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IZA DP No. 10843

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Maurice Schiff
IZA Research Fellow

Yanling Wang
Carleton University

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Education, Governance, Trade and Distance: Impact on Technology Diffusion and the East Asia-Latin America Productivity Gap*

This paper examines the impact of education, trade, governance and distance on technology diffusion and TFP in Latin America – specifically South America and Mexico (SAM) – and East Asia, over the 32 years preceding the Great Recession (1976–2007). Findings are: i) TFP rises with education, trade, governance (ETG) and trade's R&D content, and falls with distance to the (closest) North; ii) the East Asia – SAM education gap's impact equals that of trade plus governance; iii) an increase in SAM's ETG to East Asia's level raises TFP by over 100 percent and fully accounts for its TFP gap with East Asia; and iv) South America's TFP loss relative to Mexico due to its greater distance to 'US–Canada' (Europe and Japan) is 9.30 (0.02) percent.

JEL Classification: F22, J61

Keywords: East Asia and LAC, technology diffusion, productivity, education, trade, governance, distance

Corresponding author:
Maurice Schiff
E-mail: schiffmauricewilly@gmail.com

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

NON-TECHNICAL SUMMARY

Developing East Asia's 1960–2008 annual growth averaged 5.5 percent, with per capita income rising from 15% to over 70% of US income. On the other hand, Latin America's income has averaged about 30% of US income since 1900, i.e., it was twice East Asia's income in 1960 but only 36% in 2008, amounting to a relative decline of 82 percent.

This paper tries to explain the productivity gap between these regions by examining the impact of education, governance, trade and distance on technology diffusion and productivity. The analysis shows that:

i) raising Latin America's level of education, governance and trade to that of East Asia raises Latin America's productivity to East Asia's level;

ii) the increase in education has an impact on productivity that equals the sum of the impacts of raising trade and governance;

iii) the greater distance from South America to the US and Canada (USC) than from Mexico to USC reduces South America's productivity relative to Mexico's by 9.3%.

Thus, taking the productivity gain of raising education, governance and trade into account in policy formulation should be beneficial for Latin America.

1. Introduction

East Asia's 1960-2008 annual growth averaged 5.5 percent, with (per capita) income rising in 1960-2010 from 15 to over 70 percent of US income. LAC's (Latin America and Caribbean's) income has averaged about 30 percent of US income since 1900, or 200 (36) percent of East Asia's income in 1960 (2010), a relative decline of 82 percent (World Bank 2011).

This paper draws on Schiff and Wang (2017) – henceforth S-W – which reviews East Asia's economic growth studies and the trade-related technology diffusion literature[1] initiated by Coe and Helpman (2005), and provides a more detailed analysis of theory, data, empirics and results.[2] We examine the impact on the manufacturing sector's TFP of North-South technology diffusion**,** education, trade, governance and distance, and the extent to which gaps in these variables between East Asia and SAM (South America and Mexico) can account for their TFP gap. The paper is organized as follows. Section 2 presents the estimation equation and data. Section 3 provides the empirical results. Section 4 examines the TFP impact of i) changing explanatory variables from SAM to East Asia levels, and ii) South America being further away from G7 countries than Mexico. Section 5 provides some policy implications and Section 6 concludes.

2. Estimation Equation and Data

We use two measures of 'foreign R&D' for country i, denoted by RD_{ij}, $j = 1, 2$, namely: 1) Coe et al.'s (1997) North-South trade-weighted sum of developed trading partners' R&D; and 2) a combination of that measure and Keller's (2002) distance-weighted measure.

[1] This literature examined the TFP impact of North-North or North-South trade-related technology diffusion, while Schiff and Wang (2006) did so for both North-South and South-South trade.

[2] Alwyn Young (1995) famously argued that the growth gap between East Asia and the OECD was due to factor accumulation, not productivity growth. However, the comparison was made across different periods: all OECD observations are in the pre-1974 high-global-growth, high-productivity-growth period while less than a third of East Asia's 1966-1990 observations are (growth in 1966-73: 5.4%; 1973-1990: 3.2%). This biased the results, favoring accumulation over productivity.

The measures of foreign R&D are denoted by RD_{ij} $(j = 1, 2)$:

1) $RD_{i1} = \sum_k s_{ik} RD_{ik1} = \sum_k s_{ik} \left(\frac{M_{ik}}{VA_i}\right) RD_k$, where k indexes G7 countries, weight s_{ik} is the share of country k in country i's imports, and VA_i is manufacturing sector's value added in i; and

2) $RD_{i2} = \sum_k s_{ik} RD_{ik2} = \sum_k s_{ik} \left(\frac{M_{ik}}{VA_i}\right) RD_k * e^{-\delta . Dist_{i,k}}$, where $Dist$ is the distance between developing and G7 countries.

The North consists of three G7 groups: France, Germany, Italy and UK; Japan; and US and Canada (USC).[3]

We have two estimation equations:

$$\log(TFP_{it}) = \alpha + \beta \log(RD_{ijt}) + \beta^{Edu} * Edu_{it} + \beta^{Gov} * Gov_{it} + \sum_i \gamma_i D_i + \sum_i \gamma_t D_t + \varepsilon_{it}, \quad (j = 1, 2)$$

where Edu is education, Gov is governance, D_i (D_t) is a country (time) fixed effect, and ε is an error term.

Equation (1) represents Coe et al.'s approach, and equation (2) is the combination of Coe et al.'s and Keller's approaches. Education is secondary school completion ratio for population aged 15 and above (Barro and Lee, 2010), with quinquennial values annualized using a constant growth rate. Due to lack of data and following existing studies, developing countries' domestic R&D is excluded. Estimation was also conducted with developing countries' number of patent applications but the variable was not significant and had negligible impact on results.

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

Equation (2) has, to our knowledge, never been estimated. Estimation is by OLS. We did perform an IV estimation but it did not improve the results (explanations are provided in S-W). The information below is also elaborated there.

Data cover the G7 and 29 developing countries for 1976-2007, i.e., up to the Great Recession. Developing countries are Mexico and four country groups: East Asia has four countries (Hong Kong, Singapore, South Korea, Taiwan), South America seven, South-East Asia three, and "Others" (in South Asia, Africa, and Middle and Near East) fourteen. TFP is obtained from $\ln(TFP) = \ln(Y) - \alpha \ln(L) - (1-\alpha)\ln(K)$, where α is labor share. Capital (R&D) stock in South (G7) is obtained from investment (R&D expenditures), using the perpetual inventory method with 5 (10) percent depreciation. R&D expenditures are from OECD ANBERD, ISIC Revision 2 for 1973-1998 and Revision 3 for 1987 onward. Governance is an average of six indicators, ranging from – 2.5 to 2.5, from Kaufmann et al. (2011). Bilateral trade between the developing and G7 countries is from Nicita and Olarreaga (2007).

Table 1 shows East Asia has the highest values for log(TFP), governance, education, and imports/GDP. Its log(TFP) (education) (M/GDP) value is 44 (78) (82) percent above SAM's.

3. Empirical Results

Table 3 presents estimation results for equations (1) and (2). All coefficients are positive and significant at the one percent level. Adjusted R^2 is .66 in (1) and .91 in (2), suggesting (2) is the superior specification. Robustness tests were performed (e.g., with different depreciation rates for capital and R&D), with little impact on the results (see S-W). An *F*-test was also performed,

showing that (2) significantly improves estimation results relative to (1). Thus, our preferred regression is (2), which is used for the simulations.

4. Simulation

Table 3 presents the results, which measure average impacts for 1976-2007. Raising South America's governance (education) (trade) (ETG)[4] to East Asia's level raises TFP by 25.6 (81.3) (50.1) (157.0) percent and reduces the TFP gap by 13.8 (43.7) (26.7) (84.2) percent. Raising Mexico's governance (education) (trade) (ETG) to East Asia's level raises TFP by 85.0 (46.1) (43.4) (173.1) percent and reduces the TFP gap by 66.2 (34.6) (34.4) (133.9) percent. And raising SAM's [5] governance (education) (trade) (ETG) to East Asia's level raises TFP by 82.8 (33.8) (47.5) (164.1) percent and reduces the TFP gap by 52.7 (22.3) (29.8) (104.8) percent.

For distance, $dlog(TFP) = -\beta\delta e^{-\delta * Dist} d(Dist)$, where $d(Dist)$ is the difference in distance from country i_1 to a G7 country and from i_2 to that country. With $\beta = .285$ and $\delta = .76$, $\beta\delta = .217$, and $dlog(TFP) = -.217e^{-.76 * Dist} d(Dist)$. South America's average distance to USC (US + Canada) is 6.075 thousand km and Mexico's is 2.712, with $d(Dist) = 3.363$, and $e^{-\delta * Dist} = e^{-.76 * 2.712} = e^{-2.06} = .127$. The impact on South America's TFP relative to Mexico's is –.217*.127*3.363 = – 9.3%, while the impact of their distance gap to Japan and Europe is –0.02%. And RD_{i2}'s definition implies that, ceteris paribus, G7 countries' R&D growth rates have a smaller impact on TFP growth for the more distant countries.

5. Policy Implications

Our findings suggest that South America and Mexico (SAM) could significantly raise their productivity by raising educational levels, improving governance, and by raising openness

[4] ETG = 'education, trade and governance.'
[5] SAM = 'South America + Mexico.'

towards the G7. Hence, accounting for those benefits should improve policy-making in these areas. The paper also showed that for SAM countries farther from USC,

i) opening up to trade has a smaller TFP impact, and

ii) G7 countries' R&D growth rates have a smaller TFP growth impact.

Improving education and governance should therefore be relatively more important for them.

6. Conclusion

This paper examined TFP's impact of education, governance, trade (ETG) and distance. The analysis focused on SAM and East Asia in 1976-2007, and simulated the impact of distance on TFP, and of raising ETG in SAM to East Asia's level.

Main findings are:

i) TFP rises with ETG;

ii) TFP and TFP growth fall with distance to the G7's USC;

iii) Raising ETG to East Asia's level raises SAM's TFP by over 100 percent and closes its TFP gap with East Asia;

iv) The TFP impact of raising SAM's education to East Asia's level equals that of raising trade plus governance; and

v) South America's average TFP loss relative to Mexico's due to its greater distance to USC (Japan and Europe) is 9.3 percent (negligible).

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Table 1: 1976-2007 Mean of Key Variables by Region

Region	Log TFP [a]	Governance [a, c]	Educational Attainment [a, d]	M/GDP [b, c]
East Asia	2.93	.535	45.8	.60
South America	1.88	.054	26.2	.30
Mexico	2.10	-.269	24.3	.37
SAM [e]	2.04	-.027	25.7	.33

a: First 3 variables defined in Section 2; *b*: M = imports; *c* (*d*): Regional average weighted by GDP (population); *e*: SAM = South America + Mexico.

Table 2: Linear and Non-linear Estimation, 1976-2007. (Dependent Variable: log TFP) [a, b]

	Linear	Non-linear
	(1)	(2)
β	.325***	.286***
	(8.84)	(9.18)
β^{Dist}	——	.762***
		(13.74)
β^{Gov}	.587***	.536***
	(6.30)	(6.47)
β^{Edu}	.0219***	.0221***
	(3.54)	(3.32)
Year fixed effect	Yes	Yes
Country fixed effect	Yes	Yes
$adj - R^2$	.66	.91
N	874	874

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

Table 3: Impact of Change in Governance, Education and Trade from South America and Mexico to East Asian Level, and of Difference in Distance (in %)

Variable	Regions	Increase in TFP	Decrease in TFP Gap
1. Governance	South America vs. East Asia	25.6	13.8
	Mexico vs. East Asia	46.1	34.6
	SAM [a] vs. East Asia	33.8	22.3
2. Education	South America vs. East Asia	81.3	43.7
	Mexico vs. East Asia	85.0	66.2
	SAM [a] vs. East Asia	82.8	52.7
3. Trade	South America vs. East Asia	50.1	26.7
	Mexico vs. East Asia	43.4	34.4
	SAM [a] vs. East Asia	47.5	29.8
4. Sum of 1,2,3	South America vs. East Asia	157.0	84.2
	Mexico vs. East Asia	173.1	133.9
	SAM [a] vs. East Asia	164.1	104.8
		Decrease in TFP	
5. Distance	South America – USC [b] vs. Mexico – USC [b]	9.3	
	South America - Japan vs. Mexico - Japan	0.02	
	South America – Europe vs. Mexico – Europe	0.02	

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