MODAL SPLIT FUNCTIONS FOR A SWISS NATIONAL FREIGHT TRANSPORT MODEL

Nikolaus Fries (Corresponding Author)
Andrew Nash
Jost Wichser
ETH Zurich
Institute for Transportation Planning and Systems
Wolfgang Pauli Strasse 15
8093 Zurich
Switzerland

Georg Abay
Gianni Moreni
Rapp Trans AG
Uetlibergstrasse 132
8045 Zurich
Switzerland

ABSTRACT

This paper describes the development of modal split functions for the new Swiss national freight transport demand model. The project consisted of surveying people from companies and logistics providers responsible for determining what mode is used to make freight shipments in Switzerland. A Stated Preference (SP) survey was administered as part of the survey to collect the data needed for the modal split functions. In total 97 interviews were carried out and 176 valid experiments were completed. These data were used to estimate seven modal split functions: four commodity-group specific functions for the internal (Swiss) market sector and one model that included all commodity groups for the import, export and transit market sectors respectively. The model results were good with all the coefficients having the correct signs and being significant at the 95% level, and with an adjusted ρ^2 between 0.35 and 0.67. Furthermore, the predicted relevance of individual transport characteristics are consistent with expected results. The model results show that transport price and on-time reliability are of higher relevance than transport time.

1. INTRODUCTION

Modelling of freight demand has increased rapidly in recent years. New freight demand models have been developed and implemented on the regional and national levels throughout the world. These models are providing logistics and transport planners with a valuable tool to assist them in all aspects of the transport planning and decision-making process.

In 2005, following the successful launch of a national passenger transport model, the Swiss Federal Office for Spatial Development (ARE) decided to develop a national freight transport model. The two models, working together, were designed to provide a comprehensive tool for passenger and freight transport demand forecasting in Switzerland.

One of the key tasks in developing the national freight transport model was to develop modal split functions (representing shipper demand elasticities for freight transport services) and to estimate the model parameters. This task was completed by Rapp Trans AG and the Institute for Transport Planning and Systems at ETH Zurich. This paper describes the methodology used to complete this task and the resulting modal split functions.

The paper begins with an introduction to the Swiss freight transport model and current conditions. The second section describes the survey methodology and assumptions used in developing the experiments. The third section describes the survey results. The fourth section presents results of the modal split functions estimation. The final section presents conclusions including recommendations for further research.

1.1 Existing Swiss Freight Transport Models

The existing Swiss freight models apply general elasticity approaches (Arendt, 2000) and other simple methods (Ruesch et al., 2000) that no longer correspond with state-of-the-art in freight transport modelling. Therefore it was essential to establish new modal split functions able to realistically describe shippers' demand for freight transport services.

Earlier research, based on Stated Preference (SP) approaches, had already determined that the most important transport characteristics impacting freight transport mode choice were reliability, travel time, frequency, and flexibility (Bolis and Maggi, 1999, IRE and Rapp Trans AG, 2005). However, these results were based on surveys with small sample sizes and were limited to single commodity groups. They also lacked specific utility functions.

1.2 Swiss Freight Transport Modal Split Data

The first step in the project was to review existing freight transport modal split data. The project was limited to road, rail and intermodal (road/rail) transport modes since the amount of inland waterway, air and pipeline transport in Switzerland is very small. The data used to estimate actual modal split values came from 2003 (the latest year for which data from all three modes was available).

Figure 1 illustrates the actual transport volumes and Figure 2 the transport performance in Switzerland based on the 2003 data.

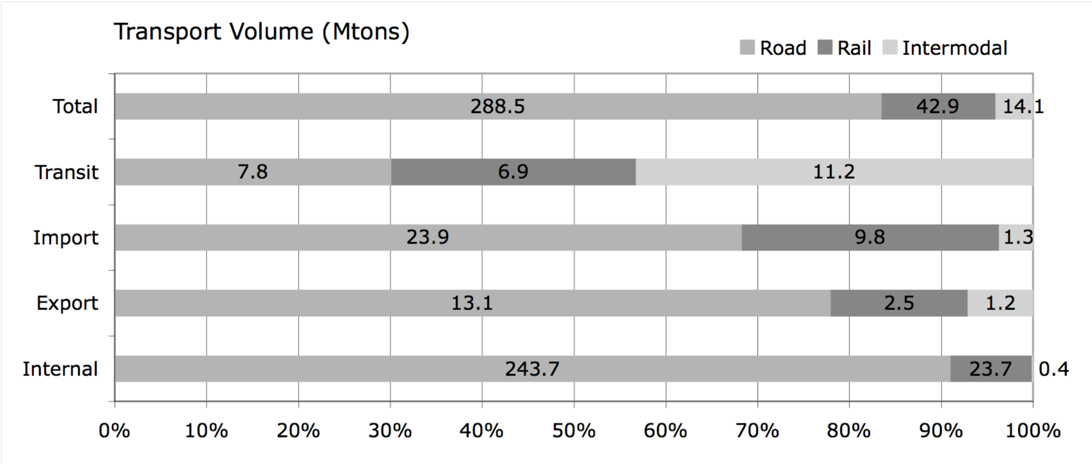

Figure 1: Existing modal split values for freight transport volume in Switzerland (Source: BfS, SBB Cargo, BLS Cargo)

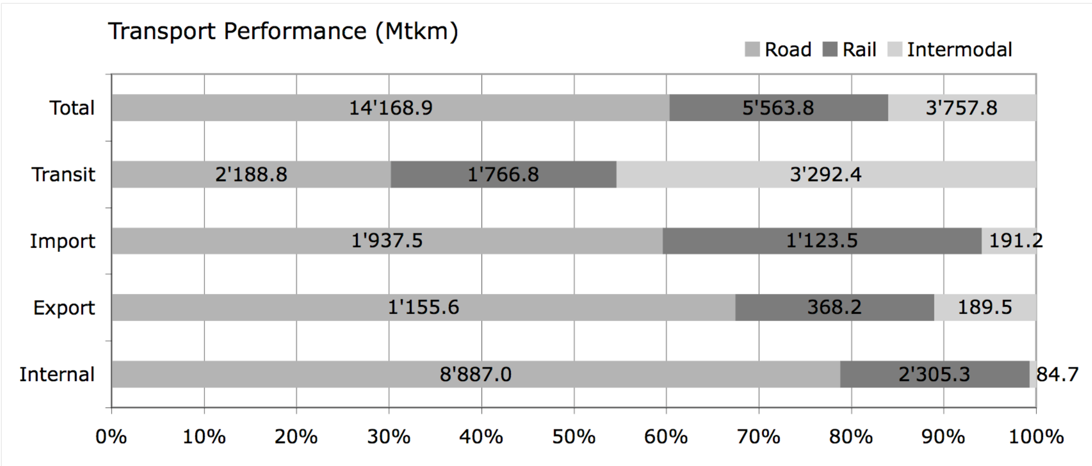

Figure 2: Existing modal split values for freight transport performance in Switzerland (Source: BfS, SBB Cargo, BLS Cargo)

As shown in Figure 1 and Figure 2, road transport is by far the most important freight transport mode in Switzerland carrying 84% of freight based on total tonnage. This is mainly due to road transport's high shares in the internal and import transport markets. In contrast, lorries carry only about 60% of freight when measured in terms of tonne-kilometres. This difference illustrates that average distances for road transport are lower than for rail and intermodal transport.

Rail transport's mode share is about 12% based on total tonnage. Rail is especially popular in the import (28%) and transit (27%) market sectors, in comparison to carrying just 8.8% of the internal transport market. Due to generally longer transport distances, rail transport's mode share with respect to transport performance is twice as high (24%) as its share measured with respect to volume.

The influence of transport distance is even more significant for intermodal transport. While the mode share for intermodal transport measured in terms of total tonnage is only 4%, when measured in terms of transport performance its share is four times higher (16%). The fact that intermodal transport on shorter distances (300 km and less) is normally not competitive is reflected clearly by the difference between the volume share in the internal transport market (<1%) and in the transit transport market (43%).

1.3 Swiss Freight Transport Distance Data

The average transport distance for internal freight shipments in Switzerland is 42 km compared to approximately 100 km for import/export and 280 km for transit shipments (note that these distances for import, export, and transit refer to the distance covered on Swiss territory only). The total average transport distance across all market sectors is 68 km.

The average transport distance data masks an important fact, namely that the volumes carried decrease significantly with increasing transport distance. For example, almost 75% of internal freight shipments are transported less than 50 km (and 29% is transported less than 10 km). Over all market sectors almost 63% of total volume is moved within a 50 km band and 95% of these shipments are transported by road.

In summary, these data show that the role of rail and intermodal transport is negligible for distances less than 50 km. Therefore, the study set a lower boundary for transport distance at 50 km.

2. SURVEY DESIGN

The freight transport mode choice decision-making process is very complex; therefore the survey design process and surveys themselves were carefully reviewed with logistics and modelling experts to insure an optimal design.

This section describes the design of the survey completed in the study to estimate modal split functions. It describes how the freight transport market was divided into different groups, the sample size determination process, how the survey was used and how the survey experiments were developed.

2.1 Commodity Groups

The project’s goal was to determine modal split functions for commodities of all industrial sectors in Switzerland. Therefore the first step in building the modal split models was to define commodity groups. To be useful, these groups must be consistent in terms of the commodity’s general characteristics, shippers’ transport requirements, and existing transport mode shares.

As part of the project, a new system of seven commodity groups was defined (see Table 1). This new system is based on three existing commodity classifications (Eurostat, the Swedish classification according to de Jong et al. (2004), and the revised uniform goods nomenclature for transport statistics – NST/R).

Commodity group	Tonnage Mtons	Share of total tonnage (%)	Modal share road (%)	Modal share rail (%)
Agricultural raw material	7.02	7.2	71	29
Food/animal feed products	20.81	21.5	93	7
Chemical/ mineral products	12.09	12.5	76	24
Iron/metal products	5.19	5.4	83	17
Building material	18.01	18.6	67	33
Manufactured goods	9.82	10.1	95	5
Other products and containers	24.06	24.8	82	18

Table 1: Commodity groups used in this project

Each of the seven commodity groups represents between 5% and 25% of the total transport volume. The modal split varies significantly between the individual groups (between 67% road share for building materials and 95% for vehicles and manufactured products), but more important than obtaining for each group the same modal split was to create groups with a homogenous modal split for the specific commodities within the group.

2.2 Sample Size

The study budget provided funding to complete approximately 90 interviews. In each interview participants were to be asked about two example shipments thus providing a total of 180 SP-experiments. Each example shipment consisted of one commodity group transported in one transport market sector (i.e. internal, export, import, transit). The distribution of experiments to the specific commodity groups was done based first on the total volume and second on the number of products per group. A lower boundary of 15 experiments per group was also set. The target distribution of experiments is presented in Table 2.

Commodity group	Transport market sector				
	Internal	Export	Import	Transit	Total
Agricultural raw material	6	3	3	3	15
Food/animal feed products	21	3	3	6	33
Chemical/ mineral products	12	0	6	6	24
Iron/metal products	6	3	3	3	15
Building material	12	0	3	0	15
Manufactured goods	15	3	3	9	30
Other products and containers	18	6	6	18	48
Total	90	18	27	45	180

Table 2: Target sample size for the survey

2.3 Survey Process and Implementation

The goal of the survey was to better understand how companies make mode choice decisions for their freight shipments. Therefore, the survey was designed to be administered to persons responsible for making mode choice decisions. These persons were either employed by the manufacturing companies themselves or by the company's logistics partner (if the company has contracted out transport logistics).

The survey consisted of two parts. Both parts were conducted by telephone. Based on the results of this study, the researchers recommend the use of telephone interviews for future studies of this kind. Using the telephone made the study more efficient by increasing the response rate (compared to written questionnaires via mail or e-mail) and significantly reducing the time needed to complete the survey in comparison to face-to-face interviews. Furthermore the researchers found that respondents were more flexible in fixing dates for telephone interviews than in-situ appointments.

The first part of the survey consisted of contacting companies to determine if they were interested in participating in the study and to find the appropriate company contact (i.e. person responsible for making shipping decisions). In total approximately 40% of companies contacted were successfully interviewed.

The second part of the survey consisted of interviewing the person responsible for making shipping decisions. The interviewees were asked to log-on to a specific website and to answer the questions supported by the interviewer. In the first section of the interview the respondent was asked to describe two typical and representative (based on yearly transport volume) shipments shipped regularly by their company. To meet the research criteria, these shipments had to be full load shipments of at least 5 tons on a single point-to-point connection with a total distance of over 50 km. The data reported by the interviewee (cost, travel time, mode) for these shipments were used to automatically develop real-life cases for use in the interview's second section (i.e. in the Stated Choice experiments).

2.4 Stated Choice Experiment Design

The project applied the Stated Choice method (a type of Stated Preference (SP) analysis) to obtain data for the modal split models. In Stated Choice surveys the respondent must choose one of several alternatives presented. This method's main advantages are that it is easy to understand, easy to perform and accurately reflects real conditions. On the other hand, it provides less information than other methods, because the interviewee can only give information for the chosen alternative. While other more complex SP methods (e.g. Stated Ranking experiments) could provide additional information, these methods were rejected since they would have had a much higher risk of errors and imprecision given the complexity of decision making in transport logistics.

In each Stated Choice experiment, interviewees were asked to complete 13 choice tasks for each example shipment; each choice task presented three different offers (one offer per transport mode: road, rail, and intermodal transport) for transporting the example shipments. Each of these offers had different characteristics.

In order not to overstrain interviewees and thus avoid inaccurate results, the number of attributes was limited to the three most important: price, transport time and on-time reliability [IRE and Rapp Trans AG (2005)]. In this case on-time reliability was defined as the share of shipments arriving within a given time slot as preset by the consignee.

The experiments were based on a fixed design rather than a fully adaptive design given the expected complexity of model estimation using adaptive design. However, the fixed design method also provides valuable information indirectly for cases in which one of the attributes is irrelevant; this is because interviewees are expected simply to neglect irrelevant attributes in these situations.

The same is true for the choice of transport modes: in certain situations (such as infrastructure availability), the interviewee may not have the option to choose between all three modes (road, rail and intermodal transport). However, the choice remains fixed for all experiments in order to model the real market inflexibilities. In cases where shippers are dependent on a single transport mode they will show no reaction to changing values of any attribute.

Each transport offer (one for each mode) was described by different values for each of the three attributes. In each task interviewees had to decide, which offer (i.e. which transport mode) they would select for the given transport case (see Figure 3).

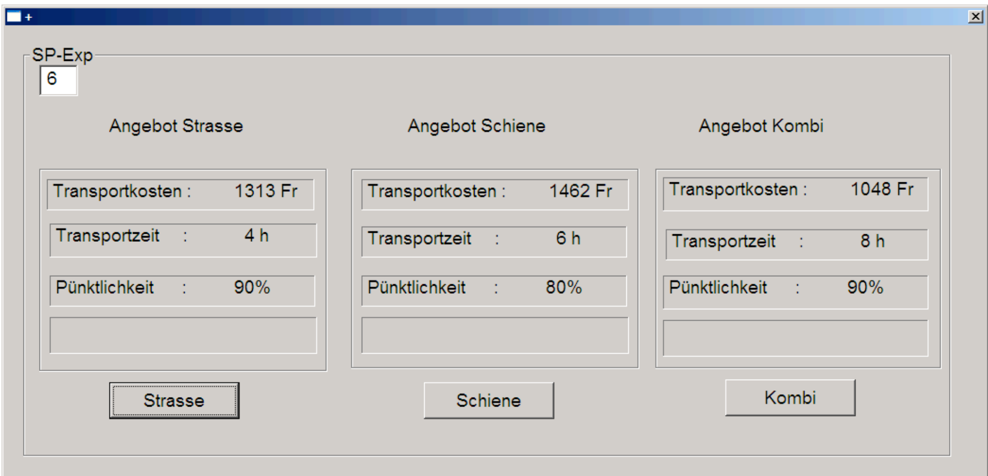

Figure 3: Example of a choice task

The number of choice tasks in any experiment depends on the number of attributes (per offer) and the number of values they may take on. In this study there were three attributes per offer (mode) and it was decided to limit the number of values each of them could take on to 3. This meant that there were 9 attributes per offer and three offers per choice task. The resulting number of possible combinations is 3^9 = 19,683. This clearly exceeds the maximum number of choice tasks that could be carried out in the study. Therefore, a software package called “Conjoint Designer” was used to construct a fractional, factorial design for the study. A fractional factorial design provides the optimal number of characteristic combinations so that the complete range of combinations can be represented as well as possible.

The fractional factorial design software determined that the optimal number of choice tasks per experiment would be 26 for the given experimental setup. Since this number would have been too high to be accepted by the respondents [Johnson and Orme (1996)], the experiments were completed by creating two blocks with 13 choice tasks each and assigning each interviewee randomly one of these blocks per experiment.

Finally, the values assigned to each of the attributes in the stated choice experiments needed to be determined. These values must be realistic and their range must be large enough to cover all possible scenarios (including future scenarios). Therefore, the values for transport price and travel time were calculated as a relative deviation of the actual value stated by the interviewee. The on-time reliability (punctuality) values were preset to 80%, 90% and 98%. The full set of values is shown in Table 3.

Attribute	Value 1	Value 2	Value 3
Transport price road	As-is	-10%	+50%
Transport price rail and intermodal	As-is	-20%	+20%
Transport time road	As-is	-10%	+30%
Transport time rail and intermodal	As-is	-15%	+30%
On-time reliability (all modes)	80%	90%	98%

Table 3: Overview of the attributes' values

3 SURVEY RESULTS

The survey was conducted between April and October 2007. A total of 97 interviews were successfully completed (70 interviews were conducted with the shipping companies and the remaining 27 were conducted with logistics service providers).

Table 4 summarizes the samples collected in these interviews by commodity group and transport type. As Table 4 shows, 179 transport samples were collected, most of which fall into the internal transport market sector.

The study's goal of obtaining a minimum of 15 samples per commodity group was achieved, however comparing Table 4 to Table 2 it can be seen that the target sample sizes for the internal and (especially) transit transport market sectors were not reached. This was due to reluctance by foreign companies to participate in a Swiss research project and because of the difficulty in finding appropriate companies shipping their goods through Switzerland (and not via the Brenner axis through Austria).

Commodity group	Internal	Export	Import	Transit	Total
Agricultural raw material	7	4	4	0	15
Food/animal feed products	24	1	5	0	30
Chemical/ mineral products	4	9	6	2	21
Iron/metal products	7	6	4	0	17
Building materials	16	0	0	0	16
Manufactured goods	15	8	9	3	35
Other products and containers	10	11	10	14	45
Total	83	39	38	19	179

Table 4: Transport samples per commodity group and segment

The detailed data analysis showed that three of the 179 transport samples were not valid, thus reducing the effective sample size down to 176.

The transport samples were analyzed based on several different criteria. First, they were categorized by distance classes. As shown in Figure 4, the distance class >600 km is clearly overrepresented. This is due to the choice of the target sample size (90 samples) for the three types of border crossing transport market sectors. Most border crossing transports operate over long distances. At distances below 600 km the number of transport samples per distance class increases with decreasing distance thus reflecting real conditions quite well. (The lowest distance class <100 km would have had more samples if transport shipments less than 50 km had been considered in the study.)

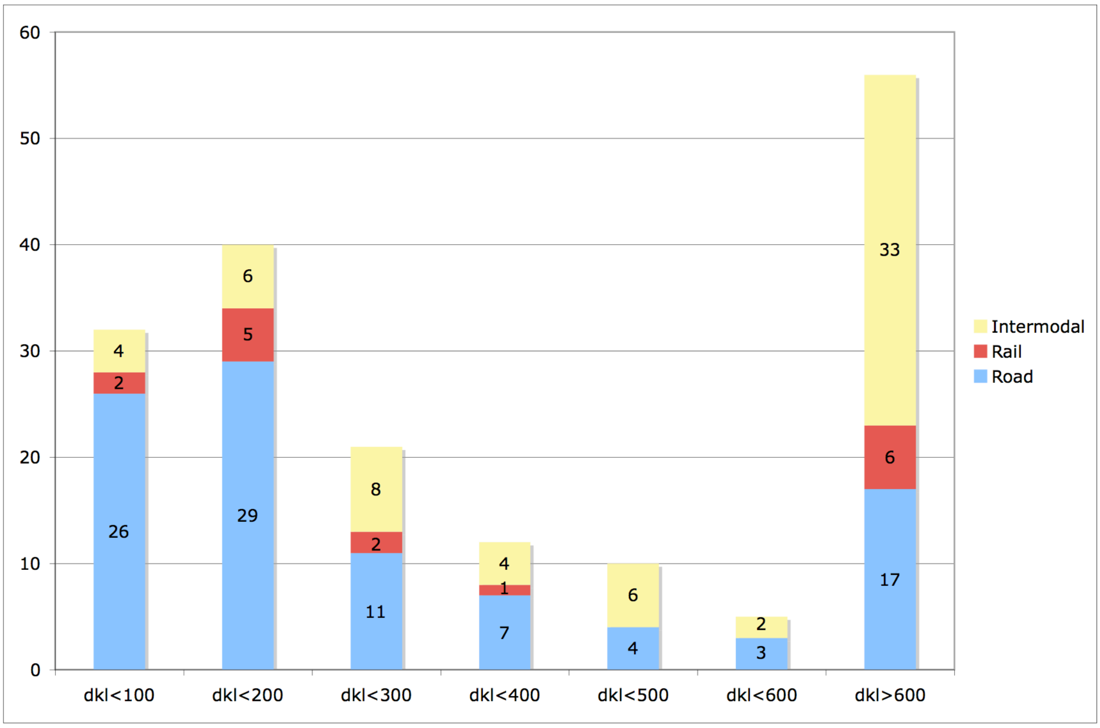

Figure 4: Transport samples per distance class and transport mode

The samples were also analyzed in terms of average shipment sizes. Figure 5 illustrates average shipment size for each commodity group. The median size of all shipments is 19 tons. This value varies, depending on the specific commodity group, between 13 t (vehicles and manufactured goods) and 25 t (agricultural raw materials). These values appear realistic, since in the building materials and manufactured goods sectors shipment sizes exceeding the capacity of one lorry (or container) are uncommon in comparison to the other sectors.

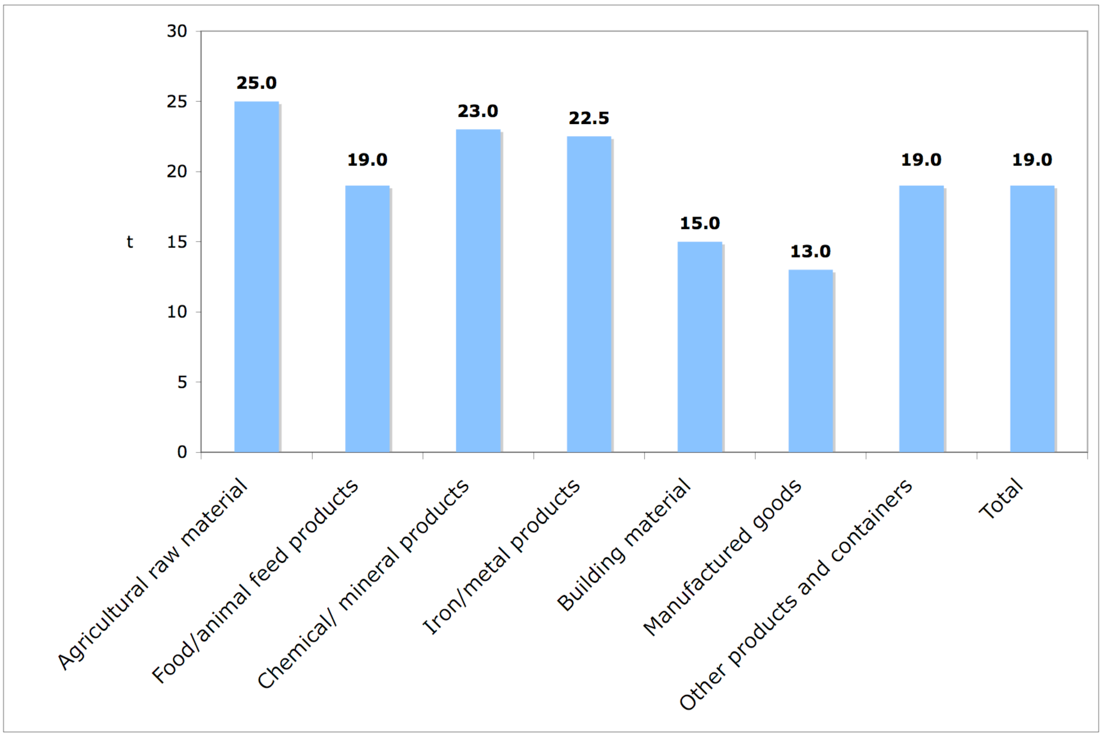

Figure 5: Average shipment sizes per commodity group (median values)

Finally, the samples were analyzed based on transport price. The analysis showed that actual prices for individual sample shipments differ significantly. Therefore median values were calculated for each transport mode (see Figure 6).

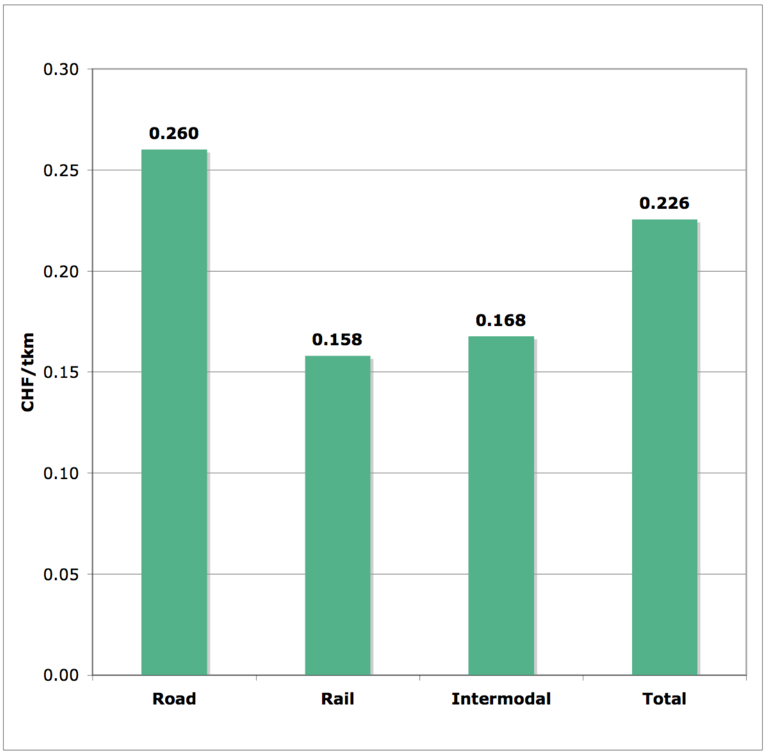

Figure 6: Average transport prices per transport mode (median values)

The large difference in average transport prices between road transport (0.26 CHF/tkm), rail (0.16 CHF/tkm), and intermodal transport (0.17 CHF/tkm), may be surprising. However, it can be explained by the fact that the survey sample contains many shipments of volume goods, which do not require the maximum loading weight of a lorry (about 24 tonnes). This results in significantly higher prices per ton-kilometre for road-based transport.

4 MODAL SPLIT MODEL ESTIMATION

4.1 General Approach

The goal of the study was to develop a separate model for each of the commodity groups and each of the transport market sectors (e.g. internal). However there were insufficient data to achieve this goal. In the end a total of seven different modal split functions were estimated: four models for internal transport, and one model each for the import, export, and transit market sectors.

The survey data was analyzed following a modelling approach based on the principles of the Random Utility Theory (see Domencich and McFadden (1975) for details). The software package LIMDEP was used for the econometric model estimation. The total number of observations from the survey was 2,288.

Two logit models used widely in transport demand modelling (the multinomial logit model (MNL) and the nested logit model (NL) [Maier and Weiss (1990); Regan and Garrido (2001)]) were tested with the project data. The MNL model was found to deliver better results than the NL model and was therefore used to develop the modal split functions.

The following transport characteristics were considered in the models as generic variables:

- transport price;
- transport time;
- on-time reliability; and
- the availability of private railway sidings.

As part of the analysis, several model specifications were tested with different (linear and non-linear) utility functions. Variables with no statistical significance (assuming a 95% probability of error) or a wrong sign were omitted. On this basis all seven models developed in this study included transport price and on-time reliability, while the models for the internal market sector additionally included the variable transport time. The private sidings variable showed statistical significance only in two of the models for the internal market sector.

The next section describes the utility functions developed for the internal market sector followed by a description of the utility functions developed for the other three transport market sectors.

4.2 Model results for the internal transport market

In the internal market sector there was sufficient data to create individual models for two commodity groups: the building materials group and the other products/containers group. A third model was developed by combining the data from the agricultural raw materials group, food/animal feed products group and iron/metal products group into a single model. A fourth model was developed by combining chemical/mineral products and manufactured goods into a second model. These groups were combined based on similarities in their composition and shipment characteristics.

The resulting utility functions are given in Table 5.

Model	Utility functions
Agricultural raw material; Food/animal feed products; Iron/metal products	U(road) = U(rail) = U(intermodal) = bc*ln(price/tkm) + bp* reliability + bt*time
Chemical/mineral products; Manufactured goods	U(road) = U(rail) = U(intermodal) = bc*ln(price/tkm) + bp*reliability + bt*time
Building materials	U(road) = U(rail) = U(intermodal) = bc*ln(price/tkm) + bp*reliability + bt*time + bg*siding
Other products and containers	U(road) = U(intermodal) = bc*ln(price/tkm) + bp* reliability + bt*time U(rail) = bc*ln(price/tkm) + bp*reliability + bt*time + bg*siding

Table 5: Utility functions for the internal transport models

The related coefficients of the explanatory variables are listed in Table 6.

Variable		Agricultural raw material; Food/animal feed prods.; Iron/metal products	Chemical/ mineral products; Manufactured goods	Building materials	Other products and containers
Price (bc)	Coefficient	-7.2289	-4.9086	-13.1674	-2.3229
	Std. error	0.9557	0.7301	2.4280	0.4499
	t-ratio	-7.564	-6.722	-5.423	-5.162
On-time reliability (bp)	Coefficient	0.1241	0.1083	0.0328	0.0458
	Std. error	0.0227	0.0291	0.0162	0.0183
	t-ratio	5.451	3.719	2.022	2.500
Time (bt)	Coefficient	-0.3090	-0.1382	-0.123	-0.0926
	Std. error	0.0764	0.4071	0.0301	0.0330
	t-ratio	-4.045	-3.395	-4.089	-2.806
Private siding	Coefficient	n/a	n/a	0.7503	1.2947
(bg)	Std. error	n/a	n/a	0.3307	0.4910
	t-ratio	n/a	n/a	2.269	2.637
ρ^2 adj.		0.6741	0.6331	0.5171	0.3658
Log-L		-542.7145	-242.7933	-228.5114	-142.8196
Observations		494	221	208	130

Table 6: Coefficients for the internal transport models

The coefficients for price and on-time reliability proved to be significant in all four models. In contrast, the coefficients for transport time and the availability of private sidings were significant only in the building materials model and in the other products and containers model. Alternative specific constants (ASC) were found to have no relevance in any of the four models.

All the coefficients show the expected sign: higher prices would have a negative impact on the probability of choosing an alternative; increased on-time reliability would have a positive impact; a longer transport time would have a negative impact, and, finally, the availability of a private rail siding would increase accessibility (to rail transport) and should therefore have a positive impact.

The quality of the models is good with an adjusted ρ^2 greater than 0.5, for all models except for the other products and containers model (which has an adjusted ρ^2 of 0.37. Although the adjusted ρ^2 for the other products and containers model is relatively low, this result is acceptable when compared to the results of earlier studies, e.g. IRE and Rapp Trans AG (2005). The lower adjusted ρ^2 for this model is mainly due to the low number of observations available for this commodity group and the low homogeneity of the sample shipments in this group.

The differences between the coefficients' values across the different commodity groups are also plausible. For example, the coefficient for transport price is the highest in the model for building materials while the coefficient for on-time reliability is lowest. In contrast, the coefficient for on-time reliability is highest in the agriculture, food, and metal products model.

4.3 Utility functions for border crossing transport

There are three types of border crossing transport: import, export and transit transport. There was insufficient data to estimate separate models for each commodity group in these three market sectors, so a single utility function was developed for each transport market sector by combining data from all commodity groups. The resulting utility functions for import, export, and transit are given in Table 7.

Model	Utility functions
Import	U(road) = as + bc*ln(price/tkm) + bp* reliability U(rail) = ab + bc*ln(price/tkm) + bp* reliability U(intermodal) = bc*ln(price/tkm) + bp* reliability
Export	U(road) = as + bc*ln(price/tkm) + bp* reliability U(rail) = ab + bc*ln(price/tkm) + bp* reliability U(intermodal) = bc*ln(price/tkm) + bp* reliability
Transit	U(road) = as + bc*ln(price/tkm) + bp* reliability U(rail) = ab + bc*ln(price/tkm) + bp* reliability U(intermodal) = bc*ln(price/tkm) + bp* reliability

Table 7: Utility functions for the import, export, and transit models

The related coefficients of the explanatory variables are listed in Table 8.

Variable		Import (all groups)	Export (all groups)	Transit (all groups)
Price (bc)	Coefficient	-5.0440	-4.2769	-5.2864
	Std. error	0.3613	0.3448	0.3156
	t-ratio	-13.961	-12.401	-16.901
On-time reliability	Coefficient	0.0597	0.0674	0.0588
(bp)	Std. error	0.0091	0.0115	0.0067
	t-ratio	6.563	5.833	8.741
ASC road (as)	Coefficient	3.4932	2.3450	-0.5166
	Std. error	0.5366	0.3022	0.1564
	t-ratio	6.510	7.759	-3.303
ASC rail (ab)	Coefficient	2.6340	0.9242	-1.5328
	Std. error	0.4883	0.2711	0.0689
	t-ratio	5.393	3.409	-22.244
ρ^2 adj.		0.6095	0.5244	0.3463
Log-L		-542.7145	-542.7145	-271.3572
Observations		494	494	247

Table 8: Coefficients for the import, export, and transit models

In these three models only price and on-time reliability showed statistical significance. Two alternative specific constants (ASC) were found to be relevant and were added as explanatory variables to the utility functions for road and rail.

As in case of the models for internal transport, all the coefficients show the expected sign. The quality of the models is generally good with an adjusted ρ^2 of more than 0.5, except in case of the transit model with an adjusted ρ^2 of only 0.35. Again, this is mainly due to the low number of observations available for this market sector and the low homogeneity of the sample shipments.

4.4 Relative importance of transport quality factors across all models

The attributes' coefficients of all seven models were compared to assess the importance of each attribute across all market sectors. This comparison makes clear that on-time reliability and price are the most important factors in freight transport mode choice. Transport time is clearly less important.

This conclusion matches well with results of a ranking question included in the first section of the interview: respondents were asked to rank their perceived relevance of price, transport time, on-time reliability, and flexibility on a 10-point scale. Mean values across all sample shipments are given in Table 9.

Attribute	Value (on 10-point scale)
Price	8.6
On-time reliability	8.2
Transport time	7.4
Flexibility	6.4

Table 9: Perceived relevance of transport characteristics (mean values of total sample)

As shown in Table 9, the values of price and on-time reliability are both above 8, while transport time is less important although of higher relevance than flexibility (note that flexibility was not included in the experiments).

5 CONCLUSIONS

This paper presents modal split functions developed for a new freight transport model for Switzerland. These functions are based on data collected in a telephone survey of shippers and logistics service providers in Switzerland and neighbouring countries. From 97 interviews a total of 176 valid transport examples were collected. The integrated SP-experiments provided 2,288 choice tasks (observations).

The data were used in a multinomial logit model (MNL) to estimate the modal split functions. The MNL model is widely used in transport modelling and, in this case, provided better results than the nested logit model (NL) approach.

The modelling results are of generally high quality. Statistical tests showed that the explanatory variables are significant on the 95% level, and that the explanatory power of the models is high (ρ^2 adjusted between 0.35 and 0.67). Furthermore, the results, i.e. the relevance of individual transport characteristics, are consistent with expected results based on the appraisal of logistics experts. The model results show that transport price and on-time reliability are of higher relevance than transport time.

The modal split functions developed in this study represent only the current situation of freight transport demand in Switzerland. Regular verification and updating is crucial to guarantee the continued validity of the modal split functions. Furthermore, since an important goal of the Swiss national freight transport model is to assess future changes in mode share, this study only considered shipments that could be transferred from one mode to another. The resulting modal split functions are therefore valid only for shipments of at least 5 tons carried over a distance of 50 km or more.

There are three main areas for further research. First, more research is needed on the problem of classifying goods into commodity groups. The problem is that all products – regardless of what they are – shipped by container are classified in the commodity group “other products and containers”. The result is that a growing amount of shipments (due to the trend towards increased containerisation) cannot be assigned to the correct commodity group, thereby creating a very diverse and, for modelling purposes difficult to handle, new group.

Second, more research is needed on the problem of double counting in intermodal transport (and monomodal transport with intermediate transhipment). The problem occurs because Swiss freight transport statistics use vehicles as reference units rather than the shipments themselves. This means that one intermodal shipment could be registered multiple times: once on the main haulage section and a second (or even third) time during the pre- and the post-haulage. This double counting creates significant biases in freight transport forecasting in Switzerland.

Third, future studies should be carried out with larger sample sizes. The sample size used in this study was not sufficient to draw universally valid conclusions for the entire Swiss freight transport market. The sample size, especially in the transit market sector, was insufficient for every commodity group. We therefore recommend carrying out larger surveys in the future to equally cover internal as well as border crossing transport. Finally, regular revealed preference (RP) surveys should be carried out to verify the model results obtained in this study. Results of these surveys could be used to efficiently adjust the modal split functions to future market developments.

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