Korea and the World Economy, Vol. 17, No. 2 (August 2016) 243-265

# Technological Distance and Bilateral Trade in Asia[*]

Sepideh Ohadi Esfahani[**] · Seyed Komail Tayebi[***]

The purpose of this study is to investigate the relationship between technological distance and bilateral trade flows in the selected Asian countries. Despite the majority of empirical analysis, we have explored the relationship between trade and technological distance through a nonparametric analysis. We thus specify an innovative version of a semi-parametric gravity model, which has been focused on explaining the role of technological distance in bilateral trade relations. Specified trade model keeps the interpretability of parametric effects of the gravity variables (such as GDP, population) and flexibility of nonparametric effects arising from, for instance, technological distance. The empirical results, which have been obtained by estimating a semi-parametric gravity model of trade over the period 1996-2013, imply the significant role of technology distance in trade flows for the Asian countries. More specifically, the relationship between technological distance and trade in a semi-parametric framework varies depending on the level of technological distance in Asia, that is, a low difference between technology levels in some Asian trading partners has led to an increase in trade flows, whereas a contrary result for some other partners.

JEL Classification: F15, O30
Keywords: technological distance, trade, gravity equation,
semi-parametric analysis

---

[*] Received April 10, 2016. Revised August 10, 2016. Accepted August 27, 2016. The authors acknowledge the support of the Center of Excellence for International Economics, University of Isfahan (CEIEUI), Isfahan, Iran.

[**] Ph. D. Candidate in Economics, Department of Economics, University of Isfahan, Isfahan, Iran, E-mail: ohadi.econ@ase.ui.ac.ir

[***] Author for Correspondence, Professor of International Economics, Department of Economics, University of Isfahan, Isfahan, Iran, E-mail: sk.tayebi@ase.ui.ac.ir

# 1. INTRODUCTION

The Heckscher-Ohlin-Samuelson (HOS) model is based on differences in factor endowments in order to foresee the trade criterion in products between two nations. Factor content of trade is processed by Heckscher-Ohlin-Vanek (HOV) model which is the augmented type of the former one. Factor content of HOV model have been studied at first by Leontief (1953) and then by Leamer (1980), Bowen, Leamer, and Sveikauskas (1987), Trefler (1993, 1995), Davis and Weinstein (2001). There is consensus that if we do not give up the assumption of identical technologies across nations, the HOV model will execute poorly.

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) considered the role of technology and innovation in trade, and 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, because the nature of competition in distinctive parts changes over time, as Vernon and Hirsch directed.

A distance between two countries, it is much more than geography; while it is history, culture, language, social relations and technological distance, it may have indirect effect on trade flows. Hence, one can conclude that although technological distance is an obstruction to trade generally, it can be a motivating force indeed (Filippini and Molinin, 2003). Technological gap between two countries may lead to import higher technology products to duplicate the technology and recreate it at a lower cost. Although, it is not clear that technological distance whether plays a positive or negative role in bilateral trade flows between two trading partners, there is still a gap in the literature through which one is not able to draw a parametric line between trade and technological distance.

Despite the gravity model's considerable empirical success, it was long criticized for lacking strong theoretical foundations. More recently, different theories have been developed to establish theoretical underpinnings of the gravity model. Anderson (1979), Bergstrand (1985, 1990), Deardorff (1998) and Eaton and Kortum (2002) have developed micro-foundations for the gravity model. Anderson (1979) provided a theoretical basis for the gravity model by assuming constant elasticity of substitution (CES) preferences and goods that are differentiated by country of origin. Bergstrand (1990) derived a gravity equation from a monopolistic competition trade model in which the countries are completely specialized in different product varieties. In this case, each country is exports one variety of a differentiated product to other countries. Deardorff (1998) has shown that the gravity model can arise from the Heckscher-Ohlin model, which explains trade based on relative differences in factor endowments across countries. Eaton and Kortum (2002) obtained a gravity equation from a Ricardian type of model, which explains trade based on relative differences in technology across countries. Following Eaton and Kortum (2002), there are some empirical studies show that technological differences are important to determine trade flows (Costinot *et al*., 2012; Chor, 2008).

The objective of this paper is to draw a nonparametric relationship between technological distance and bilateral trade flows between selected Asian countries through specifying a semi-parametric gravity model.[1) In spite of the majority of empirical analysis, there are few examinations on nonparametric gravity model, such as Henderson and Millimet (2008) relax two assumptions: (1) unobserved trade costs are a (log-) linear function of observables and (2) 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 includes all trade explanatories.

The advantage of this paper is thus to apply a nonparametric analysis to

---

[1) The sample includes Iran, South Korea, Japan, Turkey, Thailand, Pakistan, Malaysia, India, Indonesia and China, due to data availability. Most of these countries are trading partners in goods and services.

the relationship between technological distance and bilateral trade flows as well as to apply a parametric analyses to the gravity variables (GDP, population) and trade flows in Asia.

The remainder of this paper is organized as follows: section 2 reviews the literature focusing on trade and technology, section 3 specifies an augmented gravity model based upon a semi-parametric regression. The model is defined to examine effects of technological distance between selected 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 RELATED LITERATURE

International trade theory highlights the importance of technological innovation in explaining a country's international competitiveness. In the literature, for supporting the Heckscher-Ohlin model it is necessary to take into account cross-country differences in technology. According to Bowen *et al*. (1987), Heckscher-Ohlin-Vanek (HOV) models are refused in favor of models that take into account technological differences. In addition, the Heckscher-Ohlin model is refused by Trefler (1995), as the model does not allow for international technology differences and home bias in consumption. As reported by Davis *et al*. (1997), the Heckscher-Ohlin model executes better empirically by considering for technology differences. Davis and Weinstein (2001) adjust the HOV theory by allowing technological differences. In this manner, Hakura (2001) demonstrates the importance of technology differences among a small sample of industrialized countries.

One of the major issues facing the economic world is the technological change, which makes and prevents opportunities for the emerging countries to increase their technological capability. 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 affected international trade in various ways and technology is one of the key determinants of trade patterns (Fagerberg, 1988; Chadha, 2009; Montobbio and Rampa, 2005, Roper and 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. Moreover there are empirical studies using the gravity model to analyze trade flows (Cho *et al.*, 2015; Seong Kang, 2014).

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 is an important determinant of 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), while distance can be examined in terms of differences in geography, culture, language, border (Rauch, 1999; Eichengreen and Irwin, 1998) and technology. Technological distance has been investigated in the field of economics and innovation management (Jaffe, 1986; Stuart and Podolny, 1996). Wakelin (1997) indicates that choice of technological activities proxies have been between using an input to the innovation process, such as R&D expenditure or the number of scientists and engineers employed in research departments (Fagerberg, 1997; Torstensson, 1996) and an output, such as number of patents (Franz, 2007; Hinze *et al.*, 1997). Among these indices, patent data are used in this study to measure a country technological activities and its distance to other countries.

The innovation of our paper is thus to present a semi-parametric gravity model as it will be specified in the next section. Our model includes two parts: part one where ordinary variables, according to the literature, such as GDP and population have parametric relationships with the bilateral trade flows, while second part explains a nonparametric relationship between technological distance and trade. 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 is mainly designed by the data of variables through a universal distribution. One type of dispersion, the technological distance as an example, is based on the insight that two countries can be far close not only geographically but even from a technological point of view.

## 3. THE MODEL

Ricardian trade theory builds on the assumption that trade is beneficial due to comparative advantage. Comparative advantage arises because of differing costs in production or production technologies. Eaton and Kortum (2002) develop a Ricardian model of bilateral trade which is based on differences in production technologies. Countries are assumed to have differential access to technology, so that efficiency varies across commodities and countries.

This model features an arbitrary number of countries $i$=1, ..., $N$ and goods $j$=1, …, $J$. Country $i$'s efficiency in producing good $j \in [0, 1]$ is determined by $z_i(j)$. With constant return to scale, the cost of producing a unit of good $j$ in country $i$ is $c_i / z_i(j)$. By considering $d_{ni}$ as geographic barriers, delivering a unit of good $j$ produced in country $i$ to country $n$ costs:

$$P_{ni}(j) = \left( \frac{c_i}{z_i(j)} \right) d_{ni}. \tag{1}$$

Consumer in country $n$ decide to purchase good $j$ at the lowest available price $P_n(j) = \min\{P_{ni}(j);\ i = 1,\ ...,\ N\}$.

The authors assume that country $i$'s efficiency in producing good $j$ is the realization of a random variable $Z_i$ from its country-specific probability distribution $F_i(z) = \Pr[Z_i \leq z]$. It is assumed that country *i*'s efficiency distribution is Frechet:

$$F_i(z) = e^{-T_i z^{-\theta}},$$

where $T_i > 0$ and $\theta > 1$. The location of the distribution is indicated by $T_i$. The shape of this distribution is governed by a parameter $\theta$ that quantifies static gains from trade following comparative advantage.

The probability of a country *i* to successfully export to *n*, that is to offer the lowest price, is a function of its state of technology, its factor cost $c_i$ and transportation costs between the two countries, relative to the rest of the world:

$$\pi_{ni} = \frac{T_i (c_i d_{ni})^{-\theta}}{\sum_{k=1}^{N} T_k (c_k d_{nk})^{-\theta}}. \tag{2}$$

In equilibrium, this expression is equivalent to *i*'s share in the total expenditure of country *n*, $(X_{ni} / X_n)$, so that:

$$X_{ni} = \frac{T_i (c_i d_{ni})^{-\theta} X_n}{\sum_{k=1}^{N} T_k (c_k d_{nk})^{-\theta}}. \tag{3}$$

This equation already stands for the standard gravity equation in which bilateral trade is related to the importer's total expenditure and to geographic barriers.

Since Tinbergen (1962) and Poyhonen (1963), examination of international trade has been performed by various gravity model specifications. The standard variables such as GDP, population and geographical distance have been regarded to illustrate bilateral trade flows in the model. Moreover, in the augmented gravity model, there are several determinants such as economic integration, common culture and infrastructure variables, which affect trade flows. Many international economists have followed the literature to establish econometric model of bilateral trade flows, the gravity model employed in bilateral trade is stated as follows:

$$T_{ij} = A\frac{Y_i Y_j}{D_{ij}}, \tag{4}$$

where $A$ 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 ($GNP$). $D_{ij}$ denotes geographical distance between two capital cities of country $i$ and country $j$.

In the literature and the real world, a number of determining factors can be found that even affect international trade flows. Eichengreen and Irwin (1998) utilize cultural proxies (border, common language) in an augmented gravity model, exploring the effects of these indicators on bilateral trade flows.

The functional form is thus defined completely using a finite number of parameters in the initial method which is a parametric one. If the parametric model's assumptions are correct, they can construct accurate estimation and one can estimate and explain them precisely. However, advanced determining factors of trade including innovation, technology and productivity may be involved in the model through a nonparametric specification.

According to Racine (2008), nonparametric and semi-parametric techniques have pulled in a lot of considerations 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 (2003). To be innovative, in a trade gravity model, a number of variables such income, population and geographical distance can be used by 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.

In nonparametric point of view, the regression function of a dependent variable *y*, on a single variable *x* is defined as:

$$y = \mu(x) + \varepsilon, \tag{5}$$

where no assumptions on distribution, serial correlation, homoscedasticity, or functional form are created at the beginning; $\mu(x)$ is nonlinear. The general class of smoothing methods may be determined by a mean estimating function as an estimation of $\mu(x)$:

$$\hat{\mu}(x_0) = \sum_{i=1}^{n} w_i(x_0 | x_1,\ x_2,\ \ldots,\ x_n) y_i = \sum_{i=1}^{n} w_i(x_0 | X) y_i, \tag{6}$$

where a value of specific $x_0$ is conditional to the values of *x* variable, and the weights ($w_i$) sum to 1. In the case of a linear form, the least squares regression is defined simply as below:

$$\hat{\mu}(x_0) = a + bx_0, \tag{7}$$

where *a* is the constant term and *b* is slope. Accordingly, the weighing function can be defined as:

$$w_i(x_0 | x) = \frac{1}{n} + \frac{x_0(x_i - \overline{x})}{\sum_{i=1}^{n}(x_i - \overline{x})^2}. \tag{8}$$

The problem with this particular function, is that it allows every $x_i$ to be in the neighborhood of $x_0$, but it does not decrease the weight of any $x_i$ when it is far from $x_0$ (Greene, 2011). Dissimilar to 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, 1990). The point of a regression analysis is subsequently to create a reasonable analysis to the unknown response $\mu(.)$, the relationship can be modeled non-parametrically. To take into account such structure, an alternative weighing function is defined on the basis of a kernel function $K(.)$:

$$\hat{\mu}(x_0) = \frac{1}{Nh} \sum_{i=1}^{N} K\left(\frac{x_i - x_0}{h}\right), \tag{9}$$

where $N$ is the number of observations and $h$ is a smoothing parameter called the bandwidth (Cameron and Trivedi, 2005). However, econometric models may include a number of potential regressors that the relevant restrictions (dimensionality of regressors, for example) make nonparametric analysis unusable. Instead, it is possible to estimate a semi-parametric model that combines both parametric and nonparametric components.

To specify a new form of trade gravity model, we use the semi-parametric approach, Henderson and Millimet (2008), to explore a nonparametric relationship between bilateral exports and technological distance. The model is finally defined as follows:

$$\begin{aligned} LEX_{ijt} = \beta_0 + \beta_{1ij} + \beta_2 LGDP_{it} + \beta_3 LGDP_{jt} + \beta_4 LPOP_{it} \\ + \beta_5 LPOP_{jt} + \mu(Techdis_{ijt}) + u_{ijt}, \end{aligned} \tag{10}$$

where $\beta_0$ and $\beta_{1ij}$ are the model intercept and individual effects respectively, $u_{ijt}$ shows the error term of the model. $LEX_{ijt}$ denotes log of export flows from country $i$ (as an exporter) to country $j$ (as an importer) at time $t$. $LGDP_{it}$, $LGDP_{ji}$, $LPOP_{it}$ and $LPOP_{jt}$ 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. $LIN_{ijt}$ is defined as an income convergence, which is calculated as: $LIN_{ijt} = \log((GDPPC_{it} - GDPPC_{jt})^2)$, in which $GDPPC_{it}$ and $GDPPC_{jt}$ 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 estimating $\beta_6$ implies that income convergence between $i$ and $j$ expand their bilateral trade relations. By estimating $\hat{\beta}_p s$ ($p$= 2, 3, 4, 5 and 6), the results would represent the parametric effects of gravity variables on trade flows. Additionally, $\mu(Techdis_{ijt})$ explains the nonparametric part of the model, which stands for a nonparametric relationship between bilateral trade and technological distance ($Techdis_{ijt}$).

According to Baltagi and Li (2002), the curve $\mu$ can be estimated by regressing residuals from equation (10) on technological distance variable using some standard non-parametric regression estimator, for instance, a class of the kernel estimator:[2]

$$\begin{aligned}\hat{u}_{ijt} = LEX_{ijt} - \hat{\beta}_0 - \hat{\beta}_{1ij} - \hat{\beta}_2 LGDP_{it} - \hat{\beta}_3 LGDP_{jt} \\ - \hat{\beta}_4 LPOP_{it} - \hat{\beta}_5 LPOP_{jt} - \hat{\beta}_6 LIN_{ijt}.\end{aligned} \tag{11}$$

To obtain the estimates of the individual fixed effects $\hat{\beta}_{1ij}$ and regression coefficient, the authors suggest estimate model (11) in first differences using ordinary least squares and approximate first difference of unknown function $\mu$ by series $p^k(techdis_{ijt})$. Here $p^k(techdis_{ijt})$ are the first $k$ terms of a sequence of functions ($p^1(techdis_{ijt}), p^2(techdis_{ijt}), \ldots$).

Indeed, the patent application is used to make a proxy of technology, in which the variable of technological distance ($Techdis_{ijt}$) is measured as follows:

$$Techdis1_{ijt} = \log\,(Patent_{it} - Patent_{jt})^2,$$

where $Patent_i$ and $Patent_j$ denote the number of patents application registered in country $i$ and country $j$ respectively, at time $t$. Based on the above equation, the less gap between patent applications in both countries, either the more convergence in technology or the less technological distance. Another proxy for technological distance can be also defined as follows:

---

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

$$Techdis2_{ijt} = \left| patent_{it} - patent_{jt} \right| ,$$

where a less absolute value of differences in patent applications implies a less technological distance between country *i* and *j*.

## 4. EMPIRICAL RESULTS

This paper investigates the nonparametric relationship between technological distance and trade, as well impacts 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 equation (10), 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.[3] Data for Gross Domestic product (GDP), GDP per capita,[4] population and also technology proxies have been obtained from the WDI reported by the World Bank.

To estimate the equation, we use the relevant command that has been implemented by the latest versions of Stata. The command fits Baltagi and Li's double series fixed effects estimator in the case of one single variable which is considered in the model as a nonparametric factor.[5] As a single variable, we introduce the technological distance variable ($Techdis_{ijt}$) to the model in order to estimate the model.

We now reproduce values of the fitted dependent export variable in the specific confidence intervals, which are set to 95% default. To this end, we have an opportunity 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 semi-parametric estimation are considered to the

---

[3] www.comtrade.un.org

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

[5] The general syntax implemented in Stata for the command is defined as follows: *xtsemipar varlist* [*if*] [*in*] [*weight*], *nonpar* (*varname*) [*generate* ([*string1*] *string*2) *degree* (*#*) *nograph spline bwidth* (*#*) *robust cluster* (*varname*) *ci level*(*#*)].

estimation process of equation (10).[6)]

Hence, tables (1), (2) and (3) report the estimation results for the semi-parametric gravity model (equation 10) including Case I (2 knots), Case II (4 knots) and Case III (6 knots), respectively. Each table includes two parts of results: Part A indicates results using the first index, $Techdis1_{ijt}$ of technological distance and Part B shows results that are related to use of the second index, $Techdis2_{ijt}$. Also there are parametric estimates for the gravity model; and nonparametric results to show the relationship between bilateral trade flows and technological distance, which is displayed by a shaded area around the curve of the fitted values for dependent variable (bilateral trade). For parametric estimation in all cases, the empirical results reported in the tables that are namely consistent with theoretical expectations. A high level of GDP illustrates a high level of production in the exporting country which increase the capability of exports 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. This implies a larger size of economy stimulates trade flows between partners. As reported by the tables (1-3), we obtain positive and significant coefficient of population in exporter country, while the coefficient of population for the importer has not been statistically significant, indicating that the market size of the host countries, rather than that of exports, cannot play a significant role in trade relations. As unexpected, the Linder variable ($LIN_{ijt}$) has not affected bilateral export flows, since its estimated coefficient is not statistically significant, implying that there is no income convergence on trade flows in Asia due to the diversified products in different countries.

For nonparametric part in all cases, we use a kernel-weighted local polynomial fit based on an Epanechnikov kernel, confidence intervals at the

---

[6)] To fit the regression properly, each case includes the same spline, *ci* and *cluster*, but different knots1. *spline* specifies that the nonparametric fit be done by using B-splines (see Newson, 2001). 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. *knots*1 specifies a list of at least two ascending knots on which the *splines* estimated to remove fixed effects is based.

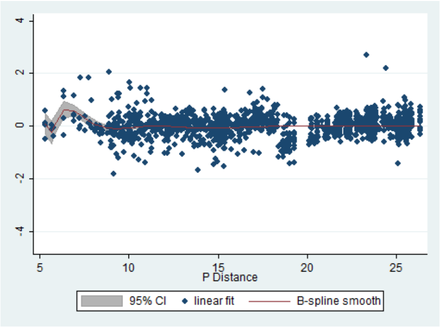
**Table 1 Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade Flows: Technological Distance Effect, Case I: (2 knots)**

Part A: $Techdis1_{ijt}$

Parametric Estimates for the Gravity Model

| Variable | Coefficient | *t*-Statistic | *P*>\|*t*\| |
|---|---|---|---|
| $LGDP_{it}$ | .3321218 | 4.34 | 0.000 |
| $LGDP_{jt}$ | .8896827 | 9.38 | 0.000 |
| $LPOP_{it}$ | 1.037956 | 1.89 | 0.034 |
| $LPOP_{jt}$ | .5763814 | 0.82 | 0.259 |
| $Linder_{ijt}$ | –.0068912 | –0.35 | 0.634 |

Nonparametric Relationship between Bilateral Trade and Technological Distance

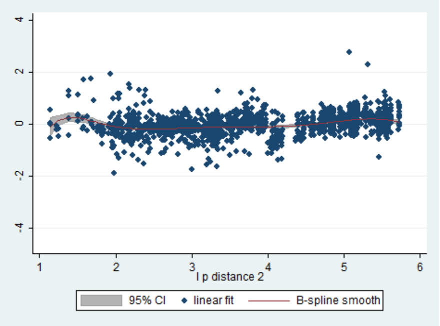


Part B: $Techdis2_{ijt}$

Parametric Estimates for the Gravity Model

| Variable | Coefficient | *t*-Statistic | *P*>\|*t*\| |
|---|---|---|---|
| $LGDP_{it}$ | .3125115 | 4.01 | 0.000 |
| $LGDP_{jt}$ | .8715184 | 9.12 | 0.000 |
| $LPOP_{it}$ | 1.095776 | 2.06 | 0.045 |
| $LPOP_{jt}$ | .6414335 | 0.93 | 0.355 |
| $Linder_{ijt}$ | –.0039786 | –0.21 | 0.837 |

Nonparametric Relationship between Bilateral Trade and Technological Distance



Source: Authors.

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 *knots*1 to show smoother quartic splines: (0(2)8) in Case I (table 1),

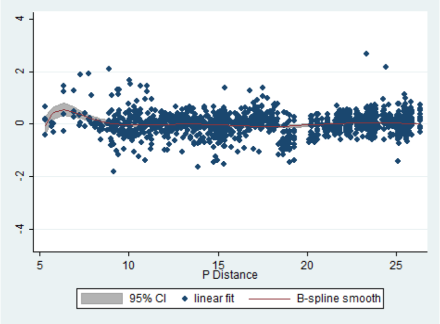
### Table 2 Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade Flows: Technological Distance Effect, Case II: (4 knots)

Part A: $Techdis1_{ijt}$

Parametric Estimates for the Gravity Model

| Variable | Coefficient | *t*-Statistic | $P>\|t\|$ |
|---|---|---|---|
| $LGDP_{it}$ | .3252278 | 4.23 | 0.000 |
| $LGDP_{jt}$ | .8841101 | 9.29 | 0.000 |
| $LPOP_{it}$ | 1.17505 | 2.22 | 0.015 |
| $LPOP_{jt}$ | .7095963 | 1.01 | 0.184 |
| $Linder_{ijt}$ | –.0069537 | –0.38 | 0.607 |

Nonparametric Relationship between Bilateral Trade and Technological Distance

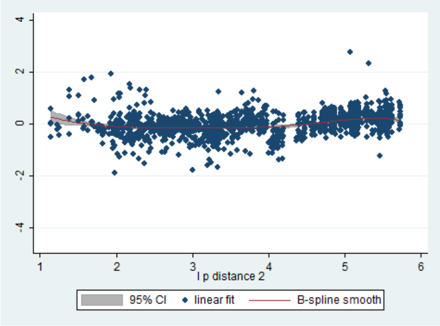


Part B: $Techdis2_{ijt}$

Parametric Estimates for the Gravity Model

| Variable | Coefficient | *t*-Statistic | $P>\|t\|$ |
|---|---|---|---|
| $LGDP_{it}$ | .3064307 | 3.84 | 0.000 |
| $LGDP_{jt}$ | .8666231 | 9.08 | 0.000 |
| $LPOP_{it}$ | 1.134433 | 2.13 | 0.039 |
| $LPOP_{jt}$ | .6600817 | 0.95 | 0.347 |
| $Linder_{ijt}$ | –.0014932 | –0.08 | 0.936 |

Nonparametric Relationship between Bilateral Trade and Technological Distance



Source: Authors.

(0(4)8) in Case II (table 2) and (0(6)8) in Case III (table 3), respectively. Charts in the tables sketch the average nonparametric fit of the technological distance variable ($Techdis_{ijt}$) in a linear dotted fit and a B-spline smooth.

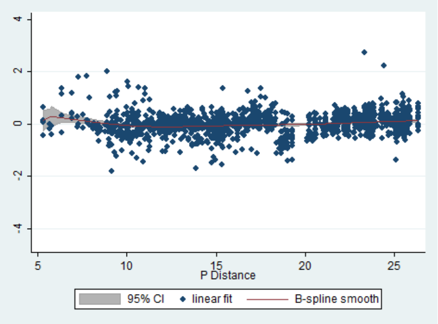
**Table 3 Estimation of Panel Semi-parametric Gravity Model for Bilateral Trade Flows: Technological Distance Effect, Case III: (6 knots)**

Part A: $Techdis1_{ijt}$

Parametric Estimates for the Gravity Model

| Variable | Coefficient | *t*-Statistic | *P*>\|*t*\| |
|---|---|---|---|
| $LGDP_{it}$ | .3168697 | 4.06 | 0.000 |
| $LGDP_{jt}$ | .8759162 | 9.22 | 0.000 |
| $LPOP_{it}$ | 1.125502 | 2.12 | 0.018 |
| $LPOP_{jt}$ | .6718475 | 0.97 | 0.192 |
| $Linder_{ijt}$ | –.0032775 | –0.17 | 0.766 |

Nonparametric Relationship between Bilateral Trade and Technological Distance

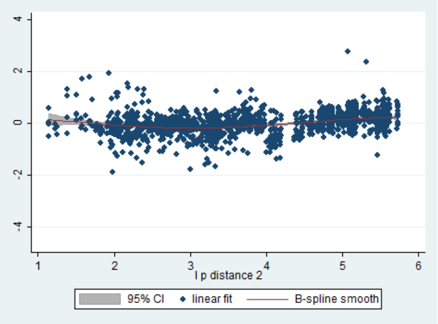


Part B: $Techdis2_{ijt}$

Parametric Estimates for the Gravity Model

| Variable | Coefficient | *t*-Statistic | *P*>\|*t*\| |
|---|---|---|---|
| $LGDP_{it}$ | .3059824 | 3.83 | 0.000 |
| $LGDP_{jt}$ | .8661744 | 9.12 | 0.000 |
| $LPOP_{it}$ | 1.138392 | 2.13 | 0.039 |
| $LPOP_{jt}$ | .66306 | 0.95 | 0.346 |
| $Linder_{ijt}$ | –.0016063 | –0.09 | 0.930 |

Nonparametric Relationship between Bilateral Trade and Technological Distance



Source: Authors.

As indicated by figures in each table, the relationship between technological distance and trade in the semi-parametric model differs within frequency of individuals (pair countries) depending on different technology levels. According to the results, for smaller levels of technological distance, trade flows catch a higher rate of growth for some Asian trading partners, the fact that has been shown by the vertical axis. The technological distance effects become more substantial while the larger gap of technology among partners leads to lower bilateral trade for some bilateral partners. However, in a deeper gap of technology (a higher level of technology distance), the results for trade are ambiguous, so that there is no specific distribution of export observations to be interpreted parametrically. Although a large number of knots are remained in the 95% confidence level, a decrease/increase in technological distance gives us an increase/decrease in 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

In this paper we explored that although the growing numbers of studies have tried to look at relationship between technology and bilateral trade relations, most of them only consider the parametric model, and they do not allow for nonparametric links between international trade and technology. Generally speaking, the core idea of this subject has relied on the fact that trade of goods and services flows between countries and regions in different environment of technologies.

Specified trade model has kept the interpretability of parametric effects of the gravity variables (such as GDP, population) and flexibility of effects arising from a nonparametric relationship between technological distance and trade flows in the case of the selected Asian countries. The empirical results shed the light specifically that in different levels of technology, Asian countries have followed different patterns of trade relations in the period under consideration (1996-2013). The implication is that countries with various levels of technology affect widely bilateral trade flows so that a low difference between technology levels in the selected Asian trading partners has led to an increase in trade flows, whereas a higher difference of technology brings more trade relations for some other partners. Asian less developed countries indeed need more technology and R&D importing from their more developed Asian partners that it can be as a result of spillover effects of trade expansion.

## REFERENCES

Anderson, James E., "A Theoretical Foundation for the Gravity Equation," *American Economic Review*, 69(1), 1979, pp. 106-116.

Arvanitis, Rigas, Wei Zhao, Haixiong Qiu, and Jian-niu Xu, "Technological Learning in Six Firms in Southern China: Success and Limits of and Industrialization Model," *International Journal of Technology Management*, 36(1-3), 2006, pp. 108-125.

Balassa, Bela, "Tariff Reduction and Trade in Manufactures among Industrial Countries," *American Economic Review*, 56(3), 1966, pp. 466-473.

Baltagi, Badi and Dong Li, "Series Estimation of Partially Linear Panel Data Models with Fixed Effects," *Annuals of Economics and Finance*, 3(1), 2002, pp. 103-116.

Bergstrand, Jeffrey H., "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence," *The Review of Economics and Statistics*, MIT Press, 67(3), 1985, pp. 474-481.

____________, "The Heckscher-Ohlin-Samuelson Model, the Linder Hypothesis and the Determinants of Bilateral Intra-industry Trade," *Economic Journal*, 100(403), 1990, pp. 1216-1229.

Bowen, Harry P., Edward E. Leamer, and Leo Sveikauskas, "Multicountry, Multifactor Tests of the Factor Abundance Theory," *American Economic Review*, 77(5), 1987, pp. 791-809.

Cameron, A. Colin and Pravin K. Trivedi, *Microeconometrics, Methods and*

*Applications*, Cambridge: Cambridge University Press, 2005.

Caves, Richard E., “Intra-Industry Trade and Market Structure in Industrial Countries,” *Oxford Economic Papers*, 33(2), 1981, pp. 203-223.

Chadha, Alka, “Product Cycles, Innovation and Exports: A Study of Indian Pharmaceuticals,” *World Development*, 37(9), 2009, pp. 1478-1483.

Cho, Taek-hee, Seong-Hoon Lee, and Young-Wan Goo, “Determinants of Imports of Petroleum-based Refinery Goods in South Korea: Network Structure and the Heckscher-Ohlin Theory,” *Korea and the World Economy*, 16(2), 2015, pp. 253-267.

Chor, Davin, “Unpacking Source of Comparative Advantage: A Quantitative Approach,” Working Papers, No. 13, Singapoure Management University, 2008.

Costinot, Arnaud, David Donaldson, and Ivana Komunjer, “What Goods Do Countries Trade? A Quantitative Exploration of Ricardo’s Ideas,” *Review of Economic Studies*, 79, 2012, pp. 581-608.

Davis, Donald R. and David E. Weinstein, “An Account of Global Factor Trade,” *American Economic Review*, 91(5), 2001, pp. 1423-1453.

Davis, Donald R., David E. Weinstein, Scott C. Bradford, and Kazushige Shimpo, “Using International and Japanese Regional Data to Determine When the Factor Abundance Theory of Trade Works,” *American Economic Review*, 87(3), 1997, pp. 421-446.

Deardorff, Alan V., “Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?,” in J. A. Frankel, ed., *The Regionalization of the World Economy*, The University of Chicago Press, 1998, pp. 7-32.

Eaton, Jonathan and Samuel Kortum, “Technology, Geography and Trade,” *Econometrica*, 70(5), 2002, pp. 1741-1779.

Eichengreen, Barry and Douglas A. Irwin, “The Role of History in Bilateral Flows,” in J. A. Frankel, ed., *The Regionalization of the World Economy*, University of Chicago Press, 1998, pp. 33-62.

Fagerberg, Jan Ernst, “International Competitiveness,” *Economic Journal*, 98(391), 1988, pp. 355-374.

____________, “Competitiveness, Scale and R&D,” in J. Fagerberg, P.

Hansson, L. Lundberg, and A. Melchior, eds., *Technology and International Trade*, Cheltenham, UK: Edward Elgar, 1997, pp. 38-55.

Fan, Jianqing and Qiwei Yao, *Nonlinear Time Series: Nonparametric and Parametric Method*, Springer Series in Statistics, New York: Springer-Verlag, 2003.

Filippini, Carlo and Vasco Molinin, “The Determinants of East Asian Trade Flows: A Gravity Equation Approach,” *Journal of Asian Economics*, 14(5), 2003, pp. 695-711.

Franz, Jared S., “Constructing Technological Distance from US Patent Data,” The Atlanta Conference on Science, Technology and Innovation Policy, Georgia Tech University, Atlanta, United States, IEEE Xplore Online Proceedings, 19-20 Oct, 2007.

Greene, William H., *Econometric Analysis*, 7th edition, New York: Prentice Hall, 2011.

Hakura, Dalia S., “Why does HOV Fail? The Role of Technological Differences within the EC,” *Journal of International Economics*, 54(2), 2001, pp. 361-382.

Hardle, Wolfgang, *Applied Nonparametric Regression*, New York: Cambridge University Press, 1990.

Hardle, Wolfgang, Marlene Muller, Stefan Sperlich, and Axel Werwatz, *Nonparametric and Semi-parametric Models*, Berlin: Springer-Verlag Berlin Heidelberg, 2004.

Henderson, Daniel J. and Daniel L. Millimet, “Is Gravity Linear?,” *Journal of Applied Econometrics***,** 23(2), 2008, pp. 137-172.

Hinze, Sybille, Thomas Reiss, and Ulrich Schmoch, “Statistical Analysis on the Distance between Fields of Technology,” *Innovation Systems and European Integration (ISE)*, Targeted Socio-Economic Research Program, 4th Framework Program of the European Commission (DGXII), 1997.

Hirsch, Seev, *Location of Industry and International Competitiveness*, Oxford: Clarendon Press, 1967.

Jaffe, Adam B., “Technological Opportunity and Spillovers of R&D: Evidence from Firms’ Patents, Profits, and Market Value,” *American Economic Review*, 76(5), 1986, pp. 984-1001.

Kang, G. Seong, “Is Korea Exploiting Its Trade Potentials in Africa?: Gravity Equation Analysis and Policy Implications,” *Korea and the World Economy*, 15(1), 2014, pp. 97-128.

Kim, Linsu, “The Dynamics of Technological Learning in Industrialization,” *International Social Science Journal*, 53(168), 2001, pp. 297-308.

Lall, Sanjaya, “Technological Capabilities and Industrialization,” *World Development*, 20(2), 1992, pp. 165-186.

____________, “The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-98,” *Journal Oxford Development Studies*, 28(3), 2000, pp. 337-369.

Leamer, Edward E., “The Leontief Paradox, Reconsidered,” *Journal of Political Economy*, 88(3), 1980, pp. 495-503 (reprinted in E. E. Leamer, ed., 2001, *International Economics*, New York: Worth Publishers, pp. 142-149).

Leitao, Nuno Carlos and Sabyasachi Tripathi, “Portuguese Trade and European Union: The Gravity Model,” MPRA Munich Personal RePEc Archive (http://mpra.ub.uni-muenchen.de/46000, MPRA Paper No. 46000, posted 9 April 2013).

Leontief, Wassily, “Domestic Production and Foreign Trade: The American Capital Position Re-examined,” *Proceedings of the American Philosophical Society*, 97, September 1953, pp. 332-349.

Libois, Francois and Vincenzo Verardi, “Semi-parametric Fixed Effect Estimator,” *Stata Journal*, 13(2), 2013, pp. 329-336.

Montobbio, Fabio and Francesco Rampa, “The Impact of Technology and Structural Change on Export Performance in Nine Developing Countries,” *World Development*, 33(4), 2005, pp. 527-547.

Newson Roger, “B-splines and Splines Parameterized by their Values at Reference Points on the x-axis,” *Stata Technical Bulletin*, 10(57), 2001, pp. 20-27.

Posner, Michael V., “International Trade and Technical Change,” *Oxford Economic Papers*, 13(3), 1961, pp. 323-341.

Poyhonen, Pentti, “A Tentative Model for the Volume of Trade between Countries,” *Weltwirtschaftliches Archive*, 90(1), 1963, pp. 93-100.

Racine, Jeffrey S., “Nonparametric Econometrics: A Primer,” *Foundation and Trends in Econometrics*, 3(1), 2008, pp. 1-88.

Rauch, James E., “Networks versus Markets in International Trade,” *Journal of International Economics*, 48(1), 1999, pp. 7-35.

Roper, Stephen and James H. Love, “Innovation and Export Performance: Evidence from the UK and German Manufacturing Plants,” *Research Policy*, 31(7), 2002, pp. 1087-1102.

Ruppert, David, M. P. Wand, and R. J. Carrroll, *Semi-parametric Regression Modelling*, New York: Cambridge University Press, 2003.

Stone, Joe A. and Hyun-Hoon Lee, “Determinants of Intra-Industry Trade: A Longitudinal Cross-Country Analysis,” *Review of World Economics* (*Weltwirtschaftliches Archive*), 131(1), 1995, pp. 67-85.

Stuart, Toby E. and Joel M. Podolny, “Local Search and the Evolution of Technological Capabilities,” *Strategic Management Journal*, 17(S1), 1996, pp. 21-38.

Tinbergen, Jan, “An Analysis of World Trade Flows,” in J. Tinbergen, ed., *Shaping the World Economy*, New York, NY: Twentieth Century Fund, 1962, pp. 20-42.

Torstensson, Johan, “Technical Differences and Inter-Industry Trade in the Nordic Countries,” *Scandinavian Journal of Economics*, 98(1), 1996, pp. 93-110.

Trefler, Daniel, “International Factor Price Differences: Leontief Was Right?,” *Journal of Political Economy*, 101(6), 1993, pp. 961-987.

____________, “The Case of Missing Trade and Other Mysteries,” *American Economic Review*, 85(5), 1995, pp. 1029-1046.

Vernon, Raymond, “International Investment and International Trade in the Product Cycle,” *Quarterly Journal of Economics*, 8(4), 1966, pp. 190-207.

Wakelin, Katharine, *Trade and Innovation, Theory and Evidence*, Cheltenham, UK: Edward Elgar, 1997.