Transport vulnerabilities and critical industries: experiences from a Finnish stevedore strike

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Abstract: Transport system is one of the critical systems in all societies. Despite growing interest towards supply chain vulnerabilities and the meaning of critical infrastructures to societies, analysis on vulnerabilities related to maritime transports in a security of supply context has not gained much interest. However, any failure in transports can have very disruptive consequences not only to companies' supply chains but also to national supply security and daily life of people. With this paper, we contribute to analysis on mitigation strategies of critical industries towards transport disruptions. Our case study concentrates on impacts of a port closure due to a strike in Finland in 2010 and companies' strategies to manage their operations during the strike, and we draw conclusions to the general structure of mitigation strategies towards logistic vulnerability.

Keywords: critical infrastructures; critical industries; security of supply; maritime transport; transport vulnerabilities; mitigation strategies; Finland.

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1 Introduction

Transport system is one of the lifeline systems in all societies. Over 80% of international shipments of goods are transported by the sea, almost 90% of EU external trade is seaborne and 40% of intra-European freight is carried by short-sea shipping. Furthermore, maritime transport has a key role in security of supply of in many member-states (UNCTAD, 2009; Commission of the European Communities, 2009). Security of supply involves all the activities that are undertaken to secure a nations' functioning and the welfare of its citizens in case of major disturbances and emergency situations. Emphasis is on preventive measures (Valtioneuvoston Päätös Huoltovarmuuden Tavoitteista 21.8.2008/539, 2010). Despite growing interest towards supply chain vulnerabilities (for a review see Craighead et al., 2007; Tang and Musa, 2010) and the meaning of critical infrastructures to societies, analysis on vulnerabilities related to maritime transports in security of supply context has not gained much interest. This is rather surprising, as any failure in transports can have very disruptive consequences not only to companies' supply chains but also national supply security and daily life of people (Rodrigue and Slack, 2002; Chen et al., 2007). Previous analysis on critical maritime transport infrastructures has looked at sources of vulnerabilities and their impacts, including terrorism (Price, 2004; Linkov et al., 2007), maritime safety and security e.g., international ship and port facility security (ISPS) code (Bichou, 2004, 2008), natural disasters and climate change (Bigger et al., 2009; Koetse and Rietveld, 2009) and strikes (Hall, 2004; Park et al., 2008), but more research is needed on consequences of transport disruptions (Chang et al., 2007).

With this paper we contribute to analysis on mitigation strategies of critical industries towards supply chain vulnerability caused by transport disruptions. A disruption is a sudden event that interrupts the material flows in the supply chain stopping movement of goods causing negative consequences (Svensson, 2000; Kleindorfer and Saad, 2005; Craighead et al., 2007; Wilson, 2007). Supply chain vulnerability is "a susceptibility or predisposition to change or loss because of existing organisational or functional practices or conditions" in the operational environment of the supply chain (Barnes and Oloruntoba, 2005; Wagner and Bode, 2006). Critical industries provide the necessary inputs and services a society is dependent on (e.g., energy, food and healthcare) and they are an essential part of critical infrastructure (chapter 2). In our paper, we show that maritime transports are critical for Finland as over 80% of the foreign trade in the country is transported by ships and many critical industries are dependent on imported supplies. Any disruption in maritime transports can thus have a major negative impact on all main sectors in the economy. As a concrete case, we analyse the impacts of a port closure in Finland in a form of a stevedore strike in the spring 2010 and companies' strategies to

manage their operations during the transport disruption caused by the strike (chapter 4), and we draw conclusions to the general structure of mitigation strategies towards logistic vulnerability.

2 Critical industries, security of supply and vulnerability

The EU defines critical infrastructure as:

> "An asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions." (Directive, 2008/114EC)

The concept stresses interdependencies within and across sectors in society. It helps to understand which industries and sectors in society would be the most suffering if there is a breakdown, malfunction, lack of availability of certain materials or other assets or any other disturbance, and where – both in a geographical and organisational sense – the problems are likely to occur (Rinaldi et al., 2001; Moteff, 2005; Hagelstam, 2005; Boin and McConnell, 2007; Murray and Grubesic, 2007; Brunner and Suter, 2008; Grubesic and Matisziw, 2008).

Security of supply includes ensuring functionality of society's critical systems and availability of critical materials. The National Emergency Supply Agency of Finland (NESA) defines the aim of the national security of supply policy as: "such a degree of preparation that the population's capacity to make a living, to carry out necessary social activities, and to achieve the material preconditions for an effective national defence are not endangered." NESA is responsible for coordinating measures for safeguarding critical infrastructure and critical production in Finland. Emphasis is on preventive measures. The critical infrastructure in Finland comprises of energy transmission and distribution networks, communication network, transport and logistics infrastructure and networks, water supply and other municipal services, and constructing and maintaining all these infrastructures. Critical production includes food supply, energy production, healthcare, production for national defence purposes and operational preconditions for export industry, above all functioning of ports and transport routes leading to ports (National Emergency Supply Agency, 2010; Valtioneuvoston Päätös Huoltovarmuuden Tavoitteista, 21.8.2008/539, 2010). Export industries have a strategic meaning for the Finnish society as over 35% of the GNP is related to exports (EK, 2010a). Critical production thus includes various activities that are all dependent on critical infrastructures.

Security of supply policy has traditionally been based on existence of reserve capacities either in the form of material stocks or infrastructure e.g., extra loading capacity in ports or transport equipment. Ensuring security of supply was the responsibility of the state government. With increased globalisation and privatisation of ownership and assets, safeguarding critical infrastructure involves building partnerships between the public and private sector. While governments are usually legally responsible for safeguarding the society's vital functions and the critical infrastructure, most of the critical infrastructure are owned, administered and operated by the private sector. Government authorities at national level thus lack the authority, expertise and the means

to control these critical operations (Lieb-Dóczy et al., 2003; De Bruijne and van Eeten, 2007; Pursiainen, 2009). For example, maritime transport chains are international and complex involving many stakeholders, majority of ships no longer sail under national flags and regulation of the maritime transports is done at international level.

Moreover, new business strategies can increase vulnerability. Jüttner et al. (2003) have identified five such matters:

1 focus on efficiency rather than effectiveness

2 the globalisation of supply chains

3 focused factories and centralised distribution

4 increased outsourcing

5 the reduction of the supplier base.

Just-in-time manufacturing, quick response, single sourcing and reduced inventory are based on high utilisation rate of the infrastructure and assets, including inventory levels, transport time or human resources (Herod, 2000). With reduced inventories and optimised systems, companies and societies are very dependent on continuous and predictable transports, efficiently functioning network of stakeholders, energy, and ICT (Svensson, 2000; Norrman and Jansson, 2004; Barnes and Oloruntoba, 2005; Peck, 2005). Several management strategies (Table 1.) have been suggested to overcome the logistic vulnerabilities at a company/supply chain level (Jüttner et al., 2003; Chopra and Sodhi, 2004; Tang, 2006; Manuj and Mentzer, 2008). We discuss their usefulness and limitations in relation to our empirical findings (chapter 5).

Table 1 Mitigation strategies towards supply chain vulnerability

Mitigation strategy	*Measures*
Avoidance	Avoiding specific products/geographical regions/suppliers/customers/traffic modes
Control	Vertical integration (upstream and downstream)
	Increased stockpiling, buffer inventories
	Excess capacity
	Contracts
Cooperation	Joint efforts to improve supply chain visibility and understanding, e.g., vendor managed inventory (VMI)
	Information sharing and communication, e.g., electronic data interchange (EDI), forecasting
	Continuity plans
Flexibility	Flexible delivery schedules
	Multiple sourcing/flexible supply base
	Localised sourcing
Postponement	Form and time

3 Research methodology

The purpose of our research was to assess maritime transport dependency of the critical industries in Finland and describe, explain and understand how the companies in these industries have prepared for transport disruptions. Our research was qualitative, following a case study methodology (Eisenhardt, 1989; Yin, 1999, 2003). We conducted 19 semi-structured personal interviews during the period 25–26 March–November 2010. Themes discussed during the interviews included (interview protocol in Appendix):

- Transport routes and modes used, volumes of materials transported and most important ports.
- Management of problems and disruptions: How did the companies prepare themselves to a situation where the transport mode or route they normally use cannot be used, and what alternatives they had during the strike? How did the companies ensure their continuous operation despite disruptions? How did they inform their suppliers and clients?
- Strategic position of the respective company in the markets and in its supply chain: how specialised is the production (e.g., each factory produces certain products only), how much flexibility does it have in its sourcing and is it e.g., the sole supplier to its clients?

Table 2 Industries included in the research

Industry	*Number of companies*	*Of which public*	*Number of employees*	*Turnover 2009*	*Number of sites outside Finland*
Energy production	2	2	5,000 to 14,000	5 to 10 billion €	10 to 20
Food supply and food exports	5	2	1,000 to 10,000	< 5 billion €	< 10
Chemicals	4	2	5,000 to 10,000	< 5 billion €	10 to 50
Pharmaceuticals and healthcare supplies	4	3	1,000 to 10,000	1 to 10 billion €	10 to 20
Freight forwarding	1		> 15, 000 (globally)	11 to 30 billion €	> 100
Forestry	1	1	> 15,000	5 to 10 billion €	> 10
Metals	1	1	5,000 to 14,000	< 5 billion €	> 20
Electronics (whole corp.)	1	1	> 100,000	> 30 billion	> 100

Notes: The data concerning the number of employees, turnover 2009 and number of sites of the companies is based on annual reports of the companies. As the number of the companies was small, their number of employees and annual turnover have been expressed as a class in order to ensure the anonymity of the companies. Data on affiliates of multinational corporations was not available separately, and we have used the figures for the whole corporation.

Table 3 Critical industries, the imports, main ports and port alternatives

Industry	*Main imported goods and materials*	*Main ports*	*Port alternatives in case main port is closed*
Energy	Oil, gas, uranium, coal	Oil: Kilpilahti and Naantali	Oil: No alternatives
		Coal: Helsinki, Naantali, Inkoo, Koverhar, Loviisa, Kotka	Coal: Hard to replace Naantali. Pori, Raahe, Kristiinankaupunki, Vaasa, Pietarsaari, Tornio, Oulu can cover partly
Food sector	Pesticides and fungicides, raw materials for fertilisers, animal feed (soya), grain, agricultural machinery	Animal feed and grain: Naantali, Kotka, Loviisa Hanko	Animal feed and grain: Uusikaupunki, Turku, Pori, Rahja, Vaasa
		Pesticides and fungisides: Vuosaari	
		Fertilisers: Uusikaupunki	
		Agricultural machinery: Kotka, Turku	
	Imported raw materials for the food industry: chemicals, packaging materials, spices, fruit, vegetables, jams and juices	Fruit and vegetables: Vuosaari, Kotka	Fruit and vegetables: Hanko, Turku
	Food imports for consumer markets and food exports	Meat in refrigerated (or reefer) containers: Vuosaari	Meat in reefer containers: no alternatives to Vuosaari
Healthcare	Pharmaceuticals, equipment, basic chemicals	Vuosaari	Kotka, Turku, Hanko
Forestry industry	Timber, fillers, coating pigments	Pulp and paper exports: Kotka, Rauma	No alternatives for pulp and paper
		Sawn wood exports: Kotka, Loviisa, imports: Rauma, Pietarsaari	
Chemical industry	Crude oil, basic chemicals, rubber	Hamina, Kotka, Rauma, Pori	Oulu, Pietarsaari, Kokkola
		Mustola, Joutseno (in lake Saimaa)	Kotka, Hamina, Vuosaari
Technology industry	Metals, minerals, fuels	Ores and metals: Raahe, Pori, Kokkola, Tornio	Use of industry-owned, private ports
		Exports of metal products: Helsinki, Turku, Lappohja (industry-owned, private port)	

Source: Lumijärvi and Tapaninen (2009), Sundberg (2009) and Company interviews

The interviews were conducted at the premises of the companies and taped on the permission of the interviewees. The persons interviewed are responsible for transport and logistics operations. Five interviews were group situations, where several persons from the same organisation were present. The companies included in the research (Table 2) are the main users of ports, transporting considerable volumes. All of the companies have international sales and several production sites outside Finland, and with the exception of five companies they all are publicly listed. Eleven of the companies have their headquarters in Finland, six of the companies are affiliates of foreign-owned companies, two affiliates of Finnish-owned corporations.

Our analysis of the interview material is based on classifying the content of each (transcribed) interview according to the above mentioned themes, and finding similarities and differences between different companies. We concentrated especially on the interview sections dealing with impacts of the stevedore strike on the companies' operations and how the companies ensured continuity of their operations. We used also written sources including information published at the companies' WWW-pages and newspaper articles concerning the impacts of the strike to complement the information our interviewees gave us, and governmental reports to assess the import dependency of the Finnish critical industries.

Most of the critical industries in Finland are very dependent on imported raw materials or other supplies (Table 3), but the rate of import dependency varies between sectors. Maritime transports in particular are critical in ensuring security of supply in Finland, because the transported volumes within the critical industries are so large or the goods transported have such characteristics that the goods cannot be transported by any other mode. Rail traffic has a central role in raw material imports from Russia. In domestic transports road traffic dominates (Lumijärvi and Tapaninen, 2009). Supplies of electronics industry, biotechnology and also certain supplies needed in healthcare are mainly transported by air. Table 3 shows that the critical industries shipments are concentrated at certain ports. These ports are thus critical nodes in the maritime transport system. If the ports mainly used are closed, there are no port alternatives for current oil, pulp and paper and meat exports in reefer containers. These industries would be suffering most from transport disruptions.

Next, we will discuss how companies in Finnish critical industries were able to handle a transport disruption: a strike closing all major ports in Finland.

4 Strike and companies' mitigation strategies

The strike of the stevedores at public ports (4–19 March 2010) stopped approximately 80% of the Finnish foreign trade. The causes for the strike were disputes between Finnish Transport Workers' Union (AKT) and Finnish Port Operators' Association (Satamaoperaattorit ry) on working hours and severance benefits. The port workers' union was requesting a compensation equivalent to one year's salary for laid-off workers. The port workers' union gave a strike warning a month before and the representatives of the employers and employees negotiated to solve their disputes. As a result the strike was postponed for two weeks (Kuusela, 2010). Because of the strike Finnish companies could not export their products and/or import raw materials, components and spare parts. They had to find transport alternatives and ways to continue operations. Our informants stressed that Finland is like an island: The Baltic Sea separates the country from

continental Europe and land transport options are limited. Finland has land border with Russia, but strict border regimes makes passing it difficult. Borders with Sweden and Norway in the North are open, but the longer distance makes this land route uneconomical. However, companies did use the route via Sweden during the strike when they could not use their normal maritime transport route. Majority of the Finnish maritime traffic is feedering to and from ocean ports Antwerp, Rotterdam and Hamburg in the Continental Europe, where goods are either reloaded to/from inter-continental vessels or from where they continue by other transport modes to their final destination.

During the stevedore strike the only option for the Finnish companies to deliver goods to ships was using a driver + trailer combination instead of containers or semi-trailers. Shipments in bulk form were only possible via private, industry-owned ports. Also, the feeder vessels delivering the containerised goods to and from the ocean ports (Hamburg, Rotterdam, Antwerp) stopped running, but companies could still use liner ferries running between Finland and Sweden, Finland and Estonia, or Finland and Germany, or transport goods by land via Sweden or using Swedish and Estonian ports for their shipments. In addition to transport adjustments the companies did all they could to secure their supply chains. Most companies were able to supply at least their key customers with the most essential goods and materials during the strike. Preventive measures the interviewees used during the strike include:

- Raising inventory levels at their own and customers' sites before the strike began.
- Changing the delivery schedule, e.g., making orders of incoming supplies earlier and/or postponing orders to customers if possible.
- Changing the transport mode and route if possible.
- Having spare capacity in production or storage.
- Buying finished/semi-products from a competitor to fulfil delivery contracts to customers in case the company's own production had to be stopped e.g., due to shortage of raw materials.
- Supplying the customer from another site (outside Finland) among the corporation's network producing the same or suitable products (transferring customer orders between the plants). However, many companies have specialised production plants producing only certain products with no compensatory production elsewhere.

With the exception of buying finished products from a competitor, the preventive measures listed above belong to control and flexibility strategies (Jüttner et al., 2003), and majority of the companies used these two strategies solely or in combination. While postpone and avoidance can be used to protect a company from market related vulnerabilities (Manuj and Mentzer, 2008), we argue these strategies do not help to avoid transport disruptions. Raising inventory levels at own and customers' sites was for many companies the first preparatory measure. The informants said their companies keep stocks to be able to supply large volumes of products constantly, to guarantee customer satisfaction and to be prepared for sudden peaks in their customers' demand. Having buffer stocks is necessary if distance from the supplier of the goods to the customers is long. However, having goods in stock ties capital and all the companies regardless of industry try to minimise their inventories. Reliability of the deliveries is thus the main concern for all companies.

The interviewees also pointed out, that for a global company with multiple production units in different countries the international network can help solve problems if there is e.g., lack of supply situation. It would be much harder for a smaller, non-global company to find solutions for logistics problems because they do not have alternatives available within their own organisation. Flexibility involves diversification of the facility locations, sourcing options and transport modes. The availability of several options can be used to protect a company against unanticipated events (Kleindorfer and Saad 2005; Manuj and Mentzer, 2008). Vertical integration, contracts and agreements are an essential part of the control strategy. Excess inventory, excess capacity and redundant suppliers also belong to the control strategy. However, stockpiling only makes sense if the product's holding costs are low and there is no danger of obsolescence. For products with high holding costs and/or high rate of obsolescence it is more recommendable to use multiple suppliers (Chopra and Sodhi 2004; Manuj and Mentzer, 2008).

Furthermore, the strike revealed companies dependency on transport services. Even though a company would organise its own transports, it would still be dependent on other companies such as ocean carriers, road hauliers, etc. who conduct the transport:

> "We are totally dependent on shipping companies and transport companies, and their choices and changes to make changes. (..) We have seen a lot of stretching during this strike that those shipping companies actually... they made changes. They unloaded in Tallinn and they helped us to... arrange transportation from Tallinn (..). But it was not so, how should I say, it was not easy and it was not fluent. So, everybody had to work a lot for that. (..) And the shipping companies, (..) their ownership is not in Finland anymore. (..). Are they interested in that there is enough food in Finnish stores?" (Import service manager, a wholesaler of consumer products)

The interviewee quoted above stresses dependence on multiple actors in the transport chain, and the ability of these other companies to provide transport services despite disruptions, e.g., a strike. If companies providing transport services had difficulties it would reverberate directly to their clients' operations. However, as many of these companies are foreign-owned, they may not be interested at all e.g., food security in a country. Due to foreign ownership it would be hard for their clients or authorities to influence the shipping and transport companies' decisions in this respect. Peck (2005), and Kleindorfer and Saad (2005) underline that preventive measures towards transport disruptions should take into account the whole transport chain. Problems 'travel' fast through global business networks, and companies should be aware of network effects when making their risk mitigation strategies (Chopra and Sodhi, 2004). Companies ought to be proactive towards vulnerability of their operations all over the world, not only in countries where they do business or where the trans-shipment points (e.g., ports) of their goods are located. Our interviewees, as the one quoted above, told the strike revealed needs to improve their preparedness in this respect.

Our empirical results show there is variation between industries how long a disruption can cause harm and which mitigation strategies can be used (Table 4). These strategies and measures refer to the ways how companies deal with disruptions in general and how they managed the strike in particular.

Table 4 Risk mitigation strategies of the case companies

Industry	*Risk mitigation strategies*	*How long production can be carried out after a disruption*
Energy production	Company 1 (coal imports): control and flexibility	Three months
	Control: several month's stocks + backup Flexibility: multiple sourcing (contracts 80% to 90%, buying from spot markets 10% to 20%), widening the energy base (biofuels and domestic energy sources)	
	Company 2: (oil) flexibility	Two to three days
	Raw materials sourced from different locations, several production sites in different countries Flexibility in contracts: own and chartered vessels, term agreements used mostly in sales, but some products sold also on spot markets	
Food supply and food exports	Company 3: (grain imports and exports) flexibility	Several months
	Several ports can be used Flexibility in schedules: postponing shipments/taking incoming deliveries earlier Multiple storage sites, farms keep their own stocks extra storage capacity can be organised	
	Company 4: (meat and meat products) control and cooperation	Two to three weeks
	Control: specifying transport requirements in contracts (e.g., transport partners' equipment) monitoring inventory levels (incoming supplies and finished products) Cooperation: joint ventures in production in emerging markets (Baltic, Russia) Importance of direct communication and personal relations when managing disruptions	
	Company 5 (animal feed and malt): control and cooperation	Two to three weeks
	The company produces several different products, animal feed production most sensitive for disruptions Control: reserve stocks, excess capacity, and capacity to change production in emergencies Cooperation: cooperation in energy, localised sourcing and contracts with farmers to reduce import dependency	
	Company 6 (wholesaler of food and consumer products): flexibility	
	Several different products, lead times between products vary Flexibility in schedules and transport modes	Between two–three days to two–three weeks

Table 4 Risk mitigation strategies of the case companies (continued)

Industry	*Risk mitigation strategies*	*How long production can be carried out after a disruption*
Food supply and food exports	Company 7 (milk products): cooperation and flexibility	Two to three days
	Cooperation: with transport companies Flexibility: multiple suppliers, several transport options possible	
Chemicals	Company 8 (basic and specialty chemicals): control and cooperation	Two weeks
	Control: increased inventory Cooperation: continuity plans	
	Company 9 (basic and specialty chemicals): control and flexibility	Two weeks
	Control: Continuity plans, increased inventory Flexibility: Changing the transport route and mode, global sourcing, alternative suppliers (in some materials only one supplier)	
	Company 10 (basic chemicals, raw materials for plastics): control and cooperation	Two to nine days
	Control: Supply contracts, vertical integration Cooperation: Continuity plans, communication (internally and with suppliers and customers)	
	Company 11 (pigments and chemicals): control and cooperation	Two weeks
	Control: increased inventory Cooperation: vendor managed inventory (VMI) with suppliers, continuity plan including alternative routing and changing transport mode, back-up carriers	
Pharmaceuticals and healthcare supplies	Company 12 (pharmaceuticals): control	Two months
	Control: buffers, safety stocks, back-up suppliers Alternative routing, changing transport mode	
	Company 13 (wholesaler of healthcare products): cooperation and flexibility	Two to eight weeks
	Cooperation: with principals and contractors Flexibility: several suppliers with multiple factory locations, several transport modes used Safety stocks	
	Company 14 (wholesaler of pharmaceuticals): control and flexibility	Three to four weeks
	Control: safety stocks by law (three and six months), Flexibility: several transport modes used	

Table 4 Risk mitigation strategies of the case companies (continued)

Industry	*Risk mitigation strategies*	*How long production can be carried out after a disruption*
Pharmaceuticals and healthcare supplies	Company 15 (wholesaler of pharmaceuticals): control and cooperation Cooperation: with principals and contractors Control: safety stocks by law (three and six months) Alternative routing, changing transport modes	Three months
Logistics/freight forwarding	Company 16: cooperation and flexibility Cooperation: communication Flexibility: in scheduling, re-routing	No info
Forestry	Company 17 (pulp and paper, sawn wood): cooperation Cooperation: vendor managed inventory (VMI) with suppliers, communication Continuity plans will be made	12 hours to two days
Metals	Company 18 (metal products): flexibility Several suppliers of raw materials, some spare capacities Ability to carry out production varies between products	From two to three weeks to several months
Electronics	Company 19 (products for power and automation technologies): postponement and flexibility Postponement: products produced to stock, engineered to order and configured to order Flexibility: several different products, balanced pool of customers in different industries, changing delivery schedules in case of problems	Two to three days

The character of the product transported or production process restricts to use of certain mitigation strategies, including the flexibility strategy. Pharmaceutical companies are vertically integrated, have a very rigorous quality control with audit procedure for their suppliers. Therefore, it is not easy for them, e.g., to change suppliers. As Table 4 shows, companies in chemical and healthcare industries rely on control or cooperation strategies. A representative of the chemical industry that uses a private port said that it would not be possible for them to adjust the timetable of their incoming and outgoing shipments very flexibly due to limited storage space and the technical requirements of the production processes. Moreover, companies with goods classified as international maritime dangerous goods (IMDG code, see IMO, 2010) have difficulties finding a suitable transport company, as their requirements often do not comply with the ship owners' capabilities. The nature of their products and requirements concerning their transportation (e.g., two products that need to be transported separately and in a different temperature within the same vessel), and the requirements for a suitable vessel due to the conditions at the Baltic Sea (ice class, double hulls, etc.) restricts the number of shipping companies capable of carrying the transport.

Some companies in the forestry industry found that none of their mitigation strategies worked when the Finnish ports were closed. Industries suffering most from transport disruption caused by the strike were main export sectors forestry, chemicals, production of metals and machinery, and also food. As discussed above, (chapters 2 and 3) all these belong to critical industries in Finland. Products requiring temperature controlled transport, including pharmaceuticals and food, do not bear interruptions at all in the transport chain and are thus very vulnerable. Some industries have constantly running processes (e.g., chemical production) and they are dependent on continuous, daily delivery of raw materials as well as continuous transports carrying finished products. Any problems with the supply chain, both lack of availability of raw materials and/or difficulties delivering the finished product, can cause production reduction or even stoppage immediately, resulting economic loss. A representative of process industry describes the situation:

> *Interviewee:* We were not able to manage our logistics during the strike in practice at all.
>
> *Question:* So, you had to close down factories?
>
> *Interviewee:* Yes, we closed most of the factories. In a strike situation our factory (at a location X), which is our biggest, can continue production for 12 hours. Then it has to be closed. Most of the production plants within three days. Some specialty factories like *Y* and *Z* and one machine in W, a couple of weeks (..). But in practice it is an impossible situation for us. (..) We are producing some of our products only in Finland (..). The other element is that for some customers we are the sole supplier. And actually that is something we are preparing now, how to tackle this question in future. It is not allowed to happen anymore. But in practice we were ... it was mission impossible for us. And also for XX (the interviewee's company's main competitor). But companies which have own industrial ports were able to operate normally." (Senior vice president of logistics, process industry)

As the interviewee says, his company was forced to shut down the first factories after two days the strike had begun. This quote shows clearly the vulnerability of focused factories and lean production (Herod, 2000; Jüttner et al., 2003; Peck, 2005). According to forestry companies, e.g., 70% of the paper production in Finland was stopped because of the strike, causing 2.5 to 3 million € losses per day to the companies. Timber production was not stopped as largely as in the pulp and paper production, but the industry suffered losses of export revenues. If the strike had continued longer, suppliers of the forestry production would have been forced to diminish or shut down their production (Metsäteollisuuden Tietopalvelu, 2010; EK, 2010b).

Besides forestry, other industries reported economic losses. Finnish Chemical Industry (2010) products are used as supplies in other industries and impacts of the strike varied depending on the subsector. Companies supplying forestry industry and plastics industry were among the first to adjust their production. In other subsectors of the chemical industry the impacts of the strike were visible within one to four weeks. Technology sector estimated loss of exports as 70 million € per day. A nickel producing company had to close down its smelting plant due to lack of nickel concentrate. Wholesalers of technical products had also difficulties getting supplies. The strike caused some changes in the retail trade, too. Supermarkets run out of certain perishable products such as imported fruit and vegetables. However, the strike did not cause any severe lack of food, as the percentage of domestic products is rather high and the share of imported

products rather marginal in Finland. Retail trade could use alternative ways of imports (Yle uutiset, 2010; EK, 2010b; Kaarenoja, 2010; Kjellberg, 2010).

With the exception of forestry industry, other industries did not face production stops due to lack of raw materials, but they were very close to it. The strike also caused process alternations. Food production companies suffered lack of imported raw materials which caused closures of some production lines and disruptions in production. Exports of meat, meat products and cheeses were first to suffer (EK, 2010b.) In meat production the final products have to be shipped out right after packing, due to limited storage capacities and perishable nature of the products. Furthermore, meat production is dependent on animals of a certain age. When the production is interrupted due to interrupted export streams, the animals will grow too old and expensive production adjustment will be necessary.

5 Conclusions

In a globalised world companies are dependent on continuous transports. Maritime transport is vital for world trade, because ships can carry large amounts of goods economically over long distances. The Finnish stevedore strike in the spring 2010 made visible the Finnish society's dependency on maritime transports very concretely, because many critical supplies including energy, pharmaceuticals and raw materials needed in export industries are imported and for many of the companies in the critical industries maritime transport is the only transport mode they can use. The strike was a concrete learning experience for the companies: it made them re-think their preparedness towards transport disruptions. Many companies realised they need to adapt their long-term countermeasures against such events. Compared with many other hazards affecting transports (e.g., accidents) a strike is different as there usually is a warning given beforehand. Had there not been a warning about the strike, or had the strike lasted a longer period, e.g., a month, or involved also land transport, several of the companies would have faced serious trouble and companies in the process industries could have been forced to shut down production within a few days (see Table 4). The strike warning allowed companies to make preparations beforehand, enabling them to continue their operations.

Our results show there are differences between industries which strategies and practical measures companies can use to overcome problems caused by transport disruptions but this should be investigated further. Characteristics of the goods transported or production process restricts the available strategies narrowing suppliers to use and transport options. Most of the strategies the companies used fall under flexibility or control, or a combination of both strategies. The companies raised their inventory levels before the strike began, they re-scheduled or postponed their deliveries, shifted customer orders between production plants among their company's production network or in the extreme case bought finished products from their competitor to fulfil their customers' order. The number of companies included in this research is small, so our results should be tested with a larger, representative sample of companies.

At the societal level the strike revealed vulnerabilities related to high import dependency of certain critical sectors, as well as concentration of cargo flows to certain ports with no alternatives. Finding ways to substitute imports with domestic supplies in the critical sectors is thus vital for the national security of supply. Governmental authorities can also inform the companies about the importance of business continuity

planning. As transport needs between industries differ, each and every company should make their own plans even though companies can learn from each other's experiences.

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Appendix

Interview protocol

1 What products, materials or any other necessary supplies are either imported or exported to/from your company via Finnish ports, especially Gulf of Finland ports? Please name the most important commodities or commodity groups (if several)

2 What are the most critical of the commodities you listed? In other words, what are the materials, goods or other supplies whose lack of supply would harm the functionality of your company most severely?

3 What are the ports that your company mainly uses for incoming/outgoing shipments? Where are the supplies that you need (raw materials, spare parts, etc.) currently arriving and how are your products transported? (If possible, tell us the whole transport route of the supplies, starting from the port from where goods are shipped to/from Finland)

4 What problems and risks have an impact on your shipments and logistics?
   - Have you got many transport alternatives for your company's shipments?
   - Where do you see the greater risks: in supply chain related matters or transports?
   - What is the strategic position of your company in relation to other actors in the transport chain? To what extend are other companies and stakeholders dependent on you? How much can your company influence on the decisions made by other parties (shipping companies, logistic service providers, suppliers, etc.)

5 How are you prepared to possible risks concerning availability of supplies and transport?
   - What kind of impacts did the strike of the stevedores closing public ports have to your company's operations?
   - How did your company manage to continue operating during the strike? What arrangements were needed before and during the strike? Do you e.g., have buffer stocks of raw materials, spare parts or other materials?

- Can you estimate the costs the strike caused you?
- How easy or difficult is it manage with risks in general? Can you e.g., change your suppliers, transport mode and ports you use? How about your clients, what can they do if something goes wrong in your company (e.g., an accident in a factory)?
- How do you ensure continuity of your company's functions during and after a possible disturbance?

6 How do you communicate about problems to your customers and suppliers? Do you have a communication strategy?

7 Can you recommend other persons to be interviewed? Was there an important topic we did not ask? Anything you would like to say in conclusion?