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Modeling and Prediction of Long-Distance Traffic Flows Through the Example of Road Transport in the Czech Republic

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ABSTRACT *The construction of large-scale long-distance roads brings an irreversible impact on the landscape and therefore its careful and precise planning is very important. For this planning we use data on the intensity of traffic flows on existing roads and statistical tools for the modeling of planned traffic flows. The main objective of this paper is the modeling of the existing intensity of traffic flows on highways and expressways in the Czech Republic by determination of the optimal distance-decay function. On the basis of the resulting model and the resulting distance-decay function, it is possible to predict the intensity of traffic in the event of the completion and commissioning of new sections of highways and expressways. The subsequent analysis will allow us to make a qualified prediction of traffic intensity in the event of the completion of the R35 expressway, or after the completion of the R35 and R43 expressways. Besides the intensity on the above-mentioned roads themselves, the paper also predicts the expected reduction in traffic intensity on the busiest highway in the Czech Republic, that is, on the D1 highway between Prague and Brno.*

KEY WORDS: traffic-flow models, long-distance traffic, distance-decay function, Czech Republic

1. Introduction

The construction of large-scale highways and expressways has become a hot topic and a priority in many post-socialist countries of Central and Eastern Europe. After 1989, in connection with the collapse of the Eastern Bloc, relatively rapid economic and social transformation processes took place in the Czech Republic. They resulted, among other things, in an exposed position of the country in the 'heart of Europe', which emphasized its macro positioning potential, which was further strengthened by the Czech Republic's accession to the European Union and the Schengen area. These facts led to an increased need for the construction of a new transport infrastructure which was to provide effective transit, as well as long-distance domestic flows of people and goods.

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The inland road and rail networks constitute crucial line elements which are exploited for the dominant flows of people and goods. The intensity of these flows increases with an increase in the size structure of the destination settlements and decreases according to the distance to the destination settlements. Transport allows the barriers of space to be overcome; this is most often expressed in terms of distance. Therefore, the distance and the size structure of settlements are often referred to as key factors influencing the formation and intensity of physical spatial interaction (Ullman 1980). The rate of decline in the intensity of traffic interactions can then be expressed by the distance-decay function.

The input data for this paper are figures on the intensity of traffic on highways and expressways from the national traffic survey carried out at regular five-year intervals by the Road and Highway Directorate of the Czech Republic. The main objective of this paper is to model these intensities through calibration of the model determining the optimal distance-decay function for long-distance traffic flows. The function thus established will allow us to model the observed flows so as to get close to the real flows. On the basis of the model thus established and the resulting distance-decay function, it is possible to predict the intensity of traffic for individual cases of the completion and commissioning of new sections of highways and expressways. Our analysis will allow us to make a qualified prediction of the traffic intensity in the event of the completion of the R35, or the completion of the R35 and R43 expressways. These predictions will include the intensity directly on these roads, as well as the expected reduction in the traffic intensity on the busiest highway in the Czech Republic, that is, the D1 highway between Prague and Brno.

The structure of the paper is as follows: the introduction is followed by a theoretical and methodological background that focuses on two separate parts: a brief description of the road network in the Czech Republic and an overview of approaches to the modeling of spatial interactions, with a detailed focus on the traffic flow models and interactions. The third section gives a detailed description of the research methodology. We tested the three basic distance-decay functions suitable for traffic flow modeling. The results of the research, including the map imaging, are presented in detail and discussed in the crucial Section 4, which brings a comparison of real and simulated traffic flows and the resultant prediction. We used original methods and data suitable for the modeling and prediction of traffic flows in the course of the planned construction of the R35 and R43. The conclusion summarizes the main findings obtained on the methodological and empirical levels and makes recommendations regarding future potential and further utilization of the research in the field of transport modeling.

The issues explored here have great importance not only in transport geography, but across all transport sciences. The modeling of spatial flows is therefore one of the most frequently used tools for the qualified evaluation and prediction of traffic intensity on a road network (Nijkamp *et al*. 1996). The added value of the article, in addition to calibration, resides in the modeling and prediction of flows on the planned communications and its focus on transit traffic and transit flows, as well as in the quality of the processed traffic intensity data. We use data from the traffic census of 2010, so the data are up to date and very accurate – in the Czech road network, nearly 7700 sections of all highways, expressways, roads in the first- and second-class categories, and some of the roads in the third-class category (14%) are surveyed. The very detailed data also indicate changes in intensity within specific areas and allow us to separate the nodal flows and transit flows with high precision, which has not often been the case in the modeling of traffic flows so far. This was the first time that calibration with a prediction of transport had been prepared for the Czech Republic. The standard gravity model without calibration or prediction has only been used before by Řehák (2004).

2. Theoretical Background

2.1. Road Transport Network in the Czech Republic

In recent years, the R35 expressway and the follow-up R43 expressway have become priority roads that are intended primarily for long-distance transport and transit through the territory of the Czech Republic in the northwest-southeast direction (see Figure 1). The alignment of the two roads corresponds significantly to the direction of the urbanized axis of Central Europe (Berlin – Prague – Vienna/Bratislava – Budapest), which is crucial for transit transport (road and rail) across the Czech Republic. It is basically an alternative route to the existing transport arteries with significant transit traffic connecting Dresden – Prague – Brno – Vienna/Bratislava via the D8, D1, and D2 highways. The importance of the R35 and R43 is also often emphasized by the required relief of the overloaded D1 highway connecting the two largest cities of the Czech Republic (Prague and Brno). The completion of the R35 and R43 should decongest the D1 highway and at the same time it should divert traffic from the towns and villages situated on the existing I/35 road (Kraft 2012; Kraft *et al*. 2014). Therefore, the completion of the R35 and R43 has recently become a topic for the political, environmental, and building lobbies, including the participation of some local NGOs.

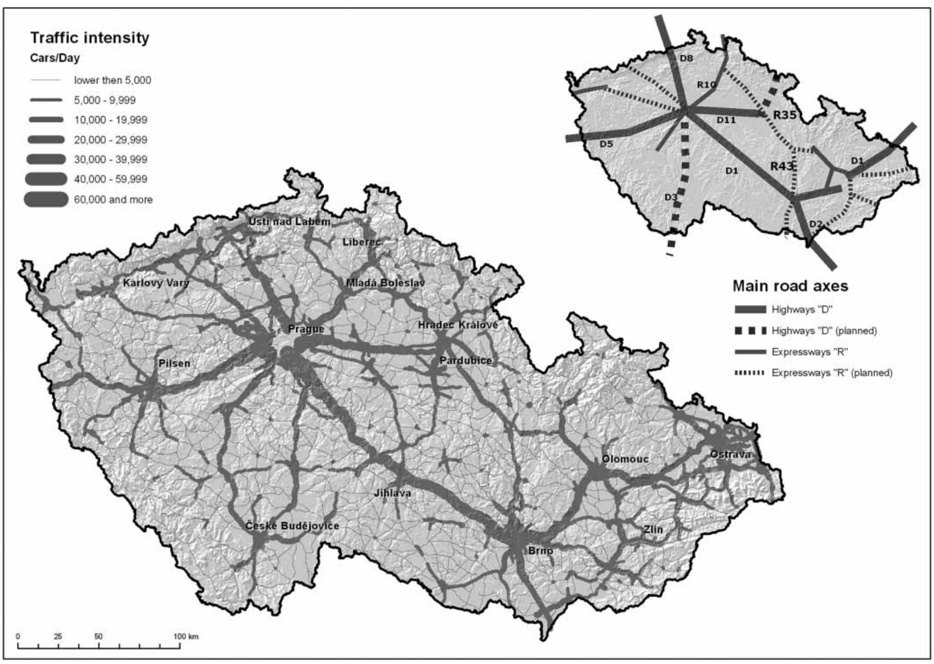

Figure 1 Basic traffic situation in the Czech Republic.
Source: Road Transport Census (2010); own processing.

However, despite a number of proclaimed advantages, it is possible to express a hypothesis that the R35 and R43 are of relatively low importance for long-distance domestic flows. For international transit flows too, their importance is probably overestimated. In terms of the organization of the inland flows, the suggested route connects rather important but relatively medium-sized populated settlement centers, which are also very far apart (e.g. Liberec – Hradec Králové – Olomouc). In addition, the route goes through territory with rather smaller population centers. In terms of transit traffic, it does correspond to the main direction of transit via the territory of the Czech Republic; however, it does not bring an adequate alternative to the aforementioned D8, D1, and D2 highways. The total distance from Dresden to Vienna or Bratislava along the existing highways is about 480 km. If the alternative route via the R35 and R43 is used, the total distance is more than 520 km. Furthermore, it is not planned to establish a capacity road that should connect the R35 section from the Czech-German border to the German A4 highway (Dresden – Görlitz).

In general, we can say that in terms of traffic in the Czech Republic, the international transit is significant, but for the overall flows of cars and trucks the inland transit intensity is far more important and dominant. This may be demonstrated by means of a comparison of transport intensity values (Figure 4): while the local minimum in the Prague – Ústí nad Labem section is 21,000 vehicles per day, the subsequent border crossing at Krásný Les – Breitenau on the D8 has an intensity of only 9100 vehicles. The local minimum in the Prague – Pilsen section is 28,400 vehicles and the subsequent border crossing at Rozvadov – Waidhaus on the D5 has an intensity of only 11,300 vehicles, etc.

2.2. Modeling of Spatial Flows

The largest and most detailed work focused on modeling traffic flows is a monograph by Ortúzar & Willumsen (2011). The authors present a wide range of models used in transport geography and transport planning. The task of modeling transit flows on individual sections of highways and expressways can be described as trip distribution modeling. It is possible to choose any of the group of gravity models and it is necessary to calibrate it beforehand (Ortúzar & Willumsen 2011, pp. 191–193). The basis is the trip matrix structure and selection of an adequate distance-decay function or distance-decay functions (e.g. Williams 1976). The summarization of individual relations for specific modeled sections is crucial (see Methods section for more details).

The modeling of spatial flows is a standard scientific task (e.g. LeSage & Pace 2008). A procedure similar to transport modeling is also used in the modeling of migration flows (Ingene 2001; Simini *et al*. 2012) or commuting (Fallick & Fleischman 2004). The basic principle, including the application of the distance-decay function, is maintained; however, there is a crucial difference in modeling commuting and traffic intensity. In the case of commuting we know the beginning and end of the movement, but we do not know its spatial alignment, while for transport we know the course of the movements, but do not know their start and end points. What commuting and transport have in common is that they can be evaluated on the basis of momentary data (e.g. as of the date of the survey), while migration data are continuous and cover a representative period of time.

The research in the field of the modeling of long-haul transport networks is associated with the development of operational research in the 1960s. The pioneering work using graph theory was published by Dial (1967), who worked with nodes and line elements of rail transport. Transport planning was supported by the use of the general gravity model. Wilson (1970) recommended for transportation the doubly constrained entropic and gravity-type model, that is, a model with limitations or specifications both on the origin and destination sides. An important part of the research is to select optimal routes for traveling between selected nodes, which is usually resolved using Wardrop's conditions in a determinist setting or stochastic user equilibrium (e.g. Sheffi 1985; Roy 2004; Ortúzar & Willumsen 2011 – all based on Wardrop 1968).

In more recent scientific works, the modeling of transport networks has been used for the optimization of decisions regarding the locations of the transport routes, and in terms of their effectiveness, as well as from the perspective of the rent situation of the lots concerned (Martínez & Donoso 2001; Martínez & Henríquez 2007). More often, it is used for jammed traffic in heavily urbanized metropolitan regions, where alternative solutions are modeled with the aim of minimizing traffic jams and collapses of the traffic system. In these cases, however, the models involve much more unpredictable factors, and therefore their application may not be in accordance with the standard rules of physics, or with Stewart's understanding of social physics (Ross & Yinger 2000; Arnott 2007). For these reasons, the majority of current research studies deal with the serious problems of traffic situations in areas that are heavily overloaded, which is even more urgent in highly urbanized areas (Condeço-Melhorado *et al*. 2014). On the contrary, this study focuses rather on the question of whether the loading of planned communications would be adequate for highways and expressways and the issue of overloading in certain sections is dealt with only indirectly (i.e. how much it will reduce the traffic intensity on the overloaded D1 near Prague).

Transport modeling has an essential use in planning spatial systems, regardless of the means of transport used (automobile, train, etc.) and regardless of the hierarchical level (local, regional, national, international, etc.). The modeling of availability in urban public transportation planning (e.g. Gulhan *et al*. 2014), as well as models of rail transport on regional and supra-regional hierarchical levels (e.g. Máthé *et al*. 2013; Yang & Wang 2013), is also practicable. In the majority of cases, quantitative analysis, mostly based on graph theory principles, is necessary for the modeling and planning of new sections of track.

To date, the modeling of traffic flow has tended to use models with restrictions, whether production-constrained, attraction-constrained, or doubly constrained models (e.g. Slater 1989; Martínez & Araya 2000; Santos Silva & Tenreyro 2006; Helpman *et al*. 2008; Klapka *et al*. 2013). This paper is not based on the probability of flow direction (as is the case of models with restrictions), as it uses a purely unconstrained model. The maximum approximation to the real flows is secured by the calibration of the model and testing of various distance-decay functions. To achieve this goal, all the relevant alternatives of the long-distance relations being modeled are put on sections of motorways (see Methods section for more details). To date the use of unconstrained models has been indicated only in the work by Bravo *et al*. (2010), but in this case, it was a different type of research, where the transport network optimization is related to land use. Hitherto, traffic flows that include calibration of the model have not been modeled in this way. Paradoxically, these models most closely resemble some models of photonic networks (e.g. Hülsermann *et al*. 2004), as these models are also based on a network composed of nodes and line connections and work with the intensity of the lines and the nodes represented by the most important centers of the study area.

3. Methods

In this paper, we use the standard methodology for modeling spatial flows such as migration and travel-to-work flows, as well as traffic flows in general, or interaction without spatial mobility (phone calls, etc.). The three basic distance-decay functions are tested:

power:

$$f(d) = \alpha d^{-\beta}$$

exponential:

$$f(d) = \alpha \exp(-\beta d)$$

quadratic-exponential:

$$f(d) = \alpha \exp(-\beta d^2).$$

In all three cases, d is the distance and α and β are (positive) function parameters that are used to calibrate the model. The power function and exponential function are the basic functions for modeling the spatial flows and the quadratic-exponential function is a composite function with a bell shape (with an inflection point), which appears to be a suitable function for modeling nodal flows (its more complex power-exponential version was used, for example, by Halás *et al.* (2014)). There are many more composite functions for modeling spatial flows, which are even more complex (e.g. Martínez & Viegas 2013; Halás *et al.* 2014), but the above-mentioned quadratic-exponential function is sufficient for our needs. The composite functions allow us to express more accurately the changing intensity of interaction in the immediate hinterland of the settlement centers, but in our paper we are interested in the long-distance traffic flows, that is, testing the interaction at greater distances (over 50 km); considering this, the intensity of the interaction in the immediate hinterland of settlement centers is irrelevant. Graphs of the three test functions are shown in Figure 2.

When modeling long-distance traffic flows, we start from the graph theory, where the graph points are the cities of the Czech Republic with over 50,000 inhabitants and the edges of the graph are their connecting lines, in cases where there is an interconnection via highways or expressways, or the potential intensity of traffic is tested on planned sections of highways or expressways. Besides the cities of 50,000 or more, one of the points on the graph is Mladá Boleslav, which has only about 45,000 inhabitants, but which, because of its economic potential (as the seat of Škoda Auto), has an important position in the regional and settlement system of the Czech Republic that is comparable to the above settlement centers. Such a selection of centers is sufficient, as the cities with a smaller population do not significantly influence the modeling of long-distance traffic flows, which has been repeatedly confirmed in previous works (Řehák 2004; Halás 2005). Because the distance between them is less than 30 km, the cities of Pardubice and Hradec Králové are considered as one point on the graph. The mass of graph points is determined by the basic quantitative information on the center – the size of the population, while in the case of Pardubice and Hradec Králové it is their sum. In the preliminary analyses, we also tested other masses, such as the number of cars, level of the traffic in the centers (defined in more detail by

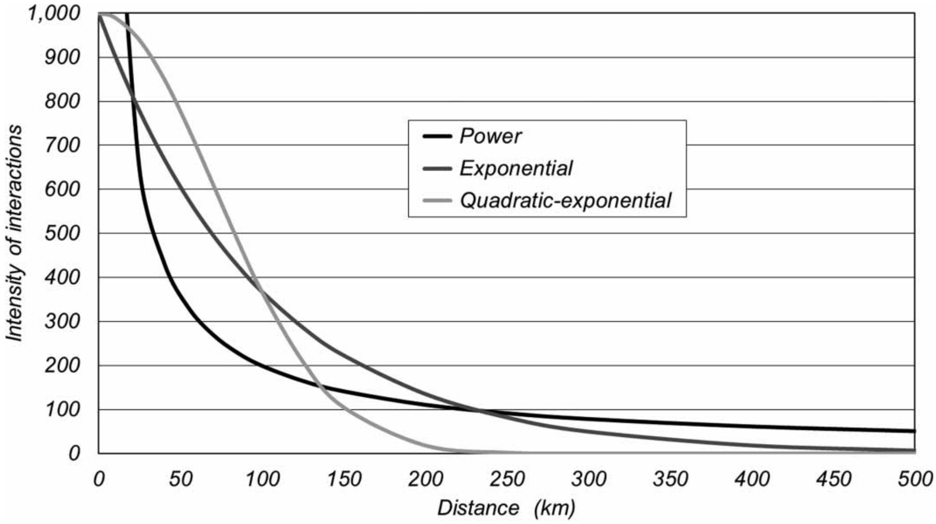

Figure 2 Basic forms of distance-decay functions for the modeling of spatial flows.

Kraft (2012)), and the so-called economic aggregate, which is widely used in Czech human geography (i.e. the product of jobs and average wages – e.g. Hampl 2005). From the available data, the population size fits best (with a correlation coefficient of real and modeled flows with a value of 0.969) and it is also a simple and representative figure suitable for modeling the overall traffic intensity (in this paper, we aimed to model the overall traffic load on the roads, which consists predominantly of two quite different modes of transport – cars and trucks).

Relations crossing the state border outside the Czech Republic are anchored in Nuremberg, Dresden, Katowice, and Bratislava. During the modeling, the cross-national relations are not completely comparable with the inland relations. Therefore, in the analysis the masses of Nuremberg and Bratislava are divided by two and the masses of Dresden and Katowice by four (similar to the procedure used by Řehák (2004), who discussed it in detail). Although there are more alternative ways of working with relations across the border, we will use Řehák's method. The above-mentioned cities do not represent specific centers, but rather the populations abroad in general. We also tested other alternatives, but the results varied only a little, and only in the sections across the border, while in the inland sections the results varied only in negligible tens of flows. We realize that every selection is subjective, but for the results of transit modeling and long-distance transport within the Czech Republic it is not crucial. For our purposes, what we found essential was the inland sections, whose intensity is significantly higher in comparison with the cross-border sections (see Section 2.1 for details).

The distance d between the centers (graph points) entering the model is determined as the minimum distance (in km) between the end points of the relation (i.e. centers) along the highways and expressway sections that are covered in the analysis. The input data include information on traffic intensity from surveys carried out in 2010 (the sum of the average daily intensity of passenger and commercial vehicles), shown in the flow map in Figure 1. We are interested in long-distance flows, so we work only with the local minimum values (the sections with the lowest traffic intensity) at each edge of the graph (a section of highway or expressway). In general, it is possible to consider the increasing intensity toward the individual settlement centers as nodal flows. Each edge of the graph (sections of highways and expressways) is modeled separately and each edge is modeled with respect to all relevant relations, that is, relations that pass through this edge (e.g. the Pilsen – Brno relation goes through the Pilsen – Prague, Prague – Jihlava and Jihlava – Brno edges). Mathematically, it is possible to define it as follows:

$$I_{ab} = \sum_{ij} f(d_{ij}) \times P_i P_j$$

for all the relations *I* and *j* passing through the section (graph edge) *a* and *b*, where I_{ab} is the modeled intensity of interactions in the section between the centers *a* and *b*, $f(d_{ij})$ is the functional value of the distance-decay function for the distance d_{ij}, P_i is the population of the center *i*, and P_j is the population of the center *j*.

Through calibration of the model in the Statistica program we get the optimal values of the parameters α and β for the distance-decay functions that are tested (the calibration of the model enables the maximum approximation of the values of the modeled flows to the values of the real flows to be calculated). According to the correlation with real flows, we determine a distance function that, when the most relevant parameters are used, reflects the real long-distance traffic flows. The result is the approximated traffic intensity on all the sections being modeled. Unlike some tasks for nodal flows (e.g. Halás *et al*. 2014), we are also looking for the optimal values of the parameter α, because it approximates the absolute value of the intensity of long-distance transport.

Unlike migration modeling, the modeling of traffic flows has significant practical applications. Using the optimal distance function, it is possible to project the anticipated traffic intensity on any potential sections of highways or expressways. In this paper, we suggest the anticipated traffic flow on the planned routes of the R35 (from Olomouc through Hradec Králové to Liberec) and the R43 (connection from Brno to the R35) and the way these sections would relieve the D1 highway. The relevance of the results is confirmed by the high correlation quotients of the real and modeled traffic. The high degree of coincidence between the real and modeled data is expressed both numerically and graphically (in maps).

4. Results

4.1. The Modeled Intensity of Traffic on Highways and Expressways

The relevance of the procedure used, as well as of all three models using different distance-decay functions, is expressed quantitatively in Table 1. To evaluate the efficiency of each model we used four statistical indicators of compliance, which measure the degree of

Table 1 Statistical indicators of compliance of models of long-distance traffic flows

function	$\alpha d^{-\beta}$	$\alpha \exp(-\beta d)$	$\alpha \exp(-\beta d^{2})$
R	0.965	0.969	0.966
R^2	0.931	0.940	0.933
IOD	6.204	6.241	6.210
SRMSE	0.146	0.142	0.145

Note: R, Correlation coefficient; R^2, Coefficient of determination; IOD, Index of dissimilarity; SRMSE, Standardized root mean square error.

correspondence between the real and model predicted traffic flows, namely the Correlation Coefficient, the Coefficient of Determination, the Index of Dissimilarity, and the Standardized Root Mean Square Error.

Analyses showed that there are no significant differences in the informative value of the models when the three basic functions are used. The reality is most closely approached in the case of the exponential function $f(d) = \alpha \exp(-\beta d)$ with the parameters $\alpha = 1.87 \times 10^{-7}$, $\beta = 8.30 \times 10^{-3}$.

This function is shown in Figure 3; considering the modeling of the long-distance traffic flows, it is bolded in the relevant distances over 50 km. The correlation coefficient of the real long-distance traffic flows and modeled long-distance traffic flows at the edges of the graph reaches up to 0.969. This represents a significantly higher similarity or reliability of the model in comparison with models of migration movements (e.g. Ingene 2001; Pellegrini & Fotheringham 2002; Bahna 2008; LeSage & Pace 2008; Simini *et al.* 2012). The graphic representation of the similarity can also be checked in Figures 4 and 5.

The modeled traffic flows plausibly describe the real load of highways and expressways. They point to the known load (or even overload) on the D1 highway, in the section linking the two dominant centers of Bohemia and Moravia, Prague and Brno. The quality of the prediction is similar in all the other inland sections. Only the Liberec – Mladá Boleslav section is slightly underestimated (by about 20%). This is due to the relatively short distance between the two centers, where the distance of 50 km is limiting for the modeling of transit traffic flows (over shorter distances it is not possible reliably to separate the long-distance roads from nodal roads). In all the other inland sections, the model is almost completely accurate. The difference between the real and modeled flows is up to 10%.

4.2. Prediction of the Intensity of Traffic on the Planned Sections of Expressways

An important benefit of the modeling of traffic flows in comparison with migration modeling is its practical application. If we manage to model the traffic flow with an accuracy in

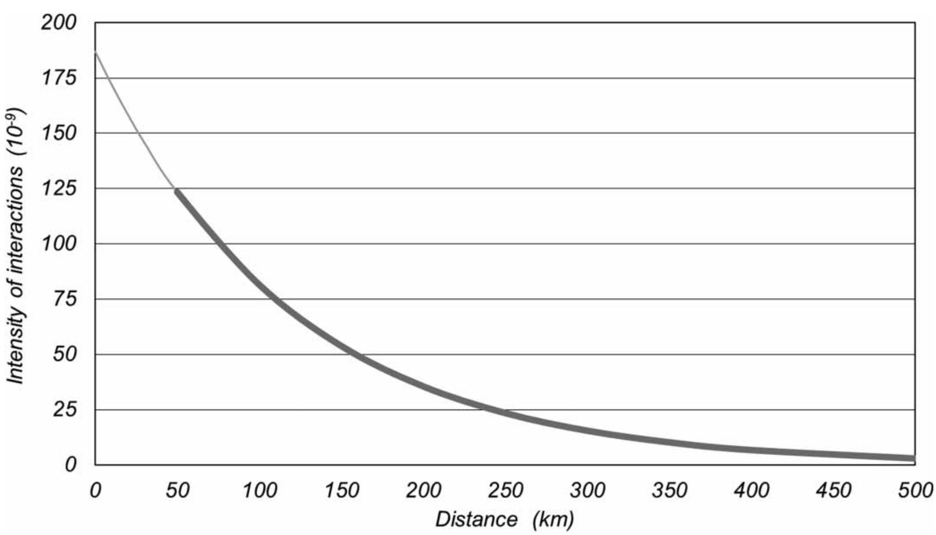

Figure 3 The optimal distance-decay function for long-distance traffic flows in the Czech Republic.

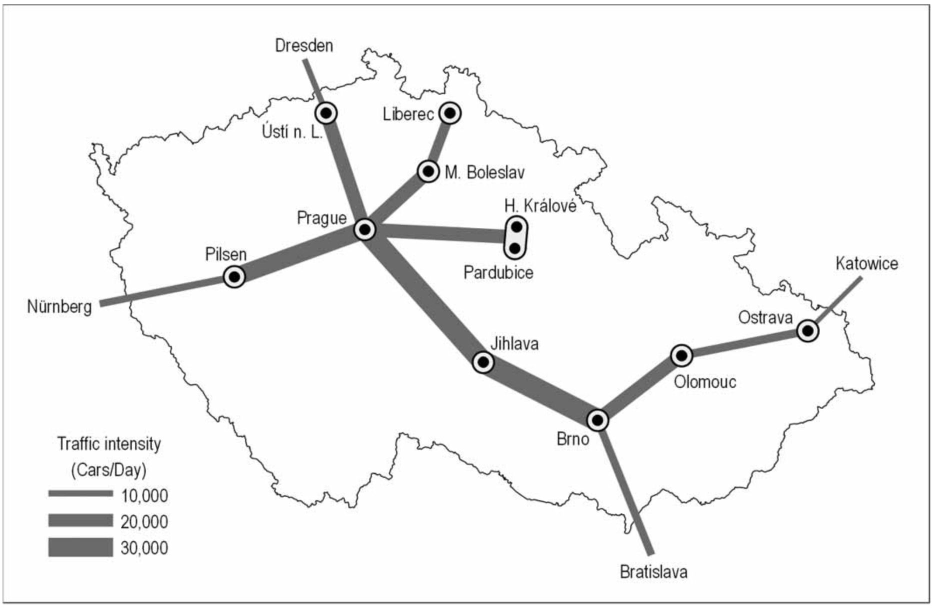

Figure 4 Real intensity of long-distance traffic on highways in the Czech Republic.
Source: Road Transport Census (2010); own processing.

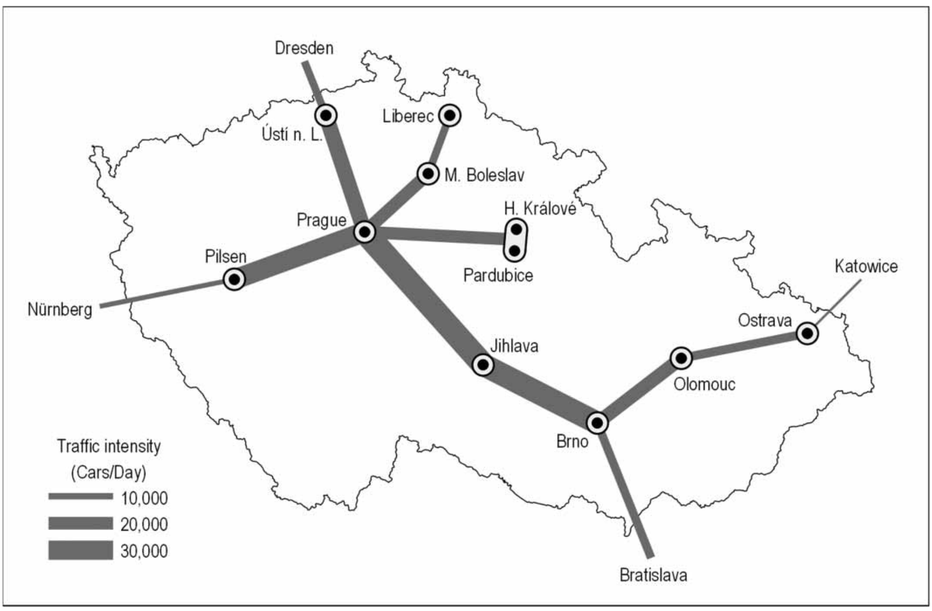

Figure 5 Modeling the intensity of long-distance traffic on highways in the Czech Republic.
Source: Road Transport Census (2010); own calculations.

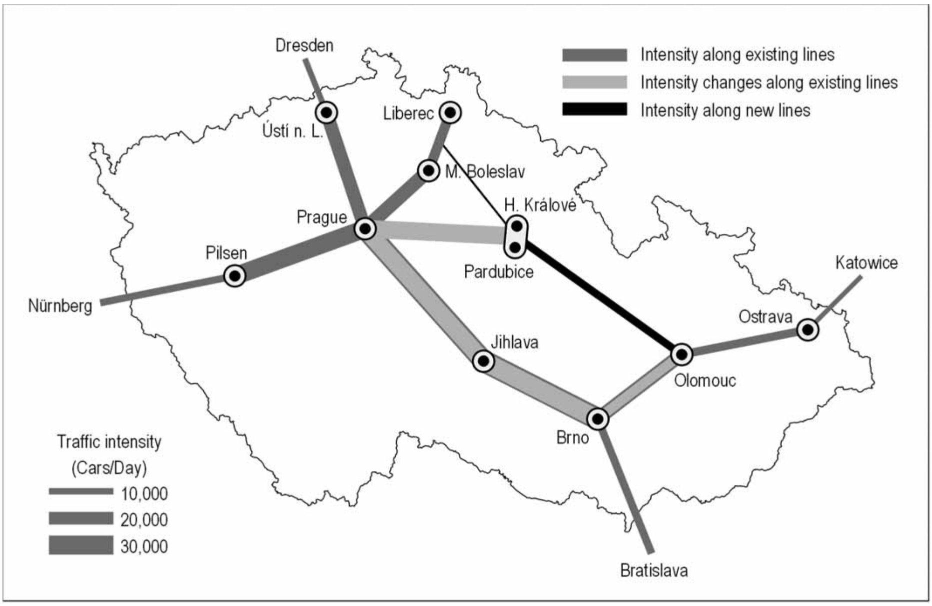

Figure 6 Prediction of traffic intensity on the planned R35 expressway.
Source: Road Transport Census (2010); own calculations.

which the value of the correlation coefficient significantly exceeds 0.95, then the accuracy of the estimation of the expected traffic intensity on the planned sections is highly reliable.

By application of the model we obtain the expected traffic intensity for the planned R35 expressway (Figure 6). In the Hradec Králové – Olomouc section, this intensity is adequate (or rather lower) for the planned four-lane expressway, but on the other hand, very high for the current two-lane road. On the other hand, the estimated traffic intensity in the Liberec – Hradec Králové section is very low. The intensity in this section would be increased only slightly even after the direction of the R35 to Brno was switched by the eventual completion of the R43 (Figure 7). These conclusions can be documented by means of exact figures. According to the model, after the completion of the R35 and R43, the traffic intensity would increase only minimally, by hardly 5% in the Liberec – Hradec Kralove section, while for the Hradec Kralove – Litomyšl section, the increase in the intensity of the traffic would be more noticeable, by up to 79% (Litomyšl is a town near the junction of the R43 with the R35). This significant increase is mainly due to the shift of the current Prague – Olomouc and Prague – Ostrava relations (as well as others, including foreign transit) from the D1 to the D11 and R35 (described in detail in the next paragraph). The intensity of the long-distance traffic on this section would approach the standard load on already-established highway sections and from this perspective the completion of the R35 expressway in conjunction with the completion of the R43 expressway is definitely beneficial.

Another important part of the discussion is the way in which the R35 and R43 expressways would relieve the congested D1 highway after their completion. It is beyond dispute that some of the long-distance sections, such as Prague – Ostrava, Prague – Olomouc, and others would move from the D1 to the D11 and R35. The model predicts that the newly-

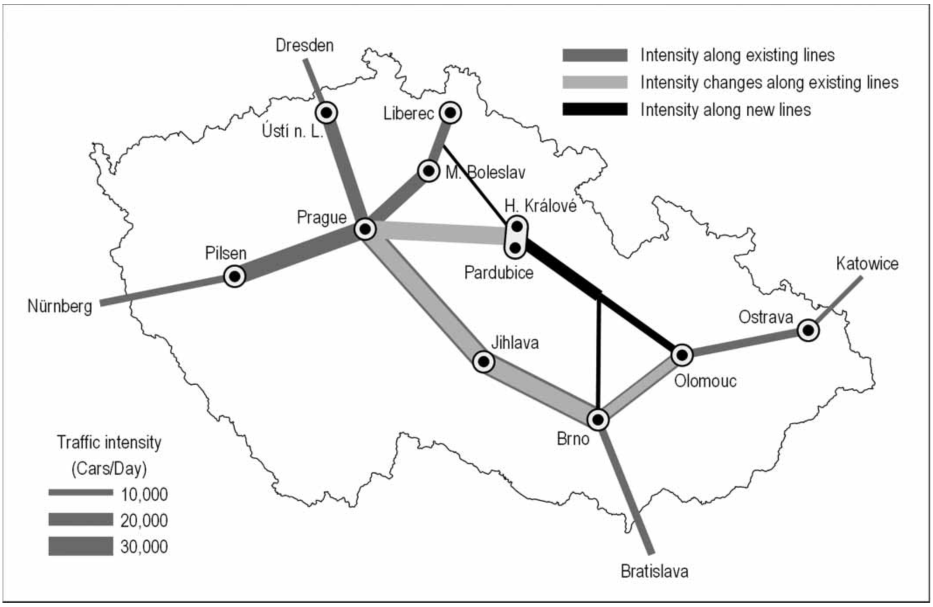

Figure 7 Prediction of traffic intensity on the planned R35 and R43 expressways. Source: Road Transport Census (2010); own calculations.

built R35 could absorb a part of the D1 transit traffic amounting to a volume of about 8000 vehicles per day. This would, *inter alia*, cause a non-negligible increase in the intensity of long-distance transport on the Prague – Hradec Králové section of the D11 highway, to a level approximately identical to that on the D5 highway between Prague and Pilsen, and about 15% lower than the current intensity of the long-distance transport on the D1 highway between Prague and Brno. The model also shows that, in fact, no substantial reduction of the intensity on the D1 highway would occur (Figure 7). The intensity of the long-distance connections would drop from approximately 35,000 to 27,000 cars per day, that is, by about 23%. However, this would happen only on the least loaded parts of the D1. For example, in the hinterland of Prague, the nominal decrease would be similar (about 8000 cars per day), but the relative decrease would be significantly lower. In the hinterland of the largest cities, the overall traffic intensity is significantly increased by nodal flows. The total intensity of the traffic on the D1 near Prague exceeds 90,000 cars per day and from this perspective its reduction by about 9% after the completion of the R35 and R43 is negligible. Therefore, it can be stated that the problem of the congested D1 highway would not be resolved by the completion of the R35 and R43 or would bring only a partial solution for a limited period of time.

Qualified modeling and prediction of transport intensity are important and should be taken into account when planning the transport infrastructure. Nevertheless, even advanced and sophisticated models are not able to capture some unpredictable consequences. One of the risks of the model's prediction accuracy is, for example, the fact that the overall effect of the spatial distribution of rail transport can change in comparison with the current situation, for example, the completion of the railway transit corridors across the Czech Republic, which could absorb a part of the transit traffic. However, because of the rapidly increasing volume and performance of road transport, it can be expected that road transport will play a key role in the future.

The results presented in this paper are concerned with the prediction of transport intensity along planned routes according to its current intensity along the existing routes. Reservations about these results can be seen at two levels. The first level represents reservations relating to possible consideration of the total (nominal) rise in the transport intensity. The second level represents a possible and less predictable increase in the international transport on some sections, because international transit traffic has a small share of the intensity along the inland sections. The share of the international transit traffic, however, may increase in the future, or it may move to other sections of roadways in comparison with the current situation. Another considerable impact may be caused by increased international demand for travel supported by the new motorway links across the Czech Republic. This demand depends on the actual development of the transport system in the Czech Republic, but also partly from the development of the transport systems of the neighboring states and other European states. For example, the potential connection of the R10 from Liberec toward the E40 European route would increase the load on the R10 and R35 in the Liberec – Hradec Králové section.

Another risk associated with the standard transport prediction models is the fact that they assume rational behavior and rational choice of transport routes on the part of the traffic participants. The authors are aware of the fact that this is not always true. However, the rationality of the choice of routes has significantly increased in recent years as a result of the use of navigation systems and electronic route planners.

5. Conclusion

The connection of regions to long-distance traffic arteries is one of the most important factors determining their further development. The accessibility of transport is one of the key factors for the entry of new investors and their activities in established regions. Any planning of the long-distance transport infrastructure should therefore be based on more sophisticated calculations aimed at optimizing the traffic network.

The model of traffic flows presented in this paper proved to be of significant viability and can be considered as a useful tool to help indicate the expected load on transport corridors. The extremely high value of the correlation coefficient (significantly above 0.95) confirms that the model is able to approximate the current long-distance transport load of highways and expressways with a high level of accuracy. This high level of accuracy of approximation gives us assurance that the model is able, with the same precision, to assess the expected intensity of long-distance transport on roads that are not just planned or under construction.

The specific results for the completion of the R35 and R43 expressways suggest a slightly below-average load in the case of long-distance transport, and specifically a significantly below-average load in the Liberec – Hradec Králové section. However, this load is extreme, considering the current state of the infrastructure in these sections, so most of the relations (especially Prague – Ostrava and Prague – Olomouc) would be moved from the R35 to the D1. The model also showed that any system of expressways in this area makes more sense if both the R35 and R43 are completed at the same time. On the contrary, it is not confirmed that this would significantly relieve the D1 highway, where the total intensity of traffic in the immediate hinterland of Prague would drop by 10% at the most.

The modeling of traffic flows is one of the most reliable and sophisticated tools for the prediction and optimization of transport infrastructure. The results of traffic models can competently determine the necessity for the construction of a suitable type of communication. Nevertheless, their practical application is often overshadowed by the lobbying of construction companies, government institutions, or regional administrations that are affected. The paper has also shown that the construction of new roads should be approached comprehensively and systematically. Qualified assessment and prediction based on interaction models must always be one of the initial steps to be taken.

On the other hand, it is necessary to point out that even the most sophisticated models cannot predict and take into consideration all the possible aspects of transport development. Changes in the current regional and municipal systems (e.g. the formation of metropolitan structures or commercial suburbanization around the big cities) and other phenomena (changes in the trans-European transport corridors, development of high-speed railways, rapid development of information, and communication technologies, etc.) and their impacts on the geographical reality are so complex and unfathomable that it is difficult to predict them. The aforementioned model and its results should therefore be taken as a tool that uses the current state of knowledge and understanding and its relevance is conditioned by a high-precision determination of the current traffic intensity.

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