Portuguese Trade and European Union: The Gravity Model

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Abstract

This research examines the determinants of bilateral trade between Portugal and European Union countries (EU-27) for the period 2000-2010, using a panel data. In this study we revisited the recent contribution as in Charoensukmongkol and Sexton (2011), Samy and Dehejia (2011), Serrano and Pinilla (2012), and Faustino and Proença (2011).

The findings show that Portuguese trade flows are according the Linder hypothesis. The international trade is explained by Heckscher-Ohlin theorem. The empirical results demonstrate that geographical distance has a negative and significant effect on bilateral trade, i.e., there is a bilateral trade increase when trade partners are close.

The economic dimension and common border are positively correlated with bilateral trade. Our results also support the hypothesis that physical capital endowment has a positive effect on bilateral trade.

Keywords: Gravity model, panel data, common border, geographical distance and factor endowment.

JEL Classification: C20, C30, F12

1. Introduction

The gravity model is analogous to Newton's law of gravity, where the sate gravity between two objects is directly related to each other and inversely related to distance. There is a consensus in the literature that Tinbergen (1962) and Poyhonen (1963) are the pioneering studies of the gravity model. Anderson (1979) and Deardorff (1998) consider that the gravity equation can explain international trade.

When the new economic geography emerged in the 1990s some authors as Krugman (1993) developed theoretical models that allow analyzing the relations between North and South considering the mobility between countries. In a context of monopolistic competition this process involves trade flows, migration and foreign direct investment.

In last years, a number of gravity models have been applied to explain the bilateral flows (Anderson 2011, Samy and Dehejia 2011, Charoensukmongkol and Sexton 2011, Serrano and Pinilla 2012).

The main objective of this paper is to examine the pattern of Portuguese trade using the arguments of gravity model. This paper considers the determinants of Portuguese Trade and European countries (EU-27) for the period 2000-2010. Our study uses country-specific characteristics (per capita income, market size, geographical distance, common border, and factor endowments) to explain the gravity model.

The paper uses a panel data. In this type of study pooled OLS, fixed effects (FE) and random effects (RE) are used. This research uses OLS with time dummies and the GMM-System estimator. The dynamic panel data (GMM-System) permits to solve the endogenity and serial correlation for same explanatory variables. Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998, 2000) developed the first differenced GMM (GMM-DIF) estimator and the GMM system (GMM-SYS) estimator. The GMM-SYS estimator is a system containing both first differenced and levels equations. The GMM- SYS estimator is an alternative to the standard first differenced GMM estimator. To estimate the dynamic model, we applied the methodology of Blundell and Bond (1998, 2000), and Windmeijer (2005) to small sample correction to correct the standard errors of Blundell and Bond (1998, 2000). The GMM- system estimator is consistent if there is no second order serial correlation in the

residuals (m2 statistics). The dynamic panel data model is valid if the estimator is consistent and the instruments are valid.

The structure of paper is a follows. The next section presents the literature review. Section 3 we formalized the econometric model. Section 4 shows the empirical results. The conclusions are presented in section 5.

2. Literature Review

The gravity model has been able to capture more and more adherents in academia. This model is analogous to Newton's Law of Gravity, which states that the gravity between two objects is directly related to their masses and inversely related to the distance them.

$$F_{ij} = G\frac{Y_i^{\alpha} Y_j^{\beta}}{D_{ij}^{\delta}} \qquad (1)$$

Where Fij denotes the flow from country i to country j. Yi and Yj are the economic sizes of the two countries, usually measured as the gross domestic product (GDP), or per-capita GDP. Dij is the distance between countries. G is a gravitational constant.

In order to facilitate the econometric estimations, we apply logs the gravity equation (1) and hence, we obtain a linear relationship as follows:

$$Ln\ Fij = ln\ G + \alpha\ ln\ Yi + \beta\ ln\ Yj - \delta\ ln\ Dij \qquad (2)$$

Where lnG corresponds to the intercept, while α, β and δ are elasticity's.

The pioneering empirical models (Tinbergen, 1962; Poyhonen, 1963; Anderson, 1979; Caves 1981; and Toh 1982) consider that geographical distance is an important determinant of gravity model. As in Rauch (1999), and Eichengree and Irwin (1998) demonstrated cultural proxies (border, common language) should be consider in gravity equation. The empirical model use dummy variables to the cultural distance, language and to the border. The cost of transport is measure usually of geographical distance. According to previous studies (Balassa, 1966; Balassa and Bauwens, 1987) there are a negative correlation between geographical distance and trade, i.e., an increase in bilateral trade is explained when the transportation cost decrease. Charoensukmongkol and Sexton (2011) analyze the effects of corruption on exports and imports. The authors apply the gravity model to Latin America and the Caribbean. The results of

Charoensukmongkol and Sexton (2011) are consistent with the literature. The market size is positively correlated with trade flows. The proximity geographical promotes international trade. This study shows that corruption reduces local exports.

Samy and Dehejia (2011) analyze the relationship between trade and labour issues for the time period 1988-2001. The results show that labour standards do not seem to be related to the deterioration in exports. This study shows that common border, geographical distance, and language are according to previous literature.

Serrano and Pinilla (2012) use a gravity model to evaluate a bilateral trade in agricultural products, in manufactures and total trade for the period 1963 and 2000. This study shows that the regional trading agreements (RTAs), common border, and cultural aspects are positively correlated with trade flows.

3. Econometric Model

Our dependent variable is bilateral trade, i.e., exports plus imports between Portugal and European countries (EU-27) for the period 2000-2007. The data for dependent variable is collected at 6-digit level at National Institute of Statistics. The explanatory variables are collected from World Bank World Development Indicators, World Bank, Washington.

3.1. Explanatory variables and testing of hypotheses

Based on the literature, we formulate the following hypothesis:

Hypothesis 1: ***The larger economic dimension increases trade***.

According to the literature (Anderson, 2011, Leitão et al., 2012, Faustino and Proença, 2011, Ferrarini, 2012, and Charoensukmongkol and Sexton 2011) we expect a positive sign. The sources of these variables are World Bank (CD-ROM, 2013).

In this paper we use the following proxies to market size:

GDPi is the absolute value of Portugal's GDP per capita (PP, in current international dollars).

GDPk is the absolute value GDP per capita of trade partner k (PP, in current international dollars).

$$\frac{1}{2} = \left(GDP^{Portugal} + GDP^{Partner}\right)$$

Hypothesis 2: ***Trade increases when partners are geographically close.***

- DIST (Geographical Distance): This is the geographical distance between Portugal and partner country. According to the gravity model, a negative sign is expected.

Samy and Dehejia (2011), and Serrano and Pinilla (2012) found a negative relationship between distance and bilateral trade. The geographic distance between Portugal and each partner in km (DIST) is the variable used. This variable is collected in CEPII dataset.

Hypothesis 3: ***Common border promotes bilateral trade.***

- BORDER, this is a dummy variable which takes values 1 and 0. Equals 1 if the partner-country shares a border with Portugal and 0, otherwise. In our sample only Spain shares common border with Portugal.

According to previous studies (Charoensukmong and Sexton 2011; and Ferrarini, 2012) a positive sign is expected.

Hypothesis 4: ***Bilateral trade predominates among countries that are dissimilar in terms of factor endowments***.

$\frac{K}{L}$ is a proxy for differences in physical endowments. It is the capital abundance is the gross fixed capital formation (formerly gross domestic fixed investment) includes land improvements; plant, machinery, and equipment purchases; as well as the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. The source of this proxy is World Bank (CD-ROM, 2013 World Development Indicators, World Bank, Washington).

3.3. Model Specification

The econometric model of Portugal's trade takes the following representation:

$$TRADE_{it} = \beta_0 + \beta_1 X_{it} + \delta t + \eta_i + \varepsilon_{it} \qquad (3)$$

Where $TRADE_{it}$ is the Portuguese bilateral trade respectively, and X is a set of explanatory variables. All variables are in the logarithm form; η_i is the unobserved time-invariant specific effects; δt captures a common deterministic trend; ε_{it} is a random disturbance assumed to be normal, and identically distributed with E (ε_{it})=0; Var (ε_{it}) $= \sigma^2 \succ 0$.

The model can be rewritten in the following dynamic representation:

$$TRADE_{it} = TRADE_{it-1} + \beta_0 + \beta_1 X_{it} - \rho\beta_1 X_{it-1} + \delta t + \eta_i + \varepsilon_{it} \quad (4)$$

4. Empirical Results

The correlations and descriptive statistics are presented in the following tables. Table 1 and table 2 show the correlations and summary statistics for each variable.

Table 1: Correlation between variables

Variables	*LnTRADE*	$LnGDP_i$	$LnGDP_k$	*LnDIM*	*BORDER*	*LnDIST*	*LnK/L*
LnTRADE	1.00						
$LnGDP_i$	0.08	1.00					
$LnGDP_k$	0.37	0.32	1.00				
LnDIM	0.41	0.46	0.96	1.00			
BORDER	0.38	0.03	0.09	0.08	1.00		
LnDIST	-0.36	-0.02	-0.64	-0.54	-0.56	1.00	
LnK/L	0.04	-0.24	-0.23	-0.22	0.02	0.18	1.00

Table 2 shows that $LnGDP_i$, $LnGDP_k$, and *LnDIM* appear to have only little differences between means and standard deviation. However, this is not the case for *LnTRADE*, *LnK/L* and *LnDIST*.

Table 2: Summary statistics

Variables	Observations	Mean	Std. dev.	Min	Max
LnTRADE	310	2.60	0.86	0.88	4.49
$LnGDP_i$	310	4.24	0.11	4.06	4.38
$LnGDP_k$	308	4.15	0.49	2.66	5.07
LnDIM	310	4.41	0.28	3.79	5.12
BORDER	310	0.03	0.18	0	1
LnDIST	310	3.42	0.24	2.70	3.99
LnK/L	282	0.51	0.47	-1.94	1.41

Table 3 reports two gravity models using OLS estimator with time dummies. The general performance of the equations is satisfactory, i.e., the coefficients are according to theoretical expectations. We use the White test to correct the heteroskedasticity.

The coefficients of income per capita ($LnGDP_i$, $LnGDP_k$) have a positive impact on bilateral trade. These variables are also introduced to control for relative size effects. Our result is according to previous studies (Helpman 1987, Hummels and Levinshon 1995, and Greenaway et al., 1994). Samy and Dehejia (2011), and Charoensukmongkol and Sexton (2011) found a positive correlation between income per capita and bilateral trade.

Table 3: Portuguese Trade and Gravity: OLS Model with time dummies

DEPENDENT VARIABLE: *LnTRADE*			
	Coefficient		
Independent Variables	Model [1]	Model [2]	Expected Signs
$LnGDP_i$	1.91(3.52)***	1.55 (2.63)***	(+)
$LnGDP_k$	1.36 (4.66)***	1.91 (4.98)***	(+)
LnDIM	3.89 (6.09)***	4.33 (5.91)***	(+)
LnDIST		-1.19 (-3.67)**	(-)
BORDER	1.74 (7.27)***		(+)
LnK/L	0.14 (1.68)***	0.21 (2.33)**	(+)
C	-0.87 (-0.56)	2.00 (0.96)	
Adjusted R-squared	0.35	0.23	
N	282	282	

t-statistics for OLS model (heteroskedasticity corrected) are in round brackets.
***/**- statistically significant at the 1%, and 5% level, respectively.

The proxy of average GDP (*LnDIM*) usually utilized to evaluate the potential economies of scales and the variety of differentiated product is statistically significant at 1% level with positive impact on bilateral trade.

The variable of capital abundance (LnK/L) is statistically significant at 1 percent level, and presents a positive correlation. This proxy is used to evaluate relative factor endowments. According to literature we can refer that the Heckscher-Ohlin factor proportions theory explains the Portuguese trade.

The coefficients of geographical distance (*LnDIST*) and common border (*BORDER*) show that bilateral trade increases when partners are close. Our finding is

supported by empirical work of (Ghatak et al., 2009; Martinez-Zarzoso et al., 2003; Samy and Dehejia 2011; and Charoensukmongkol and Sexton 2011).

Table 4 presents the results of GMM-System estimator. The model presents consistent estimates, with no serial correlation (the Arellano and Bond test for Ar(2)). The specification Sargan test shows that there are no problems with the validity of instruments used. The Windmeijer (2005) finite sample correction is used.

The lagged dependent variable ($LnTRADE_{t-1}$) presents a positive sign. As expected, the variables $LnGDP_i$, $LnGDP_k$, and $LnDIM$ have a significant and a positive effect on bilateral trade. These variables are also introduced to control for relative size effects. Our result is according to previous studies (Samy and Dehejia 2011, Charoensukmongkol and Sexton 2011, Serrano and Pinilla 2012). The coefficient of common border (*BORDER*) is positively correlated with bilateral trade, i.e., border encourages bilateral trade.

Table 4: Portuguese Trade and Gravity: GMM-System Estimator

DEPENDENT VARIABLE: *LnTRADE*			
	Coefficient		
Independent Variables	Model [1]	Model [2]	Expected Signs
$LnTRADE_{t-1}$	0.84 (4.64)***	0.88 (2.79)***	(+)
$LnGDP_i$	1.39 (7.62)***	1.14 (3.60)***	(+)
$LnGDP_k$	1.06 (5.59)***	0.95 (4.25)***	(+)
LnDIM	2.47 (6.64)***	2.10 (3.94)***	(+)
LnDIST		-0.12 (-0.60)	(-)
BORDER	0.23 (2.09)*		(+)
LnK/L	0.64 (2.76)***	0.01 (3.52)***	(+)
C	0.62 (1.12)	0.22 (0.32)	
Ar(2) test Arellano and Bond	0.49	0.50	
Sargan	0.95	0.95	
N	237	237	

*The null hypothesis that each coefficient is equal to zero is tested using one-step robust standard error. Z-statistics (heteroskedasticity corrected) are in round brackets. P-values are in square brackets; ***/* - statistically significant at the 1and 10 per cent level. Ar(2) is tests for second–order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null hypothesis of no serial correlation (based on the efficient two-step GMM estimator). The Sargan test addresses the over-identifying restrictions, asymptotically distributed X^2 under the null of the instruments' validity (with the two-step estimator).*

The coefficient differences in physical endowments (LnK/L) is positively correlated with bilateral trade. Helpman (1987), Hummels and Levinshon (1995), Faustino and Proença (2011) also find a positive sign.

5. Conclusions

The objective of this article is to analyze the country-specific determinants of Portuguese trade, using a gravity model. Our results are robust with OLS with time dummies, and GMM- System.

The coefficients of income per capita ($LnGDP_i$, $LnGDP_k$) present a positive impact on trade, when we used OLS with time dummies, and GMM- System. These results are according to the literature (Samy and Dehejia 2011, Charoensukmongkol and Sexton 2011, Serrano and Pinilla 2012).

Following previous studies (Helpaman and Krugman, 1985, Grossman and Helpman 2005), the study also includes one proxy to evaluate the economic dimension ($LnDIM$). The average of GDP per capita in log ($LnDIM$) has an expected positive sign for two econometric models (OLS with time dummies, and GMM-System).

The variable (LnK/L) used to evaluate the economic differences (factor endowments) between countries present a positive impact on bilateral trade. The studies of Helpman (1987), Hummels and Levinshon (1995), Faustino and Proença (2011) found a positive sign for this proxy.

The variables common border and geographical distance confirm the theoretical models, i.e., common border and geographical proximity promote trade inflows.

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