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ABSTRACT

Education, Governance, and Trade- and Distance-Related Technology Diffusion: Accounting for the Latin America-East Asia TFP Gap, and the TFP Impact of South America's Greater Distance to the North*

This paper examines the impact of education, governance and North-South trade- and distance-related technology diffusion on TFP in the South, focusing on South America (SA), Mexico, Latin America (LA) and East Asia for the 32-year period preceding the Great Recession (1976–2007) in a new model that integrates models of trade-related and distance-related international technology diffusion. Our model's explanatory power is 38% (62%) greater than that of the main trade-related (distance-related) model. Findings are: i) TFP increases with education, trade, governance (ETG) and imports' R&D content, and declines with distance to the North; ii) an increase in LA's ETG to East Asia's level raises LA's TFP by some 100% and accounts for about 75% of its TFP gap with East Asia; iii) raising LA's education to East Asia's level has a larger impact on TFP and on the TFP gap than raising governance or openness; iv) the TFP impact on South America relative to Mexico due to its greater distance to US-Canada (Europe) (Japan) is -18.9 (-2.13) (-9.78)%, with an overall impact of -12.4%.

JEL Classification: F13, I25, O19, O47

Keywords: education, governance, trade, distance, technology diffusion, productivity impact, Latin America, East Asia

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* We would like to thank Magali Pinat, David Tarr and participants at various seminars for their helpful comments, and Wei Jiang of Nankai University for excellent research assistance.

Introduction

Economic growth in Hong Kong, Singapore, South Korea and Taiwan (referred to as East Asia) took off in the 1960s, with an annual rate averaging over five percent in 1960-2008. East Asia's per capita income relative to the US increased from around 15 percent in 1960 to over 70 percent in 2010, while that of Latin America (LA) remained at around 30 percent over that period. Thus, per capita income in LA, which was double that of East Asia in 1960, fell to 42.8 percent of East Asia's income by 2010 (World Bank 2011, pp. 22-23), a relative decline of nearly 80 percent.

A large number of studies have examined the causes of the relative decline of LA and found that productivity differences across countries played an important role in explaining differences in their economic performance. For instance, Cole et al. (2005) find that LA's low total factor productivity (TFP) explains its poor economic performance, with the low level of TFP due mainly to high barriers to competition – including trade barriers – rather than to a low level of human capital. Similarly, Kydland and Zarazaga (2002) find that Argentina's poor economic performance in the 'lost decade' of the 1980s was mainly due to the decline in its TFP. Given its importance for economic performance, this paper's focus is on TFP and its determinants.

This study contributes to the literature on the TFP impact of trade-related North-South technology diffusion (discussed in Section 2) by: i) incorporating the impact of distance between countries in the North and the South on technological diffusion and TFP, ii) using three specifications of trade-related and distance-related technology diffusion – together with human capital and governance – and testing for which one performs best; and iii) using the preferred specification to examine the impact of differences between East Asia and LA (as well as Mexico and South America) in trade openness, human capital and governance on LA's TFP, as well as the extent to which these differences account for the gap between LA's and East Asia's TFP.

This paper is an updated version of Schiff and Wang, June 2017, with some new results:

* TFP rises with education, trade, governance (ETG) and falls with North-South distance;

* An increase of LA's ETG to East Asia's level raises LA's TFP by some 100 percent and accounts for about 75 percent of its TFP gap with East Asia;

* The TFP impact on South America relative to Mexico due to its greater distance to US-Canada (Europe) (Japan) is −18.9 (−2.13) (−9.78) percent, with an overall impact of −12.4 percent.

The paper is organized as follows. Section 2 presents the empirical framework, which comprises three technology diffusion specifications. Section 3 describes the data and data sources, and Section 4 discusses some initial findings derived from it, with Section 5 providing the empirical results. Section 6 first describes a robustness test, as well as a 'nesting' test, in order to determine the preferred specification, and then examines the impact on TFP in LA (as well as in Mexico and South America) when LA's explanatory variables are equal to the East Asia ones. Section 7 concludes.

2. Empirical Model

Our empirical analysis draws on the seminal work on trade-related technology diffusion by Coe and Helpman (1995), which is described below. It constitutes our first approach. An alternative model of technology diffusion that incorporates the impact of distance but abstracts from trade was set out by Keller (2002). He found that technology's impact on productivity declines with the distance between the technology source and recipient countries. This paper develops a third model which integrates the Coe and Helpman (1995) and Keller (2002) specifications of the technology diffusion process. This enables us to examine the impact of both North-South trade-related and distance-related technology diffusion on TFP in the South. We also provide a test to determine which of the three models is the preferred one and conduct various simulations.

Coe and Helpman (1995) construct an index of 'foreign R&D', defined as the trade-weighted sum of trading partners' R&D stocks, and find for developed OECD countries that it has a large and significant impact on TFP, so that TFP increases with the economy's openness. Other studies have obtained similar results.[1]

2.1. Measures of "foreign R&D" and estimation equation

The North consists of the G7 countries where most of the R&D is generated.[2] The R&D produced in other developed countries is mostly absorbed by the G7 countries through direct and

[1] These include Coe et al. (1997) who examine the impact of North-South trade-related technology diffusion on TFP in the South, Falvey et al. (2002), Zhu and Jeon (2003), and Lumenga-Neso et al. (2005) who introduce trade's "indirect" impact on technology diffusion and TFP. Also, Coe et al. (2008) expand on Coe and Helpman (1995) by using co-integration in their empirical analysis, and Schiff and Wang (2006, 2008) who conduct industry-level analyses of North-South and (indirect) South-South trade-related technology diffusion.

[2] The G7 accounted for 86 percent of developed countries' 2010 R&D expenditures (OECD).

indirect trade-related technology diffusion (Lumenga-Neso et al., 2005). The measures of foreign R&D are denoted by NRD_{ij}, where i indexes the developing countries, and $j = 1, 2, 3$ indexes the three NRD measures, which are as follows.

Model 1: Linear Trade-Weighted R&D

The measure for country i in this model is:

$$NRD_{i1} = \sum_k RD_{ik1} = \sum_k \left(\frac{M_{ik}}{VA_i}\right) RD_k \quad (1)$$

where k indexes G7 countries, M_{ik} is country i's imports from country k, RD_k is the stock of R&D in country k, and VA_i is GDP in country i.

Equation (1) says that, for any country i, NRD_{i1} is the sum, over all G7 countries k, of the R&D stock of country k weighted by the ratio of imports from country k to country i's GDP. This measure abstracts from the impact of distance on TFP.

Model 2: Non-Linear Distance-Corrected R&D

Keller (2002) specified a measure of foreign R&D that includes the distance, $Dist$, between technology source and recipient countries but excludes trade. His measure of NRD is:

$$NRD_{i2} = \sum_k RD_{ik2} = \sum_k RD_k * e^{-\delta.Dist_{i,k}}. \quad (2)$$

Note that Keller does not specify the channel or channels through which technology diffusion takes place. Rather, his focus is on the impact of distance, with $\delta > 0$ indicating that the impact of G7 R&D stocks on importing countries' TFP declines with their distance from the G7 countries.

Model 3: Non-Linear Trade-Weighted Distance-Corrected R&D

This paper contributes to the analysis of trade-related technology diffusion by integrating the two models (1) and (2) above. Specifically, we set forth a model that includes both distance and trade, namely:

$$NRD_{i3} = \sum_k RD_{ik3} = \sum_k \left(\frac{M_{ik}}{VA_i}\right) * RD_k * e^{-\delta.Dist_{i,k}}, \quad (3)$$

Equation (3) says that foreign R&D in country i increases with its G7 trading partners' R&D stocks, RD_k, increases with its openness to trade $\frac{M_{ik}}{VA_i}$, and declines with its distance, $Dist_{i,k}$, from the G7 trading partners (assuming $\delta > 0$).

We have three estimation equations, one for each value of j ($j = 1, 2, 3$):

$$\log(TFP_{it}) = \alpha + \beta \log\left(NRD_{ijt}\right) + \beta^{Edu} * Edu_{it} + \beta^{Gov} * Gov_{it} + \sum_i \gamma_i D_i + \sum_t \gamma_t D_t + \varepsilon_{it} \quad (4.j)$$

where NRD_{i1t}, NRD_{i2t} and NRD_{i3t} are defined, respectively, in equations (1), (2) and (3) above, Edu_{it} is country i's educational attainment, Gov_{it} is a governance index, D_i (D_t) is a country (time) fixed effect, and ε is an error term. The governance index is described in Section 3.

Due to a lack of data and following other studies on North-South trade-related technology diffusion, developing countries' domestic R&D is excluded. We did use a related measure, namely the annual number of the developing countries' US patent applications, but the variable was not significant in any of the specifications and had a negligible impact on the results.

2.2. Education and Governance

A large number of studies have examined the relationship between education and economic development (e.g., Engelbrecht 2003; Hanushek and Woessmann 2010; Lucas 1988; Meulemeester and Rochat 1995; Schultz 2010; etc.). This paper examines the impact of education on developing countries' productivity.

The literature on the role of institutions in countries' development is vast (e.g., Acemoglu et al., 2001; Engerman and Sokoloff, 1997, 2000; Knack and Keefer 1995; North, 1988; etc.). This study contributes to the literature on the role of institutions in the development process by examining the impact of governance on TFP in a trade- and distance-related technology diffusion framework. The governance index and education measure used here are described in Section 3.

3. Data Description

The data cover seven industrialized OECD or G7 countries (the G7) and 28 developing countries and over the 32-year period 1976 – 2007, the period up to but excluding the Great Recession. The G7 countries are split into three groups: United States and Canada (USC) in North America;

France, Germany, Italy and the United Kingdom in Europe; and Japan. This enables us to conduct a more careful examination of the impact of distance on TFP. The 28 developing countries are collected into four groups: 1) Hong Kong (China), Singapore, and South Korea in East Asia;[3] 2) Bolivia, Chile, Colombia, Ecuador, Peru, Uruguay and Venezuela in South America; 3) Mexico; and 4) a group of seventeen "Other Countries": Bangladesh, India, Nepal, Pakistan and Sri Lanka in South Asia; Indonesia, Malaysia and the Philippines in South-East Asia; Cameroon, Kenya and Malawi in Sub-Saharan Africa; Morocco and Tunisia in North Africa; and Egypt, Jordan, Kuwait and Turkey in the Middle and Near East.

The $\log(TFP)$ index is the difference between the logs of value-added and primary factor use, with the inputs weighted by their income shares, i.e., $\log(TFP) = \log(Y) - \alpha\log(L) - (1-\alpha)\log(K)$, where α is the labor share, defined as the ratio of the wage bill to value added. Fixed capital formation used to construct capital stocks, value added, labor and wages, is from the World Bank database (Nicita and Olarreaga 2007), all reported in current US dollars at the 3-digit ISIC codes (Revision 2) and deflated by the US GDP deflator (1991 = 100).

Capital stocks are derived from the deflated fixed capital formation series using the perpetual inventory method with a 5 percent depreciation rate, and R&D stocks are constructed from R&D expenditures using the same method with a 10 percent depreciation rate. R&D expenditure for the G7 countries is taken from OECD ANBERD, with ISIC Revision 2 (2002) covering data from 1973 to 1998 and ISIC Revision 3 (2006) covering data from 1987 onward. Since the two datasets have 12 overlapping years, we are able to match the two data sets.

The governance index is from Kaufmann et al. (2010). It consists of an average of six governance indicators and ranges between – 2.5 and 2.5.[4] distance is defined as the shortest distance between countries' capitals and is measured in thousands of kilometers.

Secondary school completion ratio for population aged 15+ and above is obtained by annualizing the five-year averages in Barro and Lee (2010).[5]

[3] Taiwan is excluded due to lack of data (not a member of international organizations collecting the relevant data).
[4] The six indicators in Kaufmann et al. (2010) are: Control of Corruption, Rule of Law, Political Stability, Absence of Violence/Terrorism, Government Effectiveness, and Regulatory Quality. They are based on 30 underlying data sources reporting the perceptions of governance of a large number of survey respondents and expert assessments worldwide. We ran a regression of Governance on a number of variables and extrapolated to early years where data are missing.

Bilateral trade data of the 28 developing countries with the G7 industrialized OECD countries at the 4-digit ISIC 2 level are from World Bank data (a description is in Nicita and Olarreaga 2007). We construct bilateral trade shares for each year and for each of the 28 developing countries with respect to each of the G7 OECD countries, and these are then used to construct the various NRD measures, as defined in equations (1), (2) and (3).

Due to missing observations, our sample is unbalanced. It has 32 panels, with 1750 observations.

4. Initial look at the data: What do they say?

Tables 1 shows the average level for the period 1976-2007 of log(TFP), governance, education and trade openness, for the four regions of interest. Figures for groups of countries are weighted averages.

Table 1: Mean of Key Variables by Region, 1976-2007 [a]
(weighted average)

Region	log TFP	Governance [b]	Educational Attainment (%) [c]	M/GDP [d]
East Asia	2.93	.535	45.8	.60
South America	1.88	.054	26.2	.30
Mexico	2.10	-.269	24.3	.37
Latin America (LA) [e]	2.04	-.027	25.7	.33

a: Variables are defined in Section 3; *b* (*c*): Regional average is weighted by GDP (population); *d*: Imports/GDP; *e*: Latin America consists of Mexico and South America.

East Asia’s average log(TFP) in 1976-2007 is 2.93 or 40 percent higher than Mexico’s 2.10, 56 percent higher than South America’s 1.88, and 46 percent higher than LA’s 2.04. East Asia also

[5] We matched the few countries not included in Barro and Lee’s dataset with those included, using indicators such as real GDP per capita, government expenditure on education as a share of GDP, and more.

has the highest governance level, with an average of .535, followed by South America (.054) and Mexico (-.269). The value for LA is -.027.[6]

Educational attainment (the percent of the population aged 15 and above with a high school degree) is highest in East Asia (45.8), followed by South America (26.2) and Mexico (24.3). The value for LA is 25.2. Thus, the educational attainment gap between East Asia and LA is 20.6 percentage points.

As for trade flows, we find that the share of trade in GDP is .60 for East Asia and .30 (.37) (.33) for South America (Mexico) (LA). The US and Japan were the main G7 trading partners of LA and East Asia over the period. The US (Japan) accounted on average for 38 (5.5) percent of LA's imports and 15 (22) percent of East Asia's imports.

5. Empirical Results

This section first addresses two econometric issues. Studies in the trade-related technology diffusion literature, including Coe and Helpman (1995), have estimated the linear equation (4.1) by OLS. The only exception we are aware of is Coe et al. (2008) who used panel co-integration estimation. They use the same data as in the OLS-estimated Coe and Helpman (1995) paper to estimate (4.1) and obtain similar results. Based on these results and following the literature, (4.1) is estimated by OLS.

Second, Keller (2002) estimated a version of (4.2) by non-linear least-squares. Following Keller's approach, we estimate both equations (4.2) and (4.3) – with NRD_{i2} and NRD_{i3}, respectively – by non-linear least squares. Estimation results for (4.1), (4.2) and (4.3) are presented in columns (1), (2) and (3) of Table 2, respectively.

Column (1) shows a positive impact on log(TFP) of log(NRD_{i1}), education and governance (the first coefficient is an elasticity and the latter two are semi-elasticities), whose values are, respectively, .325, .0219 and .587, all significant at the 1 percent level. In fact, coefficients with a t-value above 3.291 are significant at the 0.1 percent level. The adjusted R^2 is .66.

[6] Some other results (not shown) are as follows: Singapore's average governance level is 1.543, the highest among the 28 sample countries, Hong Kong's is .636, and South Korea's is .327. At .981, Chile has the second highest governance among the sample countries. And at -.904, El Salvador's has the lowest value. The latter is essentially due to the very high level of violence over the period.

Table 2: Linear and Non-linear Estimation, 1976-2007.
(Dependent Variable: log TFP) $^{a,\,b}$

	Linear	Non-linear (Excludes trade)	Non-linear (Includes trade)
	(1)	(2)	(3)
β	.325***	.234**	.280***
	(8.84)	(2.44)	(9.18)
δ	——	.722***	.760***
		(3.02)	(13.74)
β^{Gov}	.587***	.568***	.536***
	(6.30)	(6.21)	(6.47)
β^{Edu}	.0219***	.0232***	.0221***
	(3.54)	(3.19)	(3.32)
Year fixed effect	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes
$adj-R^2$	.66	.58	.91
N	1750	1750	1750

a: *t* statistics in parentheses;
b: significance level: *** $p < .01$, **: $p < .05$.

Column (2) also shows a positive impact of $\log(NRD_{i2})$, education, governance and distance, with coefficients (significance levels) equal to, respectively, .234 (5%), .0232 (1%), .568 (1%), and .722 (1% level), and with an adjusted R^2 of .58.

A positive δ indicates that distance has a negative impact on TFP (see equations (2) and (4.2)). The result on the negative impact of distance on TFP is supported by Keller (2002) who estimated the impact on TFP of North-North technology diffusion in a (4.2)-type equation and similarly found distance to have a negative impact on TFP.

In column (3), the impact on log(TFP) of $\log(NRD_{i3})$, education, governance and distance are, respectively, .280, .0221, .536, and .760, all significant at the 1 percent level. Thus, distance also has a negative impact on TFP in this specification. The adjusted R^2 is equal to .91, which is higher by 25 (33) percentage points than the adjusted R^2 in column (1) ((2)).

Existing studies on North-South trade-related technology diffusion have estimated versions of (4.1) and have ignored North-South distance as one of the determinants of the South's TFP, Keller (2002) being an exception. Our results suggest that this has resulted in a significantly worse goodness of fit (and has affected regression coefficients). The model developed in this paper contributes to the literature by integrating two approaches – i.e., the trade-related and distance-related technology diffusion ones – whose explanatory power (adjusted R^2) is 25 percentage points higher than that of (4.1).

6. Simulation

Before turning to the results, we must select one of the three equations for the simulations. We conduct two F-tests based on the fact that (4.1) and (4.2) are nested in equation (4.3). The objective is to ascertain whether including both distance and trade (in 4.3) improves the results in a statistically significant way relative to (4.1) and (4.2). The F-test value was compared to the critical value, F^*, in the F-distribution table.[7] We found that $F > F^*$ in both cases (at the 1 percent level). Thus, the hypothesis that (4.3) is the preferred one cannot be rejected.[8] Moreover, as noted above, the adjusted R^2 in (4.3) is .91, which is 25 percentage points above the .66 value for (4.1) and 33 percentage points above the .58 value for (4.2). Hence, (4.3) is our preferred equation and is selected for the simulations.

[7] The test is as follows. The value for the F-statistic is $F = \frac{(SSR_j - SSR_3)/m}{SSR_3/v}$ $(j = 1, 2)$, where SSR_j (SSR_3) is the sum of squared residuals for equation (4.j) ((4.3)), m ($m + p$) is the number of variables in equation (4.j) ((4.3)), and $v = n - (m + p + 1)$. Selecting a level of significance α, the value of F is compared to that of $F^*(\alpha, p, v)$. Both hypotheses are rejected as $F > F^*$ at .01 level.

[8] We tested for the robustness of the results of (4.1), (4.2) and (4.3) using both a 5% and a 15% R&D stock depreciation rate instead of the 10% rate. The impact on the results was negligible in both cases.

We examine what TFP would have been in South America, Mexico and LA, if governance, education and trade openness had been equal to those in East Asia, and the extent to which the difference in the levels of these variables explains their TFP gap with East Asia. Results are found in Table 3.

We also examine South America's TFP loss relative to Mexico due to its greater distance from the three G7 groups (US and Canada or USC; France, Germany, Italy and the UK in Europe; and Japan). The results are presented in Table 4. Values in Tables 3 and 4 are averages over the sample period.

6.1. Governance

The value of the governance coefficient in (4.3) is .536. Average governance is –.027 for LA and .535 for East Asia, with a gap of .562. Raising LA's governance to Asia's level raises its TFP by .536*.562 = .308, i.e., by 30.8 percent. This amounts to a reduction in LA's TFP gap with East Asia of 23.1 percent. The same logic applies to all the other simulations. Thus, raising governance from South America's (Mexico's) level to that of East Asia raises TFP by 25.6 (46.1) percent, which accounts for 19.1 (34.6) percent of the gap in TFP.

6.2. Education

The coefficient for education is .0221, i.e., a one-percentage point increase in education raises TFP by 2.21 percent. LA's (South America's) (Mexico's) average level of education over the period 1976-2004 is 25.7 (26.2) (24.3), while that of East Asia is 45.8, with a gap equal to 20.1 (19.6) (21.5), and the impact on TFP of increasing education to East Asia's level is equal to 44.4 (43.3) (47.5) percent, which accounts for 33.5 (32.5) (35.8) percent of the TFP gap.

6.3. Trade

TFP's elasticity with respect to NRD is .285, which is close to the .29 value obtained by Coe and Helpman (1995). Raising LA's (South America's) (Mexico's) import-to-GDP ratio to East Asia's level raises TFP by 23.3 (27.5) (11.6) percent, which accounts for 17.5 (20.6) (8.7) percent of the TFP gap.

6.4. Total Impact of Governance, Education and Trade

An increase in education, governance and trade to East Asia's level raises TFP in South America (Mexico) (LA) by 96.4 (105.2) (98.5) percent, which accounts for 72.2 (79.1) (74.1) percent of the TFP gap with East Asia. Thus, the difference between LA and East Asia in the levels of education, governance and trade accounts for about three quarters of the gap in their TFP.

Table 3: Change in South America's and Mexico's Governance, Education and Trade to East Asia Level: Impact on TFP (in %)

Variable	Region	Increase in TFP	Decrease in TFP Gap
1. *Governance*	South America vs. East Asia	25.6	19.1
	Mexico vs. East Asia	46.1	34.6
	LA[a] vs. East Asia	31.2	23.1
2. *Education*	South America vs. East Asia	43.3	32.5
	Mexico vs. East Asia	47.5	35.8
	LA[a] vs. East Asia	44.4	33.5
3. *Trade*	South America vs. East Asia	27.5	20.6
	Mexico vs. East Asia	11.6	8.7
	LA[a] vs. East Asia	23.3	17.5
4. *Sum of 1, 2, 3*	South America vs. East Asia	96.4	72.2
	Mexico vs. East Asia	105.2	79.1
	LA[a] vs. East Asia	98.9	74.1

a: LA = Mexico + South America; *b*: USC = US + Canada.

6.5. Distance

This section examines the impact on the TFP of South America (SA) of being farther than Mexico from each of the three G7 country groups g ($g = 1, 2, 3$), which consist of: 1) the US and Canada (USC), 2) Europe (France, Germany, Italy, UK), and 3) Japan.

Results are shown in Table 4. The average distance from South America's eight sample countries to USC is 1.89 times that from Mexico to USC,[9] with corresponding figures of 1.10 for the distance to Europe, and 1.46 for that to Japan.[10] From equation (4.3), the elasticity of TFP with respect to distance, ε, is $\varepsilon = -\beta\delta$. With $\beta = .280$ and $\delta = .760$, we have $\varepsilon = -.213$.

The difference between South America's and Mexico's TFP due to the former's greater distance from G7 country group g, is $\Delta TFP_g = \frac{TFP_{SA-g}}{TFP_{Mex-g}} - 1 = -\beta\delta\left(\frac{DIST_{SA-g}}{DIST_{Mex-g}} - 1\right)$. For USC, we have $\Delta TFP_{USC} = -\beta\delta\left(\frac{DIST_{SA-USC}}{DIST_{Mex-USC}} - 1\right) = -.213 * .89 = -.189$ or -18.9 percent; the impact for Europe is $\Delta TFP_{EU} = -.213 * .1 = -.0213$ or -2.13 percent, and for Japan, we have $\Delta TFP_{JA} = -.213 * .46 = -.0978$ or -9.78 percent.

Table 4: South America's Greater Distance to the G7 Relative to Mexico: Impact on TFP (in %)

South America – USC [a] vs. Mexico – USC [a]	- 18.90
South America – Europe vs. Mexico – Europe	- 2.13
South America – Japan vs. Mexico – Japan	- 9.78
South America – G7 vs. Mexico – G7	- 12.42

a: USC = US + Canada.

To obtain the overall impact on South America's TFP due to its greater distance to the three G7 country groups relative to Mexico, the impact above, ΔTFP_g, associated with each country group

[9] Distance is defined as the geodesic distance between capital cities.

[10] The small difference in distance to Europe and the much larger one to Japan is due to the fact that i) Mexico is North of South America – which reduces its distance to *both* Europe and Japan – but ii) it is also further West, which raises (reduces) its distance to Europe (Japan). Hence, these two location characteristics have opposite effects on the relative distance to Europe but have reinforcing effects on the distance to Japan

g has to be weighted by $\omega_{SA-g} \equiv \frac{\left[\left(\frac{M_{SA-g}}{VA_{SA}}\right)RD_g\right]}{\sum_g\left(\frac{M_{SA-g}}{VA_{SA}}\right)RD_g}$, $\sum_g \omega_{SA-g} = 1$, $g = 1, 2, 3$. Thus the overall impact $\Delta TFP_{SA} = -\sum_g \omega_{SA-g} * \Delta TFP_g = -\beta\delta * \sum_g \left[\omega_{SA-g} * \left(\frac{DIST_{SA-g}}{DIST_{Mex-g}} - 1\right)\right]$. Based on South America's trade-to-GDP ratio with, and R&D level in, each of the three G7 country groups, we find that $\Delta TFP_{SA} = -12.4$ percent.

7. Conclusion

This paper examined the impact on total factor productivity (TFP) in the South of education, governance, North-South trade and North-South distance – the latter two working through their impact on North-South technology diffusion. The analysis focused on East Asia and Latin America (LA). The literature has examined either a trade-related or a distance-related knowledge diffusion mechanism and their impact on TFP. We introduced a new mechanism that combines both the trade-related and distance-related ones. The latter significantly improved the goodness of fit of the TFP estimation equation compared to those with only trade or distance as variables affecting technology diffusion and was therefore used in the simulations of the impact in Latin America (and its sub-regions) on TFP of raising the level of its determinants to their level in East Asia. It was further used in the analysis of the impact on TFP in South America of being located farther than Mexico from the three G7 country groups.

The main findings are:

i) TFP increases with openness to trade, education, governance and imports' R&D content, and declines with distance;

ii) An increase in trade, governance and education to the East Asia level raises TFP in Latin America by about 100 percent, which accounts for about three quarters (74.1 percent) of its TFP gap with East Asia; and

iii) The TFP loss for South America relative to Mexico due to its greater distance to 'US and Canada' (Japan) (Europe) is 18.9 (9.8) (2.1) percent, with a loss with respect to the G7 as a whole of 12.4 percent.

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