A SPATIALLY DIFFERENTIATED MODELLING APPROACH FOR ANALYSING REGIONAL AIR FREIGHT DEMAND STRUCTURES

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ABSTRACT

Air freight transport plays a vital role in Germany's foreign trade and contributes to Germany's position as one of the leading exporting countries worldwide. Although the volume of air freight accounts for only 1.5 percent of the exports measured in tons, the value of air freight exports amounts to 25 percent of Germany's external trade. In particular, air freight transport forms an important part of logistic concepts and supply chains of commercial and industrial enterprises for the shipment of high-value and time-sensitive goods.

However, only relatively little research has been conducted in air transport with regard to the spatial differentiated generation and distribution of air freight compared to the state of research in passenger transport.

The main research objective is to gain advanced insights and a profound understanding of the demand generating determinants and structures of air freight on a regional scale and its distribution patterns in the transportation system. In particular, the paper aims to investigate the generation of the disaggregated industry-specific air freight demand in Germany and its interdependencies with the economic activities on a regional level. Building on these findings, the distribution of the regionally generated air freight is explored by modelling the airport choice behaviour of the air freight forwarders using a discrete choice approach.

The data gathered from a special evaluation of the German Federal Statistical Office provide information on the true origin of air freight demand based on the location of the exporting manufacturing companies. The regional generation of air freight demand of the manufacturing industry is modelled by applying multiple regression analyses. The subsequent airport choice analysis of the air freight forwarding companies will be investigated by using a discrete choice approach (multinomial logit models) and is based on data of IATA's Cargo Accounts Settlement Systems (CASS).

The estimation results of the regression analyses carried out indicate that regional air freight demand volumes are closely linked to the spatial structure and performance of the regional economy and the degree of their export orientation. The analyses of the air freight distribution patterns of the freight forwarders reveal that the airport choice of these logistic companies is primarily influenced by the ground transport times to the airports and the number of airlines providing freight capacity at the respective airports.

Keywords: *Air freight demand, air freight demand index, demand generation, distribution patterns, air freight forwarders, airport choice, multiple regression analysis, discrete choice, multinomial logit models*

1 OBJECTIVES AND RESEARCH SET-UP

Studies focussing on the spatially differentiated structures and patterns of air freight demand have not yet been much in the focus of the research community. Therefore, the analyses shall contribute to the scientific progress in this field of research, but also aim at providing findings being beneficial for strategic planning purposes of stakeholders in the air freight community such as airports, cargo airlines, logistics companies and traffic planners.

As shown in Fig. 1, the study shall comprise two main sections. First, it is objective to investigate the branches of manufacturing in Germany in terms of their air freight demand. The main focus lies on the second section exploring the spatial structures of air freight demand in Germany. Firstly, the generation of the spatially differentiated and industry-specific air freight demand is analysed and the drivers generating this demand are determined. Secondly, the distribution patterns of air freight in Germany are analysed. In this context, the research focus lies on the analysis of the airport choice of the freight forwarder locations applying discrete choice models.

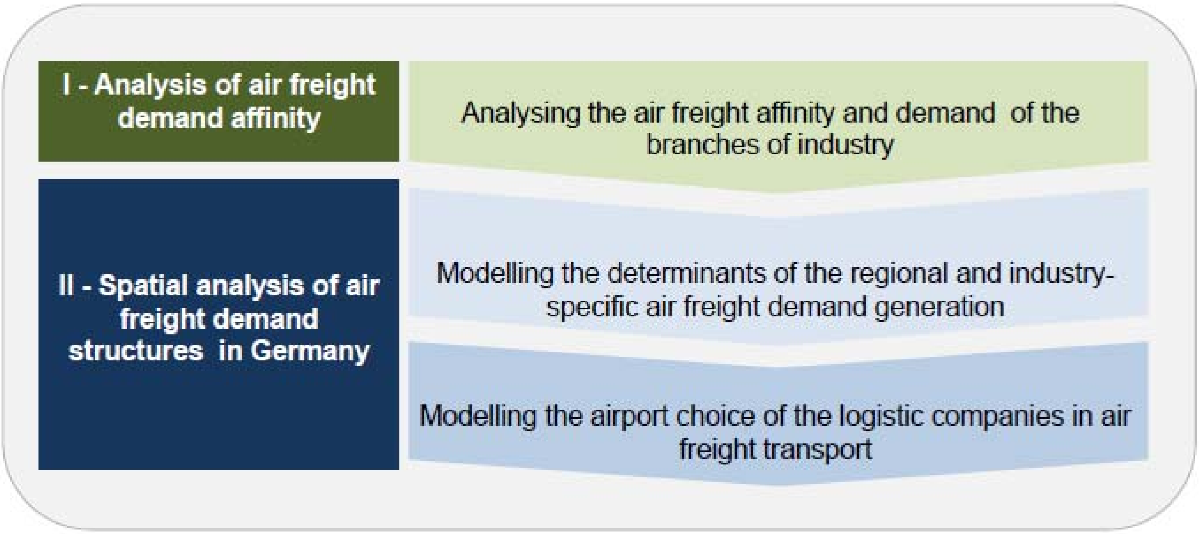

Figure 1 – Main research steps for the study

2 THEORETICAL-CONCEPTUAL BACKGROUND

2.1 Air freight demand generation

The spatially differentiated generation of air freight demand cannot be explained by only taking into consideration one single theory or concept, but needs to accommodate an integrated and holistic view. Fig. 2 shows the different theoretical-conceptual approaches the analyses and the modelling within this paper will be based on.

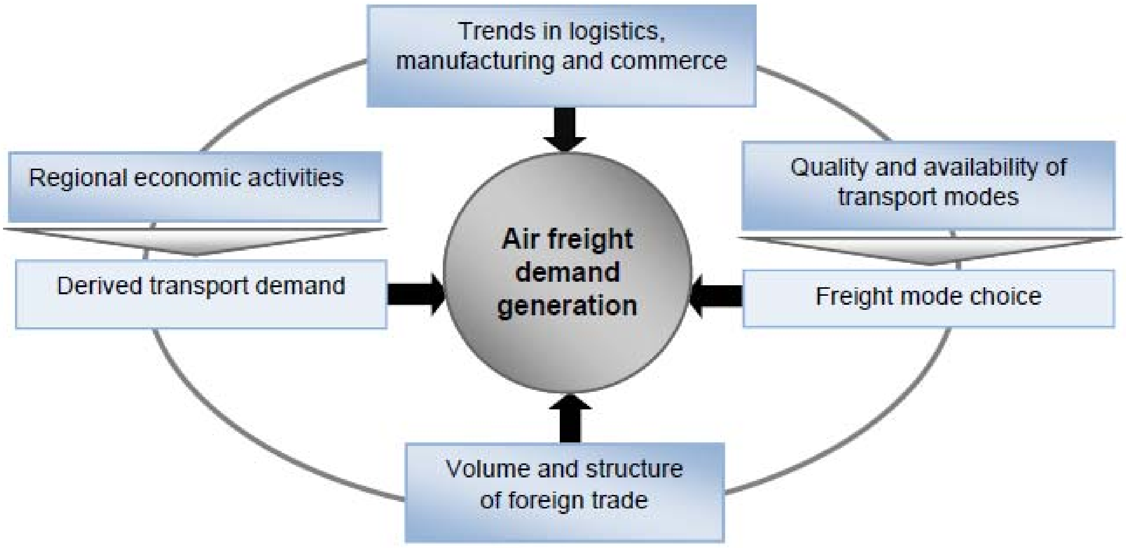

Figure 2 - Conceptual background and key drivers for air freight demand generation

One of the core concepts in transport and economic geography is based on the assumption that transport is a demand derived from social and economic activities [1]. This concept of the derived transport demand is widely applied and accepted for passenger as well as for freight related analyses in the field of transport research [2].

Besides, the generation of air freight demand is closely linked to the trade intensity and volume of external trade of a country or region. The transport of goods by air is due to the performance and cost characteristics of air freight predominantly of higher significance in international trade on long transport distances.

The freight mode choice process of the shippers is another key factor in generating air freight demand. The decision in freight mode choice is based on a price-quality assessment of the customers. The speed advantage in combination with a high safety level can be seen as the upmost quality characteristic and main competitive advantage of air freight compared to alternative transport modes, as empirical studies such as [3] and shipper surveys indicate [4].

The demand for freight transport is influenced by changes in the logistic requirements in production and international supply chains. The tendency towards a rising level of specialization and time-sensitivity of goods contributes to the increase of air freight demand.

2.2 Air freight demand distribution and airport choice

The airport choice in air passenger transport has widely been analysed by applying models of the discrete decision theory [5]. Research studies focusing on the airport choice in air freight transport predominantly approach this topic from the airline perspective [6]; [7]. In air freight transport a lack of research regarding the airport choice from the perspective of the air freight forwarders can be observed.

In traditional air freight supply chains the organization of the air freight transport from the origin of the goods to the final destination on behalf of the shippers is usually carried out by logistics companies (air freight forwarders). Therefore, the main research objective of the paper is to gain advanced insights and a profound understanding of the distribution patterns of air freight by modeling the airport choice behaviour of the air freight forwarder locations. It is objective to investigate the influencing factors on the airport choice of the air freight forwarder locations. This means, a spatial analysis of the interactions (freight flows) between the air freight forwarder locations and the airports will be conducted. This airport choice analysis will be researched by applying a discrete choice approach using multinomial logit models (MNL models).

Fig. 3 provides an overview on the influencing factors considered in the analysis. The lines between the determinants shall indicate existing interdependencies and interactions.

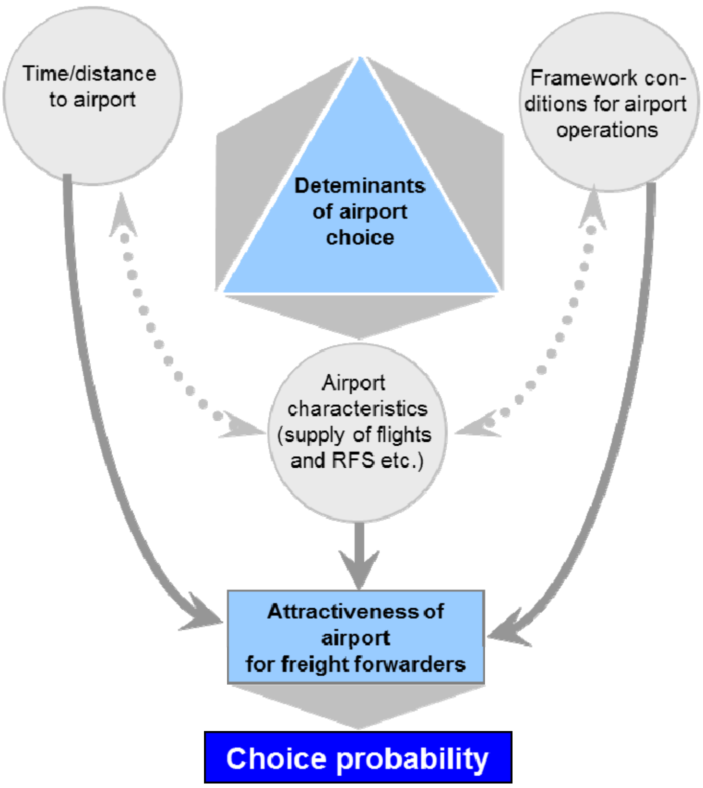

Figure 3 – Determinants of the airport choice of the freight forwarder locations

First of all, the supply of the air freight services, which are offered at the airports, has to be considered in the models, especially with regard to the supply of freighter flights and the number of airlines operating cargo services at the airport.

The supply of air transport services at an airport is influenced by external factors, which have an impact on the airport operations, in particular in terms of night flight restrictions.

Moreover, the transport times for trucking the goods between the air freight forwarders premises and the airports have to be taken into account as an increase of transport time leads to growing costs for transports.

3 EMPIRICAL RESULTS

3.1 Air freight demand affinity analysis

This first section aims at identifying the air freight affinity of the different branches of economy as a basis for the subsequent spatial analyses. In this context, an air freight demand index (ADI) is introduced. This index is calculated by comparing the air freight usage of a specific branch with the average relative air freight usage of all the other branches of industry.

The index is calculated as follows:

$$ADI_{it} = \left[\frac{AI_{it} + AE_{it}}{I_{it} + E_{it}} - \frac{\sum_{j=1}^{n} \left(AI_{jt} + AE_{jt} \right)}{\sum_{j=1}^{n} \left(I_{jt} + E_{jt} \right)} \right] * 100 \qquad (1)$$

The airfreight demand index for a commodity group (branch of manufacturing) *i* in year *t* sets the air freight demand of a branch of manufacturing composed of import and exports by air into relationship to the total foreign trade volume of this branch $I_{it} + E_{it}$. This quotient is compared with the air freight usage of all branches of manufacturing $AI_{jt} + AE_{jt}$ also related to their total trade volumes $I_{jt} + E_{jt}$.

The air freight demand index ranges between -100 and +100. In case the respective branch of manufacturing *i* solely uses air freight and all other branches choose alternative transport modes, the air freight demand index will equal a value of 100. The contrary extreme, a value of -100, would result if branch of manufacturing i never transport its goods by air freight, but all other branches would completely rely on air freight. A value of 0 means that the relative air freight demand of branch *i* equals the relative air freight demand of the other branches. Hence, a positive (negative) value implies a higher (lower) relative air freight demand compared to the other branches of manufacturing. An increasing air freight demand index for a branch of manufacturing *i* over the time period considered indicates a growing share of air freight transport demand in relation to the overall foreign trade volume of this branch and consequently highlights an increasing importance of air freight transport compared to the other branches of manufacturing.

As an outcome, the analysis shows which branches of manufacturing are the dominant users of air freight and how the industry-specific air freight demand has developed in Germany.

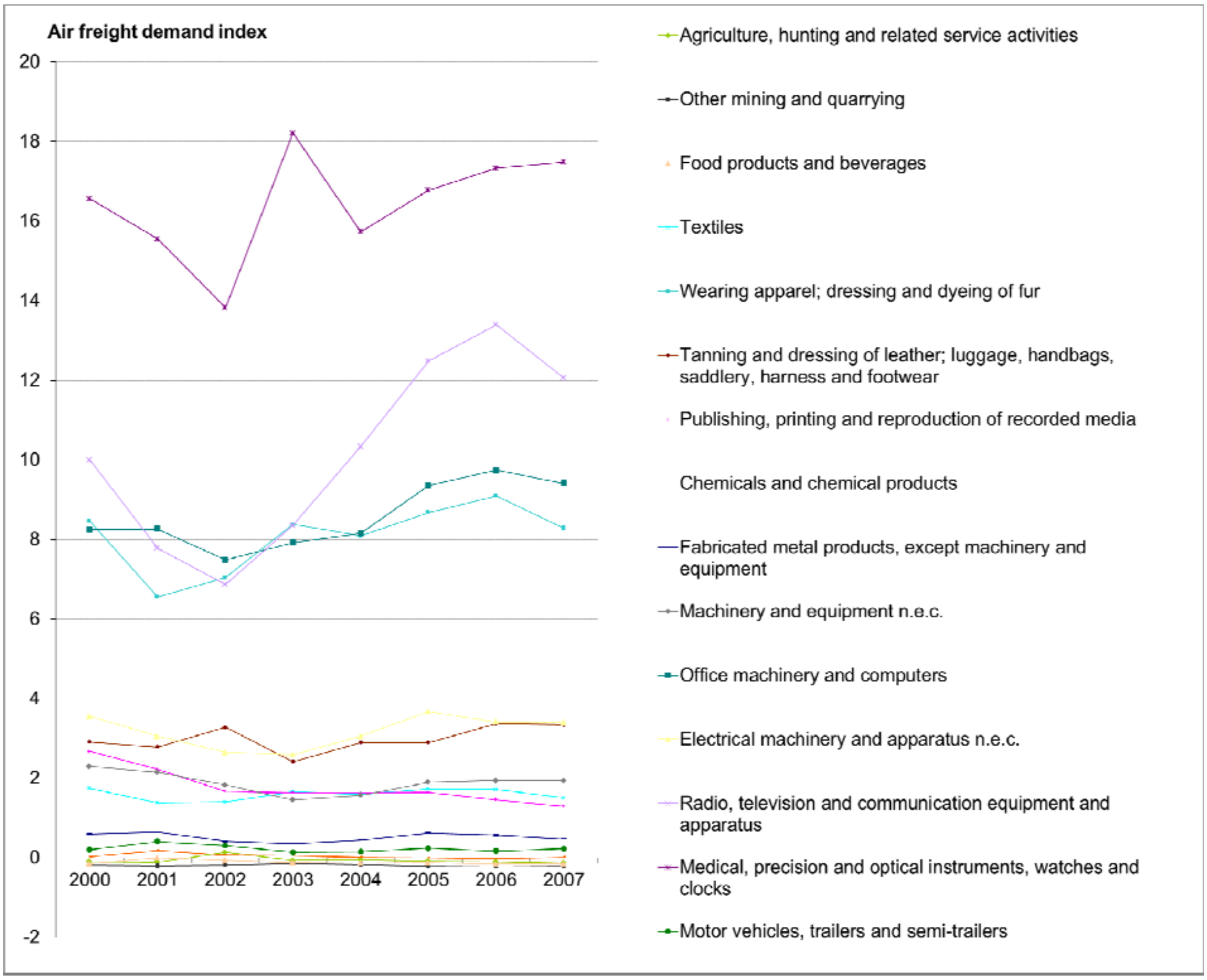

Figure 4 – Development of Air freight demand index (ADI) from 2000-2007 in Germany's manufacturing industry

The analysis of the structure of the air freight demand with regard to the air freight affinity of the different branches of industry in Germany reveals that the main portion of air freight demand is concentrated only on a limited number of branches (s. Fig. 4). These respective branches of industry on the export side comprise the chemical-pharmaceutical industry, electronic equipment producers/electrics engineering and the automobile industry. The highest air freight demand index was calculated for the branches telecommunications and radio technology as well as for precision engineering and optics. All the branches mentioned have in common that they are classified as high technology industries based on OECD definition [8].

3.2 Regional air freight demand analysis and modelling

Specification of the regression models and input variables

Based on the findings regarding the air freight affinity of the manufacturing branches, the subsequent analysis aims at identifying and evaluating the factors determining the regional distribution of the industry-specific air freight demand. For this investigation an econometric approach was chosen. As research technique, the linear multiple regression analysis is deployed. In air freight related research studies the application of regression analysis and similar statistical methods, such as gravity models, can be found in [9], [10], [11] and [12]. Prevailingly (except for the analyses in [12]), aggregated data were used to study causal relationships between economic indicators and air freight traffic. The analyses within this study account for a disaggregated approach, i.e. the generation of air freight demand is analyzed on a disaggregated regional level (the sixteen Federal States in Germany) for fourteen different branches of economy. The modeling will be carried out based on annual figures for the years 2007/2008.

Log-log models will be applied to guarantee the linear relationship in the parameters of the regression models. These models possess superior estimation characteristics compared to other model specifications that have been tested.

For the present analysis the regression function has the following form:

$$Y = f(X_1, X_2, X_3, ..., X_J) \quad \text{and} \quad Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_1 + ... + \beta_J \ln X_J + u \qquad (2)$$

with

Y = Air freight demand (export in tons) for a manufacturing branch in a Federal State of Germany in the year 2007

β_0 = Constant

β_J = Regression coefficient (j=1, 2,…,J)

X_J = Independent variables (differentiated according to branches of manufacturing and Federal States, e.g.

X_1 = Employees [LNEMP]

X_2 = Exports in tons [LNEXP]

X_3 = Dummy for High-Tech Branch according to OECD-classification [HI-TECH]

u = stochastic component

Tab. I provides an overview on the different input variables that will be taken into consideration in the regression models to explain the generation of the regional and industry-specific volume of air freight demand. Therefore, the data for these independent variables have to be gathered for each branch for all of the regions considered in the analyses.

Table I – Input variables for the modeling of regional and industry-specific air freight demand

Drivers of air freight demand	**Indicators/Input variables**
Economic activities	• Number of employees • Number of companies • Gross value added (in million Euros) • Turnover (in million Euros)
Foreign trade	• Export volume (in tons) • Export quota (in %) • Foreign direct investments (in million Euros) • Revealed comparative advantages in trade
Technology and research intensity	• High-technology industry (Dummy variable, 0/1) • Internal company investments in R&D (in million Euros)
Value intensity of the goods	• Value-weight-ratio of the goods
Air freight supply (airports)	• Available air freight capacity at the respective airports (in tons)

A special evaluation of the Foreign Trade Database of the German Federal Statistical Office (Destatis) on behalf of the author forms the primary data source for the analyses conducted within this study. These data provide information on the true origin of air freight demand based on the location of the exporting manufacturing companies.

Besides, further data sources have been used from Destatis, e.g. production, employment and economic statistics, as well as statistical and market reports from Eurostat, airport operators etc. to gather the necessary information.

Results of the regression analyses

Regarding the research question what the determining factors for the regional and industry-specific distribution of air freight are, the following results have been obtained. The regression analyses carried out indicate the upmost importance of the spatially differentiated economic structure, whereas economic parameters such as the number of persons employed (LNEMP) and the gross value added (LNGVA) generated by the respective branches can be regarded as the key determining factors. In addition, the export orientation measured in trade volume (LNEXP) and export quota of a branch of industry (LNEXPQ) influences its regional air freight demand to a high degree as well. Tab. II summarizes first empirical results of the regression analyses carried out.

Table II – Estimation results of the regression analyses

Model I N=168	R^2 (R^2_{adj}) 0.731 (0.726)	F-value 148.700***	Model II N=168	R^2 (R^2_{adj}) 0.769 (0.767)	F-value 275.195***
Coefficients	**B**	**Beta**	**Coefficients**	**B**	**Beta**
(constant)	-3.264***		(constant)	-7.293***	
LNEMP	0.802***	0.635	LNGVA	0.924***	0.801
LNEXP	0.215***	0.212	LNEXPQ	0.559***	0.166
HI-TECH (Dummy)	0.732***	0.179	HI-TECH (Dummy)	n. s.	n. s.
Dependent variable: LNCARGO n. s.: not significant at the 5 % level ***) significant at the 1 % level					

3.3 Air freight demand distribution analysis and modelling

Specification of the discrete choice models and input variables

The airport choice analyses are based on data of IATA's Cargo Accounts Settlement Systems (CASS). In the models the allocation patterns of air freight between 69 freight forwarder locations in Germany, which exported air freight in 2009, and 28 airports are taken into consideration. These airports are mostly located in Germany, but also in neighbouring European countries, such as Amsterdam, Luxembourg and Paris Charles de Gaulle. In total, 526 forwarder-airport-links are considered.

The fundamental underlying hypothesis of discrete choice models forms the assumption of individual utility maximization. Alternatives are evaluated based on a utility function and the alternative with the highest utility is supposed to be chosen [13].

The airport choice probability of a freight forwarder location is determined by the utility of each airport from the perspective of the respective freight forwarder location, i. e. the higher a freight forwarder location *L* evaluates the utility *U* of an airport A_i, the higher is the choice probability of this airport.

$$P_L(A_i) = \text{Prob}\left(U_{A_iL} \geq U_{A_jL}, \forall A_j \neq A_i\right) \qquad (3)$$

Based on the specification of the logit models the choice probability of an airport alternative $P_L(A_i)$ by freight forwarder location *L* is given with:

$$P_L(A_i) = \frac{e^{V_{A_iL}}}{\sum_{A_j} e^{V_{A_jL}}}, \forall A_j \in C, A_j \neq A_i \qquad (4)$$

The set of airport alternatives, which are available for each air freight forwarder location, is denoted with *C*. V_{A_jL} describes the utility (deterministic component), which an airport alternative A_i has for the freight forwarder location *L*.

The following factors have been taken into account in the specification of the discrete choice models to identify and evaluate the drivers, which determine the airport choice of the logistics companies:

- Air freight supply at the airports (number of airlines and freighter flights)
- Framework conditions for air freight operations at the respective airports, especially 24h-operations
- Ground transport times between the air freight forwarder locations and the airports

Tab. III provides a detailed overview on the input variables considered in the modelling.

Table III – Input variables for the airport choice models of the freight forwarder locations

Input variable	**Description**	**Data base**
Number of airlines [NAIRLINES]	Number of airlines serving the airport	IATA (2010): Cargo Accounts Settlement System
Flight movements of freighter aircrafts (departures) [FLIGHTS]	Categorical variable for each airport: 0 – airport does not operate any cargo flights 1- freighter flights to national and European destinations available 2 – Besides flights of category 1 unregular flights to intercontinental destinations have been operated 3 – Regular freighter flights to intercontinental destinations (> 50) in 2009	Federal Statistical Office (2010): German Air Transport Statistics ACI (2010): Traffic Report 2009
24-h-operations of airport [NIGHT]	1, if airport has 24-h-operations (0, else)	Boeing (2011): Airport Noise and Emission Regulations Airport Coordinator Germany (2011): Night flight restrictions at German airports
Transport time (ground transport) (in h) [TIME]	Trucking times from the locations of the forwarding agencies to the airports	Map24 (2011): 526 Forwarder location-airport-combinations considered in the modelling

The modelling has been realized using the econometric software NLogit 3.0. The dependent variable is defined as the share of the annual total air freight volume, which an air freight forwarder location delivers to an airport in the available choice set. The specification of the models is based on a variable choice set due to the fact that not all freight forwarder locations deliver their freight to all of the 28 airports.

The alternative specific constants have been generated by defining hierarchical clusters based on the Ward-Algorithm. The flown and delivered cargo volumes at the airports have been considered as variables for generating the airport clusters. The aim of the Ward-Algorithm is to build homogenous clusters by grouping objects, which minimize the variance in a group. In Tab. IV the three airport clusters and the respective airports allocated to each cluster are shown.

Table IV – Airport clusters

Clusters	Airports
1 [APBHUB]	*Big hub airports* Paris Charles de Gaulle, Frankfurt/Main, Amsterdam-Schiphol
2 [APMHUB]	*Medium hub airports* Liège, Cologne/Bonn, Leipzig/Halle, Luxembourg, Milan Malpensa, Brussels Zaventem
3 [APOTH]	*Other airports* Barcelona, Berlin Schoenefeld, Bremen, Dortmund, Dresden, Duesseldorf, Stuttgart, Erfurt, Munich, Hamburg, Frankfurt-Hahn, Hanover, Lisboa, Mannheim, Muenster, Nuremberg, Saarbruecken, Berlin Tegel, Vienna

Results of the discrete choice analyses

In the following, the estimation results of three discrete choice models are presented. For the estimation of the models the maximum likelihood method has been applied.

Model I:

- All observations are weighted equally, i. e. no differentiation is made with regard to the size of the freight forwarder locations (number of agencies or cargo volume)

Table V – Estimation results for model I

Variable	Coefficient	Standard error	t-value	p-value
NAIRLINES	0.0214	0.0086	2.4828	0.0130**
TIME	-0.6677	0.1146	-5.8244	5.73E-09***
APBHUB	1.0079	0.5211	1.9341	0.0531*
APMHUB	-0.2378	0.6740	-0.3529	0.7242 (n. s.)
***) significant at the 1 %-level; **) significant at the 5 %-level; *) significant at the 10 %-level; n.s. not significant				
pseudo-R^2(zero) = 0.6976; pseudo-R^2 (const) = 0.3498 likelihood ratio: 74.1778; α=0.005: χ^2_2 =10.597				

Model II:

- Observations, i.e airport choice decisions of air freight forwarders locations, are weighted with the cargo volumes of the respective forwarders locations

Table VI – Estimation results for model II

Variable	Coefficient	Standard error	t-value	p-value
NAIRLINES	0.0168	0.0022	7.6422	2.13E-14***
FLIGHTS	0.5987	0.1330	4.5017	6.74E-06***
TIME	-0.7531	0.0285	-26.433	2.89E-15***
APBHUB	0.6429	0.1743	3.6879	2.26E-04***
APMHUB	-1.1513	0.2620	-4.3949	1.11E-05***
***) significant at the 1 %-level; **) significant at the 5 %-level; *) significant at the 10 %-level; n.s. not significant				
pseudo-R^2(zero) = 0.7375; pseudo-R^2 (const) = 0.5386 likelihood ratio: 1893.3126; α=0,005 : χ_3^2=12.838				

Model III:

- Observations, i.e airport choice decisions of air freight forwarders locations, are weighted with the number of forwarders situated at the respective locations

Table VII – Estimation results for model III

Variable	Coefficient	Standard error	t-value	p-value
NAIRLINES	0.0196	0.0022	8.9181	2.89E-15***
FLIGHTS	0.4687	0.1201	3.9025	9.52E-05***
TIME	-0.7165	0.0260	-27.5247	2.89E-15***
APBHUB	0.6565	0.1606	4.0883	4.35E-05***
APMHUB	-0.7623	0.2225	-3.4260	6.12E-04***
***) significant at the 1 %-level; **) significant at the 5 %-level; *) significant at the 10 %-level; n.s. not significant				
pseudo-R^2(zero) = 0.6574; pseudo-R^2 (const) = 0.4808 likelihood ratio: 1842.252; α=0.005 χ_3^2 =12.838				

The quality of the models is evaluated based on pseudo-R^2 values of a model without variables (pseudo-R^2 (zero)) and with alternative specific constants (R^2 (const)) respectively.

For the basic model I without weighting the observations a pseudo-R^2 (const) of 0.3498 has been obtained, which equals a R^2 of linear regression of about 0.7 and therefore represents a reasonable value for the model fit. The introduction of weighting factors in model II and III leads to an improved model fit with pseudo-R^2 (constant) of 0.54 with freight volume related weights (model II) and 0.48 in the case the observations are weighted with number of freight forwarders situated at the respective freight forwarder locations. These values correspond to

R^2-values of more than 0.9, which can be regarded as a very good overall quality level of the models.

For model I, the number of airlines serving the airport ((NAIRLINES) and the transport times between the freight forwarder locations and the airport (TIME) are the only variables, which have a significant impact on the airport choice in case all observations are weighted equally. Consequently, it can be concluded that an increase in the number of airlines providing air freight services at an airport results in a growing attractiveness of the respective airport for the air freight forwarders and a higher choice probability.

Moreover, it is shown that airports with short transport times from the freight forwarder locations have a higher choice probability as well. That means, a reduction of transport times would lead to an increase of the air freight volume, which freight forwarders deliver to the airport assumed appropriate air freight services are available at the respective airport.

The available freighter flights and the possibility of unrestricted 24h-operations do not have a significant impact on the airport choice in model I.

In model II the airport choices have been weighted with the air freight volume of the respective freight forwarder locations, i.e. air freight forwarder locations with big freight volumes have a higher weight (importance) than locations with lower cargo volumes. The estimation results reveal that in this scenario the variables NAIRLINES and TIME are again statistically significant. Additionally, the supply of freighter flights (FLIGHTS) has significant impact on the airport choice. This result implies that freight forwarder locations with high volumes of air freight, such as Frankfurt, Kelsterbach and Munich in Germany, deliver their freight preferably to airports offering adequate direct freighter flights, e. g. Frankfurt/Main Airport or Munich Airport.

Airports offering a wide range of air freight services and freighter flights are often used as air freight consolidation and distribution locations for the freight forwarders.

In model III, the observation values, i. e. freight forwarder locations, have been weighted with the number of freight forwarders situated at the respective locations. The estimation results are similar to the results obtained for model II.

From the evaluation of the estimation results it can be concluded that unrestricted 24-hour-operations at an airport, i.e. the possibility to operate night flights, do not significantly influence the airport choice of the freight forwarders. However, if unrestricted 24h-operations lead to an improved supply of air freight services at the airport it will increase the attractiveness of the airport from the air freight forwarders perspective. In consequence, this would have positive effects regarding the airport choice and the amount of air freight delivered to this airport. Moreover, it has to be taken into account for interpreting the estimation results that the airports considered in the models represent the departure airports in the air freight transport chain based on the information in the air waybills. Therefore, these are the points, where the air freight forwarders deliver their cargo and hand it over to the airlines. These airports are not necessarily the actual departure airport in terms of loading the freight into an airplane. In continental Europe, road feeder services (air freight trucking) from secondary airports to the main air freight hubs are commonly operated and have substituted intra-European freighter flights. In consequence, 24h-operations are of inferior importance for the airports, which only serve as regional departure points for the road feeder services and as freight consolidation sites for the air freight forwarders.

4 CONCLUSION

The main portion of air freight demand in Germany is concentrated on a few branches of manufacturing. The calculation of the air freight demand index showed that the respective branches of industry on the export side comprise the chemical-pharmaceutical industry, electronic equipment producers/electrics engineering and the automobile industry. The highest air freight demand index could be observed for the branches telecommunications and radio technology as well as for precision engineering and optics.

The regional differentiated air freight demand of the branches of manufacturing is primarily influenced by the spatially differentiated economic structure. Economic indicators such as the number of persons employed and the gross value added generated by the respective branches can be seen as the essential drivers. Besides, the regional air freight demand of a branch of industry is influenced to a high degree as well by the export orientation and volume of investments in research and development of this branch.

The estimation results of MNL-models reveal that the airport choice of the air freight forwarder locations is primarily influenced by the ground transport times to the airports and the number of airlines providing freight services at the respective airports.

REFERENCES

[1] J.-P. Rodrigue, "Challenging the Derived Transport Demand Thesis: Issues in Freight Distribution", in Environment & Planning A, vol. 38, pp. 1449-1462, 2006.

[2] G. Mallard, S. Glaister, Transport economics. Theory, application and policy. Basingstoke: Palgrave Macmillan, 2008.

[3] J. T. Bowen, T. R. Leinbach, "Air cargo services in Asian industrialising economies. Electronics manufacturers and the strategic use of advanced producer services", in Papers in Regional Science, vol. 82, pp. 309–332, 2003.

[4] Unisys, "Global Shippers' Survey 2006", in Fastforward 3/2006, pp. 6-9, 2006.

[5] M. Ch. Gelhausen, "Ein Generalized Neural Logit-Modell zur Prognose von Flughafen- und Zugangsverkehrsmittelwahl", Research Report 2007-05, German Aerospace Center (DLR), 2007.

[6] F. Kupfer, "The airport choice for scheduled freighter operations in Europe": University of Antwerp, 2012.

[7] J. Gardiner, S. G. Ison, "The geography of non-integrated cargo airlines: an international study", in Journal of Transport Geography, vol. 16, pp. 55–62, 2008.

[8] T. Hatzichronoglou, “Revision of the High-Technology Sector and Product Classification”, OECD Science, Technology and Industry Working Papers,1997/2, OECD Publishing: Paris, 1997.

[9] J. D. Kasarda, J. D. Green, “Air cargo as an economic development engine: A note on opportunities and constraints”, in Journal of Air Transport Management, vol. 11, pp. 459-462, 2005.

[10] Y.-H. Chang, Y.-W. Chang, “Air cargo expansion and economic growth: Finding the empirical link”, in Journal of Air Transport Management, vol. 15, pp. 264–265, 2009.

[11] K. Yamaguchi, “International trade and air cargo: Analysis of US export and air transport policy”, in Transportation Research Part E: Logistics and Transportation Review, vol. 44, pp. 653–663, 2008.

[12] K. A. Alkaabi, K. G. Debbage, “The geography of air freight: connections to U.S. metropolitan economies”, in Journal of Transport Geography, vol. 19, pp. 1517-1529, 2011.

[13] D. McFadden, “Conditional logit analysis of qualitative choice behavior”, in P. Zarembka (Ed.): ‘Frontiers of Econometrics’, New York: Academic Press, pp. 105–142, 1974.