SERVICE TRAFFIC – AN ENTREPRENEURIAL VIEW ON TRAVEL BEHAVIOUR

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ABSTARCT

Services become more and more important in industrialized countries. Yet, very little is known about the traffic initiated by the provision of these services. Particularly, the role of firms is an unexplored field of research. However, to know how firms influence travel behaviour is crucial for practitioners and modelling commercial transport as a whole.
The paper provides new perspectives on how companies affect travel behaviour, covering the field of service traffic. We use two different empirical datasets (two German surveys) to reveal crucial predictors which allow insight into the entrepreneurial impact on travel characteristics and patterns. Applying cluster analysis and logistic regression modelling it is shown that internal structure, internal process and external structure factors have a significant impact on travel patterns and behaviour.

Keywords: service traffic, travel behaviour, company

INTRODUCTION

The economical importance of services raises the question, which amount of traffic is generated by the provision or utilisation of services. Today a share of about 20 % of total urban traffic volume in Germany is generally acknowledged as service traffic (Klein-Vielhauer 2001; Senatsverwaltung fuer Stadtentwicklung 2003; Wermuth, Binnenbruck 2003, Steinmeyer 2004). Whereas for private trips, e.g. shopping and recreational ones, it is mostly the person itself who decides where to and how to travel, for service traffic it is foremost the company the traveller works for which affects travel behaviour. Nonetheless the importance of firms' influence on daily travel behaviour and mobility patterns is still highly neglected in transportation research. Today there are only a few insights representing how firm activities determine people's travel behaviour, focusing on travel plans (DfT 2002; Roby 2010) and business travel (Aguilera 2008).
Counteracting this gap in knowledge the two German surveys "Kraftfahrzeugverkehr in Deutschland" (KiD, motor vehicle traffic in Germany) and "Service Traffic" will be conjointly

analysed for this article. By doing that, the authors will overcome the data leakages that occur if one survey is considered solely. Together the datasets provide an extensive basis of explanatory variables which help to predict companies' service traffic behaviour.
Keeping service traffic in mind the authors will use these data sets to answer the following two main questions:

1. Are there specific travel patterns generated by the provision of service?

2. If so, how do firms influence the travel behaviour identified before?

Answering these questions it becomes clear which structure and which processes of firms influence the travel behaviour. If then the characteristics of a firm are known this article helps to decide which travel behaviour is the most probable by applying a multinomial logistic regression. Moreover, the article provides a robust basis for further theoretical and empirical research in the field of service traffic and commercial transport. Against the background of the presented data challenges for service traffic and its increasing importance, this paper contributes to answer the shown research questions from the perspective of transportation science. The results will enlarge the existing national and regional knowledge for all relevant actors and provide new service traffic parameters for commercial transport modelling, prognosis and planning. The presented work is part of the research in progress at the DLR - Institute of Transport Research, Berlin. On the one hand it is fundamental research to gain a broader picture of commercial transport beyond freight transport. On the other hand the results are needed to enhance the existing transport simulation model.
The paper will continue as follows: Firstly some light is shed on the young field of service traffic research. Secondly the paper addresses the recent literature, which hints at the influence of firms regarding travel behaviour. The authors provide a robust data base for an empirical approach to answer the questions raised above and introduce the methodology used. Finally the authors highlight and discuss their results.

SERVICE TRAFFIC AS A PART OF COMMERCIAL TRANSPORT

During the last three decades a common understanding between research and planning bodies responsible for transportation planning has been established (at least in Germany): commercial transport is more than just freight transport and goods movement. Generally acknowledged is the differentiation between freight transport and service traffic.
Service traffic is defined as traffic that is generated by the provision of services of economic entities or professional activities to the exclusion of freight transport (Steinmeyer 2004; c.f. Browne et al. 2002 using “service trips” or “service movements”). The English term that we use here refers to the German “Personenwirtschaftsverkehr” (“Business passenger traffic”; c.f. Steinmeyer 2004; Steinmeyer, Wagner 2006) and includes aspects of “pure” service traffic (following the German term “Dienstleistungsverkehr”) and business trips. Service traffic is therefore traffic strictly generated by professional activities.
Nevertheless even the German research community is lacking a generally accepted and universally valid definition of service traffic so far.

Right now public planning pays very little attention to service traffic in the process of making urban policy decisions (Ruan et al. 2010). If commercial transport is considered at all, it is almost solely heavy freight transport that matters (esp. because of activities concerning greenhouse gas emissions, noise, traffic safety, or infrastructure damages). This is largely due to a lack of appropriate data describing service traffic, but also a lack of understanding of how economic activities of firms cause such traffic.

Nevertheless some national studies and regional approaches considered aspects of service traffic. But with the necessity to answer specific regional questions or substantiate political decisions they mostly differed in content (Schulz 1999; Schad et al. 2001; Browne et al. 2002; Stadt Zuerich 2004; Stadt Muenster 2007; Ruan et al. 2010).

The main source for relevant data in Germany about service traffic is up to now the study "Motor Vehicle Traffic in Germany" (Kraftfahrzeugverkehr in Deutschland, KiD 2002). These data show that a ratio of 34 % of vehicle-kilometres-travelled (VKT) by light trucks (pay load ≤ 3,5t) are caused by service traffic (Wermuth et al. 2003). This ratio is ever increasing if one looks at commercial passenger cars. 44.5 % of 101 billion VKT generated by 4.57 million cars of commercial owners in 2002 are service traffic. This enormous amount underlines the significance of this research field, especially for urban areas that attract most of the traffic volume.

Beyond that study on road service traffic so far, transportation research has to focus on the firms that bring along traffic by their economic activities.

But why do services (still) create physical traffic? All service activities rely on mobility. It forms the basic requirement for all actors in the process of service provision. For sure - today ICT offer wide opportunities to substitute some components of physical service traffic (Monse et al. 2007). This is especially true and documented for business trips (Rangosch-du Moulin 1997; Roy, Filiatrault 1998).

Nevertheless regional service traffic is a consequence of the necessary direct contact between the service provider and his customer. Those contacts are primarily carried out with cars, vans and light duty trucks these days – though transport relevant parameters (VKT, frequency, modal split) differ between services and economic sections (Menge, Lenz 2008).

At present very limited empirical knowledge is accessible to answer the questions about specific travel patterns generated by the provision of services, and how these might be influenced by the firm's structure, rules or guidelines.

THE FIRM'S INFLUENCE ON TRAVEL BEHAVIOUR

Whereas household and individual characteristics, land use and transport infrastructure are well known for their "significant effect on individual daily activity-travel patterns" (Lin 2009, p. 631), there are rarely information about the influence of firms. Many reports have been published on the transport related impact of economical characteristics, but mostly concern goods movement and commuting. Research about work related service trips and the influence of firms is scarce (Aguliera 2008, p. 1109; Enoch & Potter 2003). Only a few authors give insights on how a firm and its characteristics influence travel behaviour.

In an early paper about service traffic Schuette (1997) concludes that the company can be understood as an agglomeration of individual decisions and thus is the vital entity for the demand of service traffic. Schuette (1997) identifies *company's size* and *internal trip planning* as relevant factors for the service traffic characteristics. Moreover general findings on the firm's level prove the *economic sector* and the *number of employees* as crucial predictors for the resulting service traffic (Aguilera 2008, p. 1112). In addition Aguilera (2008) finds that the *customer structure* is a determining factor. The *number of clients*, their *geographical position* and the *form of cooperation* with these customers are assumed as important external aspects. Strongly related to the external factors are the internal ones. In detail Aguliera (2008) identifies the *existence and number of company's units*, their *spatial setting* and the *production and communication patterns*. In a similar study Menge & Hebes (2008) include the "Relative Desired Mobility" (Diana & Mokhtarian 2009, p. 4) to show the influence on mode share by entrepreneurial habit. Therefore they chose the *willingness to use public transport* as an explanatory factor for their analysis. Besides Menge & Hebes (2008) take into account the *decision-making power* within the company and show that there are to some extent significant relations between travel behaviour and the person which is responsible for service trip planning. Additionally, they show the coherence between travel behaviour and the *need for tools* which are compulsory for the provision of services offered by the firms. Whereas for maintenance tools and thus most often the use of a light commercial vehicle is mandatory, customer training requires computers and printed products. Hence this service is provided mostly by car.

Recent research shows, especially in Great Britain, that companies are more and more keen to use travel plans to control their service traffic, e.g. to reduce car fleet and thereby enhance the share of public transport and improve the companies' image (DfT 2002; Roby 2010, p. 5). The measures to implement travel plans are various. Just to mention some of them, the most important are: *the use of travel management software*, *car-pooling*, offering *on-site bicycles* and *ecological driver education* (DfT 2002; Enoch & Potter 2003; MOST 2003; Rye 2002).

In Germany the "Verkehrsclub Deutschland" (VCD) discussed various strategies and approaches for the implementation of "Green Business Travel" (VCD 2008). In 2008 they presented several best practice examples (small and medium sized as well as large firms) and a toolkit that supports companies with concrete strategies and information on green travel management. The approach is based on the presumption, that it is the firm that is responsible for mobility patterns of its employees.

However, much of the discussion is built on a pure theoretical basis. Only very little empirical research has been done so far. Hence, the authors present a practical approach in the following sections to investigate the possible influences highlighted (italic) above.

Therefore, following Aguilera (2008), the influencing factors depicted above can be summed up into four entrepreneurial categories, which are composed of: internal and external factors as well as structure and process factors (see Figure 1). These serve as empirical initial points for the authors' approach. The first two categories, internal factors, comprise the structure and processes of a surveyed company when one takes a closer look to the inside, such as the company's size, its spatial setting (both structure) and the use of Travel Management Software (process). The external factors are those which describe the company beyond its own borders, e.g. number of clients (structure) and the communication patterns between firm and client (process). To better understand the paper's assumptions,

Figure 1 shows the four categories which describe the characteristics of a firm and hence influence travel behaviour.

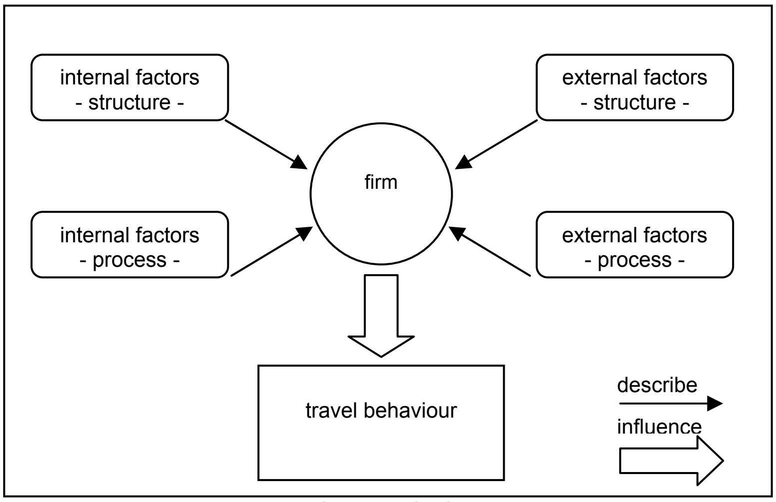

Figure 1 - Entrepreneurial factors of influence on travel behaviour

METHODOLOGY

Data used

The basis for this study on commercial transport in general and service traffic in particular are the data of the German survey „Kraftfahrzeugverkehr in Deutschland" (KiD 2002, motor vehicle traffic in Germany) and "Service Traffic".

KiD 2002

KiD was conducted in 2001 and 2002 and focuses on commercial vehicles. The KiD 2002[1] is the first nationwide data available to assess the characteristics and travel patterns of commercial motorized vehicles, including motorbikes, passenger cars as well as light commercial vehicles and heavy duty trucks (BMVBS 2003).

The questionnaire of KiD 2002 which mainly consists of a driver's log, addresses the vehicle owner and records a one day activity of the surveyed vessel. Detailed information were gathered (e.g. time of departure, destination and purpose of each trip) which enable the authors to investigate travel behaviour and specific patterns. In addition to these data detailed information of KBA (Kraftfahrtbundesamt, Federal Motor Transport Authority) about every vehicle are added, e.g. kerb weight, payload and fuel. The KiD 2002 comprises almost 77,000 vehicles and nearly 119,000 trips (cf. Table 2). The sample is representative for the whole German market in 2002. Whereas "Service Traffic" includes many internal and some external factors (cf. Figure 1), KiD 2002 only contains internal factors (mostly structure related) which can describe the companies' travel behaviour but gives no information about external factors.

[1] The successor of KiD 2002, KiD 2010, is conducted currently but data won't be available before spring 2011.

“Service Traffic”

The authors utilize empirical data of more than 1,200 firms/ establishments in Germany gathered within the project “Service Traffic”. This research project (funded by the German Federal Ministry of Economics and Technology) particularly investigated the specific causes and effects of business-to-business (B2B) service traffic. The main objectives of the project were

1. to gain extensive knowledge about companies’ service traffic structure and volume,
2. to identify optimization potentials and
3. to develop reduction strategies on a micro- and macro-economical level.

To achieve the aspired goals a multi-step survey was conducted which finally led to a consistent data set with 1,248 valid responses.

Table 1 - Structure of the "Service Traffic" sample

Economic section (NACE Rev. 1.1)		**Companies**					
			Classified by number of employees subject to social insurance				
Code	***Description***	**Total**	1–9	10–49	50–249	250+	**Total employees**
A, B	Agriculture, hunting and forestry; Fishing	24	13	5	3	3	1,727
C	Mining and quarrying	20	4	4	8	4	6,245
D	Manufacturing	228	49	46	63	70	47,225
E	Electricity, gas and water supply	37	8	11	11	7	3,508
F	Construction	51	18	12	14	7	12,243
G	Wholesale and retail trade; repair of motor vehicles (...)	82	22	25	23	12	10,485
H	Hotels and restaurants	22	11	8	2	1	644
I	Transport, storage and communication	92	28	26	26	12	14,948
J	Financial intermediation	83	18	18	20	27	35,429
K	Real estate, renting and business activities	411	166	140	80	25	25,423
L	Public administration and defence; compulsory social security	16	0	4	4	8	4,022
M	Education	23	4	7	6	6	7,983
N	Health and social work	58	16	5	13	24	21,659
O	Other community, social and personal service activities	101	38	26	28	9	9,089
Total		**1,248**	395	337	301	215	**200,630**

The interviews were held by the Omniphon GmbH as Computer Aided Telephone Interviews (CATI) between May and August 2006. A representative sample of initially 2,313 firms with employees subject to social insurance and a site in Germany were surveyed. The sample was drawn as a disproportional stratified random sample in favour of larger firms and specific economic sections (D, I, K). Weighting coefficients were formed both on a company level (applied for this article) and for the number of employees on the basis of statistics of the German Federal Employment Office (Bundesagentur fuer Arbeit). The subject of the survey in 2006 was to gain knowledge about causes, appearance, and service specific transport demand. The survey sheds light on effects of service outsourcing and the relocation of services with a focus on B2B services.

The 2,313 firms of the representative survey “Service Traffic 2006“ formed the selection basis of a in-depth study. Between May and August 2007 a total of 1,248 firms were interviewed again (structure of the random sample cf. Table 1) leading to the final data set (“Service Traffic”).

The in-depth study consisted of questions about service provision (registered by a classification of 27 different kinds of services separately) concerning suppliers and customers, contact frequencies, ICT availability and application as well as the number of employees participating in the provision of every single service. Besides that, transportation specific questions (transport demand, modal split, and vehicle characteristics) were asked.

In particular the combination of both data sets (representative basis survey and the in-depth study) represents an extensive basis for transportation related and economical questions - a data basis that will be applied for this article. Thereby the dataset mainly provides the necessary *internal factors.*

The following table (Table 2) presents a brief comparison between both datasets:

Table 2 - Data used for empirical approach

	KiD	**Service Traffic**
Regional coverage	National (Germany)	National (Germany)
Enquiry period	2001/2002	2007
Object of investigation	Vehicles	firms/ establishments
Sample size	~77,000 vehicles	1250 firms
Day-trips	~119,000	Not surveyed
Focus	Motor vehicle traffic, focus on commercial transport	Service traffic, commercial transport
Traffic modes investigated	Individual motorized traffic	Public and individual motorized and non-motorized traffic

Both data sets have been enriched by spatial data of BBR (Bundesamt fuer Bauwesen und Raumordnung; Federal Office for Building and Regional Planning). KiD 2002 and “Service Traffic” provide now general geographical information, i.e. an eight digit number which identifies the particular municipality[2]. Hence, each vehicle in KiD 2002 and each firm interviewed for “Service Traffic” can be located inside one of those municipalities. Matching

[2] In 2002 there were more than 13,200 municipalities in Germany. Due to administrative reforms there were only about 12,400 left in 2007.

BBR data with KiD 2002 and "Service Traffic" by that eight digit code allows to analyze whether a vehicle/ company is located in a) an agglomeration, b) an urbanized area or c) a rural area.[3]

Multivariate data analysis

To understand the impact of firms on the daily travel activities a multi level approach (cf. Figure 2) was developed according to the characteristics of the data sets described above. A cluster analysis of travel patterns was applied to extract different travel behaviour in a first step. Cluster analysis becomes more and more popular, especially to classify huge data sets (Kettenring 2009) and create segmentations (Diana & Mokhtarian 2009, p. 4). For a stable classification of individual travel activities a combination of short-term daily activity-travel data and long-term economical data is useful (Lin 2009, p. 627). Additionally, clustering travel behaviour means to reduce the complexity of the system of service traffic but at the same time maintain the activity and travel patterns implicitly (Lin 2009, p. 637).

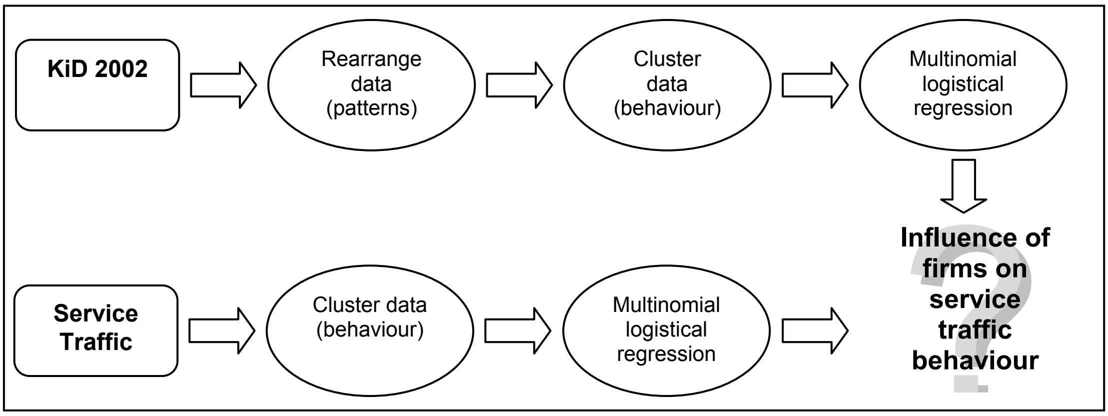

Figure 2 - Methodological approach

KiD 2002 supplies the authors with both, short-term daily activity-travel data which allow the extraction of travel patterns and some long-term data about economical characteristics. The second ones are limited and restrict a proper classification. Hence, the authors concentrate on clustering the travel patterns to shed light on differences in service traffic.

In a second step the clusters found were used for a multinomial logistical regression as a dependent variable. So differences in travel behaviour are explained (Buehler 2008).

"Service Traffic" data entail a lot more detailed variables and would allow a more stable cluster analysis. In contrast to KiD 2002 "Service Traffic" does not provide disaggregated short-term activity-travel data. However, data are available which give insight about the modal split in service traffic. Hence, a similar approach, as used for KiD 2002, is applied to "Service Traffic" data. Comparable to Diana & Mokhtarian (2009) the average vehicle kilometres driven per year for several vehicle classes were used in a first step for a cluster analysis and in a second one, for a multinomial logistic regression to reveal influences on clusters and hence travel behaviour. Keeping in mind that travel patterns analysed with KiD 2002 data only deal with motorized vehicles, we solely consider the mode share of car use

[3] A more detailed differentiation is conceivable with BBR data but is not applied in this paper.

and therefore the average vehicle kilometres driven per year. This establishes a consistent relation between both data sets.

We aspire to reach the highest comparability between the explained influences of firms on service traffic. In detail that means that for "Service Traffic" data a multinomial logistical regression model is used too and the cluster variable computed earlier serves as dependant variable, whereas a wide range of explanatory, independent variables characterising the companies are entered into the model.

Clustering and explaining travel patterns

To be able to cluster travel patterns of motorized vehicles which carried out service traffic at least once at the sample day, data of KiD 2002 were rearranged.

Each trip within KiD 2002 was reported separately because of its characteristics, i.e. a travel diary survey (cf. Table 3). That way the departure and arrival time, the origin and destination as well as the purpose of the trip were recorded, besides other information. To cluster these activities data were rearranged to a structure of 24 timeframes, each representing 60 minutes of a single day.

Table 3 - Original structure of KiD 2002

Vehicle ID	Trip ID	departure	arrival	origin	destination	purpose
i	j	t_d	t_a	P_o	P_d	z
1	1	07:30	07:45	own firm unit	customer's household	provide service
1	2	12:00	12:15	customer's household	different internal firm unit	return
1	3	12:45	12:55	different internal firm unit	external firm site	provide service
1	4	15:50	16:00	external firm site	different internal firm unit	return
2	1	06:10	06:25	own firm unit	different internal firm unit	provide service
…	…	…	…	…	…	…
n	n	t_{dn}	t_{an}	P_{on}	P_{dn}	z_n

Each of these timeframes is combined with the trip purpose (seven purposes). Moreover each time frame is coupled with the destination (10 categories). Hence there are 24*7+24*10=408 variables representing the characteristics of a vehicle and thus its daily activities (cf. Table 4). Value "0" within one variable means, the vehicle did not spend a minute within that time frame (i.e. 1 hour) for the respective purpose (z) and the respective destination (P_d). "60" means that all the time within the particular time frame was used for one specific purpose and for one specific destination. Time frames one to four (12:00 p.m. to 04:00 a.m.) are aggregated to make sure that night activities (mostly parking at companies' site) are not overestimated in the cluster model (Deneke 2004). Therefore, 357 variables are used for Cluster analysis with ClustanGraphics8 (Wishart 2006).

Table 4 - Adjusted structure of KiD 2002

Vehicle ID			timeframe					
i	$P_{d/z}$	$P_{dk}/_{zl}$	0-4	4-5	5-6	6-7	…	23-24
1	purpose	1	Variable 1	Variable 2	Variable 3	Variable 4	variable n	Variable 21
1		2	variable 22	variable 23	variable 24	variable 25	variable n	Variable 42
1		…	…	…	…	…	…	…
1		7	Variable 127	Variable 128	Variable 129	Variable 130	variable n	Variable 147
1	destination	1	Variable 148	Variable 149	Variable 150	Variable 151	variable n	Variable 168
1		2	Variable 169	Variable 170	Variable 171	Variable 172	variable n	Variable 189
1		…	…	…	…	…	…	…
1		10	Variable 337	Variable 338	Variable 339	Variable 340	variable n	Variable 357
2	purpose	1	Variable 1	Variable 2	Variable 3	Variable 4	variable n	Variable 21
2		2	variable 22	variable 23	variable 24	variable 25	variable n	Variable 42
2		3	Variable 43	Variable 44	Variable 45	Variable 46	variable n	Variable 63
…		…	variable n	variable n	variable n	variable n	variable n	variable n

According to the findings above and the data availability of KiD 2002 the measures shown in Table 5 are entered into the model as explanatory. Whereas the factors result from the literature review the measures were developed appropriate to the variables included in KiD 2002 data set.

Table 5 - Explanatory variables for KiD 2002 regression modelling

category		factor	measure(s)	scale
internal	structure	company' s size (at surveyed company unit)	number of employees	continuous
		economic sector	5 sectors (aggregated)[4]	nominal
			number of car	continuous
			number of LCV[5]	continuous
			number of HCV	continuous
		spatial setting (according to BBR classes)	spatial setting	nominal
	process	image[6]	age of vehicle stock (in months)	continuous
external	structure	none	-	-
	process	none	-	-

"Service Traffic" provides aggregated information about travel behaviour. Instead of detailed trip information about the appointed date, the companies interviewed stated the average vehicle kilometres driven per year by car, by LCV and by HCV. These three vehicle classes consider trips done by a company's vehicle, a private vehicle and a rented vehicle. As it was

[4] Referring to NACE Rev.1.1 (cf. Table 1) the aggregated economic sectors consist of the following sections: 1 (A and B), 2 (C), 3 (D and E), 4 (F) and 5 (G to Q).
[5] LCV means Light commercial vehicle (up to 3.5 t payload). HCV means Heavy commercial vehicle (more than 3.5 t payload).
[6] The image of a firm is created during its economical and social action, i.e. business activity. Hence the authors ascribe image to the internal process factors. The age of the vehicle stock serves as an approach to circumscribe image. It is assumed that the vehicle age is closely related to the image of a firm.

done for KiD 2002 the clusters were computed with ClustanGraphic8[7]. The clusters provided a basis for regression analysis with SPSS 16. An overview of the explanatory variables used for the model (according to the theoretical findings and the variables available, see above) is given in Table 6.

Table 6 - Explanatory variables for "Service Traffic" regression modelling

category		Factor	measure(s)	scale
internal	structure	company' s size (at surveyed company unit)	number of employees	continuous
		economic sector	5 sectors (aggregated)	nominal
		vehicle stock (at surveyed company unit)	number of cars	continuous
			number of LCV[8]	continuous
			number of HCV	continuous
		spatial setting (according to BBR classes)	spatial setting	nominal
		trip planning decision-maker power	decision made by traveller on its own	binary
	process	willingness to use particular modes	willingness to use local and/ or intercity public transport	binary
		number of services provided	total number of services provided	continuous
		need for tools (for the services) provided	number of services for which bulky tools are needed	continuous
		use of Travel Management Software	use of Travel Management Software	binary
external	structure	amount of clients	sum of clients for all services provided (overlap possible)	continuous
		geographical position of clients	share in customers which are closer than 50 km	continuous
	process	form of cooperation	number of customer visits (face-to-face) outside of the company's location (for all services provided)	continuous

RESULTS

KiD – mapping firms travel behaviour

Clustering results

The cluster procedure led to a five cluster solution, which explained 45 % of variance[9]. The cluster characteristics can be visualized and assessed statistically. Figure 3 shows the

[7] Some outliers have been identified with very high values of vehicles kilometres driven per year. Because of the particular characteristics of each firm and the provision of services the authors cannot deny the truth of the stated values. Hence a cluster model was computed without the outliers. Then, the cluster model found was held stable and the outliers were classified according to their values (accepting the increase in variance).

[8] Due to survey design in "Service Traffic" LCV means Light commercial vehicle (up to 3.5 t gross vehicle weight). HCV means Heavy commercial vehicle (more than 3.5 t gross vehicle weight).

[9] Eta² was calculated to assess the explained variance and thus estimate the goodness of the cluster solution (Deneke 2004).

different travel patterns based on the respective location within a timeframe. For instance all the vehicles belonging to cluster 1 were on a trip for about 25 minutes in average between 8 a.m. and 9 a.m. 15 minutes were spent at a construction site and for 8 minutes the vehicles reside at their own firm unit. Descriptive statistics show that there are (significant, α = 0.05) differences between the clusters regarding behavioural characteristics such as average trip count and vehicle kilometres driven per day (cf. Table 7). This does not only highlight the quality of the cluster solution found but also allows interpreting differences in travel behaviour.

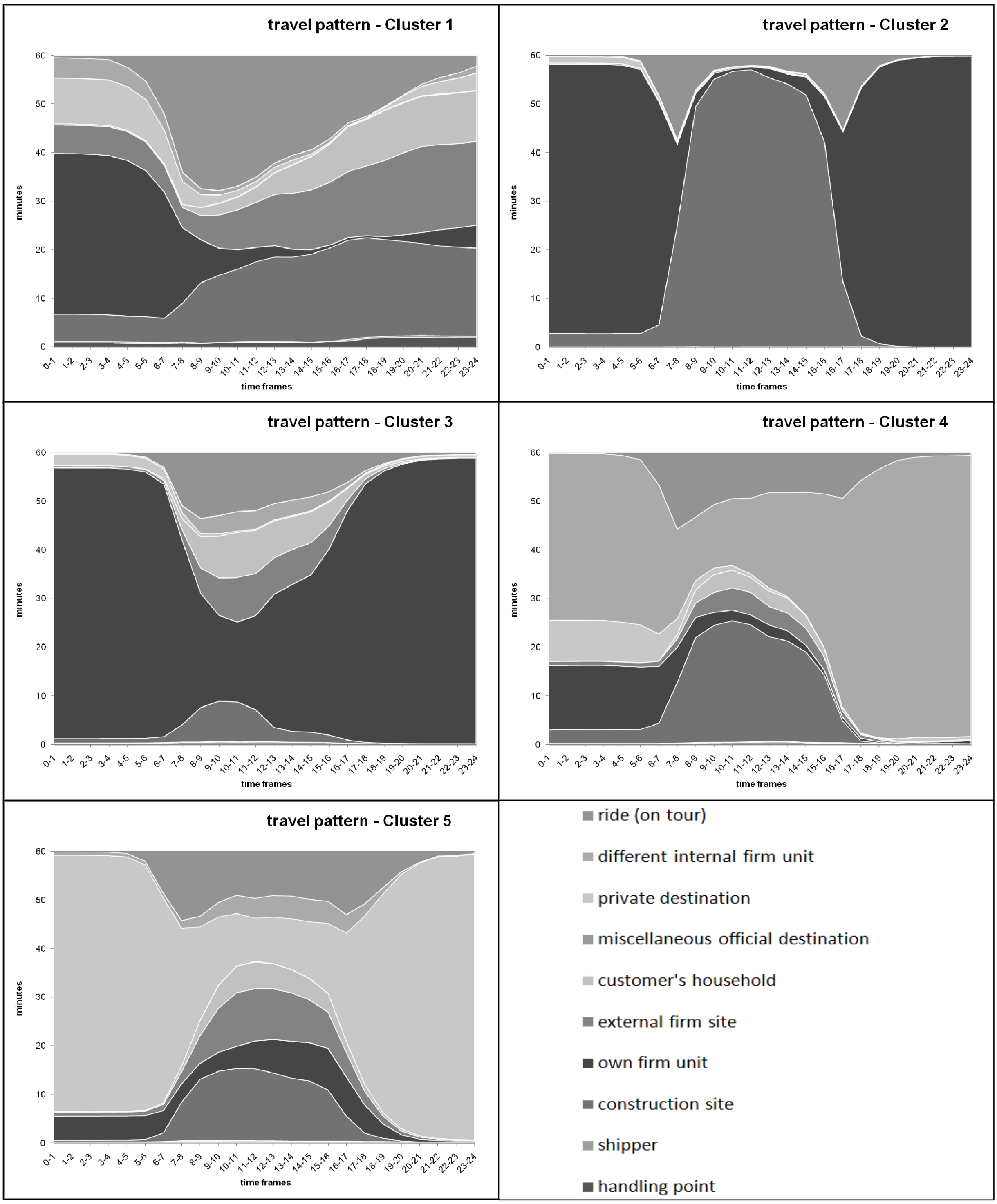

Figure 3 - Travel patterns for 5 cluster solution for KiD 2002

Figure 3 clarifies that cluster 1 is dominated by three different locations, i.e. construction site, external firm site and customer's household besides a high share of more than 20 minutes driving per 60 minutes between 07:00 a.m. and 12:00 p.m. This indicates that drivers have to cover a high distance and need a lot of time to reach customers. Both observations are also covered by statistics (cf. Table 7). The average vehicle kilometres driven per day are the highest amongst all clusters and so is the average traffic participation.
Cluster 2 shows a simple relation of a 'commute' between the driver's own firm unit and a construction site. Cluster 3 represents a standard working day for service providers. The provider visits external firm units, different internal firm units and customers' households between 7 a.m. and 7 p.m.
Cluster 4 stands for a broader mixture of time use. Nonetheless it is dominated by construction site and external firm site. Especially in the afternoon the vehicles considered in cluster 4 are located at another enterprise unit than their own.
Time spent at a private destination in the morning and the evening hours predominates cluster 5. This indicates that the origin as well as the destination of a day is the driver's home. During the day the vehicle is driven to conventional service provision destinations such as customer's household, external firm site and construction site.
Finally the cluster model shows that handling points and shippers play only a minor role for service traffic and thus can be neglected as destinations.
Differences among the five clusters also exist within economic sectors and spatial settings. Because these characteristics are explanatory variables the results for multinomial logistic regression modelling are presented in the next paragraphs.

Table 7 - Statistical description of 5 cluster solution

traffic behavioural context	Cluster number*:				
	1	2	3	4	5
weighted count of vehicles	1,062	3,170	3,696	881	3,049 *(2; 4)*
average trip count	5.4 *(2; 3; 4; 5)*	2.8	4.6 *(2)*	4.2 *(2)*	4.8 *(1; 2; 3; 4)*
average trip chain count	1.1 *(2; 3; 4)*	1.0	1.1 *(2)*	1.1	2.5 *(2; 3; 4)*
average vehicle kilometres driven per day	195.0 *(2; 3; 4; 5)*	64.2	75.8 *(2)*	83.3 *(2)*	124.7 *(2; 3; 4)*
average traffic participation in min.	229.3 *(2; 3; 4; 5)*	83.2	106.8 *(2)*	111.7 *(2)*	142.8 *(2; 3; 4)*

* Significant differences (based on a t-test) are shown in parentheses. Numbers indicate the cluster(s) with significantly lower values.

Modelling results

The modelling results are based on a customized model using a stepwise (forward entry) method. For both KiD 2002 and "Service Traffic" modelling different model requirements are checked. Multiple tests, depending on variable scales (Eta, chi-square and contingency coefficient), are applied to make sure that the model results are not corrupted by multicollinearity (Buehler 2008). Although the tests show some significant relations among the explanatory variables, the observed correlations are mostly smaller than 0.3 and hence can be neglected for the model.

Moreover different quality measures have been applied to assess goodness-of-fit of the model (Buehler 2008). Results are shown in Table 8. Taking into account the Likelihood ratio tests and the Proportional Chance Criterion the model presented below has a high quality. The model calculated is able to separate the cluster groups significantly and the results are not at random. Hence model numbers can be called reliable. Though, the Pseudo R-square (Nagelkerke) hints at the low explanation power of the explanatory variables entered into the model. Albeit the significant power of each factor to separate the clusters[10] it seems that the, due to the low R-square value, decisive explanatory variables are not available for modelling and thus are still missing. However, the results of the modelling allow first insights in how firms influence travel behaviour.

Table 8 - Quality measures for multinomial logistic regression model - KiD 2002

Quality measure	value	sig. (two-tailed)
Likelihood ratio test	1,256.4	0.00
Pseudo R-square (Nagelkerke)	0.12	-
Proportional Chance Criterion vs. modelled hit ratio	0.25 vs. 0.38	-

The algebraic sign of the coefficients (B) give insight in how each factor has influence on whether a vehicle belongs to the respective cluster or to the reference cluster 5 (cf. Table 9). An example for cluster 1 helps to clarify the results. When the firm that owns the vehicle is located in an agglomeration (internal structure category) the coefficient of -0.286 means that the odd ratio ($e^{-0.286}$) increases by of 0.75 in favour of cluster 5. In contrast: If a firm has one more LCV the odd ratios will change minimally by $^{e0.009}$ (= 1.01) in favour of Cluster 1.

Table 9 - Model summary for KiD 2002 data

factor	measure(s)	coefficient (B) - reference category: cluster 5			
		1	2	3	4
	Constant	-1.094*	-0.769*	-0.063	-1.716*
company' s size (at surveyed company unit)	number of employees	0.000	-0.002*	0.000	-0.000
economic sector (5th category is omitted due to dummy logic)	Agriculture or Fishing	-0.579	0.415	0.395	0.371
	Mining and Quarrying	-1.623*	0.171	-0.245	0.187
	Manufacturing or Electricity	-0.123	0.078	-0.215*	-0.202
	Construction	-0.235	0.743*	-0.558*	-0.203
vehicle stock (at surveyed company unit)	number of cars	-0.001	-0.008*	-0.003*	0.001
	number of LCV	0.018*	0.031*	0.008*	0.022*
	number of HCV	0.009*	-0.010*	0.006*	0.002
spatial setting (according to BBR classes; 3rd category is omitted due to dummy logic)	Agglomeration	-0.286*	-0.009	-0.255*	-0.342*
	Urban Area	0.030	0.161	0.042	0.040
Image	age of vehicle stock (in months)	0.004*	0.013*	0.009*	0.011*

* Indicates a significant impact on separating the clusters (based on Wald statistics).

This means that the more LCVs a firm possesses the more likely these vehicles have a travel pattern like cluster 1 than cluster 5. This makes sense because it is more likely that vehicles

[10] A chi-square statistic based on a Likelihood ratio test was computed by SPSS 16; α = 0.01. The power of separation of each factor is also given in Table 9.

from outside an agglomeration have to cover a bigger distance than vehicles inside an agglomeration. Moreover they are probably specialised in providing a particular service and thus overbear a bigger distance for their customers. The specialty of their service could bring the need to transport tools and goods. Thus it is advantageous to drive a LCV or HCV.
The regression model findings for cluster 2 are consistent to those of the cluster findings. If a vehicle belongs to the category of LCVs or HCVs it is more likely to travel like vehicles in cluster 2 than in cluster 5. This effect is even stronger if the vehicle is registered by a firm of the construction sector (B = 0.743). Again, this is important due to the revealed travel pattern dominated by travels to construction sites. It is noteworthy that for all four clusters the image factor (internal process category) is significantly positive whereas 'agglomeration' and the number of LCVs are negative. For the fifth cluster this means that being positioned outside an agglomeration and having a newer car (not LCV) leads to travel behaviour as described above. This might be sensible due to the fact that especially in the non-agglomeration area it is more likely to use a car for private purposes and that cars employed for service trips are staff cars used for business and private trips at the same time. Although these factors can all separate several clusters they do not provide a high explanation of variance. Therefore the next chapter will show that there are different variables - not included in KiD 2002 data - which may help to understand the firms' influence on travel behaviour.

"Service Traffic" – explaining firms influence

Clustering results

Calculating the clusters led to a four cluster solution. Eta² shows an explained variance of 24.7 %. While this seems to be a low degree of explanation one should keep in mind that travel behaviour is a multisided phenomenon and thus a high variance is 'natural'. However, it becomes clear that the respective KiD 2002 data are able to better clarify travel behaviour. Contrary to the travel patterns depicted in Figure 3, there is no such pattern available for "Service Traffic". To describe the four clusters the cluster means, the t-statistics and the t-value, which gives information about the importance of the utilised variables to define the clusters, were applied instead (Backhaus et al. 2006, p. 546).
As depicted in Table 10 all three variables 'average vehicle kilometres driven per year by car', 'average vehicle kilometres driven per year by LCV' and 'average vehicle kilometres driven per year by HCV' are overrepresented compared to all data. This means that firms within cluster 1 account for more than the average vehicle kilometres. Especially the kilometres driven with HCVs are very high (>85,000 km). Thus this cluster is named "frequent (HCV) drivers". There are only few firms within this cluster. This makes sense due to the fact that by the nature of service traffic LCV and cars are more common to use.

Table 10 - Statistical description of 4 cluster solution

average vehicle kilometres driven per year by:	descriptive measure	Cluster number* (name): 1 frequent (HCV) drivers	2 infrequent drivers	3 frequent LCV drivers	4 frequent car drivers
car	mean	39,606 *(2)*	15,758	27,595 *(2)*	89,412 *(1; 2; 3)*
	t-value	0.22	-0.26	-0.02	1.23
LCV	mean	29,393 *(2; 4)*	3,232	44,039 *(1; 2; 4)*	2,393
	t-value	0.87	-0.29	1.52	-0.33
HCV	mean	85,425 *(2; 3; 4)*	694	4,893 *(2; 4)*	1,239
	t-value	4.38	-0.21	0.02	-0.18
Weighted count of firms (n)		36.4	646.6	138.2	132.3

* Significant differences (based on a t-test) are shown in parentheses. Numbers indicate the cluster(s) with significantly lower values.

In contrast to cluster 1 the t-values of cluster 2 are negative. Hence companies within this cluster drive less than the average. Cluster two is called “infrequent drivers”. The infrequency can be caused by only short-distance trips (e.g. within agglomeration area) or by substitution by means of public transport. Cluster 3 reaches the highest values of kilometres driven by LCV and thus gets the name “frequent LCV drivers”. Cluster 4 has a maximum t-value for average kilometres driven by car and is consequently named “frequent car drivers”.
The multinomial logistical regression model is built on these four clusters and should bring some clarity into service traffic and the respective role of firms.

Modelling results

Similar to the procedure for KiD 2002 the results presented below are based on a customized model using a stepwise (forward entry) method[11] and several tests for the goodness-of-fit (cf. Tab. 11). They reveal that the model solution complies with the requirements of a multinomial logistic regression. No multicollinearity exists and there are several factors which explain the cluster separation. Indeed the explained variance, presented through R-square (Nagelkerke), of 37 % indicates that the variables entered into the model account for a high degree of explanation.[12]

Tab. 11 - Quality measures for multinomial logistic regression model - "Service Traffic"

quality measure	value	sig. (two-tailed)
Likelihood ratio test	354.35	0.00
Pseudo R-square (Nagelkerke)	0.37	-
Proportional Chance Criterion vs. modelled hit ratio	0.50 vs. 0.73	-

[11] Further modeling activities have shown that a model with main effects increases the R-square only slightly but no more explanatory factors have a significant power to separate cluster groups.
[12] The R-square value (Nagelkerke) would even increase to 61 % if the total number of firm’s units (internal structure category) is considered. Unfortunately due to missing values the case count would then diminish to less than 300. Therefore we chose a model without that factor and maintain a case count of n = 953. Further validation of ‘total number of firm’s units’ is aspired and will enable the authors to use that variable in further research.

Table 12 shows the coefficients (B) of each factor that have a significant impact to separate the four clusters.[13] Besides the significant explanatory factors presented above it is now the 'number of services provided', the 'need for tools' and the 'geographical position of customers' that show a crucial impact on separating the clusters.
The more LCVs and HCVs a firm possesses the more likely it is characterised by travel behaviour as described with cluster 1. If a company works in the manufacturing or in the electricity sector it would become less probable (B = -0.863) that it belongs to cluster 2. On the contrary the probability (odd ratio) increases by 0.42 in favour of cluster 4, which means that firms in these sectors (manufacturing or electricity) drive a lot by car to provide services (e.g. after-sales). Moreover the geographical position of the customers has a significant influence on separating clusters 2 and 4. Consistent with the assumptions above a higher share of customers within a 50 km radius leads to less vehicle kilometres driven and thus to a behaviour like the one described by cluster 4 (infrequent drivers). *Ceteris paribus* the closer the customers are to the firm the fewer kilometres are driven to provide the services. Travel behaviour like the 'frequent LCV drivers' can be ascribed more likely to firms if they own a lot of LCVs and HCVs, if they work in the construction sector and hence need tools to provide their services, e.g. installation and maintenance. Finally, for the reference category, cluster 4 (frequent car drivers), it seems to be the 'number of services provided' which is decisive to separate the corresponding travel behaviour from the others. Taking into account the negative coefficients of cluster 1 to 3 the more services a firm is providing to its customers the more likely it frequently uses the car for service trips.

Table 12 - Model summary for "Service Traffic" data

		coefficient (B) - reference category: cluster 4 (frequent car drivers)		
factor	Measure(s)	frequent (HCV) drivers	infrequent drivers	frequent LCV drivers
	Constant	-1.674*	0.517	-1.267*
economic sector (5th category is omitted due to dummy logic)	Agriculture or Fishing	6.972	7.360	8.610
	Mining and Quarrying	0.115	1.366	-2.538
	Manufacturing or Electricity	-0.395	-0.863*	0.296
	Construction	0.844	0.233	1.045*
vehicle stock (at surveyed company unit)	number of LCV	0.463*	0.099	0.612*
	number of HCV	0.741*	0.222	0.478*
spatial setting (according to BBR classes; 3rd category is omitted due to dummy logic)	Agglomeration	-0.340	0.474	0.282
	Urban Ares	-0.322	0.388	-0.543
number of services provided	Total number of services provided	-0.133	-0.055	-0.353*
need for tools (for the services provided)	number of services for which bulky tools are needed	0.355	-0.036	0.761*
geographical position of customers	share in customers which are closer than 50 km	-0.006	0.012*	0.004

* Indicates a significant impact on separating the clusters (based on Wald statistics).

[13] The significance is based on the Likelihood ratio test. Explanatory variables without significant (α = 0.05) impact are left out of the table.

CONCLUSION AND OUTLOOK

The theory indicates that the role of a firm in service traffic can be very manifold. Our empirical findings confirm this and show that companies are not only the source of service traffic but also influence the demand in many ways. Four categories of influencing factors were identified: internal structure and internal processes as well as external structure and external processes.

The results show, firstly, that several travel patterns and thus different travel behaviour exist in the field of "service traffic". They range from low traffic participation with no trip chaining to highly complex travel patterns with large values of daily kilometres driven and various destinations visited. Secondly, the results prove that characteristics of firms have significant impacts on service traffic. We revealed that most of the significant factors which influence travel behaviour belong to the internal structure category like company's size and economic sector. However, important explanatory variables also exist for the internal process and the external structure categories, e.g. need for tools and geographical position of customers. The odd ratios (e^B) of the significant factors calculated in this paper can be used to forecast and model firm's travel behaviour if their characteristics are known. Moreover this paper aids practitioners if they want to address firms to regulate service traffic in terms of sustainable transport. Now they can better understand the firm's role and act accordingly.

However, we were not able to detect significant impacts of external process factors. This might be due to insufficient data and implies further need for research by now. Gathering information about external processes is much more challenging (e.g. due to confidentiality and availability of information given by an interviewee). Nonetheless, attention should be paid to all four categories in future research, especially in forthcoming surveys.

This paper examined two German data sets to describe travel behaviour in the field of service traffic and revealed their unique purpose. Both datasets used in this article could contribute a lot to better understand service traffic. While KiD 2002 matches best to analyse travel behaviour in-depth, "Service Traffic" is most applicable to assess the firm's role in service traffic. However, both surveys show a lack of sufficient data. Whereas one data set (KiD 2002) lacks explanatory factors the second one ("Service Traffic") only offers little information about disaggregated travel behaviour. Therefore there are two alternatives for further research and the authors' work in progress. First, a new survey can be conducted which combines the strengths of both data sets used in this paper. Second, both data sets could be combined statistically to overcome the current disadvantages. The first alternative is highly complex for both accomplishment and financial reasons. The second choice is complex as well but favourable because of economical feasibility. Hence the authors will try to merge both data sets and present one integrated data set which combines the amenities of each. Furthermore, work will be done to exhaust (validation and interpretation) all available data of "Service Traffic" to consider all possible explanatory factors and augment the explained variance (R-square).

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