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The Role of R&D in Trade Expansion: A Semi-parametric Gravity Specification for East and West Asia[*]

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Abstract

In more recent years, it has become increasingly recognized that R&D (research and development) is a key driver of economic growth, a source of innovation and change, and as such stimulates improvements in productivity and economic competitiveness. It is closely associated with knowledge and flexibility, two factors that have gained new significance as a source of competitiveness in an increasingly globalized world economy.

In this paper the relationship between bilateral trade and R&D differences among selected east and west Asian countries is investigated, specifying a semi-parametric gravity model over 1990-2013. Despite the majority of empirical analysis, we explore the relationship between trade and R&D differences through a nonparametric analysis. The results confirm that there is a nonparametric relationship between bilateral exports and R&D differences for both. The implication is that countries with various levels of R&D activities, namely arising from entrepreneurial activities, can affect widely and substantially international trade flows.

Keywords: Research and Development (R&D), Trade, Gravity Model, Semi-parametric Analysis, East-West Asia.

JEL Classification: C14, F15, O30

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1. Introduction

Trade can help raise development and reduce poverty by generating growth through increased commercial opportunities and investment, as well as broadening the productive base through private sector development. It enhances competitiveness by helping developing countries to reduce the cost of inputs, acquire finance through investments, increase the value added of their products and move up the global value chain. International trade is considered as an important channel of diffusion of technological knowledge among countries (Grossman and Helpman, 1991; Keller, 2004).

Export performance is an indicator of nation's economic success. Exporting gives firms to have access to larger markets, increase their scale and raise profits, exposes them to new ideas and expertise, and encourages them to stay abreast of market trends (Fabling and Sanderson, 2009). Furthermore, export activities are also seen by policymakers as a means to improve the and thus export promotion policies are often designed to serve these firms rather than large or multinational corporations (Lederman et al., 2011). Indeed the facts behind development of economies in the today world economy rely substantially on R&D, innovation and entrepreneurial activities. Theories about the potential factors which export performance depends on can be distinguished into two main approaches: The first argument stresses the role of comparative advantages resulting from factor endowment. The second approach focuses on innovation activity as a key factor for success on international markets (Kirbach & Schmiedeberg, 2006). Most countries have benefited from technological inventions of foreign countries. A strong argument of this is that the majority of the world's R&D is performed in a handful of industrial countries, yet productivity gains are widespread over the world (Xu and Chiang, 2005).

It has been apparent for at least a century that future economic progress will be driven by the invention and application of new technologies. R&D is one category of spending that develops and drives these new technologies. Recent years have seen substantial progress towards including research and development as a capital investment within the national income accounts. There are important differences between the levels of R&D spending across the OECD countries. According to OECD estimates (2014), R&D spending has resumed growth in the OECD countries and the geography of R&D growth has changed, for example China's R&D intensity has catch up with the European Union in 2012, and Korea is, along with China, the country with the most rapidly growing R&D expenditure levels in recent years. Research and development can be a significant source for economic growth. Growth models with R&D based have been introduced by Uzawa (1965), Lucas (1988), Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992). According to these studies, growth depends on technological activities that arise from intentional investment in R&D sectors. Furthermore, research and development creates technological innovations which reduce domestic relative price of a good, thus exports increase and imports decrease (Gruber et al., 1967; Kessing, 1967 and Mansfield et al., 1979).

Technology-based theories of trade have long emphasized the role of innovation and R&D in determining the pattern of trade. Since the 60's, most contributions in the field of technology and trade have focused on the critical importance of technological change in explaining international trade patterns. Posner (1961), Vernon (1966) and Hirsch (1967) have been considered the role of technology and innovation in trade. These authors believed that investments in technology and knowledge made and kept up comparative advantages. According to Posner technology capacity is an important indicator of a region's export specialization. There is a reasonable assumption that the nature of competition in distinctive parts changes over time, as Vernon and Hirsch directed. So, one can conclude that the critical elements for competitiveness would vary over time.

Despite the majority of empirical analysis, in this paper a semi-parametric gravity model for trade is analyzed. Parametric models are fully determined up to a parameter (vector). The fitted models can easily be interpreted and estimated accurately if the underlying assumptions are correct. If, however, they are violated then parametric estimates may be inconsistent and give a misleading picture of the regression relationship. Nonparametric models avoid restrictive assumption of the functional form of the regression function. 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 (Hardle et al., 2004).

Hence the objective of this paper is to examine relationship between R&D and bilateral trade flows among selected west and East Asian countries[1] through specifying a semi-parametric gravity model. In spite of the majority of empirical analysis, there are few examinations on nonparametric gravity model, such as Henderson and Millimet (2008) which estimate several gravity models in levels and logs through the nonparametric methods by relaxing two assumptions. The first assumption is that unobserved trade costs are a (log-) linear function of observables and the second one is that the ad-valorem tax equivalents of trade costs are constant across space. However, formal statistical tests fail to test their hypotheses of an overall nonparametric gravity model, which is able to include all trade explanatories. Nonparametric methods are statistical techniques that do not require a researcher to specify functional forms for objects being estimated. Instead, the data itself informs the resulting model in a particular manner. In a regression framework this approach is known as "nonparametric regression" or "nonparametric smoothing" (Gallo et al., 2010).

The remainder of this paper is organized as follows: Section 2 reviews the literature focusing on trade and R&D, Section 3 specifies an augmented gravity model based upon a semi-parametric regression. The model is defined to examine effects of research and development differences between selected east and west Asian countries during 1996-2013. Section 4 represents and analyzes empirical results obtained by a specific panel data approach. Section 5 concludes the paper.

2. The Literature Review

One of the major issues facing the economic world is the technological change, which make and prevent opportunities for the emerging countries to increase their technological capability, which is considered as the main driver of competitiveness. In recent years, many studies have looked at the process of technological capability in the industrialization of developing countries (Kim, 2001; Arvanitis, 2006). Moreover, there is some empirical evidence suggesting that technological activities have impacted export in various ways and technology is one of the key determinants of trade patterns (Fagerberg (1988); Montobbio and Rampa (2005), Roper & Love, 2002; Lall, 1992, 2000). For the period 2000-2010, Leitao and Tripathi (2013) explored trade pattern between European Union countries and Portugal using gravity model. Their results indicated that Portuguese trade flowed as indicated by the Linder hypothesis, standing for explaining bilateral trade through income convergence between the country and its trading partners. Additionally, geographical distance was related to trade inversely while economic dimension and common border had positive effects, on the trade flows in Europe.

Harris and Moffat (2011) examine the determinants of a firm exports and the relationship between export, innovation and R&D. This study considers manufacturing and service sectors. The results support the causality resulting from innovation and R&D that leading to exporting.

Belderbos et al. (2009) examine the effect of innovation on export intensity, export growth, and the geographic scope of exports, using cross-section and panel data on Flemish firms. According to empirical results, investments in capital and technologies and the introduction of innovations, are the determinants of export.

Ghazalian and Furtan (2007) investigate the effects of innovation on primary agricultural and processed food product exports for 21 OECD countries during 1990-2003. The empirical results support that research and development in the primary agricultural sector has a positive and significant effect on export of primary agricultural and processed food products.

Chadha (2005) study the export performance of 177 Indian pharmaceutical firms for the period of 1991-2004 and examines the effect of technology and innovations on net exports by estimating the export function given other firm characteristics like size, size squared and profitability using ordinary least squares (OLS) and instrumental variables (IV) estimation under the generalized methods of moments (GMM) framework. The results show that technology proxied by foreign patent rights plays a positive effect on exports.

According to Shy (1996), innovation is "the

[1] The sample includes Iran, Turkey, India, Pakistan, South Korea, Japan, Thailand, Malaysia, Indonesia and China, due to data availability.

search for, and the discovery, development, improvement, adoption, and commercialization of new process, new products, and new organizational structures and procedures". There are some ways that innovation can influence the level of trade; innovation may result in increased product differentiation, which provides consumers with both more variety choice and higher quality products, innovation lowers the cost of production and finally innovation can reduce transaction costs along the supply chain make exports more competitive. Product and process innovation seems to be a crucial factor in gaining market share in international markets, at least in those concerning developed countries (Ghazalian and Furtan, 2007).

It is expected that countries with high level of R&D activities, may move to the forefront of the technology boundary. They may gain competitive advantages compared to other countries producing competing goods. Therefore, it is expected that the export performance of a country is positively related to its R&D behavior (Kagochi and Jolly, 2010).

Following the early work of Schultz (1953) and Griliches (1958), the relationship between productivity and R&D expenditure has been investigated. In accordance with theoretical studies, R&D has an important role as an engine of productivity and economic growth (Romer, 1990; Helpman and Grossman, 1991; Aghion and Howitt, 1992). Casual relationships at the industry level in OECD countries between R&D and productivity has analyzed (Rouvinen, 2002; Frantzen, 2003; Zachariadis, 2004), but Ortega and Marin (2008), using 65 country panel for the time period of 1960-2000, investigate this relationship at the country level. According to their results, those countries making the most effort in the R&D sector will be more productive in the future.

The gravity model has been generally used for analyzing trade flows. The pioneering studies (Tinbergen, 1962; Poyhonen, 1963, Anderson, 1979; Caves, 1981) have stated that geographic distance has been an important determinant for trade. Usually geographic distance measures the transport cost. The theoretical predictions display a negative relationship between trade and distance (Balassa, 1966; Stone and Lee, 1995). A distance between two countries, it is much more than geography; while it is history, culture, language, social relations and research and development differences, it may have indirect effect on trade flows. Technically speaking, econometric analysis of panel data is often based on the parametric manner, which requires several assumptions that are not easily to be satisfied. However, the assumptions for nonparametric panel model are few; and the model of this study is mainly designed by the data of variables through a universal distribution.

3. The Model

The standard variables such as *GDP*, population and geographical distance have been regarded to illustrate bilateral trade flows in a gravity model. However in the augmented from of this model, there are such variables like economic integration, common culture and infrastructure variables that can promote or harm international trade.

The gravity model implements Newton's law of gravitation in physics, which expresses that the gravitational attraction between two items is proportional of their masses and relates to the square of their distance conversely:

$$F_{ij} = \frac{O_i O_j}{DIS_{ij}^2} \tag{1}$$

where F_{ij} denotes gravitational attraction, O_i and O_j are the mass of two objects and DIS_{ij} is the geographical distance.

Many international economists have pursued Tinbergen (1962) to establish econometric model of bilateral trade flows, the gravity model employed in bilateral trade is stated as follows:

$$Trdae_{ij} = \gamma \frac{Y_i - Y_j}{D_{ij}} \tag{2}$$

where γ is a constant term, T_{ij} is the total trade flow from origin country *i* to destination country *j*, Y_i and Y_j are the economic size of two country *i* and *j* which usually stated as gross domestic product (*GDP*) or gross national product (*GNP*). DIS_{ij} is the distance between two country *i* and *j*. typically the geographical distance between two capital cities.

The objective of this paper is to investigate impact of technological distance on bilateral trade flows. The functional form is defined completely using a number of parameters in the initial method which is parametric. If the parametric model assumptions are correct, they can construct accurate estimation and one can estimate and explain them precisely. Otherwise, parametric models become misleading. Parametric models are contrasted with nonparametric and semi-parametric models. To describe unknown regression relationships, nonparametric methods present a flexible device. Nonparametric models make no assumptions about the functional form of the regression function. But if the number of regressor is large, these models may be difficult to explain. In order to keeping the interpretability of parametric models and flexibility of nonparametric models, these two components are joined by semi-parametric models (Hardle, 1994 and Hardle et al., 2004).

According to Racine (2008), nonparametric and semi-parametric techniques have pulled in a lot of consideration from statisticians in the recent decades, as proved by the enormous arrange of texts written by statisticians including Ruppert et al. (2003), Hardle et al. (2004), and Fan and Yao (2005).

In a trade gravity model, a number of variables such income, population and geographical distance have been used vastly via a known functional form, mostly through a parametric manner. The model is indeed flexible to include other indicators, such as technology, which may have a nonparametric relation with trade flows.

A nonparametric version of the regression function of a dependent variable y on a single variable x is defined as:

$$y = m(x) + u \tag{3}$$

where no assumptions about distribution, serial correlation, homoscedasticity, or functional form are created at the outset; $m(x)$ is nonlinear. Smoothing methods hold the value of the closest neighbor concept yet utilize more expound plans to produce smooth and well behaved functions. The general class may be determined by a conditional mean estimating function:

$$\widehat{m}(x^*) = \sum_{i=1}^{n} w_i(x^*|x_1, x_2, \dots x_n) y_i = \sum_{i=1}^{n} w_i(x^*|x) y_i \tag{4}$$

where α value of specific x^* is conditional to the values of x variable, and the weights (w_i) sum to 1.

The weights can be defined as:

$$w_i(x^*|x) = \frac{1}{n} + \frac{x^*(x_i - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{5}$$

The problem with this particular weighting function, which we look to evade here, is that it permits every xi to be in the neighborhood of x^*, but it does not decrease the weight of any xi when it is far from x^* (Greene, 2011, 213). The point of a regression analysis is subsequently to create a reasonable analysis to the unknown response m, where for n data points (X_i, Y_i), the relationship can be modeled as:

$$Y_i = m(X_i) + u_i \tag{6}$$

In spite of parametric methodology where the function m is completely depicted by a finite set of parameters, nonparametric modeling accommodates a very flexible form of the regression curve (Hardle, 1994).

Now, using Baltagi and Li's (2002) semi-parametric fixed effects regression estimator, we consider a general panel data semi-parametric model with distributed intercept of the type:

$$y_{it} = X_{it}\beta + m(z_{it}) + \alpha_i + u_{it} \tag{7}$$

where $i = 1, \dots, N$, $t = 1, \dots, T$, and $T < N$. $X_{it}\beta$ as a first part, is the parametric section of the model that contain ordinary variables and $m(z_{it})$ is the second part which is nonparametric piece that reflect the impact of technological distance on bilateral trade.

By estimating $\hat{\beta}$, it is easy to fit the fixed effects $\hat{\alpha}$ and go back to (7) to estimate the error component residual:

$$e_{it} = y_{it} - X_{it}\hat{\beta} - \hat{\alpha}_I = m(z_{it}) + u_{it} \tag{8}$$

The curve m can be fitted by regressing e_{it} on z_{it} using some standard nonparametric regression estimator.[1] To specify a new form of trade gravity model, we mainly use the semi-parametric approach to explore a nonparametric relationship between bilateral exports and technological distance. The model is defined as follows:

$$LX_{ijt} = \gamma_0 + \mu_{ij} + \gamma_1 LY_{it} + \gamma_2 LY_{ji} + \gamma_3 LN_{it} + \gamma_4 LN_{jt} + \gamma_5 Linder_{ijt} + m(R\&D\ diff_{ijt}) + u_{ijt} \tag{9}$$

[1] For Further information, see Libois and Verardi (2013).

where LX_{ijt} denotes log of export flows from country i (as an exporter) to country j (as an importer) at time t. LY_{it}, LY_{ji}, LN_{it} and LN_{jt} stand for log of gross domestic product in country i at time t, log of gross domestic product in country j at time t, log of population in country i at time t and log of population j at time t, respectively. $Linder_{ijt}$ is defined as an income convergence, which is calculated as: $Linder_{ijt}= log((YPC_{it}-YPC_{jt})^2)$, in which YPC_{it} and YPC_{jt} denote GDP per capita in country i at time t and GDP per capita in country j at time t, respectively. A negative sign of estimated γ_5 implies an income would expand bilateral trade flows between countries i and j. By estimating $\widehat{\gamma_p}$s (p = 1, 2, 3, 4 and 5), the results would represent the parametric effects of gravity variables on trade flows. Additionally, *m(R&D diffijt)* explains the nonparametric part of the model, which stands for a nonparametric relationship between bilateral trade and research and development differences *(R&D diffijt)*. Indeed, R&D expenditure is used, in which the variable of and research and development differences *(R&D diffijt)* is measured as follows:

$$R\&D\ diff_{ijt} = \left| R\&D_{it} - R\&D_{jt} \right| \quad (10)$$

where a less absolute value of differences in research and development implies a less R&D differences between country i and j. Finally, u_{ijt} shows the error component of the gravity model.

4. The Results

This study explores the nonparametric relationship between technological distance and trade, as well as the impact of a set of gravity variables on bilateral trade by using a semi-parametric gravity model, as specified in the last section. To estimate the model defined in (9), cross-section data of the selected Asian countries are used to the period 1996-2013. Data for bilateral trade have been obtained from the United Nations COMTRADE database.[1] Data on Gross Domestic product (GDP), GDP per capita[2], population and also technology proxy have been obtained from the WDI reported by the World Bank.

To estimate Equation (9) through a semi-parametric manner, we use the *xtsemipar* command, which is implemented to a latest version of Stata (e.g. Stata12)[3]. The command fits Baltagi and Li's double series fixed effects estimator in the case of one single variable entering the model non-parametrically. The general syntax implemented in Stata for the command is defined as follows:

xtsemipar varlist [if] [in] [weight], nonpar(varname) [generate([string1] string2) degree(#) nograph spline bwidth(#) robust cluster(varname) ci level(#)]

There are a number of options (such as *nonpar*, degree(#) and so on), which can be used due to specification of the model and data fitting. A compulsory option is *nonpar*, which declares which variable enters the model non-parametrically. Hence this option allows us to use the R&D difference variable (R&D *diffijt*) in the gravity model (Eq. 9) in order to analyze a non-parametric relationship between bilateral exports and R&D pattern.

Overall, by applying various options, we are able to reproduce the values of the fitted dependent variable of Iran's bilateral exports in the specific confidence intervals, which are set to 95% default. To this end, we have the opportunity to recover the error component residuals - the left hand side of Equation (9) - 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.[4]

Tables (1) and (2) report the estimation results for the semi-parametric gravity model (Equation 9) for West and East Asian countries with three cases:

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[1] www.comtrade.un.org

[2] Data on GDP per capita are used to measure the Linder variable.

[3] The program can be installed by using *ssc* syntax, that is, *.scc install xtsemipara*.

[4] *Spline* specifies that the nonparametric fit be done by using *B-splines* (see Newson [2000]). The default option is a kernel-weighted local polynomial fit based on an Epanechnikov kernel. *ci* plots confidence intervals around the polynomial smoothing or the *spline*. *Cluster* computes cluster-corrected standard errors of the estimated parameters and adjusts the inference as well as confidence intervals. *Knots1* specifies a list of at least two ascending knots on which the *splines* estimated to remove fixed effects is based.

Case I, Case II and Case III, respectively. Each table has two parts: Part A indicates parametric estimates for the gravity model; and Part B represents non-parametric relationship between bilateral trade flows and R&D differences, which is displayed by a shaded area around the curve of the dependent variable fitted values. For Part A in all cases, the empirical results reported in the tables are namely consistent with theoretical expectations. A high level of GDP illustrate a high level of production in the exporting country which raise the obtainability of export and a high level of income in the importing country mentions high imports, therefore, the signs of the GDP's for both partners *i* and *j* are significantly positive, showing that wealthier countries trade more. For the population variables, we obtain positive and significant coefficient for the exporter, while the coefficient of population in West Asian countries for the importer is negative and significant, implying the increasing size of the market is not an incentive for importing products, since the larger population leads to the greater domestic production in these countries and in East Asian countries, the estimated coefficient of population for the importer has not been statistically significant, indicating that the market size of the host countries cannot play a significant part in trade relations.

As unexpected, the Linder variable (*LINijt*) has not affected bilateral export flows, since its estimated coefficient is not statistically significant, implying no income convergence on trade flows in Asia. For nonparametric part 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 of bilateral trade, which helps to smooth B-splines. However, different values are used for knots1 to show smoother quartic splines: (0(2)8), (0(4)8 and (0(6)8), respectively. Overall, Figures shown in the tables sketch the average non-parametric fit of the research and development difference variable (R&D diffijt) in a linear dotted fit and a B-spline smooth.

As indicated by figures, the relationship between the R&D differences and trade in the semi-parametric model differs depending on the R&D differences level. According to the results, for technological distance values which are smaller, trade flows go to higher rate of growth, which has shown in the vertical axis. The technological distance effects become stronger while the larger gap of technology among partners leads to a lower rate of trade. The results support the idea that technological distance has no essentially a parametric relationship with trade, due to its various interpretation and proxies in use.

5. Conclusion

Despite the growing number of papers that have begun to look at relationship between technology and bilateral trade relations, most studies only consider the parametric model, and they do not allow for nonparametric or semi-parametric links between international trade and technology. The core of trade promotion can be indeed based on technology and entrepreneurial opportunities, in which the relationship between trade and technology may include both parametric and nonparametric analyses.

In this paper the relationship between bilateral trade and technological distance has been investigated by estimating a semi-parametric gravity model for the selected Asian countries over 1996-2013. The results have confirmed that there is a nonparametric relationship between bilateral exports and technological distance. The implication is that countries with various levels of technological activities, affect widely and significantly international trade flows. Additionally, the technology effect can be interpreted non-parametrically rather than parametrically.

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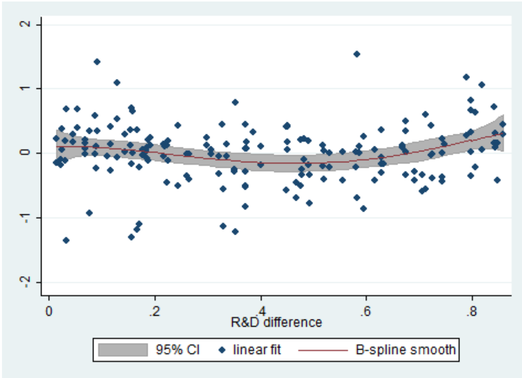
Table (1): Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade Flows: R&D Difference Effect, Case I: West Asia

Part A: (2 knots)

Parametric Estimates for the Gravity Model

Variable	Coefficient	t- Statistic	P>|t|
$LGDP_{it}$	.7575461	3.61	0.015
$LGDP_{jt}$	.6305868	2.06	0.094
$LPOP_{it}$	6.681258	1.14	0.002
$LPOP_{jt}$	-5.300279	0.92	-5.71
$Linder_{ijt}$	.00003179	0.30	0.921

Nonparametric relationship between Bilateral Trade and R&D Difference

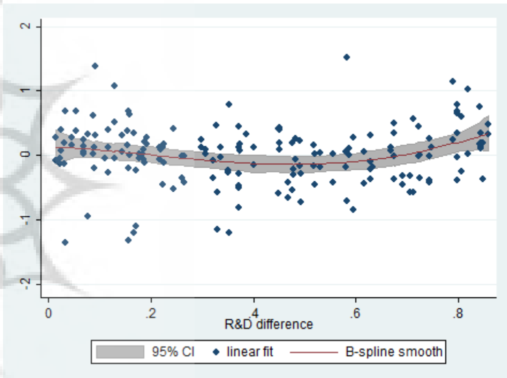


Part B: (4 knots)

Parametric Estimates for the Gravity Model

Variable	Coefficient	t- Statistic	P>|t|
$LGDP_i$	.7784683	3.44	0.018
$LGDP_j$	.651078	2.22	0.077
$LPOP_i$	6.635296	5.64	0.002
$LPOP_j$	-5.722154	-7.96	0.001
$Linder_{ijt}$	.0130632	0.54	0.612

Nonparametric relationship between Bilateral Trade and R&D Difference

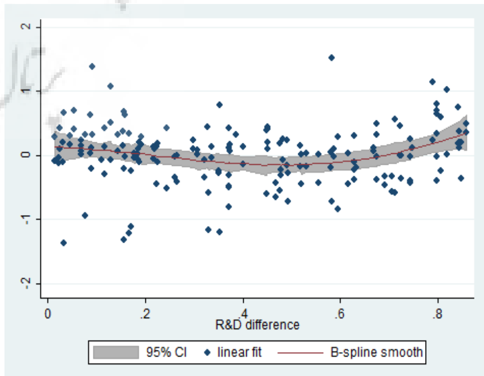


Part C: (6 knots)

Parametric Estimates for the Gravity Model

Variable	Coefficient	t- Statistic	P>|t|
$LGDP_i$	.7635919	3.45	0.018
$LGDP_j$	.635691	2.18	0.081
$LPOP_i$	6.712934	5.44	0.003
$LPOP_j$	-5.66834	-7.08	0.001
$Linder_{ijt}$	.0164209	0.79	0.464

Nonparametric relationship between Bilateral Trade and R&D Difference



Source: Authors.

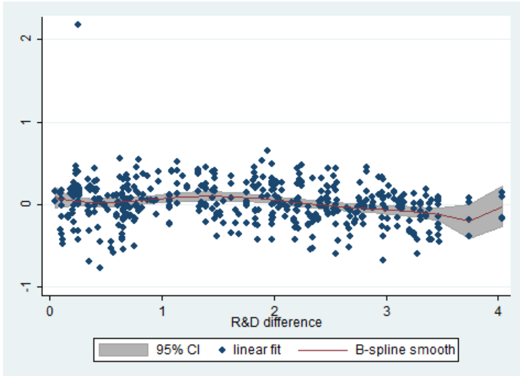
Table (2): Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade Flows: R&D Difference Effect, Case I: East Asia

Part A: (2 knots)

Parametric Estimates for the Gravity Model

Variable	Coefficient	t- Statistic	P>|t|
$LGDP_{it}$	.4184603	7.21	0.000
$LGDP_{jt}$	.8870538	5.90	0.000
$LPOP_{it}$	2.110217	4.35	0.001
$LPOP_{jt}$	.4194605	0.33	0.745
$Linder_{ijt}$	-.043892	-0.75	0.465

Nonparametric relationship between Bilateral Trade and R&D Difference

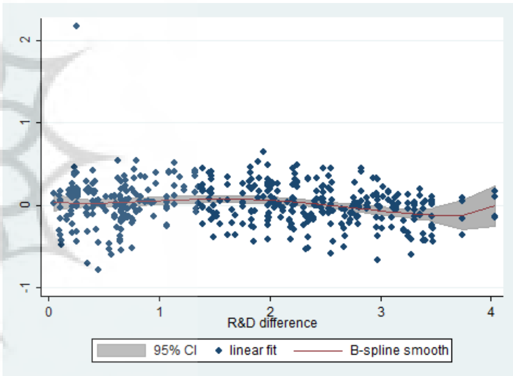


Part B: (4 knots)

Parametric Estimates for the Gravity Model

Variable	Coefficient	t- Statistic	P>|t|
$LGDP_i$	.4157105	7.21	0.000
$LGDP_j$	.8843041	5.89	0.000
$LPOP_i$	2.106989	4.39	0.001
$LPOP_j$	.4162326	0.33	0.747
$Linder_{ijt}$	-.0443669	-0.77	0.457

Nonparametric relationship between Bilateral Trade and R&D Difference

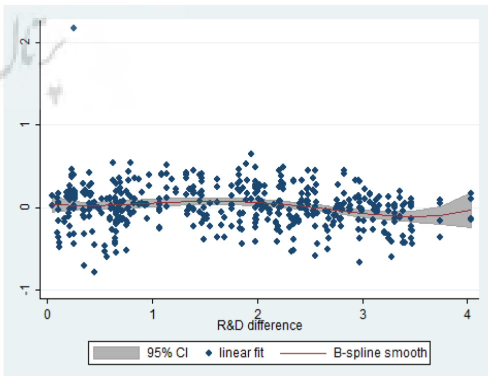


Part C: (6 knots)

Parametric Estimates for the Gravity Model

Variable	Coefficient	t- Statistic	P>|t|
$LGDP_i$	.4154412	7.21	0.000
$LGDP_j$	.8840348	5.88	0.000
$LPOP_i$	2.110051	4.39	0.001
$LPOP_j$	.4192938	0.33	0.745
$Linder_{ijt}$	-.0442466	-0.76	0.458

Nonparametric relationship between Bilateral Trade and R&D Difference



Source: Authors.