We describe these network forms and derive some consequences for transport system planning.

On the one hand transport systems will need to adjust better to a globalising economy, with a higher variation in different types of networks than ever before. The splintering of flows that occurs due to the demands of customisation and increased responsiveness will force firms to look outside their company borders for co-operation and, in the end, for scale. Thus, transport systems will need to become more flexible and acquire a more hybrid nature to accommodate both slow and large scale flows as well as small scale, just-in-time shipments.

These changes also have consequences for the scenarios that need to be built. We argue that the models that supply scenario information and policy assessments are not up the task of accounting for changes in global logistics networks. Necessary improvements include not only the extension of transport models to a global level, but also, and in particular, the proper linkages between models for global trade and transport and the inclusion of the necessary amount of logistics detail in freight transport models.

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