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Relationships between investments costs for infrastructure and for sport stadia: The case of the World Cup 2006 in Germany

BY NICOLAS BÜTTNER, WOLFGANG MAENNIG AND MARCO MENßEN, HAMBURG

1. Introduction and Description of the Problem

The costs for works involved in building, reconstructing or extending the stadia for the 2006 World Cup in Germany amount to some € 1.4 billion (cf. Table 1), a considerable part of which was financed by public funds. In addition to other costs such as security (Lutz, 2006), significant investments in infrastructure were required in connection with the construction work for the stadia. In this respect, Germany's Federal Ministry of the Interior [BMI] (2004. p. 3) stated in its third research report on the preparations for the 2006 World Cup that:

> Transport infrastructure in Germany is fundamentally capable of dealing with a major international event such as the 2006 World Cup. […] Some € 3.4 billion have been invested solely in expanding and extending the national network of major roads, which will benefit our ability to deal with extra traffic during the 2006 World Cup. In addition, further extension and expansion measures will also be completed by 2006.

This study tests whether a systematic connection exists between the type or volume of stadium investments on the one hand and the volume of investments in related infrastructure on the other.[1] In particular an examination is undertaken of whether the relative infrastructure costs in the case of "newly-built stadia" differ systematically from those relating to "stadia reconstruction or extension works". If a differentiation between these two groups should prove possible, it may then be possible to derive useful insights for major sporting events in the future, enabling simplified predictions about the expected volume of the required infrastructure measures based on the level of necessary investment in the sports venues.

The second section provides a summary description of the investments in infrastructure and stadia in Germany for the 2006 World Cup. In section three we use cluster and discriminant analysis to attempt to systematise infrastructure investments in relation to stadia investments. Section four provides a critical conclusion.

Corresponding author:
Prof. Dr. Wolfgang Maennig
Institut für Verkehrswissenschaft
Universität Hamburg
Von-Melle-Park 5
20146 Hamburg
eMail: maennig@econ.uni-hamburg.de

1 This work processes data for ten of the twelve World Cup venues. The relevant sources were not available for the venues Dortmund and Frankfurt.

Table 1: Costs for newly-built and reconstructed World Cup stadia and their capacities

Location	Costs (in € million)						Distance from previous venue	Capacity in Season 99/00	Capacity in Season 05/06	Capacity change	City inhabitants
	Total	*Federal*	*State*	*City*	*Operator*	*External*					
Berlin	242	196.0	0.0	0.0	0.0	46.0	0	76 243	76 000	-243	3 390 000
Dortmund	36	0.0	0.0	0.0	36.0	0.0	0	68 600	83 000	14 400	590 000
Frankfurt	126	0.0	20.5	64.0	0.0	41.5	0	61 146	50 300	-10 846	650 000
Gelsen-kirchen	192	0.0	0.0	0.0	33.8	158.2	0.72	62 004	61 524	-480	278 000
Hamburg	97	0.0	0.0	11.0	16.0	70.0	0	55 000	55 000	0	1 700 000
Hannover	64	0.0	0.0	24.0	0.0	40.0	0	56 000	49 000	-7 000	525 000
Kaisers-lautern	48.3	0.0	21.7	7.7	18.9	0.0	0	41 582	40 721	-861	107 000
Cologne	117.5	0.0	0.0	25.5	0.0	84.5	0	46 000	50 374	4 374	1 000 000
Leipzig	90.6	0.0	0.0	63.2	27.4	0.0	0	* 90 000	44 345	-45 655	494 000
Munich	280	0.0	0.0	0.0	280.0	0.0	9.25	63 000	66 000	3 000	1 300 000
Nuremberg	56	0.0	28.0	28.0	0.0	0.0	0	44 600	44 308	-292	490 000
Stuttgart	51.6	0.0	15.3	36.3	0.0	0.0	0	47 000	48 500	1 500	590 000
SUM	1 401.0	196.0	85.5	259.7	412.1	440.2		711 175	669 072	---	

Source: Fédération Internationale de Football Association [FIFA] (2004) as well as Skrentny (2001). Cf. also Kicker Sonderhefte Bundesliga from the years 1995/96 (1995), 1999/2000 (1999) and 05/06 (2005). Distance measurements were undertaken with the aid of Google Earth. * The team VfB Leipzig was only part of the Bundesliga - Germany's football first division - for one year and was also relegated from the second division after the 95/96 season (Maennig et al., 2005, p. 49). The spectator capacity from this season is given in Table 1 as a comparison value.

2. Infrastructure and Stadium Costs for the 2006 World Cup

Table A1 in the appendix presents all federal infrastructure measures undertaken in Germany with respect to the 2006 World Cup in the 12 venue locations. This compilation is based on the list for transport, construction and urban development of the Federal Ministry of Transport, Building and Urban Affairs [BMVBS] (BMVBS, 2005a) entitled "WM-Verkehrsprojekte des Bundes, der Länder, der Austragungsorte und der DB AG" (*World Cup transportation projects undertaken at federal, state and city level and by the German Railways*). Table A1 modifies this list by differentiating between projects determined by the World Cup and those not determined by the World Cup. This differentiation is based on the Federal Transportation Route Plan [BVWP] from the year 2003 and the relevant annexes for individual states. The BVWP 2003 groups the "urgent requirements" into "current and firmly allocated projects" and "new projects". The "current and firmly allocated projects" cover projects that were already planned in the BVWP 1991 and which are either currently in the process of enactment or due to be enacted in the near future. The corresponding projects are not determined by the World Cup since the implementation and funding decisions had already been taken before Germany's bid to host the 2006 World Cup was approved. Other measures from the "new projects" section (i.e. measures newly included in the BVWP's "urgent requirements" in the period 1991 to 2003) were added to the measures not determined by the World Cup if they were able to justifiably be classified as non-World Cup related by the relevant contact person from the venue in question.[2]

The total volume of investment for the infrastructure in the ten cities examined, under consideration of BMVBS (2005a) amounts to well over € 7 billion and is hence almost twice as high the corresponding figure for the BMVBS (2005b), i.e. € 3.7 billion.[3] The infrastructure costs for the individual venue locations displays a large spread, ranging from around € 62 million in Nuremberg to almost € 3 billion in Berlin (cf. Table A1).[4] However, the example of Berlin also illustrates in a particularly clear manner the necessity of differentiating between World Cup related and non World Cup related investments. Attention should thus be drawn, for example, to projects included in Berlin's total investment volume such as the new Central Station and the North-South Tunnel which are determined by Berlin's status as capital city, rather than as host to the World Cup. A similar situation applies to Hamburg with regard to the fourth tunnel under the River Elbe and for Cologne in relation to numerous motorway projects independent of the World Cup.

If we limit ourselves only to the World Cup related projects the absolute range is reduced to € 22.7 million in Hamburg to € 654.4 million in Berlin, without however any significant reduction in the coefficient of variation.[5] In addition the new figure of just under € 1.6 billion for infrastructure investments now only makes up around a quarter of the sum mentioned above.

From Figure 1, which shows the composition of the World Cup related projects we can see that in Gelsenkirchen, Hamburg, Leipzig and Munich the majority of funding is provided by the cities themselves, whereas in Hannover, Cologne, Nuremberg and Stuttgart funding is mainly provided by Federal Government. In Berlin, Federal Government funding even makes up 100% of the World Cup related infrastructure investments.

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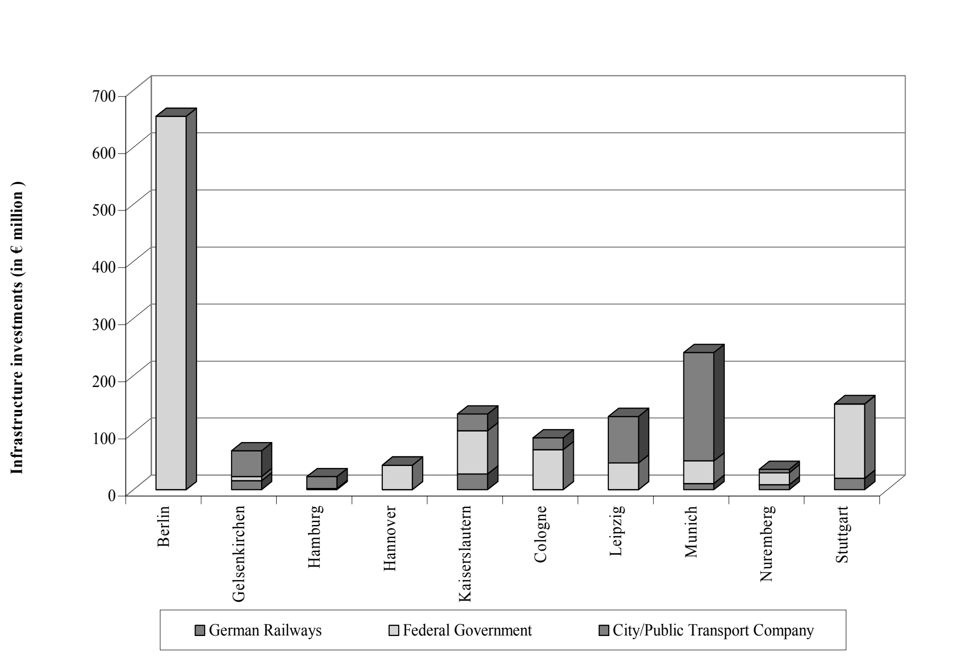
2 The "current and firmly allocated projects" listed in the BVWP 2003 include a number of projects that were realised ahead of schedule as a result of Germany's successful bid to host the 2006 World Cup, cf. information provided in a telephone conversation with Mr. Joop, Department S 10 of the BMVBS on 16.01.2006. The names of the contact persons from the individual venue locations are listed in the relevant part of Table A1 in the appendix.

3 The investment volume of € 3.7 billion given in BMVBS (2005b) was adopted and disseminated by the great majority of media in Germany. No information is available on the basis for the calculation nor on the composition of the € 3.7 billion.

4 The coefficient of variation of the total infrastructure costs stands at 1.2.

5 The coefficient of variation of the World Cup related infrastructure costs stands at 1.19.

Figure 1: Infrastructure investments in the World Cup venue locations (only World Cup related projects)



Data source: see Table A1.

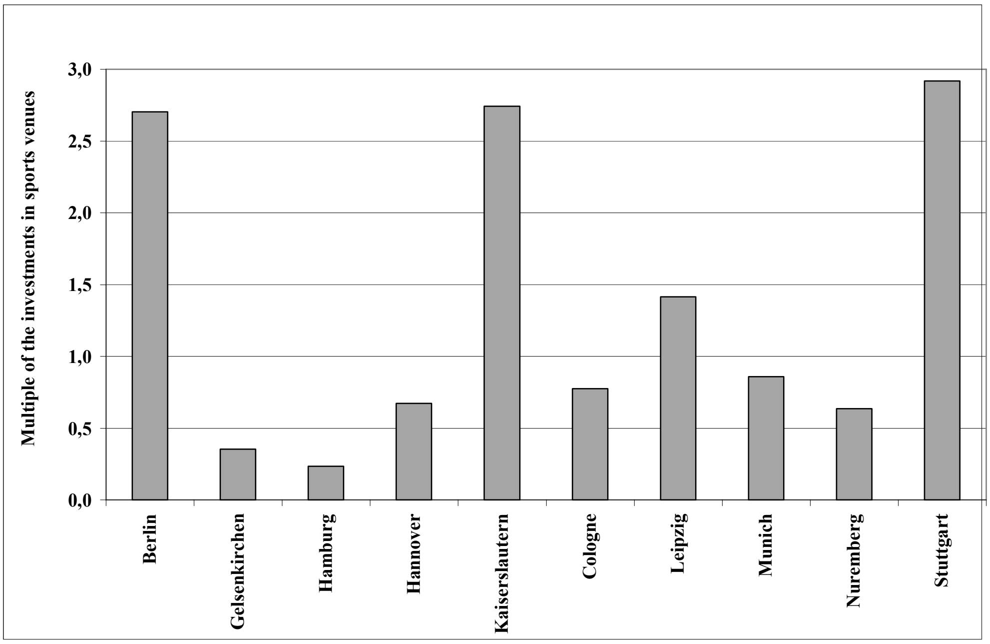
If the World Cup related infrastructure investments are set in relation to the expenditure for sporting venues, then Stuttgart, Kaiserslautern and Berlin display the highest values (Figure 2). For Stuttgart and Kaiserslautern this is due to the low costs for the reconstruction and/or extension of the individual sports venues, whilst for Berlin it can be deduced from the high investment costs in the World Cup related infrastructure. By contrast for Gelsenkirchen and Hamburg the relation is relatively low, at 0.4 and 0.2 respectively, which is a result of the high costs of the construction work for the new sports venues.

Taking into account the expenditure for sports venues and their character (new construction/reconstruction),[6] Leipzig displays relatively high World Cup related infrastructure costs for a venue location with a newly-built stadium, whilst Hannover, Cologne and Nuremberg display low relation for venue locations with reconstructed stadia. The stadia in the last three venue locations mentioned are “quasi new buildings”, which were relatively ex-

6 According to the definition provided by FIFA (2004), the stadia in Gelsenkirchen, Hamburg, Leipzig and Munich were newly-built, whilst those in Berlin, Hannover, Kaiserslautern, Cologne, Nuremberg and Stuttgart were reconstructed or (in the case of Kaiserslautern), extended.

pensive as “reconstruction works”. In the case of Hannover it should also be taken into consideration that the infrastructure had already been modernised in the run-up to the EXPO 2000.

Figure 2: Infrastructure investments as a multiple of the investments in sports venues (only World Cup related projects)



Data source: see Tables 1 and A1.

Overall it becomes clear that at € 1.6 billion for ten of the twelve World Cup stadia, the infrastructure measures are more extensive and costly than the stadium investments alone (€ 1.4 billion for 12 stadia). When planning for large-scale sporting events the focus, which hitherto has tended to be on stadium costs, should therefore be increasingly directed towards the infrastructure. In addition it can be seen that in three of the six venue locations with stadium reconstruction or extension works (Berlin, Kaiserslautern and Stuttgart), the infrastructure costs were significantly higher than the stadium costs, whilst this was the case in only one of the four venue locations with newly-built stadia (Leipzig). This leads to the hypothesis, which we will test for below: we test the assumed differentiation by relative infrastructure costs into two groups (venue locations with newly-built stadia and venue locations with stadium reconstruction or extension works) according to the allocation undertaken by FIFA (2004).

3. Methods and Results

Due to the small data set it seems appropriate to begin testing the hypothesis of a differentiation or group formation by newly-built and reconstructed stadia with the aid of a cluster analysis. The objects of the analysis are the ten World Cup venue locations which can initially be clustered according to the parameters of investments in sports venues and infrastructure investments. Furthermore it also seems appropriate in view of the apparent connection with the investments to cluster according to the parameters of the number of city inhabitants, the capacities of the sports venues,[7] the change in capacity of the sports venues and the distance of the venues to the respective previous venue. The sources of the relevant data can be seen in Table 1.

Given that according to Table 2, the parameter "capacity" is significantly correlated with "stadium costs", "city inhabitants" and "infrastructure costs", we will dispense with this parameter when performing the cluster analysis. All of the parameters are metrically scaled and were z-standardised to avoid distortions.[8]

Table 2: Bivariate correlations of the parameters

Variables	Correlations between the variables
Stadium costs and infrastructure costs	0.622
Stadium costs and capacity	0.907 **
Stadium costs and inhabitants	0.586
Stadium costs and capacity change	0.205
Stadium costs and distance to previous venue	0.676 *
Infrastructure costs and capacity	0.735 *
Infrastructure costs and inhabitants	0.814 **
Infrastructure costs and capacity change	0.082
Infrastructure costs and distance to previous venue	0.145
Capacity and inhabitants	0.793 **
Capacity and capacity change	0.321
Capacity and distance to previous venue	0.414
Inhabitants and capacity change	0.204
Inhabitants and distance to previous venue	0.087
Capacity change and distance to previous venue	0.189

Notes: * Significant at the level of 0.05 (two-sided); ** Significant at the level of 0.01 (two-sided)

Source: authors' own calculations.

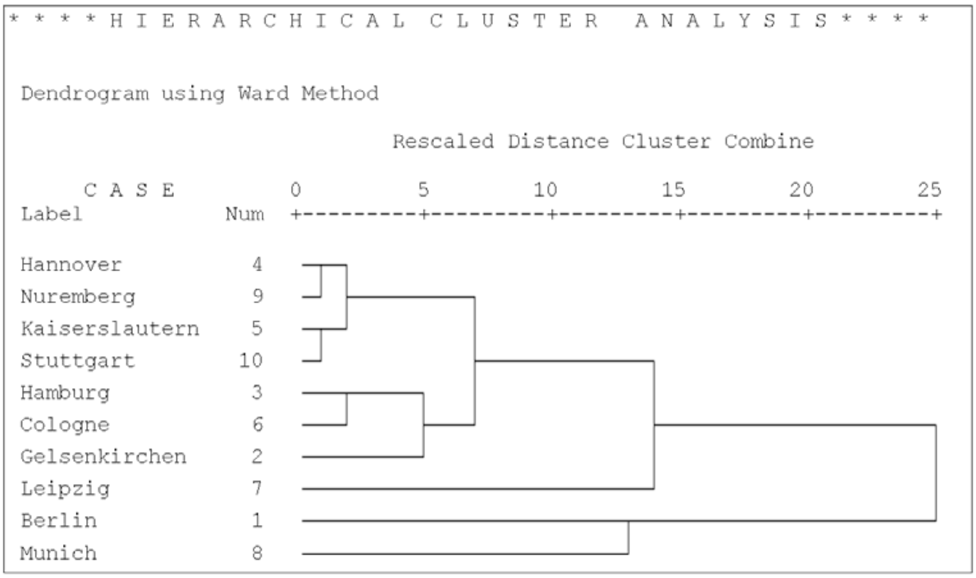
7 This refers to the capacity at the start of the World Cup season 05/06 from Table 1.

8 The standardisation is performed with $z_{ki} = \frac{x_{ki} - \bar{x}_i}{s_i}$, whereby z_{ki} describes the value of parameter i for Object k, $\bar{x}_i$ the mean of parameter i and s_i the standard deviation of parameter i, cf. Fisher, (1921, p. 1-32).

In order to attain an indicator of the "natural number" of clusters and a relatively optimal fusion algorithm for the objects, the hierarchic-agglomerative procedure according to Ward was initially used, for which the Euclidian distance was taken as a measurement of distance.[9]

The dendrogram in Figure 3 shows that the four cities Hannover, Nuremberg, Kaiserslautern and Stuttgart, all of which have sports venues that were reconstructed or extended, were allocated to a cluster. After a relatively low increase in heterogeneity, the cities Hamburg, Cologne and Gelsenkirchen are also added to this group, whereby Hamburg and Gelsenkirchen display newly-constructed stadia, and Cologne a reconstructed stadium that however has already been identified as a de facto new stadium. After a further, relatively low increase in heterogeneity Leipzig (new stadium) is then added to the group. Only the venues Berlin and Munich are allocated to the second cluster. A separation of the two clusters according to venues with reconstructed or extended sports venues on the one hand and newly-built sports stadia on the other can therefore not be recognised.

Figure 3: Cluster analysis (Ward method)

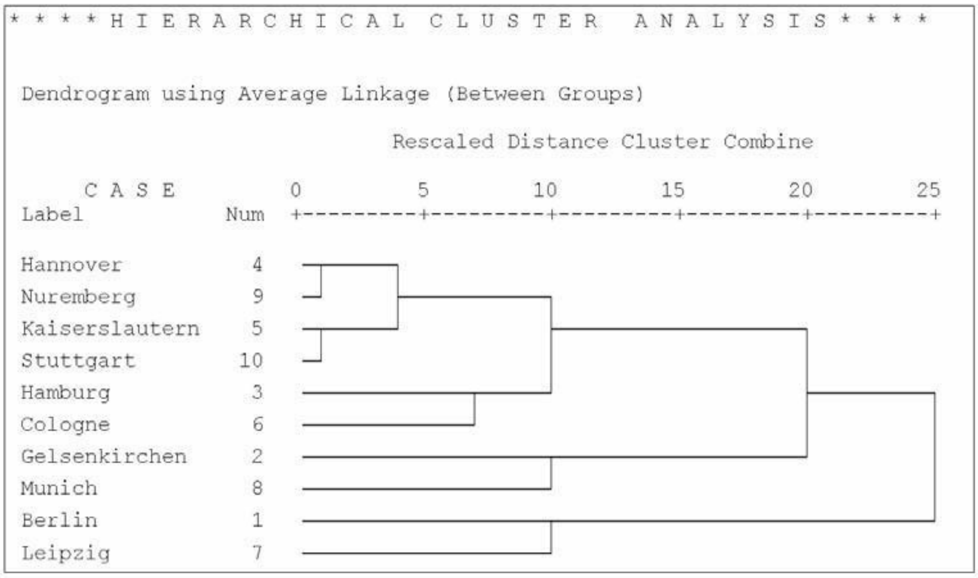


Source: authors' own illustration.

9 Cf. Ward (1963, pp. 236-244) and Moray et al. (1983, pp. 325-327). The Euclidian distance is calculated with $d_2(k,l) = \sqrt{\sum_{i=1}^{p} (x_{ki} - x_{li})^2}$ .or . $d_2(k,l) = \sqrt{\sum_{i=1}^{p} (z_{ki} - z_{li})^2}$, since z-standardisation is used, cf. Fisher (1921, pp. 1-32).

As an alternative specification the average linking method for cluster creation was used which, like the Ward method, also represents a “conservative” method (Lance and Williams, 1966, p. 374). In addition the Q correlation coefficients were used for the measurement of distance.[10] The parameters used remain the same. Figure 4 shows the result.

Figure 4: Cluster analysis (average linkage method)



Source: authors’ own illustration.

The ten analysed sports venues now fall into three clusters, with Hannover, Nuremberg, Kaiserslautern, Stuttgart, Hamburg and Cologne forming the first cluster. Gelsenkirchen and Munich form the second cluster and Berlin and Leipzig the third. In addition one may also discern the considerable heterogeneity among the objects in the second and third clusters.

It is noticeable that the reconstruction of the Berlin Olympic Stadium can still be found in the cluster of newly-built stadia, although Hamburg’s AOL Arena by contrast is allocated to the cluster which otherwise contains reconstructed and extended stadia. Figure 4 demonstrates the special position of Hamburg and Cologne among the World Cup venues with reconstruction or extension works, which is expressed in a higher level of heterogeneity in

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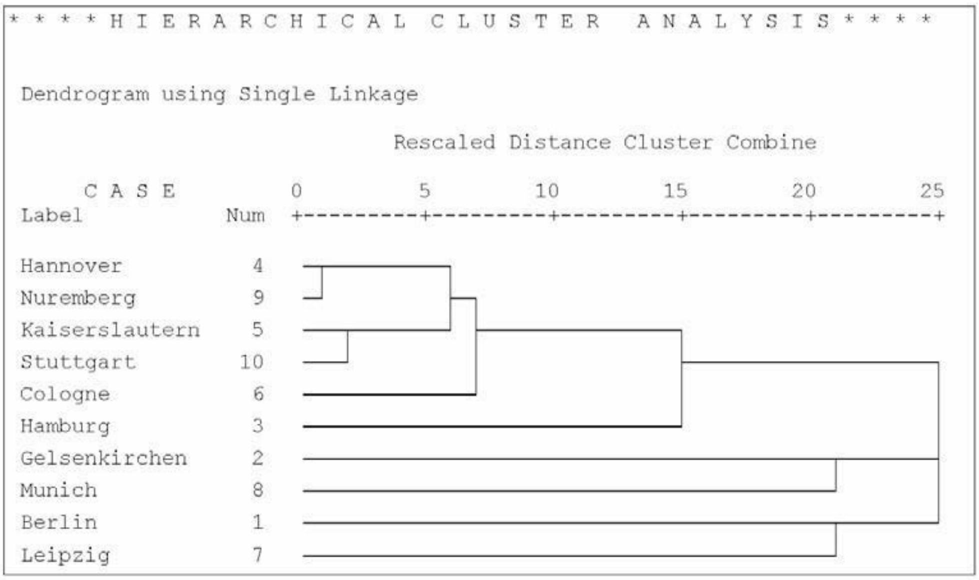
10 The Q correlation coefficients are a measurement of similarity that transfers the approach developed by Bravais and Pearson to binary parameters (Gower, 1967, pp. 623-638). Although measurement of distance is usually prevalent in metrically scaled parameters, under certain conditions the measurement of similarity may be meaningful. The Q correlation coefficient is not suited to parameter values between -1 and +1 if only two variables (i.e. parameters) are being analysed. However, this is not the case here, since the five known parameters are always included in the analyses.

relation to the other cities of this cluster. A clear and unambiguous separation between cities with reconstructed or extended stadia on the one hand and newly-built stadia on the other cannot however always be depicted.

Finally the single linkage clustering (or nearest neighbour method) was used, which is particularly good at finding elongated or large area clusters.[11] Following Figure 5 indicates the ten World Cup venues once again resolve into two clusters. Hannover, Nuremberg, Kaiserslautern, Stuttgart, Cologne and Hamburg are arranged in the first, whereby Hamburg is only allocated to this cluster after a conspicuous increase in heterogeneity. This can convincingly be explained by Hamburg's particular status as newly-built stadium among the reconstruction and extension works. The second cluster contains the objects Gelsenkirchen, Munich, Berlin and Leipzig. Berlin is the only declared reconstruction in this cluster of new buildings.

Figure 5: Cluster analysis (single linkage method)



Source: authors' own illustration.

However, this "misallocation" can also be interpreted. Berlin's € 242 million stadium reconstruction was only marginally cheaper than the most expensive newly-constructed stadium (Munich's Allianz Arena, € 280 million). The high level of heterogeneity between the

11 This is a contractive method, in contrast to the conservative methods of the Ward and average linking methods, cf. Lance and Williams (1966, p. 374).

individual objects of the "new stadium cluster" can clearly be seen. The cluster analysis thus confirms a fundamental impression of the relations between the investments as given in Figure 2: the heterogeneity, particularly among venue locations with new buildings, is apparently too great to be of use with regard to venue investments in making any statements about the expected volume of infrastructure investments.

The results of the cluster analyses which saw the allocation of the objects into two clusters (Ward method, single linkage method) was tested with a two-group discriminance analysis, in which as before the five independent variables: volume of sports venue investment costs, volume of World Cup related infrastructure costs, number of city inhabitants, change in stadium capacity and distance to previous venue were used, as well as a constant.

The variables were standardised in order to improve the explanatory power of the discriminance coefficients. The discriminance coefficients were normalised, because the eigenvector of the discriminance coefficients is only determinable up to an arbitrary factor. The normalisation was performed in such a way that the pooled variance of the discriminance values becomes equal to one: $\left(s_d^2\right)^{pool} \overset{!}{=} 1$. The values of the standardised discriminance coefficients in Table 3 show that the sports venue investments have the greatest discriminance power on which of the two clusters a World Cup venue is allocated to. To check whether and to what extent the correlations reported in Table 2 lead to distortions of the standardised discriminance coefficients, Table 3 also shows the corresponding structure coefficients. These clearly illustrate that the influence of the volume of stadium investment costs on the separation power of the discriminance variables tends to be biased downward, whilst the influence of the volume of infrastructure investment costs and the number of inhabitants tends to be biased upwards. Overall the volume of stadium and infrastructure investment costs have the greatest discriminance power in the separation of the two groups. However, the variables number of inhabitants, change in capacity and distance to previous sports venue display an isolated influence of at least 11%.

The eigenvalue of the discriminance criterion amounts to 30.00, the canonical correlation coefficient to 0.984 and Wilks' lambda to 0.032. At 18.887, the Bartlett chi-square distributed test statistic is also beyond the critical value of 11.1 for $\chi^2_{(5;0,95)}$. The null hypothesis, that the discriminance function is unsuited to the separation of the two groups, should be discounted with less than 1% probability of error.

Overall the discriminance analysis confirms the cluster analysis according to the Ward and single linkage methods as far as the goodness of the separation between the two groups is concerned (Hannover, Nuremberg, Kaiserslautern, Stuttgart, Hamburg und Cologne one the one hand and Gelsenkirchen, Munich Berlin and Leipzig on the other). The discriminance analysis also clearly shows that the separation can primarily be deduced from the variables of the volume of stadium and infrastructure investment costs and only secondarily from the auxiliary variables of number of inhabitants, change in capacity and distance to previous venue. The intended separation of the two groups into locations with reconstructed and extended stadia on the one hand and locations with newly-built stadia on the other can evidently not be achieved, even with the aid of cluster and discriminance analyses and a number of coherent auxiliary variables.

Table 3: Standardised discriminance coefficients and structure coefficients

Variable	Standardised canonical discriminance function coefficients			Structure matrix		
	Values	*Percentage of the absolute values*	*Significance ranking*	*Values*	*Percentage of the absolute values*	*Significance ranking*
Stadium costs	-3.996	36.14%	1	-0.234	40.67%	1
Infrastructure costs (World Cup related projects)	-1.084	9.80%	5	-0.116	20.09%	2
Inhabitants	2.169	19.62%	3	-0.064	11.10%	5
Change in capacity	2.595	23.47%	2	0.072	12.49%	4
Distance to previous sports venue	1.212	10.97%	4	-0.090	15.65%	3
Sum (of the absolute values)	11.056	100.00%		0.576	100.00%	

Test statistic	Eigenvalue	Canonical correlation coefficient	Wilks' lambda	Chi-square	Significance
Value	30.00	0.984	0.032	18.887	0.002

Source: authors' own calculations.

4. Summary

The costs of the 12 stadia for the 2006 World Cup amount to some € 1.4 billion. The volume of the World Cup related infrastructure investments in the 10 World Cup locations examined here amounts to some € 1.57 billion.

In addition to the insights gained from the collation and systematisation of the data, the objective of this study was to discover, with a view to the planning of future large-scale sporting events, possible relationships between the type of sports venue investments and the volume of the infrastructure investments required in each case.

However, the derivation of such a set of rules entails a number of difficulties. In the case of the 2006 World Cup the variance of the infrastructure investment costs is significantly higher than that of the sports venue investments. A separation or cluster formation in newly-built stadia on the one hand and reconstructed or extended stadia on the other was unsuccessful.

In the case of the 2006 World Cup this may be due to certain particularities. Thus historical reasons meant that the sports venues in Leipzig, which actually were centrally located and had been used previously, nevertheless provided inadequate access. In Hannover the building work on the stadium, which was officially designated as a reconstruction, but which was so elaborate as to almost be a new building, benefited from a large-scale event that had taken place a few years before (the EXPO 2000).

Particularities of this kind mean that it is not directly possible to transfer the results on the infrastructure costs of the 2006 World Cup to other large-scale sporting events and/or to other nations, especially since in contrast to the soccer World Cup, many other large-scale events essentially only take place in a single location. An attempt to systematise the volume of infrastructure costs may thus be appropriate for other events and other countries.

For economic analyses the insight remains that the infrastructure costs – for the World Cup related investments chosen here – are as a rule significantly higher than the sports venue costs alone. For the planning of future major sporting venues and large-scale events the infrastructure costs should receive more attention in comparison with the sports venue investments.

Abstract

This study uses the example of the 2006 soccer World Cup in Germany to examine whether any systematic relationships exist between infrastructure investments on the one hand and investments in the respective stadium on the other. Particular attention is paid to an examination of whether the relative infrastructure costs in the case of newly-built stadia differ from those relating to stadia that have been reconstructed or extended. Such systematic relationships, or "rules of thumb", could be used in the future to simplify the prediction of the expected volume of necessary infrastructure measures for major sporting events (other soccer World Cups, the Olympic Games, etc.) on the basis of the investment required for the sports venues. Our study makes use of a cluster and discriminance analysis and concludes that such general rules cannot be derived from the 2006 World Cup in Germany.
Keywords: Infrastructure investments; sport stadia costs; cluster analysis; discriminance analysis

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Appendix

Table A1: Infrastructure costs of the individual World Cup venue locations

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Berlin	public transport	non World Cup related	1	Railway junction Berlin Central Station/Lehrter Station. Construction of new central intercity station; transfer opportunities between North-South connections and the East-West city railway	German Railways	700.0
			2	North-South intercity railway tunnel	German Railways	500.0
			3	Gesundbrunnen station: Construction of a new, additional intercity and regional station with connections to the city railway and underground.	German Railways	315.0
			4	Expansion of the railway line from Berlin-Warsaw (Berlin-Frankfurt/Oder): expansion, modernisation and speed increase	German Railways	224.1
			5	Expansion/new construction work on the railway line Anhalter Railway, Berlin section (Berlin-Halle/Leipzig-Nuremberg-Munich) including Berlin South Station (Papestrasse)	German Railways	355.0
			6	Increasing performance of the city railway connection from Berlin's Bahnhof Zoo to the Olympic Stadium	German Railways	not available
			7	Reconstruction and modernisation of the Charlottenburg city railway station	German Railways	not available
			8	Construction of a new underground line Central Station/Lehrter Bahnhof-Brandenburger Tor (U 55) including the stations Reichstag (partial extension for commuter transport up to the World Cup in line with the Capital City Contract)	Land Berlin and BVG	28.0
			9	Construction of the missing second access points to the underground line 2 (Pankow-Ruhleben): Deutsche Oper, Sophie Charlotte-Platz and Theodor Heuss-Platz (here also with construction of lifts)	State of Berlin and BVG	8.3
	Sum					*2 130.4*
	private transport	World Cup related	1	A11 3-way motorway junction Schwanebeck - motorway interchange Uckermark, overhaul extension with addition of missing hard shoulder	Federal Government	173.1
			2	A113 3-way motorway junction Neukölln - junction Späthstrasse or Adlershof, new 6-lane section (PART)	Federal Government	314.6

			3	B5 bypass Wustermark A10 - major road - GR BB/BE (2nd lane), 4-lane expansion/ construction of new 4-lane section	Federal Government	37.5
			4	B96 A10 (junction Rangsdorf) - major road - GR BB/BE, 4-lane expansion	Federal Government	39.5
			5	B96a Schönefeld - Mahlow (2nd lane), 4-lane expansion	Federal Government	9.0
			6	B 101n Federal motorway feeder Gross-beeren, construction of new 4-lane section	Federal Government	71.6
			7	B101 Marienfelder Allee, 4-lane extension	Federal Government	9.1
			8	B5 Heerstrasse, extension with creation of a continual regular 4-lane cross-section and addition of missing left-turn lane (contained in no. 3)	Federal Government	0.0
		Sum				*654.4*
			1	A113 3-way motorway junction Neukölln - junction Späthstrasse or Adlershof, new 6-lane section (PART)	Federal Government	157.4
		Sum				*157.4*
	Sum					*811.8*
Total Sum Berlin						2 942.2

Source: Cf. BVWP (20003a, p. 97), Doelfs (2005, p. 1), Stockmann (2005, p. 4), N.N. (2005a, p. 1), N.N. (2005b, p. 1), N.N. (2005c, p. 1), email from the BVG (Berlin Public Transport), Mrs. Rubbel, from 11.08.2005 as well as information by telephone from Department S 10 of the BMVBS, Mr. Joop, from 12.08.2005. According to information by telephone from DB Netz & Betrieb (*German Railways Network and Operation*), Mr. Zimmermann, from 26.09.2005, the collated cost data on the German Railway's public transport projects are too low. However, the German Railways were not able to provide their own cost estimates for the projects in Berlin.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 1)

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Gelsen-kirchen	public trans-port	World Cup related	1	Gelsenkirchen Central Station, station redesign	German Rail-ways/State	15.7
			2	Central Station, reconstruction of the platforms to enable 2 double traction trains to stop	City of Gelsenkir-chen/ BO-GESTRA	2.5
			3	Overhead electrical cables for Line 302, double traction trains incl. disabled access, Buer, bus station	City of Gelsenkir-chen/ BO-GESTRA	7.0

			4	Additional platform for the city railway station Arena Auf Schalke	BOGESTRA	1.0
			5	Roofing of the city railway station Arena Auf Schalke	City of Gelsenkirchen/ BOGESTRA	2.5
	Sum					*28.7*
	private transport	World Cup related	1	A2 junction Essen/Gladbeck - junction Gelsenkirchen/Buer - reconstruction of the junction Essen-Gladbeck A2/B224 (6-lane extension)	Federal Government	7.5
			2	A42 new construction of the junction Schalke (No.17) to relieve junction Gelsenkirchen-Bismark (No. 18), Gelsenkirchen-Schalke (No.16, the City Center) and Gelsenkirchen-Buer (A2, No.6), improved access to Arena auf Schalke.	City of Gelsenkirchen	22.4
			3	Vinckestrasse (B226), improving performance (access road to the Arena).	City of Gelsenkirchen	2.6
			4	Uferstrasse, between Kurt Schumacher-Str. (L608) and Grothusstr. (L633), improvement in the crossing area, Arena access road.	City of Gelsenkirchen	4.3
			5	Optimisation of transport processes, improvement in transport management and signals.	City of Gelsenkirchen	2.5
		Sum				*39.3*
			1	A2 Gelsenkirchen-Buer-junction Herten (6-lane expansion)	Federal Government	45.9
		Sum				*45.9*
	Sum					*85.2*
Total Sum Gelsenkirchen						113.9

Source: Cf. BVWP (2003b, pp. 123-125). Information by telephone from the City of Gelsenkirchen, Mr. Konietzka, from 30.04.2005.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 2)

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Hamburg	public transport	World Cup related	1	City railway, modernisation of Stellingen station	German Railways Station & Service	1.9
			2	Improvement in access from the city railway station Stellingen to the stadium	City of Hamburg	1.8

		3	Improving attractiveness of the connection between the city railway station Stellingen and the shuttle bus line	City of Hamburg	4.0
		4	Reconstruction of the square in front of Othmarschen station and creation of a bus shuttle to the stadium	City of Hamburg	0.5
	Sum				*8.2*
		1	Renovation of the railway bridge Reichsbahnstrasse and modernisation of Eidelstedt station	German Railways	0.8
		2	Airport Terminal 2 extension, Airport forecourt roads	Flughafen Hamburg GmbH (*Hamburg Airport*)	Not available/ not a World Cup project according to the City of Hamburg
	Sum				*0.8*
Sum					*9.0*
private transport	World Cup related	1	Expansion Sylvesterallee for buses, taxis and pedestrians	City of Hamburg	0.6
		2	Expansion Hellgrundweg	City of Hamburg	0.6
		3	Expansion Stadionstrasse	City of Hamburg	0.3
		4	Reconstruction of the junction Hamburg Volkspark on the A7 including reconstruction Schnackenbugsallee	Federal Government/ Hamburg	2.7
		5	New construction of a bus parking area with approx. 70 places in the Schnackenburgsallee	City of Hamburg	1.9
		6	Interim bus parking area (approx. 300 places)	City of Hamburg	1.0
		7	Sign posting of the Arena in the city network	City of Hamburg	0.2
		8	Additional cameras for traffic management around the Arena (motorway junction Northwest, junction Volkspark)	City of Hamburg	0.3
		9	Dynamic parking system for the Arena	City of Hamburg	0.8
		10	Networking of the operative traffic management centres	City of Hamburg	0.0
		11	Bilingual (German/English) city public transport direction system	City of Hamburg	0.0
		12	Internet platform for the 2006 World Cup (Verkehrsinfo-Hamburg.de)	City of Hamburg	0.1

			13	Improving accessibility for parking areas around the stadium including refurbishment of approx. 8,000 parking places and improvement of a pedestrian access route from the car park to the stadium	City of Hamburg	6.1
		Sum				*14.5*
		non World Cup related	1	A7 Hamburg-Othmarschen - Hamburg-Waltershof (additional 4th tunnel for the Elbe tunnel), 8-lane expansion (tunnel construction)	Federal Government	874.3
			2	Bypass Fuhlsbüttel (1st + 2nd construction stages), 4-lane connection to airport	Federal Government	223.9
		Sum				*1 098.2*
	Sum					*1 112.7*
Total Sum Hamburg						1 121.7

Source: Cf. Notification from the Authority for Urban Planning and the Environment (BSU) Hamburg, Mr. Welschinger, from 26.07.2005 as well as BMVBS (2005a, pp.123-125).

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 3)

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Hannover	public transport		1	Passenger information and directing as a city railway security, direction and information system as well as passenger directing at the city railway stations	German Railways/ City of Hannover	0.0
		Sum				*0.0*
			1	Reconstruction of the passenger interchange at Linden station	German Railways	25.6
		Sum				*25.6*
	Sum					*25.6*
	private transport	World Cup related	1	A7 motorway junction Hannover North - junction Grossburgwedel (PART)	Federal Government	0.2
			2	A7 junction Grossburgwedel- motorway interchange Hannover-Kirchhorst (PART)	Federal Government	9.6
			3	A7 motorway interchange Kirchhorst - motorway interchange Hannover Ost (PART)	Federal Government	5.1
			4	A7 motorway interchange Hannover Ost - junction Hildesheim	Federal Government	28.1
		Sum				*43.0*
			1	A2 motorway interchange Hannover Ost - Marienborn L-GR NI/ST	Federal Government	685.0

			2	A7 motorway junction Hannover North - junction Grossburgwedel (PART)	Federal Government	31.0
			3	A7 junction Grossburgwedel- motorway interchange Hannover-Kirchhorst (PART)	Federal Government	21.1
			4	A7 motorway interchange Kirchhorst - motorway interchange Hannover Ost (PART)	Federal Government	21.1
			5	B217 bypass Weetzen Evestorf	Federal Government	32.0
		Sum				*790.2*
	Sum					*833.2*
Total Sum Hannover						833.2

Source: Cf. BVWP (2003c, pp. 115-116), N.N. (2003, pp. 1-2), N.N. (2005d, p. 2), information from the Department of "Coordination and Citizens' Service" of the City of Hannover, Mr. Sonnenberg, from 30.04.2005, as well as information by telephone from 11./12.08.2005 from Department S 10 of the BMVBS, Mr. Joop.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 4)

Location	**Sector**	**Allocation**	**No.**	**Name**	**Responsible**	**Costs (in € million)**
Kaisers-lautern	public trans-port	World Cup related	1	Reconstruction of the Central Station with a direct pedestrian path to the stadium and construction of platform 4	German Railways, Investor "Betze-Galerie"	5.0
			2	Redesign of the square in front of the station with central bus station	City of Kaiserslau-tern	10.0
			3	Regional and City railway Rhein-Neckar	German Railways	7.0
			4	Extension of the city railway line beyond Kaiserslautern to Homburg	Federal Government, State, German Railways	15.5
		Sum				*37.5*
			1	Paris-East France-Southwest Germany railway line (POS) on the German side	German Railways	270.0
		Sum				*270.0*
	Sum					*307.5*
	private trans-	World Cup related	1	A 63 (PART)	Federal Government	75.6
			2	North Expressway: expansion of the Mainzer Strasse; 4-lane expansion of the Mainzer Strasse (partly completed)	City of Kaiserslau-tern	3.0

		3	South Expressway: expansion of the Zollamtstrasse, expansion of a city road and a previously private German Railways area to form a 2 lane roadway (length approx 950 m.). Construction of a roundabout at the junction with the Bremerstrasse. Connection to the Trippstadter Strasse with traffic light controlled junction.	City of Kaiserslautern	2.3
		4	South Expressway: expansion of the crossing Logenstrasse/Eisenbahnstrasse, expansion of the crossing in the context of the South Expressway project. The crossing is expanded with turn-off lanes and traffic lights.	City of Kaiserslautern	1.0
		5	Expansion of the Pirmasenser Strasse: complete reconstruction of the heavily damaged street with park areas, pedestrian footways and cycling traffic lights	City of Kaiserslautern	0.6
		6	South Expressway: 4-lane expansion of the Dammstrasse in the context of the South Expressway project (length approx. 500m). The street is widened to the north (German Railways property) and the railway bridge demolished. The measure comprises connection with the crossing Brandenburger Strasse/Hohenecker Strasse and junction with the Königstrasse (both with traffic lights).	City of Kaiserslautern	4.8
		7	Expansion of the Eisenbahnstrasse: the Eisenbahnstrasse is the main connecting road between the Fritz-Walter Stadium and the inner city area. In the remaining section it is to be expanded between Karl-Marx-Strasse and Logenstrasse (including park areas and pedestrian paths).	City of Kaiserslautern	1.0
		8	South Expressway: expansion of the crossing Logenstrasse/Rudolf-Breitscheid-Str., expansion of the crossing in the context of the South Expressway project. The crossing is to be expanded with turn-off lanes and traffic lights. The measure to be completed in advance as part of the subsidy planning for the expansion of the Rudolf-Breitscheid-Strasse.	City of Kaiserslautern	0.7

		9	Completion of the redesign of the pedestrian precinct: the pedestrian precinct had already been redesigned over recent years in the sections Fackelstrasse and Riesenstrasse. The remaining section in the Marktstrasse should be completed by the 2006 World Cup.	City of Kaiserslautern	1.2
		10	Redesign of the Willy-Brandt-Platz (square in front of the town hall): elimination of building deficiencies (PART)	City of Kaiserslautern	0.4
		11	Creation of a city information system: this should be completed by the 2006 World Cup and provide information to visitors at entrances to the city and in the inner city area .	City of Kaiserslautern	0.4
		12	Bus parking area Bremerstrasse: the surface of the bus parking area is to be renewed. A stairway to be built between the bus parking area and the stadium. Bus parking area Kniebrech: surface to be renewed.	City of Kaiserslautern	0.2
		13	Reconstruction and renovation of the roads and footpaths around the stadium	City of Kaiserslautern	0.7
		14	Construction of the "Schweinsdell" car park with 2600 spaces directly by the A6	City of Kaiserslautern	2.5
		15	Opening of the military exit as additional motorway exit for a direct connection to the "Schweinsdell" Park and Ride area (Kaiserslautern East).	City of Kaiserslautern	0.5
		16	Rendering of the car park surface in IG-North	City of Kaiserslautern	0.1
	Sum				*95.0*
	non World Cup related	1	A6 Kaiserslautern West - junction Landstuhl	Federal Government	not available/ not a World Cup project according to the City of Kaisers-lautern
		2	B270 A6 Siegelbach	Federal Government	not available/ not a World Cup project according to the City of Kaisers-lautern
		3	A 63 (PART)	Federal Government	21.9

			4	B 37 bypass Hochspeyer	Federal Government	15.3
			5	North Expressway: 4-lane expansion of the Ludwigstrasse	City of Kaiserslautern	3.9
			6	Redesign of the Willy-Brandt-Platz (square in front of the town hall): elimination of construction deficiencies (PART)	City of Kaiserslautern	0.3
		Sum				*41.4*
	Sum					*136.4*
Total Sum Kaiserslautern						443.9

Source: Cf. BVWP (2003d, p. 132), Glahn (2003, p. 1), Bross (2003), N.N. (2005e), notification from the Department of Law and Order – Traffic Authority of the City of Kaiserslautern, Mr. Dressing from 26.07.2005 and information by telephone from 11./12.08.2005 from Department S 10 of the BMVBS, Mr. Joop. Two private transport projects listed under (2005a, p. 11), the expansion of the A6 Kaiserslautern West - junction Landstuhl as well as the connection of the B270 to the A6 near Siegelbach, are completely unrelated to the 2006 World Cup according to the City of Kaiserslautern and for this reason are not even listed here under the summary including the non World Cup related projects.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 5)

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Cologne	public transport	non World Cup related	1	Inclusion of the Cologne/Bonn Airport in the German Railway's intercity network and Cologne's city railway network	German Railways	19,1
			2	Reconstruction of the city railway station RheinEnergie Stadium, extension of city railway line 1 and connection with planned city railway station Bonnstrasse	City of Cologne, German Railways	6.9
			3	City railway connection Cologne/Bonn Airport – planned city railway station Bonnstrasse	City of Cologne, German Railways, VRS, State of NRW	3.0
			4	Construction of the city railway station Bonnstrasse with related measures including extension of city railway line 1 to city railway station Bonnstrasse and creation of the P+R area with 400 spaces	City of Cologne, German Railways, VRS, State of NRW	7.1
			5	Installation of a direction system at the public transport connections and at stops from where the RheinEnergie Stadium can be reached on foot	City of Cologne, German Railways, VRS	3.8

Sum					*39.9*
private trans-port	World Cup related	1	A4 new junction Bonnstr. (L 183) in sector Frechen, new construction	Federal Government	3.0
		2	A3 motorway interchange Cologne-East - motorway junction Heumar, 8-lane expansion	Federal Government	67.0
		3	P+R area Bonnstr., 1st building stage	City of Cologne	Contained in no. 3 (public transport)
		4	Expansion of the traffic management system to the area of the stadium: dy-namic traffic information and directions, pedestrian direction system and local resident protection plans	City of Cologne	0.6
		5	Dürener Str. (B 264) from Marsdorfer Str. to the federal motorway A1	City of Cologne	9.8
		6	Cycle and pedestrian paths around the stadium	Kölner Sportstätten GmbH (*Cologne Sports Venues*)	0.4
		7	Dynamic traffic information and direc-tions	City of Cologne	1.3
		8	Inclusion of the stadium car parks in the car park traffic direction system	City of Cologne	Contained in no. 7
		9	Dürener Str. from Salzburger Weg to Marsdorfer Str. (3-lane expansion) including lane signalling system	Landesbe-trieb Straßenbau NRW (*NRW state-run road con-struction company*)	1.6
		10	Renovation of roads and paths around the stadium	City of Cologne	1.3
		11	Construction and rebuilding work on the stadium car parks as well as measures to redesign the area around the stadium	Kölner Sportstätten GmbH (*Cologne Sports Venues*)	6.0
	Sum				*90.9*
	non World Cup rela-ted	1	A1 motorway interchange Cologne-North-German Railways Aachen-Cologne line, 6-lane expansion	Federal Government	99.0
		2	A1 German Railways Aachen-Cologne line - motorway interchange Cologne-West, 6-lane expansion	Federal Government	106.0
		3	A4 junction Weisweiler - junction Düren (m) (o Rur bridge), 6-lane expan-sion	Federal Government	46.6

			4	A4 motorway interchange Kerpen - motorway interchange Cologne-West, 6-lane expansion	Federal Government	78.0
			5	A1 junction Remscheid - TR Remscheid, 6-lane expansion	Federal Government	32.9
			6	A4 junction Eschweiler - junction Weisweiler, 6-lane expansion	Federal Government	46.5
			7	Cycle/pedestrian path from Schulstr. to Bonnstr.	City of Cologne	0.1
			8	Expansion of the traffic management system to the area of the stadium: dynamic traffic information and directions, pedestrian direction system and local resident protection plan	City of Cologne	0.2
		Sum				*409.3*
	Sum					*500.2*
Total Sum Cologne						540.1

Source: Cf. BVWP (2003b, pp. 123-125) as well as information from the Office of Urban Development and Statistics of the City of Cologne, Mr. Kolm, from 08.07.2005 and from 18.01.2006. Cf. information from the Office of Urban Development and Statistics of the City of Cologne, Herr Kolm, from 18.01.2006. According to the City of Cologne, the extensions with regard to the BMVBS (2005a, pp.13-14) are World Cup related projects under the responsibility of the Landesbetrieb Straßenbau NRW (*North-Rhine-Westphalia state-run road construction company*), the City of Cologne and the (*Cologne Sports Venues*). The City of Cologne bears a proportion of approx. € 14 million of the overall infrastructure costs. If calculations are based just on the World Cup related projects, the City of Cologne's share is still some € 10.9 million.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 6)

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Leipzig	private trans-port	World Cup related	1	A14 motorway interchange Schkeuditz - junction Central Leipzig, 6-lane expansion and overhaul with hard shoulder extension	Federal Government	46.7
			2	S1, relocation south of Lindenthal (motorway access road to the A 14, Leipzig North)	State of Saxony	1.6
			3	S1, relocation north of Lindenthal (motorway access road to the A 14, Leipzig North)	State of Saxony	Contained in no. 2
			4	S 8a western airport approach road	State of Saxony	Contained in no. 2
			5	S38a, relocation near Liebertwolkwitz	State of Saxony	Contained in no. 2

		6	S 43 new, expansion near Großpösna	State of Saxony	Contained in no. 2
		7	Marschnerstrasse from Käthe-Kollwitz-Str. to Ferdinand-Lassalle-Strasse	City of Leipzig	0.8
		8	Expansion of junction Leutzscher Allee/Waldstrasse	City of Leipzig	1.5
		9	Junction Leutzscher Allee/ Friedrich-Ebert-Str. (roundabout)	City of Leipzig	0.4
		10	Rückmarsdorfer Strasse with bridge over German Railway facilities	City of Leipzig	5.8
		11	Junction Merseburger Str./Hupfeldstr. as well as Merseburger Str./Rückmarsdorfer Str.	City of Leipzig	3.1
		12	Jahnallee from Zeppelinbrücke-Leibnizstr.-Rosenthal	City of Leipzig	25.3
		13	Junction Goerdelerring	City of Leipzig	4.0
		14	Johannisplatz	City of Leipzig	5.4
		15	Pragerstr./city railway line 15 with Prager Brücke (Section Kregelstr. - An der Tabaksmühle)	City of Leipzig	14.8
		16	Expansion of the Lützener Str. between Zschochersche Str. and Odermannstr.	City of Leipzig	1.5
		17	Friedrich-Ebert-Str. - Westplatz	City of Leipzig	2.7
		18	Station Angerbrücke	LVB GmbH	4.0
		19	Willy-Brandt-Platz	LVB GmbH	10.7
	Sum				*128.3*
	non World Cup related	1	A38 southern ring road Leipzig: junction Leipzig Southwest (B186) - junction Leipzig South (B2/B95), construction of new 4-lane section	Federal Government	155.9
		2	A72 BA: junction Borna North - junction Borna South (bypass Borna) construction of new 4-lane section	Federal Government	12.9
		3	A72 BA 1.1: motorway interchange Chemnitz (A4/A72) to Hartmannsdorf, construction of new 4-lane section	Federal Government	53.0
		4	A72 construction stage 1.2: Hartmannsdorf - Niederfrohna, construction of new 4-lane section	Federal Government	45.0
		5	A14, junction Central Leipzig - junction Leipzig-Messegelände	Federal Government	49.4
		6	A38 South ring road Leipzig: junction Leipzig-South - junction Leipzig-Southeast, construction of new 4-lane section	Federal Government	52.3

			7	A38 South ring road Leipzig: junction Leipzig-Southeast - motorway junction Parthenaue, construction of new 4-lane section	Federal Government	49.2
			8	North Expressway Schönefeld with Hermann-Liebmann-Bridge	City of Leipzig	34.1
			9	Eisenbahnstr. (from Rosa-Luxemburg-Strasse - Torgaustrasse)	City of Leipzig	4.3
		Sum				*456.1*
	Sum					*584.3*
Total Sum Leipzig						584.3

Source: Cf. BVWP (2003e, pp. 138-139), information from the Building Department of the City of Leipzig on the World Cup transport projects under the responsibility of the City of Leipzig from 24.06.2005 as well as information by telephone from 11./12.08.2005 from Department S 10 of the BMVBS, Mr. Joop. Since the City of Leipzig was not able to provide any information on measures under the responsibility of the Leipziger Verkehrsbetriebe (*Leipzig Transport Companies*) [LVB], 13 public transport measures that are listed in BMVBS (2005a, p. 15) are not taken into consideration in the above table. This means that the investment sum for transport infrastructure measures in the World Cup location Leipzig is on the low side.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 7)

Location	**Sector**	**Allocation**	**No.**	**Name**	**Responsible**	**Costs (in € million)**
Munich			1	Installation of a traveller information system (DEFAS) and a direction system at all connection points	City of Munich / German Railways	11.0
			2	Underground line 6: extension and expansion of Fröttmaning station, line refurbishment to cope with a capacity of 20,880 persons per hour, expansion and extension of the connecting station Marienplatz, creation of a passenger information system	MVV	98.6
	Sum					*109.6*
	private trans-port	World Cup related	1	Installation of a traffic direction system and its connection with the traffic management network on the federal major road network	City of Munich / Federal Government; AV Bayern	14.6
			2	Construction of a main road between the A9 (junction-Munich-Fröttmaning) and the A99 (partial connection sta-dium)	City of Munich	50.1

			3	A9, reconstruction of the junction Munich Fröttmaning	Federal Govern-ment/City of Munich	6.9
			4	A99, reconstruction westbound motor-way interchange Munich-North (partial connection stadium)	Neubau (Kostenträger Stadt)	19.8
			5	A9 motorway interchange Neufahrn motorway interchange; A9 Munich North; motorway interchange Munich North - junction Munich Frankfurter Ring	Federal Government	39.3
		Sum				*130.7*
			1	A99 Langwied (A8) - Unterpfaffen-hofen (A96) m junction Germering	Federal Government	30.9
		Sum				*30.9*
	Sum					*161.6*
Total Sum Munich						271.2

Source: Cf. BVWP (2003f, pp. 87-88), N.N. (2005f) as well as information from the District Administration Department of the State Capital Munich, Mr. Reif, on World Cup projects under the responsibility of the City of Munich from 24.05.2005.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 8)

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Nurem-berg	public trans-port	World Cup related	1	Expansion des city railway station Franken Stadium and increase in capacity to 15200 persons per hour – construction of a new special platform	German Railways	8.5
			2	Construction of a direction system from the relevant public transport stops to the stadium and back	City of Nuremberg, VGN, VAG, German Railways	Stadium; contained in measure 5 (IV)
			3	Creation of an intermodal travel sched-ule information service that can be accessed via PDA and UMTS mobile phones	VGN, Ger-man Rail-ways, Free State of Bavaria	0.1
			4	Dynamic destination display (DEFIS) at selected stops	VAG	1.9
			5	Dynamic transmission of video images between VAG and the police	VAG	0.1
	Sum					*10.6*
			1	A6 motorway interchange Nurem-berg/South (flyover)	Federal Government	21.0

port		2	Refurbishment/reinforcement of roads and car parks in the area directly around the stadium (VIP parking area, stadium forecourt, parking direction system pylons, car park S2, car park S5, Hans-Kalb-Strasse/Karl-Steigelmann-Strasse, street lighting, cycle stands, Max-Morlock-Platz	City of Nuremberg	2.7
		3	Connecting the motorway management's traffic computer center to the police's city traffic center and the City's traffic computer	Federal Government/AV Bavaria, City of Nuremberg	Contained in measure 3
		4	Installation of a dynamic parking direction system	City of Nuremberg	Contained in measure 3
		5	Installation (improvement) of a pedestrian direction system from the car parks to the stadium	City of Nuremberg	0.2
		6	Expansion of the Gleiwitzerstr. between Breslauer Str. and K.-Schönleben-Str.	City of Nuremberg	1.0
		7	Additional right-turn lane from the Breslauer Str. into the Regensburger Str.	Nuremberg Department of Roadworks	0.2
	Sum				*25.1*
		1	Completion of a dynamic traffic direction system leading from the federal motorway network via the inner-city road network to the car parks around the stadium; including renewed expansion of the traffic direction system	Federal Government, Free State of Bavaria, City of Nuremberg	26.5
	Sum				*26.5*
Sum					*51.6*
Total Sum Nuremberg					62.1

Source: Cf. Information from the Economics Department about the World Cup related transport projects under the responsibility of the City of Nuremberg, Mr. Jülich, from 25.07.2005 and from 17.01.2006. The costs for the two supplemented infrastructure measures in the public transport sector, both of which were the responsibility of the Nuremberg Transport Company VAG, were provided by the Economics Department of the City of Nuremberg. According to information from the City of Nuremberg from 17.01.2006, these are World Cup related projects. In addition the City of Nuremberg differs from the BMVBS (2005a, p. 18) in listing 16 instead of eight infrastructure measures in the private transport sector. Of the 16 stated private transport projects, nine were however listed under No.2 of the World Cup related projects and two under No. 1 of the non World Cup related projects in Table

2, so that the total number of eight infrastructure measures in the private transport sector given by BMVBS (2005a, p. 18) remains.

Table A1: Infrastructure costs of the individual World Cup venue locations (Cntd. 9)

Location	Sector	Allocation	No.	Name	Responsible	Costs (in € million)
Stuttgart	public trans-	World Cup	1	Modernisation of the city railway station Gottlieb-Daimler-Stadium, expansion of the station, construction of a second platform.	German Railways/ City of Stuttgart	10.5
			2	Modernisation of the station Stuttgart-Bad-Cannstatt	German Railways/ State	9.5
	Sum					*20.0*
	private trans-port	World Cup related	1	A8 junction-Wurmberg-junction Heimsheim, 6-lane expansion	Federal Government	77.0
			2	B14 extension in Stuttgart (Südheimer Platz-Schattenring) construction of new 4-lane section (PART)	Federal Government	53.1
			3	Completion of the junction of the Martin-Schrenk-Weg to the Benzstrasse.	LHS Stuttgart	0.1
			4	Re-signing of "ball" to "stadium" pictogram	LHS Stuttgart	0.1
			5	Pedestrian direction system in Bad Cannstatt	LHS Stuttgart	0.2
			6	Emergency management	LHS Stuttgart	0.1
		Sum				*130.5*
			1	B14 extension in Stuttgart (Südheimer Platz-Schattenring) construction of new 4-lane section (PART)	Federal Government	5.4
		Sum				*5.4*
	Sum					*135.9*
Total Sum Stuttgart						155.9

Source: Cf. BVWP (2003g, pp. 79-80) as well as information from the Economics Department on the World Cup transport projects under the responsibility of the LHS (*State Capital*) Stuttgart, Mrs. Delarue from 15.07.2005. Three additional projects were also supplemented for Stuttgart (cf. Nuremberg). The costs for these three infrastructure measures in the private transport sector, all of which were under Stuttgart's responsibility, were provided by the Office for Public Order of the LHS Stuttgart. According to this information, the projects were World Cup related.

Einzelhandel und Verkehr – Ergebnisse einer Multiagentensimulation von Konsumentenentscheidungen

VON JÜRGEN RAUH, WÜRZBURG, TILMAN A. SCHENK, LEIPZIG
UND PHILIP ULRICH, OSNABRÜCK

1. Das Individuum im Raum: Theorie und Modellbildung

Die Modellierung räumlicher Phänomene in den sozialwissenschaftlich orientierten (Teil-) Disziplinen der Raumwissenschaften basierten in der Vergangenheit meist auf aggregierten Ausgangsdaten. Obwohl diese Vorgehensweise bereits grundsätzlich in Frage gestellt worden ist (OPENSHAW 1978), wurde und wird sie bis in die Gegenwart praktiziert (u.a. WILSON & BENNETT 1985, LÖFFLER & KLEIN 1989, GÜSSEFELDT 2002), wofür mehrere Gründe anzuführen sind: Einerseits sind soziodemographische Daten in den meisten Fällen nicht auf individueller Ebene verfügbar, weil ihre Erhebung nicht mit Datenschutzrichtlinien vereinbar ist oder schlicht Kosten in nicht zu rechtfertigender Höhe verursachen würde. Andererseits fehlten bislang auf technischer Seite sowohl effiziente Modellierungsansätze für Massendaten, als auch die ausreichenden Rechnerkapazitäten. Dabei waren, ausgehend von der theoretischen Basis einer „Verhaltensgeographie“ (THOMALE 1974, WIESSNER 1978) bzw. „Mikrogeographie“ (TZSCHASCHEL 1986), später einer „Handlungstheorie“ (WERLEN 1987, 2000, WIRTH 1981, 1999), schon recht früh Versuche mit Individualmodellen gemacht worden (GOLLEDGE & TIMMERMANS 1988, TIMMERMANS, ARENTZE, JOH 2002). Häufig wird jedoch kritisiert, dass individuelle Modellierung Raumstrukturen als Ergebnis massenhafter individueller Entscheidungen begreift, was in einzelnen Anwendungen genügen mag und verlockend einleuchtend erscheint: Verkehrsströme entstehen, weil sich viele Individuen (unabhängig voneinander) zur selben Zeit für eine bestimmte Route entscheiden, Städte entstehen, weil viele Individuen denselben Wohnstandort wählen. Vernachlässigt werden dabei mögliche Einschränkungen der individuellen Entscheidungsfreiheit (MEUSBURGER 1999), deren Darstellung derzeit mit dem Konzept der Institutionen (u.a. SCHAMP 2003) intensiv diskutiert wird. Weiterhin wird gefordert, einen Informationsaustausch und die Kooperation zwischen den Individuen stärker in solche Modellierungen zu integrieren.

Anschriften der Verfasser:

Prof. Dr. Jürgen Rauh
Institut für Geographie
Universität Würzburg
Am Hubland
97074 Würzburg
e-mail: juergen.rauh@mail.uni-wuerzburg.de

Dr. Tilman A. Schenk
Institut für Geographie
Universität Leipzig
Johannisallee 19a
04103 Leipzig
tilman.schenk@uni-leipzig.de

Philip Ulrich
Gesellschaft für wirtschaftliche
Strukturforschung mbH
Heinrichstraße 30
49080 Osnabrück
ulrich@gws-os.de

Die Anwendung von agentenbasierten Mikrosimulationen geben nun der Forschung die Möglichkeit, dem Anspruch handlungsorientierter Ansätze auch auf der Modellierungsebene gerecht zu werden, und damit vielfältige Einflussgrößen auf individueller Ebene einzubeziehen. Diese Arbeit hat zur Aufgabe, aus den als Kaufkraftströme modellierten Interaktionen zwischen Nachfragern und Anbietern im Lebensmitteleinzelhandel Verkehrsströme bzw. Aufwände der Haushalte abzuschätzen. Damit ergibt sich sowohl die Möglichkeit, das zugehörige Modell anhand von empirischen Daten zur Mobilität der Haushalte zu validieren und andererseits verkehrsbezogene Fragestellungen zu bearbeiten. Die Methoden zur Ermittlung von Kaufkraftströmen haben sich unabhängig von Verkehrsmodellen entwickelt, um Marktgebiete und Einzugsbereiche von Geschäften und Zentralen Orten abzugrenzen. Mit den soziodemographischen Daten von gesamten Teilgebieten können mit Gravitationsmodellen oft Interaktionen und Bewegungen mit ausreichender Genauigkeit geschätzt werden (LÖFFLER 1999: 52-54). Gravitationsmodelle sind auch lange die Grundlage für Berechnungen in den Verkehrswissenschaften gewesen, werden aber seit den 1980er Jahren immer stärker durch handlungsorientierte Ansätze ersetzt (PEZ 1999: 99; FOX 1995: 105). Auf der Ebene von Stadtteilen oder Siedlungen können ermittelte Kaufkraftströme mit Hilfe von durchschnittlichen Einkaufsbeträgen je Einkauf in Verkehrsströme umgewandelt werden. Ein Verfahren wurde von SCHÄFER (2003) für das Untersuchungsgebiet in Nordschweden bereits angewendet. Aus der Modellierung von Einkäufen auf der Mikroebene, der einzelner Haushalte oder Familien, ergeben sich Einkaufsfahrten, deren Häufigkeit sowohl nach den Merkmalen des Haushalts als auch nach denen des jeweils besuchten Geschäfts (etwa nach Betriebsform) variiert werden kann. Die Berücksichtigung von Einkaufshäufigkeiten bei der Analyse von sich verändernden Pkw-Verkehr ist auf jeden Fall sinnvoll, wenn nicht sogar notwendig.

2. Modellierung und Simulation des Lebensmitteleinkaufs in der Region Umeå (Schweden)

2.1 Gegenstand der Untersuchung

Konsumverhalten steht im Spannungsfeld zwischen seinen rationalen und hedonistischen Bestandteilen. Dabei können beide als nutzenorientiert angesehen werden, beim hedonistischen Verhalten steht dann statt eines rationalen, d.h. monetarisierbaren, ein emotionaler Nutzen im Vordergrund. Ein Modell des Konsumverhaltens sollte also in der Lage sein, beide Komponenten zusammenzuführen. Für die rationalen Bestandteile der Entscheidung zur Ausgabe eines Geldbetrages sind Modelle auf Aggregats- und Individualbasis gleichermaßen geeignet und können sogar formal ineinander überführt werden (LÖFFLER, RAUH, SCHENK 2005). Hedonistische Entscheidungsabläufe sind dagegen stärker von individuellen Eigenschaften, aber auch Situationen und kurzfristigen Anreizen, die zu spontanen Reaktionen von Individuen führen, abhängig. In diesem Bereich liegen die Stärken des Multiagentenansatzes, da er das Handeln von Individuen, als Agenten modelliert, wahlweise abhängig oder unabhängig voneinander ohne zusätzliche beschränkende Annahmen, v.a. räumlicher Art, darzustellen in der Lage ist (TROITZSCH 2000).

Davon unberührt ist die Frage zu klären, welche rationalen oder hedonistischen Bestandteile der Einkaufsstättenwahl in den Entscheidungsprozess der Agenten einbezogen werden sollen. Diese müssen operationalisiert, zueinander in Beziehung gesetzt (gewichtet) und schließlich miteinander verknüpft werden. Alle drei Vorgänge stellen eine Herausforderung dar, da die Einflussfaktoren zunehmend weniger von „harten" sozio-ökonomischen Verhältnissen (Einkommen, sozialer Status, etc.) der Konsumenten abhängen, sondern impulsiven und z.T. erst während des Einkaufs produzierten Bedürfnissen folgen. Aufgrund dieser Entwicklungen erscheint es aussichtsreich, eher unterschiedliche Einkaufstypen (u.a. „smart shopper", Bequemlichkeits- und Erlebniskäufer) zu unterscheiden (HEINRITZ, KLEIN, POPP 2003: 155ff). Auch hier sind individuenbasierte Modellierungsansätze deutlich besser geeignet als ihre aggregierten Gegenstücke. Dennoch werden auch Individualmodelle des Konsumentenverhaltens nie ganz ohne verallgemeinernde Annahmen (etwa: gleichartige Verknüpfung der Nutzenkomponenten durch alle modellierten Individuen) auskommen, um die Resultate überschaubar und bewertbar zu halten. Es ist das Wesen eines jeden Modells, ein vereinfachtes Bild der Realität zu sein, das soviel Information wie nötig, jedoch so wenig wie möglich, einbezieht. Im vorgestellten Fall wird ein solches Modell für den Lebensmitteleinkauf der Bevölkerung einer ganzen Region aufgestellt.

2.2 Untersuchungsgebiet und Datengrundlagen

Die Arbeitsmarktregion Umeå in Nordschweden besteht aus sechs Kommunen mit insgesamt 140.000 Einwohnern, 70.000 davon in der Universitätsstadt Umeå, auf einer Gsamtfläche von 13.500 Quadratkilometern. Die benachbarten Kommunen bestehen jeweils aus einem Zentralen Ort mit 2 bis 3.000 Einwohnern und einem dünn besiedelten Hinterland. Die Stadt Umeå bietet eine recht diversifizierte Einzelhandelslandschaft mit traditionellen Kaufhäusern in der Innenstadt und mittelgroßen Supermärkten mit Vollsortiment in den Wohngebieten. Darüber hinaus bilden zwei Hypermärkte die Ankergeschäfte von zwei Einkaufszentren in externer Lage, ein drittes befindet sich in Planung (LÖFFLER & SCHRÖDL 2002). Die Zentralen Orte des Umlands weisen zumindest zwei Vollsortimenter, jeweils einer der beiden nationalen Marken Konsum und Ica, auf. Jedoch haben die kleineren Lebensmittelgeschäfte im Ländlichen Raum in den letzten Jahren einen massiven Rückgang erfahren. Etwa die Hälfte dieser Geschäfte musste seit Mitte der 1990er Jahre schließen. Für die Modellierung steht eine Datenbasis für alle 132 Geschäfte in der Region vom Schwedischen Statistischen Amt und vom Konsumentverket zur Verfügung (GBV & KO 1997). Sie enthält Lagekoordinaten (in einem 100-Meter-Raster), Umsatzzahlen, Größe der Verkaufsfläche und das Betriebsformat. Nationale Studien verschiedener Organisationen (PRO 2004) erlaubten die Zuteilung eines Preis- und Sortimentmerkmals zu jedem Format. In einer eigenen Erhebung wurden die Geschäfte zusätzlich bezüglich der Qualität ihrer Produkte, des angebotenen Services (Beratungspersonal und Bedienungstheken) und der Atmosphäre des Geschäfts eingestuft.

Als Nachfrageseite fungiert eine Datenbank aller Einwohner der Region (SCB 2002b), die dank einer Kooperation mit der Universität Umeå im Spatial Modelling Centre in Kiruna eingesehen und verwendet werden konnte. Sie enthält für jedes Individuum Informationen über seinen Wohn- und Arbeitsort (Lagekoordinaten im 100-Meter-Raster), Alter, Geschlecht, verfügbares Einkommen und eine Familien-ID, über die die Individuen zu Haushalten zusammengefasst werden können. Auch hier ermöglichten nationale Studien zum Ausgabeverhalten, einen Bezug zwischen Einkommen und Ausgabebeträgen für Lebensmittel herzustellen (SCB 2002a). Eine Konsumentenbefragung in Umeå diente zusätzlich dazu, Regressionsgleichungen für Konsumpräferenzen bezüglich der kartierten Geschäftsattribute abhängig von den sozioökonomischen Merkmalen der Befragten zu erhalten.

2.3 Modellannahmen und Simulationsablauf

Beim Lebensmitteleinkauf bildet der Haushalt die Konsumeinheit, die Entscheidung für ein bestimmtes Geschäft wird jedoch individuell gefällt. Aus diesem Grund wird von der Simulation zunächst ein Haushaltsmitglied (über 16 Jahre) zufällig ausgewählt, den Einkauf stellvertretend für die Familie zu tätigen. Diese bewerten anschließend alle Geschäfte mittels einer Linearkombination ihrer persönlichen Präferenzen (abgeleitet aus sozioökonomischen Merkmalen durch die Befragungsergebnisse) und der Geschäftsattribute. Die Distanz vom Wohnort, bzw. der Distanzzusatzaufwand beim Einkauf auf dem Weg zum Arbeitsplatz, tritt dabei als nutzenmindernder Faktor auf (Gleichung 1). Logistische Wahrnehmungsfunktionen überführen zusätzlich die empirischen Skalen der Geschäftsattribute in wahrgenommene.

$$W_{i,g} = \frac{1}{d_{i,g}} \sum_k P_{i,k} * \beta_k (A_{g,k}) \qquad (1)$$

mit:

$W_{i,g}$	Bewertung des Geschäfts *g* aus Sicht des Konsumenten *i*
$d_{i,g}$	Distanz zwischen Konsument *i* und Geschäft *g*
k	Bewertungskriterium (z.B. Preis-, Qualitätsniveau, Sortimentsbreite, …)
$P_{i,k}$	Präferenz des Konsumenten *i* für Kriterium *k*
β_k	Wahrnehmungsfunktion für Kriterium *k*
$A_{g,k}$	Attributwert des Geschäfts *g* im Kriterium *k*

Gemäß dieser Bewertung übertragen die Agenten einen Anteil ihres Lebensmittelbudgets auf den Umsatz des betrachteten Geschäfts, der in seiner Summe mit dem realen Umsatz verglichen wird. Dieser Vergleich erlaubt, eine Güte der Umsatzschätzung durch das Verhaltensmodell anzugeben. Neben der Validierung auf dieser globalen Ebene bieten individuenbasierte Ansätze jedoch auch die Möglichkeit, das lokale Verhalten der Agenten zu bewerten. Dazu können die Einkaufspfade einzelner Agenten betrachtet und einer qualitativen Überprüfung unterzogen werden. Aufgabe der Modellkalibrierung ist, auf beiden Ebenen ein valides Ergebnis zu erzeugen.

2.4 Implementierung

Zur Implementierung wird das Simulationsshell SeSAm genutzt, das am Lehrstuhl für Künstliche Intelligenz an der Universität Würzburg entwickelt wurde (KLÜGL 2001, www.simsesam.de). In SeSAm werden drei Typen von Objektklassen unterschieden: Agenten, Ressourcen und die Welt. Alle drei können Variablen besitzen, die Ressourcen unterscheiden sich von den anderen Typen durch das Fehlen eines Aktivitätsgraphen. In dessen Knoten werden die abzuarbeitenden Aktionen für die Agenten und die Welt festgelegt. Sie sind durch gerichtete Kanten mit einander verbunden, wodurch die Reihenfolge der Simulationsschritte vorgegeben wird. Die Kanten können zusätzlich mit Bedingungen belegt werden, so dass auch Verzweigungen des Aktivitätsgraphen nach verschiedenen Situationen möglich sind.

Im vorgestellten Modell werden die simulierten Familien als Agenten dargestellt, die Geschäfte, da ihnen kein „Verhalten" zugestanden wird, als Ressourcen. Außerdem werden noch die Maschen des 100m-Gitters als Ressourcen vorgehalten, was später bei der Distanzberechnung von Vorteil ist, da dadurch die Größe der Distanzmatrix deutlich verringert werden kann. Die Welt nimmt übergeordnete Aufgaben wahr.

Zur ausführlichen Diskussion des Modells zum Lebensmitteleinkauf wird auf SCHENK et al. (2004), SCHENK et al. (2005) und LÖFFLER, RAUH, SCHENK (2005) verwiesen. Im Folgenden wird nun der Fokus auf den Einsatz der Simulation zur Abschätzung von Distanzaufwänden beim Lebensmitteleinkauf in verschiedenen Szenarien gerichtet.

3. Abschätzung von Distanzaufwänden

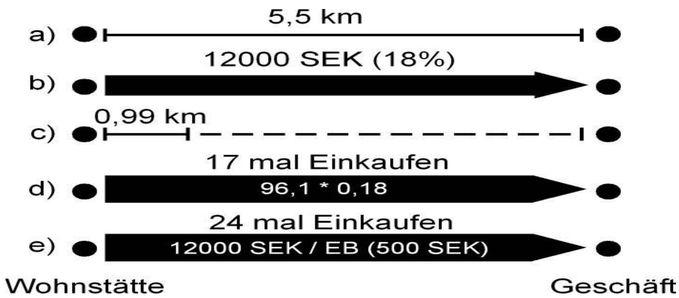
3.1 Stand der Mobilitätsforschung

Da die entscheidenden Einflussgrößen für die Wahl der Einkaufsstätte im verwendeten Modell bereits enthalten sind, gilt es, jene für das „Verkehrsverhalten" entweder zu ergänzen oder Präferenzberechnungen im Sinne der Mobilität zu verändern. Im Allgemeinen besteht Unsicherheit über die Einflussgrößen für Einkaufshäufigkeiten und deren Richtung und Stärke. Als theoretische Grundlage für die Betrachtung von zirkulärer Mobilität kann etwa die Time Geography von HÄGERSTRAND herangezogen werden, die deutlich macht, dass die Bewegungen des Menschen, sowie sein gesamter Tagesablauf, das Ergebnis von unterschiedlichen Zwängen sind, die im Raum-Zeit-Kontinuum wirksam werden (HÄGERSTRAND 1970:146f, GOLLEDGE & STIMSON 1987). Wichtige Erkenntnisse konnten in quantitativen Studien, so etwa durch das individualbasierte Modell von KUTTER (1973), bestätigt werden. Dort wurden der Tagesablauf und damit auch die Verhaltensmuster für die Häufigkeit von individuellen Ortsveränderungen stark von dem sozialen Status der Person und deren Zugehörigkeit und Position zu und in einem Haushalt abhängig gemacht. Kutter unterscheidet etwa Schüler, Hausfrauen, Beschäftigte, Rentner als wichtige Gruppen (KUTTER 1973: 236-240). Diese und andere Ansätze machen die einzelnen Dimensionen der individuellen Mobilität des Menschen (Ziele, Entfernungen, Häufigkeiten, Zeitaufwand) nicht vorhersehbar. Gerade bei der Untersuchung von Einkaufsfahrten bleibt so meist nur die Identifizierung von prägenden Einflussgrößen und deren ansatzweise Gewichtung. Letztere kann durch multivariate Datenanalysen aus empirischem Material ermittelt werden, ist jedoch je nach Untersuchungsgebiet und Methodik unterschiedlich (HOFMAYER 1997: 12). Allgemein kann keine Einflussgröße, die für die Verteilung der Ausgaben auf unterschiedliche Geschäfte als prägend angenommen wird, für die Wirksamkeit auf Einkaufshäufigkeiten ausgeschlossen werden. Eine Besonderheit des Lebensmitteleinkaufs ist die Notwendigkeit, Variablen auf der Haushalts- und Personenebene zu unterscheiden, da Entscheidungen auf beiden Ebenen getroffen werden können. Bei gleicher Bedarfsmenge ist die Einkaufshäufigkeit bei Grundbedarfsgütern zudem auch eine Maßzahl für das durchschnittliche Einkaufsvolumen. Daher spielt etwa die Pkw-Verfügbarkeit eine große Rolle (HOFMAYER 1997:8f). Wichtige Merkmalsgruppen sind neben der Motorisierung die Haushaltsgröße (Bedarfsmenge), Berufstätigkeit der Haushaltsmitglieder (personelle Zeitressourcen) und die Lebenszyklusphase des Haushalts. Zusätzlich haben die Raummerkmale des Wohnstandorts einen Einfluss (HOFMAYER 1997:145f). Unterschiedliches Verhalten bei der Fristigkeit der Bedarfsdeckung wird auch durch die Präferenzen für unterschiedliche Betriebsformen wirksam, die auch ein Ergebnis dieser Einflussgrößen sind. Je nach gewählter Betriebsform wird unterschiedlich oft eingekauft, dies zeigen empirische Studien in Deutschland und Schweden (z.B. KAGERMEIER 1991: 38, KULKE 1994, GARVILL, KNUTSSON, MARELL, WESTIN 2003: 28, LÖFFLER & SCHRÖDL 2002).

3.2 Modellierung der Interaktionen

Ausgangspunkt für eine Berechnung von Verkehrsvorgängen sind die in Abbildung 1 dargestellten Informationen über die Interaktionen: Die euklidische Distanz zwischen der Wohnstätte der Familie und einem Geschäft (a) sowie der Ausgabebetrag pro Jahr am jeweiligen Geschäft (b). Im Beispiel werden 12000 Schwedische Kronen (SEK) ausgegeben, was etwa 18% der gesamten Ausgaben pro Jahr ausmacht. Der Wert 0,18 ist ein Wert für die relative Attraktivität des Geschäfts aus Sicht der Familie, als Ergebnis der Bewertungsfunktion (1).

Abbildung 1: Schema zur Berechnung der Distanzaufwände der einzelnen Familien



Quelle: Eigene Darstellung

Die in (c) dargestellte gewichtete Distanz ergibt sich durch die Multiplikation dieses Wertes mit der Distanz. Die Summe aller Werte für die einzelnen Geschäfte ergibt die Distanz pro Einkauf, die von der Familie pro Jahr zurückgelegt wird. Die Einkaufshäufigkeit am Geschäft lässt sich mit Hilfe zwei verschiedener Methoden berechnen.

- Für Methode 1 wird die Einkaufshäufigkeit pro Jahr gemäß den Ausgabeanteilen pro Jahr gewichtet (Fall d) in Abb. 1). Im vorliegenden Modell konnten unter Verwendung empirischer Daten (SCB 1999b) je nach Haushaltstyp unterschiedliche Einkaufshäufigkeiten pro Jahr angesetzt werden. Im Beispiel errechnet sich die Einkaufshäufigkeit am Geschäft durch die Einkaufshäufigkeit insgesamt pro Jahr für Zusammenlebende ohne Kind (96,1) und der relativen Attraktivität. Die Einkaufshäufigkeit an einem gewissen Standort ist damit zusätzlich von weiteren Haushaltseigenschaften abhängig.
- Für Methode 2 sind die Einkaufshäufigkeiten am Standort stattdessen zusätzlich vom Betriebstyp abhängig. Der Einkaufsbetrag (EB) wird je nach Geschäftstyp verschieden angesetzt. Damit wird die Attraktivität, gemäß empirischen Erkenntnissen (SCB 1999b), im Sinne der Mobilität angepasst (Fall e) in Abb. 1). Die verwendeten Geschäftstypen ergeben sich aus der Einteilung in Betriebsformen und die Einstufung für Preis, Qualität und Sortiment.

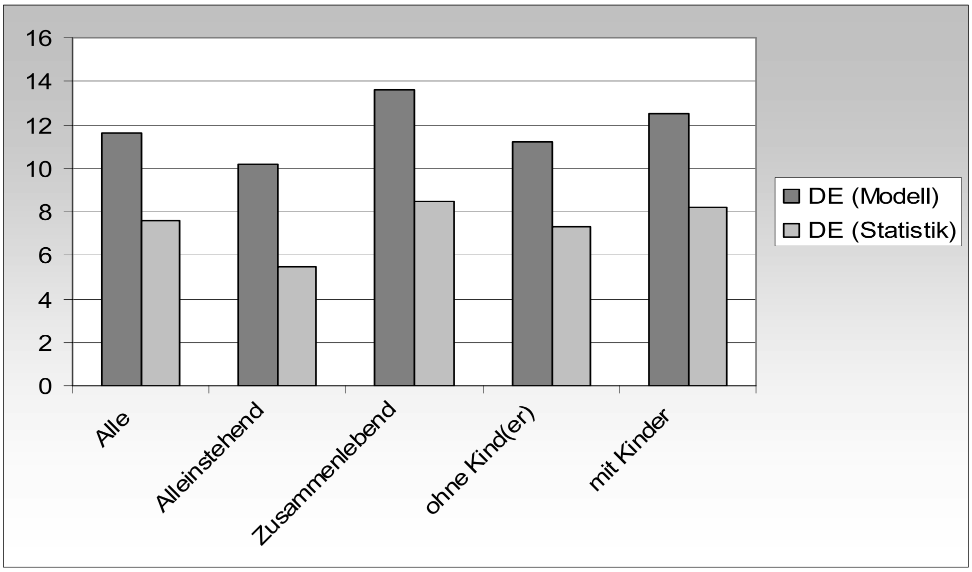
So ergibt sich für Methode 1 (d) nur für den Einkauf am dargestellten Geschäft ein jährlicher Distanzaufwand von 95 km, für Methode 2 (e) beträgt er 132 km.

3.3 Vergleich mit der amtlichen Mobilitätsstatistik

Während der 1990er Jahre wurden in Schweden jährlich Umfragen zur Mobilität der Bevölkerung durchgeführt (z.B. SCB 1999a). Aus jenen Daten können nicht nur Einkaufshäufigkeiten für verschiedene Haushaltstypen sondern auch deren durchschnittliche Distanz pro Einkauf ermittelt werden. Da die im Modell verwendeten Datensätze detaillierte Informationen über Haushaltsgrößen und Haushaltstypen enthalten, konnten die ermittelten Werte aus dem Simulationsmodell mit offiziellen Daten von Mobilitätserhebungen verglichen werden. Trotz einiger Schwierigkeiten bei der Umrechnung von unterschiedlichen Reise-/Wegeniveaus und der insgesamt kleinen Stichprobe können Orientierungswerte für den Lebensmitteleinkauf ermittelt werden. Für die Umrechnung ist entscheidend, dass beide Werte, der Durchschnitt der Summen der gewichteten Distanzen und die angegebenen Werte in der Statistik, sich auf die Einheit „Einkauf" als ein Teil einer Wegekette beziehen. Abbildung 2 zeigt die recht hohe Übereinstimmung der auf Familienniveau für unterschiedliche Haushaltstypen ermittelten Distanz pro Einkauf des Modells mit den empirischen Daten (SCB 1999b).

Die systematisch erhöhten Werte für das Modell ergeben sich aufgrund des durch die Modellannahmen wenig eingegrenzten Aktionsradius der Familien. Alle Geschäfte der gesamten Region wurden von den Agenten wahrgenommen und bewertet. Auch sind die empirischen Werte für ganz Schweden, d.h. für die überwiegend städtische Bevölkerung, erhoben. Für Beispielfamilien aus Umeå ergeben sich Werte, die näher an den ermittelten empirischen Werten liegen, während für ländliche Räume extrem hohe Werte modelliert werden (siehe Tabelle 2).

Abbildung 2: Vergleich der Distanzaufwände der Familien durch die Modellberechnung mit der amtlichen Statistik



DE = Distanz pro Einkauf im Jahr 1997 (in km)
Quelle: Statistik des Riks-RVU 1996-1998 (SCB 1999b), eigene Berechnungen

3.4 Auswirkungen von Veränderungen der Angebotsstruktur

Als planungsrelevante Fragestellung im Kontext von Einzelhandel und Verkehr werden im Rahmen des Leitbildes der nachhaltigen Stadtentwicklung die Verkehrswirkungen von Änderungen in der Angebotsstruktur teilweise kontrovers diskutiert (HOLZ-RAU 1991, KULKE 1994, REINHOLD, JAHN, TSCHUDEN 1997, BORSDORF & SCHÖFFTHALER 2000). Insbesondere die Auswirkungen der Ansiedlung von großflächigem Einzelhandel an nicht-integrierten Standorten oder auch allgemein des Wandels im Einzelhandel auf den Stadtverkehr (Belastung durch Mehrverkehr und Lärm) sowie die Haushalte und die Umwelt („Zwangsmobilität“, Energieverbrauch) wird insbesondere seit den 1990er Jahren in der Wissenschaft intensiv diskutiert (vgl. HESSE 1999, HEINRITZ, KLEIN, POPP 2003: 184f, HAGSON 2003: 5). Zu beachten sind dabei die vielseitigen Wechselwirkungen zwischen neuem und bestehendem Einzelhandel, zwischen Einkaufsverhalten und Verkehrsmittelwahl und deren Anpassung.

Das vorliegende Simulationsmodell eröffnet die Möglichkeit, Teilaspekte dieser Entwicklungen anhand folgender Hypothesen zu analysieren:

1) Durch eine Ausdünnung des Versorgungsnetzes im Einzelhandel kommt es in der Summe zu längeren Einkaufswegen, aber auch überwiegend zu einer erhöhten Distanz pro Einkauf. Zu diesem Ergebnis kommen die meisten Studien (KULKE 1994: 290, HOLZ-RAUH 1991: 302, REINHOLD et al 1997: 114). Dies bedeutet, dass sich bei unveränderter Mobilität (Zahl der Einkäufe) der Gesamtdistanzaufwand für die meisten Familien erhöht.
2) Jedoch kann es mit der Veränderung der Mobilität, d.h. durch eine Anpassung des Einkaufsverhaltens, zu einer Verringerung des Distanzaufwandes kommen.

Über Verkehrsaufwände und über Belastung von Straßen oder durch Lärm können hier keine Aussagen gemacht werden. Hier geht es zunächst um den Aufwand des Konsumenten. Für die vorliegende Untersuchung konnten die Angebotsveränderungen im Zeitraum von 1997 bis 2004 kartiert werden, in dem die Zahl der Lebensmittelgeschäfte in der Region von 132 auf 85 sank. Dabei ergaben sich wenige Veränderungen für den großflächigen Einzelhandel (>400m² Verkaufsfläche). Bedeutend ist die Ansiedlung des Hypermarkts „ICA Maxi" am südöstlichen Stadtrand von Umeå. Innerhalb der Stadt Umeå wurden einzelne mittelgroße Supermärkte aufgegeben. Die Supermärkte der Innenstadt sind unverändert geblieben. Der größte Teil der Schließungen betraf kleinflächige Angebotsformen wie Kioske und Tankstellenshops (schwed. Service- und Trafikbutiker) sowie Supermärkte unter 400 m² Verkaufsfläche (schwed. Lanthandel), insbesondere im ländlichen Raum der Region. Mit einem Rückgang der Anzahl von 45% zeigt sich eine starke Ausdünnung dieses Standortnetzes für die gesamte Region, auch für das Stadtgebiet von Umeå. Für die nördlichen Regionen Schwedens ist seit Jahrzehnten eine besonders starke Ausdünnung des Versorgungsnetzes in den ländlichen Räumen zu beobachten, worauf die Politik mit Blick auf die regionale Entwicklung mit Maßnahmen (Subventionen) reagiert hat (LÖFFLER 2004: 18).

Für eine Analyse über die Art und das Ausmaß der Veränderungen der Mobilität und des Einkaufsverkehrs wird angenommen, dass die Eigenschaften der Bevölkerung – Größe, Zusammensetzung, Einkommen etc. – sich zwischen 1997 und 2004 nicht verändert haben. Die Analyse soll keine fundierte Prognose beinhalten. Vielmehr werden eindeutige Tendenzen festgehalten, sowie die Ergebnisse der Methoden verglichen. Für die Berechnung von Gesamtdistanzaufwänden für Familien bzw. die gesamte Region werden die beiden oben bereits geschilderten Methoden verwendet. Für beide Methoden ist die Einkaufshäufigkeit abhängig von den Familien-/Einkäufermerkmalen, die für die Berechung der Einkaufspräferenzen bestimmend sind. Für Methode 1 bleibt bei eintretenden Veränderungen der Einzelhandelsstruktur die Zahl der Einkäufe pro Jahr gleich. Je nach Betriebstyp werden für Methode 2 Einkaufsbeträge zwischen 50 SEK (Tankstelle) und 550 SEK (SB-Warenhaus) zugewiesen. Bei eintretenden Veränderungen der Einzelhandelsstruktur verändert sich die Zahl der Einkäufe pro Jahr. So können Ergebnisse von abgelaufenen Veränderungen der Einzelhandelsstruktur oder von Szenarien als Prognose analysiert werden. Gemäß den Ergebnissen der Einkäufersimulation kommt es für Methode 1 zu einer Erhöhung des Gesamtdistanzaufwandes zwischen 1997 und 2004 (Tabelle 1). Für die Methode 2 kommt es zu einer Verringerung des Gesamtdistanzaufwandes innerhalb der Region. Der Grund ist die geringer angesetzte Einkaufshäufigkeit (höhere Einkaufsbeträge) für den großflächigen Einzelhandel, dessen Bedeutung zugenommen hat. Die durchschnittliche Einkaufshäufigkeit ging von 87 auf 80 Einkäufe pro Jahr zurück.

Tabelle 1: Veränderung des Gesamtdistanzaufwandes (in km pro Jahr) für die Methoden

	1997	2004	Veränderung
Methode 1	671.463	695.508	+3,58%
Methode 2	739.663	714.977	-3,34%

Quelle: Eigene Berechnung

Jedoch sind die Familien recht unterschiedlich von der Veränderung des Gesamtdistanzaufwandes betroffen. So kommt es nach Methode 1 nur für 58% aller Familien zu einer Zunahme der Distanz pro Einkauf. Für einen Großteil der Familien in Umeå ergibt sich, durch eine stärkere Kaufkraftbindung für die Stadt Umeå, eine Verringerung.

Tabelle 2: Veränderungen der durch das Modell errechneten Distanzaufwände einzelner Familien zwischen den Angebotsstrukturen 1997 und 2004

			1997			2004			Veränderung	
Methode 1		HH	DE	D	H				D	
	1 Innenstadt	210	3,19	330,4	103,6	2,96	306,5	103,6	-7,21%	
	2 Nordmaling	100	25,97	1926,7	74,2	27,83	2064,7	74,2	7,16%	
	3 Gimonäs	200	5,48	526,6	96,1	3,27	314,2	96,1	-40,33%	
	4 Obbola	110	13,19	1361,1	103,2	11,24	1159,9	103,2	-14,78%	
Methode 2		HH	DE	D	H	DE	D	H	D	H
	1 Innenstadt	210	3,79	461,5	121,9	3,34	386,3	115,5	-16,30%	-5,25%
	2 Nordmaling	100	24,06	1205,2	50,1	25,94	1234,9	47,6	2,46%	-4,99%
	3 Gimonäs	200	5,68	660,8	116,3	4,00	364,4	91,2	-44,86%	-21,58%
	4 Obbola	110	12,93	1953,3	151,1	11,48	1278	111,3	-34,57%	-26,34%

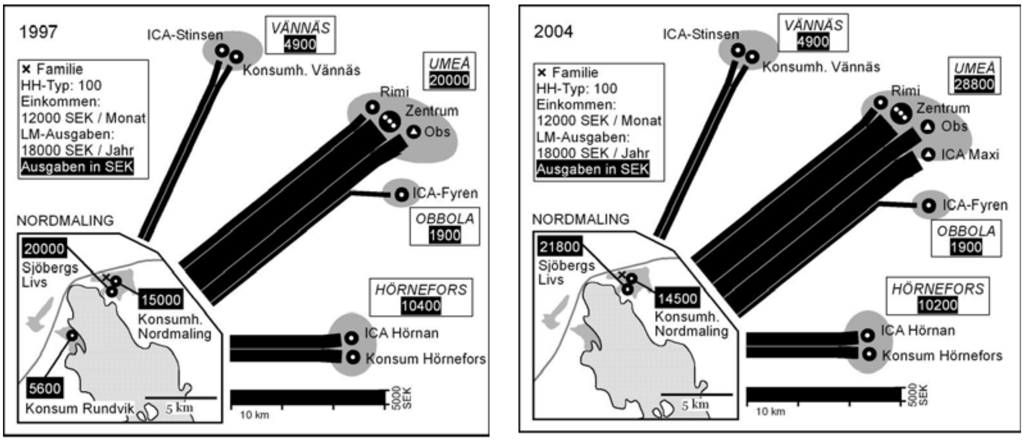
DE = Distanz pro Einkauf (gesamt); D = Gesamtdistanzaufwand im Jahr; H = Anzahl der Einkäufe pro Jahr; HH = Haushaltstyp

Quelle: Eigene Berechnungen

Zum Vergleich werden in Tabelle 2 Beispielfamilien mit Wohnung in verschiedenen Teilen der Region herangezogen. Die Lage zum neuen SB-Warenhaus in Umeå ist besonders bedeutsam. Für Familie 1 mit Wohnung in der Innenstadt gibt es kaum Veränderungen für die Haupteinkaufsstätten. Familie 2 wohnt in Nordmaling. Im 5km entfernten Rundvik hat ein Geschäft geschlossen, in dem 1997 ca. 6% der lebensmittelrelevanten Kaufkraft ausgegeben wurden. Die Familie 3 im Umeå-Stadtteil Gimonäs hat mit ICA-Maxi in unmittelbarer Nähe eine neue attraktive Einkaufsmöglichkeit bekommen. Familie 4 im Umeå-Vorort Obbola reagiert auf eine Schließung eines mittelgroßen Supermarktes im Osten von Umeå. Das neue SB-Warenhaus ist fast genauso weit entfernt. Für viele Familien entscheidet die Neuverteilung der Ausgaben auf die beiden SB-Warenhäuser in Umeå meist schon darüber, ob sich die Gesamtdistanz erhöht.

Die Jahreswerte für alle Geschäfte bringt nicht genügend Einsicht in die Ursachen für die Veränderungen. Mit der Betrachtung der vom Modell generierten Einkaufslisten einzelner Familien können einige wichtige Zusammenhänge besser analysiert werden. Dazu speichert das Simulationsprogramm für jede Familie die Ausgabebeträge an den einzelnen Geschäften. Abbildung 3 zeigt die räumliche Verteilung der Ausgaben auf die ersten 8 Geschäfte der Ausgaberangliste für die beiden Jahre. Zusätzlich sind die Distanzen zwischen den Geschäften und der Wohnung der Familie 2 in Nordmaling angegeben. Durch die Schließung einer bedeutenden Einkaufsstätte (Konsum Rundvik) und die Ansiedlung des neuen Hypermarktes kommt es zu großen Verschiebungen der Kaufkraftströme. Dabei werden Einkäufe bei Konsum mit 5 km pro Einkauf durch Einkäufe bei ICA Maxi mit 47 km nahezu ersetzt.

Abbildung 3: Verteilung (Modellberechnung) der Kaufkraft (in schwed. Kronen SEK, gerundet) einer Familie in Nordmaling auf verschiedene Geschäftsstandorte 1997 und 2004.



Quelle: Eigene Berechnungen

Die Gründe für die hohen Werte für die Distanz pro Einkauf und deren Anstieg werden bereits bei der Betrachtung der wichtigsten Einkaufsstätten deutlich. Das Wegfallen ehemaliger Einkaufsstätten und eine neue attraktive und weit entfernte Einkaufsstätte führen zu einem erhöhten Gesamtdistanzaufwand.

In Tabelle 3 sind die Auswirkungen auf die Einkaufshäufigkeiten in unterschiedlichen Einkaufsstätten für die Familien in Nordmaling und Obbola und der Einfluss der verwendeten Methode zu sehen.

Tabelle 3: Veränderung der Anzahl der Einkäufe pro Jahr

Familie in...		Haupteinkaufsstätte (1997)	ICA Maxi	andere näher gelegene Geschäfte*	übrige Geschäfte
Nordmaling	Methode 1	+1	+6	-6	-1
	Methode 2	+1	+3	-5	-1
Obbola	Methode 1	-23	+81	-10	-49
	Methode 2	-36	+80	-15	-68

* im Vergleich zu ICA Maxi; Quelle: Eigene Berechnungen

Die bereits beschriebenen Entwicklungen für die Familie in Nordmaling haben zur Folge, dass in Geschäften, die näher als ICA Maxi liegen, 6 bzw. 5 Einkäufe weniger getätigt werden. Stattdessen wird sechsmal bei ICA Maxi eingekauft, bzw. dreimal für Methode 2. Für die übrigen Geschäfte und die Haupteinkaufsstätte (Sjöbergs Livs) ergeben sich kaum Unterschiede.

Für die Familie in Obbola werden noch stärkere Verschiebungen prognostiziert. Die bisherige Haupteinkaufsstätte wird ersetzt durch das neue SB-Warenhaus, welches fast genauso weit entfernt ist. Zusätzlich wird ein großer Teil der Ausgaben von weiter entfernten Geschäften zu ICA-Maxi verlagert (49 bzw. 68 Einkäufe). Besonders deutlich wird die Wirkung der Methode 2. Im Vergleich zu Methode 1 werden mehr distanzaufwändige Einkäufe durch weniger Einkäufe bei ICA Maxi ersetzt, da größere Einkaufsbeträge angewendet werden.

4. Fazit

Das agentenbasierte Modell reproduziert in etwa die Distanz pro Einkauf und berücksichtigt auch im Bezug auf die Mobilität den Einfluss der Haushaltszusammensetzung. Mit einer Vorauswahl an wahrgenommenen Geschäften und weiteren Verbesserungen des Einkaufsmodells ist möglicherweise eine noch bessere Übereinstimmung zu erreichen. Die Einkaufshäufigkeit ist für Gesamtdistanzaufwände der Familien oder zumindest deren Veränderung entscheidend. Wenn zentrale Einflussgrößen für diese Dimension der Mobilität umgesetzt werden können, ist es möglich, eine differenzierte Sicht auf die Auswirkungen des Wandels im Einzelhandel zu erlangen. Da der Lebensmitteleinkauf von alltäglichen Gewohnheiten geprägt (habituell) ist, ist eine starke Veränderung von Einkaufshäufigkeiten innerhalb von 5 Jahren nicht wahrscheinlich. Der Wandel im Einzelhandelsangebot führt für die Mehrzahl der Haushalte im Untersuchungsgebiet zu erhöhten Entfernungen pro Einkauf. Der nächste Schritt für eine bessere Modellierung von Auswirkungen auf den Verkehr in der Stadt ist eine Implementierung der Wahl des Fortbewegungsmittels. Die beiden Entscheidungen – über die Einkaufsstätte und das Fortbewegungsmittel – müssen als miteinander verwoben umgesetzt werden. Mit Blick auf Einkaufshäufigkeiten ist es notwendig, mehrere Einflussgrößen gleichzeitig zu berücksichtigen. Dies kann, neben weiteren Merkmalen zum Umfeld der Familien auch die Raumstruktur (Land-Stadt) sein.

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Abstract

The study shows how an agent based simulation of consumer choice behaviour in grocery shopping can be used to elaborate on questions of traffic induced by the supply with daily goods. The functionality of a model and simulation of consumer choices with an agent based approach on the level of an entire region in northern Sweden is outlined. That model is then used to estimate the households' distance efforts on their shopping trips. The results show a remarkable consistency with official mobility statistics. Subsequently, the changes in those interaction patterns caused by alterations in the spatial structure of retail outlets, particularly the closure of stores in the rural areas and new large scale retail establishments in town edge locations, are examined. While an increase of distance efforts especially for the rural population can be shown, their urban counterparts may even take advantage of shorter shopping trips due to a higher local buying power allocation.
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Cost-Benefit Analysis of the Electronic Stability Program (ESP)

BY HERBERT BAUM, SÖREN GRAWENHOFF AND TORSTEN GEIßLER, COLOGNE

Contents

1. Aim and approach of the study

Traffic safety is one of the main issues of national and European transport policy. In the year 2001, the European Commission set the goal to halve the number of people killed on roads between 2000 and 2010.[1] The reason for the prioritisation of road safety can be seen in the costs to society arising from accidents. Estimations assume that

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Authors' address:
Prof. Dr. Herbert Baum
Dr. Sören Grawenhoff
Dr. Torsten Geißler
Institute for Transport Economics at the University of Cologne
Universitätsstr. 22
50923 Cologne, Germany
e-mail: h.baum@uni-koeln.de

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1 European Commission, White Paper – European transport policy for 2010: time to decide, Brussels 2001, p. 66

these costs accrue to € 160 billion per year in the European Union.[2] In Germany, accident costs amounted to about € 30.9 billion in the year 2004.[3]

There is worldwide consensus that the improvement of road safety requires a holistic approach which covers the three pillars vehicle technology, infrastructure and the human driver. On European Union level, beyond action taken in the Road Safety Action Programme[4] and the eSafety initiative[5], this view is also adopted by the CARS 21 group.[6]

The importance of new vehicle technologies for achieving the aim of an improved road safety is emphasised in all road safety programs. The Electronic Stability Program (ESP) is widely regarded as one of the most promising safety-relevant technologies, which often are referred to as Driver Assistance Systems. ESP has been introduced onto the market over 10 years ago. Therefore, the potential of ESP to avoid or mitigate accidents has been analysed and proven in several studies.

In the following a socio-economic impact assessment will be carried out for the Electronic Stability Program. It will be quantified which amount of accidents and accident costs might be avoided in the European Union with the help of the ESP-equipment of cars. There are two main results of the study:

- In a first step the accident cost savings, which can be achieved with ESP-equipment of cars, are compared with the costs of equipping cars with the system. This enables the calculation of a Benefit-Cost-Ratio.
- It is further examined, how effective measures to foster market penetration could be in the future in terms of higher accident (cost) savings. Therefore, future accident (cost) savings are calculated for two forecast scenarios. In the first scenario (Trend Scenario), the development of ESP-equipment-rates is forecasted under the assumption that ESP continues to be an optional system. In the second scenario (Scenario “Mandatory Equipment”), the equipment rates are forecasted under the assumption that from 2008 onwards all newly registered cars in the European Union are equipped with ESP.

The geographical scope of the study comprises the European Union of 25 member states. In order to gain spatially differentiated results, the EU-25 is subdivided into the following areas: Germany, France, Italy, Spain, United Kingdom, EU-15, EU-25.

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2 European Commission, Road Safety – Results from the transport research program, Brussels 2001, p. 2

3 Bundesanstalt für Straßenwesen (Bast), Volkswirtschaftliche Kosten durch Straßenverkehrsunfälle in Deutschland 2004, BASt-Info 02/06, Bergisch Gladbach 2006

4 European Commission, European road safety action programme, COM (2003) 311, Brussels 02.06.2003

5 European Commission, Information and Communication Technologies for Safe and Intelligent Vehicles, COM (2003) 542, Brussels 15.09.2003.

6 European Commission. Enterprise and Industry Directorate-General, CARS 21 – A Competitive Automotive Regulatory System for the 21st Century, Final Report, Luxembourg 2006, p. 32

2. Cost-Benefit Analysis

2.1 Methodical approach

The Cost-Benefit-Analysis (CBA) is an economic assessment tool, which provides methods for evaluating the social desirability of investments in certain projects, services, systems etc. The fundamental idea of a CBA is that public decisions should be based on economic considerations as it is done in the private sector (e.g. profit and loss accounts).

The result of a Cost-Benefit-Analysis constitutes the calculation of a Benefit-Cost-Ratio, which can be formally expressed as follows:

$$BCR = \frac{\sum_{t=0}^{T-1} Bt(1+i)^{-t}}{\sum_{t=0}^{T-1} Ct(1+i)^{-t}}$$

BCR = Benefit-Cost-Ratio
T = Time horizon of analysis (pre-defined)
Bt = Benefits for the year t
Ct = Costs for the year t
i = discount rate

Subject of the CBA in this study are the costs and benefits which are connected with the ESP-equipment of cars. The benefits lie in the improved vehicle stability due to ESP which leads to accident cost savings. Two steps are needed to assess the benefits: First, the benefits have to be quantified in physical terms. This means that the number of avoided accidents has to be determined. Secondly, the resulting physical benefits have to be valued monetarily in order to compare them with the costs. The costs consist of the costs to install and operate the ESP. After the temporal harmonisation of benefits and costs the relation of benefits and costs, the so called Benefit-Cost-Ratio, can be calculated constituting the final result of the analysis. If the benefits exceed the costs, the Benefit-Cost-Ratio is larger than one and the measure is profitable for society.

2.2 Benefits of ESP

2.2.1 Accident avoidance potential of ESP – literature review

ESP assists the driver actively in keeping track and direction by direct intervention into the braking and motor-management system. The system constantly measures the longitudinal and lateral dynamics of the vehicle depending on the driver action and identifies critical driving situations. It then stabilises the vehicle by braking the different wheels individually and by lowering the engine torque. With these functionalities ESP is able to avoid skidding of vehicles and is thus also able to avoid accidents due to the loss of vehicle control. Several analyses of accident statistics show that skidding accidents roughly constitute 20 % of all car accidents. The different results are shown in Table 1.

Table 1: Share of car skidding accidents in relation to all car accidents

Authors of the study	Publication year	Analysed area / Data used	Car skidding accidents / all car accidents	
			Injury accidents	Fatal accidents
Langwieder, K., Gwehenberger, J., Hummel, T.	2004	International field tests	25 %	35 – 40 %
Unselt, T., Breuer, J., Eckstein, L., Frank, P.	2004	Germany	21 %	43 %
Sferco, R., Page, Y., LeCoz, J.Y., Fay, P.	2001	European accident Causation Survey (EACS)	18 %	34 %
Page, Y., Cuny, S.	2004	France	20 %	40 %

Source: Knoll, P. M., Langwieder, K., Der Sicherheitseffekt von ESP in Realunfällen, Überlegungen zum volkswirtschaftlichen Nutzen von prädiktiven Fahrerassistenzsystemen, Vortragsunterlagen anlässlich der 2. Tagung "Aktive Sicherheit durch Fahrerassistenz" am 4./5. April 2006, Garching bei München.

It can be seen that the potential accident avoidance of ESP lies at about 20 % for injury accidents and ca. 40 % for fatal accidents. The higher potential of ESP to avoid fatal accidents than injury accidents stems from the fact, that the ESP-relevant skidding accidents are over-proportionally very severe accidents. The share of skidding accidents in all accidents is therefore higher for fatal accidents than for injury accidents.

These skidding accidents constitute the theoretically possible accident avoidance potential of ESP, since these accidents can be influenced with the help of ESP. The second relevant question is, how many of these accidents will actually be prevented by ESP. This questions aims at answering the effectiveness of ESP concerning the relevant accidents.

In general it can be said, that the larger the referred accident group, the lower is the effectiveness rate. The more precisely the relevant accidents are consisting only of ESP-relevant accidents, the higher is the effectiveness rate. If, for example, ESP is able to avoid 50 % of all skidding accidents (effectiveness rate = 50 %) and skidding accidents make up 30 % of all accidents, than the effectiveness rate of ESP referring to all accidents is 15 %.

Analyses of real accident data started in 2002 and 2003, verifying the effectiveness estimations:

– Tingvall e.a. used the "induced exposure method" to analyse the effectiveness of ESP.[7]

[7] Tingvall, C., Lie, A., Krafft, M., Kullgren, A., The effectiveness of ESC (Electronic Stability Control) in reducing real life crashes and injuries, in: Traffic Injury Prevention, vol. 7, issue 1, March 2006, pp. 38-43

This method consists of analysing the accident events of vehicles with and without ESP. First, an accident type which is insensitive to ESP is chosen (e.g. rear end crashes). The crash number relation between ESP-equipped vehicles and not equipped vehicles for this accident type is taken as a reference. Deviations from this relation concerning ESP-sensitive accidents are taken as a result of the ESP. Related to all accidents (excluding rear end accidents), 16.7 % of crashes with personal injuries could be avoided by ESP. For fatal accidents, this effectiveness rate increased to 21.6 %.

– Other studies have proven effects in about this magnitude. A study conducted by the NHTSA showed a reduction of 35 % of single vehicle accidents[8], another study by Unselt e.a. found out a 40 % reduction referring to loss-of-control crashes.[9] These results are underlined by two similar studies from DaimlerChrysler and Volkswagen. After the introduction of ESP as standard equipment in Mercedes-Benz cars, the share of driving accidents dropped from about 20 % to 12 %, a reduction of 40 %. Vehicles from other manufacturers showed a reduction of 2.5 percentage points, which equals a reduction of only 13 %. This can be explained by the fact that only some of the other vehicles had been equipped with ESP at that time. A similar analysis has been undertaken by Volkswagen. Here, accidents, where a car left the road have been chosen as the accident category sensitive to ESP. The share of this accident category decreased from ca. 13 % to about 7 %, a reduction of about 46 %.[10]

The different studies mentioned above show fairly similar results. The findings ba-sed on real accident events with and without ESP show, that around 40 % of ESP-sensitive car accident types (= driving accidents; accidents, where a vehicle leaves the road; single vehicle accidents etc.) are actually avoided. These accidents make up about 15 % to 40 % of all car accidents depending on the category used to define ESP-sensitive accidents. This means that referring to all car accidents, 6 % to 16 % reduction of personal damage accidents can be attributed to ESP.

2.2.2 Accident avoidance potential of ESP estimated in this study

Basis of the EU-wide accident avoidance estimation in this study are the “Statistics of road traffic accidents in Europe and North America” issued by the United Nations.[11]

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8 Dang, J., Preliminary results analysing the effectiveness of Electronic Stability Control (ESC) systems, DOT HS 809 790, Washington 2004, in: Anders, L., Tingvall, C., Krafft, M., Kullgren, A., The effectiveness of ESC…, loc. cit.

9 Unselt, T., Breuer, J., Eckstein, L., Frank, P., Avoidance of „loss of control crashes“ through the benefit of ESP, FISITA Conference Paper No. F2004V295, Barcelona 2004, in: Anders, L., Tingvall, C., Krafft, M., Kullgren, A., The effectiveness of ESC…, loc. cit.

10 Knoll, P. M., Langwieder, K., Der Sicherheitseffekt…, loc. cit.

11 United Nations Economic Commission for Europe (UNECE), Statistics of Road Traffic Accidents in Europe and North America, New York and Geneva 2003, 2004, 2005

It is an appropriate data source because it contains accident data for nearly all 25 EU-member states and also distinguishes between the following kinds of accidents:

- Accidents between vehicle and pedestrian,
- Single vehicle accidents,
- Accidents between vehicles, of which:
  - Rear-end collisions,
  - Collisions due to crossing or turning,
  - Head-on collisions,
  - Others (including collisions with parked vehicles).

The most relevant kind of accident for ESP is the single vehicle accident, which is defined as "Accident involving no collision with other road users, even though they may be involved, i.e. vehicle trying to avoid collision and veering off the road, or accident caused by collision with obstructions or animals on the road".[12] There might be accidents in other accident categories, where ESP could help mitigating the accident. However, this effect is marginal compared to the accident avoidance effect of ESP. Accidents which can be avoided by ESP are nearly exclusively single vehicle accidents.

Therefore, Table 3 displays the number of single vehicle accidents, the killed and injured persons reflecting the accident situation of the year 2003. In the EU-25 the share of single vehicle accidents ranges between 15% (United Kingdom) and more than 30% (Sweden, Finland). In Germany the share is 27.5% while the average in the EU-25 amounts to 22%. Concerning the persons killed in single vehicle accidents, more than 30 % of the fatalities in the European Union are due to single vehicle accidents. The share of injured persons due to single vehicle accidents (20%) is roughly the same as the accident quota.

However, the displayed data refers to all types of vehicles, not only cars. Moreover, ESP helps to avoid accidents by preventing the skidding of cars. Therefore, only single vehicle accidents with a previous skidding of the car, which caused the accident, can be avoided. These two conditions limit the number of single vehicle accidents where ESP helps. Information about skidding is only available from in-depth databases. In the case of Germany, they show that about half of all car accidents (50.6%) where the car was the main causer involve skidding. In addition, cars have been the main causers in roughly two third of all single vehicle accidents (67.72%). In the result, it means that 34.27% of all single vehicle accidents are caused by skidding cars in Germany.

12 United Nations Economic Commission for Europe (UNECE), Statistics…, loc. cit., New York and Geneva 2003, 2004, 2005, p. 126

Table 2: Number of single vehicle accidents and persons killed and injured in single vehicle accidents (2003)

	Single vehicle accidents			Single vehicle accidents / All Accidents [%]		
	Number of acci-dents	Number of killed persons	Number of injured persons	Share of acci-dents	Share of killed persons	Share of injured persons
Belgium	11,083	637	13,387	23.4	42.9	20.5
Czech Rep.	8,752	513	11,406	32.0	35.5	32.2
Denmark	1,607	117	1,934	23.8	27.1	23.0
Germany	97,357	2,795	116,478	27.5	42.3	25.2
Estonia	570	41	864	29.5	25.0	34.0
Greece	2,779	582	3,297	17.6	36.3	15.9
Spain	26,970	2,024	38,746	27.0	37.5	25.7
France	19,176	2,258	22,915	21.3	39.4	19.8
Ireland	1,192	98	1,094	19.9	29.3	13.2
Italy	38,558	1,794	48,110	16.2	26.6	14.2
Cyprus	512	32	689	21.7	32.7	20.2
Latvia	1,324	184	1,837	26.0	35.5	29.2
Lithuania	1,316	218	1,822	22.1	30.7	25.1
Luxemburg	269	19	347	37.4	35.8	33.0
Hungary	4,626	310	6,466	23.2	23.4	24.3
Malta	3,033	6	237	21.7	32.7	20.2
Netherlands	6,580	364	7,492	20.8	33.5	19.7
Austria	9,755	321	11,706	22.5	34.5	20.6
Poland	10,171	1,403	13,924	19.9	24.9	21.8
Portugal	6,795	271	9,096	16.4	20.0	16.5
Slovenia	812	33	1,025	8.8	11.9	8.1
Slovakia	1,856	211	2,287	21.7	32.7	20.2
Finland	2,299	111	3,041	33.3	29.3	33.5
Sweden	5,531	186	7,299	30.1	35.2	26.9
U.K.	32,135	847	40,947	15.0	24.1	14.3
TOTAL	**295,058**	**15,375**	**366,446**	**21.7**	**32.7**	**20.2**

Source: United Nations Economic Commission for Europe (UNECE), Statistics of Road Traffic Accidents in Europe and North America, New York and Geneva 2003, 2004, 2005, Own calculations

This resulting proportion of relevant single vehicle accidents is based on accident figures for Germany, thus relating to German road traffic conditions. Due to differences in the traffic conditions throughout the European Union, the accident avoidance potential of ESP in cars in other countries can differ from the situation in Germany.

First it is taken account of the fact that the share of cars in the vehicle fleet differs in the member states. Thus a weighting factor is calculated based on the proportion of cars in the vehicle fleet. The weighting factors for the different analyzed areas are displayed in Table 3. They are used to adopt the above stated proportion of single vehicle accidents which are caused by a skidding car in Germany (34.27 %) to the diverse traffic conditions in the different areas.

Table 3: Weighting factor reflecting the share of cars in total vehicle stock

Member State(s)	Proportion of cars compared to total vehicle stock (Cars, Bus, Goods vehicles, Powered two-wheelers)	Weighting factor	Share of single vehicle accidents caused by skidding cars (Germany: 34.27)
U. K.	85.9 %	1.02	34.96
Germany	84.5 %	1.00	34.27
Italy	72.5 %	0.86	29.47
Spain	76.4 %	0.90	30.84
France	77.5 %	0.92	31.53
EU-15	78.9 %	0.93	31.87
EU-25	79.0 %	0.93	31.87

Source: European Commission, Directorate – General for Energy and Transport, Energy & Transport in figures 2005, Own calculations

Different traffic situations are accounted for by using the number of single vehicle accidents in the member states as a calculation basis. As stated above, single vehicle accidents make up 27.5 % of all accidents in Germany leading to an overall proportion of relevant accidents of 9.4 % (referring to all accidents, see Table 3). In other European member states the share of single vehicle accidents in all accidents is varying between 15 % and 37 % (see Table 3).

With this method, the number of ESP-relevant accidents in the European member states is calculated. However, it cannot be assumed that all of these accidents are actually avoided by ESP. An effectiveness rate has to be determined, which specifies how many of the single vehicle accidents caused by skidding cars are really avoided with the help of ESP. Zobel states this rate with 80 %.[13]

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13 Biber, C., Unfallforscher fordern zum Umdenken bei den Sicherheitsprüfungen auf, Meldung vom 10.06.2005 unter www.auto-reporter.net (Artikelnummer 20050610-000004), Zugriff am 08.08.2006

The main conclusions for the accident savings calculations due to ESP can be summarized:

- The accident avoidance potential of ESP is restricted to single vehicle accidents (as defined according to the UN-Statistics), which constitute between 15 % and 37 % of all injury accidents in the member states of the EU-25 (see Table 3).
- 34.27 % of the single vehicle accidents are caused by skidding of cars e.g. in Germany. This proportion is adopted to different traffic situations in other member states by using a weighting factor based on the proportion of cars in the vehicle fleet (see Table 3).
- 80 % of these single vehicle accidents caused by skidding cars are avoided due to the equipment of ESP (= Effectiveness rate of ESP).

These assumptions lead to an accident avoidance potential, which is in line with the findings of other studies presented in the previous chapter. This can be shown for Germany with the help of the following Table 4, where the estimated accident / fatality reduction for Germany relating to all accidents / fatalities is calculated:

Table 4: Calculated accident avoidance potential of ESP in Germany in percent

Effects in Germany	Share of single vehicle accidents in all accidents (See Table 2)	34.27 % of the single vehicle accidents are caused by a skidding car (see Table 3)	Effectiveness of ESP = 80 %, Result: Share of avoided accidents by ESP in cars concerning all accidents	Only 67.72 % of all accidents are caused by cars, Result: Share of avoided accidents by ESP in cars concerning all car accidents
Injury accidents	27.5 %	9.4 %	7.5 %	11.1 %
Killed persons	42.3 %	14.5 %	11.6 %	17.1 %

Source: Own calculations

First, the share of single vehicle accidents is extracted from Table 2. In a second step, this number of single vehicle accidents is reduced, because only 34.27 % of these single vehicle accidents are caused by a skidding car. Given the assumed effectiveness rate of 80 %, the accident avoidance potential of ESP calculated in this study is rather small, shown in the second column from the right. In order to compare these shares with the findings from most of the other studies, it has to be considered, that these studies are referring the stated accident avoidance potential to car accidents only. The calculated shares in the second column from the right in Table 4 are however reflecting the accident avoidance potential of ESP in cars concerning all accidents (caused by cars, trucks, motor bikes etc.). In order to compare the accident calculations in this study with the results of other studies, the accident avoidance potential of ESP in cars has to be referred to car accidents only. They make up about 67.72 % of all accidents (in the case of single vehicle accidents).

Besides that, Knoll and Langwieder have synthesised accident analyses of ESP and summed up that a reduction of injury accidents by 7 – 11 % and a fatality reduction by 15 – 20 % in Germany can be expected.[14] Hence, their results are nearly similar to the conclusions in this study.

For the EU-25 it has been assumed in a study published by the eSafety-Forum, that in the year 2020 roughly 2,900 to 3,900 lives could be saved, if the ESP equipment rate in the vehicle stock amounts to 73 %.[15] Consequentially, the maximum accident avoidance potential (= 100 % penetration) of ESP is in this study assumed to be between 3,970 and 5,300. With 3,988 avoided fatalities calculated as the maximum accident potential in this study (See Table 6), the results of this study are also well comparable.

2.2.3 Calculation of accident savings in the EU-25

In some of the member states ESP already reached significant car penetration rates. This means that parts of the accident reduction potential of ESP was already realised in 2003. It is assumed, that there exists a linear functional relation between car equipment rate with ESP and avoided accidents. For example, if 50 % of the cars are equipped with ESP, also 50 % of the accidents, which could be avoided if all cars were equipped with ESP, are avoided.

Based on German figures reflecting the year 2003 conditions this means that the number of single vehicle accidents (= 97,357, see Table 2) cannot be reduced by 27.42 %[16] due to ESP in the future, because some of the vehicles had already been equipped with ESP. It is estimated, that in 2003 about 14.2 % of the German car fleet had been equipped with ESP. This means that about 3.9 % (0.142 x 27.42 %) of the single vehicle accidents were already being avoided at that time. By extending the car penetration rate from 14.2 % to 100 %, a further 23.52 % accident reduction (27.42 % – 3.9 % = 23.52 %) could be achieved. The hypothetical number of single vehicle accidents in Germany without the use of ESP can be calculated as follows:

$$97{,}357 / (1-(0.3427 \times 0.8 \times 0.142)) = 101{,}301$$

The relationship between car penetration rate and accident avoidance for this example is illustrated in Figure 1. In order to take account of this circumstance, the virtual accident figures for 2003 are calculated in Table 5 according to the above stated formula under the premise that no car had been equipped with ESP in this year. Therefore, the estimated ESP-penetration rate of the vehicle stock is included in Table 5. Finally, the number of single vehicle accidents as well as the killed and injured persons is calculated as explained above for the hypothetical situation that no car had been equipped with ESP in 2003.

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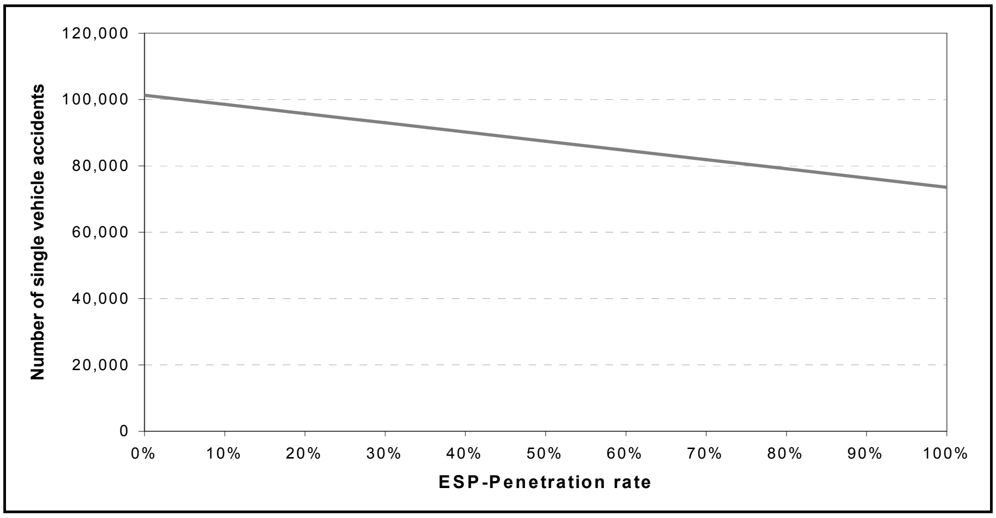
14 Knoll, P. M., Langwieder, K., Der Sicherheitseffekt…, loc. cit., Ch. A.4

15 E-Safety-Forum, Final Report and Recommendations of the Implementation Road Map Working Group, Brüssel 2005, S. 51

16 34.27 % single vehicle accidents caused by skidding cars with an effectiveness of 80 % results in an overall single vehicle accident avoidance of 27.42 %.

Figure 1: Relationship between ESP-penetration rate of car stock and single vehicle accident avoidance in Germany



Source: Own figure

Starting from these hypothetical single vehicle accident figures, the avoidable accidents due to 100 % penetration of the car stock for the year 2003 can be calculated. To refer again to the German example, there would have been 101,301 single vehicle accidents in Germany without any ESP-equipment. Under the premise that in Germany 34.27 % of all single vehicle accidents are caused by a skidding car and that ESP can avoid 80 % of these, then 27,773 accidents could have been avoided if all cars had been equipped with ESP:

$$101{,}301 \times 0.3427 \times 0.8 = 27{,}773$$

That would have reduced the number of single vehicle accidents to 73,528 (101,301 – 27,773). Under the equipment rate in Germany of 14.2 % in 2003, 3,944 accidents were actually avoided:

$$101{,}301 \times 0.3427 \times 0.8 \times 0.142 = 3{,}944$$

This led to a realised number of single vehicle accidents of 97,357 (101,301 – 3,944, see Table 5). The resulting accident avoidance potential, which is defined as the difference between the number of single vehicle accidents without ESP (Equipment rate = 0 %) and the number of single vehicle accidents with an ESP-equipment rate of 100 %, is calculated in Table 6. In the EU-25, nearly 4,000 fatalities could be avoided, if all cars were equipped with ESP. In Germany alone, the avoidance potential amounts to 800 fatalities.

Table 5: Persons killed and injured due to single vehicle accidents without ESP-equipment

	Single vehicle accident situation in 2003 under given ESP-Penetration rates (Figures from UN-statistics)				Share of single vehicle accidents caused by skidding car [%]	Effectiveness of ESP	Hypothetical single vehicle accident situation without ESP-equipped cars		
	Accidents	Persons killed	Persons injured	Estimated ESP-Equipment rate of car stock			Accidents	Persons killed	Persons injured
U.K.	32,135	847	40,947	4.3	34.96	0.8	32,526	857	41,445
Germany	97,357	2,795	116,478	14.2	34.27		101,301	2,908	121,196
Italy	38,558	1,794	48,110	2.6	29.47		38,796	1,805	48,407
Spain	26,970	2,024	38,746	6.3	30.84		27,396	2,056	39,358
France	19,176	2,258	22,915	8.6	31.53		19,601	2,308	23,423
EU-15	262,086	12,424	325,889	7.5	31.87		267,195	12,666	332,242
EU-25	295,058	15,375	366,446	6.7	31.87		300,186	15,642	372,815

Source: Own calculation based on manufacturer information and United Nations Economic Commission for Europe (UNECE), Statistics…, loc. cit., 2003, 2004, 2005

Table 6: Potential accident avoidance due to ESP-equipped cars in the European Union (2003)

	Hypothetical single vehicle accident situation without ESP-equipped cars (0 % ESP-penetration)			Share of single vehicle accidents caused by skidding car	Effectiveness of ESP	Accidents avoided …	Fatalities avoided…	Injured persons avoided…
	Accidents	Persons killed	Persons injured			…with full ESP-penetration of car stock (100 % ESP-penetration)		
U.K.	32,526	857	41,445	34.96	0.8	9,097	240	11,591
Germany	101,301	2,908	121,196	34.27		27,773	797	33,227
Italy	38,796	1,805	48,407	29.47		9,147	426	11,412
Spain	27,396	2,056	39,358	30.84		6,759	507	9,710
France	19,601	2,308	23,423	31.53		4,944	582	5,908
EU-15	267,195	12,666	332,242	31.87		68,124	3,229	84,708
EU-25	300,186	15,642	372,815	31.87		76,535	3,988	95,053

Source: Own calculations

In order to demonstrate the differences between fatalities in single vehicle accidents, the number of actually avoided fatalities under given ESP car-penetration rates and the potential total number of avoidable fatalities if all cars were equipped with ESP, these three figures are stated in Table 7.

Table 7: Number of fatalities in single vehicle accidents, fatalities avoided due to ESP-equipment of cars and maximum ESP avoidance potential in cars

	Fatalities in single vehicle accidents without ESP	Number of avoidable fatalities with full equipment of cars with ESP	Fatalities avoided with actual ESP-car equipment rate (2003)
United Kingdom	857	240	10
Germany	2,908	797	113
Italy	1,805	426	11
Spain	2,056	507	32
France	2,308	582	50
EU-15	12,666	3,229	242
EU-25	15,642	3,988	267

Source: Own calculations

2.2.4 Monetary valuation of accident savings in the EU-25

While the calculation of the physical benefits of ESP on basis of accident statistics is rather straightforward, the monetary valuation of accidents is a controversial matter. However, it is needed to give information about the cost-effectiveness of safety measures like ESP.

Traditionally, the monetary valuation of accident costs has been based on economically measurable effects of accidents. These effects include reproduction costs (e.g. medical treatment, vehicle repair costs, administrational costs) and costs due to lost economic output (e.g. periods of disability or death). More recently another approach has become popular, which is based on the consideration that measuring only the economical effects of injury and death is insufficient and that other consequences like pain, grief and suffering of the victim and its family should be included in accident cost calculations. Because this approach takes into account that there exists a value of life independently from economic considerations, it is also referred to as the Human-Cost-Approach whereas the first calculation method is usually termed Damage-Cost-Approach.

Both methods are used by the EU member states. For example Sweden and the United Kingdom include Human Costs in some way in their accident calculations on the basis of surveys asking for the respondents' willingness to pay for a reduction in accident risk. Other countries like Germany restrict their calculation to economically measurable damages.

Table 8: Cost rates for monetary evaluation of accident cost savings in the European Union

	EU-Cost-Rates [€]
Fatality	1,000,000
Seriously injured person	135,000
Slightly injured person	15,000

Source: European Commission, Proposal for a Directive of the European Parliament and of the Council amending Directive 1999/62/EC on the charging of Heavy Goods Vehicles for the use of certain infrastructure, Brussels 2003, p. 33

In most safety evaluations on a European level, accident cost rates are used which have been proposed by the European Commission. Since the accident data employed in this study does not differentiate between seriously and slightly injured persons, other data has to be used. In Germany, about 30 % of all persons injured in single vehicle accidents suffered from severe injuries while 70 % only have been slightly injured. It is assumed that this proportion holds true for all member states of the European Union, which leads to an average cost rate for an injured person of € 51,000. It is further assumed that additional property damage costs per accident of € 6,000 arise on average.[17]

Congestion costs consist of additional consumption of time and fuel as well as of additional emissions of air pollutants and Carbon Dioxide. They have been stated with € 15,000 for fatal accidents and € 5,000 for injury accidents.[18] Here, congestion costs are cautiously estimated with € 5,000 for fatal and injury accidents. This leads to the following accident cost rates used in this study:

Table 9: Accident cost rates for monetary evaluation of ESP-safety benefits

Personal damage costs per killed / injured person	Costs in €
Killed person	1,000,000
Injured person	51,000
Property damage and congestion costs per accident	**Costs in €**
Property damage costs	6,000
Congestion costs	5,000

Source: European Commission, Proposal…, loc. cit., p. 33; Statistisches Bundesamt, Verkehr – Verkehrsunfälle 2003, Fachserie 8 / Reihe 7, Wiesbaden 2005, p. 64; Abele, J., Baum, H., Exploratory study…, loc. cit., Brussels 2005, p. 117

17 Abele, J., Baum, H., Exploratory study…, loc. cit., Brussels 2005

18 ICF Consulting, Cost-Benefit Analysis of Road Safety Improvements, London 2003

With this accident cost information and the number of avoidable accidents (see Table 6) the monetary benefits of ESP can be calculated. The results are displayed in Table 10. For example in Germany, the accident analysis showed, that with a 100 %-penetration of the car stock 27,773 accidents could be avoided (based on accident figures for 2003, see Table 6). According to the cost rates, this results in property damage and congestion cost savings of € 305.5 Mill (27,773 x (€ 6,000 + € 5,000)). Together with these accidents, 797 lives could have been saved and 33,227 injuries of persons could have been avoided. With the determined cost rate of € 1 Mill. per fatality this results in cost savings of € 797 Mill. for fatalities. The cost savings due to avoided injuries accrue to € 1,694.6 Mill. (33,227 x € 51,000). The total accident cost savings for Germany sum up to € 2,996.4 Mill.

Table 10: Potential accident cost savings due to ESP (100 % ESP-penetration of cars) in the European Union

	Personal damage costs in Mill. € (killed persons)	Personal damage costs in Mill. € (injured persons)	Property damage and congestion costs in Mill. €	SUM in Mill. €
United Kingdom	240.0	591.1	100.1	931.2
Germany	797.0	1,694.6	305.5	2,797.1
Italy	426.0	582.0	100.6	1,108.6
Spain	507.0	495.2	74.3	1,076.5
France	582.0	301.3	54.4	937.7
EU-15	3,229.0	4,320.1	749.4	8,298.5
EU-25	3,988.0	4,847.7	841.9	9,677.6

Source: Own calculations

2.3 Costs of ESP

In the previous chapter, the accident cost savings have been calculated as the difference between a situation without any ESP-equipment and a situation with a penetration of 100 %. Accordingly, the costs for equipping the whole car fleet with ESP have to be calculated. Therefore, the following information is needed:

- Number of cars in the reference year (2003),
- Costs of ESP-equipment (investment and operation),
- Useful life of ESP.

The number of cars in the reference year is given in Table 11. Additionally, the costs of equipping one car with ESP are stated with € 130.[19] This value reflects the additional equipment costs for ESP as an addition to an existing Antilock Braking System (ABS), which is standard in EU-25. Operation costs normally do not occur, so that the total costs of equipping the whole car fleet with ESP equals the multiplication of the car number with the costs.[20]

Table 11: Number of cars in the EU-25 in 2003 and investment costs for ESP-equipment (100 % equipment rate)

	Car Stock 2003 in Mill.	Costs of equipping one car with ESP in €	Investment costs in Mill. €
United Kingdom	26.992	130	3,508.96
Germany	44.657		5,805.41
Italy	32.584		4,235.92
Spain	18.688		2,429.44
France	29.360		3,816.80
EU-15	189.672		24,657.36
EU-25	212.496		27,624.48

Source: European Commission, Directorate –General for Energy and Transport, Energy & Transport in figures 2005, Own calculations

However, ESP would not only avoid accidents and the resulting costs for one year, but for each year until it is taken out of use. Since ESP cannot be retrofitted, the lifetime of ESP is equal to the lifetime of a car. The average lifetime of a car in the European Union is 12 years.[21] From this follows that the investment costs have to be spread over 12 years, because ESP is avoiding the calculated accidents in each of the twelve years. The yearly costs can be calculated with the annuity method. This method takes into account possible interest earnings, which could have been realized at the capital market if the money had not been spent for ESP at the beginning of the useful life (= Opportunity costs). The calculation of the yearly costs is as follows:

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19 The cost estimation was verified by experts in the eIMPACT Market Scenario Workshop, Brussels 25 Sep 2006, mimeo.

20 Obviously it is impossible to equip the total car fleet with ESP immediately, since ESP cannot be retrofitted. Thus, only new cars could be equipped and total stock penetration cannot be reached before the last not equipped car is phased out. Normally, this takes about 12 years, which is the average useful life of cars in the European Union. However, for Cost-Benefit-Calculations, this is not of importance, because the benefit-cost-ratio is assumed to be independent from the actual penetration rate. If only 10 % of the vehicle fleet is equipped, only 10 % of the benefits can be realized, but only 10 % costs incur as well.

21 Abele, J., Baum, H., Exploratory study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles, Study on behalf of the European Commission – DG INFSOC, Brussels 2005, p. 117

$$g = K_0 \cdot \frac{i \cdot (1+i)^n}{(1+i)^n - 1}$$

g = yearly costs
K_0 = investment sum (material and labour costs)
i = interest rate
n = economic lifetime

The interest rate is determined with 3 %. The resulting yearly costs are shown in the following table:

Table 12: Costs for ESP-equipment of car stock

Member States	Investment costs (K_0) in Mill. €	Yearly costs (g) in Mill. €
United Kingdom	3,508.96	352.52
Germany	5,805.41	583.22
Italy	4,235.92	425.55
Spain	2,429.44	244.07
France	3,816.80	383.44
EU-15	24,657.36	2,477.13
EU-25	27,624.48	2,775.21

Source: European Commission, Directorate – General for Energy and Transport, Energy & Transport in figures 2005, Own calculations

2.4 Benefit-Cost-Ratio for ESP

Finally, the benefits and costs of equipping cars with ESP can be compared and a Benefit-Cost-Ratio can be calculated (see Table 13). The resulting Benefit-Cost-Ratios vary between 2.4 and 4.8, showing the efficiency of investing into ESP-equipment in the EU-25. The highest Benefit-Cost-Ratio has been calculated for Germany, the lowest for France. The average Benefit-Cost-Ratio for the EU-25 lies at 3.5. The differences between the different member states follow mainly from varying numbers of single vehicle accidents, killed and injured persons in the member states. For example in Germany, there are about 5 times more single vehicle accidents and injured persons than in France in the hypothetical single vehicle accident situation (see Table 6). However, the number of cars in Germany is only 1.5 times higher than in France (see Table 11), which explains the difference in the Benefit-Cost-Ratio.[22] The main conclusion to be drawn is that the investment into the ESP-equipment of cars is cost-efficient throughout the European Union. According to the calculations, € 3.5 of accident costs to society are saved in the EU-25 for each € spent for ESP-equipment of cars.

22 Especially in the case of France it has been stated, that in France a very high share of accidents remains unreported, which leads to substantial undercounting. In fact it has been assumed, that the number of reported accidents has to be corrected by the factor 2.5 in order to receive an estimation of the number of all accidents. For Germany, no undercounting has been assumed, for most other member states a factor of 1.38 has been employed (See ICF Consulting, Cost-Benefit Analysis of Road Safety Improvements, London 2003, pp. 3-4). This seems to be the most plausible explanation for the low Benefit-Cost-Ratio in France.

Table 13: Benefit-Cost-Ratios for ESP in the EU-25

Member States	Yearly benefits in Mill. €	Yearly costs in Mill. €	Benefit-Cost-Ratio
United Kingdom	931.2	352.52	2.6
Germany	2,797.1	583.22	4.8
Italy	1,108.6	425.55	2.6
Spain	1,076.5	244.07	4.4
France	937.7	383.44	2.4
EU-15	8,298.5	2,477.13	3.4
EU-25	9,677.6	2,775.21	3.5

Source: Own calculations

There is some evidence that the actual Benefit-Cost-Ratios could even be higher than calculated in this study. This stems from the fact that the employed accident database includes only personal damage accidents and cost calculations thus only include accidents with personal damage. While for humanitarian reasons this focus on personal damage accidents is sensible, it leads to an underestimation of the real safety benefits to society. In Germany for example, costs caused by accidents with personal damage (personal damage costs and property damage costs in accidents with personal damage) only account for slightly more than 60 % of the total accident costs. The other 40 % of the total accident costs consist of property damage costs arising in accidents with only property damage (= accidents without injuries and fatalities). Thus, the inclusion of property damage only accidents into the calculations could increase the accident cost savings due to ESP significantly. If it is assumed that this relationship between the costs of personal damage accidents and property damage accidents holds true for ESP-sensitive accidents throughout Europe, the Benefit-Cost-Ratio for EU-25 would rise to about 5.8, if property damage accidents were included into the calculations (see Table 14).

Table 14: Estimated Benefit-Cost-Ratios for ESP in the EU-25 including property damage accidents costs

Member States	Yearly benefits in Mill. €	Yearly costs in Mill. €	Benefit-Cost-Ratio
United Kingdom	1,552.0	352.52	4.4
Germany	4,661.8	583.22	8.0
Italy	1,847.7	425.55	4.3
Spain	1,794.2	244.07	7.4
France	1,562.8	383.44	4.1
EU-15	13,830.8	2,477.13	5.6
EU-25	16,129.3	2,775.21	5.8

Source: Own calculations

The attainable accident cost savings due to property damage only accidents are transferred from Germany to the European level. A more accurate calculation would be possible when the database for property damage only accidents will be improved in the future.

Table 15: Results of selected Cost-Benefit-Calculations for Driver Assistance Systems

Analysed Driver Assistance System	Benefits in Mill. € (rounded)	Benefit-Cost-Ratio	Remarks	Study
ESP	10,000 – 16,000	3.5 – 5.8	Calculations for EU-25 Full penetration in car fleet	This study
Information and Warning Functions	40 – 300	1.2 – 1.5	Calculations for EU-15 Varying results for different penetration rates	Baum, H., Schulz, W. H. et al., Socio-Economic-Assessment of CarTALK 2000-Applications, Final Report, September 2004
Communication-based Longitudinal Control	50 – 1,000	1.1 – 4.0		
Tow-Bar-System for Heavy Goods Vehicles	55 – 105	4.1 – 4.4	Calculations for Germany Varying results for different penetration rates	Geißler, T., Automated Highway Systems – Konzept, Bewertungsmethodik und empirische Auswirkungsanalyse des CHAUFFEUR-Systems, Köln 2001
Longitudinal Control	50 – 140	0.8 – 1.3	Calculations for Germany Varying results for different penetration rates	Zackor, H., Keller, H. u.a., Entwurf und Bewertung von Verkehrsinformations- und –leitsystemen unter Nutzung neuer Technologien, Berichte der BASt, Heft V70, Bergisch Gladbach 1999
Adaptive Cruise Control	500 – 1,000	0.9 – 1.2	Calculations for EU-25 Varying results for different penetration rates	Abele, J., Baum, H., Exploratory study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles (SEiSS), Teltow 2005
Lane Departure Warning and Lane Change Assistance	170 – 1,500	2.0 – 2.1		
Automated Speed Control	n/a	1	Calculations for Great Britain Calculations for many Driver Assistance Systems	Perrett, K.E., Stevens, A., Review of the potential benefits of road transport telematics, TRL Report 220, 1996
Driver and Vehicle Monitoring	n/a	0.5		
Integrated Automated Driving	n/a	1.1		

Source: Own compilation

When comparing the absolute benefits of different systems it also becomes clear that ESP represents one of the most beneficial systems for the European transport system. This makes clear that ESP represents a building block of an Intelligent Transport System in the European Union.

3. Benefits of a mandatory ESP-equipment of all cars from 2008 onwards

After having shown that equipping cars with ESP is cost-effective, it is analysed how many accident and accident cost savings could be achieved, if from 2008 onwards every car will be mandatory equipped with ESP (Scenario "Mandatory Equipment"). These savings are compared to a situation without any activity to support ESP market penetration (Trend Scenario).

3.1 Forecast of equipment rates with and without a mandatory equipment

The forecast of equipment rates of the car stock is based on information about actual and past ESP-equipment rates for newly registered cars in the European Union. Time series for ESP-equipment rates of newly registered cars since 1995 in the different analysed areas of the European Union have been established.

With the penetration rates for newly registered cars the penetration of the car stock can be figured out as follows:

- Number of car stock and newly registered cars per year based on historical data and car park development forecasts.
- With the ESP-penetration of new cars, which has been estimated on basis of information from Robert Bosch GmbH, the number of newly registered vehicles with ESP and the share of these vehicles regarding the total vehicle stock can be calculated.
- Each year, newly registered cars with ESP (according to the ESP-penetration rate amongst newly registered cars) add to the car stock.
- Twelve years after market introduction, the cars with ESP registered in the first year of market introduction have to be subtracted from the vehicle stock, because according to the assumption about average useful life of cars and ESP, they are taken out of service.
- For the Scenario "Mandatory equipment", the ESP-penetration rate for newly registered cars is set to 100 % from 2008 on.

The ESP-penetration of the total EU car stock is displayed in Figure 2. The figures behind the graphs in this figure are listed in the following Table 16. With the estimation of these equipment rates for the two scenarios, the differences in accident and accident cost savings can be calculated.

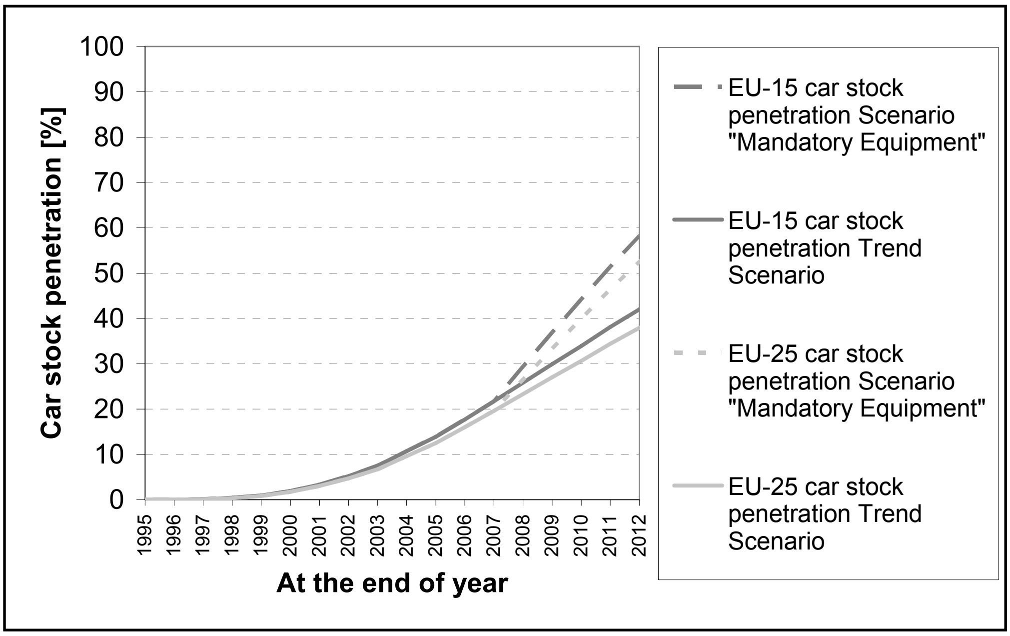
Table 16: Car stock penetration with ESP for the Scenarios "Trend" and "Mandatory Equipment" in the European Union and selected member states

Member State	Scenario	At the end of Year								
		1995	1996	1997	1998	1999	2000	2001	2002	2003
United Kingdom	Trend	0.0	0.0	0.1	0.2	0.4	0.9	1.6	2.6	4.3
	Mandatory Eq.	0.0	0.0	0.1	0.2	0.4	0.9	1.6	2.6	4.3
Germany	Trend	0.0	0.0	0.2	0.8	1.7	3.6	6.4	10.1	14.2
	Mandatory Eq.	0.0	0.0	0.2	0.8	1.7	3.6	6.4	10.1	14.2
Italy	Trend	0.0	0.0	0.0	0.2	0.6	1.0	1.6	2.6	3.7
	Mandatory Eq.	0.0	0.0	0.0	0.2	0.6	1.0	1.6	2.6	3.7
Spain	Trend	0.0	0.0	0.1	0.3	0.7	1.3	2.4	3.9	6.3
	Mandatory Eq.	0.0	0.0	0.1	0.3	0.7	1.3	2.4	3.9	6.3
France	Trend	0.0	0.0	0.1	0.4	0.9	2.0	3.8	5.9	8.6
	Mandatory Eq.	0.0	0.0	0.1	0.4	0.9	2.0	3.8	5.9	8.6
EU-15	Trend	0.0	0.0	0.1	0.4	0.9	1.9	3.3	5.2	7.5
	Mandatory Eq.	0.0	0.0	0.1	0.4	0.9	1.9	3.3	5.2	7.5
EU-25	Trend	0.0	0.0	0.1	0.3	0.8	1.7	3.0	4.7	6.7
	Mandatory Eq.	0.0	0.0	0.1	0.3	0.8	1.7	3.0	4.7	6.7

Member State	Scenario	At the end of Year								
		2004	2005	2006	2007	2008	2009	2010	2011	2012
United Kingdom	Trend	6.7	9.5	12.6	15.8	19.1	22.4	25.6	29.0	32.2
	Mandatory Eq.	6.7	9.5	12.6	15.8	23.7	31.5	39.1	46.7	53.9
Germany	Trend	19.1	24.1	30.0	35.9	41.8	47.6	53.1	58.6	63.2
	Mandatory Eq.	19.1	24.1	30.0	35.9	43.9	51.6	59.1	66.3	72.6
Italy	Trend	5.6	7.9	10.7	13.9	17.1	20.3	23.5	26.9	30.5
	Mandatory Eq.	5.6	7.9	10.7	13.9	22.0	30.2	38.1	45.9	53.7
Spain	Trend	9.5	13.0	17.6	22.5	27.5	32.7	38.0	43.8	49.7
	Mandatory Eq.	9.5	13.0	17.6	22.5	32.2	41.6	50.6	60.0	69.1
France	Trend	11.7	14.4	18.0	21.9	26.0	30.2	34.5	38.9	43.0
	Mandatory Eq.	11.7	14.4	18.0	21.9	30.1	38.2	46.1	53.8	60.9
EU-15	Trend	10.7	13.9	17.7	21.7	25.8	29.9	33.9	38.1	42.0
	Mandatory Eq.	10.7	13.9	17.7	21.7	29.4	36.9	44.2	51.4	58.2
EU-25	Trend	9.6	12.5	16.0	19.6	23.3	27.0	30.6	34.4	37.9
	Mandatory Eq.	9.6	12.5	16.0	19.6	26.5	33.3	39.9	46.4	52.5

Source: Own estimations, information from manufacturers

Figure 2: Car stock penetration with ESP for the Trend Scenario and the Scenario “Mandatory Equipment” in the European Union



Source: Own estimations, information from manufacturers

3.2 Cost-Benefit-Results with and without a Mandatory Equipment

Starting point of the calculations is the single vehicle accident situation in 2003 as stated in Table 5. Avoidable due to equipment of cars with ESP is only a fraction of these accidents, killed and injured persons, because only 30 to 35 % of these single vehicle accidents are caused by skidding cars. Furthermore, an effectiveness of 80 % in avoiding these accidents has been assumed.

The resulting figures in Table 6 at the right side represent the maximum avoidable accidents, fatalities and injured persons (Car equipment rate = 100 %). In order to compare the accident avoidance for the Trend scenario and the scenario “Mandatory Equipment”, the accident avoidance potential is multiplied with the penetration rate in that year (see Table 16). Since the penetration of cars in the two scenarios starts to differ from 2008 onwards, the accident avoidance for the two scenarios grows apart from that point in time.

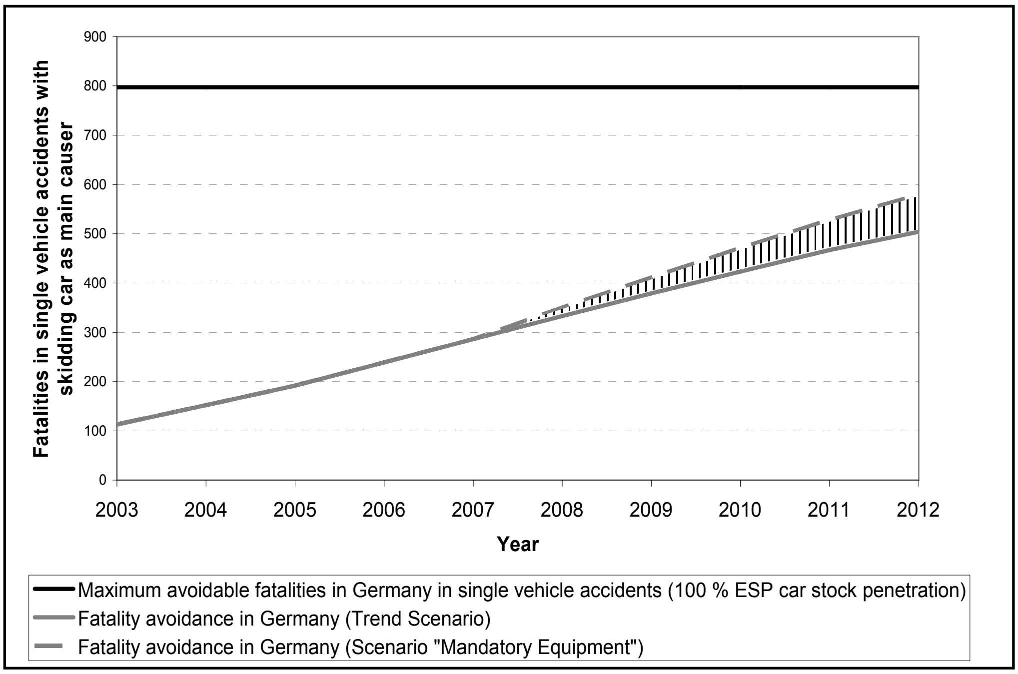
The calculations for comparing the accident situation for the Trend Scenario and the Scenario “Mandatory Equipment” have been performed for all relevant accident variables:

- Accidents,
- Fatalities,
- Injured Persons,
- Accident costs (= Benefits),
- Equipment Costs.

3.2.1 Fatality avoidance for the Trend Scenario and the Scenario “Mandatory Equipment”

The calculations are exemplified for the fatality savings in Germany for the Trend Scenario and the Scenario “Mandatory Equipment”. Figure 3 shows the number of avoided fatalities for the Trend-Scenario and the Scenario “Mandatory Equipment” from 2003 until 2012.

Figure 3: Avoidance of fatalities until 2012 for the Scenarios “Trend” and „Mandatory Equipment“ on the basis of accident data from 2003



Source: Own calculations

The black line represents the maximum avoidance potential of ESP, if all cars are equipped with the system. The figure is based on the calculations carried out in chapter 2 and equals the accident avoidance potential stated in Table 6 (797 avoidable fatalities). Under the equipment rate of 14.2 % in 2003 in Germany (see Table 16), 113 fatalities are avoided in this year (797 x 0,142). Given the assumed penetration development, the number of avoided fatalities rises from that year on. Until 2007, there is no difference in accident and fatality savings between the two scenarios, since in accordance with the assumptions the penetration rates are identical (see Table 16).

Table 17: Avoided fatalities between 2008 and 2012 for the Scenarios "Trend" and „Mandatory Equipment" on the basis of accident data from 2003

Member States	Scenario	Avoided fatalities in the year					
		2008	2009	2010	2011	2012	SUM
United Kingdom	Trend	46	54	61	70	77	**308**
	Mandatory Equip.	57	76	94	112	129	**468**
	Difference	**11**	**22**	**33**	**42**	**52**	**160**
Germany	Trend	333	379	423	467	504	**2,106**
	Mandatory Equip.	350	411	471	528	579	**2,339**
	Difference	**17**	**32**	**48**	**61**	**75**	**233**
Italy	Trend	73	86	100	115	130	**504**
	Mandatory Equip.	94	129	162	196	229	**810**
	Difference	**21**	**43**	**62**	**81**	**99**	**306**
Spain	Trend	139	166	193	222	252	**972**
	Mandatory Equip.	163	211	257	304	350	**1,285**
	Difference	**24**	**45**	**64**	**82**	**98**	**313**
France	Trend	151	176	201	226	250	**1,004**
	Mandatory Equip.	175	222	268	313	354	**1,332**
	Difference	**24**	**46**	**67**	**87**	**104**	**328**
EU-15	Trend	833	965	1,095	1,230	1,356	**5,479**
	Mandatory Equip.	949	1,192	1,427	1,660	1,879	**7,107**
	Difference	**116**	**227**	**332**	**430**	**523**	**1,628**
EU-25	Trend	929	1,077	1,220	1,372	1,511	**6,109**
	Mandatory Equip.	1,057	1,328	1,591	1,850	2,094	**7,920**
	Difference	**128**	**251**	**371**	**478**	**583**	**1,811**

Source: Own calculations

From 2008 onwards, there is a growing difference in the number of saved fatalities for the two scenarios, because the penetration rates develop differently. Thus in 2008, there would be 17 more fatalities avoided, if mandatory equipment was introduced in 2008. In 2009, this figure would rise to 32, in 2012, the difference would equal 75 fatalities. During the 5 years from 2008 to 2012, 233 additional lives could be saved. This figure would rise further in the years after 2012, because the differences in the market penetration of ESP would persist for a long time beyond 2012.

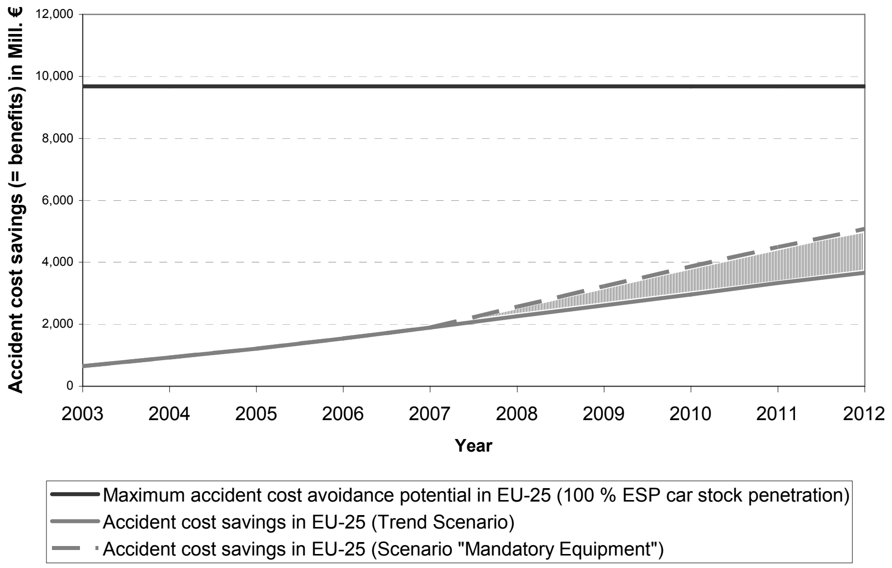
The development of the fatality savings for the two different scenarios in Germany is also displayed in Table 17. The figures in the table for Germany are identical with the figures, which lie behind the graphs in Figure 3 for the time period from 2008 to 2012. The aggregated difference between the Trend Scenario and the scenario "Mandatory Equipment" between 2008 and 2012 (= 233 fatalities) represents the hatched area in Figure 3. Additionally, the results for the other investigated areas for the years from 2008 to 2012 are given in Table 17. They are all calculated by multiplying the maximum number of avoidable fatalities, if all cars are equipped with ESP (see Table 6), with the ESP-penetration in the respective year (see Table 16). It can be seen that, with an equipment of all newly registered cars from 2008 onwards in the EU-25, about 1,800 additional fatalities could be avoided until 2012 in the EU-25 compared to the Trend Scenario. In the years after 2012, further deaths could of course be prevented.

3.2.2 Accident cost avoidance and equipment cost development for the Trend Scenario and the Scenario "Mandatory Equipment"

As outlined before, the calculations in the previous chapter have been carried out for the other accident variables as well (Accidents, Injured persons, accident cost savings, equipment costs). The calculations concerning the accident cost savings and the equipment costs development for the Trend Scenario and the Scenario "Mandatory Equipment" are presented in this chapter.

Similar to figure Figure 3, Figure 4 shows the development of accident cost savings for the Trend Scenario and the Scenario "Mandatory Equipment". Again, the black line represents the maximum achievable accident cost savings in the EU-25, if all cars are equipped with ESP (Car equipment rate = 100 %). It amounts to slightly less than € 10 billion, if only the accident cost savings in personal damage accident costs are considered (see also Table 13). The grey lines illustrate the development of the accident cost savings in the years 2003 to 2012 for the Trend Scenario and the Scenario "Mandatory Equipment". They are calculated by multiplying the maximum accident cost savings for the EU-25 stated in Table 13 (€ 9,677.6 Mill.) with the market penetration rates given in Table 16. It can be seen, that the maximum potential accident cost savings are utilised to a larger extent in the scenario "Mandatory Equipment" from 2008 onwards. If mandatory equipment for all newly registered cars with ESP in the EU-25 becomes effective in 2008, then about € 5.1 billion accident cost savings can be achieved in 2012. This represents about half of the maximum potential accident cost savings. In the Trend Scenario, only € 3.7 billion accidents costs are saved in 2012.

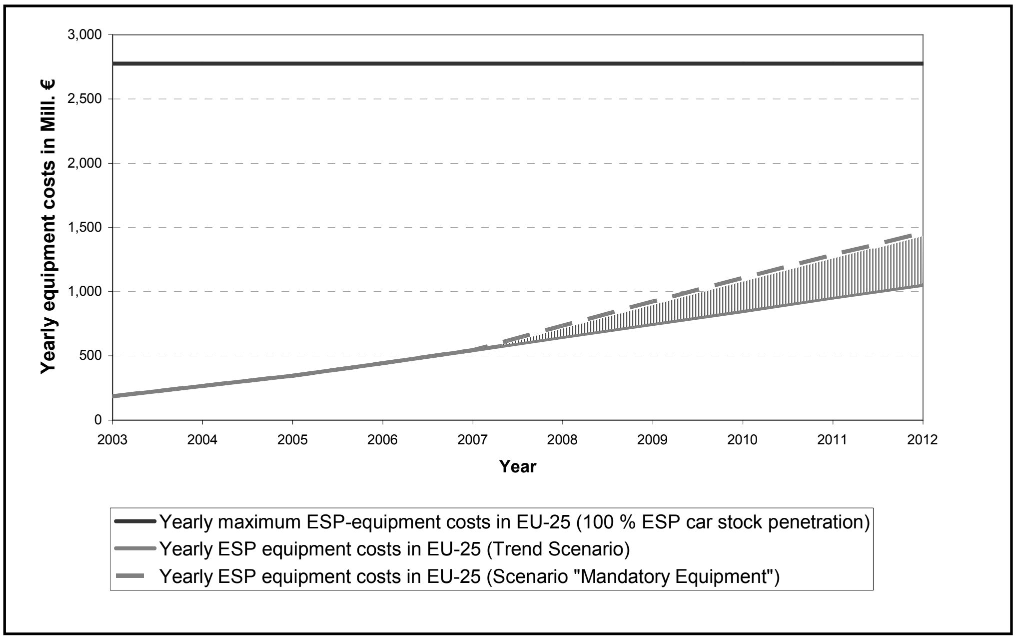
Figure 4: Development of accident cost avoidance in the EU-25 for the Trend Scenario and the Scenario „Mandatory Equipment“



Source: Own calculations

The additional accident costs savings (= benefits) due to higher ESP equipment rates of cars are obviously connected with higher equipment costs. Given the fixed investment costs of € 130 and a fixed average useful life of ESP of 12 years, the costs develop proportionally to the benefits. They can be calculated by multiplying the maximum yearly equipment costs for a car penetration rate of 100 % in EU-25 (= € 2,775.21 Mill., see Table 13) with the actual penetration rates in the different years (see Table 16). The equipment cost developments for the Trend Scenario and the scenario "Mandatory Equipment" are displayed in Figure 5. As in the two figures before, the black line represents the yearly maximum equipment costs in the EU-25, if all cars (= 100 %) are equipped with ESP. The grey lines display the cost development for the two scenarios. Due to higher equipment rates in the Scenario "Mandatory Equipment" the equipment costs rise to a greater extent than in the Trend Scenario from 2008 onwards. According to the benefits, the yearly equipment costs in the Scenario "Mandatory Equipment" in 2012 amount to about half of the maximum yearly equipment costs for a car equipment rate of 100 %. This is due to the fact that – according to the market penetration calculations – 52.5 % of the car stock in the EU-25 is equipped with ESP in 2012 (see Table 16). As a result, the Benefit-Cost-Ratios are independent from the market penetration rate and remain unchanged for different years and scenarios.

Figure 5: Development of equipment costs in the EU-25 for the Trend Scenario and the Scenario „Mandatory Equipment“



Source: Own calculations

The fact that Benefit-Cost-Ratios stay constant under given model assumptions becomes clearer in Table 18, where the values for the EU-25 underlying Figure 4 and Figure 5 are presented for the years 2008 to 2012. Here, the development of the accident cost savings for the two different scenarios and the development of the equipment costs for the two scenarios are stated. Additionally, the Benefit-Cost-Ratios for both scenarios and for each year are calculated by dividing the benefits by the costs. It can be seen, that they remain unchanged by scenario or year. The also calculated differences in benefits and costs for the two scenarios represent the hatched areas in Figure 4 and Figure 5. It can be seen, that the additional benefits arising due to mandatory equipment between 2008 and 2012 accrue to € 4.39 billion. In 2012 alone, additional accident cost savings worth nearly € 1.4 billion can be achieved. Obviously, there will be even more additional accident cost savings in the years after 2012. The additional accident cost savings are always 3.5 times higher than the additional equipment costs.

Table 18: Development of accident cost savings, yearly equipment costs and Benefit-Cost-Ratios between 2008 and 2012 for the Trend Scenario and the Scenario „Mandatory Equipment“ in the EU-25

		Year					
		2008	**2009**	**2010**	**2011**	**2012**	**SUM**
Accident cost savings (= benefits)	Maximum accident cost savings in Mill. € (100 % ESP car stock penetration)	9,677.6	9,677.6	9,677.6	9,677.6	9,677.6	**48,388.0**
	Accident cost savings in Mill. € (Trend Scenario)	2,254.9	2,613.0	2,961.3	3,329.1	3,667.8	**14,826.1**
	Accident cost savings in Mill. € (Scenario „Mandatory Equipment“)	2,564.6	3,222.6	3,861.4	4,490.4	5,080.7	**19,219.7**
	Difference (Scenario “Mandatory Equipment” – Trend Scenario)	**309.7**	**609.6**	**900.1**	**1,161.3**	**1,412.9**	**4,393.6**
Yearly equipment costs	Maximum yearly equipment costs in Mill. € (100 % ESP car stock penetration)	2,775.2	2,775.2	2,775.2	2,775.2	2,775.2	**13,876.0**
	Yearly equipment costs in Mill. € (Trend Scenario)	646.6	749.3	849.2	954.7	1,051.8	**4,251.6**
	Yearly equipment costs in Mill. € (Scenario „Mandatory Equipment“)	735.4	924.1	1,107.3	1,287.7	1,457.0	**5,511.5**
	Difference (Scenario “Mandatory Equipment” – Trend Scenario)	**88.8**	**174.8**	**258.1**	**333.0**	**405.2**	**1,259.9**
Benefit-Cost-Ratio (Trend Scenario)		**3.5**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**
Benefit-Cost-Ratio (Scenar. „Mandatory Equipment“)		**3.5**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**

Source: Own calculations

3.2.3 Aggregated Results

The same calculations, which were presented in the previous two chapters for fatality savings, accident cost savings and equipment costs, have also been carried out for the development of the avoidance of accidents and injured persons. These results are displayed together with the fatality savings and accident cost savings in Table 19 in an aggregated form. For each member state resp. for EU-15 and EU-25 as a whole, the aggregated yearly differences between the Trend Scenario and the Scenario "Mandatory Equipment" in accident figures for the time period from 2008 to 2012 are shown. The additional fatalities avoided are therefore identical with the sum of differences shown in Table 17. Likewise, the additional accident cost savings for the EU-25 in the years 2008 to 2012 (= € 4,393.6 Mill.) are identical with the sum of differences shown in Table 18.

Table 19: Additional accident savings between 2008 and 2012 due to a mandatory ESP-equipment of all newly registered cars from 2008 onwards compared to the Trend Scenario

Member States	Additional accidents avoided	Additional fatalities avoided	Additional injured persons avoided	Additional accident costs saved in Mill. € (without PDO accidents)	Additional accident costs saved in Mill. € (including PDO accidents)
United Kingdom	6,058	160	7,721	620.2	1,033.7
Germany	8,109	233	9,703	816.7	1,361.2
Italy	6,547	306	8,170	793.8	1,323.0
Spain	4,177	313	6,001	665.4	1,109.0
France	2,794	328	3,340	529.8	883.0
EU-15	34,335	1,628	42,692	4,182.3	6,970.5
EU-25	34,746	1,811	43,156	4,393.6	7,322.7

Source: Own calculations

Besides the 1,800 additional lives saved between 2008 and 2012, about 43,000 more injured persons could be circumvented by a mandatory equipment in the EU-25 compared to a situation, where ESP-equipment of cars remains voluntary. Together with the property damage and congestion costs of the 34,746 avoided accidents, the additional accident cost savings of such a mandatory equipment amount to nearly € 4.4 billion. In order to achieve this additional benefit sum, € 1.26 billion (see Table 18) have to be invested into the equipment of cars with ESP between 2008 and 2012 (Benefit-Cost-Ratio = 3.5).

As argued earlier, the inclusion of property damage only accidents will increase the benefits (and with that the benefit-cost ratio to 5.8). Hence, it will also increase the additional benefits which stem from the mandatory equipment compared to the trend scenario. This effect is illustrated in the last column of Table 19. Including an estimation for PDO accident costs, the additional benefits of the mandatory equipment amount to € 7.3 billion in the period 2008 – 2012.

It has to be noted that road safety has improved in the past. The number of injured persons in road traffic in the member states of the EU-25 declined from about 1.9 Mill. in 1992 to 1.74 Mill. in 2004 (which equals a yearly growth rate of about -0.64 %). The number of fatalities decreased even stronger in that time period from 66,558 (1992) to 43,358 (2004), which means a yearly reduction of -3.5 %.[23] Reason for this is a multitude of other measures besides ESP (e.g. improvement of infrastructure, better inspection regimes for vehicles, other technical improvements etc.) that help improving road safety. If this trend continues in the future, accident numbers will decline even without further diffusion of ESP. As a consequence, the accident avoidance potential of ESP might decrease in the future.

Under the presumption, that the number of fatalities declines by -3 % and the number of injured persons and accidents declines by -1 % each year from 2003 onwards, the additional fatality savings would amount to roughly 1,400 only. The additional accident cost savings would equal about € 3.8 billion. This smaller accident avoidance potential of ESP would influence the calculations for both scenarios and would also lead to a yearly declining Benefit-Cost-Ratio. This can of course not be taken as an argument against the promotion of ESP as a safety-enhancing measure. Because every effort to improve road safety could be considered as redundant, if one argues that road safety increases anyway due to other measures which are implemented. The question to be answered is, which of the measures is the most cost-effective one based on actual accident figures. Therefore the calculations have been carried out on the database of 2003.

Abstract

The introduction of the Electronic Stability Program (ESP) is widely regarded as one of the most effective measures for accident prevention in road vehicles. Single vehicle accidents caused by skidding cars could be largely prevented with this system. The profitability of ESP from the society of point of view is proven by a cost-benefit analysis for the EU-25 (base year: 2003). When full equipment of the car stock is assumed, about 75,000 accidents – resulting in 4,000 fatalities and 100,000 injuries – could be avoided. The benefit-cost ratio amounts to 3.5 without appraisal of property damage only accidents. It accounts for 5.8 when property damage is included. It is also investigated which additional impact can be realised when every new car will be equipped with ESP from 2008 onwards (scenario "mandatory equipment") compared to the trend scenario. The calculations show that 1,800 fatalities and 43,000 injuries could be additionally prevented due to the faster deployment. The additional benefits in the period 2008-2012 amount to 4.4 bill. € (without property damage) or 7.3 bill. € (including property damage). In the light of these results ESP turns out to be a very efficient measure for improving road safety.

[23] European Commission – Directorate General Energy and Transport, available under "http://ec.europa.eu/transport/roadsafety/road_safety_observatory/doc/ historical_evol.pdf

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