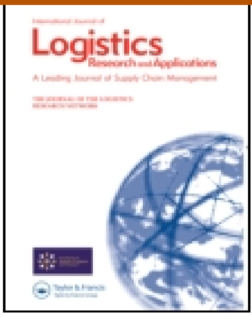

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Logistics costs in Norway: comparing industry survey results against calculations based on a freight transport model

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This paper presents estimates of logistics costs in Norway. Two different methodological approaches are taken: (i) use of the national freight transport model for Norway, in which logistics costs as a share of gross domestic product (GDP) are obtained from national freight flows between municipalities in Norway and from foreign trading partners and (ii) use of a survey of industry representatives, where the results are aggregated to the macro level and yield logistics costs as a share of GDP. The transport model includes detailed cost functions for transport and other logistics cost components along with a module for optimal shipment size, frequency and mode choice. Although the two approaches are quite different, we find almost identical estimates of transport costs. For the other logistics cost components (warehousing, capital costs, insurance, wastage, packaging and administration), the survey-based approach yielded slightly higher estimates, indicating that the freight transport model does not cover all logistics cost components.

Keywords: logistics costs; freight transport model; survey; transport costs

1. Introduction

Norway is located on the periphery of Europe, with Norwegian industry placed some distance from the main European marketplaces. Norwegian exports are to a large extent raw materials from the primary sectors and semi-finished industrial products, i.e. with a production structure that renders Norwegian industry part of larger international supply chains. Norway has one of the highest wage and price levels for consumer goods and services in the world, thus handicapping the export industry in the competition over prices. Norwegian manufacturing and wholesale trade have witnessed a large degree of centralisation in production and warehousing in recent decades, a development that, together with the overall growth in consumption of an expanded variety of goods, has led to an increase in transport and the distances covered. The annual domestic freight transport by road was 5.3 times higher in 2008 than in 1970, while the volume transported was only 1.6 times higher, i.e. about a 300% increase in average transported distance (Vågane 2012).

Transport is a main component of logistics costs, but not the only one. Others include warehousing, capital costs, insurance, obsoleteness/wastage, packaging and logistics administration (Naula, Ojala, and Solakivi 2006; Solakivi et al. 2009). The costs of logistics can be calculated using a variety of methods and data sources, although a survey of the literature shows that these can be divided into two main classes (Radelet and Sachs 1998; Limao and Venables 2001; Anderson

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and Van Wincoop 2004): (i) one is the application of available national accounts data or other statistical sources as national customs data or cif/fob ratios provided by the International Monetary Fund;[1] and (ii) the other is by obtaining industry-specific logistics costs data from the manufacturing and wholesale industries or quotes from carriers and logistics service providers. In this article we introduce a third method, applying the national freight transport model for Norway to obtain estimates on industry-specific logistics costs. The model estimates are compared against survey results among Norwegian manufacturing and wholesale traders, where the results on an industry level are aggregated to the macro level yielding logistics costs as a share of Norwegian mainland gross domestic product (GDP).

Estimating logistics cost components by use of different data sources and methodologies can enhance the estimation, inasmuch as the two approaches supplement each other. Combining different methods in an attempt at measuring the same phenomena, termed method triangulation (Jick 1979), also represents a specific type of validation of the methods applied. If estimates from different methods converge, they will mutually validate one another, which is termed convergent validity (Campbell and Fiske 1959). Together with other studies presenting estimates of logistics cost shares, our dual-method estimates can be used as a kind of benchmark for assessing the plausibility of logistics/transport cost functions in other applications. Comparisons with similar international studies on the costs of logistics are given in the final sections of the article.

2. Previous studies of logistics costs

Traditionally, logistics has been restricted mainly to dealing with the distribution and storage of finished goods. However, in recent years this view has evolved towards a more holistic framework where logistics is seen as the link between supply base and market place – including the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory, as well as information flows (Christopher 2005). Rather than treating each sub-element in isolation, the total systems concept aims at integrating the different elements within one single integrated logistics system, recognising the interrelation between the different elements in relation to costs and performance. It is well known in the management literature that there is a linkage between integrated logistics and increased efficiency and productivity (Lambert, Robeson, and Stock 1978; Gopal and Cypress 1993; Gustin, Daugherty, and Stank 1995; Daugherty, Ellinger, and Gustin 1996). However, lack of information on the total costs of logistics, and in particular of each activity of the integrated logistics system, is a significant barrier to increasing the cost efficiency of the supply chain. Maintaining the desired customer service level, and hence a competitive advantage, is crucial in minimising the costs of logistics.

Previous studies have applied different aims and definitions of what to include in logistics costs, and this to some extent explains the difference in cost estimates. Rodrigue and Nottenboom (2013) report that it is not uncommon for transport costs to account for 10% of the total costs of a product, while others report more than 20% markup, on average, over production costs (Anderson and Van Wincoop 2004). Earlier estimates have found that warehousing, inventory carrying and handling of goods typically constitute about 30% of total production costs (Sayer 1986). McCann (1996) refers to Miller and Vollmann (1985) when stating that total logistics costs have been estimated as being 65% of total industrial overheads, and that these in turn account for up to 80% of production value-added, thus the suggestion that the total cost of logistics accounts for over 50% of total industrial value-added. Based on an artificial neural network modelling of several countries in the world, Rodrigues, Bowersox, and Calantone (2005) estimated a global average cost of logistics to be 13.8% of GDP and the European average 13.3%, while in Denmark, for example, the cost as a share of GDP was estimated to be 13.6%.

There have been a few earlier empirical investigations into distance-related costs in Norwegian manufacturing. Using available statistics and previous studies, Bjørnland and Lægreid (2001) estimated logistics costs in Norwegian manufacturing to be 10.4% of GDP in 1997, declining from 12.2% in 1990. In other studies, logistics costs are calculated to be 16.4% of the total export value (NOU 1988) and 9.1% of turnover of the Norwegian manufacturing industry (Natedal 2003).

Studies have found significant differences in transport costs as percentages of total operating costs between sectors of a country (Diamond, Spence, and Britain 1989; Pirog III and Lancioni 1997), indicating that country averages conceal variations among different sectors in the same country. Some claim, though, that the proportion of transport costs in relation to overall production costs is relatively small in well-developed economies, and that minor changes in transport costs resulting from infrastructure investment or changed framework conditions for the logistics service sector have a limited effect on the business performance of an individual firm (Parkinson 1981). Others dispute this, stating that variations in transport costs – between sectors and, to an even greater extent, between individual firms – show that logistics costs play a significant role in strategic decision-making in some sectors and firms, and that this has a rippling effect throughout the economy (OECD 2002). While transport costs traditionally have been the focal point of study when it comes to distance-related costs and trade-offs in the location of production and consumption, more recent scientific applications treat total logistics costs as the decisive variable. When studying the locational behaviour of production firms, it can be shown that variation in the total costs of logistics with respect to haulage length is much more important for a firm's performance than are transport costs alone (McCann 1996).

Applying surveys of firm representatives, *Finland State of Logistics 2009* (Solakivi et al. 2009) calculated the cost of logistics at 19% of Finland's GDP. Another survey-based study of logistics costs in the Baltic Sea region, presented within LogOnBaltic (Ojala et al. 2007), showed a logistics cost share in manufacturing industries of between 8% and 20% of turnover; while the logistics cost share in wholesale trading companies in the Baltic Sea region was between 10% and 23% of turnover.

At firm level, logistics costs are often measured as a percentage of sales, in absolute costs or based on weight, activity or sales unit (SCD 2006). Logistics costs are often presented as shares of production costs, of turnover or of GDP, which enables comparison of results across studies. However, differences in cost levels may be concealed. Although two countries can have the same logistics cost share, the actual cost level can differ considerably between them.

3. Logistics costs calculated using the Norwegan national freight transport model

In this section of the paper, logistics costs of Norwegian manufacturing and wholesale trade industries are calculated by employing the Norwegian national freight transport model (De Jong et al. 2013), which is often referred to as the 'logistics model'. In a second step, the results are compared with the results from the industry survey.

3.1. *The Norwegian national freight transport model*

The logistics model is a normative cost minimisation tool (De Jong et al. 2013). It can be described as an aggregate-disaggregate-aggregate (ADA) model system in which production to consumption (PC) flows and the network model are specified at an aggregate level for the purpose of data availability. Between these two aggregate components there is a logistics model that explains the choice of shipment size and transport chain, including mode choice for each leg of the transport chain. This is a disaggregated model at company level, which is the decision-making unit in

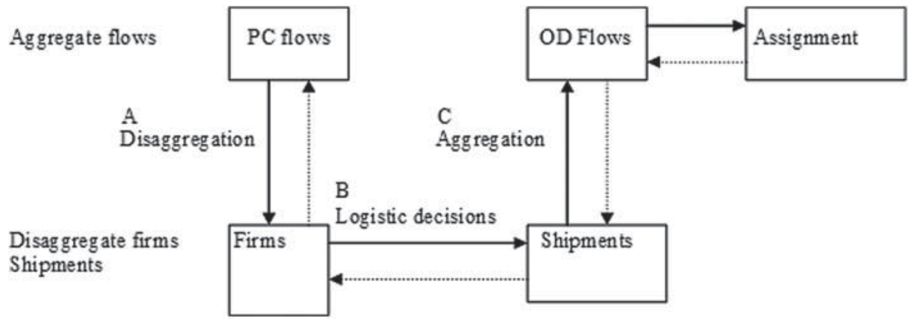

Figure 1. ADA structure in the logistics model (de Jong et al. 2013).

freight transport. A schematic representation of the model structure is given in Figure 1, the top and bottom levels displaying the aggregated and disaggregated models, respectively.

The commodity flow matrices represent commodity flows between production (P) and consumption (C) zones, where zone level is mainly municipalities within Norway, countries in Europe and continents outside Europe. In sum, there are approximately 535 zones in the model. In the ADA system, the logistics model takes the PC flows as input and produces flows between place of origin and destination (OD)[2] for the network assignment.

In a first step, the optimal transhipment locations from the list of available terminals are determined for each type of transport chain and OD zone in a transport chain generation module. In a second step, shipment size and transport chain (i.e. the number of legs, selection of modes and vehicle types) are determined by enumerating all the available options for a specific firm-to-firm flow and selecting the one with the lowest logistics costs (the 'transport chain choice'). Information about transport infrastructure (distance and time for each mode) is given from a network model within the logistics model (Hovi 2007). Different inventory-theoretic model specifications have been derived in the literature for the optimisation of shipment sizes (Baumol and Vinod 1970; Chiang, Roberts, and Ben-Akiva 1981; Vieira 1990; Park 1995). Optimisation in the logistics model is done under the assumption that each product and each company (or rather each annual firm-to-firm flow) is optimised independently – shipment size depending on the economies of scale in transport – through the functions for transport and logistics costs. The major components of the applied logistics model are (Hovi et al. 2011):

- Commodity flow matrices representing annual commodity flows between Norwegian municipalities and between municipalities and abroad distributed between 32 commodity groups (Vold 2006; Hovi and Johansen 2013).
- Zonal business information, i.e. number of delivering and receiving firms of each commodity in the matrices (Madslien, Steinsland, and Vingan 2006).
- Transport cost functions (based on prior studies and expert knowledge of cost levels in the transport and logistics sector), representing operative time and distance-dependent costs for 54 different vehicle types, including loading, discharging and reloading. (Grønland 2011).
- Cost functions for logistics costs such as ordering, storage, capital costs for commodities in storage and during transport, etc. (Grønland 2011).
- Network, representing the physical infrastructure for each mode (road, sea, rail and air) by transport time and distance, including terminal locations for consolidation and reloading between modes (Madslien, Steinsland, and Vingan 2006; Madslien, Steinsland, and Grønland 2012).

"The total annual logistics costs G of commodity k transported between firm m in production zone r and firm n in consumption zone s of shipment size q using logistic chain l"

(De Jong and Ben-Akiva 2007, 953) are given in the following equation[3]:

$$G_{kr_m s_n q_l} = O_{kq} + T_{rs} + D_r + Y_{rsk_l} + I_{kq} + K_{kq}, \quad (1)$$

where G is the total annual logistics costs, O is order costs, T is transport, consolidation and distribution costs, D is costs of deterioration and damage during transit, Y is capital costs of goods during transit, I is inventory costs (storage costs) and $K$is capital costs of inventory.

Transport costs, T, comprise link-based costs (distance costs and time costs) and costs for loading, unloading and reloading. Distance costs are based on average figures for fuel consumption of the relevant mode and vehicle type. Time costs include staff costs, capital costs and costs of insurance. Capital costs for vehicles in transportation are based on investment costs and depreciation over a period leading to a positive remaining value. Annual time costs of capital, tax, insurance and logistical administration are based on empirical data for the relevant vehicle type. The conversion of annual costs to costs per hour is based on annual operating time and estimated additional handling at the terminal. The information on transport distance and transport time in the network module is used as the basis for estimating transport costs, which is one of the elements when deciding on the optimal transport solutions in the model. Transport costs related to empty running are not included in the model, however.

Inventory costs, I, are given in the cost function inputs as inventory holding costs per hour per tonne per commodity type. The time component is time at the warehouse of the receiver calculated on the basis of the total annual demand for the product and annual shipment frequency. Only logistics cost components that affect the choice of frequency, shipment size and mode choice are included in the cost functions. Inventory holding costs in the model include the cost of renting a warehouse and rough estimates on warehouse maintenance costs segmented in accordance with type of commodity. The costs of holding safety stock are not included in the model as these will not usually have any impact on optimal shipment sizes (Chopra and Meindl 2007), making this a reasonable modelling assumption. In models based on optimisation of fill-rates there is often a link between shipment size and safety stock, where shipment sizes are optimised prior to the level of safety stock, making the behavioural assumption hold in such models as well.

The capital costs of goods in transit, Y, are calculated using commodity group-specific average monetary values (NOK/tonne/hour) for exports and domestic trade (which is also used for imports) multiplied by a 6% interest rate (including a 2% risk and wastage premium) and total transport chain time, which is link time and time at the terminal (transfer time, waiting at the terminal for the vehicle/vessel for the main haul transport), but not mobilisation/positioning time at the sender or receiver. The capital costs of the inventory, K, are calculated using the same time component as used for the inventory costs, I, together with the capital costs per tonne per hour as used for Y.

3.2. *Correcting for empty runnings*

The freight transport model does not take into account costs associated with empty runnings, only costs related to the carrying of goods. To correct for this, we adjusted the transport cost results from the model with the ratio of *total transport kilometres* to the number of *loaded transport kilometres* from the national road freight transport statistics. Inclusion of the correction factor renders transport costs calculated by the national freight model comparable with the actual freight rates that customers meet. The correction factor corresponds to the following ratio:

$$\text{Correction factor} = \frac{\text{Loaded kilometres} + \text{Unloaded kilometres}}{\text{Loaded kilometres}} = 1.33.$$

Table 1. Transport and other logistics costs computed using the national freight transport model for Norway, turnover in corresponding industries and imports and exports of commodities to and from Norway.

	Domestic	Import	Export	Total
Transport costs	60,926	35,511	27,896	124,332
Other logistics costs	19,888	27,203	13,373	60,463
SUM logistics costs	80,814	62,713	41,269	184,796
Turnover in mining, manufacturing, wholesale trade and construction and building industries				1,925,607
Foreign trade (excluding crude oil and natural gas)		504,481	358,288	
Turnover mining industry, manufacturing industry, wholesale trade and construction and building, excluding export value	1567,319			
Transport costs in share of turnover	3.9%	7.0%	7.8%	6.5%
Other logistics costs in share of turnover	1.3%	5.4%	3.7%	3.1%
Sum logistics cost share	5.2%	12.4%	11.5%	9.6%
Transport costs in share of logistics costs	75.4%	56.6%	67.6%	67.3%
GDP				1,987,362
Logistics costs as share of GDP				9.3%

Note: All counts in million NOK and percentages (2010); the average exchange rates in 2010 were about 8 NOK/EUR and about 6 NOK/USD.

Data on total loaded and unloaded kilometres are taken from the national road freight transport statistics. Ideally, mode-specific correction factors should have been applied, but because of lack of data for sea, rail and air transport, the same factor is used for all modes of transport.

3.3. *Model results*

Estimated transport costs and total logistics costs from the national freight model are summarised in Table 1 together with turnover in the corresponding industries. The base year for the model is 2010.

In applying the logistics model, we estimated the total cost of logistics to be NOK 185 billion in 2010, which corresponds to 9.3% of Norwegian mainland GDP (i.e. excluding Norwegian offshore petroleum activity). Transport costs represented 3.9% of turnover for domestic deliveries, 7.0% for imports, while exporters had the highest transport cost share of turnover of 7.8%. On average, total logistics costs amounted to 9.6% of turnover of all goods' suppliers. Transport costs were 67% of total logistics costs, on average, while domestic suppliers had the highest transport cost share of logistics of 75%.

3.4. *Transport cost shares in different industry sectors*

The logistics model distinguishes between 32 different commodity groups and delivery chains (from manufacturer to wholesaler (PW), from manufacturer to consumer (PC) and from wholesaler to consumer (WC)), thus enabling transport cost shares by industry to be estimated. This is shown in Table 2.

The transport model calculates the average transport cost shares among the manufacturing industries to 7.4% of turnover. However, the model provides quite a large variation among the different industry sectors, ranging from 3.9% of turnover in the production of machinery and equipment to 16.4% of turnover in the manufacturing of paper and paper products. The transport cost shares for the wholesale traders are calculated as 5.5% of turnover. Logistics costs in Euro per 1000 tonne for different commodity groups are given in the Appendix.

Table 2. Transport cost share in per cent of turnover by different industries computed by use of the logistics model.

	Logistics model (%)
Mining and quarrying	13.0
Manufacturing	7.4
Food products, beverages and tobacco	9.0
Manufacture of wood and wood products	8.8
Manufacture of paper and paper products	16.4
Printing and reproduction of recorded media	10.0
Refined petroleum, chemical and pharmaceutical products	8.6
Rubber, plastic and mineral products	13.6
Basic metals	10.6
Machinery and other equipment n.e.c.	3.9
Textiles, leather, furniture and other manufacturing	8.2
Construction and building	4.9
Wholesale trade	5.5

4. Logistics costs estimated from a survey of Norwegian manufacturing and wholesale trade

The main focus of the conducted survey was to quantify the cost of logistics per cost component in the Norwegian manufacturing and wholesale trade industries, while differentiating between industry and region (Hovi and Hansen 2010). We were inspired by similar studies conducted for Finland (Naula, Ojala, and Solakivi 2006; Solakivi et al. 2009) and the Baltic Sea region (Ojala et al. 2007). Our chosen survey methodology would therefore enable direct comparison with survey results from other countries in Northern Europe.

4.1. *Data collection and research methodology*

A web-based questionnaire was chosen as the preferred industry survey tool. Invitations containing links to the questionnaire were e-mailed to potential industrial respondents during November and December 2008, i.e. partly to named individuals working as logistics managers or assistant directors and partly to the general mailing addresses of firms. The survey sample was based on member firms of the Federation of Norwegian Industries – an association within the Confederation of Norwegian Enterprises – and members of the Norwegian Shippers' Council. In addition, supplementary e-mail contact information was derived from the commercial business database Kompass Norge. The use of online tools for survey data collection is growing in popularity in the social sciences, mainly due to relatively low operating costs compared to more traditional postal surveys and due to the speed and accuracy by which the survey can be conducted (Fleming and Bowden 2009). Other appealing features of web-based questionnaires are the wide range of design possibilities embedded in this tool; for example, the use of different colours, images and multimedia, as well as the possibility to filter questions based on previous answers.

In an attempt to increase the number of respondents in our survey, recipients invited to participate were given the opportunity to benchmark their own logistics costs within their industry and against the average for all industries as recompense for participating. Displaying the reported figures to the respondents in a benchmark exercise also served as a quality check of the data. Prior to the main survey, a pilot survey was conducted in order to test the questionnaire. Based on the feedback from the pilot survey, no major revision was made to the questionnaire or survey design, and as a consequence the data collected in the pilot were included in the total data material. Table 3 lists the numbers of invitations sent out by e-mail and the corresponding answers received containing

Table 3. Number of invitations and answers received; pilot survey, main survey and total.

	Pilot	Main survey	Total
Invited firms	280	8470	8750
Returned because wrongly addressed	27	1042	1069
Number of respondents opening the survey	71	1322	1393
Incoming answers	49	805	854
Incoming answers with information about costs of logistics	38	502	540
Used answers with information about costs of logistics	35	490	525
Response rate	13.8%	6.6%	6.8%

information about the costs of logistics in the Norwegian manufacturing and wholesale trade industries.

Our invitation was sent to 7681 e-mail addresses, and of 1393 that were opened 854 answered one or more questions and 540 the questions relating to the components of logistics costs. Of these, 15 answers lay outside reasonable limits of logistics costs and were deleted from the final sample. The response rate among firms was 7.0%. Deducting the 15 answers that were deleted, the rate of completed responses was 6.8%.

There are several possible explanations for the relatively low response rate:

- Low competence about the level of logistics costs in general and of the components of logistics costs in particular.
- Not all invited firms were in the target group for the survey.
- Addresses of the type *firmpost@firm.no* result in a lower response rate than inquiries to named persons.
- Many firms seemingly did not see the benefits of participating in this type of comparative survey.

Another reason for the low response could have been that firms received more than one invitation. The 525 answers applied in the study are unique, however, in relating to 525 different firms.

4.2. *Survey results*

The cost of logistics was defined in the survey as including the following components: transportation, including inbound, outbound and internal transport as well as loading and unloading; warehousing; capital tied up in transportation and warehousing; packaging; insurance; obsoleteness and wastage; and logistics administration.[4] Compared to the logistics cost expression in the freight transport model, our survey definition was more wide-ranging and detailed. Figure 2 illustrates the different logistical cost components presented to respondents in the survey asked to quantify each component as a percentage of turnover or as absolute values. Additional information obtained about firm turnover enabled calculations of cost shares for all firms.

The disaggregated level of the logistics costs in Figure 2 helped to ensure that the respondents included all logistics cost components in their answer. However, the answers from industry representatives were taken at face value, as it was not possible to assess the extent to which respondents applied different methods for arriving at their estimated logistics costs.

Table 4 and Figure 3 summarise the main results of the survey, with logistics costs as a percentage of turnover for the manufacturing, wholesale trade and building and construction industries for 2007.

Table 4 indicates that logistics costs constitute, on average, 13.7% of the turnover in Norwegian manufacturing, wholesale trade and the building and construction industries. Wholesale trade has the highest cost shares in the survey, while building and construction have the lowest.

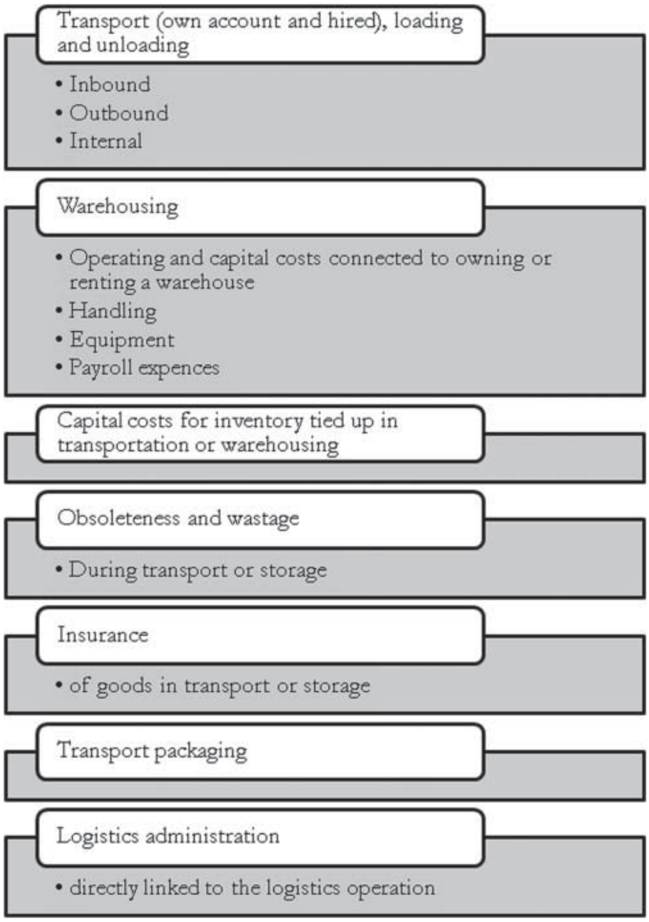

Figure 2. The differerent logistics cost components quantified in the survey.

Table 4. Average cost of logistics as a percentage of turnover by main industry (2007), unweighted averages.

	Cost of logistics (%)	Number of observations
Manufacturing industry	13.2	248
Wholesale	15.7	127
Building and construction	12.3	82
Recycling	23.6	8
Waste	37.0	9
Others	13.2	51
All firms	14.2	525
All firms excluding recycling and waste	13.7	508

Transportation at 41% of total logistics costs is the largest cost component. Warehousing and capital costs amount to a further 38%, while the other components sum to about 21% of the total. Warehousing costs are, on average, higher for wholesale traders, while transportation is about the same for both manufacturing and the wholesale trade.

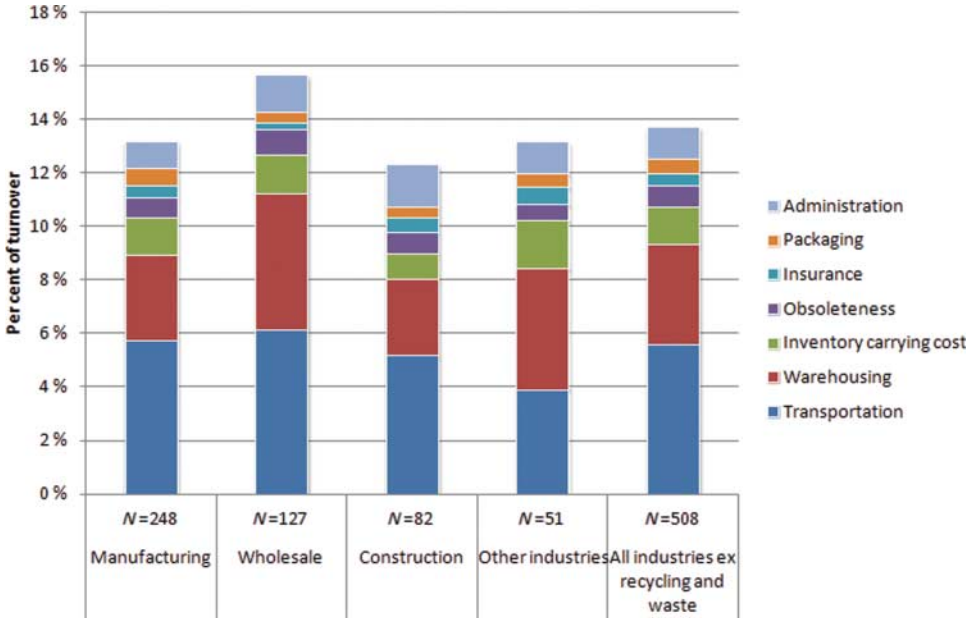

Figure 3. Average costs of logistics in percentage of turnover broken down into cost components, by main industries, unweighted averages.

4.3. *Logistics costs among firms purchasing third-party logistics services*

In the survey, companies were asked if they purchased third-party logistics (3PL) services, and if they confirmed their use they were asked to specify which part of the logistics operation they outsourced. About 36% answered that they had outsourced parts or even the entire logistics operation, 44% answered that they did not buy these services, while the remaining 20% either did not answer or stated that they did not know. The survey results show that smaller companies buying 3PL services have higher logistics costs than smaller companies not buying 3PL services, while for larger companies (more than 50 employees) the opposite is the case. One possible explanation is that smaller companies buying 3PL services have a better overview of logistics costs than smaller companies that do not buy these services and where these costs are entered in the company's operating costs.[5] Another possible explanation is that the gain from purchasing 3PL services is greater for larger companies, where outsourcing of logistics activities leads to a saving in personnel costs in the company. Smaller firms do not necessarily have the opportunity to save on personnel costs, since these companies do not have employees allocated solely to the performance of logistics operations, but have additional tasks as well. The costs of logistics by company size for companies in the survey that confirmed the use of 3PL provider as part of their logistics operation are shown in Figure 4.

Among companies that use a third party in their logistics operations there are economies of scale in the costs of logistics. This clear trend was not found for the entire survey sample, however, and one reason could be that larger companies seem to pay for both inbound and outbound transportation more frequently than smaller companies do, suggesting that strong market operators want to control the entire value chain as a means of better identifying potential savings. As indicated in Figure 4, although some of the sub-samples have a low number of observations, there seem to be economies of scale in both warehousing and transportation for the companies that confirmed the use of 3PL services. However, this trend is more apparent in the warehousing component than in the transportation cost component, possibly reflecting that the cost gain in centralising the

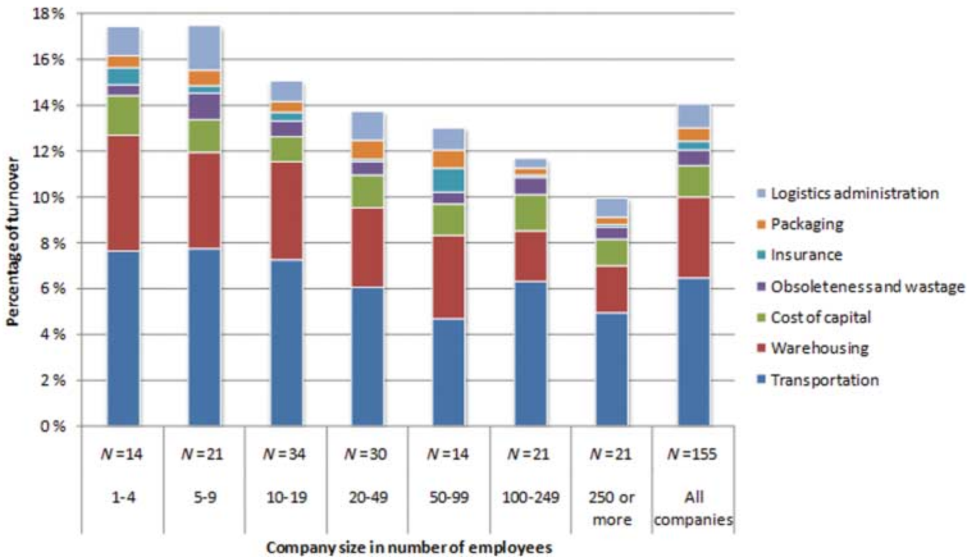

Figure 4. Costs of logistics as a percentage of turnover among firms using 3PL providers, split into cost components, by firm size represented by number of employees and unweighted averages.

warehousing structure is higher than the increase in transport costs that follows from operating a larger geographic market.

4.4. *Macro results*

The results from the survey are used to calculate logistics costs at the macro level and also the ratio of logistics costs and Norwegian mainland GDP, i.e. as a percentage of GDP. The sample is stratified by subclasses of industry (Nace2) and size of turnover (2 classes). Each industry segment from the sample was weighted by the number of firms in each stratum and also by aggregated turnover in each stratum. The main difference between these approaches is that weighting by number of firms gives smaller companies relatively greater weight, while weighting by turnover gives larger companies relatively greater weight (as larger companies will contribute more to the average when weighting by turnover within each stratum). The results are presented in Table 5, similar to the results from the freight transport model estimates, and in Table 6 by main industry and in sum.

The average logistics cost components are higher in the weighted than in the unweighted average. Moreover, the logistics cost shares are lower when the weights are based on turnover rather than number of firms. Weights based on turnover lead to higher weights on average for larger companies. In particular, wholesale trade companies obtain a significantly lower cost share estimate when weighted by turnover rather than by number of firms. Wholesale trade of electrical equipment and machines, an industry segment with a low logistics cost share, constitutes a major share of total turnover, but not the total number of firms (Hovi and Hansen 2010).

The survey results were further weighted by each industry segment's share of total turnover and aggregated over the segments to find the total costs of logistics in Norway, which we calculated by this method to be NOK 254 billion in 2007, corresponding to 14.7% of Norwegian GDP (2007) in the mainland economy.

As can be seen from Tables 2 and 5, the survey results yield lower transport cost shares on average for manufacturing industry compared to results from the national freight transport model, while the transport cost shares for the construction industry and wholesale trade industry are

Table 5. Transport cost share in per cent of turnover by different industries computed by use of results from the survey.

	Survey (%)
Mining and quarrying	15.1
Manufacturing	6.1
Food products, beverages and tobacco	7.8
Manufacture of wood and wood products	7.0
Manufacture of paper and paper products	4.9
Printing and reproduction of recorded media	7.5
Refined petroleum, chemical and pharmaceutical products	6.7
Rubber, plastic and mineral products	11.2
Basic metals	6.2
Machinery and other equipment n.e.c.	3.8
Textiles, leather, furniture and other manufacturing	5.3
Construction and building	5.2
Wholesale trade	6.1

Table 6. Unweighted and weighted costs of logistics in share of turnover by main industry and cost component. Averages weighted by turnover and number of firms, respectively.

	Cost component							
	Transportation (%)	Warehousing (%)	Cost of capital (%)	Obsoleteness and wastage (%)	Insurance (%)	Packaging (%)	Administration (%)	Total (%)
Unweighted average								
Manufacturing	5.8	3.2	1.4	0.8	0.5	0.6	1.0	13.2
Wholesale trade	6.1	5.1	1.4	0.9	0.3	0.4	1.4	15.7
Building and construction	5.2	2.8	1.0	0.8	0.5	0.4	1.6	12.3
All industries	5.6	3.8	1.4	0.8	0.4	0.5	1.2	13.7
Average weighted by number of firms								
Manufacturing	6.2	3.1	1.2	0.7	0.4	1.0	1.2	13.8
Wholesale trade	6.7	6.1	1.3	0.4	0.2	0.2	1.9	16.7
Building and construction	6.6	2.4	0.9	0.7	0.4	0.2	1.8	13.0
All industries	6.3	4.0	1.1	0.5	0.3	0.3	1.6	14.2
Average weighted by turnover								
Manufacturing	7.0	2.6	1.4	0.8	0.5	0.9	1.0	14.1
Wholesale trade	5.0	4.3	1.4	0.6	0.2	0.4	1.1	13.0
Building and construction	6.5	2.5	0.9	0.8	0.7	0.4	1.6	13.3
All industries	6.1	3.3	1.3	0.7	0.4	0.6	1.2	13.5

higher in the survey results. There are several differences in the estimated transport shares for each industry, the reasons being, first, that the estimates are based on two very different frameworks. The second is that the model estimates do not take into account how different sub-industries can have different transport agreements (Incoterms) and therefore, to varying extents, have to bear the cost of transportation of the goods. A third explanation is differences in cost allocation relating to imports and exports, and in the degree to which the transport costs are covered by Norwegian firms. A fourth possible explanation relates to the cost of empty runnings. We have used a general correction factor, but the probability of receiving a return load will often depend on the type of specialised transport available. For instance, a tank truck will nearly always be empty on the return journey.

5. International comparison

The methodology chosen for the survey enables us to compare the results with similar studies from other countries, in particular the results from Finland – State of Logistics (Naula, Ojala, and Solakivi 2006; Solakivi et al. 2009) and LogOnBaltic (Ojala et al. 2007). Our survey-based estimate of the cost of logistics in the Norwegian economy, 14.7% of the Norwegian mainland GDP, was lower than the corresponding figure for Finland: 19% (Solakivi et al. 2009).

5.1. *Manufacturing*

Figure 5 compares the results from LogOnBaltic with the results from our study for manufacturing companies, including the building and construction sector.

LogOnBaltic shows a logistics cost share in manufacturing industries of between 11% and 15% of turnover when excluding the extreme values of West Mecklenburg and Lithuania. The corresponding result from our Norwegian study is 12.8% and is in line with results from the Baltic Sea region.

In general, the uncertainty attached to survey results decreases with the number of respondents in each subcategory of the survey. The results from Finland – State of Logistics are based on a larger sample than the results from our survey, and hence carry a lower degree of uncertainty than the Norwegian results. Figure 6 illustrates the uncertainty in the results from our survey and compares the Norwegian results for the manufacturing subcategories with the results from the corresponding manufacturing categories in Finland – State of Logistics 2009. Ninety per cent confidence intervals are calculated for every subcategory in our survey, the figure then illustrating the range and average in each of the manufacturing categories.

Figure 6 shows that for some of the manufacturing subcategories the uncertainty in the results from our survey is quite large. However, for 9 out of 14 manufacturing subcategories the Finnish average figures are outside the confidence interval calculated for our results. This is a strong indication that the cost of logistics as a percentage of turnover in Norwegian manufacturing is lower than in Finnish manufacturing.

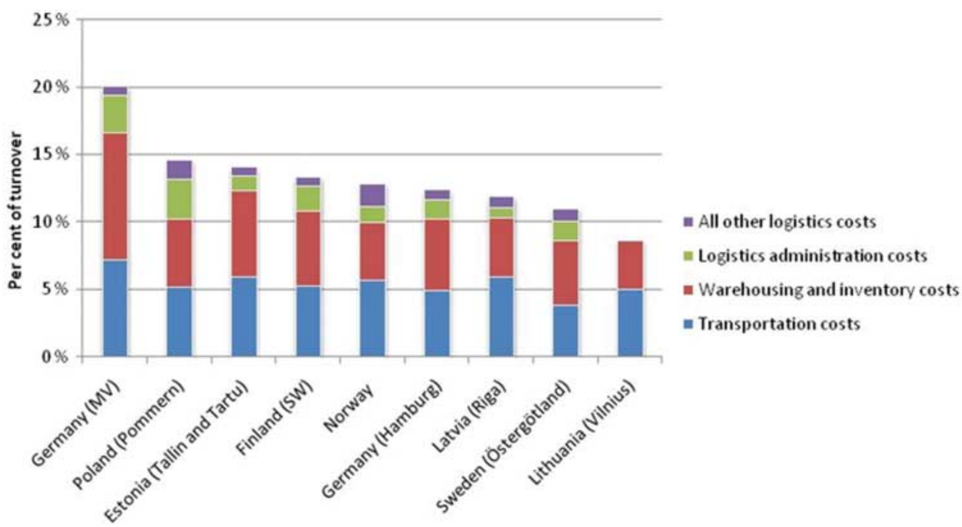

Figure 5. Logistics cost shares for manufacturing industries from LogOnBaltic compared to results from our study for Norway. Manufacturing here includes building and construction.

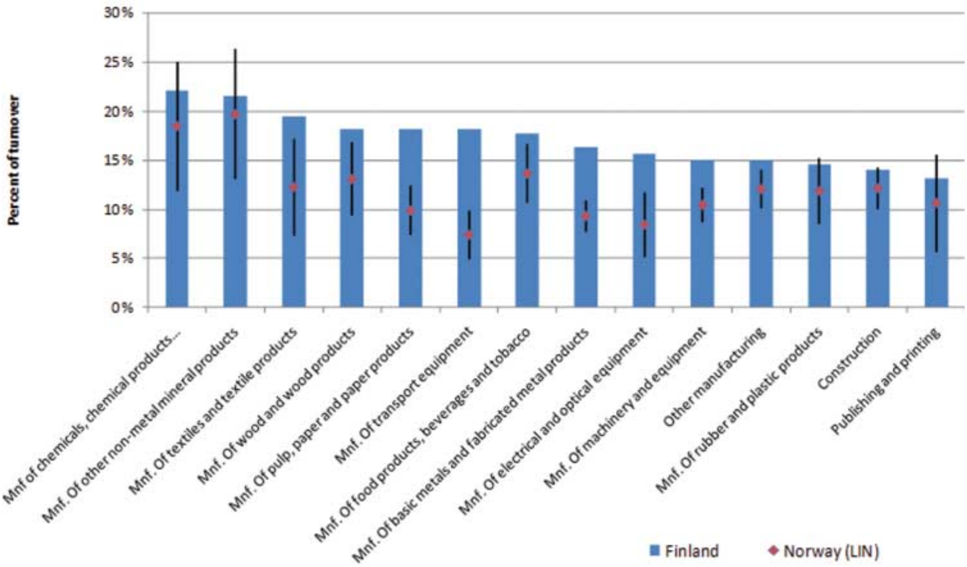

Figure 6. Logistics cost results and attached uncertainties for manufacturing industries from our Norwegian study compared with results from Finland – State of Logistics 2009.

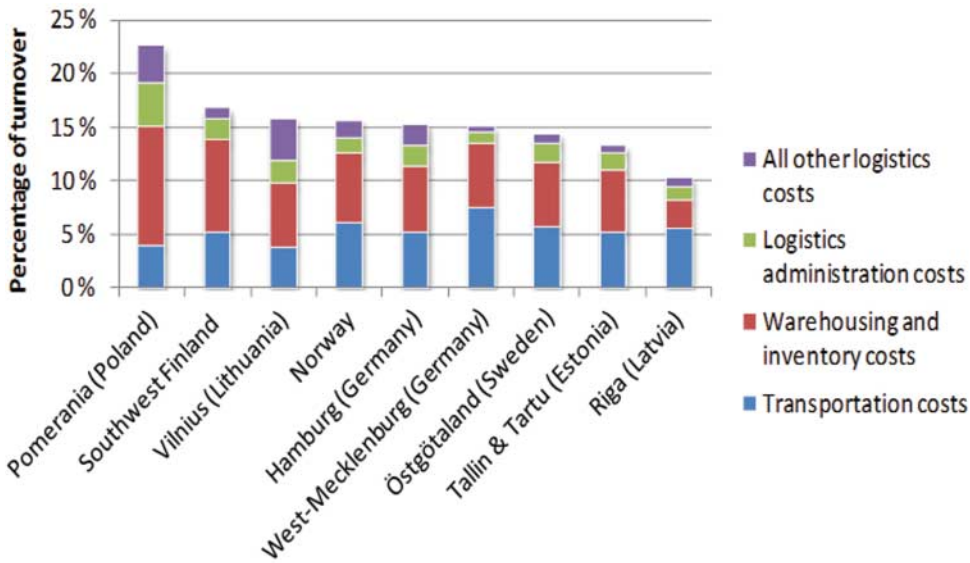

Figure 7. Results for wholesale industries from LogOnBaltic compared to the results from our study for Norway.

5.2. *Wholesale trade*

Figure 7 displays the results for the wholesale trading companies in the LogOnBaltic study compared to the Norwegian wholesale traders from our survey. For wholesale trade, Pomerania (Poland) has the highest logistics cost share at 22.6% of turnover, while Latvia has the lowest at 10.4%. The other results for wholesalers in the LogOnBaltic study vary between 13% and 17% of turnover. In Norwegian wholesale trade, the share is 16.7% of turnover, and hence in the upper region compared to the results from the Baltic Sea region.

6. Discussion and conclusions

This study has presented estimates of the costs of logistics in Norway based on two different methodological approaches: (i) use of the national freight transport model ('logistics model'), where logistics costs as a share of GDP are obtained from national freight flows between municipalities and from international trade, from detailed cost functions for transport and other logistics cost components and a module for optimal shipment size, frequency and mode choice and (ii) survey results from industry – also aggregated to the macro level – yielding logistics costs as a share of GDP.

Applying the national freight transport model, the logistics costs were estimated to be 9.3% of mainland GDP. Based on the survey, the average cost of logistics in Norwegian manufacturing and wholesale trade is calculated to be 13.7% of turnover, 5.6% of which is the transport costs share. The main reason for this deviation in costs is that, in the freight transport model, only logistics cost components that affect the choice of frequency, shipment size and mode choice are included in the cost functions, while costs of operating a warehouse (e.g. equipment and employees) are not included. The freight transport model gave an average cost share for the other logistics cost components equal to 3.1% of turnover, while the corresponding average cost share from the survey was 7.4%. When the sample in our survey was weighted according to the number of firms in each industry segment in national statistics, logistics costs amounted to 13.5% of turnover and the transport cost share 6.3%, and while weighting with respect to turnover in each industry segment in national statistics, logistics amounted to 14.2% of turnover and the transport cost share 6.1%. Aggregating the survey results up to a share of Norwegian mainland GDP yielded an estimate of the cost of logistics of 14.7%.

Although we presented a definition of logistics cost components to the survey respondents, also showing an illustration, the industry representatives might still have included slightly different elements in their answers. Yet, we do not find any reason for systematic error in the survey-estimated logistics costs. We have applied two different methods for logistics cost estimation. However, to some extent, components in the national freight transport model are based on input from the same population of industry representatives that were sampled for our survey (Grønland 2011). Thus, claiming full independence between the two methods can be considered as unwarranted. The sources (samples of industry representatives) of the model's cost functions and of the survey responses are still not identical; and the processing of the cost information in our two methods is different. Thus, we find that there is a convergence validation in obtaining similar results for the overall logistics cost share and the transport cost share.

The differences between the model and the survey results are substantially higher for the other logistics cost components than transport costs, most probably reflecting the fact that the model does not include all logistics cost components included in the survey. Although we cannot rule out other factors affecting the results, we believe these component differences primarily indicate omissions in the cost components of the freight transport model; and that the survey results thus might be applied for further model amendments. Compared to the weighted results from the survey of industry representatives, where transport costs constituted 6.1% of turnover on average for all companies, the results from the logistics model give only a slightly higher estimate on the transport cost share, namely 6.5%. This might have some relevance for benchmarking of logistics/transport cost functions in other applications.

Since the freight transport model distinguishes between different value chains and different commodities, we compared transport costs in shares by sub-industries. The logistics model leads to higher transport shares on average for manufacturing industries compared to the results from the survey, while transport cost shares for the construction and wholesale trade industries are lower from the model. An explanation could be differences in the transport agreements, where different industries cover different parts of transport costs. Taking this into account, there seems to be quite good compliance between estimates from the logistics model and the survey results at the sub-industry level.

In general, logistics costs indicated in the survey of industry representatives constituted a lower share of turnover of companies producing or trading commodities of high value, and vice versa for companies producing or trading with low-value products. This was the case despite the fact that commodities with low value are transported mainly over short distances, while high-value commodities often have a specialised production structure and are often transported over long distances. This might indicate errors in reported cost shares, possibly going in opposite directions. Since Norwegian exports to a large extent consist of raw materials and semi-finished industrial products, while imports are dominated by raw materials and consumer goods, the logistics costs shares are higher for exporting companies than for importing companies in the survey.

The international comparisons in this paper show that estimated costs of logistics in the Norwegian manufacturing and wholesale trade industries are in line with results from comparable studies in the Baltic Sea region. A comparison between our Norwegian results and results from Finland show that, with a reasonable degree of certainty, we can conclude that logistics costs as a percentage of turnover in Norwegian manufacturing are lower than in Finnish manufacturing. Even if Norwegian logistics cost shares are in line with those of neighbouring countries, it is worth stressing that the cost level in Norway is among the highest in the world, and therefore the real costs of logistics are higher in Norway than in the other countries in the applied international comparison.

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Notes

1. The supplier (exporter) reports freight (trade flow) costs exclusive of freight and insurance (fob), while the purchaser (importer) reports freight (trade flow) costs inclusive of freight and insurance (cif). Thus, comparing fob and cif from trading partners yields an indirect measure of transportation costs (Yeats 1978).
2. OD are the places where the freight is loaded, unloaded and eventually reloaded. For example, in a transport chain where rail is used and the distribution is with truck at both ends, the PC flow is divided into three OD flows: the first is from place of production to the first rail terminal by truck; the second is between two rail terminals by rail and the third is from the second rail terminal to the place of consumption by truck.
3. Each cost component is based on a bottom-up approach.
4. The definition of capital cost in our survey is equivalent to the sum of the two capital cost components in the freight transport model: the capital costs of goods in transit and the capital costs of the inventory. In NOU (1988), the logistics costs of exported goods (exempting offshore exports of oil and gas) were defined as comprising transportation (57%), warehousing (33%), packaging (5%), insurance (3%) and inventory/capital costs (2%) and were found to constitute 16.4% of the export value. Bjørnland and Lægreid (2001) estimated logistics costs in Norway in 1997 (exempting offshore activity) comprising transportation (64%, that is 6% transportation time costs and 58% direct transport costs), warehousing (18%), packaging (14%) and insurance (4%), finding that logistics costs constituted 10.4% of GDP (compared to 12.2% in 1990).
5. One might argue that in-house logistics costs are not directly comparable to 3PL prices, if the latter includes a profit element. However, assuming a competitive market, where firms do consider buying a service or carrying it out by themselves, we still find that the comparison has relevance.

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Appendix

Table A1. Logistics costs for different commodity groups, estimated from the national freight transport model.

	Transport costs in Euro per 1000 tonne km	Other logistics costs in Euro per 1000 tonne km
Bulk food	106	59
Consumption food	153	44
Beverages	109	18
Fresh fish	411	89
Frozen fish	28	6
Other fish (conserved)	468	772
Thermo input	570	52
Thermo consumption	106	42
Machinery and equipment	287	154
Vehicles	67	20
Gen cargo, high value	556	235
Gen cargo, living animals	1109	331
Gen cargo, building materials	137	15
Gen cargo, inputs	56	15
Gen cargo, consumption	96	32
Saw logs	163	38
Pulpwood	37	3
Pulp and chips	45	2
Paper intermediates	77	23
Wood products	80	5
Paper products and printed matters	453	146
Mass commodity	34	4
Coal, ore and scrap	3	0
Cement, plaster and cretaceous	52	7
Non-traded goods	41	3
Chemical products	44	19
Fertilisers	16	1
Metals and metal products	66	18
Aluminium	33	2
Refined products	16	30
All products	49	19

Note: The average exchange rate in 2010 was about 0.125 EUR/NOK.