Institute for Development

EXTENDED GRAVITY MODEL OF POLISH TRADE.

EMPIRICAL ANALYSIS WITH PANEL DATA METHODS

TOMASZ BRODZICKI

KATARZYNA ŚLEDZIEWSKA

DOROTA CIOŁEK

STANISŁAW UMIŃSKI

Institute for Development

Working Papers no. 003/2015

Instytut Rozwoju

Institute for Development Working Papers

Working Paper no. 003/2015 (022) ver. 1

ISSN 2082-7318

Publisher:

Instytut Rozwoju

ul. A. Mickiewicza 10

81-832 Sopot, Poland

e-mail: office@instytut-rozwoju.org

Working Papers are written by the Staff of the Institute for Development or by experts working in association with them. The views expressed in the Working Paper are the author's alone and do not necessarily correspond to those of the Institute for Development. Comments and enquiries should be addressed to:

Instytut Rozwoju
ul. A. Mickiewicza 10
81-832 Sopot, Poland
e-mail: office@instytut-rozwoju.org

This paper exists in Polish and English and can be downloaded from the website
www.instytut-rozwoju.org

Extended gravity model of Polish trade. Empirical analysis with panel data methods

August 2015

Tomasz Brodzicki
Katarzyna Śledziewska
Dorota Ciołek
Stanisław Umiński

Abstract

The goal of this paper is to investigate the determinants of the intensity of bilateral trade flows of Poland with its trade partners at the general (country level) with the use of trade gravity approach. The analysis is carried out for 234 trade partners of Poland in the period 1999-2013.
In the basic version of the trade gravity model we take into account the standard factors suggested by the literature of the subject. In its extended version we control for additional factors including: relative endowments of factors of production, technological gap as measured by TFP and relative patenting performance, quality of institutions, impact of regional and bilateral trade agreements or exchange rate volatility. The impact of the Polish diaspora is also taken into account. In order to investigate the impact of the global crises on trade intensity we construct and introduce a variable depicting the severity of the crises for individual trade partners. In an attempt to obtain unbiased results we utilize semi-mixed effect method using PPML estimator as suggested in recent empirical articles. In most of the cases the coefficients for the traditional gravity determinants are economically sensible and their impact on the dependent variable is statistically significant and robust.

JEL classification: C23, F10, F14, F15
Keywords: trade gravity, Poland, panel data

The research was conducted and financed within the grant of National Science Centre "Analysis of international trade of Poland in the light of new trade theories. Implications for economic policy at the crisis era" (2012/05/B/HS4/04209) chaired by prof. Krystyna Gawlikowska-Hueckel.

We would like to thank Jakub Kwiatkowski for his help in collecting the trade data. The paper will be presented during the ETSG 2015 conference in Paris.

Tomasz Brodzicki, PhD, University of Gdansk, Economics of European Integration Division; Institute for Development, Sopot; t.brodzicki@instytut-rozwoju.org
Dorota Ciołek, PhD, University of Gdansk, Faculty of Management, Department of Econometrics; Institute for Development, Sopot; dorotaciolek@wp.pl
Stanisław Umiński, PhD, University of Gdansk, Faculty of Economics, Research Center on European Integration; Institute for Development, Sopot; s.umiski@instytut-rozwoju.org
Katrzyna Śledziewska, PhD, Faculty of Economic Sciences, University of Warsaw, k.sledziewska@gmail.com

1. Introduction

Gravity has become the most important "tool" in international trade analysis over the years. Other "flagship" trade theories are useful for determination the ground of exports/imports performances (specialization patterns and trade directions). However it is gravity that enables to determine and to predict real trade flows and consequences of preferential trade agreements. Gravity model is also used in interpretations of non-trade relations between countries (i.e. migration and FDI).

The framework of the model is based on the analogy with the Newtonian theory of gravitation reflecting the relationship between the size of economies, the amount of their trade and the distance between the trade partners. Currently, the model went through remarkable evolution in terms of empirical specification (for instance heterogeneity theorem by Krugman and Melitz).

After studying numbers of researches related to gravity, an important conclusion is that authors are rather flexible in selection of variables (in particular independent variables) based on the context of their particular analyses. Apart from standard variables as distance and economic potential – a set of specific variables is included. In international trade these can be for instance: economic integration agreements, currency unions, access to the sea, historical circumstances as specific links between former metropolises and their colonies, the common language, common cultural heritage, etc. Very detailed description of possible variables used in gravity equations was presented by Kepaptsoglou, Karlaftis & Tsamboulas (2010), also thorough examination of gravity theory, tools and methods was given by Head & Mayer (2014). Gravity models are characterised by possibility to interpret coefficients as elasticities, which is a positive aspect – however it may somehow create interpretational problems of models parameters.

Namely, recently, Silva & Tenreyro (2006) in their seminal paper have raised a problem that has been ignored so far by both the theoretical and applied studies. In particular they argued, that the logarithmic transformation of the original model is not a relevant approach to estimate elasticities. Because, the multiplicative trade models with multiplicative error do not satisfy the assumption of the homoscedasticity of the error term since there is dependency between the error term of transformed log-linear model and the regressors, which finally causes inconsistency of the ordinary least squares estimator or the random and fixed effects estimator. As an alternative, authors propose the estimation of the gravity model in levels using the Poisson pseudo-maximum likelihood estimator. Moreover, most recently, Proenca et al. (2015) suggested a semi-mixed effects method which relaxes the very strict assumptions of RE but keeps more restrictions than FE. Therefore, we select the latter as the most relevant approach to study the determinants of the intensity of bilateral trade flows of Poland with its trade partners all over the world in in the period 1999-2013.

The rest of the paper is organised as follows: section 2 reviews estimation procedures, section 3 presents the model for empirical analyses and describes the data sources, finally section 5 discusses briefly estimation results.

2. Estimation procedure

There has been plenty of theoretical and empirical studies focusing on estimation procedures that fit to the gravity models for bilateral trade using cross-sectional of panel data[1]. The discussion refers especially to correct econometric specification of the model as well as appropriate estimation method. The simples form of the gravity equation for trade, relevant to Tinbergen (1962) approach, states that the trade flows from country *i* to country *j*, denoted by T_{ij}, is proportional to the GDPs of two countries' (Y_i, Y_j)and inversely proportional to the distance between the countries, D_{ij}. However, it should be taken into account that the trade is not the same as the physical force of gravity at least because it depends on many uncertainties connected with economic and social activities, therefore it should be treated as a stochastic process. Furthermore, Anderson and van Wincoop (2003) argued that the traditional gravity equation is not correctly specified, as it does not take into account additional variables representing specific effects of exporter and importer. That is way in most of empirical studies the gravity models include many other variables (economic, sociologic, geographic) influencing the trade values. As it was explained above the set of variables consists of the binary time-invariant D_{ij} (similar to the distance), non-binary time-invariant information Z_{ij}, and other time-varying variables which may vary also over *i*, *j* or both (*i, j*), denoted as X_{ijt}. Additionally when panel data models are used it is possible to include unobserved individual (*i*) and time effects (*t*) but also effects of pairs of countries (*i,j*) and all of them may be treated as fixed or random. Such models are defined as three-way effect panel data models. The stochastic version of the panel data gravity equation has the form:

$$T_{ijt} = \alpha_0 Y_{it}^{\beta_1} Y_{jt}^{\beta_2} Z_{ij}^{\gamma} X_{ijt}^{\alpha} e^{\delta D_{ij} + v_t + \eta_{ij}} \varepsilon_{ijt}, \qquad (1)$$

where v_t are time effects which could account for business cycles, η_{ij} are unobserved heterogeneity effects, and ε_{it} is stochastic effort term. Further, α_0, β_1, β_2, γ, α, δ are unknown coefficients.

There is a long tradition in the trade literature of log-linearizing equation (1) and estimating the parameters of interest by OLS, using the equation:

$$\ln T_{ijt} = \ln \alpha_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \gamma \ln Z_{ij} + \alpha \ln X_{ijt} + \delta D_{ij} + v_t + \eta_{ij} + \ln \varepsilon_{ijt}. \qquad (2)$$

But, as Santos Silva and Tenreyro (2006) argue, the validity of the procedure depends critically on the assumption that $\ln \varepsilon_{ijt}$ are statistically independent on the repressors. When the assumption is not valid, OLS estimation is inconsistent and biased. The problem has been ignored so far by both the theoretical and applied analyses. In practice, heteroscedasticity is quantitatively and qualitatively important in most gravity models, even when controlling fixed effects. So as the variance in the error term ε_{ijt} in equation (2) depends on Y_i, Y_j, D_{ij} and other variables it means that the expected value of $\ln \varepsilon_{ijt}$ will also depend on the repressors,

[1] The review of such analyses was presented for example by Proença, Sperlich and Savaşcı (2015).

violating the condition for consistency of OLS. Is suggests that this estimation method leads to inconsistent estimates of the elasticities of interest.

Another problem connected with estimation of the log-linearizing gravity equation is question of zero flows – trade between several pairs of countries is equal zero because the courtiers did not trade in a given period or the value of trade was very low. The existence of observations for which the dependent variable is zero creates a problem for the use of the log-linear form of the gravity equation. Several methods have been developed to deal with this problem. The first simply approach is to drop the pairs with zero trade from the data set, but then results of the estimation are not reliable as some information is omitted. The second method is to use T_{ijt}+1 as the dependant variable in the regression however, as such rescaling of the data leads to inaccurate estimation results. The next solution, used for example by Frankel & Wei (1993), is to estimate the multiplicative equation using nonlinear least squares (NLS), which is an asymptotically valid estimator for equation (1). However, the NSL can be very inefficient in this context, as it ignores the heteroscedasticity in the data (see Santos Silva & Tenreyro (2006).

As a solution to both of estimation problems (inconsistency of OLS and zero flows) Santos Silva & Tenreyro (2006) proposed the Poisson pseudo-maximum-likelihood (PPML) estimator, which is often used for count data. They notice that if economic theory suggests that *y* and *x* are linked by a constant-elasticity model of the form $y_i = \exp(x_i \beta)$, the function $\exp(x_i \beta)$ is interpreted as the conditional expectation of y_i given *x*, denoted $E[y_i \mid x]$. A possible way of obtaining an efficient estimate the parameters of interest is using pseudo-maximum-likelihood (PML) estimator based on some assumption on the functional form of $V[y_i \mid x]$. Under an assumption that the conditional variance is proportional to the conditional mean β can be estimated by solving the following set of first-order conditions:

$$\sum_{i=1}^{n} [y_i - \exp(x_i \tilde{\beta})] x_i = 0 . \qquad (3)$$

The authors claim that for this estimator the data do not have to be Poisson and y_i does not have to be integer for the estimator based on the Poisson likelihood function to be consistent. Additionally when using this estimator there is no problem of zero flows [2]. Also Westerlund and Wilhelmsson (2009) emphasized that the PPML estimator is solution to overcome the zero trade observations. The estimating regression of gravity model using PPML method has the following form:

$$T_{ijt} = \exp[\ln \alpha_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \gamma \ln Z_{ij} + \alpha \ln X_{ijt} + \delta D_{ij} + v_t + \eta_{ij}] \varepsilon_{ijt} . \qquad (4)$$

It should be noticed that in regression (4) the time effects, v_t, and pair specific effects η_{ij} are estimated as fixed effects what causes that some of time-invariant effects cannot be estimated.

[2] It should be noticed that there are some studied suggesting some doubt on the generality of the estimator for empirical trade models. For example, Martinez-Zarzoso (2013) shows that in several situations feasible GLS combined with the log-transformation can have a better performance than PPML.

Another extension of the gravity model estimation is proposed by Savaşcı (2011) who suggest to estimate equation (4) with the aid of a mixed effect PPML, where the pair effects η_{ij} are random effects to control for unobserved cross-section heterogeneity. The obvious problem that occurs in such a model is to prevent misspecification due to the independence assumption for the random effects. But in the context of small area statistics, Lombardía and Sperlich (2011) introduced a new class of semi-mixed effects models. In terms of panel econometrics, one could say that they extended the Mundlak device for random effects models.

According to implication of the above discussion, the estimation of all gravity models presented in the paper have been performed by the use of the PPML procedure with robust standard errors within Stata (StataCorp. 2011).

3. The empirical model

In a classic paper Anderson and Wincoop (2004) used export shares of the trade partners in order to estimate the strength of gravity in this model. The use of county-pair effect allows to eliminate the potential bias of mutual resistance described in the literature of the subject. An alternative approach can be utilized (eg. Helpman, Melitz & Rubinstein 2008), in which the values of total trade flows is utilized. In our study the value of exports from Poland to a given trade partner in million EUR is the explained variable ($Export_{ijt}$).

The estimated empirical panel model with country-pair effects for total export takes the following general form:

$$Export_{ijt} = \exp\left[\ln \alpha_0 + \beta_1 \ln Y_{jt} + \beta_2 \ln D_{ij} + \gamma \ln X_{ijt} + \rho \ln Z_{ij} + v_t + \eta_{ij}\right] \varepsilon_{ijt} \qquad (5)$$

where Y_j is the size of partner, D_{ij} is the distance to partner and X_{ijt} is the conditioning set of variables describing bilateral trade relations.

The basic explanatory variables include: size of partner as measured by log of real GDP (real GDP) or log of population (population) and the log of distance between trade partners (distance). The distance is proxied by geographical “as the crow flies” remoteness from Warsaw to trading partner’s capital (in kilometres).

Two countries of similar size (as measured by real GDP) should trade more than two countries of dissimilar sizes. Helpman and Krugman (1985) have shown that the smaller the difference in the relative size of economies trading with each other, the larger the volume of mutual trade and greater intensity of IIT because as economies become more similar in terms of their market size, the potential for overlapping demand for differentiated products is enhanced.

We adopt two different measures of similarity and and expect the coefficients to be statistically significant and positive. The first one, sim, is calculated using the following formula utilizing data on GDP of Poland and trade partner:

$$\text{sim} = \ln\left|1 - \left(\frac{Y_h^{PL}}{Y_h^{PL} + Y_f^c}\right)^2 - \left(\frac{Y_f^c}{Y_h^{PL} + Y_f^c}\right)^2\right| \quad (6)$$

Secondly, following Balassa and Bauwens (1988), we calculate the difference in GDP of Poland and its trading partner j, DIFE, as follows:

$$DIFE_{ij} = 1 + \frac{w\ln(w) + (1-w)\ln(1-w)}{\ln 2} \quad (7)$$

where $w = \frac{GDP_j}{GDP_j + GDP_i}$.

At the same time, two countries at similar level of development should trade more intensely that countries characterized by significant gap in the level of development. We adopt the following measure of gap in the level of development (rlf) and expect the coefficient to be statistically significant and negative. Increase in the gap should decrease intensity of bilateral trade and thus negatively influence Polish exports.

$$\text{rlf} = \ln\left|\text{ypc}_j - \text{ypc}_i\right| \quad (8)$$

We furthermore utilize a large number of dummy variables for adjacency, border, differences in factor endowments, technology gap or differences in productivity. Furthermore, we take into account the impact of bilateral trade agreements.

Data sources

We utilize COMEXT data set as a principal source of data. Comext is a statistical database on intra-EU and extra-EU trade of goods managed by Eurostat, the Statistical Office of the European Commission.

For the set of explanatory variables we utilize a number of data sources. The most important being the Penn World Tables 8.0 by Feenstra et al. (2013). We utilize as well World Development Indicators (WDI) dataset as well as Worldwide Governance Indicators dataset (WGI) compiled by Kaufmann et al. (2010) both provided by the World Bank. The data for patent applications come from the United States Patent and Trademark Office (USPTO).

4. Econometric results and discussion

The estimation of basic and extended specifications of the empirical model has been performed using a semi-mixed effects method suggested in a recent paper by Proenca et al. (2015) with dummy variable for membership in the EU (EU) serving as a clustering variable. The estimation has been carried out in STATA 12. The results are provided in Tables 1 & 2.

The analysis is carried out for 234 trade partners of Poland in the period 1999-2013. The explained variable is the value of exports from Poland in million EUR. The usual zero adjustment is not necessary as we take into account the level of exports and not the standard log of exports.

Various specifications of the model have been tested. The number of specifications shown in the paper has been restricted for obvious reasons. The results are not sensitive to inclusion of time effects. As they do not significantly increase the fit of the model we have decided not to present them in the Table.

The general fit of the model is high – explaining from 76 to 93 percent of the variation in exports depending on the specification. The results are robust to potential modifications.

In most of the analyzed specifications the coefficients on traditional determinants such as real GDP of trade partner and distance between partners are economically sensible and their impact on the dependent variable is statistically significant. Intensity of Polish exports decreases in distance to trade partner and increases in partners size – larger countries tend to trade more with Poland. Geographical proximity has been shown to be an important determinant of bilateral trade flows as it is associated with lower transportation and information costs.

The impact of membership in the European Union (EU) is clearly positive and statistically significant. Poland exports more, ceteris paribus, to partners from within the internal market of the European Union (free flow of goods and services within he free trade area and common market rules). We would like to stress here once again that we treat EU as our clustering variable.

The impact of gap in development as shown by rfl is negative as expected in most of specifications however it is statistically significant only in a few of specifications. All in all, Poland tends to export more to countries at similar level of development.

As the index of similarity (sim) is correlated with log of GDP in order to test the Helpman and Krugman hypothesis we include in model M2 logarithm of population (population) as a measure of partners size. The coefficient on sim is however not statistically significant which is to some extent surprising. The result, as has been checked, to a large extent depends on the utilized estimation technique. This is also the case with DIME.

Adjacency plays a significant role as expected. Poland exports more to neighboring countries – the impact of both border and border length is positive and statistically significant at 1 per cent level. The border effect has been positively verified. Furthermore, Poland exports more, ceteris paribus, to countries with better quality of institutions as proxied by rule of law.

The coefficient on eurozone dummy (euro) is positive but statistically insignificant. This could be due to inclusion of a dummy for EU partner countries. If we drop it, the coefficient on euro becomes positive and statistically significant. The result yields support for the existence of the so-called Rose effect (Frankel & Rose 2002). Taking into account that already most of Polish exports goes to eurozone as well as the gradual expansion of the Eurozone the costs of staying outside of the single currency area in terms of the unutilized export potential are rather high.

The impact of exchange rate volatility on Polish exports as measured by log of standard deviation of daily exchange rates of PLN observed over a period of a year (S volatility) is negative but not statistically significant. The impact of volatility to USD (xr), available from PWT 8.0, is however significant and has the presumed direction. Less volatility clearly stimulates bilateral trade.

The size of the Polish migrant community as proxied by log of Polish migrants in a given partner country (diaspora) has surprisingly negative and significant impact on Polish exports. The statistics is available from OECD only for a limited number of partner economies which could potentially bias the results.

Next three specifications (please refer to Table 2) analyze the impact of the difference between Poland and its trade partners in factor endowments, productivity and technological sophistication on intensity of Polish exports. First of all, greater difference in K/L ratio (dif K/L ratio) has robust and positive impact on intensity of Polish exports. This could point to still important significance of classic factor endowments differences as postulated by HO theory and its modern extensions (Heckscher & Ohlin 1991) in explaining a significant portion of Polish trade relations.

Secondly, greater difference in productivity levels as measured by total factor productivity ratios (dif TFPratio) decreases export intensity. Poland seems to export more to countries at similar level of productivity and thus technological sophistication.

Thirdly, the impact of the technological gap as measured by the log of absolute difference in relative patent applications (per 1 mln population) in USPTO (dif abs CUMP) is statistically insignificant. The results are sensitive to the method of accounting for the gap.

Last but not least, the results concerning the impact of regional or bilateral trade agreements need a longer comment. First of all we have to take into account that most of Polish exports has intra-EU nature with eurozone countries (and in particular Germany) playing the most important role. The trade flows within the EU are regulated by common market rules. If we account for free trade areas (FTA), customs unions (CU) as well as economic integration agreements (EIA) with extra-EU states, the impact of all is positive but statistically significant only for FTAs.

If we extended to all Regional Trade Agreements (RTA) controlling for specific relations with Post-Soviet countries (post-Soviet) the impact of RTA on the dependent variable is positive and significant at 5 per cent level.

In the last specification we account for overall level of competitiveness as indicated by the value of Global Competitiveness Index calculated by WEF (GWCI_V) – weighted index of twelve basic pillars of competitiveness (Schwab 2014). The impact is statistically significant and positive in accordance with our expectations.

5. Conclusions

The goal of this article was to investigate the determinants of the intensity of Polish exports to its trade partners (country level). The analysis was carried out for 234 trade partners of Poland in the period 1999-2013 with the use of panel gravity modelling. We have utilized a newly suggested and superior semi-mixed approach with the Poisson pseudo-maximum-likelihood (PPML) estimator. EU membership (EU) played the role of the clustering variable.

The gravity framework proves to be robust. The fit of the empirical model is high. The impact of standard determinants of gravity including partners size and distance on the dependent variable (level of exports) is highly statistically significant and in accordance with general expectations. The impact of size similarity has not been proven. Adjacency has a robust and positive impact. This applies as well to EU membership and membership in the eurozone (responsible presently for most of Polish exports with dominant role of Germany – the main Polish trade partner).

In its extended version of the model we have controlled for additional factors including: relative endowments of factors of production, technological gap as measured by TFP and relative patenting performance in the USPTO (at the global technology frontier), quality of institutions, impact of regional and bilateral trade agreements or exchange rate volatility. Exchange rate volatility has negative impact on exports. Greater difference in K/L ratio has robust and positive impact on intensity of Polish exports, which could point to still important significance of classic factor endowments differences as postulated by HO theory. At the same time Poland seems to export more to countries at similar level of productivity and thus technological sophistication.

Some of the results were highly surprising, such as the negative impact of Polish diaspora, and require further investigation. The present study will be deepened and extended along several dimensions such as technological gap and sectoral analysis (GTAP sectors).

Literature

Anderson J., Van Wincoop E. (2003), Gravity with Gravitas: A Solution to the Border Puzzle, American Economic Review, Vol. 93(1), pp. 170-192.

Anderson J., (2011), The Gravity Model, Annual Review of Economics Vol. 3(1), pp. 133-160.

Balassa B., Bauwens, L. (1988), Changing trade patterns in manufactured goods: An econometric investigation, Amsterdam: North Holland.

Feenstra R. et al. (2013), The Next Generation of the Penn World Table, NBER Working Paper no. 19255.

Frankel J., Wei S. (1993), Trade Blocs and Currency Blocs, NBER Working Paper no. 4335.

Frankel J., Rose A. (2002), An estimate of the effect of common currencies on trade and income, Quarterly Journal of Economics, pp. 437-466.

Gopinath G., Helpman E., Rogoff K. (2004), The Handbook of International Economics, Vol. 4, North-Holland: Elsevier.

Head K., Mayer T., (2014), Gravity Equations: Workhorse, Toolkit, and Cookbook, in: Gopinath G., Helpman E., Rogoff K., The Handbook of International Economics, Vol. 4, North-Holland: Elsevier.

Heckscher E. F., Ohlin B. G. (1991), Heckscher-Ohlin trade theory, Cambridge: MIT Press.

Helpman E., Krugman P. (1985), Market structure and foreign trade, Cambridge: MIT Press.

Helpman E., Melitz, M.J., Rubinstein Y. (2008), Estimating trade flows: trading partners and trading volumes, Quarterly Journal of Economics, Vol. 73, pp. 441–486.

Helpman H., (1987), Imperfect Competition and International Trade. Evidence from Fourteen Industrial Countries", Journal of the Japanese and International Economies, Vo1. 1, pp. 62-81.

Kaufmann D., et al. (2010), The Worldwide Governance Indicators: Methodology and Analytical Issues, World Bank Policy Research Working Paper No. 5430.

Kepaptsoglou K., Karlaftis M.G., Tsamboulas D., (2010), The Gravity Model Specification for Modeling International Trade Flows and Free Trade Agreement Effects: A 10-Year Review of Empirical Studies", The Open Economics Journal, no. 3, pp. 1-13.

Lombardía M.J., Sperlich S. (2012), A new class of semi-mixed models and its application in small area estimation, Computable Statistcial Data Analysis, Vol. 56, pp. 2903–2917.

Martinez-Zarzoso I. (2013), The log of gravity revisited, Applied Economics, Vol. 45, pp. 311–327.

Proença I., et al. (2015), Semi-mixed effects gravity models for bilateral trade, Empirical Economics, Vol. 48(1), pp. 361-387.

Santos Silva J., Tenreyro S. (2006), The log of gravity, The Review of Economics and Statistics, Vol. 88 (4), pp. 641-658.

Savaşcı D. (2011), Three studies on semi-mixed effects models, Dissertation presented for the degree of Doctor of Philosophy at the Faculty of Economic Sciences of the Georg-August-Universität Göttingen.

Schwab K. (2014), The Global Competitiveness Report 2014–2015: Full Data Edition, Davos: World Economic Forum.

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

Westerland J., Wilhelmsson F. (2009), Estimating the gravity model without gravity using panel data, Applied Economics, Vol. 43, pp. 641–649.

Appendix

Table 1. Results of estimation for Polish exports

	(1) E_exp2	(2) E_exp2	(3) E_exp2	(4) E_exp2	(5) E_exp2	(6) E_exp2	(7) E_exp2	(8) E_exp2	(9) E_exp2	(10) E_exp2
distance	-1.644***	-1.668***	-1.663***	-1.223***	-1.221***	-1.640***	-1.634***	-1.635***	-1.638***	-1.594***
	(0.0683)	(0.0782)	(0.0759)	(0.0512)	(0.0504)	(0.0658)	(0.0673)	(0.0750)	(0.0689)	(0.0956)
real GDP	0.997***			0.839***	0.843***	0.993***	1.001***	0.998***	0.993***	1.255***
	(0.0367)			(0.0203)	(0.0202)	(0.0346)	(0.0354)	(0.0366)	(0.0371)	(0.0750)
rlf	-0.0277			0.0330	0.0159	-0.0327	-0.0806**	-0.0253	-0.0300	-0.279***
	(0.0295)			(0.0356)	(0.0339)	(0.0292)	(0.0334)	(0.0299)	(0.0291)	(0.0537)
EU	0.697***	1.796***	1.790***	0.954***	0.949***	0.674***	0.547***	0.704***	0.676***	0.759***
	(0.0688)	(0.0998)	(0.0975)	(0.0780)	(0.0767)	(0.0835)	(0.0778)	(0.0695)	(0.0692)	(0.107)
population		0.982***	0.980***							
		(0.0506)	(0.0484)							
sim		-0.0221								
		(0.0772)								
DIFE			-0.0581							
			(0.184)							
border				0.671***						
				(0.0897)						
border lenght					0.110***					
					(0.0142)					
euro						0.0418				
						(0.0829)				
rule of law							0.140***			
							(0.0467)			
S volatility								-0.202		
								(0.480)		
xr									-8.83e-05***	
									(2.16e-05)	
diaspora										-0.0958***
										(0.0318)
Constant	5.794***	14.84***	14.85***	3.956***	4.049***	5.868***	6.193***	5.720***	5.855***	4.631***
	(0.303)	(0.416)	(0.418)	(0.416)	(0.394)	(0.320)	(0.311)	(0.322)	(0.307)	(0.789)
No of obs.	2,125	2,125	2,125	2,125	2,125	2,125	1,777	2,125	2,125	189
R-squared	0.831	0.762	0.760	0.874	0.875	0.832	0.865	0.830	0.830	0.889

*Note: All regressions carried out using semi-mixed effect ppml with EU as clustering variable). * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated using STATA 12. Dependent variable - total exports in million EUR.. Total number of observations (No of obs).*

Appendix

Table 2. Results of estimation for Polish exports

	(11)	(12)	(13)	(14)	(15)	(16)
	E_exp2	**E_exp2**	**E_exp2**	**E_exp2**	**E_exp2**	**E_exp2**
distance	-1.655***	-1.641***	-1.642***	-1.594***	-1.619***	-1.663***
	(0.0594)	(0.0659)	(0.0688)	(0.0717)	(0.0748)	(0.0729)
real GDP	1.009***	1.016***	0.992***	1.020***	0.992***	0.991***
	(0.0301)	(0.0387)	(0.0360)	(0.0378)	(0.0375)	(0.0301)
rlf	0.0443	-0.0358	-0.0651**	-0.0231	-0.00935	-0.0147
	(0.0287)	(0.0305)	(0.0318)	(0.0267)	(0.0313)	(0.0392)
EU	0.543***	0.756***	0.658***	0.797***	0.764***	0.604***
	(0.0637)	(0.0770)	(0.0727)	(0.0830)	(0.0726)	(0.0780)
dif K/Lratio	1.682***					
	(0.147)					
dif TFP ratio		-0.663***				
		(0.215)				
dif abs CUMP			0.0274			
			(0.0168)			
FTA				0.272***		
				(0.0767)		
CU				0.0628		
				(0.121)		
EIA				0.187		
				(0.114)		
RTA					0.00912**	
					(0.00458)	
Post Soviet					0.137	
					(0.0944)	
GWCI						0.120**
						(0.0554)
Constant	-2.806***	6.006***	6.051***	4.978***	5.447***	5.641***
	(0.792)	(0.298)	(0.287)	(0.393)	(0.382)	(0.400)
No of obs.	2,125	2,125	2,125	2,125	2,125	736
R-squared	0.906	0.845	0.834	0.836	0.829	0.931

*Note: All regressions carried out using semi-mixed effect ppml with EU as clustering variable). * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated using STATA 12. Dependent variable - total exports in million EUR.. Total number of observations (No of obs).*

Institute for Development
Ul. A. Mickiewicza 10 | 81-832 Sopot
e-mail: office@instytut-rozwoju.org
www.instytut-rozwoju.org