APPROACH FOR HANDLING HETEROGENEOUS GOODS IN INTERMODAL FREIGHT NETWORKS - REVISITED

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ABSTRACT

At the 9th WCTR in Seoul, we outlined six approaches for coping with heterogeneous goods in freight networks giving frequent real-world examples of Logistics Service Providers' actions. This article is a follow-up re-using the conceptual framework developed in 2001, developing the theory further and analysing how the approaches are used in real-world network operations in 2013. We find indications on that European transport of heterogeneous goods has become increasingly complex and certainly more complicated over the studied period, not least due to the growth in transport network size and scope. Some of the tricks used by Logistics Service Providers to cope with the heterogeneous goods are described, characterised, segmented and analysed to arrive at rather generalised knowledge. A case study shows how a Swedish Logistics Service Provider has changed its consolidation network to encompass logistically demanding pharmaceuticals in its general flow.

Keywords: Heterogenous goods, Intermodal freight transport systems, Operations

INTRODUCTION

Pressured by low profit margins, shippers' strong negotiating strength and policy makers' call for increased transport efficiency, the logistics service providers (LSPs) look for economies of scale and enhanced resource utilisation in their consolidation network operations. In general, transport distances and the size of vehicles and vessels increase and the size of each individual consignment decreases, which fosters intermodality and implies that a larger number of consignments have to be consolidated in each moving load unit, ship, train, lorry or aeroplane. The prolonged recession in many parts of the world also incentivises LSPs to fill their networks with new goods categories including hazardous, oversized, theft-prone and temperature-controlled consignments. All this necessitates further efforts to manage the goods flow in order to tranship quickly and cheaply between transport means and traffic modes in intermodal transport chains.

Over the years, shippers have been much more particular about their demand and von der Gracht and Darkow (2010) found that the expert opinions in their Delphi study almost unanimously agreed that the trend towards even more advanced logistics services will hold to the scenario target year of 2025. Globalisation has also implied that LSPs must either find niches or widen the scope of their services in terms of geography, traffic modes, consignment sizes and goods categories. A few firms have met this demand by mergers and acquisitions to form giant global players like Maersk, DB Schenker, DHL and UPS. This is necessary in order to meet the demands for a wide logistics service portfolio when their main customers, who likewise have grown in size and geographical scope, out-source their logistics activities or require “one-stop-shopping”.

In order to manage their increasingly complex operations, the LSPs are likely to implement autonomous and self-controlled systems (PriceWaterhouseCoopers, 2009), which requires rigid information systems and internal regulations that diminish the role of the flexible transport planner, the so-called “fixing forwarder”. This implies that all consignments regarded as somewhat awkward are less smoothly transported within the logistics systems and particularly hazardous goods require ICT solutions fulfilling society control regulation (Batarliene, 2007). The increasing number of consignments in each unit then implies a certain risk that a large share of the units require special attention or that the awkward goods must be transported in separate transport systems.

At the 9th WCTR in Seoul, we outlined six approaches for coping with goods requiring special attention in freight networks giving frequent real-world examples of LSP’s actions (Woxenius, *et al.*, 2001). This article is a follow-up, developing the theory further and taking a longitudinal stance on how the LSPs have refined their operations. The main purpose of this article is to use the conceptual framework developed in 2001, match it with transport market developments since then and analyse how the approaches are used in consolidation network operations. What we called *goods requiring special attention* is now referred to as *heterogeneous goods* (HG) as some of the approaches actually aim at accommodating HG without manual intervention.

The LSPs’ network operations are matched with external factors like shipper demands, legislation for hazardous cargo and, of course, with the advance of knowledge in literature since 2001. The analysis of applied strategies for coping with HG is framed in a case study of how a Swedish LSP operating an extensive consolidation network incorporated pharmaceutical products in their general consolidation network. Information was gathered by public sources like media coverage and press releases but mainly through a structured interview with the responsible quality manager.

The article focuses logistics markets requiring consolidation of parcels, general cargo and part loads, thus excluding mail and full loads. Although taking a perspective of European production systems involving more than one traffic mode, most of the presented facts and ideas can be generalised to single-mode transport as well as to other parts of the world.

In the next section, theories on heterogeneous goods, logistics complexity and the equalizing role of terminals are presented. Then a number of approaches for handling the problems are presented followed by the case study illustrating some of the ideas put forward. Finally, some general conclusions from the study are drawn.

TERMINALS AND HETEROGENEOUS GOODS

When defining heterogeneity, it is important to bear in mind that what can be considered heterogeneous to one actor may be considered fully homogenous to another. In a large-scale system where standardised handling is necessary, heterogeneity drives cost (Arnäs, 2007). To define HG, the framework from Lambert *et al.* (1998) is used, where they describe five factors that influence the price/cost of transport for a product.

- Density, D
  - The weight-to-volume ratio influences the transport cost, mainly because low density products, like tissue paper, never utilise the full weight of the load carrier.
- Stowability, S
  - The degree to which a product can fill the available space in a load carrier. The concept of *cube utilisation* is used, which means that the ideal situation occurs when the product completely fills an imaginary *cube*.
- Ease or difficulty of handling, H
  - Products with poorly designed interfaces or with non-uniform physical properties are more costly to transport.
- Liability, L
  - When the value-to-weight ratio is high, the product often carries a higher transport cost due to increased liability of the transporter.
- Market, M
  - In addition to the product-related factors above, there are several market-related factors that influence the cost/price of a transport:
    - Competition
    - Location of markets
    - Regulations
    - Traffic balance
    - Seasonality changes
    - Internationality

The transport cost, C_T is therefore a function of the four variables, D, S, H, and L together with the market-related factors, M.

Equation 1 The cost of a transport is a function of the four parameters Density, Stowability, Ease of Handling, Liability, and Market

$$C_T = f(D, S, H, L) + f(M)$$

It is assumed that *f(M)* is constant in relation to the variables studied here and will therefore be disregarded in future equations.

For a transport system, the parameters, D, S, H, and L are often regulated in the pricing strategy, for example for domestic road freight (DHL, 2013; DSV Road AB, 2013):

- D: When the density is lower than 280 kg/m^3, the price is calculated based on the assumption that the actual density is 280 kg/m^3 leading to a higher calculated weight, in turn leading to a higher price.
- S: The length density is calculated to 1950 kg/metre of the load unit. This means that

goods that cannot be consolidated (for instance no other goods can be stowed on top) are calculated to a weight that is higher, leading to a higher price. For instance, a pallet of less than 130 cm height that is on-stowable counts as 400 kg.

- H: Consignments exceeding the following measurements cost extra due to handling and stowage difficulties: height > 2,5 m, length > 6 m, width > 2,4 m.
- L: Temperature-sensitive, dangerous, or theft-prone goods are subject to prior notification to the transporter and connected to a cost increase.

This means that in most transport systems, there are limits regulating the product-related parameters in the cost function.

Heterogeneous goods (HG) are defined as goods where one or more of the parameters Density (D), Stowability (S), Ease of handling (H), or Liability (L) are outside their accepted ranges.

Hultén (1997, pp 65-66) states that "(…) the terminal must not only provide connectivity in terms of appropriate handling equipment but also bridge the gap between the means of transport in terms of frequency, capacity and time (…)". One extreme is here that of a sea-port where lorries carrying one to three Twenty foot Equivalent Units (TEUs) are coordinated with ships carrying up to 18 000 TEUs. On the other side of the scale is cross-docking in a hub-and-spoke system where lorries or airplanes of similar sizes are coordinated without intermediate goods storage.

Hultén's model of the terminal function as bridging gaps in frequency, capacity and time assumes that the goods are homogeneous and that the terminal, as well as the links on either side, are able to handle them. When the two links that are connected to a terminal have different specifications for what are considered homogenous/heterogeneous goods, the terminal needs to be able to bridge this gap. Therefore, the model needs to be extended to encompass yet another gap: goods heterogeneity. The bridging can be done at different levels, depending on the nature of the heterogeneity.

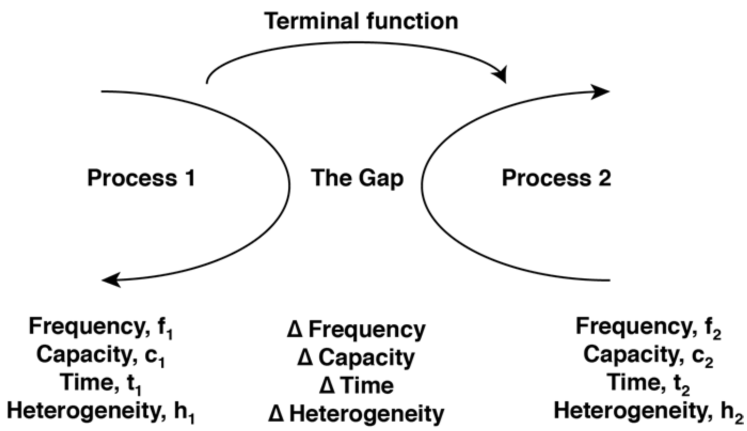


Figure 1 – The function of the terminal expressed as bridging gaps of frequency, capacity, time and heterogeneity between two separate transport processes (adapted from Hultén, 1997).

COMPLEXITY AND THE CONTROL OF A TRANSPORT SYSTEM

Heterogeneity is a term that is centred on how the consignments are perceived by actors in the system. It does not say anything about how the system behaves or what decisions are made and why. To address these issues, we need a framework that can explain how the system is constructed, how its operations are planned and how it is run. The term *complexity* and its application on transport and logistics is not new and it is extensively covered by several authors (see, e.g., Hultén, 1997, Franzén, 1999, Waidringer, 2001, Nilsson, 2003, 2005 and 2006 and von der Gracht and Darkow, 2010).

The literature identifies three general principles in systems complexity, *descriptive, computational* and *uncertainty-based complexity* (Klir, 1991). Descriptive complexity stems from the number of entities in the studied system and how much information is needed to describe them, i.e., variety. This is an indication on the complexity in how the system is constructed. For a terminal network, the descriptive complexity could be described in terms of the number of links and nodes and computational complexity is the difficulty in planning the operations in the system. In a transport network, the computational complexity resides in tasks like the allocation of resources and routing of vehicles. Uncertainty-based complexity is the difficulty in managing a running system. The Prussian Field Marshal Helmuth von Moltke the Elder (1800-1891) once said that "*No plan of battle survives unchanged from first contact with the enemy"*. This is a good description of the uncertainty-based complexity, which in a transport network can be observed when, because of unforeseen events, the system fails or produces unwanted output.

When controlling a transport process, the consignment needs to be manipulated in such a way that its trajectory ends with a desired goal state. The three complexity types (descriptive, computational, and uncertainty-based) represent obstacles that the controlling system needs to eliminate in order for the consignment to reach the goal state. The control of the transport process is thus a battle against complexity, waged on three fronts. The control can also be divided into three temporal scopes: long-term, medium-term, and short-term.

The *long-term control* mainly consists of designing the regulated system in such a way that short- and medium-term control become less difficult. The time span when exercising long-term control is measured in years and by reducing the descriptive complexity, the tasks of planning and operating the system can be simplified. The *medium-term control* is more fine-grained than the long-term control, has a time span of months to weeks and it is where most of the planning takes place. While the outer boundaries of the system are defined through the long-term control, several design aspects can be left to medium-term decisions. *Short-term control* focuses on the actual transport process itself, and what operations to perform. The time span ranges from weeks down to minutes and seconds.

Table 1 – The control scopes, their tasks, time spans, and how they affect complexity (Arnäs, 2007).

Control scope	**Long-term**	**Medium-term**	**Short-term**
Time span	Years to months	Months to weeks	Weeks to minutes
Driving questions	What states should the system be able to assume? What component types are required for the system to assume these states?	What components are needed in the system? How are the various interfaces designed?	What state changes should be performed and how?
Important tasks	**Design:** Define the overall structure of the system. Define acceptable use cases.	**Design/operate:** Define actual use cases.	**Operate/monitor:** Control the actual trajectory as it progresses through the system.
Complexity reduction	Descriptive complexity is reduced by **robust design**	Computational complexity is reduced by **good planning**	Uncertainty-based complexity is reduced by **creating order**
Examples from the transport domain	Designing terminal structure. Designing a new route or corridor.	Reserve space on vehicles/vessels in advance without having exact knowledge of the consignment.	Loading and unloading of goods. Transport of a single consignment.

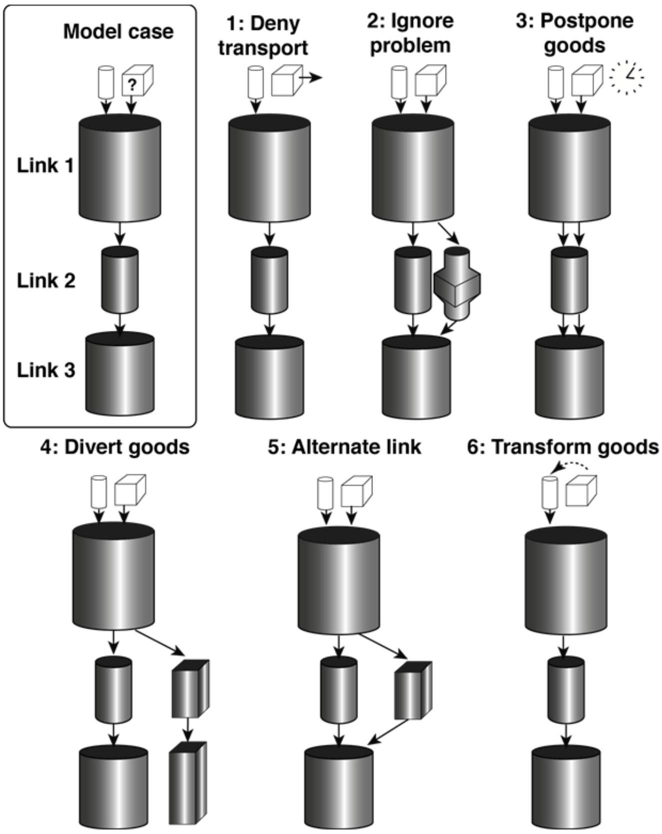
Control by design means that the system that will traverse the desired trajectory is designed in advance so that there will be few alternative trajectories during the actual transport process. The descriptive complexity can be reduced during the design phase. In the medium-term control, more detailed design is often present, as well as some direct operations. These operations are not yet associated to any single consignment. They are often concerned with allocation of resources or positioning of unit loads in anticipation of a future transport. In this scope, the computational complexity becomes an issue.

The short-term control can be of two modes; one active – operation, and one passive – monitoring. In the operating mode, the interface of the consignment is manipulated in order to achieve the goal state. Decisions have to be made and there are more than one alternative trajectory. In the monitoring mode, the consignment is observed as it traverses an already predetermined trajectory. If the consignment deviates from the planned trajectory, the control mode changes to operating. Due to the inherent uncertainty-based complexity that resides in transport systems, decisions need to be made during the transport process that would not have been possible to make during the medium- or long-term control scopes.

An indication of the move from the “fixing forwarder” to more rigid systems is that DB Schenker, dominating the Swedish LSP market, has approached University of Gothenburg asking for equipping the logistics students with more management skills. DB Schenker has experienced problems with the current generation of terminal managers in the sense that their self image is based on the ability to solve practical and immediate problems with the mobile phone in the hand. Instead, DB Schenker requires managers able to create systems not needing constant manual intervention.

HANDLING HETEROGENEOUS GOODS – SIX APPROACHES

The options for dealing with HG in intermodal transport of consolidated cargo can be summed up in six different approaches. In the figure below, the first case illustrates the different elements that are used to describe the approaches. Two goods types, Homogenous (cylinder) and Heterogeneous goods (cube), are to pass through three links (in this case three traffic modes). The cube represents goods that are regarded as HG in link 2, but not in link 1 and 3. In the model, there are two gaps to be bridged, Link 1- Link 2 and Link 2 - Link 3. Six distinctly different approaches for handling the situation in bridging the gap between the links 1 and 2 (or more accurately, solving the problem) are identified and presented in the figure below.



There are six principally different approaches to handle HG as shown in the figure. The white cylinder represents homogenous goods and the cube represents HG.

1: Deny transport. Do not permit goods regarded as heterogeneous to enter system.

2: Ignore the problem. The LSP or consignor does not take into account future problems in the supply chain (SEP – Somebody Else's Problem).

3: Postpone goods. This approach is sometimes necessary when physical, capacity or regulatory restrictions limit the transport of heterogeneous goods to certain departures.

4: Divert goods. Accept the goods and change to different system when problem arises.

5: Use alternate link. Substitute the link where the problem is identified.

6: Transform goods. Change the properties of the goods so that it will not be regarded as HG by the system.

Figure 2 – Approaches for handling heterogeneous goods (HG) in intermodal transport systems.

In reality, some of the approaches can be combined, but in many cases they are implemented separately.

1. Deny transport

The first approach for dealing with HG simply means that the LSP does not allow certain goods to be transported in the channel. This could be done directly by applying strict rules for acceptable consignment parameters or indirectly by pricing transport of HG in order to deter orders.

This approach represents a very simple way of dealing with HG, but obviously entails a loss of customers if carried out in its entirety. Therefore, it is believed that this approach is not applied very often, since it seems unlikely that a LSP would deny a customer, especially any of the larger customers, an occasional HG-consignment. A customer, who has been denied a transport, would have to turn to a niche operator in order to have its HG transported.

There is a certain risk that this approach results in a lower resource utilisation or customer service since separate transport systems have to be established, thus loosing economies of scale.

Example: *An ordinary mailbox at the post office is used to deny consignments that are considered too large for the regular mail handling system. If a customer needs to send an oversized item (i.e. regarded as HG somewhere in the chain), it needs to visit a post office for manual service. The customer also pays an extra fee due to the extra attention the goods requires or, depending on the design of the mail system, for sending it in a totally separated channel. As an alternative the customer can contact an express delivery service. The same occurs when the consignment is either theft sensitive or extra urgent, yet complying with the regular mail size, and thus forwarded as registered post and express mail respectively. In all these cases the consignments are denied as regular mail.*

2. Ignore the problem

Also in this case, the decision of sending the HG, although it does not fit the transport channel completely, is made by either the consignor or the LSP. In other words, it is one of these two parties that pass on the difficulties of encompassing the goods downstream in the transport channel, i.e. make it Someone Else's Problem (SEP).

Just like approach one, ignoring the problem is not very sophisticated, but relies heavily on the creativity, initiative and good will of the individuals involved in operating the bottleneck link. This approach will be less likely to work out in the future, since the "fixing forwarder" disappears due to the standardisation of the channels.

The problem is aggravated by the fact that many international transport chains involve nodes with different availability and relative factor prices for machinery and labour. A problem seen as minor in one country with low man-hour costs can thus lie in the intolerable region of the FN-diagram in another country.

Example: In intermodal road-rail transport, it is very common that the consignor reports a lower unit load weight than the factual hoping that it will not be noticed. This is usually no problem for the rail leg with generous weight restrictions, but might very well imply problems during post-haulage by road. For international shipments, it might be no problem for the pre-haulage by road in one country but violate the road transport legislation in the post-haulage country.

3. Postpone goods

Postpone goods, like the name implies, means delaying the transport of the goods. This can be while waiting until there is enough compatible HG to fill one transport unit, waiting for available capacity or for certain departures dedicated for, say, hazardous cargo. In the model by Hultén (1997), this approach can be described as overcoming large differences in both time and capacity by letting the terminal "*do all the work"*.

Neither this approach is very refined, but it does require some kind of scheme for dealing with HG, unlike the previous two. When the goods finally is transported through the channel, it can be done in one of two ways, either the entire transport channel transforms into one appropriate for HG, or only the most problematic link is changed. Thus, at certain times, the characteristics of the channel change to accommodate the goods. This is common in ferry shipping, in which certain types of hazardous cargo cannot be transported together with passengers. During night time with fewer passengers, certain departures are allocated to hazardous cargo. Hence, the link is physically the same, but taking the measure of postponing the hazardous consignment the mix with passengers can be avoided. Similarly, road tunnels might have restrictions on how many lorries with hazardous goods that can be in the tunnel at any given time. The simple way of handling the case with maximum number of hazardous goods lorries is obviously to require that lorries wait until others have left the tunnel and the advanced one is to implement an electronic slot booking system such as demonstrated by the EU-funded SMARTFREIGHT project (SMARTFREIGHT, 2010).

This approach is probably, among the ones requiring planning on some level, the easiest one to coordinate since separate channels, with no interactions, are used.

Example: In container shipping, there is normally a limited number of container positions equipped with electrical power supply for reefer engines. Once these are filled, remaining reefer containers have to wait for the next departure offering spare reefer slots. Vice versa is not a problem since dry freight containers can use the refer slots without restrictions.

4. Divert goods

If the bottleneck link is unable to accept the goods classified as HG, another route through the network can be chosen (see, e.g., Woxenius, 2012a) applying route assessment tools (see, e.g., Batarliene, 2008, Kheirkhah*, et al.*, 2009 and Verma, 2009). When the nonconforming link is passed, the goods continue in separate channels. Again, this approach requires more planning from the LSP than the previous one, but less than the following approach, alternate link.

Example: The Öresund link between Malmö in Sweden and Copenhagen in Denmark consists of a bridge followed by a tunnel. According to safety regulations, the road transport of dangerous goods across the link is prohibited between 06:00 and 23:00 (Öresundsbron, 2013). A Swedish road haulier that normally uses the link to drive through Denmark to Continental Europe must consider, should his vehicle be loaded with dangerous goods. A shipping line operates a freight-only service between the ports of Malmö in Sweden and Travemünde in Germany. This would be a plausible alternative for the road haulier carrying dangerous goods.

5. Use alternate link

This is very similar to diverting the goods, but after the problematic link is passed, the two goods flows converge, indicating that a good deal of planning and an advanced information system is required by the LSP. As a matter of fact, this approach leads to the most complex system of all six.

Example: Austria and Switzerland apply a weekend driving ban for heavy goods vehicles between 15.00 Saturdays and 22.00 Sundays as well as nightly, although Austria allows less noisy lorries during nights (van den Engel, 2010). An LSP serving the cross-Alpine market normally sending their lorries on road through Austria and Switzerland might find that they only occasionally want to pass during the banned hours. On those occasions, the LSP can choose to use a Rolling Highway service, in which full lorries are driven onto low-built rail wagons, and then transport by rail through the Alps and yet comply to the regulations in Germany and Italy. Hence they can avoid waiting during the bans. With larger flows they can plan their loading operations in such a way that some are driven on road while others use the

Rolling Highway service.

6. Transform goods

In this case, the decision is with the consignor, who transforms his goods in order for it to conform to the standard of the transport channel. The transformation can be done through changing the package or the goods itself as discussed by Woxenius (2012b) mentioning a sailing boat designed to fit into a maritime container (Container Yachts, 2013). Like approach 1, deny transport, this one defers all the difficulty in sending the HG to the consignor.

The more odd, but yet frequently sent, the HG is, the higher the probability that this approach will be utilised. It is today common to consider logistics consequences already when designing new products, although packaging is a powerful tool for implementing a standardised interface between product and transport system. From a transport system perspective it is the consignment, i.e. the goods in its package, and not the product itself that is of importance when discussing HG.

Example: The classic example of transforming goods is that of the flagpole. When the transport system did not accept the dimensions of the flagpole the only long-term solution was to change the flagpole by cutting it to pieces (or make a telescopic construction) so that the entire pole could fit in one container. The consignee could then assemble the pole on site.

Comparison between the approaches

In approaches 1-5, the decision of whether and how to send the HG through the transport channel is made by the LSP (with possible exception of approach 2). It is only in approach 6, that the decision is placed at the consignor's, however demanding input from the LSP. The degree of planning required from the LSP, in order to carry out the haulage, increases as one moves from approach 1 to approach 5. This means that the later the planning of the transport is made, the fewer options for putting the HG through there is. In the end, only the approaches of denying transport or to ignore the problem, remain.

Another difference between the approaches is that in approach 2, the links, that classify the goods as heterogeneous, are forced to handle the goods regardless of the increased disturbance potential, while in approach 3-5, the links are replaced or subjected to planned changes. For using approaches 1 and 6, no alterations to the channels are necessary, in the former one, the goods have to be sent with a LSP applying a different approach, and in the latter one, the goods itself is transformed.

When analysing the approaches using the modified model from Hultén (1997), a number of points can be made:

- All of the strategies except number 2 and 6 acknowledges the gap in heterogeneity and takes measures to prevent negative effects.
- Strategy 2 (ignore the problem) does not take into account the difference in capacity when changing link.
- Strategy 3 (postpone) relies heavily on the process of bridging the gap.
- The strategies 4 (divert) and 5 (alternate link) do not bridge the gap, but instead change to

a target process more in sync with the source process. In strategy 5 the system then redirects the goods to the original chain, thereby demanding that the next process (link number 3) will be able to handle the differences in *f, C* and *t.*

- Strategy number 6 (transform) is pre-emptive in such a way that the goods themselves do not instigate a widening of the gap in the supply chain.

AN ILLUSTRATIVE CASE

In the article for the 9th WCTR (Woxenius*, et al.*, 2001), a case study on health products requiring climate-controlled transport from Germany to Sweden was used for illustrating and discussing the approaches. For the same purpose, this article uses a contemporary example where an LSP addresses heterogeneous goods by encompassing medicinal products with high transport quality demands in its general flow of consolidated goods.

The Swedish pharmacy market was deregulated when the state monopoly was abolished in 2009. At the time there were some 930 pharmacies in Sweden with a turnover of 2,6 billion € of prescribed pharmaceuticals, 430 million € of non-prescribed pharmaceuticals and 650 million € of other products (Apoteket AB, 2010). The state-owned monopolist Apoteket AB sold two thirds of its pharmacies but private firms also started new ones. Consequently, the number increased to 1350 pharmacies in 2012 (DB Schenker, 2012). The pharmacies are required to offer a high service level to customers but cannot afford keeping large stocks of all products in each pharmacy. Distribution to the pharmacies is since decades dominated by a few privately owned wholesalers, which solved the increased complexity of serving multiple customers and an increasing number of outlets with short lead times by outsourcing the physical distribution.

From May 2012, Oriola, one of the market leading wholesalers, contracted DB Schenker to distribute its whole assortment from Oriola's central warehouse in Enköping (DB Schenker, 2012). The products require room temperature, that is to be kept in the interval 5-25 degrees Celsius, and the lead time is less than 24 hours to pharmacies all over Sweden. Sweden stretches between many temperature zones and in winter temperatures drop well below 30 degrees minus and summer witnesses periods with above 30 degrees. The high cost and severe consequences of a broken temperature chain obviously imply that the temperature must be tightly monitored and controlled. The regulation has been slightly strengthened over the last years, but most important is the increased focus on control, logging of data and documentation as well as the awareness of the regulation. As such it reminds of the situation when European road regulation became a bit stricter but above all the enforcement by use of digital tachometers.

DB Schenker offers dedicated services for temperature-controlled goods and its Logistics division serves pharmaceutical firms with warehousing and distribution services (DB Schenker, 2010), but then as a dedicated and adapted service detached from other clients flows, hence using the *alternate link* approach. The normal general cargo flow, internally denoted as "public freight transport" was not rigged to fulfil the high standards set by medicinal products (Kron, 2013), but yet it decided to produce the transport service as part of its consolidation system to get economy of scale in the capillary distribution. From Enköping in central Sweden, DB Schenker's division Coldsped uses its refrigerated lorries for long-distance transport to DB Schenker's approximately 25 consolidation terminals around Sweden, but from there it is part of the Land division's normal system. One exception is that Oriola for security reasons require rigid lorries, not curtain-sided. Home deliveries are, however, diverted with dedicated vans delivering directly from the terminals and some refrigerated goods is distributed all the way by Coldsped (Kron, 2013). Nevertheless, if not globally unique, it is very unusual to transport pharmaceuticals as general cargo and it is not done by DB Schenker in other countries where the approach *Deny transport* is applied.

Oriola's products are packed in sealed green plastic boxes to protect the goods from shocks and minor temperature shifts but also to make them neutral so potential thieves do not know which box to steal. Some boxes are also equipped with extra insulation or cooling elements to send refrigerated products, but to DB Schenker, all boxes are equal and the requirements are the same for all boxes (Kron, 2013) and it actually does not differ from other cargo, although it is controlled and documented much more carefully. It is hence an example of the approach *Transform goods* as the interface to DB Schenker and its contracted road hauliers has not changed.

The challenge was that the full transport system needed to fulfil not only the expectations of Oriola but also maintain to serve all other shippers fulfilling their demands for quality and low costs. Consequently, DB Schenker upgrades its information significantly with implementation in the autumn of 2013 and, according to Kron (2013), Oriola's demands for real time control and documentation is the benchmark and the system is to be validated by Oriola. There is a certain challenge to increase the staff awareness of documentation. Kron's professional background is in the pharmaceutical industry, where the attitude is "what is not documented has not happened", while the transport industry attitude is more of "goods delivered and problem solved, it does not get better of writing down what was done and how" (Kron, 2013). To raise awareness and competence, 4000 own employees and 5000 drivers at contracted road hauliers have passed a web based course (DB Schenker, 2013).

Oriola accepted that DB Schenker started without all processes in place but required a temperature control system to be implemented as soon as possible. In May 2013, all consolidation terminals were equipped with dedicated areas for Oriola's goods and temperature was monitored there as well as on all lorries used in the distribution (DB Schenker, 2013). The terminals have fixed thermometers but not the lorries. Instead, special green boxes equipped with temperature logging and communication equipment are placed among the other green boxes for accurate temperature logging during transport. With the temperature monitoring in place, the long-distance transport might also be transported by normal lorries most time of the year.

The fixed installations and the boxes communicate with DB Schenker's information system every five minutes (Kron, 2013) and logs the temperature curve for each shipment and archives it for five years (DB Schenker, 2013). If there is a risk that the temperature zone is not held, it sends a warning to the lorry driver's handheld computer and to the terminal manager's mobile phone (Myrsten, 2013). This is done 30 minutes before temperature demands are definitely violated (Kron, 2013) and, hence, there is an option to *divert goods* to secure the temperature chain. According to Kron (2013), there has been frequent warnings during the trimming process and a few instances of a broken temperature chain, ironically lower than 5 degrees in the far south of Sweden. The system is however not yet tested during summer.

Although not being strictly intermodal, the use of different divisions and contracted road hauliers and different links, it shares many features of an intermodal transport chain. DB Schenker has not applied the simple approaches *Deny transport, Ignore the problem* or *Postpone goods*, but the more advanced approaches of *Use alternate link* and *Transform goods* and, in case of deviations in temperature, *Divert goods*. What this case study actually demonstrates is that when DB Schenker has implemented its new information system, Oriola's goods is, apart from the demand for rigid distribution lorries and some liabilities, actually not heterogeneous in the normal state since the rest of the system is adapted. It is first when the temperature risks to fall outside the allowed zone that dedicated actions are taken.

COMPARING 2001 WITH 2013

In 2001, the tools available for transport companies to handle HG were not as developed as they are today. During the years since our previous study, the transport industry has undergone a significant digitisation process. In the large transport networks, paper based information is now replaced with digital alternatives. Planning and optimisation is done with computers that greatly increases efficiency (Perego*, et al.*, 2011). Because of this, the available methods available to handle HG are now different than just a decade ago. Some aspects that have changed notably are the possibility for increased efficiency, effectiveness and also improved planning capabilities in the supply chain (Marchet*, et al.*, 2012). This has impact on how the six handling approaches can be implemented. The approaches Divert goods and Alternate link can become the preferred alternatives for the transporter if the available digital information about the goods has enough detail and accuracy to facilitate real-time changes in the execution of the transport.

Strategies for accommodating HG in consolidation networks and in intermodal freight transport systems are needed for increasing resource utilisation and facilitating economies of scale in the networks. Such strategies are helpful when developing robust systems and it avoids the use of expensive niche operators developing dedicated systems with, in general, a bad resource utilisation.

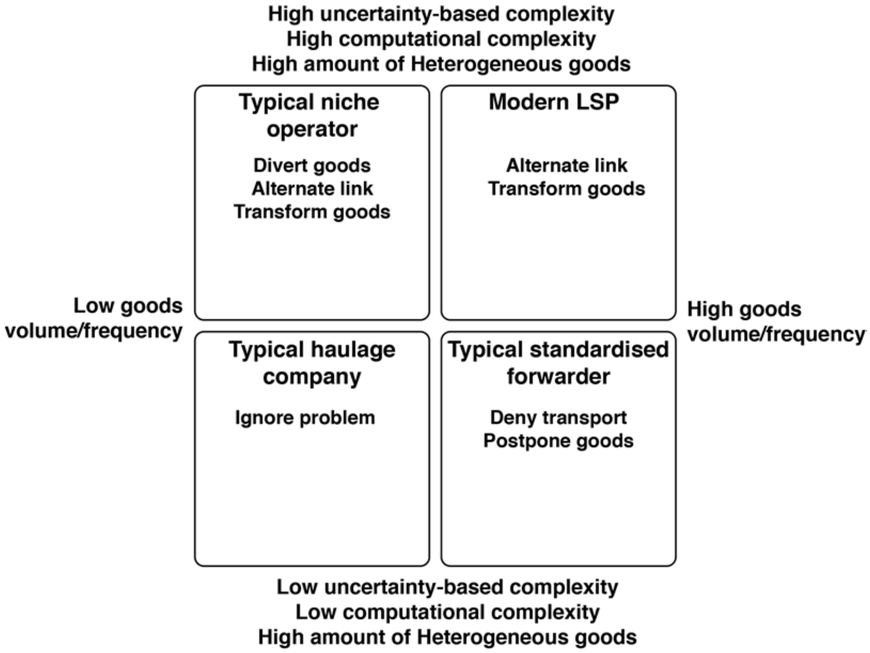


Figure 3 – Diagram of how the strategies are applied in different situations depending on complexity, goods heterogeneity and goods volume/frequency.

The figure above shows a diagram of how different types of transport companies may handle HG depending on the overall complexity and goods volume/frequency in the system. When dealing with low volume/frequency as well as low complexity, there is no real reason to have a strategy, and the problem will most likely be ignored or handled ad hoc as it arises. There is a market for niche operators when the complexity is high but goods volumes are low. The large-scale operators have difficulties in handling these shipments and often let the niche operators keep this market segment. The niche operator is often equipped to handle the heterogeneity using sophisticated strategies such as Divert, Alternate link and Transform. The large-scale operators differ when it comes to the handling of complexity and heterogeneity. The classic approach has been to deny or maybe postpone HG. But through the use of ICT, modern LSPs have gained increased ability to control single shipments instead of large batches as was the case before. These LSPs have the ability to Divert or use Alternate links on very short notice and will be a threat to some of the niche operators in time.

CONCLUSIONS

In this article, it is shown that European transport of heterogeneous goods has become increasingly complex and certainly more complicated over the studied period. It is shown that heterogeneous goods cause severe and growing problems, not least due to the induced network complexity. The tricks used by LSPs to cope with the heterogeneous goods are described, characterised, segmented and analysed to arrive at rather generalised knowledge.

Strategies for accommodating heterogeneous goods in consolidation networks and in intermodal freight transport systems are needed for increasing resource utilisation and facilitating economies of scale in the networks. Such strategies are helpful when developing robust systems and it avoids the use of expensive niche operators developing dedicated systems with, in general, a bad resource utilisation.

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