# The gravity model as a tool for the international trade analysis – a case study of the Western Balkans

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**Abstract**

Using data from the Western Balkan countries, the study attempts to answer a question if a general gravity model can work effectively regardless of the scope of analyzed countries and if the commonly used measures describing "distance" are adequate. The region of the Western Balkans seems to be a challenging research object as a number of political, historical, economic and cultural issues emerge as potentially important trade determinants.

In the research a standard gravity model is tested and the results are compared with a model augmented by variables representing: border effect, war and post-war effects, minorities, difference in factor endowments, religious and language distance, FTA and FDI stock. In the panel data model, pooled OLS, fixed and random effects models are estimated in order to check for robustness of the results.

The findings show that there are many determinants of trade specific for this region, which need to be included in the model in order to make it well suited to the data. A particular attention is paid to communicational, cultural and historical factors, such as similarities in language and religious structures, wars or ethnical minorities. All of them appear to have a statistically important influence on the value of trade.

***Keywords:*** *Western Balkans, gravity model, international trade, trade determinants*

***JEL Classification:*** F140, F150, F400

## 1. Introduction

The gravity model has been widely used as a method of an empirical research related to various aspects of international trade. In its standard form, the model was set to explain bilateral trade (or alternatively exports or imports) with "mass" of the trading countries and "distance" between them, which was a parallel to the Newtonian gravity equation (see Tinbergen, 1962, Pöyhönen, 1963 and Linneman, 1966) . The "mass" was usually proxied by GDP and/or population of the trading partners, whereas the "distance" by a physical distance between their capital cities or main economic regions (see Kandogan 2009, Wydymus 2012). As the gravity model of trade turned out to be a successful tool in explaining determinants of international trade, its econometric versions have evolved with numerous new potential variables being added to the standard model. A question arises, if and which of the proposed additional variables should be included in the gravity model of trade? And what is their

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relation to one another and to the main concept of the gravity model, stating that trade is a function of "masses" and "distance"?

The answer to the first question is the feasibility of the "standard" model (not including additional variables) to explain the bilateral trade. Shall countries GDPs, populations and geographical distance explain the trade between them sufficiently, no need would exist to suspect other factors to have any significant influence on it. However, this study shows that the inclusion of a variety of other factors helps the model to better explain the trade values.
As for the second question, the need arises to categorize all measures of "distance" into groups representing its physical, political, economic, cultural, communicational and historical aspects. This would bring a better understanding of their nature and effects. In the literature similar categorizations were presented i.a. by Zeliaś (1991), Anderson and van Wincoop (2004) and most recently by Melitz (2008) and Melitz and Toubal (2012), who cast a light on cultural and communicational aspects of "distance" in trade.

The region of the Western Balkans seems to be a sound example of the socio-cultural factors come into meaning, as it encompasses a number of important characteristics. It lies in the joint of the three big religions: Catholicism, Orthodoxy and Islam. Its citizens speak mostly similar, though not the same languages (except Albania)[2]. There used to be unstable periods, including wars and conflicts in recent years[3]. There is a significant difference in the economic welfare among the countries of the region[4]. Thus, this study attempts to answer a question, if in the case of the Western Balkan countries one could define trade determinants other than offered by the standard gravity model and, if so, which ones.

In the second part of this paper, the standard and the augmented gravity models of trade are presented (2.1 and 2.2 respectively). It includes a list of all "distance" variables categorized into six sections. The results of the research for all three types of the model specifications are presented in the part 3. A concluding part follows, presenting the main findings and hints for further research.

[2] Serbian, Croatian and Bosnian belong to South-Western Slavic and Macedonian to South-Eastern Slavic languages (www.ethnologue.com, accessed: 30.09.2013)
[3] Since 1995, the region experience war conflicts between Bosnia and Serbia (1995), Croatia and Serbia (1995), Kosovo and Serbia (1998,1999) and Kosovo and Macedonia (2001) (Department of Piece and Conflict Research, Uppsala University. In this research, conflicts with Kosovo as one of the parts are attributed to Albania, due to ethnical closeness of those two entities.
[4] In 2007, Albania had the lowest level of GDP per capita in all the region - 3,376 USD, whereas Croatia had the highest – 13,406 USD (UNCTAD STAT).

## 2. The standard and the augmented model

The survey encompasses bilateral trade of the five Western Balkan countries: Albania, Bosnia & Herzegovina, Croatia, Serbia & Montenegro and Macedonia, in years 1995-2007. Only the bilateral trade within the region was examined, which was supposed to provide information on intra-regional determinants of trade[5]. The beginning of the analyzed period is connected with the data availability and its end with the time when Montenegro split from Serbia, which would make further econometrical analysis biased.

The goal of this paper implied comparison of the goodness of fit of the standard and the augmented model. Both of them were specified threefold: as pooled data by OLS, as fixed effects model and as random effects model. The adjusted R-square statistic of the pooled and fixed effects models were used for a comparison. The random effects model served as a benchmark for the interpretation of the regression results. In case of both standard and augmented models the dependent variable was the value of export of a country i to a country j in a year t. The models were specified as power functions, which allows the parameters to be interpreted as elasticities of the variables. For the purpose of simplicity, the models were computed as log-linear functions.

### 2.1. The standard model

In the standard model (see Equation 1), GDP and population of both countries served as a representation of their "mass", whereas physical distance between their capital cities proxied the "distance" as a whole.

$$EXP_{ijt} = a_0 GDP_{it}^{a1} GDP_{jt}^{a2} POP_{it}^{a3} POP_{jt}^{a4} DIST_{ij}^{a5} e^{\delta_{ijt}} \quad (1)$$

where $EXP_{ijt}$ – export from country i to country j in year t, $GDP_{it}$ – country's *i* GDP in year *t*, $GDP_{jt}$ – country's *j* GDP in year *t*, $POP_{it}$ – country's *i* population in year *t*, $POP_{jt}$ – country's *j* population in year *t*, $a_0$ – constant, $a_1 - a_5$ – parameters, $\delta_{ijt}$ – error term.

Shall the standard model demonstrate a high goodness of fit to the empirical data, one could see no premise for further extending it with new variables, representing potential trade determinants. The pooled data and fixed effects specifications were chosen for the core comparison of the adjusted R-square statistic. However, it must be noted that the fixed effects may already comprise information on bilateral relations between countries, which were to be examined with the augmented model.

[5] Such way of trade analysis is rather rare, as one of the early examples see (Zeliaś, 1988).

## 2.2. The augmented model

In case of the augmented model, Equation 2. was presented in a vector notation due to a large number of variables. The first two vectors encompass variables which characterize "masses" of exporting and importing countries. On the other hand, the following six vectors represent variables of six types of "distance": physical, political, economic, cultural, communicational, historical. Unlike Anderson and van Wincoop (2004), who propose three types of "cost" or "distance": policy barrier, transport costs and wholesale and retail distribution costs, this paper attempts to cover recent findings in trade analysis, which show a significant influence of cultural, communicational and historical issues on trade (see for instance Guiso et al. 2009, Helble 2007, Kandogan 2009, Lewer and van der Berg 2007, Melitz 2008, Melitz and Toubal 2012).

$$EXP_{ijt} = a_0 x_{it}^{\beta 1} m_{jt}^{\beta 2} df_{ijt}^{\beta 3} dp_{ijt}^{\beta 4} de_{ijt}^{\beta 5} dku_{ijt}^{\beta 6} dko_{ijt}^{\beta 7} dh_{ijt}^{\beta 8} e^{\delta_{ijt}} \quad (2)$$

where $EXP_{ijt}$ – export from country $i$ to country $j$ in year $t$, $x_{it}$, $m_{jt}, df_{ijt}, dp_{ijt}, de_{ijt}, dku_{ijt}, dko_{ijt}, dh_{ijt}$ – vectors of variables representing: $x_{it}$ – "mass" of the exporter ($i$), $m_{jt}$ – "mass" of the importer ($j$), $df_{ijt}$ – physical "distance" between $i$ and $j$, $dp_{ijt}$ – political "distance" between $i$ and $j$, $de_{ijt}$ – economic "distance" between $i$ and $j$, $dku_{ijt}$ – cultural "distance" between $i$ and $j$, $dko_{ijt}$ – communicational "distance" between $i$ and $j$, $dh_{ijt}$ – historical "distance" between $i$ and $j$, $a_0$ – constant, $\beta 1 - \beta 8$ – vectors of parameters, $\delta_{ijt}$ – error term.

Table 1 includes a description of certain variables representing "distance" in the augmented model. They are classified into groups according to the division of types of "distance". There are eight binary variables (BORDER, FTA, WAR, WAR+1, WAR+2, WAR+3, WAR+4, WAR+5), three variables being natural logarithms of the nominal values (DIST, PERCAP_DIFF, MINOR) and two indexes which follow specifications presented by Klimczak (2013), namely RELIG and LANG. Thus, the augmented model included twelve new variables representing the "distance" between countries and one (FDI stock) representing "mass" of an exporter (not reported in the Table 1).

| Variable | Type of „distance” | Description of variable | Data source |
|---|---|---|---|
| DIST | Physical | Great circle distance between capital cities | CEPII |
| BORDER | Physical | Takes value of “1” when countries have a common border | Geographical atlas |
| FTA | Political | Takes value of “1” when countries signed a FTA | Various sources |
| PERCAP_DIFF | Economic | Difference in GDP per capita | UNCTAD |
| MINOR | Cultural | Minority of exporting in importing country | Various sources |
| RELIG | Cultural | Sum of differences of shares of three main religions | www.worldmapper.org |
| LANG | Communicational | Index representing probability that two randomly chosen persons will be able to communicate, weighted by similarity of languages | www.ethnologue.com |
| WAR | Historical | Takes value of “1” if countries were in state of war in the given year (in case of the Kosovo war, the index concerns Albania) | Uppsala University |
| WAR+X (“X” taking values 1-5) | Historical | Takes value of “1” if countries had been in state of war x years before the given year (in case of the Kosovo war, the index concerns Albania) | Uppsala University |

**Table 1** Variables representing “distance” in the augmented model

## 3. Results

In the first step, the standard model was regressed basing on three specifications: as pooled data by OLS, as fixed effects model and as random effects model. The results are shown in Table 2.

| | POOLED - OLS | | | FIXED | | | RANDOM | | |
|---|---|---|---|---|---|---|---|---|---|
| | **para.** | **p-value** | | **para.** | **p-value** | | **para.** | **p-value** | |
| const | 11.98 | 0.0006 | *** | 48.72 | 0.1661 | | 14.52 | 0.2268 | |
| GDPexp | 1.87 | <0.0001 | *** | 1.23 | <0.0001 | *** | 1.39 | <0.0001 | *** |
| POPexp | -1.27 | 0.0000 | *** | -1.29 | 0.6514 | | -0.78 | 0.3418 | |
| GDPimp | 0.74 | 0.0001 | *** | 0.90 | 0.0007 | *** | 0.69 | 0.0019 | *** |
| POPimp | -0.04 | 0.8886 | | -5.70 | 0.0565 | * | -0.31 | 0.7024 | |
| DIST | -2.61 | <0.0001 | *** | n/a | n/a | | -2.55 | 0.0120 | ** |

**Table 2** Regression results of the standard model

The adjusted R-squared values of the pooled and the fixed effects specifications were 0.43 and 0.83 respectively. These results show significant differences among country pairs. Their variability would explain 40pp of the variability of exports, which suggests investigating the country-pair effects in more detail by introducing to the model a series of explanatory variables representing "distance" between the countries. The results of the augmented model are presented in the Table 3.

After augmenting the model, the adjusted R-square values in pooled and fixed effects specifications grew to respectively 0.74 and 0.87, which shows that the augmented model fits empirical data better (or significantly better, as in the case of the pooled data). Furthermore, only 0.13 pp difference between the two specifications (pooled and fixed) suggests a significant part of the bilateral effects (meaning "distance") to be covered by the proposed explanatory variables.

In order to evaluate which model specification (pooled, fixed or random effects) was mostly suitable for the empirical data, a series of three tests was conducted. At first, a test was run on differing group intercepts. According to the null hypothesis that groups have a common intercept. The test statistics provided: F(19, 204) = 12.3651 with p-value = P(F(19, 204) > 12.3651) = 8.81944e-025. This brought a conclusion that the null hypothesis was rejected, which meant the fixed effects model was more appropriate then the pooled one.

In the next step, the Breusch-Pagan test was run to verify a hypothesis, that variance of the unit-specific error = 0. Test results showed asymptotic test statistic: Chi-square(1) = 219.833 with p-value = 9.83455e-050, proving that the random effects model suited data better than the pooled one.

| | **POOLED - OLS** | | | **FIXED** | | | **RANDOM** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **para.** | **p-value** | | **para.** | **p-value** | | **para.** | **p-value** | |
| const | -4.77 | 0.2266 | | 6.61 | 0.8780 | | -7.48 | 0.2789 | |
| GDP exp | 0.99 | 0.0006 | *** | 0.79 | 0.0086 | *** | 0.89 | 0.0004 | *** |
| POP exp | -2.72 | <0.0001 | *** | 1.45 | 0.6491 | | -3.02 | 0.0001 | *** |
| GDP imp | 0.04 | 0.8486 | | 0.18 | 0.5936 | | 0.17 | 0.4344 | |
| POP imp | -1.44 | 0.0014 | *** | -2.33 | 0.4742 | | -1.91 | 0.0100 | *** |
| DIST | 5.70 | <0.0001 | *** | n/a | n/a | | 6.68 | 0.0016 | *** |
| BORDER | 5.53 | <0.0001 | *** | n/a | n/a | | 6.13 | 0.0004 | *** |
| WAR | -1.97 | 0.0007 | *** | -1.29 | 0.0021 | *** | -1.37 | 0.0018 | *** |
| WAR+1 | -3.55 | <0.0001 | *** | -2.45 | <0.0001 | *** | -2.61 | <0.0001 | *** |
| WAR+2 | -0.62 | 0.1939 | | -0.07 | 0.8348 | | -0.17 | 0.6417 | |
| WAR+3 | -0.64 | 0.1754 | | -0.18 | 0.5914 | | -0.25 | 0.4890 | |
| WAR+4 | -0.89 | 0.0672 | * | -0.23 | 0.5071 | | -0.33 | 0.3597 | |
| WAR+5 | -0.27 | 0.5701 | | 0.24 | 0.4867 | | 0.19 | 0.6023 | |
| MINOR | 0.06 | 0.0560 | * | n/a | n/a | | 0.07 | 0.2668 | |
| PERCAP _DIFF | -0.13 | 0.2329 | | 0.02 | 0.8131 | | -0.03 | 0.7650 | |
| RELIG | 3.16 | 0.0046 | *** | n/a | n/a | | 4.52 | 0.0039 | *** |
| LANG | 8.16 | <0.0001 | *** | n/a | n/a | | 9.19 | <0.0001 | *** |
| FTA | 0.94 | 0.0008 | *** | 0.32 | 0.1327 | | 0.46 | 0.0364 | ** |
| FDI | 0.01 | 0.9472 | | 0.24 | 0.0440 | ** | 0.17 | 0.1225 | |

**Table 3** Regression results of the augmented model

At the end, the Hausman test was carried out to see if the fixed effects is more appropriate than the random effects model. The null hypothesis suggested that the GLS estimates used in the random effects model are consistent. Asymptotic test statistic: Chi-square(13) = 38.8818 with p-value = 0.0002 showed that the null hypothesis should be rejected and thus the fixed effects model would be more appropriate than the random effects one.

As for the signs of the statistically important explanatory variables, only in one case it was opposite to expectations[6]. Namely, DIST had a positive sign, which was probably biased by including a strongly correlated (at -0.81 rate) BORDER variable.

Among other explanatory variables, the strongest influence on trade has been performed by LANG, with values of the parameter 8.16 and 9.19 for pooled and random effects data respectively (in fixed effects model this variable, as well as the further two, as time-invariant could not be evaluated). It was followed by BORDER (with parameter values 5.53 and 6.13) and RELIG (3.16 and 4.52) variables. All of them were significant at $p < 0.01$ level. Those results should turn the attention to communicational and cultural features as trade determinants. Geography seems to play constantly an important role in trade, too, at least the effect of adjacency between trading countries.

A clear message comes also from the analysis of the effects of war on trade. The effect of the historical "distance" as a whole doesn't seem to be explicit. Only variables WAR and WAR+1 show statistical significance[7]. It would mean that a year after the war its negative effects still ban the mutual economic relations, but in the following years the situation gets normalized quite quickly, although a little negative effect lasts at least two more years.

The two variables with expected, although very little and statistically unimportant values are MINOR and PERCAPDIFF, representing another cultural and economic set of factors. The last variable representing "distance" (a political one) is FTA. Its parameter took the value of 0.94, 0.32 or 0.46 for pooled, fixed and random effects models respectively, with the first and the third one being statistically important. At the end of the set, a FDI variable was presented, which belonged to the factors representing "mass" of a given country, and especially its endowment in technology factor. It also showed little or none significance with positive (as expected) parameters of just 0.01, 0.24 and 0.17.

## Conclusions

The study contributed to several concerns connected with specification of the gravity model of trade. Firstly, it appears that the so-called standard model, in which trade is explained only by GDP, population and geographical distance, doesn't fit well enough to the empirical data. Thus, a necessity exists to supplement it with variables representing other types of "distance", especially with political, economic, cultural, communicational and historical ones.

[6] The POP variables don't have expected signs.
[7] One may treat WAR+4 in pooled specification as an incident.

Secondly, the fixed effects model proved to be the best suited to data, followed by the random effects model. It means that even after controlling for a wide range of country-pair specific factors, still unobserved bilateral effects determine the trade between countries.

Thirdly, in the case of the Western Balkans the usually neglected, non-economic issues of communication, culture and history seem to play the most important role in explaining the patters of trade. As this fact may be partly an outcome of the region's internal diversity, further studies are needed to reconfirm these results basing on a larger number of countries.

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**References**

Anderson, J. E., & van Wincoop, E. (2004). Trade costs. *Journal of Economic Literature*, *42*(3), 691-751.

Guiso, L., Sapienza, P., & Zingales, L. (2009). Cultural biases in economic exchange, *Quarterly Journal of Economics*, 124, 1095-1131.

Helble, M. (2007). Is God good for trade. *Kyklos*, *60*(3), 385-413.

Kandogan, Y. (2009). A gravity model for components of imports. *Review of Applied Economics*, *5*(1-2), 99-115.

Klimczak, Ł. (2013). Determinanty handlu wzajemnego państw Bałkanów Zachodnich, *Zeszyty Naukowe Podkarpackiej Szkoły Wyższej w Jaśle*, (submitted)

Lewer, J., & van den Berg, H. (2007). Estimating the institutional and network effects of religious cultures on bilateral trade. *Kyklos*, *60*(2), 255-277.

Linneman, H. (1966). *An econometric study of world trade flows*. Amsterdam: North-Holland Publishing Co.

Melitz, J. (2008). Language and foreign trade. *European Economic Review*, *52*(2008), 667-699.

Melitz, J., & Toubal, F. (2012). Native language, spoken language, translation and trade, *Centre for Economic Policy Research*, Discussion Paper No. 8994.

Pöyhönen K. (1963). Towards a General Theory of International Trade, *Ekonomiska Samfundet Tidskrift*, *16*(1963), 69-78.

Tinbergen, J. (1962). *Shaping The World Economy. Suggestions for an International Economic Policy*, New York: The Twentieth Century Fund.

Wydymus, S. (2012). System współzależności wskaźników makroekonomicznych w grawitacyjno-potencjałowym modelu polskiego handle zagranicznego. In Wydymus, S. & Maciejewski, M. (Eds.), *Handel i współpraca międzynarodowa w warunkach kryzysu gospodarczego*. Kraków: Fundacja Uniwersytetu Ekonomicznego w Krakowie.

Zeliaś, A. (Ed.) (1988). *Metody statystyki międzynarodowej*, Warszawa: PWE.

Zeliaś, A. (Ed.) (1991). *Ekonometria przestrzenna*. Warszawa: PWE.