A highway is not a panacea: Evaluating the labor-market impact of a new highway in Slovakia

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Abstract

In this paper, we explore the effect of transport infrastructure on regional labor markets by examining the impact of a new highway in central Slovakia, put into use in two stages: in 2000 and 2011. Our results show that although the unemployment of the whole region declined after the construction of the highway, we observe opposing effects at the municipal level: a decrease of unemployment in the municipalities near the first highway segment but a surge in unemployment rate of the municipalities in the vicinity of the second section. A possible explanation for these divergent patterns could be the different characteristics of the two regions, such as the quality of human capital or the ex-ante degree of industrialisation.

Keywords: infrastructure; regional development; unemployment
JEL Codes: H54, O18

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Introduction

Regional disparities in Slovakia in terms of unemployment rate are relatively high: districts in western and north-western Slovakia exhibit low unemployment rates, while unemployment rates tend to be relatively high in south-eastern and eastern Slovakia. A possible explanation for this pattern is the fact that the districts in the west of the country have an access to a highway that connects them to the European road networks (see Figure 1).[1] According to the transport performance index measuring accessibility of regions in the EU, Bratislava and the surrounding area belong the regions with an above average accessibility in the EU, while the rest of the country belongs to the least accessible areas in the EU (Djikstra et al.,2019). Habrman and Žúdel (2017) note that this might have helped north-western Slovakia to attract sizeable FDI, notably the assembly facilities by VW, Peugeot-Citroën, KIA and Samsung. On the contrary, eastern Slovakia suffers from lack of connection to the trans-Europe highway network combined with unfavourable geography: the centre of the country is mountainous, making road transport slow and vulnerable to bad weather.

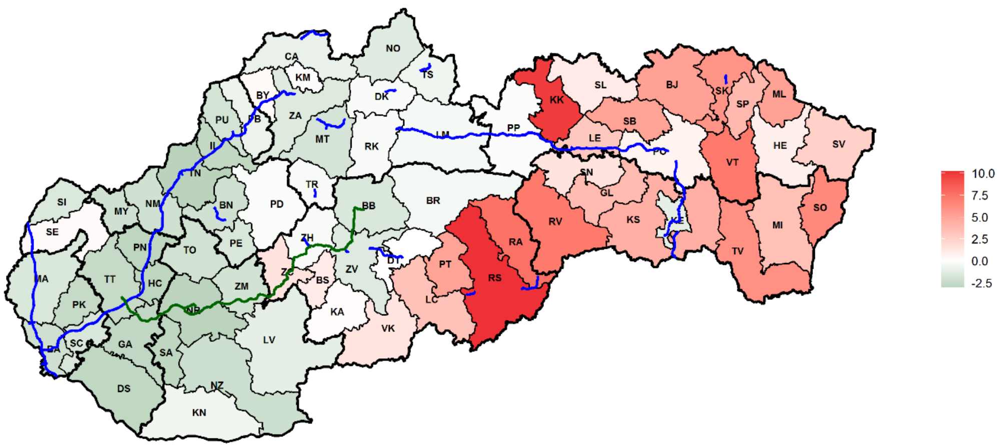

Figure 1: Highway network and the difference between districtual and national unemployment rate in 2019. Data source: CDB. Note: Green lines represent the R1 highway, while blue lines represent the other highways.

Construction of highways might be an attractive policy option for politicians. Consider a decision-maker who faces a choice whether to invest in a new highway or an education reform. While both alternatives might stimulate the economy, the benefit of the former is in its tangibility: it is easier for the population to be aware of a new highway than appreciate something as abstract as an education reform. In other words, construction of a highway also gives politicians the opportunity to take credit for large-scale high-visibility public investment projects and/or to distribute patronage across regions.

[1] In 2021 the two largest cities located on the two sides of the country, Bratislava and Košice, were finally connected by means of the highways in Hungary, thus connecting the eastern Slovakia to the pan-European TEN-T network. As this still constitutes a diversion, it does not significantly improve the accessability of Eastern Slovakia. See https://spectator.sme.sk/c/22772212/bratislava-is-finally-linked-to-kosice-through-hungary.html

Furthermore, it raises public consumption and employment while the road is under construction, and it may lead to an increase in economic activity when the new road is open. Hence, assuming the public is unaware of the costs and benefits associated with different policy choices, the decision maker may opt for the new highway to enhance their prospects of re-election.

The possible link between growth of economic activity and construction of highways stimulates discussion on the topic. However, the existing literature is inconclusive, which might be caused by two factors. Firstly, some analyses may suffer from methodological shortcomings that do not consider possible endogeneity stemming from selection bias, as a highway is usually constructed to connect more economically significant areas. Consequently, the ex-ante higher level of economic development may amplify the impact. Secondly, the capacity of a highway to generate economic activity may depend on certain enabling aspects, such as the mobility of production factors (Banerjee et al., 2012), level of human capital (Habrman and Žúdel, 2017) or quality of institutions (Crescenzi et al., 2016). Furthermore, Crescenzi and Rodríguez-Pose (2012) point out that the impact of highways may have decreasing returns to scale.

With this paper we would like to contribute to this ongoing discussion on the impact of highways on unemployment in Slovakia. Similarly to Mikloš (2016), we evaluate the impact of a new highway, R1, on unemployment. In contrast to the previous studies conducted in Slovakia, however, we evaluate the impact of a new highway on the municipal level, which has several benefits. Notably, it allows us to cope with potential endogeneity by applying the inconsequential unit approach. Under the assumption that a highway is built to connect mainly cities as the main centres of economic activity, this method concentrates on rural municipalities, as the selection of the rural areas that are near a highway can be considered largely random. Conducting the analysis on municipal level enables us to differentiate between urban and rural municipalities. Furthermore, on municipal level we also have access to a longer time series facilitating a study an examination of the completion of constructions of both sections of R1: Trnava - Nitra in 2001 as well as Nitra – Banská Bystrica in 2011.

We find that that the first section is associated with a reduction in the unemployment rate in municipalities within 30 kilometres of the R1, while the municipalities near the later section experienced an increase in unemployment after its construction. This contrast in the results might be caused by differences in initial conditions in the two regions, such as human capital or industrialization, that could have been exacerbated by the proximity to Bratislava, the country's capital. Moreover, the time of the opening of the Trnava-Nitra section coincided with the investment of Peugot-Citroën in Trnava. This might have had spillover effects on the region via production linkages that might have been bolstered by the improvement of infrastructure.

Literature review

Expenditure on transport infrastructure is often regarded as a means for enhancing productivity and reducing regional disparities in an economy. This view's economic rationality is founded on the premise that access to new markets improves the exchange of goods, services and human capital. Regions lacking infrastructure may struggle to attract investment and a qualified labour force, as well as to provide its citizens with a high standard of living. Banerjee et al. (2012) note that it was the impact of massive railroad construction on economic growth witnessed during the period of industrialization of

Western Europe and North America that continues to place infrastructure investment into the forefront of development discussion.

Studies examining the impact of public infrastructure investment have gained momentum three decades ago. Aschauer (1989) modified the Solow-Swan model of economic growth by distinguishing between public and private investment, with the assumption that both components influence production equally.[2] Subsequently, he demonstrated that public investment, most notably that directed into infrastructure, played a key role in boosting productivity in the United States in the post-war era.[3] This view is supported by classical trade literature, which points out that transport infrastructure may reduce transport expenses and thus facilitate expansion of trade routes, which in turn increases the profitability of firms and enables them to expand into new markets (Crescenzi and Rodríguez-Pose, 2012).

According to the New Economic Geography, however, the role of infrastructure development is rather ambiguous. Assume there are two regions, one more centrally-located and industrialized, and the second more peripheral and lagging behind in industrialization. Suppose that a highway is constructed to connect the two regions. A subsequent reduction of transportation costs may lead to a lower level of protection of firms in the periphery. Consequently, due to the assumption of increasing returns to scale linked to a higher number of firms and varieties in the center, the central firms will find it advantageous to expand to the market of the peripheral region (centrifugal forces) Yet, the prosperity enjoyed by the firms from the central region may stimulate the establishment of new firms, what could in turn lead to higher prices of production factors. Some firms might consequently choose to relocate to the periphery to take advantage of the lower costs of production (centripetal forces). However, it is not clear it is not clear which of these two forces would prevail, making it possible to expect agglomeration as well as dispersion of economic activity resulting from new infrastructure projects (Puga, 2002; Redding and Turner, 2015).

The ambiguity in the nature and direction of effects is mirrored in the results of empirical studies. In their meta-analysis of 776 results, Holmgren and Merkel (2017) find that the expected elasticity of investments in transport infrastructure with respect to economic output lies in the range of -0.06 to 0.52. They further find that the impact is positive mainly for construction and manufacturing sectors. Likewise, Redding and Turner (2015) observe in their extensive literature review that highways are effective in attracting new residents into their proximity. In contrast, they find that the effect is less clear when it comes to boosting economic activity in the nearby municipalities or regions.

The previous studies of the impact of construction of highways on unemployment in Slovak context are inconclusive as well. Habrman and Žúdeľ (2017) find that the presence of a highway within 30 kilometres of a district town reduces unemployment in that district. Other analyses implemented a quasi-experimental approach by looking at the effect of a newly constructed highway. Mičúch and Tvrz

[2] Holmgren and Merkel (2017) point to other methods of modeling infrastructure expenditure in the neoclassical model of economic growth, such as the production function or the investment rate. This, however, does not change the expectations of the positive impact on economic activity.

[3] Vanhoudt et al. (2000) warn that there may be reverse causality in this study, since richer and more productive economies allocate more funds into infrastructure development and upgrading.

(2015) observe that unemployment decreased in districts with a new highway segment 9 months after its construction. At the same time, however, the unemployment increased in the neighboring districts. Baláž et al. (2018) conclude that construction of new segments of highways after 2000 led to an increase in wages and number of firms, but had an insignificant impact on unemployment. Likewise, Mikloš (2016) yield an insignificant result of constructing the segment of R1 between Nitra and Banská Bystrica on districtual unemployment.

There are numerous possible explanations for the ambiguity of the above-mentioned results. As Crescenzi and Rodríguez-Pose (2012) contemplate, the impact might become negligible or even counterproductive after highway density surpasses a certain minimum threshold required to connect the region, due to the high costs of construction. In this context, Rodríguez-Pose et al. (2018) point to a massive infrastructure construction in Spain in the past 30 years, and show that the usage of these new roads remains very low.[4] Thus, Rodríguez-Pose et al. (ibid) label road infrastructure as “white elephants”, since politicians often prefer to make use of highway construction to send a signal to voters about the completion of a major project during their term of office than, say, an educational reform, which takes time until its effects become visible. As a result, something is built which looks nice in the eyes of the voters, but may actually be expensive and impractical.

The mere construction of the new highway should not be regarded as a panacea in itself. On the contrary, the impact of highways depends on several underlying economic factors. Crescenzi et al. (2016) point out that the investment in highway development has had favourable impact in the EU regions only in interaction with institutional quality. They justify this result by the fact that better institutions are associated with more efficient allocation of funds, so that such countries are less likely to build "white elephants". Given the high costs associated with the construction of infrastructure projects, in addition to political abuse, there is also a risk of collusion and corruption or delays in construction. Moreover, Banerjee et al. (2012) explain the weak impact of the proximity to a highway in China by the low mobility of factors of production. Likewise, the quality of human capital is crucial. Habrman and Žúdeľ (2017) find that in Slovak districts with higher-quality human capital, the impact of highways and expressways on unemployment is more favourable. If, on the other hand, the region does not have an attractive workforce from an investor's point of view, the connection of this region to a highway will not work wonders. In this context, Duranton and Venables (2018, p. 16) emphasize that “No one would doubt that a completely isolated place will be poor, or that most rich places are well connected. But it does not follow from these observations that all well-connected places are rich or that improving connectivity necessarily brings development.”

Additional explanations of the ambiguous impact of highway construction on economic performance may also be related to methodological caveats. Redding and Turner (2015) point out that the choice of the treatment group is non-random. As the choice of a particular infrastructure route is likely to be influenced by the level of economic activity in a given region or by political factors, the possibility of endogeneity in the models needs to be addressed. An instrumental variable is the traditional solution,

[4] For instance, Rodríguez-Pose et al. (2018) mention the toll highway Madrid-Toledo with a planned utilization of 25 000 cars per year. However, the actual use after the opening was 2 800 cars per year in 2008, decreasing to only 881 cars per year in 2016. The new highway failed to attract cars from an already built parallel section, resulting in this very poor usage.

and specifically in this case in the form of historical infrastructure (Duranton and Turner, 2012) or planned transport routes (Baum-Snow, 2007; Ciani et al., 2020).[5] An alternative is to use the so-called "inconsequential unit approach". This involves cutting down the sample of the treatment group to regions that found themselves in it to a certain extent randomly. For example, Chandra and Thompson (2000) mention that highways are often built to connect two cities, and the choice of these cities may not be entirely random. Yet, the choice of rural areas through which the highway passes is largely subject to chance (and geography). Therefore, in their analysis, they exclude metropolitan areas and focus only on rural areas. In addition to taking into account the problem of endogeneity, according to Redding and Turner (2015), a distinction needs to be made between growth and reorganization of economic activity. In particular, in addition to attracting new investment, the completed highway may shift economic activity from a neighbouring region, which lies further away from the new road. To deal with this problem, it is recommended to estimate the impact of the new highway on the observable differences in the region itself (reorganization), as well as to compare with other regions in the country (growth). For instance, Ciani et al. (2020) find that even though a new highway in the Calabria region in Italy had a favourable effect on municipalities in its proximity, it did not help Calabria to converge economically.

Previous studies examining the impact of highways on unemployment in Slovak districts have not sufficiently addressed these methodological problems. Therefore, we would like to contribute to this discussion with our study, by improving the methodology for analysing the impact of the completed highway R1 on unemployment on municipal level in central Slovakia.

Data and methodology

In this study, we aim to contribute to the discussion of the impact of highways on unemployment by focusing on the R1 highway crossing central Slovakia (Figure 2). The construction of a highway in central Slovakia was planned already during the 1970s by reconstructing segments of the main roads in the region. However, the whole process embodies the sluggish construction of highways in Slovakia caused by lack of prioritisation of projects and public procurement processes that encouraged pro-cartel behaviour (Kovalčík, 2017).[6] This then leads to an inefficient allocation of resources. In the case of the R1 it meant that the segments between Trnava and Nitra were completed in 2000, while the segments between Nitra and Banská Bystrica were finished in 2011. In the future, the R1 should lead to Ružomberok, where it will connect to the D1 highway, and in Žarnovica, it should connect to the future R2 route leading to Košice. It was through the later opening in 2011 that the districts of Zlaté Moravce, Žarnovica, Žiar nad Hronom, Zvolen and Banská Bystrica as well as part of the Nitra district

[5] Though in the former case, it is important to describe the purpose of building the historical infrastructure. For instance, Donaldson (2018) and De Benedictis et al. (2018) in their analysis of British infrastructure in India and roman roads, respectively, stress that these infrastructure projects were primarily motivated by military expansion. If, on the other hand, the primary motivation would have been economic, the use of historical infrastructure data might not fully solve the "chicken-and-egg" problem, as the historical road connection might have reflected the economic development of cities at the time of construction and amplified their progress. The development boost since then might, in turn, have inspired more recent construction of infrastructure.
[6] A big turning point in the former problem was achieved in 2020 as the methodology for prioritisation of infrastructure investments was developed (ÚHP, 2020).

east of Nitra, were connected to the existing network of highways. At the same time, the R1 improved the accessibility of the Banská Štiavnica district and the northern part of the Levice district.

By conducting the analysis at the municipal level, we want to assess whether the newly-established connection to the highway has changed the economic structure of the districts. Specifically, we are interested in examining whether the inhabitants of the municipalities near the R1 were able to gain a better foothold in the labour market thanks to new job opportunities, in comparison with the inhabitants of municipalities further from the highway. We take advantage of the two milestones, the completion of the Trnava-Nitra segments and Nitra-Banská Bystrica in 2000 and 2011, respectively.

We obtained data on unemployment for the years 1996 to 2019 from the Office of Labour, Social Affairs and Family of the Slovak Republic (ÚPSVaR). Due to the presence of outliers in the unemployment rate in some municipalities, we discarded the first five and last five percent of the distribution of the average of this indicator for the entire period under review. Figure 2 shows the composition of the control and treatment groups. We constructed the treatment group by means of distances from the municipality to the nearest exist on R1 using auxiliary roads open street maps: it consists of municipalities within the 30-kilometre radius of R1 exits.[7] We further distinguish the treatment group into two parts: municipalities close to exits of the Trnava-Nitra section (TT-NR) and municipalities close to exits of the Nitra-Banská Bystrica (NR-BB) section. The control group consists of municipalities from the surrounding districts, whereby we removed municipalities located within the 30-kilometre radius of the D1 highway that was constructed earlier in the northern part of central Slovakia, as such municipalities were already well connected to the highway network.

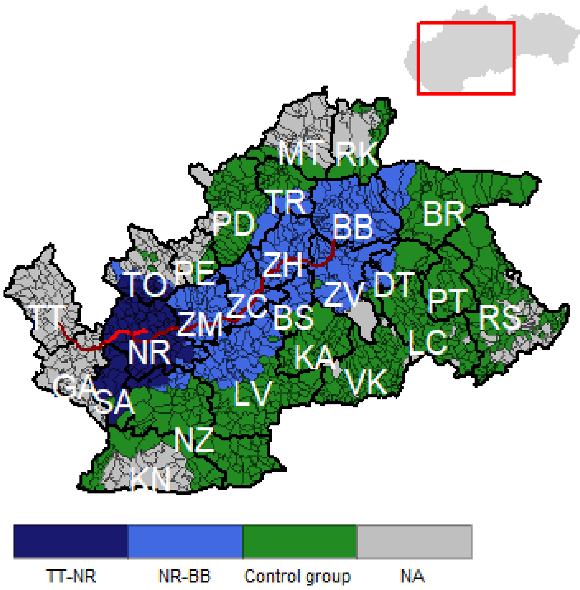

Figure 2: Composition of the treatment and control groups. Source: CDB and Open Street Map (processed by Michal Páleník). Note: the red and dark red lines represent the R1 and PR1BINA segments, respectively. The dark and light blue areas represent the two treatment groups, green is the control group and grey denotes the municipalities excluded from the sample (outliers as well as municipalities close to the D1 highway.

[7] We have also used other thresholds to define proximity to R1 for robustness checks: 15 km, 20 km, 40 km. The results are similar and available upon request.

For the evaluation, we use the method of difference in differences in the following form:

$$u_{it} = \beta_0 + \delta_1 r_{it}^1 + \delta_2 r_{it}^2 + \delta_3 p_{it}^1 + \delta_4 p_{it}^2 + \delta_5 r_{it}^1 * p_{it}^1 + \delta_6 r_{it}^2 * p_{it}^2 + \sum_{j=1}^{3} \beta_{ijt} x_{ijt} + \alpha_i + \tau_t + \varepsilon_{it} \quad (1)$$

where u_{it} represents the unemployment rate for a given municipality i in year t. The first row represents the two treatment groups (r_{it}^1, r_{it}^2) and treatment periods corresponding to the two phases in which the highway was completed (p_{it}^1, p_{it}^2) along with the interactions denoting the impact of the highway on the municipalities in its proximity. Moreover, x_{ijt} denotes socio-economic control variables (population density, average age of population and migration balance). The last line consists of individual and fixed time effects (a_i and τ_t) and the residuals (ε_{it}). We are particularly interested in the coefficients δ_5 and δ_6, as they measure the difference between the control and treatment groups in the period following the opening of the individual sections. We have obtained the data on socio-economic control variables from the Statistical Office of the Slovak Republic.

In addition, we are interested in the overall impact of the distance from R1 on unemployment. Therefore, we also estimate the following model:

$$u_{it} = \beta_0 + \delta_1 r_{it}^1 + \delta_2 r_{it}^2 + \delta_3 p_{it}^1 + \delta_4 p_{it}^2 + \delta_5 r_{it}^1 * p_{it}^1 * d_{it} + \delta_6 r_{it}^2 * p_{it}^2 * d_{it} + \sum_{j=1}^{J} \beta_{ijt} x_{ijt} + \alpha_i + \tau_t + \varepsilon_{it} \quad (2)$$

where we define the distance (d_{it}) for the year 1999 as the distance from Trnava, in the years 2000 to 2010 as the minimum distance of the municipality from the nearest exit of the highway section Trnava - Nitra and in the years 2011 to 2018 as the minimum distance of the municipality from the nearest exit to the R1.

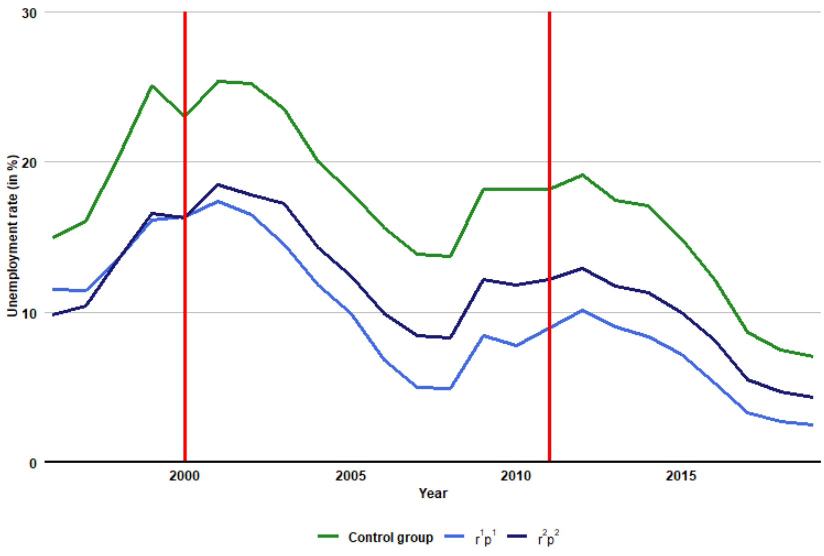

Figure 3: Development of unemployment in the control group and two treatment groups. Data source: SO SR. Note: The dark blue and blue lines represent the two treatment groups, the control group is in green and vertical lines indicate the connection of individual sections to the highway network.

In Figure 3, we can observe the development of unemployment rate in the control group and treatment groups. Both treatment groups have a significantly lower unemployment rate than the rest of the sample. The differences between the individual groups remain approximately the same throughout the period. The only exception is the development observed in the section between Trnava and Nitra following the opening of the R1, where the rate of unemployment has significantly reduced in the municipalities in its vicinity.

Results

The opening of the two segments of the R1 highway had distinct effects on municipalities. In Table 1, we can see the results of the impact of the construction of the highway. The first segment from Trnava to Nitra reduced unemployment in municipalities near the R1 by about two percentage points above what is observed in more distant municipalities. On the other hand, unemployment in municipalities near the later constructed section from Nitra to Banská Bystrica increased after the completion of the section. This difference can be linked to the distance from Bratislava and the related connection to the pan-European TEN-T network. Municipalities near the first section may have had certain predispositions (for example, they may have been more developed in terms of industrialization and human capital), which were amplified by the new highway section. Moreover, at the time of the construction of the section between Trnava and Nitra, a new Peugot-Citroën's manufacturing plant was located in the region, which could have had favourable effects in the region. Both effects are weaker in magnitude (and statistical significance) in cities compared to rural areas, and the effect of the former section is even insignificant for urban municipalities. The reason can be twofold. From the statistical point of view, the rural municipalities constitute a large part of our sample and therefore captures stronger effects. From the economic point of view, for instance, Redding and Sturm (2008) point out that larger municipalities are more robust to exogenous shocks that impact trade barriers as they may have it easier to specialize and access other markets.

Table 1: Impact of highway construction on cities and villages

	(1) u_{it}	(2) u_{it}	(3) u_{it}	(4) u_{it}	(5) u_{it}	(6) u_{it}
Constant	13.18***	8.18***	7.70***	8.15**	29.98***	5.76**
	(0.19)	(2.56)	(2.41)	(2.61)	(10.03)	(2.76)
p_{it}^1	2.49***	2.29***	2.25***		2.02	2.40***
	(0.25)	(0.28)	(0.28)		(1.67)	(0.29)
$r_{it}^1 * p_{it}^1$	-1.91***	-1.92***	-1.55***		--1.04***	-1.85***
	(0.21)	(0.22)	(0.20)		(0.44)	(0.22)
p_{it}^2	-7.80***	-8.24***		-8.19***	-3.85	-8.33***
	(0.25)	(0.36)		(0.36)	(2.75)	(0.37)
$r_{it}^2 * p_{it}^2$	1.73***	1.69***		1.53***	0.87	1.69***
	(0.30)	(0.30)		(0.29)	(0.78)	(0.31)
Total observations	19104	19104	19104	19104	936	18168
Number of municipalities	796	796	796	805	39	757
Sample municipalities	All	All	All	All	Urban	Rural
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Socioeconomic controls	No	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.578	0.578	0.575	0.577	0.776	0.577

R^2	0.578	0.579	0.575	0.577	0.783	0.578
F-statistic	261.9	235.4	242.7	239.6	102.1	228.0

Note: The dependent variable is the unemployment rate in a municipality. Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

The impact of the new section of R1 varies across different altitudes. In the lower attitudes we can observe in table 2 a negative impact of the highway on municipal unemployment near the Trnava-Nitra section, while insignificant results for Nitra-Banská Bystrica. For higher-lying municipalities we even see an increase in unemployment. The heterogeneity in the impact across these quintiles may be caused by a positive correlation with the distance from the highway.[8] The increase in unemployment in higher-lying municipalities could also occur due to the migration of the population to lower-lying municipalities, which may dispose with an attractive labour market.

Table 2: Impact of highway construction on municipalities at different altitudes

	(1) [107 ;153] u_{it}	(2) [153;202] u_{it}	(3) [202;293] u_{it}	(4) [293;455] u_{it}	(5) [455;972] u_{it}
Constant	9.46*	18.81***	13.12***	-3.38	4.25
	(4.95)	(6.34)	(4.85)	(6.39)	(5.71)
p_{it}^1	-1.64**	2.58***	3.81***		
	(0.63)	(0.76)	(0.57)		
$r_{it}^1 * p_{it}^1$	-1.24***	-2.99***	-2.58***		
	(0.38)	(0.45)	(0.37)		
p_{it}^2	-12.60***	-8.70***	-6.62***	-6.85***	-6.45***
	(0.79)	(0.84)	(0.73)	(0.95)	(0.70)
$r_{it}^2 * p_{it}^2$	1.33	0.15	0.18	1.67***	2.29***
	(0.88)	(0.72)	(0.56)	(0.67)	(0.60)
Total observations	3480	3792	3720	3624	3624
Number of municipalities	145	158	155	151	151
Sample municipalities	Yes	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.732	0.623	0.590	0.476	0.522
R^2	0.735	0.626	0.593	0.480	0.526
F-statistic	73.08	85.04	77.61	52.98	53.50

Note: The dependent variable is the unemployment rate in a municipality. p_{it}^1 is omitted from the last two models due to lack of observations in those quantiles of altitude. Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 3 shows the results of the impact of highway construction on municipalities, taking into account their distance from the highway. Following the opening of the Trnava-Nitra section in 2000, we observe a decrease in unemployment by approximately 0.07 percentage points for each additional kilometre of distance within the radius of 30 km from the R1 highway. Therefore, if the municipality is located 20 km from the newly opened section of the highway, unemployment in it should fall by 0.14 percentage points. On the other hand, the opening of the Nitra-Banská Bystrica highway section does

[8] The correlation is around 44% for the municipalities in the two treatment groups.

not statistically reduce the unemployment rate in the surrounding municipalities. The robust difference in results between the segments of R1 may be related to the findings of previous literature that suggests the impact of highway construction on economic outcomes depends on other factors, such as human capital.[9]

Table 3: Impact of highway construction on municipalities in interaction with distance

	(1)	(2)	(3)	(4)	(5)	(6)
	u_{it}	u_{it}	u_{it}	u_{it}	u_{it}	u_{it}
Constant	13.18***	7.66***	7.70***	7.67***	28.96***	4.74
	(0.19)	(2.60)	(2.61)	(2.61)	(9.97)	(2.80)
p_{it}^1	2.45***	2.24***	2.23***		1.86	2.34***
	(0.25)	(0.28)	(0.28)		(1.67)	(0.29)
$r_{it}^1 * p_{it}^1 * d_{it}$	-0.07***	-0.07***	-0.06***		-0.04**	-0.07***
	(0.01)	(0.01)	(0.01)		(0.02)	(0.01)
p_{it}^2	-7.50***	-7.99***		-7.96***	-3.90	-8.12***
	(0.24)	(0.36)		(0.36)	(2.77)	(0.37)
$r_{it}^2 * p_{it}^2 * d_{it}$	0.05**	0.05**		0.04**	0.03	0.05***
	(0.02)	(0.02)		(0.02)	(0.04)	(0.02)
Total observations	19104	19104	19104	19104	936	18168
Number of municipalities	796	796	796	796	39	757
Sample municipalities	All	All	All	All	Urban	Rural
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Socioeconomic controls	No	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.575	0.576	0.575	0.575	0.775	0.575
R^2	0.575	0.576	0.575	0.574	0.781	0.575
F-statistic	269.2	232.6	241.3	238.9	96.83	225.00

Note: The dependent variable is the unemployment rate in a municipality. Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Conclusion

Previous studies find that the impact of highways on economic activity is ambiguous. The reason might be that the effect seems to be conditioned by a number of factors, such as institutional quality and human capital. It may be the case that declining economies of scale come into play after a minimum threshold of highways in a region is constructed. Another possibility is that the highways tend to be constructed to connect economically prosperous areas, thus constituting a reverse causality problem, which might not be addressed correctly.

With this analysis, we contribute to the debate by analysing the impact of connecting a new section to the existing highway network. We investigate the impact of the opening of the R1 highway on the unemployment rate in the regions of central Slovakia. The highway was connected in parts: the Trnava-Nitra section in 2000 and the Nitra-Banská Bystrica section in 2011. Similarly to Chandra and Thompson (2000), our analysis addresses the problem of reverse causality by applying the "inconsequential unit approach" that considers the impact on rural areas, assuming that their proximity to a highway is a

[9] We have also examined the impact of highway construction on population change. However, these results did not exhibit statistical significance. These results are available upon request.

result of a random selection. We thus present a more causal results of the impact of a new highway on economic activity.

Our results suggest that while the municipalities around the Trnava-Nitra section experienced a decrease in the unemployment rate, in the municipalities near the Nitra-Banská section experienced an increase in the rate of unemployment in comparison with municipalities further from R1.

The difference in the impact of the two sections of R1 on the unemployment rate at the municipal level may be justified by the fact that the highway itself does not reduce employment. Municipalities near the Trnava-Nitra section may have had more favourable predispositions (such as better human capital and a higher degree of industrialization), which were strengthened by their connection to the pan-European TEN-T network. The connection of this section overlapped in time with Peugot-Citroën's investment in the region, which could have had seepage effects through suppliers (and which was probably motivated by the prospect of improved road infrastructure). The Nitra-Banská Bystrica section, in contrast, could have caused an outflow of labour force instead of an inflow of companies. Another factor that could have played a role is the importance of physical geography – the municipalities located near the Nitra-Banská Bystrica segment are located in higher altitudes. Our results show that if the cost of building highways in Slovakia is reduced and accompanied by other measures to support the regions and reforms, connecting less developed regions to the existing highway network can help reduce unemployment.

References

Aschauer, D. A. (1989). Does public capital crowd out private capital? *Journal of monetary economics*, *24*(2), 171-188.

Banerjee, A., Duflo, E., & Qian, N. (2012). *On the road: Access to transportation infrastructure and economic growth in China* (No. w17897). National Bureau of Economic Research.

Baum-Snow, N. (2007). Did highways cause suburbanization? *The quarterly journal of economics*, *122*(2), 775-805.

Chandra, A., & Thompson, E. (2000). Does public infrastructure affect economic activity? Evidence from the rural interstate highway system. *Regional Science and Urban Economics*, *30*(4), 457-490.

Ciani, E., de Blasio, G., & Poy, S. (2020). *A Freeway to Prosperity? Evidence from Calabria, South of Italy* (No. 820). Department of Economics, University of Siena.

Crescenzi, R., & Rodríguez-Pose, A. (2012). Infrastructure and regional growth in the European Union. *Papers in regional science*, *91*(3), 487-513.

Crescenzi, R., Di Cataldo, M., & Rodríguez-Pose, A. (2016). Government quality and the economic returns of transport infrastructure investment in European regions. *Journal of Regional Science*, *56*(4), 555-582.

De Benedictis, L., Licio, V., & Pinna, A. M. (2018). The long-term effects of the historical Roman road network: trade costs of Italian provinces. Tech. rept. Centre for North South Economic Research, University of Cagliari and Sassari.

Donaldson, D. (2018). Railroads of the Raj: Estimating the impact of transportation infrastructure. American Economic Review, 108(4-5), 899-934.

Duranton, G., & Turner, M. A. (2012). Urban growth and transportation. *Review of Economic Studies*, *79*(4), 1407-1440.

Duranton, G., & Venables, A. J. (2018). Place-based policies for development. The World Bank.

Franco, A. P., Galiani, S., & Lavado, P. (2021). Long-term effects of the Inca Road (No. w28979). National Bureau of Economic Research.

Habrman, M., & Žúdel, B. (2017). Od Tatier k Dunaju, diaľnice stavajú. *Institute of Finance policy paper, http://www. finance. gov. sk/Default. aspx*.

Holmgren, J., & Merkel, A. (2017). Much ado about nothing? A meta-analysis of the relationship between infrastructure and economic growth. *Research in Transportation Economics*, *63*, 13-26.

Kovalčík (2017). Diaľničné sľuby politikov a realita – úplne odlišné svety. Available at: https://www.ineko.sk/file_download/1074/Dialnicne+sluby+politikov+a+realita.pdf

Mičúch, M. & Tvrz, S. (2015). Aby nezamestnanosť v okrese klesla, iba otvoriť diaľnicu nestačí. *Biatec*, 4-10.

Puga, D. (2002). European regional policies in light of recent location theories. *Journal of economic geography*, *2*(4), 373-406.

Redding, S. J., & Sturm, D. M. (2008). The costs of remoteness: Evidence from German division and reunification. American Economic Review, 98(5), 1766-97.

Redding, S. J., & Turner, M. A. (2015). Transportation costs and the spatial organization of economic activity. In *Handbook of regional and urban economics* (Vol. 5, pp. 1339-1398). Elsevier.

Rodríguez-Pose A., Crescenzi R., Di Cataldo M. (2018) Institutions and the Thirst for 'Prestige' Transport Infrastructure. In: Glückler J., Suddaby R., Lenz R. (eds) Knowledge and Institutions. Knowledge and Space, vol 13. Springer, Cham. https://doi.org/10.1007/978-3-319-75328-7_11

ÚHP (2020). Priority vo výstavbe cestnej infraštruktúry. Available at: https://www.mfsr.sk/files/archiv/80/prioritizacia_vlada_20200916.pdf

Vanhoudt, P., Mathä, T., & Schmid, B. (2000). How productive are capital investments in Europe? *EIB papers*, *5*(2), 81-106.