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Effects of European Sovereign Debt (Leverage) Crisis on Bilateral Trade Flows

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Abstract
Outbreak of 2009 European sovereign debt (leverage) crisis has been one of the most crucial economic events of recent years. Accordingly, researchers devoted a great deal of efforts to elucidate origins and consequences of this crisis, particularly focusing on its potential effect on international trade flows. Yet in the literature, there have been rare studies on exploring the effects of sovereign debt crisis on the bilateral trade flows of Eurozone members. In this study, by using an augmented gravity model, we have studied the effect of sovereign debt crisis on bilateral trade flows within Eurozone countries. In this regard, we have used cross-section data from six European countries including Germany, France, Italy, Spain, Portugal and Greece for the period of 1995-2013, and then have estimated the model with a semi-parametric panel data approach. The empirical results have shown that scales of economies and markets play significant parametric roles in the bilateral trade flows in the Eurozone while debt crisis explains trade relations non-parametrically.

Keywords: Sovereign Debt Crisis, Bilateral Trade Flows, Gravity Model, Semi-Parametric Estimation.

JEL Classification: F17, H63, C23, C14.

1. Introduction

Empirical evidence has proven that trade can be a powerful engine to enhance economic development and poverty reduction (Winters et al., 2004). Hence, a large number of countries -whether developed or developing- have pursued a trade-led growth strategy and regional integration in recent decades and continued trade liberalization as a main tool to strengthen their economic situation. Accordingly, the main goal of economic integration of Eurozone economies has been to boost economic growth through facilitating and fostering trade inside and outside the union

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(Vijil, 2014). Euro, as the common currency across the Eurozone block, was introduced with the belief that the greater fiscal and monetary union across countries will guaranty fiscal harmonization and solvency among the European countries (Skintzi and Refenes, 2006). Many researches have shown the positive effects of Euro Area integration on the members' macro-economy[1]. Serlenga and Shin (2007), for instance, study the effects of Euro Area integration on trade flows, and find that Euro appreciation has positive effect on the EU Members' trade. Furthermore, the Euro is found to promote EU integration by eliminating exchange rate-related uncertainties.

A sovereign debt[2] crisis[3] (SDC), however, erupted in late 2009 and early 2010 with downgrading of the Greek sovereign debt and led to dramatic economic and social changes. The widening of sovereign spreads[4] in several Eurozone countries has been accompanied by divergent financial and macroeconomics developments. While in the "core" countries[5] financing conditions remained broadly in line with the European Central Bank's official rates, industrial production continued expanding and unemployment barely increased, while in the "peripheral" countries[6] the picture was clearly in opposite direct (Neri and Ropele, 2014 and Bao and Yang, 2013).

Regarding the effect of SDC on international trade, while many economists are agreed that international trade is one of the most important factors in explaining financial crises[7], research on the reverse causality has been surprisingly rare (Bao and Yang, 2013). It is expected that a financial crisis would cut back imports through recession in a macro-economy[8].

[1] See Guiso et al (2004), Brou and Ruta (2007), Campos et al (2014) and Henrekson et al (1997).

[2] First issued by the Bank of England to raise funds for war against France back in 1693, sovereign bonds are considered by investors as almost risk free assets under the assumption that governments are too big to fail and default on coupon payments of these instruments.

[3] Sovereign debt crisis (SDC) refers to an event when a country is unable to repay its debts incurred from banks and investors. In such event, the country enters a state of financial distress, which may lead to renegotiation or restructuring of debt (Banks, 2010). A country has a higher probability of defaulting if they have significantly high debt/GDP (leverage) ratio of its economy (Yue, 2010).

[4] In the event of financial difficulty, governments are expected to raise taxes, create money supply and take other measures to pay off the debts. Bond indices represent country economic health to a large degree, since bonds are essentially government debts.

[5] Germany, Netherlands, France, Austria, Belgium and Finland are commonly referred to as the Eurozone core countries.

[6] Greece, Ireland, Portugal, Spain and Italy are the so-called peripheral countries of the Eurozone.

[7] See for example Krugman (1979), Eichengreen and Rose (1999), Glick and Rose (1999), Forbes (2000), Calvo and Reinhart (1999) and Mendoza (2001).

[8] A devaluation of a national currency will increase the volume of exports and reduce the volume of imports. Classic international trade theory shows that devaluation improves the trade balance if the Marshall-Lerner condition is satisfied. Because in a financial crisis a country usually experienced a devaluation of its national currency, the same analysis would apply, that is, the affected countries' imports will decrease, but their exports will increase after the crises. Furthermore, financial crises (including currency crises, banking crises, or both) could also affect trade through channels besides the exchange rate (Ma and Cheng, 2005).

Exports, however, might be boosted due to a devaluation of the domestic currency and a drop in domestic demand resulted from the crisis. So the overall effect of SDC on foreign trade is unclear (Ma and Cheng, 2005).

The objective of the present study is then, to evaluate the effect of European sovereign debt crisis (ESDC) on bilateral trade flows of the Eurozone members, the theme that has been rare in litreture. To this end, we apply a version of trade gravity model which was first borrowed from natural science by Tinbergen (1962), and then was applied to explain the determinants of varying types of flows, such as migration, flows of buyers to shopping centers, and bilateral trade. In the context of international trade flows, factors like sizes of countries, distance as well as some other time-invariant cultural factors have been main determinants of trade flows (Serlenga and Shin, 2007).

To study the effect of the ESDC on the selected countries' trade flows, we add the Eurozone countries' sovereign debt variable as an explanatory variable to the model specification. Sovereign debt (SD) data for Eurozone countries are measured and reported as a portion of GDP while the raw data for SD are on the basis of Eurozone governments' leverage. By definition, the leverage is the ratio of debt to equity of an economic agent. Accordingly, if it is supposed that the government relies on tax revenues to service its debt, the ratio of SD to GDP (as the base of tax revenues in government finance) is in fact a measure of government's leverage.

Additionally, to estimate the model, we would use semi-parametric approach. Since the only parametric method is somehow restricted to variables' inter-relationship, and requires several assumptions which are not easily to be satisfied. Besides, in the parametric estimation approach, a full parametric model is specified, and so there is the risk of the model misspecification, which can yield biased estimates on the model (Fox and Taqqu, 1986 and Sowell, 1992).

The reminder of the paper is organized as follows. Section 2 reviews the literature on ESDC and the methodology of non-parametric approach. Section 4 describes the data used in this study. a semi-parametric trade gravity model for the selected European countries. Section 5 analyzes the results which have been obtained by estimating the model. Section 6, at the end, concludes the relevant remarks.

2. Literature Review

In late 2008 and early 2009 an unceasing SDC brought the European common currency area into distress, arising from the need of refinancing governments' debts. Eurozone's public debts amounted to 85.3% of its GDP in 2010 and, according to European Central Bank (ECB), rose steadily to even more than 100% for some Eurozone countries in 2013, namely 129% for Portugal, 133% for Italy and 175% for Greece.

Researchers have pointed to various factors as the causes of SDC fluctuations. Waliullah and Parvez-Ahmed (2014), for instance, have addressed a number of factors as the reasons of the ESDC. These factors include the real-estate bubbles in U.S. and the subsequent global recession, gap of economic strength and structure between core and peripheral members of Eurozone, international trade imbalances, socio-political tensions, wavering political resolve, lack of transparency on fiscal accounts, undershooting of GDP growth and worsening global conditions. In addition, according to Waliullah and Parvez-Ahmed (2014), the loosely controlled practices further caused a real estate bubble in Europe, which drew the situation closer to a financial crisis.

As to the effects and consequences of SDC, while it may unfold through multiple channels simultaneously, the ultimate outcome is a contraction in output, a loss in the number of employees, a weaker financial system and, more generally, a decline in living standards. SDC may also be accompanied by currency crisis and cause deterioration in businesses' and households' confidence (Neri and Ropele, 2014).

There are rare papers which have focused on exploring effect of financial crisis (especially SDC) on international trade, whereas a vast number of studies have addressed the role of international trade in so-called financial contagion[1]. Nonetheless, as Ma and Cheng (2005) hold, if financial crises do not affect countries' trade flows at all, financial crises could not be transmitted through trade channel. In what follows, we will thus review scant number of studies conducted on this topic.

Ma and Cheng (2005), by using gravity model, analyzed how financial crises affected international trade in the last two decades. They showed that imports could decrease during and after a banking crisis, whereas exports rise during crisis and fall after the crisis. Estimating a model of bilateral trade between fifty countries over the period of 1979-1998 by real-world data, they have found that the empirical results were generally consistent

[1] See Zhu and Yang (2004).

with the theoretical predictions, especially in 1991–1998. Additionally, Na et al. (2013) investigated the impact of the ESDC on the global economy through a trade chain implementation worldwide. They used a multi-national multi-sector CGE model of Global Trade Analysis Project to simulate the role of crisis in the world economy. The results showed that global economic growth suffered from a serious damage over 2010-2012. Affected by ESDC, the average annual growth rate of the global economy decreased by 0.65% and global unemployment rate rose by 1.81%. Global trade was also in depression and the average annual trade growth was reduced by 1.14%.

Abdul et al. (2013) analyzed trade dynamics following past episodes of financial crises. Using an augmented gravity model and 179 crisis episodes from 1970-2009, they found that there was a sharp decline in a country's imports in the year following a crisis while exports were not adversely affected, and remained close to the predicted level in both short and long runs.

Berman and Martin (2010) used a bilateral gravity framework to investigate the effects of financial crises on trade, specifically banking crises in the period of 1976-2002. Their focus was on the effect of financial crises on export flows of trading partners, and particularly on the vulnerability of Sub-Saharan African economies to financial crises in advanced economies. They found that financial crisis in a trading partner had a moderate but long-lasting effect on exports, and that the effect was larger (10 to 15 percentage) for African exports.

Kiendrebeogo (2012) examined the effects of financial crisis on international trade, using data from 69 developing and developed countries over the period of 1971-2010. The empirical results showed that the crisis-hit countries tend to experience slower growth in exports and current balance. The negative impact of financial crisis was more pronounced in less developed countries, appears to be stronger on current account than that on total exports, and is exacerbated when banking, currency and sovereign default crises occurred at the same time. Furthermore, the quality of financial institutions and sound macroeconomic policies exerted a mitigating effect on the negative impact of financial crises on trade flows. Finally, the result shows that exports of goods were more resilient in the face of a financial crisis than exports of services.

The review of literature in this section reveals that just one study addresses the effects of ESDC on international trade (indirectly), while others examine the effects of different financial crises on trade flows. Hence, there is a substantial lack of literature in this topic and the shortage is more crucial for the ESDC. Accordingly, the importance of this study as the first research on the effects of ESDC on Eurozone countries' bilateral trade, by using the gravity model is very clear.

It is also apparent from the literature that all studies on the relationship between financial crisis and trade have mostly applied parametric approach to estimate the model. However, the obvious problem in such method is the misspecification of the model due to the independence assumption for the random effects. Besides, in contrast to fundamental assumption that all variables of the gravity model are normally distributed, it is expected that many economic variables fallow no specific distribution during crisis time. These problems may make parametric approach prone to estimation biases and errors. To overcome these problems, one might apply non-parametric approach to estimate gravity model for panel data.

Nonparametric approach, in contrast, avoids restrictive assumptions of the functional form related to a parametric regression function and the model is mainly defined by the data of variables. In this sense, the model typically grows in size to accommodate the complexity of the data. More specifically, in non-parametric approach, an unknown functional form of variables, $m(X)$, is estimated such that fits the data well and is sufficiently smooth (Savasci, 2011).

Additionally, non-parametric method relies on fewer assumptions which make it more robust. Specifically, the non-parametric approach covers techniques that do not rely on the assumption that data belonging to any particular distribution (Stuart et al, 2008). Another justification for the use of non-parametric methods is simplicity. In certain cases, even when the use of parametric methods is justified, non-parametric methods may be easier to use. Due to both simplicity and greater robustness, non-parametric methods are seen by some statisticians as leaving less room for improper use and misunderstanding (Savasci, 2011).

Nonetheless, some problems become uncontrollable as the number of the variables in non-parametric method increases. In the literature, this fact is known as the curse of dimensionality (Savasci, 2011). Other problems are the lack of interpretability and the choice of smoothness. To address the curse of dimensionality, interpretability and the modeling idea, an accepted compromise is found by the semi-parametric modeling. Semi-parametric models combine components of parametric and nonparametric models; keeping the easy interpretability of the former and retaining some of the flexibility of the latter (Santalova, 2009). The basis for many semi-parametric models is the generalized linear model (Nelder and Wedderburn, 1972). Hence, semi-parametric regression estimators are becoming standard tools for applied researchers.

Accordingly, in the present study, we will use the semi-parametric approach to estimate the specified model of the gravity to evaluate ESDC effects on bilateral trade flows of the selected European countries. A main reason to the country selection of European relies on the currency union and financial integration which are now in approach.

3. Data Description

To test the validity of the assumption of normal distribution and hence the suitability of using parametric estimation approach, we apply the "Normal Distribution Statistic" (NDS) to test whether data belong to a normal distribution. That is, we calculate mean and standard deviation of the ESDC data set once for period 1995-2008 and then for period 1995-2013[1].

The NDS returns the probability that a normally distributed random variable (X) with a given Mean and Standard Deviation, takes a value less than or equals to data. In other words, in the case of a continuous distribution, it gives the area under the probability density function from minus infinity to x. Hence, the cumulative distribution function (CDF) of a continuous random variable can be expressed as the integral of its probability density function (PDF):

$$F_X(x) = \int_{-\infty}^{x} f_x(t)dt \quad (1)$$

where $F_X(x)$ and $f_X(x)$ denote respectively the CDF and the PDF of a Normal Distribution with a given Mean and Standard Deviation and x denotes the given data. Table (1) reports the NDS measures of the ESDC variable over the period 1995-2013, which have been obtained as a result of using mean and standard deviation for the period 1995-2008, mainly before the global financial crisis in 2008.

[1] In the first case, parameters are calculated from the no-crisis state and the parameters calculated in the second case comprise the effects of SDC.

Table (1): The NDS Measures of the ESDC Variable
(Using the Mean and Standard Deviation of the Period 1995-2008)

Country	Germany	France	Spain	Greece	Italy	Portugal
1995	0.042039	0.073013	0.823689	0.173847	0.963046	0.471594
1996	0.158487	0.223239	0.90464	0.306341	0.95296	0.416138
1997	0.249873	0.330033	0.882643	0.155958	0.892271	0.277198
1998	0.30873	0.339036	0.842179	0.082275	0.765	0.133261
1999	0.382487	0.2782	0.801317	0.365446	0.701561	0.121541
2000	0.282767	0.175048	0.715344	0.585165	0.421898	0.102814
2001	0.197573	0.150727	0.586229	0.606122	0.40306	0.20325
2002	0.326597	0.303622	0.476311	0.463564	0.237843	0.341449
2003	0.683665	0.69142	0.340674	0.192989	0.17801	0.482787
2004	0.823579	0.84	0.26054	0.275447	0.161698	0.621012
2005	0.937064	0.917754	0.176653	0.920047	0.253069	0.869314
2006	0.916239	0.764988	0.105344	0.843425	0.284993	0.913407
2007	0.751263	0.779913	0.058684	0.820811	0.146393	0.889055
2008	0.859809	0.960886	0.114012	0.973096	0.274141	0.954028
2009	0.998795	0.999996	0.527894	1	0.855711	0.999626
2010	1	1	0.782786	1	0.936877	0.999999
2011	0.999994	1	0.94464	1	0.960363	1
2012	0.999998	1	0.998767	1	0.997208	1
2013	0.999966	1	0.999914	1	0.999881	1

Source: Authors

The NDS shows the cumulative distribution values of the data is based on the specified normal distribution. It is clear that, with the commonly used 5% confidence level, the statistic value of greater than 0.95 or less than 0.05 would result in rejection of the hypothesis that the data belong to the specified normal distribution. As it is evident from the Table (1), there are considerable count of numbers less than 0.05 or greater than 0.95, hence the A/F hypothesis would be easily rejected and it might be confirmed that for no countries, the ESDC volume (leverage) values fit a normal distribution. Figure (1) also displays the NDS trend of the ESDC variable for six European countries in the sampling, indicating indeed, the deep fluctuations of the variable rather than its smoothness. In principles, such results confirm no distribution for the ESDC variable and thus no parametric relationship, between the variable and trade flows.

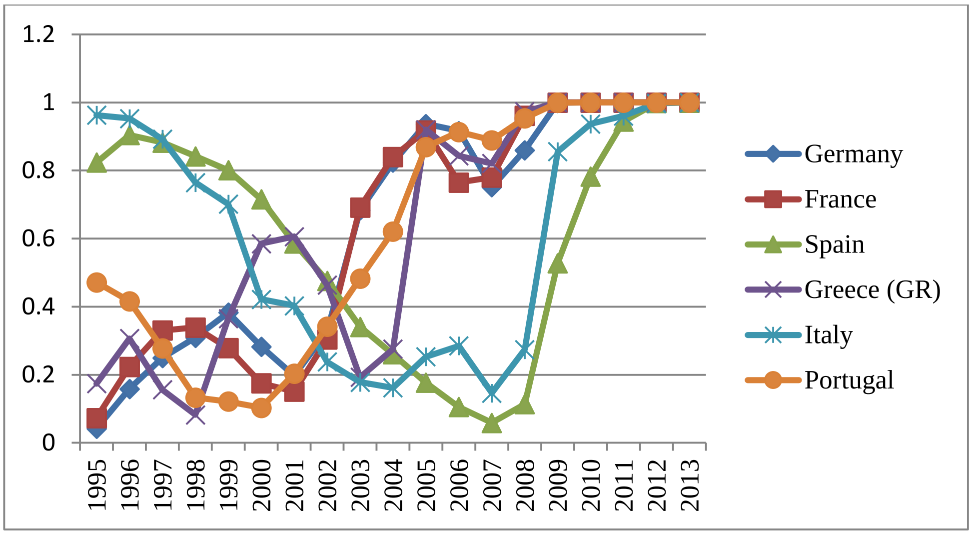

Figure (1); Fluctuations in SD for all Selected European Countries in the Sample (Using the Mean and Standard Deviation of the Period 1995-2008)

Source: Authors

Moreover, Table (2), reports the NDS measures of ESDC through calculating mean and standard deviation for the whole period of consideration, i.e. 1995-2013. Figure (2) also displays the NDS trend of the SD variable for the selected European countries, when Mean and Standard Deviation are calculated by using data of the whole period of consideration.

Table 2: The NDS Measures of the ESDC Variable (Using the Mean and Standard Deviation of the Period 1995-2013)

Country	Germany	France	Spain	Greece	Italy	Portugal
1995	0.090173	0.152433	0.624881	0.230241	0.810414	0.294342
1996	0.159539	0.213009	0.722482	0.258906	0.787557	0.280343
1997	0.199769	0.245341	0.692875	0.225643	0.685738	0.244236
1998	0.223755	0.247933	0.644823	0.20237	0.544374	0.199129
1999	0.25307	0.2301	0.602044	0.270112	0.488763	0.194573
2000	0.213281	0.196682	0.523797	0.310475	0.290548	0.186753
2001	0.1774	0.187703	0.423745	0.314516	0.278706	0.222858
2002	0.230898	0.237653	0.347797	0.288014	0.177709	0.261302
2003	0.38291	0.353071	0.26002	0.234892	0.141099	0.29718
2004	0.466233	0.415767	0.209235	0.252786	0.130944	0.333661
2005	0.579023	0.467606	0.155133	0.403868	0.186942	0.424042
2006	0.551068	0.380905	0.106239	0.371809	0.206277	0.451558
2007	0.419515	0.387181	0.070475	0.364636	0.121306	0.435335
2008	0.494531	0.516727	0.112447	0.447101	0.199704	0.489133
2009	0.818521	0.827832	0.382687	0.693685	0.639009	0.679291
2010	0.967484	0.886577	0.584031	0.887651	0.755924	0.812956
2011	0.939316	0.932681	0.78693	0.979882	0.804043	0.929514
2012	0.952287	0.968383	0.965905	0.939766	0.943994	0.983221
2013	0.913026	0.981949	0.990554	0.987258	0.987481	0.990008

Source: Authors

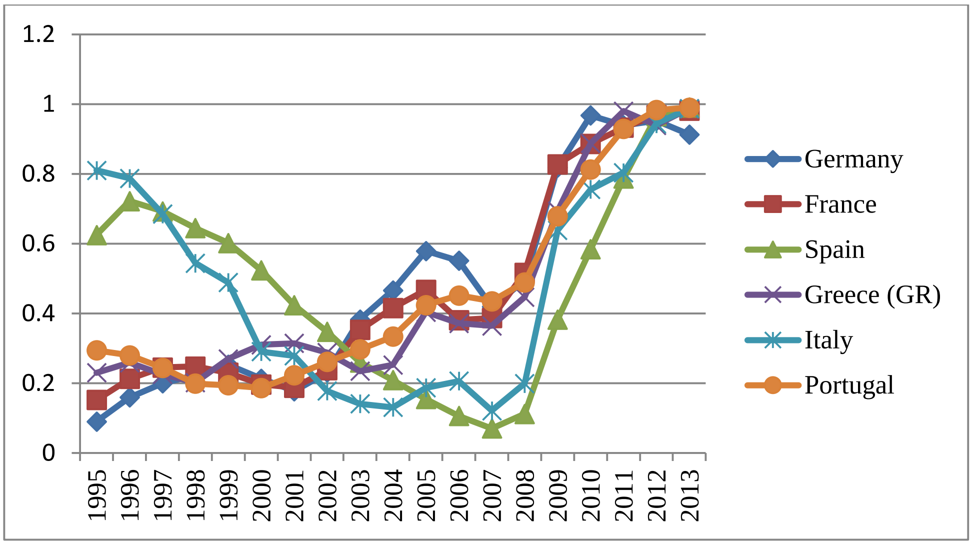

Figure (2); Fluctuations in SD for all Selected European Countries in the Sample (Using the Mean and Standard Deviation of the period 1995-2013)

Source: Authors

Table (2) and Figure (2) show that ESDC variable is not normally distributed for six selected European countries. Consequently, the same justification would be held and hypothesis rejected to this case as well, namely a non-parametric approach would be more reliable. This would convince one to use the semi-parametric method rather than parametric approach to estimate the gravity model of the study.

4. The Methodology

To develop trade model since recent decades, Tinbergen (1962) has attributed the flows of trade between nations using the gravity concept borrowed from natural sciences. As of its introduction to economics, the gravity equation has established itself as the most successful and celebrated empirical model in international trade (Olivero and Yotov, 2012). In the context of international trade flows, factors like sizes of countries, geographical distance as well as time-invariant cultural factors are considered as the important determinants of trade flows between them (Serlenga and Shin, 2007). Thus, trade flow between two countries (i and j) takes the form of:

$$F_{ij} = G\frac{M_i M_j}{D_{ij}} \qquad (2)$$

where F_{ij} is bilateral trade flows, M_i and M_j are the economic masses of each country, respectively, D_{ij} is the distance between the economic centers (capital cities) of both countries and G is a constant. In contrast to abstract and simple form of the basic model, in applied works, the model is often extended by including variables to account for common languages, tariffs, access to the sea, colonial history, exchange rate regimes, and other variables of interest (Mjema et al, 2012). Being deployed to analyze trade flows between countries, the model has also been used in international relations including evaluating the impact of treaties and alliances on trade. In other occasions the model has been used to test the effects of trade agreements and organizations such as the North American Free Trade Agreement (NAFTA) and the World Trade Organization.

At the same time, some researchers have used the gravity model to account for the effects of financial crises on the trade flows. Bai (2012), for instance, use gravity model to examine the effects of global financial crisis on Chinese exports. He shows that the global financial crisis affects economic conditions of the main economies such as the U.S., Japan and European countries. Zamani and Vaez Barzani (2012), using gravity model and data from 1998-2010 for some developing and developed countries, show the negative effect of financial crisis on international trade in the countries under consideration. Their results prove that such incidence seems to be significant to explain a sharp fall in the world exports. Zhu and Yang (2004) study the existence and severity of financial crisis contagion using the gravity model and data of financial crises originated in Mexico, Asia, Russia, and Brazil in the 1990s. They find empirical support for psychic distance in analyzing financial crisis contagion. Ma and Cheng (2005) use gravity model to analyze how financial crises affects international trade, finding evidence in support of "contagious crisis" in the last decade. Having applied a semi-parametric gravity trade model, Tayebi and Ohadi Esfahani (2014) conclude that there is a nonparametric relationship between bilateral exports and technological distance for the selected Asian countries in which relevant ttrade data have been considered over the period 1996-2011. Additionally, gravity variables (GDPs, populations and Linder variable) have affected significantly, while parametrically, export flows in the region.

The common procedure to estimate Gravity equations with panel data is based on the OLS of the transformed log-linear specification including several fixed effects to control for country unobserved heterogeneity. This may lead to a lack of efficiency due to the great number of parameters to be estimated (especially if panels have few time periods). It makes impossibility of estimating the effect of time-invariant variables. On the other hand, the log-linear specification of the gravity equation has been found to lead often to inconsistent estimation, as first has been noticed by Santos Silva and Tenreyro (2006). This is because parametric panel model requires a lot of assumptions which are not easily to be satisfied. Besides, in the parametric estimation approach, a full parametric model is specified, and so there is the risk of misspecification, which can yield biased estimates (Fox and Taqqu, 1986 and Sowell, 1992).

As an alternative, Santos Silva and Tenreyro (2006) proposed to apply the Poisson pseudo maximum likelihood to estimate the original model without the use of a log-transformation. But, it is well known that a natural extension of a Poisson modeling is the introduction of subject specific random effects which automatically will capture the over-dispersion. The obvious problem that occurs now is to prevent misspecification due to the independence assumption for the random effects. To overcome this problem, one might use semi-parametric gravity model for panel data.

Nonparametric models avoid restrictive assumptions of the parametric regression function while they include many advantages so that their applicability is much wider than the corresponding parametric methods and also, due to the reliance on fewer assumptions, non-parametric methods are more robust. Another justification for the use of non-parametric methods is their simplicity. In certain cases, even when the use of parametric methods is justified, non-parametric methods may be easier to use. Due to their simplicity and robustness, non-parametric methods are seen by some statisticians as leaving less room for improper use and misunderstanding.

Semi-parametric models combine components of parametric and nonparametric models, keeping the easy interpretability of the former and retaining some of the flexibility of the latter (Santalova, 2009). Hence, semi-parametric regression estimators are becoming standard tools for applied researchers.

In this paper we have introduced a methodology, which follows Tayebi and Ohadi Esfahani (2014), to estimate a semi-parametric specification of the panel gravity model to explore the effects of ESDC on bilateral trade flows of European countries located in the Eurozone. The general form of semi-parametric panel data model is defined as follows:

$$y_{\mathrm{it}} = \mathrm{X}_{\mathrm{it}}\theta + \mathrm{f}(z_{it}) + \alpha_i + \varepsilon_{it} \qquad i = 1, \dots, N; t = 1, \dots, T \; where \; T \ll N \qquad (3)$$

where y_{it} is dependent variable and $X_{it}\theta$ is parametric section of the model contain ordinary variables and $f(z_{it})$ is second part which is non-parametric piece that reflect the impact of ESDC.

To eliminate the fixed effects, α_i, a common procedure, inter alia, is to difference (1) over time which leads to

$$y_{it} - y_{it-1} = (X_{it} - X_{it})\theta + [f(z_{it}) - f(z_{it-1})] + \varepsilon_{it} - \varepsilon_{it-1} \quad (4)$$

An evident problem here is to estimate consistently the unknown function of $z \equiv G(z_{it}, z_{it-1}) = [f(z_{it}) - f(z_{it-1})]$. What Baltagi and Li (2002) propose is to approximate $f(z)$ by series $p^k(z)$ (and therefore approximate $G(z_{it}, z_{it-1}) = [f(z_{it}) - f(z_{it-1})]$ by $p^k(z_{it}, z_{it-1}) = [p^k(z_{it}) - p^k(z_{it-1})]$) where $p^k(z)$ are the first k term of a sequence functions $(p_1(z), p_2(z), \dots)$. They then demonstrate the $\sqrt{N}$ normality for the estimator of the parametric component (i.e., $\hat{\theta}$) and the consistency at the standard non-parametric rate of the estimated unknown function (i.e., $\hat{f}$). Equation (3) therefore boils down to

$$y_{it} - y_{it-1} = (X_{it} - X_{it})\theta + p^k(z_{it}) - p^k(z_{it-1})]\gamma + \varepsilon_{it} - \varepsilon_{it-1} \quad (5)$$

which can be estimated consistently using ordinary least squares. Having estimated $\hat{\theta}$ and $\hat{\gamma}$, it is easy to fit the fixed effects $\hat{\alpha}_i$ and go back to (2) to estimate the error component residual

$$\hat{u}_{it} = y_{it} - X_{it}\hat{\theta} - \hat{\alpha}_i = f(z_{it}) + \varepsilon_{it} \quad (6)$$

The curve f can be fitted by regression $\hat{u}_{it}$ on z_{it} using some standard non-parametric regression estimator (Libois and Verardi, 2013).

As previously discussed, an empirical trade model relies on the gravity approach while including two parts: parametric (part A) and non-parametric (part B), in which it is so- called a semi-parametric gravity model. It is defined as follows:

$$lTRADE_{iet} = \lambda_0 + \lambda_{ij} + \lambda_1 LGDP_{it} + \lambda_2 LGDP_{et} + \lambda_3 LPOP_{it} + \lambda_4 LPOP_{et} + \lambda_5 DIS_{ie} + \lambda_6 LER_{it} + \lambda_7 LER_{et} + f(CRISIS_t) + U_{iet} (7)$$

where $LTRADE_{iet}$, that log of exports from country *i* to country *e* at time *t*, stands for the dependent variable in the model. $LGDP_{it}$ (Logarithm of importer GDP), $LGDP_{et}$ (logarithm of exporter GDP country), $LPOP_{it}$ (logarithm of importing country's population), $LPOP_{et}$ (logarithm of exporting country's population), DIS_{ie} (logarithm of geographic distance between exporting and importing countries), LER_{it} (exporting country's exchange rate) and LER_{et} (importing country's exchange rate). In this study, the $Crisis_t$ indicator is used to show ESDC crisis variable that seems to affect trade flows and explains the non-parametric part of the model, which stands for a non-parametric relationship between bilateral trade and crisis. U_{iet} denotes the error terms at time t.

This paper thus explores the impacts of the ESDC crisis as well as a set of explanatory variables on bilateral trade through specifying a semi-parametric gravity model. Hence, to estimate Equation (6) through a semi-parametric process, we use the syntax of *xtsemipar* in stata which fits Baltagi and Li's double series of the fixed effects estimator in the case of one single variable which enters the model non-parametrically[1]. Overall, we are able to reproduce the values of the fitted dependent variable of bilateral exports in the specific confidence intervals, which are set to 95% default. To this end, we have the chance to recover the error component residuals, which can then be used to draw any kind of nonparametric regression. Three cases of the Stata command options for *xtsemipar* are considered to the estimation process of Equation (9). To fit the regression properly, each case includes the same *spline*, *ci* and *cluster*, but different *knots1*[2].

5. Empirical Results

Tables (1), (2) and (3) report the results of estimating Equation (7) using panel data of the selected EU countries during 1995-2013. The country sample includes Greece, France, Spain, Portugal and Italy. Data on GDP, population and exchange rate have been obtained from the World Bank database[3]. Export data have been gathered from the Uncomtrade website[4] and geographic distance data are taken from Indo[5], respectively. Finally, cross- section data for ESDC are obtained from the European Central Bank[6].

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[1] Related the syntax in Stata(13): *xtsemipar varlist [if] [in] [weight], nonpar(varname) [generate([string1] string2) degree(#) nograph spline bwidth(#) robust cluster(varname) ci level(#)].*

[2] These options which include 2, 4 and 6 knotes, identify the distribution of observations which can be fitted with interval confidence of 95%.

[3] www.worldbank.org

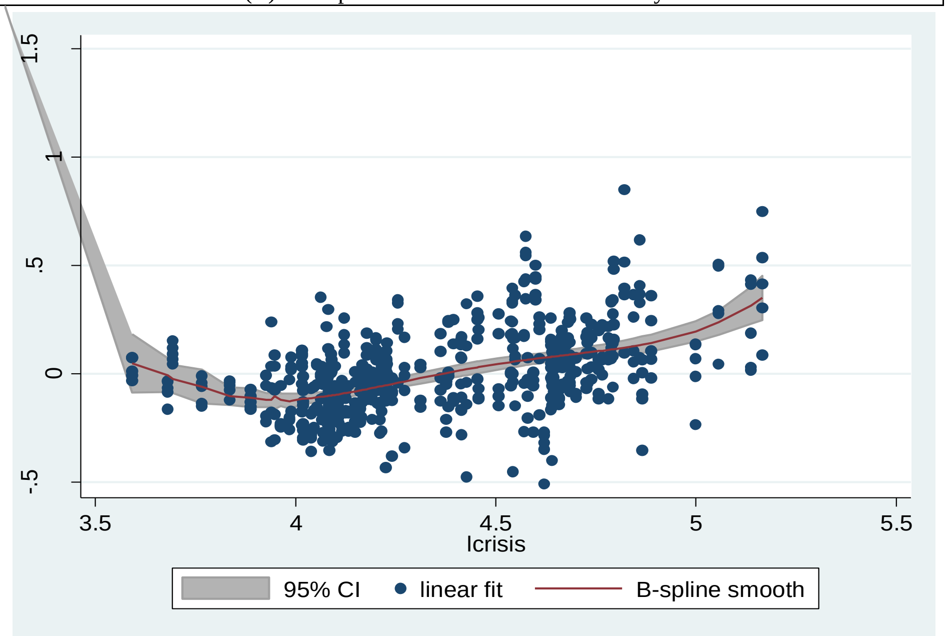
[4] www.uncomtrade.org

[5] www.indo.com

[6] http://sdw.ecb.europa.eu/browse.do?node=bbn192

Table 1: Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade: ESD Crisis Effect, Case I, (2 knots)

Part (A): *Parametric Estimates for the Gravity Model*			
Variable	Coefficient	t statistics	Pr > |t|
lgdpe	0.97	4.98	0.000
lgdpi	2.07	5.75	0.000
lpope	-2.12	-2.89	0.012
lpopi	-1.36	-1.51	0.153
lexe	1.25	7.34	0.000
lexi	1.47	6.49	0.000
Part (B): Non-parametric Results for the Gravity Model			

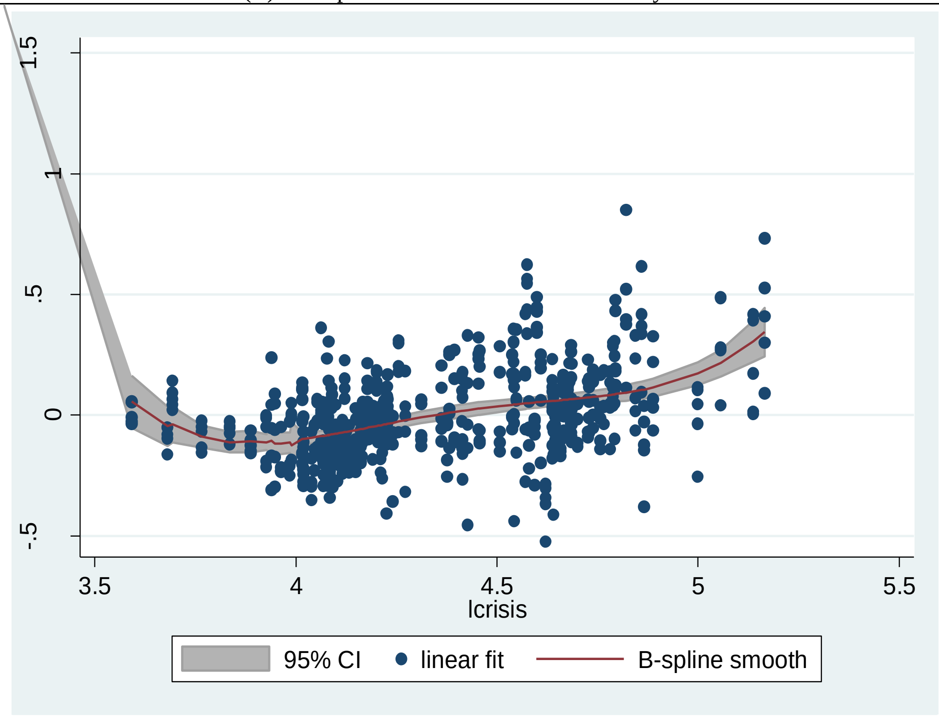


Source: Authors

Table 2: Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade: Debt Crisis Effect, Case II, (6 knots)

Part (A): *Parametric Estimates for the Gravity Model*			
Variable (log)	Coefficient	t statistics	Pr > |t|
lgdpe	1.05	4.96	0.000
lgdpi	1.95	5.02	0.000
lpope	-1.83	-2.76	0.015
lpopi	-1.25	-1.34	0.201
lexe	1.23	7.57	0.000
lexi	1.44	6.91	0.000

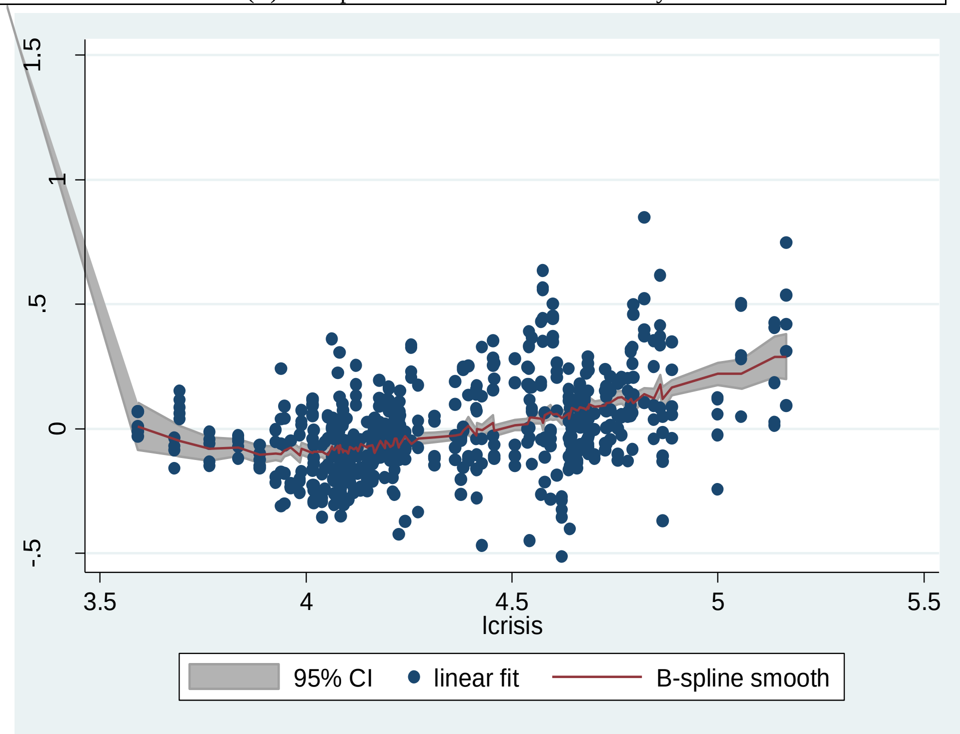
Part (B): Non-parametric Results for the Gravity Model



Source: Authors

Table 3: Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade: Debt Crisis Effect, Case III, (6 knots)

Parametric Estimates for the Gravity Model (Part A)			
Variable (log)	Coefficient	t statistics	Pr > |t|
lgdpe	1.05	5.19	0.000
lgdpi	2.02	5.35	0.000
lpope	-2.11	-3.37	0.005
lpopi	-1.37	-1.49	0.158
lexe	1.25	7.59	0.000
lexi	1.50	6.74	0.000
Part (B): Non-parametric Results for the Gravity Model			



Source: Authors

Empirical results which have been reported by Tables (1), (2) and (3) include two parts: A and B. Part A represents the parametric relationships between bilateral trade and GDPs, populations and exchange rates of European trading partners. The estimated coefficients for GDPs of both partners (exporter and Importer) are statistically significant implying the direct effect of economic scales on trade flows.

More specifically, an increase in the partners' GDP has resulted in trade expansion among the European countries. In addition, the coefficient of GDPs are significant for all cases (case I, case II and case III), in which it means the GDP variable is a major determinant of the European trade relations.

The coefficient of the exporter's population, on the other hand, has negative and significant sign, which indicates the larger domestic market in an European exporting country would lead to the lower exports to its trading partners in the Europe. The empirical results, however, do not confirm a significant effect of the importer population on the European bilateral trade flows. In addition, any appreciation in the exchange rate would cause an increase in export flows in the region, as the related coefficient is statistically significant with positive sign.

For Part B in all Cases, we use a kernel-weighted local polynomial fit based on an Epanechnikov kernel, confidence intervals at the level of 95% and standard errors clustered at the geographical distance level. The variable of geographical distance is a major determinant bilateral trade, which helps to smooth B-splines.

However, different values are used for *knots1* to show smoother quartic splines: (0(2)8) in Case I, (0(4)8) in Case II and (0(6)8) in Case III, respectively. Overall, Figures shown in the tables sketch the average non-parametric fit of the crisis variable (*crisis*) in a linear dotted fit and a lined B-spline smooth. Out of the results, Case III indicates a better fit, revealing the fact that there has been a nonparametric relationship between bilateral trade and crisis over 1995 – 2013. The results support the idea that debt crisis has no essentially a parametric relationship with trade, due to its various interpretation and proxies in use.

5. Conclusion

In this paper the relationships between bilateral trade and sovereign debt (leverage) crisis for six selected EU countries have been investigated by specifying a semi-parametric gravity model over 1995-2013. The results have confirmed that there is a nonparametric relationship between bilateral trade flows and debt crisis in the Eurozone during the period under consideration. The implication is that various indicators of crises are found to be significant while they affect the trade relations through complicated ways, implying the existence of a non-parametric or a non-linear relationship between trade and debt crisis.

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