Spatial patterns of transport accessibility and traffic load in Czechia: towards a typology of the new road infrastructure impacts

Marek Petráš and Viktor Květoň
Faculty of Science, Charles University, Prague, Czech Republic

ABSTRACT
We analyse the impacts caused by the construction of new road infrastructure between 2005 and 2015 in Czechia, EU. The results provide an answer to which municipalities were affected by the construction of new road infrastructure or how the accessibility of individual regional centres changed. The study works with two key variables: a change in the accessibility of regional centres and a change in traffic load inside municipalities. The key output of the analysis is a map, thanks to which it is possible to assess the impact of the new roads in a broad context. The effects on accessibility to regional centres are much more concentrated in only a few areas where significant transport infrastructure has been lacking so far (e.g. east, southeast, southwest, or northwest part of Czechia). Impacts on traffic load are, on the other hand, distributed more evenly in space, not only on the main transport routes.

1. Introduction

New road infrastructure in Czechia is focused on either development of the motorway network or the construction of bypasses of municipalities and cities, usually on roads of I. or II. class of importance. While in the first case it is mainly a matter of speeding up the connection between the two areas and thus increasing the degree of their interaction (see e.g. Halás et al., 2010), the construction of the bypass is primarily to help reduce traffic load inside the municipality (Elias & Shiftan, 2011). Thus, both types of construction serve a common goal in the long run: to increase the local quality of life, although both motorways and the bypass contribute to this quality in a slightly different way.

Between 2005 and 2015, approximately 1280 km of entirely new roads or motorways opened in Czechia, thus taking over the traffic load from the older road infrastructure. At the same time, new roads are being created unevenly in the country – this means that in one region the number of new roads is greater than in another region. Therefore, some municipalities were more affected by the construction of road infrastructure than others. At present, however, there is no clear overview in Czechia of which municipalities benefited the most from the construction of new infrastructure and which, on the contrary, did not. There is no evaluation on how much the individual municipalities are affected by the new infrastructure. In such a case, it is difficult to assess other – longer-term – impacts of the infrastructure on life in the municipality. In the article, we focus on this research gap.

This research aims to create a comprehensive typology of municipalities according to the extent to which they were affected by the newly opened road sections. A new methodological approach will help find an answer to the specific aspects in which the construction of new road infrastructure impacts life in the affected municipality. We use two key characteristics, the development of which can be clearly attributed to the newly built infrastructure:

- Change in traffic load – i.e. a change in the intensity of traffic that passes through the municipality
- Change in transport accessibility – change in time accessibility to regional centres

While the change in traffic load within the municipality can be attributed mainly to newly built bypasses, motorway infrastructure has brought increased time availability of regional centres, which according to long-term geographical research may affect the development of municipalities in the hinterland (see e.g. Blažek & Uhlíř, 2011 or Krugman, 1991). Sometimes, however, the opposite is also true: motorways have...
reduced traffic in the municipalities lying on the original main route, and bypasses have accelerated their journey to regional centres, as the transit route avoids city centres. For this reason, it is appropriate to evaluate both characteristics together.

The added value of this article is the development of a methodological approach, complex data analysis and map visualisation, thanks to which we can look at the construction of new roads in Czechia in a relatively broad context and from various angles. Thanks to the created map, we can find answers to various questions:

- Which municipalities were most affected by the construction of new road infrastructure from 2005 to 2015?
- In which municipalities did the most significant change in traffic congestion within the built-up area occur at that time? How significant was the change at the municipal level?
- Which municipalities have the most significant change in accessibility to key regional centres in recent years? How many minutes did the new road infrastructure save in commuting from individual municipalities to the regional centres by car?
- How did the accessibility change to the most important regional centres in the evaluated period? Which regional centres gained the most through the construction of new infrastructure, i.e. became the most accessible centre for the other municipalities?
- How does the accessibility of individual regional centres correspond with the administrative boundaries of regions?

In chapter 2, we focus on theoretical concepts that work with the use of the road network and its impacts. In chapter 3, we explain the methodology. Chapter 4 presents the results, which we also discuss in summary (chapter 5).

2. Conceptual framework

Assessing the impacts of new infrastructure on the behaviour of individuals, companies or the overall impact on the development of the region is a relatively common topic of geographical research. In particular, the change in accessibility (El-Geneidy & Levinson, 2007), the relationship between changes in accessibility and changes in employment (Gibbons et al., 2019; Meijers et al., 2012), the level of business activity in a region with a motorway compared to other regions (Holl, 2004 or Melo et al., 2010) or the effects of new infrastructure on property prices (Hoogendoorn et al., 2019) are addressed.

A very important topic at the moment is the impact assessment of new rail infrastructure, specifically High Speed Rail (HSR). The situation before and after the construction of HSR in Spain is addressed by Monzón et al. (2013). A key aspect is the change in accessibility. Another important research are those from Sánchez-Mateos and Givoni (2012) and Wang and Duan (2018). This is because these researches focus on typology: they define which cities in the UK and China, respectively, have gained the most from the new situation and which cities can be described as losers. They assess how fundamentally their accessibility to other regions has changed. While Sánchez-Mateos and Givoni (2012) works with accessibility to London, Wang and Duan (2018) work with the average change in accessibility to all locations in a region, not forgetting to work with the accessibility of train stations themselves – a door-to-door approach. Importantly, for all these authors, they try to define areas that benefit from HSR, but equally they do not neglect areas that have lost out due to HSR – they have ceased to be on important routes, manifested, for example, in reduced accessibility to development centres due to reduced services on conventional rail.

However, it is also important to assess accessibility to regional development centres in terms of road infrastructure. Such research is particularly relevant where road infrastructure capacity is not yet fully developed and where there are major qualitative changes in accessibility on an ongoing basis. This is also the case in the Czech Republic, which currently lacks a relatively significant part of its motorway network.

Any expansion of the road network in such a region therefore leads to a change in the importance of the individual regional centres. This is simply because infrastructure expands faster around some regional centres than around others. The aim of this study is, among other things, to highlight which cities are more and less prospective in this respect.

The issue of the road network and its impact on accessibility has recently been addressed, for example, in the study by Chen et al. (2020) in the case of China. Similarly, the road network, this time in conjunction with air transport, was addressed for the definition of accessible and less accessible regions in Australia by Meire et al. (2019). The aim of both studies was to regionalise – in the first case, the hinterland of major cities, and in the second case, the well and poorly accessible regions. Our research aims to combine both – to define the change in hinterland for each development centre based on road transport accessibility, and on the other hand to compare which regions have become most accessible in recent years and are therefore most affected by new infrastructure.

To address issues like this, it is first and foremost necessary to delimit the territory appropriately – in other words, to define which part of the territory is ‘affected’ by the new infrastructure and which is ‘unaffected’, which can then act as a control group.
Indeed, inappropriate delimitation of the research area may misinterpret infrastructure impacts. We consider the following two to be key aspects in assessing where the impacts of the new road infrastructure occur:

- Change in transport accessibility – i.e. a change in time accessibility to regional centres
- Change in traffic load – i.e. a change in the intensity of traffic that passes through a given place

Why did we choose exactly these two? It is very important, that both indicators represent an objectively defined change that can be directly attributed to the newly opened infrastructure – they are in principle measurable immediately after the new road is put into operation and we can be certain that only reason for that change is the new infrastructure. While the concept of accessibility is commonly used in geographic research (as can be seen from the literature presented), the assessment of traffic load is more common for local traffic studies. Below we present why we consider appropriate to combine both aspects.

2.1. Transport accessibility

The new road infrastructure is changing accessibility in the area, reducing transport time between two points in space. At the same time, the road network is being built in such a way as to speed up the commuting, especially to the most important centres in the region, where economic and social activity is concentrated (see, for example, Hampl, 2005).

The distance between the centres has a much broader impact, especially on their interaction. The role of distance is most elegantly expressed in Tobler’s so-called First Law of Geography, which states that everything is related to everything else, but near things are more related than distant things (Tobler, 1970, p. 236). In other words, the size of municipalities and their mutual proximity is proportional to the interaction between them. In this case, the commute of the inhabitants from one municipality to another is considered an interaction.

The strength of the interaction – i.e. the size of the traffic flow – between localities is commonly used to define the so-called functional regions, which divide the geographical area into territorial units, within which there is a strong mutual interaction in the territory. Thus, traffic links serve as a key indicator for defining the regional sphere of influence of settlement centres (Kraft, 2014).

The degree of accessibility thus affects the degree of connectivity between units. By increasing accessibility, i.e. by bringing one municipality closer to another in a matter of time, their connection will usually increase. Accessibility is a key characteristic influencing the quality of life in the broadest sense. And what is important for our research, the main ‘culprit’ for such a change is the new transport infrastructure.

2.2. Traffic load

The second indicator we work with is a traffic load (or traffic congestion). It is important to say that we are using this indicator not as a measure of connectivity (i.e. the bigger the traffic load, the bigger the connectivity between two places), but as a measure of quality of life in the location – i.e. the bigger the traffic load, the worse the quality of life in that exact place around the road. Traffic load is determined by the number of vehicles that pass through a given section of road in a certain period of time. Local transport and transit transport can be divided.

The change in road occupancy is basically twofold: continuous and abrupt. The continuous change in traffic load may be related to the daytime and the rush hours – see, for example, the study of Moya-Gómez and García-Palomares (2017). The abrupt change in traffic load is associated with the new traffic situation at a given location. The total number of vehicles on the selected road is influenced by the construction of a bypass or highway, which motivates drivers to use another road.

The construction of bypasses or new motorways leads to a reduction in the occupancy of the original road. Around this road, some characteristics, including noise (this phenomenon in the vicinity of roads is dealt with by Ongel & Sezgin, 2016), amount of NOx emissions in the air (see, e.g. Bronnum-Hansen et al., 2018) or pedestrian safety (e.g. Elias & Shiftan, 2011) are affected.

Therefore, reduced road traffic has a significant and basically positive effect on the local quality of life, at least from the point of view of health and safety. Whether lower road congestion also negatively affects the local economy is the subject of several other studies with different results (e.g. Collins & Weisbrod, 2000; Parolin, 2011; Sloman et al., 2017; Srinivasan & Kockelman, 2002). Nor should it be forgotten that, on the contrary, the congestion of a particular road may increase as a result of new construction; for example, by the fact that the initially minor local road becomes an important route, which drivers use for getting to the newly built motorway entrance.

To sum it up: The accessibility measure indicates how the quality of life in certain place is changing thanks to the new possibilities (by bringing cities closer). The traffic load – on the other hand – shows us in which places is now more pleasant to live in (because of traffic calming). This is why we propose this combination of indicators; because we understand that the new roads influence the quality of life in two different aspects: the regional one (change in accessibility) and the local one (change in traffic load).
3. Data and methodology

3.1. Situation in Czechia

The development of the road and especially the motorway network in Czechia struggles with lengthy approval processes, obtaining planning and building permits is blocked in many respects, e.g. by the failure to find a consensus between the state and local governments on the appropriate route of a given motorway. Surprisingly, the availability of funds is not such a problem in road building, thanks, among other things, to existence of Cohesion Fund of the EU, which our country uses for motorway building and reconstruction. Figure 1 below shows the final state of the motorway network, which, according to current estimates, is very unlikely to be completed even by 2035.

The map shows that the final form of the motorway network in the Czech Republic can be divided into two areas. In the western part of the country (historically, Bohemia) the motorway network is being built in the direction to Prague, while in the eastern part of the country (historically, Moravia) the situation is somewhat more complex. This is partly due to the historical planning of the routes, which were prepared during Czechoslovakia, i.e. at a time when Slovakia was part of the state (and Moravia was thus a region in the middle of the country). The geopolitical situation during the Cold War is also responsible for the fact that the connection to Vienna in Austria was completely ignored for some time. Nowadays, the network is again defined at EU level by the TEN-T corridors. Other minor changes in motorway routeing have also been influenced by the new regional organisation and the related desire to better connect all regional centres. All this together made the planned motorway network in Czechia to look like you can see in the Figure 1 (for more, see e.g. Prášil, 2007).

We decided to compare the change in availability and traffic load between 2005 and 2015. The reason is the availability of data and detailed information on the traffic load on individual roads obtained through the Traffic Census, which is implemented approximately every five years by the Directorate of Roads and Motorways in Czechia. Thus, we had a relatively detailed database of data on changes in traffic, which can be related to a specific time interval.

Which roads and motorways were built in Czechia during that time? Several major sections of the motorway network were completed between 2005 and 2015. The largest is the part of the D1 motorway between Olomouc and Ostrava and a smaller part between Brno and Zlín. Thanks to these two relatively large sections, the region of Ostrava and Zlín were connected to the motorway network for the first time ever. Among the other major sections, it is worth mentioning the D11 motorway between Prague and the eastern Bohemian twin town of Hradec Králové – Pardubice, thanks to which these two regional centres have a direct motorway connection to Prague. In contrast to this motorway, the newly opened motorway sections near Karlovy Vary and České Budějovice are not connected to other motorways to Prague, they are just separate sections; these two regional centres are still not connected to the network.

In addition to these, a number of smaller motorway sections have been opened, as well as a large number of lower category roads (these sections can be seen on the Main Map). These are mostly bypasses of towns located on the busiest roads. Such sections can range from 10 to 1 km in length and are created in different parts of the country, primarily based on

![Figure 1. Planned final state of the motorway network in the Czech Republic (Orange – already built motorways, Green – motorways opened between 2005 a 2015, red – not yet built).]

Source: Directorate of Roads and Motorways in Czech Republic (2018), custom adjustments.
how quickly they can pass the approval process. This is also true for motorways. As a result, even motorway sections are not commissioned in the Czech Republic on the basis of geographical prioritisation, but simply on the basis of where the approval process can be completed first. This can be best seen in the example of the D3 motorway (Prague – České Budějovice), which is considered a priority, but due to the complex approval process (caused to some extent also by the more complicated topography) will not be completed before a number of lower priority sections in the eastern (Moravian) part of the network.

### 3.2. Methodology

Territorial analysis using GIS tools is used to identify the municipalities most affected by the new road infrastructure between 2005 and 2015. All crucial activities were performed in the ArcGIS ArcMap 10.7.1 system.

The preparation of the map was divided into the following phases:

(a) **Collection of background data**

To implement the map, it was necessary to obtain several types of data:

- Data on new road infrastructure from 2005 to the present. We requested this data from the Directorate of Roads and Motorways in Czechia. It is vector GIS data containing all newly built sections of the road built at that time. Each new section of the communication had information with the date of opening. If the road was only reconstructed, but its route did not change, such roads were not included in this selection.
- Data related to the traffic load. The Directorate of Roads and Motorways again provided the data. The traffic census in 2005 and 2016 was used.
- We used two primary sources as background data. ArcCR database is a freely accessible database containing data for all administrative units, including municipalities. Another group of data was obtained from the OpenStreetMap (OSM) database – in their case, it was the current road network in Czechia and surrounding countries and all buildings.

(b) **Creation of a road network valid for 2005 and 2015 and definition of regional centres**

We then proceeded to create a road network based on the information obtained. From the current road network from OSM, we removed individual sections of newly built roads according to data so that we had a road network valid as of 31 December 2015 and further as of 1 January 2005. At the same time, centres were defined: large cities to which accessibility was calculated. In Czechia, all 13 regional capitals were selected as centres. From abroad, only agglomerations exceeding 500,000 inhabitants were also chosen. This difference can be justified by the fact that the language barrier prevents the inhabitants of municipalities in Czechia from commuting to work and services in foreign cities to the same extent as they commute to centres in Czechia. Thus, 13 centres in Czechia, 9 were defined abroad, i.e. a total of 22 centres.

(c) **Definition of average speed for individual roads and delimitation of built-up area**

To calculate the change in accessibility, it was necessary to define the average speed on the roads. However, it also depends on whether it is a built-up area or not. Data from OSM were used for this. Using the Delinate Built-up areas function, it was possible to generalise the polygons of individual buildings into continuous built-up areas. It was a relatively long-term calculation, due to the large amount of data (individual buildings). For this reason, the action was carried out only for the territory of Czechia and not for the territory of other states. The individual roads were then assigned average speeds. If the road sections were completely within the built-up area defined in the previous point, they were considered to be roads within the built-up area. Data on average speed were used using the article by Hudeček (2008) but were specified for our situation as shown in Table 1. In the case of foreign roads, therefore, only one average speed was defined based on the average share of urban and non-urban area in Czechia.

(d) **Carrying out an analysis of accessibility to the centres in 2005 and 2015**

Subsequently, a network analysis was performed twice. Once on the road network from 2005 and the second time on the network from 2015. The Closest Facility function was used – the three fastest available

| Table 1. Average car speed on individual road types. |
|---------------------------------------------------|
| **Type of road** | **Average speed in urban area (km/h)** | **Average speed outside urban area (km/h)** |
|------------------|----------------------------------------|--------------------------------------------|
| 3rd class road   | 20                                     | 40                                         |
| 2nd class road   | 25                                     | 55                                         |
| 1st class road   | 30                                     | 70                                         |
| Trunk road       | 40                                     | 80                                         |
| Motorway (incl. abroad) | X                                      | 120                                        |
| 1st and lower class road link | 20                     | 40                                         |
| Trunk or motorway link | X                                      | 40                                         |
| 2nd class abroad | 50                                     |                                            |
| 1st. class abroad | 65                                     |                                            |
| 1st and 2nd class road link abroad | 35                     |                                            |

Source: Open Street Maps, Hudeček (2008).
centres were selected for each municipality, regardless of whether they were Czech or foreign.

For each municipality we therefore had information on the 3 most accessible centres from 2005 and the three most accessible centres from 2015, as well as the time of travel to these cities.

(e) Performing an analysis of traffic load

While the data for the availability analysis were ready, now the occupancy analysis also had to be prepared. Using a visual comparison of the situation before and after construction in the surrounding new road, we defined the sections on which the occupancy was to change. Subsequently, we compared the number of passing vehicles from 2005 and 2016 for selected sections and accordingly we defined:

- municipalities where traffic has calmed down in its centre (decrease in traffic load to at least 70% of the original intensity, on road sections passing through a larger part of the municipality)
- municipalities where traffic has calmed down on its outskirts (decrease in traffic load to at least 70% of the original intensity, on road sections passing through the outskirts of the municipality)
- municipalities where there was an intensification of traffic compared to the previous situation (increase in traffic load to at least 130% compared to the previous intensity)

The maps available on Figure 2 are showing the results.

### Table 2. Categorisation of municipalities according to the size of time saved.

| Type of time saving | Number of municipalities in the category | % from all municipalities |
|---------------------|----------------------------------------|--------------------------|
| Little or no change | 4549                                    | 72.7%                    |
| Regional centre     | 13                                      | 0.2%                     |
| Time save between   | 1332                                    | 21.3%                    |
| 16 and 30 min       | 328                                     | 5.2%                     |
| 31 and 60 min       | 36                                      | 0.6%                     |
| 60 min              |                                         |                          |
| Total               | 6258                                    | 100.0%                   |

Data source: own research.

### 4. Results

Thanks to the performed approach we can evaluate which municipalities and regions gained the most in the construction of new road infrastructure between 2005 and 2015, how the new infrastructure changed the importance of individual centres and in which
municipalities the new infrastructure contributed to reducing traffic.

4.1. Change in the availability of centres

While in 2005, the journey to the three nearest centres from any municipality in Czechia took an average of 212 min, in 2015, it was only 202 min. Getting to the three nearest centres is 10 min faster in 2015. Table 2 shows that the time saved was not evenly distributed among all municipalities. Only 27% of them recorded savings of more than 15 min. The map shows that the most significant savings in commuting to the centres were recorded by municipalities in the east, further east from Prague or north of České Budějovice.

Table 3 shows that, on average, the most minutes per municipality were saved in the Moravian-Silesian Region (Ostrava). For the municipalities of this region, the three nearest centres are closer by an average of 33 min. On the other hand, the Vysočina Region (Jihlava) and the South Moravian Region (Brno) achieved the smallest changes. These differences correspond relatively well to the number of newly built kilometres of roads, which is understandable. However, the connection is not directly proportional because it plays a role where exactly the roads in the region are built and to what extent they bring the centre closer to other municipalities. As shown in the map detail of Figure 2, in the case of Ostrava, but also Zlín, new roads led directly to the given centres and thus influenced a relatively large number of municipalities in the vicinity.

The map shows the area of the influence of individual centres in black boundaries, newly for 2015. The municipalities marked in red are those that changed their traffic relationship in the evaluated period – compared to 2005, they changed the centre, which is now the most accessible for them. Table 4 also serves this purpose. We can read from it that most municipalities in this way were again acquired by Ostrava (up to 40 municipalities on the west side, which took over mainly from Olomouc), then Hradec Králové (which acquired several municipalities on the southwestern edge of its region from Prague or Pardubice), and also České Budějovice (from Jihlava and Prague). Olomouc lost the most in this sense precisely because new roads were built mainly in the vicinity of the centres from neighbouring regions, such as Zlín or Ostrava. The thicker white line in the map shows the administrative boundaries of individual regions (whose names are used in the previous table). It is now possible to compare the administrative affiliation with the actual transport accessibility of the centre. We can see that Pardubice, for example, has much less accessibility in this respect – their region is divided according to accessibility by centres such as Hradec Králové, Olomouc or Brno. On the other hand, Pardubice, thanks to its accessibility by car, ‘takes over’ part of the municipalities in the west from the Central Bohemian Region.\(^1\) In general, the map revealed a disproportion between the normative borders of the regions and the borders according to actual transport accessibility.

The map also enables to evaluate the changes in congestion, results are shown in Table 5. Here, too, the results follow to some extent the number of newly built roads in the region. It can be seen that in the vicinity of the newly built sections of motorways (on the borders of the Olomouc, Ostrava and Zlín regions, west of the Hradec-Pardubice agglomeration, north of České Budějovice), the number of such affected municipalities is concentrated in clusters. The statistics also include those municipalities that received a new bypass, thanks to which transit traffic

Table 3. How many minutes did the new road infrastructure save in commuting from individual municipalities to the regional centres by car? The sum for all municipalities in the region.

| Name of the region (and its regional centre) | Total minutes saved for all municipalities | Average number of minutes saved on a municipality | Number of municipalities in the region | Km of new opened roads |
|--------------------------------------------|-----------------------------------------|---------------------------------------------|----------------------------------|-------------------|
| South Bohemian region (České Budějovice)   | 7 854                                   | 13                                          | 624                              | 129               |
| South Moravian region (Brno)                | 2 031                                   | 3                                           | 673                              | 32                |
| Karlovy Vary region                         | 1 808                                   | 13                                          | 134                              | 109               |
| Vysočina region (Jihlava)                   | 2 373                                   | 3                                           | 704                              | 21                |
| Hradec Králové region                       | 3 962                                   | 9                                           | 448                              | 51                |
| Liberec region                              | 525                                     | 2                                           | 215                              | 22                |
| Moravian-Silesian region (Ostrava)          | 9 995                                   | 33                                          | 300                              | 271               |
| Olomouc region                              | 7 863                                   | 19                                          | 402                              | 119               |
| Pardubice region                            | 4 144                                   | 9                                           | 451                              | 70                |
| Plzeň region                               | 2 990                                   | 6                                           | 501                              | 33                |
| Central Bohemian region (Praha)             | 9 528                                   | 8                                           | 1144                             | 134               |
| Ústí nad Labem region                       | 5 847                                   | 17                                          | 354                              | 136               |
| Zlín region                                 | 4 603                                   | 15                                          | 307                              | 96                |
| Total                                      | 63 343                                  | 10                                          | 6258                             | 1283              |

Data source: own research.
was removed from the built-up area. For example, in the Plzeň region, there are quite a lot of such solitary roads; moreover, they are relatively evenly distributed across the whole region.

**5. Summary**

Using own methodological approach, we were able to clarify how the impacts of the new road infrastructure in Czechia are regionally differentiated. This methodological approach can be replicated in other countries as well.

While the road infrastructure around the largest cities such as Prague and Brno has been developed for a relatively long time, in recent years, investment has been made mainly in motorways in other regions. The highest effects of accessibility are currently in the regions where significant transport infrastructure has

| Table 4. For how many municipalities is the centre the closest one? Number of municipalities for which this centre is the fastest available by car in a given year. |
|---------------------------------------------------------------|
| **Name of regional centre** | **2005** | **2015** | **Change** |
| Praha | 880 | 868 | -12 |
| Brno | 728 | 722 | 6 |
| Jihlava | 728 | 732 | 4 |
| Plzeň | 602 | 599 | -3 |
| Olomouc | 577 | 507 | -70 |
| Hradec Králové | 540 | 563 | 23 |
| České Budějovice | 507 | 525 | 18 |
| Liberec | 327 | 327 | 0 |
| Ústí nad Labem | 310 | 301 | -9 |
| Zlín | 300 | 324 | 24 |
| Pardubice | 298 | 289 | -9 |
| Ostrava | 235 | 275 | 40 |
| Karlovy Vary | 191 | 191 | 0 |
| Dresden (GER) | 4 | 4 | 0 |
| Wrocław (PL) | 3 | 3 | 0 |
| Bratislava (SVK) | 1 | 1 | 0 |
| **Total** | 6258 | 6258 | |

Data source: own research.

| Table 5. How many municipalities registered lesser traffic load? Distribution according to individual regions. |
|---------------------------------------------------------------|
| **Name of region** | **Municipality with lower congestion in its centre** | **Municipality with lower congestion on the outskirts** | **Municipality with higher congestion** | **Number of municipalities in the region** | **% of municipalities with changed congestion volume** |
| South Bohemian region (České Budějovice) | 8 | 5 | | 624 | 2% |
| South Moravian region (Brno) | 2 | 1 | | 673 | 0% |
| Karlovy Vary region | 7 | | | 134 | 5% |
| Vysočina region (Jihlava) | 2 | | | 704 | 0% |
| Hradec Králové region | 4 | 7 | 1 | 448 | 3% |
| Liberec region | 2 | 3 | | 215 | 2% |
| Moravian-Silesian region (Ostrava) | 15 | 8 | | 300 | 8% |
| Olomouc region | 11 | 5 | | 402 | 4% |
| Pardubice region | 5 | 3 | | 451 | 2% |
| Plzeň region | 7 | 1 | | 501 | 2% |
| Central Bohemian region (Praha) | 16 | 5 | 1 | 1144 | 2% |
| Ústí nad Labem region | 4 | 3 | | 354 | 2% |
| Zlín region | 5 | 5 | | 307 | 3% |
| **Total** | 88 | 46 | 2 | 6258 | 2% |

Source: own research.
long been lacking, such as Ostrava, Zlín, Budějovice, but also the northwest of the republic. The change in the traffic load in a built-up area of the municipality corresponds to these new sections to some extent (the main routes have shifted from 1st class roads intersecting the municipality to motorways that are outside the built-up area). However, the change in traffic load also occurs in a completely different group of municipalities, where the construction of bypasses displaced transit from the built-up area.

Thus, while the impacts of the new road infrastructure on accessibility are mainly concentrated in a smaller number of areas, the impacts of new infrastructure on traffic load are more evenly distributed in space and not only on the main transport routes.

Software

ArcMap 10.7.1 and Microsoft Excel 2019 were used for data preparation and visualisation. The key functions implemented by the ArcMap application were (in addition to standard spatial operations): Network Analyst – Closest Facility, Delineate Built-up Areas.

Notes

1. In the case of Pardubice, it is necessary to reflect on the railway network; this city is an important railway junction, and when counting commutes to Pardubice by rail, the region of influence is much closer to the administrative form of the region. On the other hand, the main roads from the eastern part of the region are historically directed more towards Hradec Králové and Olomouc.

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Data availability

Data containing the results of the analysis at the municipality level are available from the corresponding author, Marek Petráš, upon reasonable request. The Directorate of Roads and Motorways in Czechia provided, upon request, default data about road openings and traffic loads (here and here are shown in the interactive form). Background data were obtained from open sources like Open Street Maps (here) or ArcCR Database (here).

ORCID

Marek Petráš © http://orcid.org/0000-0001-6268-9454
Viktor Květoň © http://orcid.org/0000-0002-8339-0811

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