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Risk trade-off linked to temporary storage in the transport network

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ABSTRACT

Purpose of this paper

Today's demand on high supply chain performance requires higher awareness about supply chain risks and uncertainty. The purpose of this paper is to analyse the role of temporary storage in the transport network in a supply chain perspective. The primary research question concerns the purpose or role of temporary storage and whether management of temporary storage can contribute to reducing risks and uncertainty in the supply chain.

Design/methodology/approach

Within the described framework of supply chain systems in a transport network, and the management and control of risk and uncertainty, theoretical modelling has been used as a basis for logical deduction of the conclusions. The findings are then supported and verified by two case studies.

Findings

Temporary storage in transit is located between nodes in the transport network. The temporary storage function will act as a supply chain disturbance neutralizer, thereby reducing risks and uncertainty within the supply chain. The use of temporary storage also means exposing the transport more for antagonistic threats, i.e. primarily a larger theft risk. To avoid both supply chain disturbance and increased theft risk there are three types of solutions; improved and more exact scheduling of delivery time, availability of secure parking spaces whenever a resource needs to make a temporary stop, and utilizing tracking and tracing systems. These reductive measures can be applied jointly, and as a combined toolbox they can contribute to reducing the risk and uncertainty in the supply chain.

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Research limitations/implications (if applicable)

A comprehensive inventorying of appropriate methods to optimize temporary storage in transit has not been carried out. The deduced research results are based on theory and limited case study support and will primarily serve as a general guideline.

Practical implications (if applicable)

From a security point of view, temporary storage offers a crime opportunity, which needs to be reduced in order to achieve lower total supply chain risk and uncertainty. This paper describes the role of temporary storage in a supply chain risk context and provides guidelines related to the trade-off between security concerns and supply chain efficiency.

What is original/value of paper

This paper illuminates the purpose and the drawbacks of temporary stops in the flow of goods within the transport network. The conditions for temporary storage in transit, related to controlling different types of risk and uncertainty in the supply chain, have been scarcely analyzed in previous research.

Keywords: Supply chain management, supply chain risks, temporary storage, transport network configuration, secure parking

1. Background

The foundation of trade is the ability to move or transport a product from the source to the customer and still make a profit (Landes, 1998). The scope of logistics pertains to all activities from the supplier to the customer to provide the right product at the right time and the right place (Christopher, 1998). To be successful, all aspects of operations and information need to work together. The supply chain is a network of autonomous or semi-autonomous business processes that produce physical goods or services to customers (Lin et al., 1998). Christopher (2005) defines the supply chain as "*The network of organisations that are involved through upstream and downstream relationships in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer*". These processes can be in the same or different organisations.

The framework of a supply chain has three major components, supplier, manufacturer and customer. Supply chains end with the end user and begin with the supply of the raw material. The current economic trends argue for the need for specialization instead of emphasising the need for vertical integration (e.g. economies of scale). This trend forces large organisations to rely on partners, suppliers, consultants, and other types of external firms to deliver customer value to their marketplaces. The need for coordination of processes involved and companies that deliver this value is what supply chain management (SCM) aims to solve (Samaranayake, 2005). Supply chain management is in this context described as reduction of uncertainty (Mason-Jones et al., 1998). Therefore, several supply chains can exist at the same time and place in the transport network.

One of the major risks during transport is the risk for cargo theft. Cargo theft represents a value, which for the European Union area is estimated to be €8.2 billion each year. Considering all transports, it gives an average value of €6.72 per trip. About 41 percent of all incidents have occurred during the driving phase of the transport and nearly 60 percent during a stop. The two commonly used methods are either *threats against the driver* or *tearing the canvas of the load unit*. In 15 percent of the incidents, the lorry is stolen together with the goods. Another 15 percent represent hijacking and robbery (EP, 2007).

The Transported Asset Protection Association, TAPA, representing high-value technology cargo, estimated the worldwide loss ratio to 0.025 percent of the total revenue (revenue $307 billion and losses $77 million, respectively). Benchmark participant loss rates varied from 0.0038 percent to 0.25 percent of total revenue. The losses presented for individual modes of transport are as follows: road 74.6 percent; air 23.1 percent; rail 0.8 percent; and sea 1.5 percent (TAPA, 2006). This indicates that the risk for losses varies greatly between different modes of transport. It is no surprise that road and air together account for 97 percent of all losses. These two modes of transport are primarily used by the participants of the survey, depending on their high value goods.

The UK is considered as a risky part of the EU regarding cargo theft (EP, 2007), with an average loss per incident at €47,146. This cost has increased by 14.6 percent, compared to 2006 figures. The classification of the 2,284 recorded cases of cargo theft during 2007 was as follows: theft of lorries 51 percent; theft from lorry 28 percent; attempted theft 7 percent; hijack and attempts 4 percent; deception 2 percent; theft (other) 7 percent; warehouse 1 percent. Almost half of the stolen lorries were recovered within 48 hours (TruckPol, 2007).

Gathering accurate numbers for cargo theft losses is difficult or in many cases impossible, due to limited reporting by the transport industry and the lack of a national law enforcement system requiring reporting and tracking uniformity (ECMT, 2001). Despite these figures, cargo theft generally has had a low priority status in most countries and is often perceived largely as the cost of doing business (EC, 2003).

Cargo theft has shown a tendency to focus on lorries that are temporarily parked at roadside, often waiting for loading and unloading opportunities (EP, 2007; TruckPol, 2007). Temporary parking of this kind has increased in recent years, due to a number of reasons, including the reduced time windows available for loading and unloading that result from higher transportation frequency and the application of lean and just-in-time principles in logistics (Cusumano, 1994). At the same time, improved security measures in terminals make such temporarily parked lorries a more frequent target for criminal attacks, according to the theory of crime displacement (Ekwall, 2009 - a).

The different modus operandi is used differently, depending on where the attack is executed. The locations are described in terms of different steps in a road transport from consignor to consignee, which starts with loading the goods and ends when unloading them. Eurowatch has developed a threat/risk matrix based on the data on cargo theft in road transports over a seven-year period (Robinson, 2009). The matrix presented in Table 1.1 relates modus operandi and the location of attacks.

Table 1.1: Threat/risk matrix, road transport using Eurowatch data 2002-2009, 4 represents the highest risk (Robinson, 2009)

	Hijack	Robbery	Theft from vehicle	Theft of vehicle	Fake police	Fake accident	Deception
Load point	2	3	2	3	1	1	4
Driving	4	1	1	1	4	4	2

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Insecure parking	2	4	4	4	3	1	2
Secure parking	2	2	3	3	1	1	2
Near-end location	4	3	3	4	3	1	3
Unload point	2	3	2	3	1	1	4

The purpose of the transport network is to move the goods physically within a certain supply chain to fulfil the scope of logistics. This means the transport network integrates the supply chain with the fulfilment of its transport demands only physically (Bowersox et al., 2002). A measure to reduce risk and uncertainty in the supply chain is to transfer risk and uncertainty to the transport network, but such risks and uncertainties must be controlled in the transport network, so that one risk is exchanged for another. The common link is the temporary storage function in the transport network.

The function of the temporary storage is twofold. First, it is a place where the physical goods wait for a short period of time to achieve the required flexibility in relation to the scheduling of the supply chain or the transport network. Second, for legal and other reasons, cargo carriers need to park, refuel, or rest. The temporary storage is found between nodes, thus along the links in the transport network. The temporary storage close to a terminal or warehouse has an additional function as a waiting place before scheduled unloading, according to the just-in-time principle. The temporary storage function as time buffer in just-in-time distribution is closely related to the uncertainty of each transport. In a typical intermodal transport the first and last part of the freight are transported by road, and in-between other modes of transport are used. As a consequence of this, road transport needs a temporary storage place near the intermodal terminal, if there is no waiting area inside the terminal borders.

In general, the observation can be made that temporary roadside parking serves as a temporary storage facility, bringing flexibility into the supply chain and thus reducing some of the time-related risk and uncertainty. The temporary storage provides the opportunity to exchange supply chain risks and uncertainty for transport network risks and uncertainty. The disadvantages of this exchange include wasted valuable transport time and the added vulnerability to cargo theft.

2. Research purpose and methodology

The purpose of this paper is to analyse the role of temporary storage in the transport network in a supply chain perspective. Can the disadvantages be avoided and at the same time the benefits of the reduced supply chain risk and uncertainty obtained? The research presented here follows the tradition of logistics to use a system approach to answer research questions (Aastrup et al., 2008; Hellström, 2007; Gammelgaard, 1997; Gammelgaard, 2004). The main idea of system theory is to illuminate holistic thinking; it is based on the assumption that a whole system is different from the sum of its components (Churchman, 1968; Von Bertalanffy, 1969; Hellström, 2007, Ekwall, 2009 - b). According to Hellström (2007), one of the main issues in system theory is how elements interact with each other in the system. This paper uses the supply chain as the overall system and sees the transport network as the physical link, or element, in the supply chain. This perspective implies that the interaction between the transport network and the supply chain is analysed out of a risk minimisation strategy.

The analysis uses several sources, combining supply chain quality and risk with a view of cargo crime properties, to address this research question, i.e. what purpose or role temporary storage has and whether the temporary storage concept can contribute to reducing risks and uncertainty in the supply chain, while controlling the vulnerability to antagonistic threats. Thus, the research methodology is based on a frame of reference comprising supply chain systems in a transport network, combined with the management and control of risk and uncertainty. Theoretical modelling has been used as a basis for logical deduction of the conclusions. The findings are then supported and verified by two qualitative case studies, addressing the temporary storage function in a supply chain perspective and a transportation network perspective, respectively. The information in the two cases is collected during interviews that involve few questions and focus on the description of the need for temporary storage and the functionality of such storage.

3. FRAME OF REFERENCE

3.1. The supply chain and the transport network

Christopher (2005) defines the supply chain as: *The network of organisations that are involved through upstream and downstream relationships in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer”*. The goal for all involved organisations is to provide the ultimate customer with the right product and the right time and place. The physical flow of products through the supply chain is conducted by a transport network. Transport networks are designed to use economy of scale when moving products from consignor to consignee through nodes and links in a supply chain. Transport nodes are terminals, warehouses, harbours and airports, while transport links are means of connecting the nodes. Goods enter and exit the network through inbound and outbound gateways (Lumsden, 2006). The transport network affects cost and throughput time, and if used smartly it can even increase the value of the product (Lambert et al., 1993).

The different network constraints, together with the economy of scale, have generated several different transport network designs. One of the most common is the hub and spoke configuration, which achieves both effectiveness and efficiency. This system connects all nodes with the fewest possible links and maximizes space. The major disadvantage of this is normally longer lead times for delivery from consignor to consignee (Lumsden et al., 1999). To make the hub and spoke design efficient, all transport and terminal activities need to be co-ordinated. This means that the supply chain has to adjust, to some extent, to the transport network. This scheduling gives the transport network a routine and a systematic rhythm, but inside this rhythm the transport network is always changing, i.e. locations, routes, goods, volume, etc.

3.2. Risk, complexity and uncertainty

The business risk is commonly stated as the likelihood for an adverse event combined with the economical impact of that event. The entire risk handling process is referred to as risk management. The striving to minimize personal business risk has always been a part of doing business (Waters, 2007). Risk management is, therefore, the pursuit of the optimum balance between potential profit and risks (Doff, 2008). This means that risk management includes all activities normally referred to as management (Hardy, 1999).

The research with regard to risks in a supply chain is fairly new and started with risks and purchase (Khan, 2007). Since then several authors have addressed the relationship between risk and supply chains (Robinson et al., 1967; Williamson, 1975, 1979; Burnes et al., 1998; Burnes et al., 1996; Womack et al., 1990; Cousins et al., 2004; Hood et al., 2005; March et al., 1987; and Kraljic, 1983;). Studies of supply chain risks seldom address the causes of risk (Christopher et al., 2004 - a, 2004 - b; Juttner, 2005; and Sheffi, 2001). They simply mention supply chain risk sources without discussing causes such as theft, smuggling, sabotage, and criminal activity other than terrorism or the practical transfer of risks between the supply chain and the transport network.

According to Juttner et al. (2003) supply chain risk management is defined as ‘‘*the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole*’’.

To be successful, all aspects concerning operations and information need to work together. Juttner (2005) states that risk-taking is generally perceived as an inevitable aspect of supply chain management. At any case, the risks that exist within a certain supply chain need to be managed. Therefore, the managing of risks and threats against supply chain performance is effectuated by security and resilience in order to decrease the supply chain vulnerability. Christopher and Lee (2004) suggest that the increased vulnerability in supply chains is a result of the drive towards more efficiency. This normally means lesser inventory levels and more use of just-in-time delivery. This can lead to a higher level of uncertainty and risk.

In research publications the main remedy against uncertainty and risk within the supply chain is to increase the level of collaboration between stakeholders. Supply chain collaboration has, however, proven very difficult to implement (Ekwall et al., 2008; Cousins, 2002). The reasons for this are mainly overconfidence in technology, failures in establishing when and with whom to collaborate and the fundamental lack of trust between partners or stakeholders in the supply chain. Collaboration barriers are not addressed in this paper, only the risk and uncertainty within the supply chain and its relationship with the transport network.

According to Prater (2005), the increasing use of information systems has improved the efficiency for the actors in the supply chain, but their intrinsic uncertainty has also increased at the same time. This development depends also on the increasing complexity and competition in the business. This complexity increase is caused by factors like irregular demand pattern, cost reduction, product specifications, and customer consolidation (Peck, 2005). The sources of supply chain uncertainty are closely related to the configuration of the supply chain, such as the distance between supplier and customer, but also the available resources (Wilding, 1998). This uncertainty is in many cases the same as the vulnerability caused by external or internal factors. The external vulnerability is caused by uncertainty in demand and forecasting and also the complexity of the supply chain, while the internal vulnerability is the same as problems in manufacturing (Prater et al., 2001). The uncertainty in demand is increased by the bullwhip effect; therefore reducing the bullwhip effect is one way to reduce uncertainty in the supply chain (McCullen et al., 2002).

The relationship between supply chain uncertainty and freight transport uncertainty is direct. Freight transport, even if it normally also generates small amounts of uncertainty to the supply chain, is used to reduce the supply chain uncertainty. This is achieved through the use of factors like scheduling, outsourcing of logistics activities, delivery frequency, and volume. There is often a trade-off between the cost and the performance of the supply chain where stock-holding cost and delivery frequencies are sources of uncertainty, which generate risks in the supply chain (Lalwani et al., 2006).

3.3. Risk related to supply chain systems

Supply chains can in general be described via a systems approach in logistics research. The description of the context and the boundaries of the supply chain are essential in order to understand the description of each supply chain. If each supply chain is separated into several different sub-systems, together they provide a wider understanding of both the context and the different boundaries. According to Arnäs (2007) and Sjöstedt (2005) is it useful to separate logistics and transport from each other and instead emphasize the dialectic relationship between the terms or systems. The logistics system is constituted by three structured elements/components: *products*, *locations* and *facilities*. The transport system is constituted by three structured elements/components: *vehicles/vessels*, *freight* and *ways & terminals*.

This dialectic relationship provides an excellent description of the supply chain content of products and infrastructure, but it lacks the organizational element and also the wider environment, within which everything acts. Adding two additional systems, representing the organizational structure and the wider environment, to those stated above (logistics and transport) facilitates interpreting the context and boundaries for the supply chain system (Juttner et al., 2003).

The four levels are presented with elements and content descriptions. These elements and descriptions are of a general nature and shall not be regarded as decisive, more as illustrative and explanatory. Further, a description of the major risk sources and the different risk management strategies, normally used to manage and control the risk consequences, and is attached to each level. The system of supply chain risks is presented in table 3.3.1.

Table 3.3.1: System of supply chain with risk description and risk management strategies (based on Juttner et al., 2003 and Peck, 2008)

Level	Elements	Content description	Risks	Risk management strategies
1	Products and processes	Inventory and Information flows	*Negative* - variance, inefficiency, lack of responsiveness, demand uncertainty	Substitution of information for inventory; better visibility, velocity and control
2	Assets & infrastructure dependencies	Fixed & mobile assets	*Negative* - loss of link or nodes factors	Insurance and contingency/business continuity planning
3	Organisations and inter-organisational networks	Contractual & trading relation-ships, financial wellbeing	*Positive and negative* - financial decisions/ organisational failure	Contractually governed: partnering; dual sourcing; outsourcing
4	The wider environment	Economy, society and the forces of	*Positive and negative* - forces of nature: geological, meteorological	

		nature	and pathological	

The business in general considers the risk sources at each level differently. A risk at the second level is normally considered as negative, while the same risk source may in the perspective presented at the third level imply a new business opportunity, which is normally considered positive. The main focus of this paper is at the first and second level, which implies that risks are in general considered negative here. The great advantage of using the four levels (or subsystems) to describe the supply chain system is that it automatically provides a contextual understanding and boundaries to the problem of antagonistic threats towards logistics business.

Acquisition practices and strategies, like single sourcing, just-in-time, or a reduction of supply base, all have the potential to create disturbances throughout the supply chain. The trust in e-procurement tools also brings additional risks to the supply chain (Giunipero et al., 2003). All risk and uncertainty, in a supply chain perspective, will be transferred through a transport network. If designed and used wisely, the network can reduce the risk and uncertainty in the supply chain, in particular by the use of temporary storage functions. Then it is important that temporary storage specific risks are lower than the replaced supply chain risks. In terms of supply chain systems this is a good example of how both the first and second levels can co-operate in order to reduce the total risk, and how the risk can be transferred from one level to another.

3.4. Transfer of ownership – transfer of risk

A major and very common risk in business relationships is the communication risk – which misunderstandings and misinterpretation occur, because of communication deficiencies. This may affect the transfer of ownership of the goods on their way from consignor to consignee, which then decides who is responsible for bearing the risk associated with the transport. One established asset in prevention of miscommunication is the Incoterms 2000, issued by the International Chamber of Commerce, ICC. Incoterms (International Commercial Terms) provide standardized terms of delivery for consignors, consignees and freight forwarders. In addition they comprise obligations for buyers and sellers, such as whether the consigner or consignee effectuates payment for the transport service, customs requirements, cargo insurance and compensation requests from the logistics service provider or carrier. The operator commissioned for the transportation has in his turn responsibility only towards the part that purchases the freight service (Stöth 2004). There has been a development in recent years to move the ownership transfer point downstream. Using Incoterms 2000 categorization this means that EXW (Ex Works, the seller makes the goods available at his premises) has become more unusual, while DDP (Delivered Duty Paid, the seller pays for all transportation costs and bears all risk until the goods have been delivered and pays the duty) is now more common. In terms of supply chain risk it implies that the customers reduce their supply risk source. This is done to reduce the overall supply chain risk, by almost eliminating the supplier uncertainty. In systems of supply chains Incoterms 2000 offer a valuable toolbox for the transfer of risk at the first and second level (cf. table 3.3.1) to the third level. If this is not possible, the risks at the first level can be exchanged for the risks at the second level. By using the different Incoterms intelligently, in combination with extended liability contracts, it is possible for actors/stakeholders to transfer their risk to another participant in the supply chain (Ekwall et al., 2008).

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4. The function of temporary storage

The present trend of leanness and general low inventory levels, together with the outsourcing trend, imposes new demands on transport skills and functions. The lower inventory level reduces the robustness in the supply chain against disturbances. Then, in case of a disturbance, the supply chain will close down quicker and with a higher cost attached than it otherwise would have done. Therefore it is vital for every company to find a balance between inventory levels and the risk for disturbances in both in- and outbound logistics. This balance depends on factors like improved logistics and production planning, based on long-term and proactive relationships between buyer and seller. The flow of goods is scheduled by the buyer (Das et al., 1997). One big problem in both global and local sourcing is the time factor. Long or variable lead times, combined with shipments in consolidated volumes, only increase the difficulty of reaching the right balance between inventory level and supply chain robustness. If the transaction or transport includes overseas movement, it will affect both the lead time and the variability of it, thereby increasing the risk for supply disruption. An increased distance between supplier and buyer also adds uncertainty due to longer lead time, complex transhipment procedures and potentially more transport disruptions.

Purchasing professionals have successively adopted policies and routines to reduce the impact and to prevent future incidents after a certain event already happened. These professionals used multiple supply sources and larger safety stocks. The reason was that risk stimulated the creation of safety buffers instead of improving the poor supply chain performance. The drawback of this practice is that safety stock often limits performance and also reduces the competitive advantage, by increasing the stock cost and prolonging the lead time. It is anticipated that future supply chain professionals must direct their attention toward the uncertainty caused by risks in the corporate environment. The companies, which best reduce this type of uncertainty, are the most likely to reach the goal of generating bottom-line performance. This requires that in the future the role of a supply chain professional becomes more strategic (Giunipero et al., 2003).

The temporary storage function as time buffer in just-in-time distribution is closely related to the uncertainty of each transport. Normally there is a relationship between transport distance and the exact time of arrival. A longer distance (or longer transport time) means a larger uncertainty in time of arrival. This is solved by the use of time windows for delivery. These time windows are normally not adjusted according to the needs from the transport network. They are scheduled after the needs or demands from the terminal, warehouse, or a factory's internal activity. Because of this, the transport network needs temporary storage close to certain delivery nodes. This activity can be seen as an uncertainty-reducing function in the supply chain.

The need for securing the material forwarding activity of the transport network contributes to reducing both the overall risk and the uncertainty of the supply chain. This is achieved by scheduling the supply chain needs with regard to in- and outbound logistics activity. The consignee wants the goods within a certain time-window, and the uncertainty in this delivery is the consignee's inbound logistics risk. The consignor's outbound risk consists of the uncertainty of the outbound gateway and the transport network process plus control and environmental risk sources. The uncertainty of the outbound logistics must meet the demand from the consignee's inbound delivery window.

The usage of temporary storage is also affected by regulatory and legal issues. The conditions in the transport network are governed by different laws and regulations, which differ from one country to another. Within the European Union, the regulations have been co-ordinated. This harmonization of laws and regulations will probably continue in the future.

The current regulation for lorry driving acts as a restriction on working time and may be decisive for the need of temporary parking or temporary storage. It states that the driver is allowed to drive for 4.5 hours before a break, for 9 hours before day rest (a few hours extra in some cases, twice a week), and furthermore perform other tasks for 4 hours before day rest (Swedish ordinance SFS 1992:47), so a 14-hour working day is possible. The allowed working time per week is 56 hours over 6 days, plus an additional 28 hours in other (non-driving) activities. This regulation applies for vehicles over 3.5 metric tonnes. Lighter vehicles have no limitation regarding driving hours; however, the day rest should be at least 11 hours (Swedish ordinance SFS 1994:1297).

The main function of the temporary storage concept is to act as a short time stockpile. The reasons behind this have been clarified previously in this paper, but they can be simplified by referring to both external and internal requirements in the supply chain. The supply chain's internal demand can be illustrated by the scheduling of the transport and the delivery time by extended use of just-in-time delivery. The supply chain's external requirements come both from the local environment (risks from criminal activities, etc.) and authorities (laws and regulations regarding transport, etc.), so risks and uncertainties emerge from both internal and external factors in the supply chain. For internal reasons temporary storage places close to the terminal reduce uncertainty by making it smoother to schedule all deliveries according to demands and needs in the receiving terminal. This also reduces the upstream risks. The demands of external authorities on temporary storage will induce regulations regarding working hours, employee safety, refuelling, customs passage, etc.

The environment surrounding the temporary storage and the supply pipeline can increase both risk and uncertainty in the supply chain. According to Sherman (1995), crime will, in the future, be six times more predictable by location than by perpetrator. It is easy to understand that predictable traffic movement of goods will attract criminals. A repeatedly used location provides desirable goods, which are however guarded to some degree. Therefore, the crime risk at temporary storage areas will, in the future, become more evident. These areas need to be secured than today and thereby both contribute to reducing the risk and uncertainty within the supply chain and avoid adding theft risk to the transport network.

5. Cases of temporary storage

The function of the temporary storage can be described with two different cases. The two cases take two different perspectives on this problem. Case 1 addresses the function in the supply chain perspective and case 2 in the transport network perspective. Both are based on qualitative case studies with the focus on assessing real operational usage of a temporary storage function in order to reduce both supply chain risk and transport risk.

5.1. Case 1 – temporary storage in a supply chain perspective

One of the market leading wholesalers in consumer electronics has centralised their logistics activities in order to achieve effective logistics. All suppliers to the wholesaler are scheduled to deliver the ordered products to their central warehouse within a certain time-window. The Incoterms 2000 principle of DDP (delivered duty paid) is the preferred term between the wholesaler and all his suppliers. This means that the wholesaler has no risk, until the goods are unloaded at his terminal within the appointed time-window. If the supplier or, more exactly, the supplier's logistics service provider misses the time-window or the paperwork is erroneous, unloading is not allowed and the lorry is forced to wait for a new time-window. Therefore, each driver must plan the drive in such a way that the risk of missing the scheduled time-windows is at a minimum and that all documents are in order. The practical outcome of this is that Lorries arrive early and wait close to the warehouse for their time-window, or if they are not allowed to unload, they wait close to the warehouse, while the consignor corrects the paperwork. In either case, the area surrounding the warehouse (up to 2 km) has become a temporary storage area for loaded Lorries. This concentration of Lorries loaded with high-value products has an attractive influence on potential cargo thieves. To reduce the theft risk, the local management has decided to allow Lorries to wait within the warehouse fences, but only if they are scheduled to unload during the same day.

5.2. Case 2 – temporary storage in a transport network perspective

A logistics service provider (LSP) stroke a bid deal with a new customer which would double the turn-over. The new customer is a manufacturer of high-value electronics and he is therefore focused on security within the transport chain. The customer also has high demands on accuracy and effectiveness in all goods movement. To fulfil the demands from the new customer, the LSP added more control points to achieve better control over the position of each shipment. The purpose behind this was to identify an actual track, instead of a presumed track of goods. The customer demanded that all weak spots, vulnerable to theft, be avoided. Therefore, the customer reviewed the actual security level in all LSP terminals and also the security between them. To reduce the weak spots during road transport, the LSP tried to reduce all temporary stops. These stops were before decided by each driver. The LSP scheduled all lorry movement with the customer's goods so that all temporary stops would be avoided. The receiving terminal or the consignee was involved in such a way that they received an early warning that the shipment was on its way to be prepared to receive it directly when it arrived.

6. Analysis of the temporary storage function

The dialectic relationship between logistics and transport (Arnäs, 2007; Sjöstedt, 2005) and the four levels of supply chain systems (Juttner et al., 2003) provides excellent models for analysing the two cases. The two cases fit right into that figure, where case 1 addresses the focal company's situation in the supply chain and case 2 shows the transport network perspective. In both cases the temporary storage is a concern for the company to either reduce its own supply risk (case 1) or reduce its customers' supply chain disturbance (case 2). In both cases the main threat to the use of temporary storage is cargo theft. In other words, the security needs in the transport network, combined with the risk reduction in the supply chain imply less use of temporary storage by scheduling the movement. If the lorry needs to stop, due to regulations, refuelling, etc., it is only allowed to stop at secure parking spaces. The need for the temporary storage shall be compared with the potential increased theft risk that a certain location/stop constitutes. This is obvious from the statistics from Eurowatch (Robinson, 2009) where near-end location and insecure parking are the two most risky places for a lorry to stop at.

In case 1 the supply chain's need for just-in-time deliveries is combined with a penalty for missing the time-window that leads to an extended use of a near-end location temporary storage and the consequential increased risk for cargo theft (cf. Robinson, 2009). A holistic perspective of supply chain risks would in this case imply that the consignee in case 1 collaborates with his suppliers, in order to solve together the problems directly linked to the *near-end location* temporary storage function. This collaboration may comprise that the consignee (and maybe other nearby terminals) build and operate a secure parking, close to the receiving terminal, with free access (the cost may be included in the freight) for all inbound transport to the involved terminals. This will ensure that the temporary storage function, in a supply chain perspective, will reduce risk and uncertainty while the transport-related risk and uncertainty is also held at a minimum.

In principle there are only two valid risk management strategies for managing supply chain risk and uncertainty to obtain a satisfactory balance between profit and cost/risk/uncertainty, namely mitigation and transfer. Mitigation of risk refers to robustness against consequences, while risk transfer normally involves the use of insurance policies. The function of the temporary storage is primarily to mitigate supply chain risk and uncertainty by transferring elements of uncertainty to the transport chain/network and thereby increasing the resilience of the supply chain. In order to fulfil this objective, it is important that the risk and uncertainty directly linked to the usage of the temporary storage are also mitigated or transferred. The function of temporary storage is twofold. First, it is a place where physical goods wait for a short period of time to achieve the sometimes necessary elasticity for the scheduling of the supply chain or transport network. Second, for legal and other reasons, cargo carriers need to park, refuel, and rest. Temporary storage is located between nodes in the transport network and acts as a supply chain disturbance neutralizer, reducing risk and uncertainty within the supply chain. To avoid both supply chain disturbance and increased theft risk there are three types of solutions. *Firstly*, improved and more exact scheduling of delivery time. *Secondly*, availability of secure parking spaces whenever a resource needs to make a temporary stop. The *third* and most suggested reductive measure is to utilize tracking and tracing systems. All of these reductive measures can work together, and as a combined toolbox they can contribute to reducing the risk and uncertainty in the supply chain.

7. Conclusions

This paper is an attempt to describe and assess the role of temporary storage in a supply chain perspective and its abilities to reduce risk and uncertainty. The internal need for the temporary storage is vital for the overall performance of the supply chain, regarding both cost efficiency and shorter lead-time. This depends on the scheduling that governs the transport by managing the delivery time and place. From a security point of view, temporary storage will offer a location for crime opportunity, which needs to be reduced in order to achieve control of the total supply chain risk and uncertainty. This statement is strongly supported by table 1.1, which presents statistics from Eurowatch between the years 2002-2009. According to Robinson (2009) the most dangerous location is a *near-end location* or at an *insecure parking,* depending on which modus operandi is considered most threatening. This shall be compared with the reason behind the need for a *near-end location* stop or *parking*, where the *near-end location* stop is derived from the involved supply chains’ need to reduce the internal risks, while the need for parking derives mainly from legal requirements.

In general, there are a number of basic methods to control risk, i.e. by elimination or avoidance, transfer, isolation, segregation, modification, reduction, protection, training, warning, supervision, rescue, and repair. The crucial risk here is cargo theft in temporarily parked Lorries. Elimination of the risk means that either the lorry or the perpetrator will not be there. This can be achieved by routing and careful transport planning with exact scheduling of delivery, or by temporary storage facilities of the consignee, allowing loaded Lorries or

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trailers to be dropped off without an extended waiting time. The use of slot-times, similar to the air traffic network, is one way to achieve that. There are several methods and approaches for delivery scheduling, including software support from LIS – logistics information and ERP systems, genetic algorithms of operations research, and other feasible solutions.

Transfer of the risk is contingent upon the agreed transfer of ownership, the insurance situation, and whether the principles of crime displacement are applicable. Isolation, where the consequences do not affect the object studied, and segregation, where an adverse event cannot cause domino effects, may be achieved by technological means. The use of secure parking spaces whenever a resource needs to make a temporary stop, the use of hard-body lorries and trailers, intelligent locking devices, etc. contribute to the protection of the goods. Supervision and rescue may be effectuated by utilizing different types of tracking and tracing systems, which is the commonly most suggested reductive measure. Available risk control options can be applied synergically and as a combined toolbox contribute to reducing both risk and uncertainty in the supply chain.

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