Estimating the impact of transport costs on firms’ choice of transport chain and shipment size

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Kristofer Odolinski[1], Karin Ek[1]

[1] VTI, the Swedish National Road and Transport Research Institute

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Keywords

Stochastic freight model; Disaggregate freight model; Freight mode choice; Transport chain; Shipment size; Commodity flow survey.

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Kristofer Odolinski [a,*], Karin Ek [a]

[a] The Swedish National Road and Transport Research Institute (VTI), Box 55685, SE-102 15, Stockholm, Sweden.

* Corresponding author (kristofer.odolinski@vti.se)

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1. Introduction

A freight transport model is an important tool in policy analysis, where measures such as regulations, taxes and infrastructure investments can be evaluated with respect to their impact on transport demand. The Swedish national freight transport model, Samgods, considers the minimisation of firms' annual logistics cost in order to model mode choice in terms of transport chains for shipments. The current version of the logistics module in Samgods is deterministic which means that only the factors included in the cost minimisation problem will determine mode choice. Unobserved factors are thus not taken into account and the empirical link may be weak given that actual behaviour of firms is not fully considered. Another weakness is the corner solutions where small changes in cost factors can generate unrealistically large changes in freight flows and modal shares, and vice versa, larger changes in cost factors can have no effect at all (Abate et al., 2019).

A stochastic logistic module that is based on the observed behaviour of firms can address some of the abovementioned shortcomings of the deterministic model. For example, it can provide a smoother model where the S-shaped relationship between the (logit) probability and the representative utility implies that the impact on very low or very high utilities of an option results in small changes of its choice probability. This reduces the risk of implausibly large shifts in freight flows and modal shares (Merkel et al., 2022).

As pointed out by Abate et al. (2019), there is an extensive literature on stochastic models of mode choice and shipment size choice. However, this literature often considers all commodity types combined, or only a few commodity types, where some examples (using the Swedish CFS) are De Jong and Johnson (2009), Habibi (2010), Abate et al. (2016), and Caspersen et al. (2016). Studies that consider all or most of the commodity groups are Lindgren et al. (2019) and Abate et al. (2019) who use CFS 2016 and CFS 2004/2005, respectively. They estimate one model for each commodity group and address the implementation of a stochastic logistics module in Samgods. The transport cost is one important factor for the firms' choice, yet some of the transport cost parameters in Lindgren et al. (2019) are not statistically significant and most of them are interactions with transport chains, which is against the idea that 1 SEK is always 1 SEK, that is, it should not matter which alternative it is spent on. Moreover, three of the 16 commodity groups (1: Prod. of agricult. & hunting; 11: Machinery; and 13: Furniture) lack an estimated cost parameter. Abate et al. (2019) provide statistically significant cost estimates for almost all their 14 commodity groups: the exception is Metal ores (part of our commodity group 3) for which the coefficient has the unexpected positive sign and is not statistically significant. It can be noted that Abate et al. and Lindgren et al. (2019) restricted their models to a linear specification of transport costs since one aim with their study was to compare their stochastic model with the deterministic model in Samgods which uses linear costs.

The purpose with this study is to estimate how sensitive the choice of logistics arrangement is to transport costs. Using multinomial logit models and choice data of individual shipments from the Swedish CFS 2016 and CFS 2021, the aim is to provide transport cost estimates for all 16 commodity groups that can be implemented in a stochastic logistics module for Samgods.

Like Abate et al. (2019), one cost coefficient is estimated for all alternatives since it should not matter which alternative 1 SEK is spent on, yet our study also compares a linear specification of cost against a logarithmic specification, and we consider all 16 commodity groups in Samgods, whereas 14 groups are included in Abate et al. (2019). The use of a logarithmic specification, however, implies that 1 SEK is not always 1 SEK since the cost coefficient depends on the cost level. Here it can also be noted that the use of a logarithmic specification complicates the use of logsum to measure consumer surplus in logit choice models, which concerns the monetisation of a logsum change in utility. This is described in De Jong et al. (2007) who also present two methods to deal with this issue. The complexity of these methods needs to be evaluated against what is gained in terms of model fit when using a logarithmic specification instead of a linear specification, yet this is beyond the scope of this paper. Another contribution to the previous stochastic model estimations on the Swedish CFS is the use of empirical midpoints of shipment sizes to control for the impact of ordering cost and holding cost.

The rest of the paper is structured as follows. Section 2 presents the data used in the estimations and the process of combining the datasets from CFS and Samgods. The method is described in section 3 followed by estimation results in section 4. Section 5 provides a discussion and conclusions.

2. Data

We make use of the Swedish Commodity Flow Survey (CFS) to estimate discrete choice models for freight transport. The CFS provides information on business' movement of goods within Sweden and internationally. The government agency Transport Analysis is responsible for the survey, which has been carried out in 2001, 2004/2005, 2009, 2016, and 2021. Information from the two latest surveys (2016 and 2021) on outgoing and incoming shipments has been retrieved together with information on transport cost and transport time from Samgods for chosen and non-chosen (available) transport alternatives. These years are not exceptional with respect to the level of freight traffic in ton-km or with respect to mode share, as shown in Figure 1. Note that air transport has relatively low ton-km (max 64 million ton-km, whilst the mean and median is 32 and 36 million ton-km, respectively) and is therefore not visible in Figure 1.

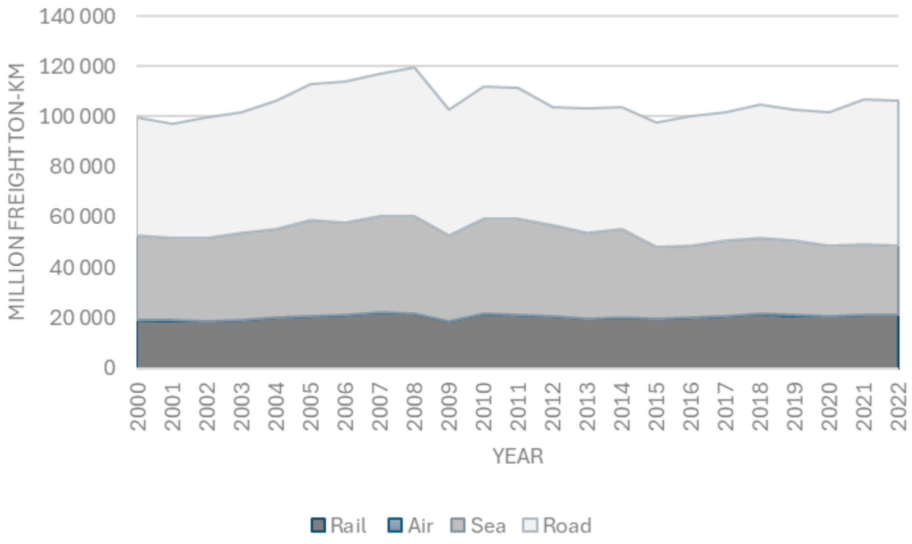

Figure 1. *Freight ton-km in Sweden, 2000–2022 (Source: Trafikanalys, 2023)*

The CFS comprises information on firms' individual shipments such as their origin, destination, weight, cargo type, commodity type, and mode(s) of transport. Commodities are classified using the European Standard goods classification for transport statistics, NST 2007. Commodity groups in Samgods are based on the same system. The relationship between the NST 2007 categories and the Samgods commodity groups is presented in Table 1.

Table 1. Commodity groups in Samgods.

No.	Name	NST 2007
1	Products of agriculture, hunting, and forestry; fish and other fishing products. Not timber	1, excl. timber
2	Coal and lignite; crude petroleum and natural gas	2
3	Metal ores and other mining and quarrying products; peat	3
4	Food products, beverages, and tobacco	4
5	Textiles and textile products; leather and leather products	5
6	Wood and products of wood and cork (except furniture); pulp, paper, and paper products; printed matter and recorded media	6
7	Coke and refined petroleum products	7
8	Chemicals, chemical products, and man-made fibres; rubber and plastic products; nuclear fuel	8
9	Other non-metallic mineral products	9
10	Basic metals; fabricated metal products, except machinery and equipment	10
11	Machinery and equipment; medical, precision, and optical instruments	11
12	Transport equipment	12
13	Furniture; other manufactured goods	13
14	Secondary raw materials; municipal wastes and other wastes	14
15	Timber	part of 1.
16	Air freight	part of 8.

The transport cost per shipment in Samgods are based on cost functions that include distance-based costs, time-based costs of the vehicle (i.e., time costs of cargo are excluded), vehicle/vessel specific costs for loading and unloading, transfer costs at terminals, ports, and airports (De Jong and Baak, 2023). The transport time information is generated by Level of Service (LOS) matrices per vehicle type and consists of time for loading (sender) and unloading (receiver), transfer time and waiting time at the terminal, and link time. See Vierth et al. (2009) and de Jong and Baak (2023) for more information on the logistics module in Samgods.

2.1 Combining datasets

The observed transport choice in the CFS is linked to a solution in Samgods's logistics module choice set using its shipment weight, transport chain, origin, and destination. Samgods's logistics module comprises 14 chain types and 16 weight classes (shipment sizes). The continuous weight variable in CFS is thus classified into the discrete weight classes, which are listed in Table 3 and Table 4 in section 2.2.

Regarding the transport chains, how they are defined differ between the CFS and Samgods. We therefore translate the CFS transport chains to a shortlist of chain types in Samgods, using the list provided in Lindgren et al. (2019). See Table 2. Also following the approach in Lindgren et al. (2019) we exclude any Samgods chains containing ferries from the chosen data. This is because the CFS does not differentiate between vessels and ferries, making identification of either choice unreliable, and vessels are by far the more common choice.

Like Jensen et al. (2019), we define "main" transport modes based on a mode hierarchy in the transport chains. Sea transport is attributed the highest level in the hierarchy, and sea transport is thus the main mode in all transport chains with at least one leg of sea transport. The remaining transport chains comprise combinations of either truck and rail, truck and air, or truck only. The main transport modes for these are rail, air, and truck, respectively (see Table 2). This means that rail or air is the main transport mode when combined with truck whilst truck is the main transport mode if no other mode has been used (note that rail and air is never part of the same transport chain in our data).

The dummy variables for the main transport modes are interacted with the 16 weight classes. This generates 64 alternative specific constants (ASCs). However, we do not observe all these combinations within any of the commodity groups – see descriptive statistics in Table 3 and Table 4 (section 2.2 below). Those that are not observed are excluded as explanatory variables in the estimation. Also, many of the combinations have low frequencies which in some cases generates estimates with a low accuracy and are therefore dropped. We also test ASCs for all combinations of chain and weight classes in the estimations (and exclude one combination which forms the baseline). This gives us (14x16-1 =) 223 ASCs, many of which are not observed and many of which are estimated with low accuracy (p-values close to 1).

In addition to combining transport chains and shipment sizes (weight classes) in CFS and Samgods, we link the geographic zones in Samgods to the origin and destination in the CFS. This requires different approaches given that Samgods has its own system of defining its geographical zones. The graphical representation of the European Samgods zones in Samgods version 1.2.1 are shown in Figure 2.

Table 2. Correspondence list for "main" mode and chain types in Samgods and CFS.

No.	Main transport mode	Shortlist chain type in Samgods	Chain type in CFS (V=road, J=rail, S=sea, L=air, X=unknown)
1	Road	Truck	V
2	Sea	Vessel	S, SX
3	Rail	Rail	J, JX
4	Sea	Truck-Vessel	SV, SVS, VS, VSX
5	Sea	Rail-Vessel	JS, JSJ, JSX, SJ, XSJ
6	Road	Truck-Truck-Truck	VXV, VX, XV
7	Rail	Truck-Rail-Truck	JV, VJ, VJV, VJX, JVJ
8	Sea	Truck-Ferry-Truck	-
9	Sea	Truck-Vessel-Truck	VSV, VSVSV
10	Air	Truck-Air-Truck	All chains containing L
11	Sea	Truck-Ferry-Rail-Truck	-
12	Sea	Truck-Rail-Ferry-Truck	-
13	Sea	Truck-Vessel-Rail-Truck	SJV, SVJV, VSJ, VSVJ, VSJV, XSJV, VSVJV
14	Sea	Truck-Rail-Vessel-Truck	VJS, VJSJ, VJSJV, VJSV, VJSX, VJVS, VJVSV, VJX, JSJV, JSV, JVS

Figure 2. *The geographical zone division of Europe in Samgods version 1.2.1.*

Within Sweden, the geographical zones align with the Swedish municipalities, and we can thus use municipality codes to combine the CFS and Samgods zones. Outside of Sweden, zones can correspond to a part of a country, an entire country, or a collection of countries. In general, the closer a country is to Sweden, the more granular its geographical zones. Outside of Europe, geographical zones can represent a single country (if the country is a significant trading partner to Sweden) or groups of countries meant to represent a continent (Trafikverket, 2024).

When origins and destinations of shipments within countries are represented by a single zone in Samgods, either on its own or as part of an aggregated zone, we use country codes to combine CFS and Samgods zones. However, linking the CFS origins and destinations in countries that are divided into multiple zones in Samgods is a bit more complicated. The most detailed information provided in the CFS for international shipments is either their place name, as per the 2016 survey, or post code, as per the 2021 survey. To link this information to the geographical zones in Samgods, we utilize the fact that Samgods includes polygons for all zones within Europe, i.e. the geographical area where foreign zones can represent a section of a country.

We then use two datasets that connect post codes to representative centroids: one from Eurostat (2023) covering the European Economic Area, and one from the Office for National Statistics (2023) covering the United Kingdom. By matching country codes and place names or postcodes in the CFS with these two datasets, we can assign point-coordinates to the origins and destinations in the CFS. These coordinates can then be intersected with the Samgods zone polygons.

The CFS and the two datasets are matched over multiple iterations to account for errors, name variations, and additional information in the place names and postcodes in the CFS. However, not all these variations can be accounted for without compromising the precision of the matches. Moreover, the two datasets do not cover all the place names and postcodes included in the CFS. If no point-coordinate match can be found, the origin or destination is matched to the Samgods zone representing the capital of its respective country, similar to the approach in Lindgren et al. (2019).

2.2 Descriptive statistics

The total number of chosen shipments used in the estimations vary between the commodity groups (see section 3 describing the random sampling that is used in order to speed up the estimations). The frequencies of chosen (observed) shipment size for commodity groups 1–8 are presented in Table 3. The corresponding information for commodity groups 9–16 is presented in Table 4.

Table 3. Weight class and observed frequency of shipments per transport mode, commodity groups 1–8. Groups 1, 4, 5, and 7 each comprise a 20 percent random sample from CFS.

Weight class		**1: Prod. of agricult. & hunting**				**2: Coal, petrol., natural gas**				**3: Metal**				**4: Food**			
No.	kg	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air
1	0-50	36		20,282	2			73	1	8		783	21	36	3	128,811	14
2	51-200	18		7,400	1			115	1	22		281	3	66	8	55,621	3
3	201-800	7	1	22,298	1			141		30	1	336	3	163	22	39,492	4
4	801-3,000	15	27	75,289	2	5		97		23	93	810	2	199	56	25,121	3
5	3,001-7,500	8	18	69,816	1	1		40		22	54	689	1	166	115	9,529	2
6	7,501-12,500	3	19	30,440				11		29	32	1,389	1	135	140	3,196	
7	12,501-20,000	20	13	25,063		6		38		33	8	3,685		268	142	2,599	
8	20,001-30,000	5	10	26,469		11	2	49		201	326	1,357	1	223	669	2,896	
9	30,001-35,000		1	17,326		2		4		142	1	1,573	1	4	77	1,253	
10	35,001-40,000	3	1	34,493		1		31		169	2	1,676		5	195	3,854	
11	40,001-45,000	1		22,857		2		32		50		1,636		5	130	2,169	
12	45,001-100,000	2	2	1,885		5		12		441	36	2,259		12	377	180	
13	100,001-200,000	1	1	143		3				17	26	32		6	14	45	
14	200,001-400,000			50		4				19	2	19		3	6	27	
15	400,001-800,000	1	3	23		2				37	4	12		2	5	36	
16	800,001-	2	27	11		559		1		2,270	370	11		6	5	5	

Weight class		**5: Textile**				**6: Wood, excl. timber**				**7: Coke & refin. petrol.**				**8: Chemical prod.**			
No.	kg	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air
1	0-50	18,825		164,045	1,670	308	616	53,081	929	2	1	211	1	676	20	37,612	1,992
2	51-200	132		385	18	205	4	11,539	100	6		287		501	11	9,832	153
3	201-800	72	1	167	10	438	8	10,788	43	21	1	341		767	13	8,653	78
4	801-3,000	52	1	48		810	62	14,084	21	42	4	897		953	22	6,415	44
5	3,001-7,500	26		26	1	710	63	7,808	5	20	1	1,131		617	68	3,053	14
6	7,501-12,500	26	3	18		664	74	3,714	2	27	3	968		367	63	1,644	2
7	12,501-20,000	6		3		1,942	169	3,501	7	6	1	231,169		632	99	4,460	
8	20,001-30,000	1				5,147	1,040	10,772	60	28	7	62		859	303	1,995	3
9	30,001-35,000	1				444	49	3,001	2	2		22		56	13	628	
10	35,001-40,000					516	43	4,282	1	4		30		122	32	805	
11	40,001-45,000					174	83	1,420	1			29		97	36	1,176	
12	45,001-100,000					623	2,625	1,044	1	2		33		98	209	308	
13	100,001-200,000					154	126	130		6		1		15	8	16	
14	200,001-400,000					154	81	57		22				21	2	3	
15	400,001-800,000					116	70	24		55				20	1	13	
16	800,001-					160	62	18		1,811				41	1	1	

Table 4. Weight class and observed frequency of shipments per transport mode, commodity groups 9–16. Groups 11 and 15 each comprise a 20 percent random sample from CFS.

Weight class		**9: Non-metallic mineral**				**10: Metal products**				**11: Machinery [a]**				**12: Transp. equip.**			
No.	kg	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air
1	0-50	446		9,091	74	2,282	120	48,090	3,409	881	10	23,519	8,534	1,190	12	17,391	421
2	51-200	322	2	4,581	20	1,854	133	17,672	880	382		2,849	664	1,400	7	10,466	168
3	201-800	378	4	5,008	16	2,251	289	15,385	447	418	3	2,001	467	2,685	12	9,386	529
4	801-3,000	347	11	6,394	2	1,780	598	10,546	151	229	1	855	244	12,637	188	11,132	273
5	3,001-7,500	244	14	4,996	1	1,554	568	5,442	25	151		333	23	4,521	59	2,129	40
6	7,501-12,500	67	6	3,389	1	1,393	829	2,600	6	70		119		1,495	57	1,628	9
7	12,501-20,000	80	4	4,937		1,719	786	2,135	7	34	3	48	3	1,103	109	1,983	9
8	20,001-30,000	208	14	3,865	3	2,600	1,505	3,833	3	55	2	19		634	51	1,360	7
9	30,001-35,000	24	6	2,330	1	237	135	924		8		4	1	74	4	71	
10	35,001-40,000	9	2	3,065		236	134	1,072		4		5		38	7	374	
11	40,001-45,000	14	2	1,665	1	152	147	474				1		536	4	6	
12	45,001-100,000	15	10	1,140		505	1,010	350	8	2		7		50	43	350	
13	100,001-200,000	1	8	48		128	58	40				1		3	47	82	
14	200,001-400,000			11		50	30	20	1			1		1	14	26	
15	400,001-800,000	2		8		15	43	1								12	
16	800,001-	91		10		24	141	1					1		10	14	
Weight class		**13: Furniture**				**14: Waste**				**15: Timber [a]**				**16: Air freight**			
No.	kg	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air	Sea	Rail	Road	Air
1	0-50	871	267	31,110	1,241	2		41				329		127		106,093	15,018
2	51-200	431	66	8,880	31	2		14		1		9,269		60		20,539	360
3	201-800	340	30	5,469	11	2		16		5		13,954		118		12,929	178
4	801-3,000	278	13	2,871	3	1		16		17		26,326		79		4,057	128
5	3,001-7,500	217	1	825				61		182		64,148		62		672	42
6	7,501-12,500	82	1	196	1	2		163		25		67,413		28		301	1
7	12,501-20,000	64	5	65		4	3	48		9		81,422		43		245	1
8	20,001-30,000	228	73	201	1	33	8	228		19	4	78,404		17		298	
9	30,001-35,000		8	12		13		93		46	4	40,092		1		18	
10	35,001-40,000			31		13	5	111		199	4	73,975		11		16	
11	40,001-45,000					7		16		376	1	192,811				5	
12	45,001-100,000		1	3			4	7		1,795	42	156,068				11	1
13	100,001-200,000			7		2					53	1,281					
14	200,001-400,000					2	1	1		4	58	672					
15	400,001-800,000	1				4				4	256	406					
16	800,001-					17		2		54	926	823					

3. Method

We use an econometric framework which considers the shippers' discrete choice of both transport chain and shipment size (see, e.g., Piendl et al., 2017 for a literature review on the econometric models that are based on logistics costs). This choice depends on the utility of transport chain t and shipment size s which in this paper is represented by

$$V_{st} = \beta_1 C_{st} + \beta_2 T_{st} + \beta_3 (1/W_{st}) + \beta_4 W_{st} + \boldsymbol{\theta} \boldsymbol{X}_{st} + \varepsilon_{st} \qquad (1)$$

where C is transport cost, T is transport time, W is transport weight (empirical midpoints for each transport chain and shipment size combination), and $\boldsymbol{X}$ is a vector of control variables comprising alternative specific constants (see section 2.1), dummy variables for international shipments, and for shipments using container as the load type. These dummy variables are interacted with dummy variables for the main transport mode, where at least one of the mode interactions is dropped and forms the baseline. ε_{st} is an error term and $\beta_1, \beta_2, \beta_3, \beta_4$ and $\boldsymbol{\theta}$ are parameters to be estimated.

Multinomial logit (MNL) models are estimated where the probability of choosing transport chain t and shipment size s, among K other transport chains and J other shipment sizes, is given by

$$P_{st} = \frac{exp(V_{st})}{\sum_k^K \sum_j^J exp(V_{jk})} \qquad (2)$$

$V_{st} V_{st} = \beta_1 C_{st} + \beta_2 T_{st} + \beta_3 (1/W_{st}) + \beta_4 W_{st} + \boldsymbol{\theta} \boldsymbol{X}_{st} + \varepsilon_{st}$. The transport weight specification is included to consider the frequency of shipments and holding unit costs to control for holding and order costs, which are not included in the transport costs from Samgods. These may vary within the ASCs that are based on combinations of weight class and main modes, where for example the main mode sea could be only sea (e.g., tanker) or comprise a chain of modes (e.g., truck-vessel-truck). Definitions of the variables included in the preferred models are presented in Table 5.

Transport cost C has a linear specification in eq. (1). However, in the estimations we also test a logarithmic transformation of this variable and evaluate the model fit by comparing the log likelihoods of the different specifications.

Table 5. Definitions of variables in model estimations.

Variable	Definition	Varies across choices?	Source
cost	Transport cost (SEK) per shipment and OD-pair for weight class *s* and transport chain *t*.	Yes	Samgods
time	Transport time (units) per shipment per OD-pair for weight class *s* and transport chain *t*.	Yes	Samgods
weight_tons	Empirical midpoint of shipment size (tons) per weight class *s* and transport chain *t*.	Yes	Transport Analysis[a]
d.intl	Dummy for international shipments.	No	CFS
d.cont.	Dummy for load type container.	No	CFS
d.sea	Dummy for sea as main transport mode.	Yes	CFS & Samgods
d.rail	Dummy for rail as main transport mode.	Yes	CFS & Samgods
d.air	Dummy for air as main transport mode.	Yes	CFS & Samgods
d.truck	Dummy for truck as main transport mode.	Yes	CFS & Samgods
d. WC1–d. WC16	Dummy variables for weight class 1 to 16.	Yes	CFS & Samgods

[a] Transport Analysis is a Swedish government agency.

If the commodity group has less than 200,000 observed shipments from the CFS, we use the whole sample. Otherwise, like Lindgren et al. (2019), we make use of a 20 percent random sample of each commodity group (1, 4, 5, 7, 11, and 15) to speed up the estimation procedure (Stata/IC 16.1 is used for the estimations). The impact of this random sampling seems to be small: we made a comparison for commodity group 1, which generated a cost coefficient at -1.925 using the 20 percent random sample and -1.949 using the whole sample. In addition, we randomly sample 10 alternatives for each shipment, including the chosen alternative (this should give consistent MNL estimation results – see Manski and McFadden, 1981). This also speeds up the estimation procedure since each shipment has up to 224 alternatives based on combinations of 14 transport chain types and 16 weight classes. This is done for all the commodities.

4. Results

Estimation results from the preferred model specifications for commodity groups 1–8 and 9–16 are presented in Table 6 and Table 7, respectively. Other model specifications that were tested included a full set of ASCs, i.e. all combinations of the 14 transport chains and 16 weight classes, which generated coefficients with low accuracy, sometimes a statistically significant non-expected sign for the cost coefficient (indicating problems with multicollinearity) and in some cases convergence problems. A nested logit model was tested for commodity group 3, using the main modes sea and rail together in a nest. This did not have a significant impact on the results, i.e. compared to our MNL results. Therefore, we did not pursue estimating nested logit models for the other commodities. It can be noted that Lindgren et al. (2019) concluded that the nested logit model predicted at least as well as the MNL but with higher computational requirements.

The main transport mode and shipment sizes dummies that are included vary between commodity groups. In certain cases, the accuracy of the estimates is low (p-values at 1 or close to 1), especially when the mode and shipment size is not observed (see Table 3 and Table 4), and these were therefore dropped from the estimations (see empty cells in Table 10 and Table 11). This is also the case for some of the ASCs with very low frequencies. The baseline ASC in the estimations is truck (main transport mode) and weight class 1 (0-50 kg), except for commodity groups 7 and 15 which have relatively few observations for this ASC. Instead, truck and weight class 7 (12,501-20,000 kg), and truck and weight class 11 (40,001-45,000 kg), is the baseline for group 7 and 15, respectively.

Table 6. Estimation results, commodity groups 1–8. Standard errors in parentheses.

Commodity group	**1: Prod. of agricult. & hunting**	**2: Coal, petrol., natural gas**	**3: Metal**	**4: Food**	**5: Textile**	**6: Wood, excl. timber**	**7: Coke & refin. petrol.**	**8: Chemical prod.**
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
ln(cost)	-1.925***	-1.012***	-1.564***	-1.645***	-2.439***	-1.465***	-2.824***	-1.359***
	(0.015)	(0.126)	(0.028)	(0.015)	(0.048)	(0.011)	(0.024)	(0.013)
ln(time)	-20.405***		-0.413***				-7.074***	
	(0.286)		(0.047)				(0.088)	
ln(time)#d.dom		-13.386*		-0.561***	-19.849***	-1.220***		-0.618***
		(7.578)		(0.085)	(1.623)	(0.062)		(0.065)
1/weight_tons	0.471***	0.034	-0.028***	0.643***	0.001***	-0.008***	-1.191***	-0.021***
	(0.020)	(0.026)	(0.004)	(0.031)	(0.0002)	(0.0002)	(0.011)	(0.001)
weight_tons	0.010***	2.31E-04	0.0003***	0.001	-1.533***	0.002***	1.40E-03***	0.001***
	(0.001)	(1.88E-04)	(9.15E-06)	(0.001)	(0.408)	(0.0001)	(2.94E-05)	(0.0002)
d.intl#d.sea	-2.412***	-3.668	-0.508	2.743***		2.506***	12.928***	2.121***
	(0.585)	(2.898)	(1.321)	(0.678)		(0.126)	(3.822)	(0.190)
d.intl#d.rail	10.279***		-3.282**	-2.042***		0.579***	5.025	
	(0.307)		(1.320)	(0.559)		(0.091)	(3.835)	
d.intl#d.road		-1.180	-4.248***	-1.046*	7.882***	1.694***	8.988**	-0.071
		(3.694)	(1.318)	(0.554)	(0.493)	(0.094)	(3.820)	(0.091)
d.intl#d.air	-31.953***	-3.603			5.311***			-1.806***
	(2.985)	(9.576)			(1.291)			(0.114)
d.cont.#d.sea		-11.213***	1.047	5.902***		3.516***	9.644*	5.447***
		(2.036)	(1.089)	(0.334)		(0.232)	(5.339)	(1.008)
d.cont#d.rail			0.115	4.712***		2.951***		6.240***
			(1.145)	(0.266)		(0.237)		(1.018)
d.cont#d.road		-17.908	1.588			2.495***	12.662**	4.058***
		(115.819)	(1.111)			(0.234)	(5.295)	(1.014)
Number of ASCs[a]	41	26	46	52	22	59	35	54
Log likelihood, Intercept only	-815,309	-2,876	-48,467	-640,402	-427,215	-331,975	-546,298	-197,200
Log likelihood	-263,210	-658	-23,145	-96,995	-6,614	-104,196	-12,623	-50,873
Number of cases from CFS after sampling	354,084	1,249	21,049	278,085	185,537	144,127	237,254	85,632

***, **, *: Significance at the 1%, 5%, and 10% level, respectively. [a] See Table 10 for estimation results.

Table 7. Estimation results, commodity groups 9–16. Standard errors in parentheses.

Commodity Group	9: Non-metallic mineral	10: Metal products	11: Machinery	12: Transp. equip.	13: Furniture	14: Waste	15: Timber	16: Air freight
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
ln(cost)	-1.929***	-1.167***	-0.942***	-1.063***	-1.652***	-4.056***	-3.166***	-1.716***
	(0.018)	(0.008)	(0.019)	(0.012)	(0.023)	(0.237)	(0.012)	(0.014)
ln(time)	-0.664***	-0.314***				-0.396	-4.961***	-0.376***
	(0.040)	(0.014)				(0.336)	(0.028)	(0.047)
ln(time)#d.dom			-0.693***		-0.711***			
			(0.176)		(0.189)			
1/weight_tons	1.40E-02***	-0.009***	0.031***	0.470***	-0.001*	-0.064**	-19.037***	0.091**
	(3.80E-04)	(0.0002)	(0.001)	(0.022)	(0.0004)	(0.026)	(0.104)	(0.037)
weight_tons	4.00E-03***	0.002***	-0.064**	-0.098***	-0.046***	0.027	2.25E-03***	0.001
	(2.28E-04)	(0.0001)	(0.025)	(0.007)	(0.010)	(0.018)	(1.15E-04)	(0.008)
d.intl#d.sea	8.208***	0.516***	3.424***	2.614***	1.438***	0.025		
	(0.472)	(0.106)	(0.555)	(0.093)	(0.294)	(0.758)		
d.intl#d.rail	-2.336***	-0.902***	-2.442***				-4.242***	
	(0.387)	(0.098)	(0.438)				(0.244)	
d.intl#d.road	-0.190	-1.022***		1.738***	-0.226	2.018***	0.251***	
	(0.346)	(0.090)		(0.087)	(0.158)	(0.537)	(0.086)	
d.intl#d.air			2.178***	2.099***	3.108***			3.832***
			(0.185)	(0.158)	(0.409)			(0.094)
d.cont.#d.sea	2.361**	4.182***	0.129			-1.074**		
	(1.042)	(0.168)	(4.444)			(0.461)		
d.cont#d.rail	1.970*	5.302***						
	(1.113)	(0.173)						
d.cont#d.road	0.517	2.091***	-1.021					7.765***
	(1.065)	(0.175)	(4.466)					(0.942)
d.cont#d.air			-5.513					
			(4.471)					
Number of ASCs[a]	51	57	36	52	35	32	38	28
Log likelihood, Intercept only	-121,874	-315,058	-96,598	-195,390	-124,190	-2,169	-1,868,000	-371,773
Log likelihood	-42,033	-102,965	-13,903	-73,318	-14,911	-679	-485,523	-47,115
Number of cases from CFS after sampling	52,929	136,828	41,952	84,857	53,935	942	811,436	161,459

***, **, *: Significance at the 1%, 5%, and 10% level, respectively. [a] See Table 11 for estimation results.

The coefficient for ln(time) had the non-expected sign for commodity groups 2, 4, 5, 6, 8, 11, 12, and 13. Different specifications were tested to evaluate what is driving this result, which seems to be international shipments given a positive interaction term between international shipments and time. The time coefficient for domestic shipments is negative for these commodity groups (except group 12) and this interaction term is kept in the preferred models. The transport time for international shipments could be correlated with other aspects than transport time alone, i.e. the choice is made on other grounds. Here it can also be noted that the cost variable includes time-based costs of the vehicle which means that this effect is not captured by the transport time coefficients.

Interactions between international shipments and main mode show the most likely mode for this type of shipments. For example, commodity group 1 (Products of agriculture & hunting) is more likely to be shipped abroad by rail compared to the other modes and least likely by air, whilst sea is the likely main mode for international shipments of commodity group 9 (Non-metallic mineral).

We also include interactions between container and main mode, however, for some commodity groups, these are dropped due to low accuracy (p-values close to 1) and sometimes even convergence problems. Results show that commodity group 2 (Coal, petroleum, natural gas) is not very likely to be shipped with container, whilst other commodity groups are, such as group 4 (Food), 6 (Wood, excl. timber), 7 (coke & refined petroleum), and 8 (chemical products).

Turning to the model estimates for the empirical midpoints of shipment sizes, the proxy variable for frequency of shipments (1/weight_tons) is statistically significant for all commodity groups except for group 2. The coefficient for frequency of shipments is positive for group 1, 2, 4, 5, 9, 11, 12, and 16, indicating that a higher frequency of shipments implies higher utility, and vice versa for the other commodity groups. The coefficients for average weight is statistically significant in most cases (except for groups 2, 4, 14, and 16), and is positive for groups 1, 2, 3, 4 (low accuracy), 6–10, 14 (low accuracy), 15, and 16 (low accuracy). We thus have a mix comprising either positive coefficients for both frequency of shipments and average weight per shipment, or opposite signs for these coefficients. There is also one group (13) for which both coefficients are negative. To evaluate these effects, we calculate the impact per commodity group given the empirical midpoints of shipment sizes per weight class and transport chains.

The average effects per weight class and commodity group are presented in Figure 3 and Figure 4 (relatively extreme values for weight class 1 and 2 are excluded from the illustrations for some commodity groups due to expositional convenience), indicating that the impact on the utility either increases or decreases with weight class and in most cases converges to zero. Put differently, the utility increases with lower weight class for commodity groups 1, 2, 4, 9, 11, and 12 (vice versa for the other commodity groups), which is generated by the positive and relatively large coefficient for 1/weight_tons where lower weights imply higher frequencies. This is expected given the type of commodities within each group comprising 1 (Products of agriculture and hunting), 4 (Food products, beverages, and tobacco), 9 (Non-metallic mineral products), 11 (Machinery and equipment), and 12 (Transport equipment). For example, food products are expected to require frequent shipments rather than large shipments with respect to weight. Note that the coefficient for group 2 (Coal, petroleum, and natural gas) is positive but not statistically significant.

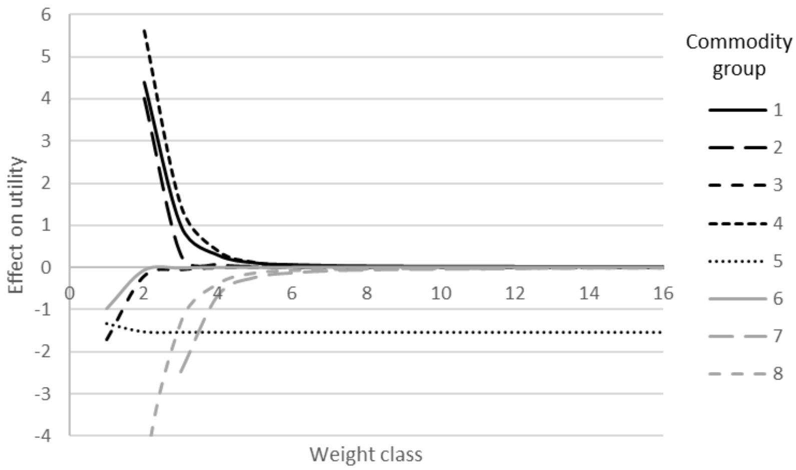

Figure 3. *Average impact of 1/weight + weight on multinomial log-odds, commodity groups 1–8.*

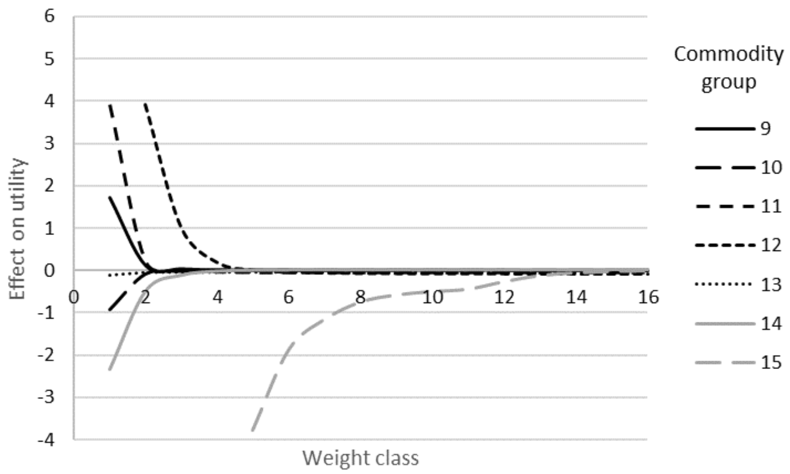

Figure 4. *Average impact of 1/weight + weight on multinomial log-odds, commodity groups 9–15.*

For comparison with past literature, we present the cost coefficients and log likelihoods of different model specifications in Table 8. These models are 1) log transformed cost, including empirical midpoints of shipment size for each transport chain, i.e., the variables 1/W and W; 2) log transformed cost, excluding 1/W and W; 3) linear cost, including 1/W and W, and 4) linear cost, excluding 1/W and W. A logarithmic specification for transport costs outperforms its linear counterpart as indicated by the higher log likelihoods and also by the AIC and BIC of the models (see

Table 9). Including the variables 1/W and W is also preferred based on the log likelihoods and the AIC and BIC, except for commodity groups 14 and 16 which has a slightly lower BIC when 1/W and W are excluded (see

Table 9).

It should be noted that the transport cost variable in Lindgren et al. (2019) is in the unit SEK per tonne, whilst it is SEK per shipment in our study as well as in Abate et al. (2019). Hence, the linear cost coefficients in Lindgren et al. (2019) are not comparable with our estimates (and in a different order of magnitude). The commodity groups in Abate et al. (2019) follows the Samgods 35 classification, whilst we use the Samgods 16 classification. Given that most of the Samgods 16 groups comprise more than one Samgods 35 group (see Edwards et al. 2019, p. 89), we are not able to make a comparison with all the estimates in Abate et al. However, groups 5 (Textile), 11 (Machinery), 12 (Transp. equip.), 13 (Furniture), and 14 (Waste) correspond to one of the Samgods 35 groups for which Abate et al. provide estimates. The transport cost coefficient estimates for group 12 and 15 are in the same order of magnitude as our linear cost estimates: -1.05E-05 compared to -3.03E-06, and -8.47E-06 compared to -4.44E-06 in our study and in Abate et al., respectively. For groups 5, 11, and 13, the cost estimates in Abate et al. are much higher. In fact, 46 557, 11 034, and 18 times higher, respectively. If the variables 1/weight_tons (proxy variable for frequency of shipments) and weight_tons are dropped, the differences in cost estimates become much smaller. Our estimates are then 3.3, 2.5 and 2.8 times higher than the estimates in Abate et al. (2019) for groups 5, 11, and 13 respectively.

Table 8. Estimation results, models with log transformed costs (incl. and excl. empirical midpoints of shipment size) and linear costs.

Commodity group	***Cost coefficient***			
	ln(C), [a]	*ln(C), excl. 1/W and W,* [a]	*C,* [b]	*C, excl. 1/W and W,* [b]
1: Prod. of agricult. & hunting	-1.925	-2.011	-0.0004	-0.0004
2: Coal, petrol., natural gas	-1.012	-0.549	-0.0000005	-0.0000001
3: Metal	-1.564	-0.669	-0.000001	0.00000005
4: Food	-1.645	-1.896	-0.00004	-0.00006
5: Textile	-2.439	-2.596	-0.00000002	-0.0003
6: Wood, excl. timber	-1.465	-1.582	-0.000005	-0.000003
7: Coke & refin. petrol.	-2.824	-1.285	-0.0000002	-0.00002
8: Chemical prod.	-1.359	-1.448	-0.00003	-0.00002
9: Non-metallic mineral	-1.929	-1.967	-0.00004	-0.00003
10: Metal products	-1.167	-1.245	-0.00002	-0.00002
11: Machinery	-0.942	-1.170	-0.00000001	-0.00006
12: Transp. equip.	-1.063	-1.311	-0.00001	-0.00002
13: Furniture	-1.652	-1.686	-0.00004	-0.0002
14: Waste	-4.056	-3.985	-0.00001	-0.00001
15: Timber	-3.166	-0.541	-0.0001	-0.00009
16: Air freight	-1.716	-1.729	-0.00000004	-0.00005

[a] See Table 6, Table 7, Table 10, and Table 11 for control variables in the model estimations. [b] Same control variables as in Table 6, Table 7, Table 10, and Table 11, except that 'cost' is linear (no logarithmic transformation).

Table 9. Log likelihood (LL) and information criterion AIC (BIC in parentheses).

Commodity group	*lnC*, [a]		*lnC*, *excl. 1/W and W*, [a]		*C*, [b]		*C, excl. 1/W and W*, [b]	
	LL	AIC (BIC)	LL	AIC (BIC)	LL	AIC (BIC)	LL	AIC (BIC)
1: Prod. of agricult. & hunting	-263,210	526,515 (527,033)	-264,248	528,588 (529,084)	-269,930	539,957 (540,474)	-273,493	547,077 (547,573)
2: Coal, petrol., natural gas	-658	1,385 (1,559)	-749	1,561 (1,726)	-698	1,464 (1,639)	-876	1,817 (1,981)
3: Metal	-23,145	46,402 (46,847)	-25,474	51,057 (51,486)	-25,301	50,715 (51,160)	-26,886	53,880 (54,309)
4: Food	-96,995	194,110 (194,742)	-98,388	196,891 (197,502)	-105,827	211,774 (212,406)	-125,457	251,031 (251,642)
5: Textile	-6,614	13,281 (13,555)	6,658	13,366 (13,620)	-13,986	28,026 (28,300)	-71,432	142,914 (143,167)
6: Wood, excl. timber	-104,196	208,527 (209,199)	-105,628	211,388 (212,040)	-118,398	236,932 (237,604)	-124,775	249,682 (250,334)
7: Coke & refin. petrol.	-12,623	25,333 (25,790)	-28,231	56,545 (56,981)	-65,254	130,595 (131,052)	-90,766	181,616 (182,051)
8: Chemical prod.	-50,873	101,873 (102,462)	-51,886	103,894 (104,465)	-60,452	121,031 (121,620)	-63,398	126,917 (127,488)
9: Non-metallic mineral	-42,033	84,189 (84,730)	-42,982	86,083 (86,607)	-50,686	101,494 (102,035)	-53,270	106,657 (107,181)
10: Metal products	-102,965	206,064 (206,723)	-104,768	209,667 (210,306)	-115,052	230,238 (230,896)	-121,886	243,902 (244,541)
11: Machinery	-13,903	27,898 (28,296)	-14,670	29,429 (29,809)	-15,136	30,363 (30,761)	-28,835	57,758 (58,138)
12: Transp. equip.	-73,318	146,752 (147,294)	-76,072	152,255 (152,779)	-78,557	157,229 (157,771)	-87,812	175,736 (176,259)
13: Furniture	-14,911	29,903 (30,268)	-14,928	29,933 (30,280)	-19,977	40,036 (40,401)	-22,845	45,769 (46,116)
14: Waste	-679	1,436 (1,625)	-682	1,438 (1,617)	-1,005	2,089 (2,278)	-1,034	2,143 (2,322)
15: Timber	-485,523	971,135 (971,646)	-568,635	1,137,354 (1,137,841)	-544,959	1,090,005 (1,090,516)	-561,937	1,123,959 (1,124,446)
16: Air freight	-47,115	94,299 (94,638)	-471,26	94,315 (94,635)	-67,904	135,876 (136,216)	-98,559	197,182 (197,502)

5. Discussion and conclusions

This study has presented estimates on firm's choice of transport chain and shipment size. Multinomial logit models for each of the 16 commodity groups has been estimated using the CFS for 2016 and 2021, providing statistically significant coefficients for the transport cost per shipment. A logarithmic specification of costs provides a better model fit compared to a linear specification, where the latter has been used in most previous studies on the Swedish CFS (one exception is Jensen et al., 2019, who use a nested logit framework that includes both the CFS and the French ECHO data, and tests logarithmic specifications as well as spline functions).

As noted by Combes (2014), a downside with the CFS is that it lacks variables such as the shipper-receiver commodity flow rate, which forms the basis for the decisions of shippers. This is problematic when trying to model decisions of firms that try to optimise their shipment sizes. Our study tried to handle this by using empirical midpoints of shipments sizes per weight class and transport chain. Specifically, a proxy for the frequency of shipments where used (1/weight_tons) together with the average weight in tons. This had a substantial impact on the transport cost coefficients for some of the commodity groups.

Future research could look into retrieving more information that underlies the decision of the shippers, such as travel time reliability and infrastructure capability (e.g., linespeed, maximum axle load, and maximum train length when considering the rail infrastructure's capability), which could be of interest when evaluating their impact on cross-elasticities for different transport modes.

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Appendix

Table 10. Estimation results for alternative specific constants, commodity groups 1–8. Standard errors in parentheses.

Commodity group	**1: Prod. of agricult. & hunting**	**2: Coal, petrol., natural gas**	**3: Metal**	**4: Food**	**5: Textile**	**6: Wood, excl. timber**	**7: Coke & refin. petrol.**	**8: Chemical prod.**
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
d.sea#WC1	11.382***		-6.483***	-11.799***	7.223***	-7.822***	32.142***	-9.240***
	(0.652)		(0.388)	(0.403)	(0.494)	(0.136)	(0.822)	(0.201)
d.sea#WC2	25.975***		-5.780***	21.130***	5.459***	-7.532***	-7.739***	-9.429***
	(1.295)		(0.267)	(1.438)	(0.508)	(0.142)	(0.511)	(0.213)
d.sea#WC3	27.972***		-4.610***	26.951***	7.754***	-5.664***	-9.177***	-8.038***
	(1.560)		(0.249)	(1.605)	(0.554)	(0.133)	(0.321)	(0.213)
d.sea#WC4	34.129***	8.289**	-2.857***	29.805***	12.226***	-3.627***	-7.033***	-6.630***
	(1.428)	(3.360)	(0.268)	(1.652)	(0.903)	(0.130)	(0.242)	(0.214)
d.sea#WC5	33.040***	7.422**	-1.350***	31.746***	18.163***	-2.139***	-5.715***	-5.454***
	(1.517)	(3.489)	(0.271)	(1.663)	(1.972)	(0.133)	(0.304)	(0.218)
d.sea#WC6	32.889***		-0.252	32.673***	28.115***	-1.338***	-3.990***	-5.104***
	(1.834)		(0.253)	(1.665)	(4.075)	(0.135)	(0.281)	(0.222)
d.sea#WC7	37.262***	10.073***	0.487**	33.972***	34.505***	0.304**	-5.409***	-3.974***
	(1.420)	(3.386)	(0.246)	(1.664)	(5.692)	(0.132)	(0.485)	(0.220)
d.sea#WC8	34.380***	10.899***	2.529***	34.200***	48.434***	1.589***	-3.270***	-3.361***
	(1.538)	(3.377)	(0.188)	(1.664)	(10.003)	(0.131)	(0.295)	(0.220)
d.sea#WC9		9.781***		30.884***	61.634***	-0.243*	-5.086***	-5.580***
		(3.428)		(1.735)	(13.238)	(0.141)	(0.814)	(0.256)
d.sea#WC10	35.537***	9.408***	3.284***	31.241***		0.047	-4.410***	-4.715***
	(1.641)	(3.519)	(0.195)	(1.720)		(0.140)	(0.600)	(0.237)
d.sea#WC11	28.831***	10.041***	2.067***	31.350***		-0.900***		-4.768***
	(6.898)	(3.448)	(0.230)	(1.721)		(0.153)		(0.242)
d.sea#WC12	34.665***	11.448***	4.912***	32.972***		0.871***	-4.091***	-4.382***
	(1.674)	(3.420)	(0.191)	(1.686)		(0.141)	(0.855)	(0.243)
d.sea#WC13	32.554***	11.186***	2.842***	33.276***		0.452***	-0.947*	-5.130***
	(1.985)	(3.441)	(0.313)	(1.712)		(0.160)	(0.524)	(0.343)
d.sea#WC14		12.486***		33.674***		1.292***	2.659***	-4.265***
		(3.465)		(1.774)		(0.166)	(0.301)	(0.318)
d.sea#WC15	28.037***	11.922***	5.356***	34.028***		1.417***	5.560***	-3.660***
	(3.001)	(3.529)	(0.273)	(1.865)		(0.179)	(0.241)	(0.341)
d.sea#WC16	30.665***	17.935***	9.618***	35.775***		0.934***	10.234***	-2.965***
	(2.407)	(3.501)	(0.225)	(1.932)		(0.312)	(0.192)	(0.379)
d.rail#WC1				-58.405***		-2.313***	31.350***	-9.565***
				(2.507)		(0.066)	(1.114)	(0.254)
d.rail#WC2				21.982***		-8.682***		-10.068***
				(1.473)		(0.503)		(0.328)
d.rail#WC3	7.835		-4.351***	29.901***	-0.484	-6.530***	-14.087***	-8.729***
	(783.347)		(1.014)	(1.752)	(1.271)	(0.358)	(1.035)	(0.307)

***, **, *: Significance at the 1%, 5%, and 10% level, respectively.

Commodity group	1: Prod. of agricult. & hunting	2: Coal, petrol., natural gas	3: Metal	4: Food	5: Textile	6: Wood, excl. timber	7: Coke & refin. petrol.	8: Chemical prod.
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
d.rail#WC4	32.332***		1.668***	33.953***	5.273***	-2.724***	-11.556***	-6.993***
	(1.321)		(0.169)	(1.795)	(1.388)	(0.140)	(0.590)	(0.252)
d.rail#WC5	33.974***		3.109***	36.478***		-1.071***	-11.208***	-4.081***
	(1.334)		(0.201)	(1.800)		(0.142)	(1.118)	(0.184)
d.rail#WC6	34.956***		3.624***	37.968***	22.169***	-0.367***	-8.700***	-3.274***
	(1.338)		(0.237)	(1.800)	(3.777)	(0.135)	(0.725)	(0.189)
d.rail#WC7	35.449***		3.237***	38.803***		1.394***	-7.393***	-2.382***
	(1.344)		(0.392)	(1.800)		(0.106)	(1.117)	(0.174)
d.rail#WC8	35.755***		7.216***	40.671***		3.735***	-4.594***	-0.576***
	(1.369)		(0.177)	(1.798)		(0.080)	(0.519)	(0.154)
d.rail#WC9	32.162***		1.966*	39.374***		1.015***		-3.397***
	(1.734)		(1.017)	(1.800)		(0.164)		(0.315)
d.rail#WC10	31.820***		2.786***	40.287***		1.035***		-2.447***
	(1.806)		(0.729)	(1.798)		(0.172)		(0.232)
d.rail#WC11				40.086***		1.871***		-2.123***
				(1.798)		(0.136)		(0.223)
d.rail#WC12	34.672***		6.725***	41.347***		5.914***		0.149
	(1.554)		(0.254)	(1.797)		(0.083)		(0.164)
d.rail#WC13	33.984***		7.106***	39.864***		3.842***		-2.056***
	(1.787)		(0.281)	(1.818)		(0.127)		(0.388)
d.rail#WC14				40.133***		4.216***		-2.701***
				(1.856)		(0.149)		(0.727)
d.rail#WC15	34.399***		7.132***	40.699***		4.491***		-2.905***
	(1.647)		(0.579)	(1.917)		(0.163)		(1.019)
d.rail#WC16	34.772***		-56.776***	41.215***		4.580***		-2.576**
	(1.829)		(2.102)	(2.120)		(0.201)		(1.030)
d.air#WC1		-21.085	0.578	-36.804***	7.408***	2.678***	244.504***	4.136***
		(25.429)	(1.335)	(1.741)	(1.224)	(0.094)	(4.446)	(0.083)
d.air#WC2		10.825	-1.886	25.105***	7.036***	0.976***		-0.106
		(11.557)	(1.423)	(1.560)	(1.273)	(0.137)		(0.154)
d.air#WC3			-0.485	33.862***	10.201***	1.722***		0.537***
			(1.420)	(1.825)	(1.308)	(0.182)		(0.181)
d.air#WC4			1.828	37.002***		2.670***		1.634***
			(1.476)	(1.906)		(0.244)		(0.216)
d.air#WC5			1.955	38.930***	18.092***	2.932***		2.054***
			(1.645)	(1.965)	(2.589)	(0.462)		(0.313)
d.air#WC6						2.498***		0.510
						(0.718)		(0.741)
d.air#WC7						3.787***		
						(0.397)		
d.air#WC8						6.181***		1.108*
						(0.176)		(0.608)

***, **, *: Significance at the 1%, 5%, and 10% level, respectively. Standard errors in parentheses.

Commodity group	1: Prod. of agricult. & hunting	2: Coal, petrol., natural gas	3: Metal	4: Food	5: Textile	6: Wood, excl. timber	7: Coke & refin. petrol.	8: Chemical prod.
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
d.air#WC9						2.883***		
						(0.718)		
d.air#WC10						2.304**		
						(1.007)		
d.air#WC11						2.328**		
						(1.007)		
d.air#WC12						3.186***		
						(1.008)		
d.road#WC1	BASELINE	BASELINE	BASELINE	BASELINE	BASELINE	BASELINE	63.309***	BASELINE
							(0.599)	
d.road#WC2	25.769***	8.188*	-0.588***	31.143***	1.634**	-1.184***	-9.422***	-3.205***
	(1.105)	(4.207)	(0.119)	(1.518)	(0.117)	(0.032)	(0.102)	(0.098)
d.road#WC3	31.676***	10.056**	0.462***	36.456***	0.206	-0.008	-11.855***	-2.066***
	(1.255)	(4.379)	(0.135)	(1.735)	(0.205)	(0.037)	(0.096)	(0.104)
d.road#WC4	35.304***	10.329**	2.619***	38.387***	3.174***	1.520***	-10.286***	-1.109***
	(1.288)	(4.402)	(0.135)	(1.787)	(0.688)	(0.043)	(0.072)	(0.109)
d.road#WC5	37.444***	10.228**	4.228***	39.555***	10.465***	2.487***	-7.737***	-0.406***
	(1.297)	(4.422)	(0.146)	(1.797)	(2.061)	(0.052)	(0.059)	(0.115)
d.road#WC6	38.094***	9.162**	6.051***	39.675***	17.991***	2.799***	-6.074***	-0.244**
	(1.299)	(4.438)	(0.152)	(1.798)	(3.877)	(0.060)	(0.056)	(0.121)
d.road#WC7	38.764***	10.204**	7.729***	40.249***	24.720***	3.284***	BASELINE	1.130***
	(1.300)	(4.421)	(0.155)	(1.798)	(5.709)	(0.063)		(0.121)
d.road#WC8	39.175***	10.583**	6.944***	40.772***		4.573***	-7.070***	0.688***
	(1.301)	(4.424)	(0.161)	(1.798)		(0.062)	(0.161)	(0.123)
d.road#WC9	39.215***	8.400*	7.446***	40.428***		3.736***	-7.708***	0.119
	(1.302)	(4.477)	(0.166)	(1.797)		(0.069)	(0.283)	(0.131)
d.road#WC10	39.854***	10.72***	7.636***	41.496***		4.206***	-7.213***	0.244*
	(1.302)	(4.424)	(0.167)	(1.797)		(0.069)	(0.248)	(0.130)
d.road#WC11	39.417***	10.522**	7.585***	41.071***		3.074***	-7.229***	0.845***
	(1.303)	(4.429)	(0.168)	(1.797)		(0.073)	(0.267)	(0.128)
d.road#WC12	37.631***	10.494**	8.112***	39.536***		3.258***	-5.378***	-0.189
	(1.304)	(4.443)	(0.171)	(1.798)		(0.078)	(0.211)	(0.142)
d.road#WC13	35.774***		5.782***	39.412***		2.481***	-10.886***	-1.809***
	(1.317)		(0.259)	(1.805)		(0.122)	(1.455)	(0.285)
d.road#WC14	34.937***		6.201***	39.353***		2.351***		-2.979***
	(1.348)		(0.308)	(1.815)		(0.165)		(0.596)
d.road#WC15	31.919***		6.817***	40.742***		1.859***		-0.992***
	(1.555)		(0.362)	(1.873)		(0.237)		(0.341)
d.road#WC16	23.975***	10.745**	7.261***	39.579***		1.845***		-3.352***
	(2.319)	(4.693)	(0.377)	(2.290)		(0.282)		(1.027)

***, **, *: Significance at the 1%, 5%, and 10% level, respectively. Standard errors in parentheses.

Table 11. Estimation results for alternative specific constants, commodity groups 9–16. Standard errors in parentheses.

Commodity group	9: Non-metallic mineral	10: Metal products	11: Machinery	12: Transp. equip.	13: Furniture	14: Waste	15: Timber	16: Air freight
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
d.sea#WC1	-9.751***	-5.996***	-4.295***	16.873***	-5.801***	-2.241**		-6.231***
	(0.304)	(0.068)	(0.555)	(0.942)	(0.311)	(1.100)		(0.115)
d.sea#WC2	-8.050***	-5.778***	-1.760***	40.388***	-5.161***	-1.892	129.273***	-2.210*
	(0.295)	(0.072)	(0.566)	(2.024)	(0.312)	(1.209)	(1.284)	(1.206)
d.sea#WC3	-6.032***	-4.755***	-0.514	45.396***	-4.267***	2.386*	20.062***	1.121
	(0.290)	(0.073)	(0.564)	(2.180)	(0.311)	(1.275)	(0.534)	(1.422)
d.sea#WC4	-3.788***	-3.863***	0.034	48.966***	-2.367***	5.225***	-3.064***	3.074**
	(0.287)	(0.076)	(0.555)	(2.212)	(0.303)	(1.502)	(0.279)	(1.475)
d.sea#WC5	-2.415***	-2.760***	0.824	49.476***	-0.785***		-3.546***	4.473***
	(0.288)	(0.080)	(0.531)	(2.218)	(0.285)		(0.113)	(1.477)
d.sea#WC6	-2.351***	-2.067***	0.981*	49.602***	-0.476*	12.268***	-5.602***	4.772***
	(0.306)	(0.083)	(0.520)	(2.219)	(0.273)	(1.544)	(0.224)	(1.470)
d.sea#WC7	-1.659***	-1.412***	1.074*	50.346***	0.282	14.139***	-7.361***	5.786***
	(0.302)	(0.084)	(0.548)	(2.219)	(0.255)	(1.524)	(0.355)	(1.448)
d.sea#WC8	-0.240	-0.729***	2.408***	50.816***	2.342***	17.164***	-6.533***	5.095***
	(0.289)	(0.083)	(0.629)	(2.221)	(0.217)	(1.496)	(0.257)	(1.432)
d.sea#WC9	-1.661***	-2.654***	1.164	49.957***		17.065***	-4.055***	3.204*
	(0.349)	(0.105)	(0.810)	(2.227)		(1.581)	(0.175)	(1.716)
d.sea#WC10	-2.553***	-2.562***	1.032	49.874***		17.515***	-2.229***	5.651***
	(0.437)	(0.106)	(0.979)	(2.233)		(1.596)	(0.108)	(1.411)
d.sea#WC11	-1.951***	-2.894***		53.217***		16.625***	-1.369***	
	(0.389)	(0.117)		(2.231)		(1.645v	(0.093)	
d.sea#WC12	-1.363***	-1.241***	2.565	53.271***			2.078***	
	(0.385)	(0.097)	(1.601)	(2.252)			(0.072)	
d.sea#WC13	-2.712***	-2.076***		59.865***		17.981***		
	(1.043)	(0.126)		(2.515)		(3.126)		
d.sea#WC14		-2.264***		74.476***		16.201***	-1.868***	
		(0.172)		(3.255)		(5.517)	(0.513)	
d.sea#WC15	-1.228	-3.094***				12.444	-0.408	
	(0.789)	(0.283)				(10.691)	(0.517)	
d.sea#WC16	-3.559***	-3.257***				4.944	0.985**	
	(0.807)	(0.360)				(17.745)	(0.488)	
d.rail#WC1		-6.163***	-13.298***	-31.281***	-4.434***			
		(0.105)	(0.456)	(1.267)	(0.158)			
d.rail#WC2	-3.061***	-6.257***		37.984***	-4.890***			
	(0.716)	(0.102)		(2.031)	(0.192)			
d.rail#WC3	-1.228**	-4.723***	-0.812	41.971***	-4.506***			
	(0.508)	(0.079)	(0.731)	(2.172)	(0.235)			
d.rail#WC4	1.709***	-2. 509***	0.303	47.792***	-3.266***			
	(0.315)	(0.068)	(1.025)	(2.217)	(0.314)			
d.rail#WC5	4.539***	-1.180***		48.504***	-3.334***			
	(0.297)	(0.073)		(2.225)	(1.011)			

***, **, *: Significance at the 1%, 5%, and 10% level, respectively.

Commodity group	9: Non-metallic mineral	10: Metal products	11: Machinery	12: Transp. equip.	13: Furniture	14: Waste	15: Timber	16: Air freight
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
d.rail#WC6	5.464***	0.142**		49.489***	-2.362**			
	(0.425)	(0.071)		(2.225)	(1.020)			
d.rail#WC7	5.512***	0.471***	4.601***	51.270***	0.192	16.630***		
	(0.556)	(0.074)	(0.730)	(2.223)	(0.521)	(1.436)		
d.rail#WC8	7.614***	1.612***	4.443***	51.470***	4.125***	18.320***	-5.749***	
	(0.304)	(0.071)	(0.885)	(2.227)	(0.264)	(1.407)	(0.558)	
d.rail#WC9	6.931***	-0.603***		50.269***	2.827***		-4.551***	
	(0.465)	(0.111)		(2.281)	(0.477)		(0.507)	
d.rail#WC10	6.395***	-0.444***		51.718***		18.906***	-4.252***	
	(0.719)	(0.112)		(2.262)		(1.567)	(0.507)	
d.rail#WC11	5.887***	-0.223**		51.774***			-5.984***	
	(0.845)	(0.109)		(2.289)			(1.080)	
d.rail#WC12	8.971***	2.182***		57.310***	2.453**	20.022***	-0.293*	
	(0.351)	(0.078)		(2.270)	(1.107)	(1.958)	(0.169)	
d.rail#WC13	9.540***	0.013		62.951***			1.317***	
	(0.411)	(0.154)		(2.367)			(0.153)	
d.rail#WC14		0.003		74.782***		18.631***	1.812***	
		(0.204)		(2.768)		(5.561)	(0.145)	
d.rail#WC15		0.552***					2.974***	
		(0.183)					(0.112)	
d.rail#WC16		1.768***		135.610***			5.609***	
		(0.176)		(6.671)			(0.141)	
d.air#WC1	2.905***	0.230***	-2.342***	-11.263***	0.314			2.111***
	(0.348)	(0.087)	(0.224)	(0.537)	(0.401)			(0.094)
d.air#WC2	5.133***	-0.569***	4.233***	43.380***	-2.211***			2.023*
	(0.398)	(0.093)	(0.244)	(1.995)	(0.447)			(1.200)
d.air#WC3	7.133***	0.055	5.165***	49.859***	-1.299**			3.519**
	(0.414)	(0.101)	(0.255)	(2.173)	(0.512)			(1.423)
d.air#WC4	6.746***	0.219*	5.779***	51.301***	-0.506			5.483***
	(0.785)	(0.123)	(0.264)	(2.206)	(0.717)			(1.474)
d.air#WC5	8.748***	-0.416*	4.570***	51.140***				5.589***
	(1.062)	(0.222)	(0.341)	(2.219)				(1.480)
d.air#WC6	9.634***	-1.178***		50.725***	1.127			2.552
	(1.062)	(0.420)		(2.239)	(1.089)			(1.770)
d.air#WC7		-0.932**	3.846***	51.381***				2.869
		(0.391)	(0.704)	(2.240)				(1.755)
d.air#WC8	10.780***	-1.721***		51.974***	2.254**			
	(0.681)	(0.586)		(2.249)	(1.090)			
d.air#WC9	9.879***		3.945***					
	(1.063)		(1.274)					
d.air#WC11	10.047***							
	(1.062)							

***, **, *: Significance at the 1%, 5%, and 10% level, respectively. Standard errors in parentheses.

Commodity group	**9: Non-metallic mineral**	**10: Metal products**	**11: Machinery**	**12: Transp. equip.**	**13: Furniture**	**14: Waste**	**15: Timber**	**16: Air freight**
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
d.air#WC12		0.067						
		(0.368)						
d.air#WC14		-0.796						
		(1.006)						
d.air#WC16			68.564***					
			(24.838)					
d.road#WC1	BASELINE	BASELINE	BASELINE	BASELINE	BASELINE	BASELINE	545.469***	BASELINE
							(3.048)	
d.road#WC2	3.309***	-0.533***	4.249***	44.760***	0.188***	1.665**	137.718***	2.129*
	(0.069)	(0.028)	(0.152)	(2.035)	(0.047)	(0.700)	(0.806)	(1.197)
d.road#WC3	4.984***	0.443***	5.085***	48.974***	1.256***	4.652***	28.865***	3.479**
	(0.077)	(0.033)	(0.160)	(2.178)	(0.057)	(0.835)	(0.206)	(1.420)
d.road#WC4	7.040***	1.332***	5.509***	50.972***	2.353***	8.614***	-0.851***	4.250***
	(0.087)	(0.039)	(0.170)	(2.212)	(0.072)	(0.953)	(0.041)	(1.470)
d.road#WC5	8.863***	1.809***	5.845***	51.284***	2.861***	14.418***	-3.240***	4.425***
	(0.101)	(0.047)	(0.206)	(2.219)	(0.103)	(1.085)	(0.019)	(1.471)
d.road#WC6	9.725***	1.753***	5.597***	52.033***	2.879***	17.191***	-2.921***	4.688***
	(0.110)	(0.053)	(0.286)	(2.220)	(0.147)	(1.168)	(0.013)	(1.458)
d.road#WC7	10.800***	1.886***	5.417***	53.047***	2.875***	16.799***	-2.098***	5.203***
	(0.115)	(0.055)	(0.423)	(2.221)	(0.215)	(1.256)	(0.010)	(1.440)
d.road#WC8	10.747***	2.625***	5.290***	53.552***	4.803***	18.338***	-1.829***	5.700***
	(0.117)	(0.054)	(0.660)	(2.223)	(0.252)	(1.292)	(0.009)	(1.414)
d.road#WC9	10.762***	1.515***	4.718***	51.944***	2.859***	19.050***	-1.697***	3.444**
	(0.122)	(0.065)	(0.966)	(2.229)	(0.452)	(1.403)	(0.009)	(1.414)
d.road#WC10	11.020***	1.730***	5.112***	54.058***	3.759***	19.174***	-0.971***	3.477**
	(0.122)	(0.064)	(1.028)	(2.229)	(0.414)	(1.437)	(0.008)	(1.404)
d.road#WC11	10.495***	1.086***	3.579**	50.481***		17.314***	BASELINE	2.452*
	(0.124)	(0.073)	(1.462)	(2.269)		(1.502)		(1.441)
d.road#WC12	11.183***	1.278***	7.962***	57.433***	3.091***	18.238***	0.592***	4.171***
	(0.132)	(0.081)	(1.741)	(2.257)	(0.862)	(1.794)	(0.007)	(1.357)
d.road#WC13	9.033***	-0.084	11.745***	65.832***	10.241***		-1.894***	
	(0.200)	(0.173)	(3.840)	(2.464)	(1.565)		(0.036)	
d.road#WC14	8.200***	-0.293		70.484***		15.181***	-0.674***	
	(0.351)	(0.237)		(2.677)		(5.536)	(0.054)	
d.road#WC15	8.166***	-2.935***		109.643***			0.316***	
	(0.420)	(1.005)		(4.938)			(0.083)	
d.road#WC16	7.504***	-2.997***		134.826***		2.807	2.001***	
	(0.423)	(1.009)		(6.694)		(17.743)	(0.136)	

***, **, *: Significance at the 1%, 5%, and 10% level, respectively. Standard errors in parentheses.