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Article

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Regional Structure of Foreign Direct Investment in Slovakia – a District-level Gravity-type Model 2009 – 2016

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Abstract

The paper develops a district-level gravity-type model of foreign direct investment (FDI) stock in Slovakia using Poisson Pseudo Maximum Likelihood estimation based on the most recent investment data compiled by the National Bank of Slovakia (NBS). Population and wages as well as distance from Bratislava, access to freeway and presence of universities are shown to be statistically significant determinants of FDI stock. The statistical significance of distance from regional capital and size of the largest city could not be established, which we believe is a result of the small size of Slovakia's districts, dense network of public transportation and a low number of cities of the size required for agglomeration economies. The estimated single-core gravity-type model is robust to different specifications of distance, use of different estimation methods and omission of outliers.

Keywords: *foreign direct investment, Slovakia, gravity model, PPML, freeways*

JEL Classification: F21

Introduction

A fast-growing economy guarded by the peaks of the High Tatra Mountains, Slovakia has been dubbed the "Tatra Tiger" for the last two decades. The country's GDP per capita has tripled between 2000 and 2015 and has reached 74% of the OECD average compared to a mere 45% at the beginning of the period (World Bank, 2017). It has attracted a considerable number of foreign investors and has become one of the world's leading exporters of automobiles. However, the results of the FDI-induced growth have not been spread evenly throughout the country. While Bratislava is now the fifth richest region in the European

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Union, Central and Eastern Slovakia still belong to the last quartile of the bloc (Eurostat, 2018).

It has long been known that regional inequalities are not unrelated to the foreign investors' tendency to agglomerate (Bailey and Driffield, 2002). Numerous papers have been published since 1990s on location choices of foreign investors in various countries of the world: USA (Friedman, Gerlowski and Silberman, 1992; Head, Ries and Swenson, 1995), France (Crozet, Mayer and Mucchielli, 2004), China (Zhao and Zhu, 2000; Belkhodja, Mohiuddin and Karuranga, 2017), Mexico (Jordaan, 2008), four Central and Eastern European countries (Resmini, 2007), Hungary (Boudier-Bensebaa, 2005), Poland (Chidlow, Salciuviene and Young, 2009) or Romania (Hilber and Voicu, 2010) to mention a few. The studies mostly apply gravity modelling using logit or OLS estimation methods and often separate investors by their country of origin. Regional distances within the studied country are seldom included in the analysis; hence these researches usually do not develop national gravity models (a partial exception is Resmini (2007) and a few others as detailed in the next section). Moreover, there is no such work which statistically examines regional determinants of FDI in Slovakia. Given it is a small country with a non-centrally located capital city, a district-level gravity-type model is an ideal choice to explore national determinants of FDI. The contribution of out paper is therefore twofold: it is one of the relatively few papers which uses gravity-like modelling to empirically examine drivers of FDI on sub-national level and it also significantly enhances the knowledge on FDI structure and its determinants in Slovakia's districts. The motivation behind the research stems from the current prolonged national debate on the importance of highway construction in the country and the associated prioritization of different routings. We have the ambition to verify whether highways play a crucial role in Slovakia's district-level FDI patterns, and to identify other significant factors that come into play.

The method used in the paper is based on gravity models of FDI applied to an intra-country setting. Unlike traditional models though, the paper is not interested in the country of origin of the FDI and hence it does not include distance between Slovakia and the investment-source country among independent variables. Instead, similar to Broadman and Recanatini (2001) it uses distance of Slovak districts from Bratislava, as it is the undisputed center of Slovak economy's gravity, the seat of the majority of institutions and – due to its proximity to Austria, Czech Republic and Hungary – the usual point of entry. The logic is similar to using the so-called "capital city dummy" in studies of regional FDI (Brock and Urbonavicus, 2008), but it goes beyond that approach. As a result, this is not a standard gravity model, rather a gravity-type one.

The paper is divided into six sections. After a brief introduction a literature review focusing on gravity models of FDI and domestic location choices of foreign investors is offered. Section two provides a concise overview of the development of FDI in Slovakia along with the current distribution of stock. Section three presents data sources and explains the methodological choices taken while the next section features the model, discussion and robustness checks. Finally, the last section concludes with some final remarks and ideas for further research.

1. Literature Review

The origins of the gravity model go back to the field of international trade, where it was successfully used to empirically predict trade flows between countries. Introduced by Tinbergen (1962) and Linnemann (1966), this approach suggests that trade flows between countries are affected by the income of trading countries and by the distance between them. Originally, the model was heavily criticized for its empirical nature and for statistical issues, but during the following decades a number of further contributions have been published that addressed these deficiencies (see Anderson, 1979; Bergstrand, 1985; Deardorff, 1998, or Anderson and van Wincoop, 2003).

After empirical successes in the area of international trade flows, gravity models have been applied successfully to other types of international flows (migration, trade flows in regional integration). Since the 1990s, the gravity model has been also extensively used for the analysis of the determinants of foreign direct investment. Although there are some data limitations in the case of FDI flows (limited availability of bilateral FDI flows data), the gravity model has become a very popular tool in the area of FDI empirical studies. Additionally, the FDI gravity model is well-grounded in the theoretical FDI frameworks (see Dunning's eclectic OLI paradigm).

The standard FDI gravity model is very similar to the trade models as it uses the GDP of the host and home countries and the geographical distance between countries as independent variables explaining bilateral FDI flows. The popularity of the gravity model has led to its enhancement by a wide range of other variables that include endowment of labor force (Bevan and Estrin, 2004), infrastructure (Egger and Pffaffermayr, 2004), cultural similarity (Buch, Kokta and Piazolo, 2003), bilateral trade (Portes and Rey, 2005), European integration (Di Mauro, 2000), single European currency (De Sousa and Lochard, 2011), unemployment rate (Roberto, 2004), unit labor costs (Bevan and Estrin, 2004) or tax-haven related variables (Haberly and Wójcik, 2014).

In the last decade, the gravity model has also increasingly been used to explain FDI location decisions of foreign investors on the regional level. Broadman and Recanatini (2001) explain the spatial distribution of FDI inflows into Russia using panel data for the period of 1995 – 2000. They conclude that market size, infrastructure development, policy environment and agglomeration effects explain the majority of variations of FDI inflows to Russia on the regional level. Linden and Ledyaeva (2006) expanded on their work as they introduced new variables into the gravity model (natural resources abundance, skilled labor abundance, capital city advantages). Using a cross-sectional data set for the period 1998 – 2002 they concluded that there are only two important factors of FDI presence in a region: economic performance measured by gross regional product and the general level of regional infrastructure's development. Xinzhong (2005) used the gravity model to analyze the regional distribution of FDI inflows into China. He concluded that the spatial distribution of FDI inflows to China is primarily influenced by the level of the FDI stock in the region, by the labor costs, market size and by the level of economic development. In a very influential recent study, Millimet and Roy (2015) applied a subnational gravity model on US state-level data to test the pollution haven hypothesis. They found a negative and economically significant impact of strict environmental laws on inbound FDI in the chemical sector.

Schäffler, Hecht and Moritz (2014) used the gravity model to analyze regional distribution of German FDI projects in the Czech Republic. Using an extensive database of German FDI projects the authors concluded that their findings were generally in line with expectations of the gravity model as GDP and distance emerged as the main drivers of the regional distribution of German investments in the Czech Republic. However, the authors observed certain distinctions between FDI in the manufacturing sector and the service sector. While FDI in the service industry flows predominantly into regions with high employment in services and with above-average wages, FDI in industry are influenced mainly by the supply of high-skilled labor.

2. Foreign Direct Investment in Slovakia – a Brief Overview

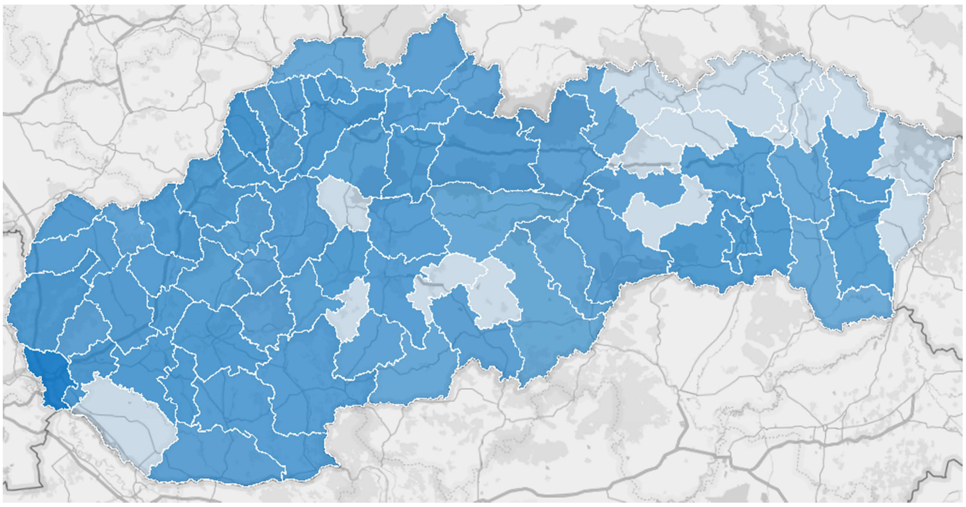
When analyzing the patters of FDI inflows, three separate time periods can be observed during the brief history of the independent Slovakia. The first time period starts in 1993 and lasts until the turn of the century. It is defined by relatively low FDI inflows to Slovakia, as the average annual FDI inflow reached mere 739 million USD between 1993 and 1999 (UNCTAD, 2017). A freshly independent Slovakia was not able to compete with its better-known neighbors (Hungary, Poland, and Czech Republic) and the erratic economic policies of

1993 – 1998 did not help to increase the interest of potential investors either. Moreover, the country suffered from setbacks in the area of European integration, as it was not invited to start negotiations about the EU accession together with its neighbors at the Luxembourg summit in 1997.

The investment attractiveness of Slovakia started to change after the general elections of 1998, when economic reforms where initiated and the process of integration into the EU and NATO was quickly restarted. Foreign corporations responded to the changes and a period of high FDI inflows to Slovakia started in 2000 that lasted until the global economic crisis in 2009. This was a decade of peak FDI inflows with a yearly average of 3,963 million USD (UNCTAD, 2017). The increased FDI inflows were the result of overdue privatization transactions (banking, energy sector, industry) and an increasing number of large greenfield FDI projects. Global automotive companies were the leading investors during these years (VW, Kia, PSA), but there were major projects also in electronics industry (Samsung), machinery industry and in the area of shared service centers (Dell, Lenovo, HP, AT&T and others). FDI inflows clearly contributed to economic growth and job creation during this time period and Slovakia was transformed into a powerhouse of the automotive industry.

Figure 1

FDI Stock per capita in Slovakia by District (2016)



Note: Darker districts have higher FDI stock per capita.

Source: Own elaboration in Excel 3D Map based on NBS (2019).

The global economic crisis of 2008 – 2009 shook the foundations of the global economy and contributed to a global decline of FDI flows. This decline could be witnessed also in Slovakia and the year 2009 marks the start of the third distinct time period of FDI inflows to Slovakia which is characterized by weaker and more volatile inflows. The average yearly FDI inflows dropped to 829 million USD between 2009 and 2016 thanks to the decreasing level of greenfield projects and increased use of debt instruments by the global corporations. The number of large-scale FDI projects dropped considerably after 2009, although the corporations in the automotive industry continued to expand their presence in Slovakia (albeit with smaller projects). On the other hand, the increased profit repatriation and a large scale use of debt instruments (included in the FDI statistics) led to a new phenomenon in Slovakia – negative FDI inflows between 2013 and 2016. The lower inflow of new equity capital into Slovakia after 2012 was not able to counterbalance the increased negative flows of profit repatriation and this led to four years of negative FDI inflows. However, the giant greenfield investment of Jaguar Land Rover in Slovakia tipped the balance of FDI inflows back into positive levels.

The regional distribution of FDI inflows in Slovakia was uneven since its independence in 1993. According to the latest available final data from the NBS (2019; for the year 2016) Bratislava region including the capital Bratislava has a 69% share on the total FDI stocks in Slovakia. For comparison, the cumulative share of the next two best regions on the total FDI stocks (Žilina region and Trenčín region) was 13%. Besides the economic power of the capital of Slovakia, the dominance of Bratislava region has mainly been caused by the methodology of FDI statistics. As an example, Bratislava region was greatly boosted by privatization FDI inflows that were entered in the FDI statistics into the region of the headquarters of the privatized companies, which was typically Bratislava. Even if Bratislava is not taken into account, the share of the regions of Western Slovakia (Trnava, Trenčín and Nitra – 16%) on the total FDI stocks in Slovakia is significantly higher than the share of the regions of Central Slovakia (Žilina and Banská Bystrica – 9%) and Eastern Slovakia (Košice and Prešov – 7%).

T a b l e 1

FDI Stock in Slovakia – Top 10 Districts (2016)

District	Region	1,000s EUR	District	Region	1,000s EUR
Bratislava	West	29,712,813	Brezno	Center	13,615
Košice	East	1,748,980	Veľký Krtíš	Center	12,298
Žilina	Center	1,553,742	Trebišov	East	11,039
Nitra	West	915,799	Gelnica	East	0
Senec	West	753,522	Levoča	East	0
Púchov	Center	640,590	Medzilaborce	East	0
Trenčín	West	623,387	Poltár	Center	0
Trnava	West	614,130	Stropkov	East	0
Malacky	West	536,851	Turčianske Teplice	Center	0
Galanta	West	535,794	Dunajská Streda	West	–207,705

Source: Own elaboration based on NBS (2019).

The lopsidedness of FDI stocks in Slovakia is visible also on the district level. The districts with the highest FDI stocks (Table 1) are almost exclusively situated in Western Slovakia. Similarly, the regions with the lowest level of FDI stocks mostly belong to Central and Eastern Slovakia. This situation raises serious questions about the contribution of FDI inflows to decreasing regional differences and creates a serious strain on the labor market in the western part of Slovakia. It also opens a question of why investors prefer some regions of Slovakia over others. The standard answers of FDI literature (as seen in section 1) which can be applied to our case include availability of labor force, better infrastructure or higher level of education combined with agglomeration effects. Moreover, an additional country-specific factor must be mentioned here: Western Slovakia is the country's gate to the Western European market, where the majority of exports flow. It is therefore not only Bratislava itself, but also the regions of Trnava, Trenčín as well as Žilina which have the good fortune of being on the border with Austria and the Czech Republic. The advantage is three-fold: (1) *Geographical* – they are closer to the important markets. (2) *Infrastructural* – they have better connections to the important markets. (3) *Network-related* – they are closer to a dense network of suppliers and producers in the same value chain enabling the regions and the investors therein to make use of the related synergies. These factors act gravitationally and can help explain the inequality of FDI distribution in Slovakia.

3. Data and Methodology

Gravity models have been used as a work-horse of international trade and FDI analysis for decades. However, at least until Anderson and van Wincoop's 2003 paper, the models had no strict theoretical background. Since then the theoretical research has intensified and many mistakes have been identified that are frequently made by authors (WTO, 2012). The vast majority of the mistakes – some have even classified them into gold, silver and bronze medal mistakes (Baldwin and Taglioni, 2006) – can be prevented by choosing the right estimation method and choosing the correct specification.

As a standard, simple gravity models of FDI take the form

$$FDI_{ij} = \mathrm{G} \cdot \frac{GDP_i^{\beta_1} \cdot GDP_j^{\beta_2}}{\mathrm{DIST}_{ij}^{\beta_3}} \cdot \varepsilon_{ij} \tag{1}$$

where G is the gravity constant, DIST represents the distance between countries i and j and ε is the error term. The models are usually transformed into a log--linear or into a multiplicative form (Santos Silva and Tenreyro, 2006), depending on the approach taken. As can be seen from the equation, the essence of the gravity model is to express FDI stock or flow as a function of economic dimensions of two countries (usually GDP) and their mutual distance. Dozens of other variables are often added to the model to capture their effect on FDI. Cross-sectional models focusing on a single country (see e.g. Lien et al., 2012) omit economic-dimension variable of the host country as it remains constant. In a similar way, due to the fact that our research is not interested in the country of origin of the FDI in Slovak regions, the economic-dimension variable of the source country is omitted. Consequently, the distance is not calculated from foreign partners, but following the approach of Broadman and Recanatini (2001), from the capital city, Bratislava. Given the specific peripheral position of the city within Slovakia, the reasoning is based on the following factors: First, it is the center of gravity of the Slovak economy. It is one of the richest regions of the EU as a whole and its GDP per capita is over 150% higher than the GDP of the second-best-performing Slovak NUTS-2 region (Eurostat, 2018). Second, it is the seat of the majority of the institutions the investors have to deal with when settling in the country. Third, it is the center of information and lobbying. Last but not the least, Bratislava can be considered Slovakia's gate to the Western European market as it is only a 5-minute drive away from Austria and is also very-well connected to the Czech Republic, being located on the West-East as well as North-South highway corridors. It can be therefore reasonably expected that, ceteris paribus, FDI declines with the distance from Bratislava; hence the model takes a gravity-like form.

Arguably the most important decision in any research is choosing the right statistical method. Gravity-type models of FDI are no exception. Some of the methods used in previous research include ordinary least squares regression (Bénassy-Quéré, Coupet and Mayer, 2007; Davies and Kristjánsdóttir, 2010), panel data analysis (Bevan and Estrin, 2004), pooled ordinary least squares (Buckley et al., 2007), generalized methods of moment estimator (Lien, Oh and Selmier, 2012; Millimet and Roy, 2015), Tobit (Gao, 2005; Stein and Daude, 2007), Heckman transformation (Davies and Kristjánsdóttir, 2010), or Poisson Pseudo Maximum Likelihood (PPML; Santos Silva and Tenreyro, 2006; Bénassy-Quéré, Coupet and Mayer, 2007). There has been a wide array of literature debating suitability of each of the methods with the majority of scientific voices currently leaning towards Heckman or PPML (Burger, van Ooert and Linders, 2009; WTO, 2012).

The main issue present in almost any gravity-type model is the problem of zeroes. The log of zero is not defined; hence a system to deal with observations with zero values has to be established. Multiple approaches have been suggested and used to solve this issue. The simplest solution is excluding the observations where variables take a value of zero (Rose, 2000). However, this procedure might lead to a loss of important information, especially if the zeroes are not randomly distributed. Another option is adding a small constant to the value of variable, for example Bénassy-Quéré, Coupet and Mayer (2007) add 0.3 to FDI to circumvent this problem. Again, this might lead to a systematic bias in results. Other problems include heteroscedasticity in data and multicollinearity. Consequently, many authors turn away from OLS and related models and choose more sophisticated specifications instead.

Taking the same approach, we use the PPML estimation in the present paper. This decision was based on several considerations. First, the model uses a non--linear dependent variable, thus avoiding the issue of having to drop zero FDI stock values (even though this still does not solve the negative-FDI-stock problem). Second, PPML was shown to provide robust results in the presence of heteroscedasticity (WTO, 2012). Third, the main issue of PPML – limited-dependent variable bias when a significant part of the observations are censored (Gómez--Herrera, 2013) – does not apply in our case. Last but not the least, it is relatively easy to compute, widely known and readily interpretable (see Santos Silva and Tenreyro, 2006 for details). Nevertheless, even though PPML is the only estimation method applied consistently throughout the paper, robustness checks show that results are robust to other approaches as well, such as Tobit estimator with left-censoring at zero on the log of FDI stock, or even a simple OLS.[1]

Throughout the paper we use panel data for the period 2009 – 2016. For many of the variables newer data is available, yet the district-level FDI statistics were final only until 2016 at the time of the last revision of our research. The starting year was selected as it is the year of adoption of euro as Slovakia's national currency and including prior years into analysis would necessarily involve exchange-rate related inaccuracies.

Choosing correct variables for the model is another key task. This, however, often depends on the availability of data. The most complete database of Slovakia's foreign direct investment with the highest level of detail is operated by the NBS (2019). The data on district-level flows and stocks of FDI is divided into equity capital, reinvested earnings and provision of long-term and short-term intra-company loans in line with the statistical practices of the UN. FDI totals are almost always available, however for up to 18% of the districts (depending on the year) the division is not reported due to confidentiality restrictions. These are mainly smaller districts of Eastern Slovakia with low number of investors where publishing full statistics would effectively lead to disclosure of individual

[1] A previous version of this paper was fully based on Tobit estimation. Importantly, the differences in results between Tobit and PPML turned out to be minor.

companies' data. As a result, we use FDI totals. We verify that the missing confidential data do not affect our results in one of the robustness checks. FDI stocks are preferred over FDI flows due to the latter's high volatility.

The main ingredients of any type of gravity models in international economics are distance, economic, demographic and dummy variables. In case of gravity models of FDI, gross domestic product is usually the main economic variable of choice (Bevan and Estrin, 2004; Davies and Kristjánsdóttir, 2010, etc.). As the GDP is not obtainable for Slovakia's districts, we use total wages instead (calculated as a region's population multiplied by average monthly wage). Arguably, while GDP can be considered a measure of total income, wages are one of the components of this income, and just like the GDP in absolute value they can be reasonably used to represent economic size of a region. As such, total wages are the best proxy of GDP that is available at the district level in Slovakia. Average monthly wages as well as district-level population numbers are taken from the Statistical Office of the Slovak Republic (2019). Both FDI and wages are expressed in euros in current price terms.

For administrative purposes, Slovakia is divided into 8 regions and 79 districts. With the exception of Bratislava and Košice, each district consists of a district capital and its surroundings. Usually the districts are named after the largest cities, but there are a few politically-historical exceptions.[2] Bratislava and Košice are the largest cities in the country and they consist of five districts each. While this has certain advantages from the point of view of administration, in the current research this division is undesirable and we count both cities as single districts. This allows us to avoid inaccuracies which would necessarily arise because of zero distance between separate districts of the same city as well as due to the fact that it would be impossible to choose a single district as the center of gravity.

Travel distance in kilometers and travel time in minutes between district capitals and Bratislava are employed as proxies for distance. While the former is standard, the latter has also been widely used (Tuan and Ng, 2004; Davies and Guillin, 2014; Schäffler, Hecht and Moritz, 2014), mainly in studies focusing on smaller regions where geographical factors (mountain passes, ragged shoreline, etc.) and infrastructure quality can lead to significant differences in travel time between equidistant destinations; time can therefore be a better proxy for distance than mileage.[3] The Google Maps app was of a great help for obtaining both distance and time. From among the variety of routes the application offered,

[2] For example, Dubnica nad Váhom is not a district capital and belongs to the Ilava district, even though it has 4-times more inhabitants than the town of Ilava itself.

[3] Banská Bystrica and Veľký Krtíš are both 212 km from Bratislava, but the travel time differs by more than half an hour. Trenčín and Komárno are also at almost equivalent distances from Bratislava, but the travel time to the former is 33 minutes (31%) faster.

we have always chosen the most optimal one, i.e. the shortest one in terms of time under perfect road conditions. Consequently, the optimal route is not necessarily the shortest one in terms of distance. Only domestic roads were taken into account – this might sound self-explanatory, but for example the trip from Komárno to Bratislava is 30 minutes shorter on Hungarian roads than on domestic ones. However, traveling via Hungary translates into extra costs (due to potential delay at the borders and a separate toll system); hence we did not take this possibility into account. In general, Slovakia is a small country with relatively proportionally dispersed districts and a non-centrally located capital. The dispersion of distance values is limited – maximum distance between two Slovak districts is 500 km or 327 minutes.

A similar approach was chosen to obtain data on distance between district capitals and regional capitals. Due to the fact that district capitals are sometimes closer to a regional capital of a different region than to the regional capital of their own, two separate variables were created – one for the respective and one for the closest regional capital. The difference is sometimes considerable, e.g. 101 vs. 62 kilometers for Spišská Nová Ves.

Binary variables used include dummies for freeways, universities, various town sizes, presence of regional capitals in the district and border dummies. All of them are usual in FDI-related literature of gravity as well as of non-gravity type (see for example Broadman and Recanatini, 2001; Cheng and Kwan, 2000) and have a straight economic logic. Access to freeways is a proxy of better infrastructure (Klier, Ma and McMillen, 2004). The presence of universities increases the quality of labor force (Siedschlag et al., 2013). Larger cities bring agglomeration economies (Capello and Camagni, 2000). Proximity of regional capitals simplifies and shortens administrative procedures. Border effect reduces costs of information acquisition (due to the presence of minorities and shorter logistics chain) for investors from neighboring countries (Mariotti and Piscitello, 1995), but also differentiates between EU-bordering regions and non-EU-bordering regions, the first of which are sometimes found to be preferred by foreign investors, as in the case of Poland (Cieslik, 2005).

Only 42% of Slovakia's districts have direct access to freeways (defined as dual-carriageway roads with controlled access) and 24% have universities. Even though Slovakia is a relatively small country with a high inter-district mobility, we believe these factors could be playing a significant role in attracting foreign investors: a district with freeways and universities might be more attractive than a district without them. The same should apply to industrial parks (Guagliano and Riela, 2005), where we use a variable summing up total area of industrial parks in individual districts, but also construct a related dummy as an alternative.

The sources of all the variables and units used in the model are summarized in Table 2.

T a b l e 2

Variables and Sources Used

Variable	Unit	Source
Foreign direct investment, stock	1,000s euros	NBS (2019)
Average monthly wage	Euros	Statistical Office of SR (2019)
Population	People	Statistical Office of SR (2019)
Distance	Kilometers	Google (2017)
Time	Minutes	Google (2017)
Industrial parks and their area	Units, hectares	Ministry of Economy of the Slovak Republic (2017)
Various dummies (freeways, universities, town size, regional capitals, border, border with Czechia etc.)	1/0	Own elaboration

Note: All data for 2009 – 2016. Nominal prices in euros.

Source: Own elaboration.

In line with the empirical trade literature the log specification is used whenever possible. The starting district-level model has the following form:

$$\begin{aligned} lnFDI_T = \beta_0 + \beta_1.lnTWAGE_T + \beta_2.lnDIST_T + \beta_3.Dummy1_T + \ldots \\ + \beta_X.DummyX_T + \beta_T.TimeDummy_T + \varepsilon_T \end{aligned} \quad (2)$$

Taking into account that PPML will be the used estimation method, the model needs to be transformed following Santos Silva and Tenreyro (2006) to:

$$\begin{aligned} FDI_T = \exp[\beta_0 + \beta_1.lnTWAGE_T + \beta_2.lnDIST_T + \beta_3.Dummy1_T + \ldots \\ + \beta_X.DummyX_T + \beta_T.TimeDummy_T]\varepsilon_T \end{aligned} \quad (3)$$

Before we proceed further, let us devote some lines to what Baldwin and Taglioni (2006) called the gold medal error, i.e. omitting Anderson and van Wincoop's (2003) multilateral trade resistance (MTR, sometimes also called remoteness) from the model specification. As the reasoning goes, gravity models of trade are biased if they do not include an independent variable capturing the fact that bilateral trade between two countries is dependent on their remoteness from markets (defined not only geographically) and on the remoteness of all other countries in the world. Current trade literature has accepted this almost as an axiom and the vast majority of works use a variant of MTR. In gravity models of FDI, however, the consensus is non-existent and current papers (including some higher profile ones) generally do not include MTR as a separate independent variable (Kimura and Todo, 2010; Qian and Sandoval-Hernandez, 2015; but see for example Fournier, 2015) and prefer tackling the problem using fixed-effects models. In our case, we argue that omitting MTR does not significantly bias results due to the simple fact that no matter what indicator is used, differences in global remoteness of individual Slovak districts are negligible. This is caused by the small area of the country and its position in Central Europe, which is in general one of the "least remote" regions of the world. Constructing intra-country (as opposed to global) remoteness indices for each district would not be sensible either based on the same arguments. Moreover, the non-geographical dimension of MTR does not apply, because all the districts are subject to the same national laws – the only difference being higher government aid allowance in some districts, which in this situation is not a determinant of FDI, but actually a government response to the low FDI inflows to some regions.

4. Results and Discussion

The core of virtually any gravity model of FDI is composed by two elements: distance and GDP. If they are not found to be statistically significant there is either a serious flaw in the model or the data does not follow a gravity pattern and other approach should be chosen. The same should be the case with the gravity-type models of FDI on sub-national level. However, there are two differences.

First, in a small landlocked country like Slovakia it makes no sense to measure distance in a standard way in kilometers from home country of the foreign investor. This could be applicable when studying territorial structure of FDI in Canada, USA, Russia or in other large economies, but will arguably not have much importance in our case, where distances between districts are minimal. Moreover, FDI data by district by country of origin are not available due to confidentiality restrictions.

We will therefore use road distance between Bratislava and the district capital. It can be argued that proximity to Bratislava has effect on FDI distribution because (1) Bratislava has historically been the economic and political hub of Slovakia, (2) it is the seat of the majority of institutions and (3) it has a very favorable geographic location close to Vienna, a major market in Central Europe. As a result, it can be expected that there will be a negative relationship between FDI stock in a district and its distance from Bratislava.

Second, as mentioned before, the data on GDP for Slovak districts is not available, therefore total wages were chosen instead. Similar to GDP, the variable should have a positive effect on FDI stock. This means that – ceteris paribus – districts with higher total wages (which means they have either higher average wage, are more populated or both) should have a higher FDI stock than less populated districts and/or districts with lower total wages.

T a b l e 3

Results of PPML Estimations with Distance, 2009 – 2016

	(1)	(2)	(3)	(4)	(5)
Dependent variable: FDI					
Intercept	–11.217*** (1.037)	–8.981*** (0.879)	–7.811*** (1.091)	–9.475*** (1.021)	–10.796*** (1.215)
lnTWAGE	1.407*** (0.051)	1.253*** (0.043)	1.190*** (0.055)	1.290*** (0.053)	1.348*** (0.063)
lnDIST	–0.358*** (0.021)	–0.363*** (0.018)	–0.373*** (0.020)	–0.352*** (0.018)	–0.348*** (0.017)
D_FWAY	–	0.883*** (0.073)	0.788*** (0.078)	0.729*** (0.082)	0.865*** (0.082)
D_UNI	–	–	0.192** (0.080)	0.222*** (0.080)	0.301*** (0.075)
D_20,000	–	–	–	–0.322*** (0.086)	–
D_50,000	–	–	–	–	–0.393*** (0.108)
Model characteristics					
R-squared	0.963	0.973	0.973	0.974	0.974
Observations	491	491	491	491	491

Notes: Own calculations. Robust standard errors in parentheses. Distance from Bratislava (kms). Year dummies used. * Significant at 10%. ** Significant at 5%. *** Significant at 1%.

Source: Own elaboration based on sources shown in Table 2.

Hence – as is standard with gravity models of FDI or trade – our models have two main independent variables. The coefficients of both turn out to be highly statistically significant and have the expected signs in all the models tested (Table 3). Logical and straightforward economic and statistical interpretation is the first indication that the econometric specification is correct. The independent variables are not correlated with each other[4] and the number of outliers is low. The lnTWAGE coefficient has a value of approx. 1.2 which is similar to the coefficient of lnGDP in previous research using PPML (Bénassy-Quéré, Coupet and Mayer, 2007) or other estimation techniques (Kimura and Todo, 2010; De Sousa and Lochard, 2011; etc.). It might appear that the distance coefficient has a relatively low value, but FDI literature has already shown that this is normal when using PPML estimation due to its different structure (Fourier, 2015; Bénassy-Quéré, Coupet and Mayer, 2007) and approach to heteroscedasticity (Santos Silva and Tenreyro, 2006); moreover, we cannot forget that the present paper is using a different definition of distance (i.e. intra-country) and has different specifications than regular gravity models of FDI.

It could be expected that access to freeways (defined as presence of multi-lane highways designated as D- or R-roads in the district) and universities are important determinants of FDI as well. Indeed, a simple analysis shows that

[4] The correlation coefficient is $r = -0.26$.

districts without universities and direct access to freeways have the lowest average FDI – 77 million euros compared to 175 million euros for those with universities but without freeways and 232 million euros for districts without universities but with freeways (Figure 2). The average skyrockets to 2.4 billion for districts with both freeways and universities, and even if Bratislava as an obvious outlier is omitted from the analysis the average for the last group remains high at 594 million euros. All our models confirm both of these expectations and the coefficients of freeways and universities are positive and statistically significant (models 3 – 5).

Figure 2

Average FDI Stock per District by Presence of University and Freeway (2016)

Source: Own elaboration based on sources shown in Table 2. FDI stock in thousand EUR.

A positive effect of access to freeways on FDI is in line with the literature (see for example Cheng and Kwan, 2000). High quality roads increase the size of the local market, make domestic as well as international deliveries faster, and most importantly, are crucial for just-in-time production. 30 out of 71 districts in Slovakia have access to freeways. The positive effect of universities might seem to be more difficult to explain, but is not entirely absent from the literature either. In general, it might be expected that the presence of universities leads to a higher supply of well-educated workforce in the district and should therefore have a positive effect on foreign companies' location decisions. On the other hand, however, it has been argued that high labor quality does not necessarily have to be an important determinant of FDI in the manufacturing sector (Kinoshita and Campos, 2003) and that indicators of tertiary education do "not reflect the level of specific skills that workers would need to have to encourage more foreign investment", especially in services (Walsh and Yu, 2010).

Moreover, as Slovakia is a small country, the education-to-FDI-link logic might have an important caveat: short distances and good public transportation system enable inhabitants from other districts easy access to university education and make them more mobile in search for employment. Only 15 districts (21%) neither have a university nor border a district which has one, the problem being limited mainly to Eastern and Central Southern Slovakia.[5] Notwithstanding the above mentioned pitfalls, the estimations confirm previous results of other authors (Chidlow, Salciuviene and Young, 2009; Siedschlag et al., 2013) that education has an important impact on FDI location decisions on sub-national level.

The interpretation of dummy variables in PPML models is not as straightforward as with regular OLS estimation, but can be done through an exponential adjustment of the coefficients β to e^{β}–1. Based on model 3, the access to highways increases FDI stock by 120%, while the presence of universities has a relatively modest 21% impact. The former might appear exaggerated, but a previous study using freeway dummies has shown on effect of up to 105% for US counties (Klier, Ma and McMillen, 2004); other papers applying density of paved roads have also shown a strong effect of the road infrastructure variable on FDI (Cheng and Kwan, 2000; Deichmann, Karidis and Sayek, 2003). The effect of universities was shown in other studies to be even higher than in our case, e.g. over 50% in the European Union (Siedschlag et al., 2013), but in that research only the top 500 universities in the world were taken into account.

The last two columns of Table 3 build on model 3, but include additional district-related dummies. They show that having a large town (defined by number of inhabitants) within the district has a negative effect on FDI stock. This is an entirely counterintuitive result that will need to be explored further in the text.[6] Combinations of other variables included in our analysis led to no satisfactory statistically significant results (dummy for capital city, dummy for regional capital, dummy for Bratislava and Košice, dummies for various sizes of district capitals, dummy for airports, etc.; results not reported here).

To sum up, the results of basic PPML models indicate that there is a positive dependence of FDI stock on total wages, access to freeways and presence of universities, and a negative dependence on distance from Bratislava. Other independent variables included in the study turned out to be either statistically insignificant or (as in models 4 and 5) their sign has no clear interpretation. To test these results in a slightly altered environment, we divide the single indicator of

[5] „Field offices" are not counted as universities due to the fact that they do not have legal subjectivity nor separate accreditation.

[6] The same results were obtained for various definitions of "large towns", incl. 10,000 inhabitants, 40,000 inhabitants and 100,000 inhabitants.

total wages into two separate independent variables of population and average wage in each district (Table 4). The conclusions remain valid with similar levels of statistical significance.

Table 4

Results of PPML Estimations with Distance 2, 2009 – 2016

	(6)	**(7)**	**(8)**	**(9)**	**(10)**
Dependent variable: FDI					
Intercept	–29.848*** (2.508)	–21.350*** (2.701)	–20.104*** (2.720)	–20.923*** (2.387)	–24.231*** (2.491)
lnPOP	4.519*** (0.369)	3.262*** (0.415)	3.186*** (0.405)	3.168*** (0.369)	3.482*** (0.372)
lnWAGE	1.106*** (0.054)	1.101*** (0.053)	1.040*** (0.065)	1.136*** (0.067)	1.212*** (0.071)
lnDIST	–0.196*** (0.029)	–0.259*** (0.028)	–0.270*** (0.029)	–0.256*** (0.025)	–0.236*** (0.026)
D_FWAY	–	0.668*** (0.084)	0.572*** (0.086)	0.528*** (0.086)	0.644*** (0.090)
D_UNI	–	–	0.190** (0.081)	0.233*** (0.083)	0.327*** (0.078)
D_20,000	–	–	–	–0.297*** (0.091)	–
D_50,000	–	–	–	–	–0.460*** (0.110)
Model characteristics					
R-squared	0.971	0.975	0.975	0.976	0.977
Observations	491	491	491	491	491

Notes: Own calculations. Robust standard errors in parentheses. Distance from Bratislava (kms). Year dummies used. * Significant at 10%. ** Significant at 5%. *** Significant at 1%.

Source: Own elaboration based on sources shown in Table 2.

Statistical significances and coefficient signs remain similar even when travel time from Bratislava is used as a proxy for distance (Table 5). This confirms the role of the first four variables; however, it still shows the puzzling situation of negative and statistically significant signs for large city dummy (over various size definitions). Previous studies (Blanc-Brude et al., 2014) have found quite the opposite, i.e. that more rural population (hence in Slovakia's case smaller towns) has negative influence on foreign firms' subnational location decisions, and basic economic logic suggests that larger cities should be positively correlated with FDI. Therefore, we need to explore possible explanations.

Considering an unusual urban structure of Slovakia with both largest cities located in opposite regions of the country, it might be possible that a single-core gravity-type model is not appropriate, but a dual gravity-type model with centers of gravity in both Bratislava and Košice should be used. This, however, did not lead to any statistically significant results and even a brief look at Figure 1 and Table 1 shows that no Eastern districts other than Košice are important FDI receivers.

Table 5

Results of PPML Estimations with Time, 2009 – 2016

	(11)	**(12)**	**(13)**	**(14)**	**(15)**
Dependent variable: FDI					
Intercept	–10.871*** (1.129)	–9.042*** (0.931)	–7.991*** (1.157)	–9.764*** (1.057)	–11.159*** (1.264)
lnTWAGE	1.391*** (0.056)	1.258*** (0.046)	1.202*** (0.058)	1.308*** (0.055)	1.369*** (0.065)
lnTIME	–0.399*** (0.025)	–0.399*** (0.021)	–0.409*** (0.023)	–0.385*** (0.020)	–0.380*** (0.020)
D_FWAY	–	0.837*** (0.073)	0.748*** (0.079)	0.690*** (0.082)	0.835*** (0.084)
D_UNI	–	–	0.174** (0.082)	0.211*** (0.079)	0.297*** (0.075)
D_20,000	–	–	–	–0.355*** (0.086)	–
D_50,000	–	–	–	–	–0.427*** (0.108)
Model characteristics					
R-squared	0.965	0.973	0.974	0.975	0.975
Observations	491	491	491	491	491

Notes: Own calculations. Robust standard errors in parentheses. Distance from Bratislava (minutes). Year dummies used. * Significant at 10%. ** Significant at 5%. *** Significant at 1%.

Source: Own elaboration based on sources shown in Table 2.

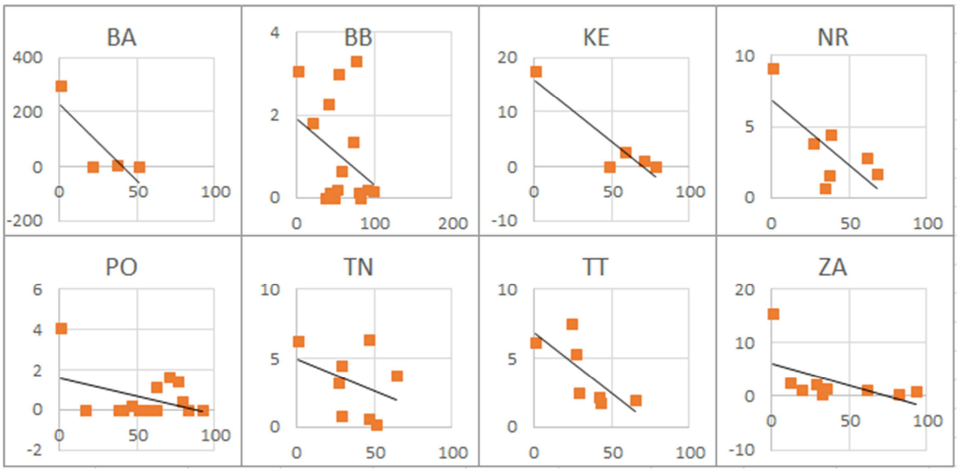
Another potential omission in the model could be the lack of regional dimension. Each district of Slovakia belongs to one of the eight regions. It could be the case that due to a combination of exogenous factors each one of these has different levels of attractiveness for foreign investors (hence a regional dummy should be used) or regional distance of each district from the closest regional hub as an alternative indicator of distance should be considered. A set of simple correlation charts between FDI stock and regional distance for districts in each region (Figure 3) demonstrates that if no other factors are controlled for, there is a negative relationship between district's distance from the closest regional capital and FDI stock, which is in line with expectations. However, once the standard independent variables are included in the model this relationship cannot be proved to be statistically significant.

In countries like China, special economic zones have traditionally had an important role in determining the structure of FDI inflows (Cheng and Kwan, 2000). While these have never existed in Slovakia, the country has a number of industrial parks located in 42 districts. If major industrial parks were located in small towns or in the countryside, these could potentially attract a considerable number of foreign investors and lead to the paradox of a negative relationship between large cities and FDI; however, this is not the case. Neither industrial park dummy nor their size in hectares proved to be statistically significant variables in any of the regressions run.

Moreover, their coefficients were negative.[7] The reason for the existence of the "big town" paradox appears to be much simpler: correlation with other independent variables. Both D_50,000 and D_20,000 are correlated with lnTWAGE, D_FWAY and D_UNI, with the correlations coefficients reaching up to 0.69. Two facts have to be taken into account here. First, there is a freeway in every large city and in every regional capital. Hence when the city-related dummy is 1, the freeway dummy always has the value of 1 as well. Second, regional capitals and cities over 50,000 inhabitants are located in some of the richest districts of Slovakia, all of them within the upper quartile of the average wages. As a result, the correlation is high for a sub-set of data with large cities and regional capitals, and conversely, low for a sub-set of data with other districts. This inconsistency has caused the counterintuitive outputs of models 4 and 5.

Figure 3

Relationship between FDI Stock and Distance from Regional Capital by Districts (2016)



Note: Horizontal axes represent distance in kilometers of district capital to the closest regional capital; vertical axes represent FDI stock in 100 million euros. Note that the closest regional capital does not always have to be the administrative regional capital. BA – Bratislava. BB – Banská Bystrica. KE – Košice. NR – Nitra. PO – Prešov. TN – Trenčín. TT – Trnava. ZA – Žilina.

Source: Own elaboration based on sources shown in Table 2.

An additional possible explanation relates to the small size of the cities and districts in Slovakia. Given the good quality of transport infrastructure and short distances, the location decisions of foreign investors might be influenced by exogenous factors in addition to the ones we considered. Knowing a city is mere 20 minutes away, an investor might prefer a relatively "distant" location if better

[7] Results not reported here.

conditions are offered, local politicians and negotiators show more flexibility, or even if the place under consideration has a certain geographical or aesthetical charm; there are thousands of minor factors that differ from village to village. Moreover, previous research has shown that agglomeration economies require a certain city size to matter (Capello and Camagni, 2000; Kanemoto, Ohkawara and Suzuki, 1996); while the limit varies with researchers and industries, it is safe to assume that only Bratislava and potentially Košice are above it in Slovakia. The differences between a city of 20,000 or a city of 60,000 inhabitants are arguably not too important for foreign investors. It is therefore obvious that the unexpected coefficient signs of D_20,000 and D_50,000 result from various factors, including their low importance and high correlation with other dependent variables; hence both dummies should be dropped from further studies.

Taking into account all the previous analyses we come to the conclusion that model 3 constitutes the most appropriate expression of FDI determinants in Slovakia on district level. We will subject it to multiple robustness checks to verify whether its regression coefficient estimates remain consistent when outliers are dropped or when alternative estimation methods are used.

Table 6 presents estimation results for five different variants of our dataset without outliers, potential outliers or districts whose exclusion could potentially lead to changes in the estimation equation. In model 16 the Bratislava district is dropped from the analysis. It is the capital, the most populous and richest part of Slovakia with the highest share on country's GDP. Considering it is the core of our gravity set-up, it is vital to see whether the estimation results are robust to its exclusion. In model 17 only districts where wages are within one standard deviation from dataset average are considered. Other researchers usually set the limit at 2 standard deviations, however on average only 3 districts would be dropped using this method and it would lead to virtually the same results. Model 18 takes a completely different approach and is based only on districts with towns larger than 20,000 inhabitants. The reasoning behind this step is that rural districts might be using a different combination of factors to attract FDI than cities and hence significantly influence the estimation equation. Model 19 excludes Bratislava and the other seven regional capitals while the final model 20 drops the districts with confidential data. As we mentioned in the "Data and methodology" section, for the majority of years the data on total FDI stock is available, however, its division into equity capital, reinvested earnings and provision of long-term and short-term intra-company loans is not provided for certain districts due to confidentiality restrictions. These districts are dropped just to verify that missing data does not influence FDI stock and the behavior of regression coefficients.

T a b l e 6

Robustness Checks, 2009 – 2016

	(16) **w/o BA**	**(17)** **w/o outliers**	**(18)** **cities > 20,000**	**(19)** **w/o reg. capitals**	**(20)** **w/o confidential**
			Dependent variable: FDI		
Intercept	–8.337*** (1.150)	0.390 (1.912)	–10.511*** (1.053)	0.619 (1.542)	–7.564*** (1.117)
LnTWAGE	1.227*** (0.064)	0.778*** (0.104)	1.328*** (0.053)	0.786*** (0.082)	1.180*** (0.056)
lnDIST	–0.404*** (0.042)	–0.494*** (0.060)	–0.347*** (0.017)	–0.594*** (0.049)	–0.376*** (0.020)
D_FWAY	0.771*** (0.083)	0.577*** (0.083)	0.798*** (0.110)	0.650*** (0.085)	0.729*** (0.080)
D_UNI	0.183** (0.079)	0.379*** (0.090)	0.087 (0.102)	0.343*** (0.077)	0.199** (0.080)
			Model characteristics		
R-squared	0.759	0.665	0.978	0.630	0.973
Observations	483	360	299	427	429

Notes: Own calculations. PPML regressions with robust standard errors in parentheses. Distance from Bratislava (kms). Year dummies used. Models: 16 – without Bratislava; 17 – without districts with wages above/below average +- one standard deviation; 18 – only regions with cities over 20,000 inhabitants; 19 – without regions of district capitals; 20 – without districts with confidential data. * Significant at 10%. ** Significant at 5%. *** Significant at 1%.

Source: Own elaboration based on sources shown in Table 2.

Robustness checks show no significant differences from the main equation (Table 6); only in model 18 coefficient of the dummy for universities loses it statistical significance. This can be explained by a relatively high correlation between districts with cities with 20,000 or more inhabitants and districts with universities. Indeed, almost 40% of the districts with larger cities have a university. Conversely, in districts without cities over 20,000 inhabitants the university ratio drops to 9% and a separate PPML analysis (not reported) shows D_UNI having a strong highly statistically significant and positive coefficient.

To further verify our results, we use alternative estimation methods. Ordinary least squares regression, heteroscedasticity-consistent standard errors, as well as Heckman's maximum likelihood selection model and Tobit regression (Table 7) lead to the same coefficient signs and statistical significances as in the main model.

The robustness checks indicate that the coefficient estimates of the critical core variables are robust and it appears the structural validity of the model is satisfactory. Total wages, access to freeways and universities have positive effects on FDI stock in a district while distance from Bratislava plays a negative role. The distribution of FDI in Slovakia exhibits patterns of gravity behavior and district-level gravity-type model can be used to describe or potentially also to predict it.

T a b l e 7

Robustness Checks – Alternative Estimation Methods, 2009 – 2016

	(21) Pooled OLS	(22) HC SE	(23) Heckman MLE	(24) Tobit
Dependent variable: lnFDI				
Intercept	–7.657** (3.058)	–4.187*** (1.237)	–4.453*** (1.388)	–7.530*** (1.690)
LnTWAGE	1.214*** (0.167)	1.025*** (0.066)	1.049*** (0.074)	1.214*** (0.908)
lnDIST	–0.578*** (0.112)	–0.580*** (0.042)	–0.587*** (0.044)	–0.574*** (0.046)
D_FWAY	1.037*** (0.192)	0.986*** (0.082)	0.843*** (0.817)	1.030*** (0.081)
D_UNI	0.303* (0.190)	0.307*** (0.073)	0.408*** (0.077)	0.302*** (0.088)
Model characteristics				
Adj. R^2	0.725	0.701	–	–
Standard error	0.934	1.895	–	–
Lambda	–	–	–0.790*** (0.097)	–
Observations	491	491	480	491

Notes: Own calculations. Robust standard errors in parentheses. Distance from Bratislava (kms). For model 23, lnWage used as a selection variable (0.008***). * Significant at 10%. ** Significant at 5%. *** Significant at 1%.

Source: Own elaboration based on sources shown in Table 2.

Conclusions

The present paper used Poisson Pseudo Maximum Likelihood estimation to develop a district-level gravity-type model of FDI stock within Slovakia. The results show that the distribution of FDI in Slovakia has a gravity nature, being positively influenced by total wages (also by population size and wages separately) and negatively influenced by distance from Bratislava.

We have shown that access to freeways and presence of universities have a positive effect on FDI stock. The former is in line with literature (Cheng and Kwan, 2000) while the latter contradicts some (Walsh and Yu, 2010) and confirms other studies (Chidlow, Salciuviene and Young, 2009).

Although some authors have asserted the theoretical inapplicability of tertiary education as an important determinant of FDI in manufacturing and services (see Kinoshita and Campos, 2003 or Walsh and Yu, 2010), our results attest the logic that regions with higher educational level attract more investment; at least this has been the case in Slovakia. Some models surprisingly show a negative effect of the city size on FDI. Two main explanations are offered as to why this is incorrect: high correlation with other independent variables (wages, freeways and universities), and low number of cities of the size required for agglomeration economies.

These results significantly enhance the knowledge on FDI determinants in Slovakia and can be used by local policy makers to improve their FDI policies. Importantly, they can become a part of the current debate in Slovakia on the importance of physical infrastructure for foreign investors and prioritization of certain freeway projects especially in the Southern part of the country. Even though several local functionaries have recently claimed that the role of freeways in investors' location decisions is overrated, our research shows quite the opposite.

As usual, the approach chosen is not without issues. Standard disclaimers valid for the majority of FDI gravity models can be applied: confidentiality of some data, the problem of zeros, omitted variables etc. may have affected the results. However, we believe we have chosen an effective method to minimize these issues and the robustness checks show the model performs well under different settings even using different estimation methods. Moreover, all the coefficients have an easy interpretation and follow basic economic logic.

The research could be further enhanced by introducing FDI-home-country variables into the model; yet this is hindered by unavailability of data and goes far beyond the scope of this paper. Other ideas for future research include differentiating between various quality levels of road infrastructure, running separate regressions by type of economic activity, or using alternative indicators of education level. Panel data analysis of a longer time period could be another possible enhancement. Our approach could also be used for the whole Central European region to test the hypothesis on a much broader level.

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