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Abstract
The discussion about the relationship between openness and economic growth is still open. The dissent is about the theoretical foundation of the relationship, and about the robustness of the positive effect that is presented in the empirical arena. Our paper has the purpose of incorporating new evidence to the discussion. To do that, we improve the process of TFP estimation and use new data sources. Our principal result is that there are important differences between groups of countries with regard to the relevant factors that explain the technological performance.

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1. Introduction

The discussion about the relationship between openness and economic growth is still open. The dissent is about the theoretical foundation of the relationship, and about the robustness of the positive effect that is presented in the empirical arena. Between the benefits of openness are frequently mentioned the existence of technological spillovers, the exploitation of comparative advantages, scale effects, reductions of the X-inefficiencies and so on. On the other hand, it is possible the specialization in technological exhausted sectors.

Some authors have asserted that the impossibility of reaching an agreement is due to the lack of an indicator that reflects efficiently the outward orientation of the economy, and due to the inexistence of total factor productivity (or multifactor productivity)[3] estimations of high-quality (Edwards, 1998). Other scholars (Krugman, 1994; Rodrik, 1995; Rodríguez & Rodrik, 2000) question methodological aspects and doubt about the results that the most-quoted authors have stated with absolute certainty[4]. Miller & Upadhyay (2000 and 2002) and Gonzalez (2002), for their part, find evidence about the positive effect of openness on the economic performance but with differences between groups of countries when they control for dissimilar structural/geographical characteristics.

Our paper has the purpose of incorporating new evidence to the discussion. To do that, we improve the process of TFP estimation and use new data sources. Particularly we are interesting in the dissimilar effects of openness and policy orientation on TFP growth after controlling for structural characteristics of the countries. This paper reintroduces the Rodriguez and Rodrik' question: "do trade restrictions operate differently in low- versus high-income countries?" (p. 61). Our principal result is that there are important differences between groups of countries with regard to the relevant factors that explain the technological performance.

The outline of the paper is as follows. Section 2 lays out the TFP growth model. Section 3 presents the empirical specification, the description of the data and reports the estimations of the TFP growth rates. Section 4 shows the empirical specification, data and results of the regressions on TFP growth rates. Final considerations are discussed in the section 5.

2. Openness and TFP

The mechanism by which openness affects the TFP could be explained through a simple model introduced by Edwards (1989 and 1998). Suppose that the economy have the following production function:

$$Y_t = B_t\left(K_t, L_t\right)$$

[3] Hereafter, TFP

[4] See, for example, Dollar (1992), Sachs y Warner (1995), Harrison (1996) and Edwards (1998)

where K, L and B are the capital stock, the labor measured in efficiency units and the TFP, respectively. Then, the growth of product in each moment depends on the rate of growth of each factor.

Suppose that there are two sources of growth of the TFP: one is associated with the domestic capacity for innovation, while the other is associated with the domestic capacity for absorption of the foreign technological progress. The mathematical expression that resumes these relationships is the following:

$$\dot{B}/B = \delta + \theta(W - B)/B$$

where δ is the domestic rate of innovation that depends on human capital, θ measures the speed which the foreign technological progress is absorbed by the domestic economy. This variable depends on the openness and the restrictiveness of the trade policy. W is the world technological level. $(W\text{-}B)$ is the technological gap between the domestic and the world economies and captures the catch-up effect. The greater is the technological gap between the domestic and the world economy, greater is the progress that is induced from outside. Variable g is the rate of growth of W with $g \geq \delta$. It is possible to prove that the domestic technological level, B, in the steady state is $B = [\theta/(\theta+g-\delta)]W$ and $\dot{B}/B = g$.

In short, PTF growth rate depend positively on human capital and openness, and negatively on trade restrictions. With Miller & Upadhyay (2000, 2002), we consider that countries with different levels of development are in different technological positions. Then, we hope that the more the country got to improve the income level, the less important is geographical and political restriction to trade in the explanation of TFP growth rate.

3. TFP growth rate estimation process

Our departure point is the development accounting exercises performed by Klenow and Rodriguez-Claire (1997) and Hall and Jones (1999). Accordingly, consider the following aggregate production function with constant returns,

$$Y = K^{\alpha} H^{\beta} (AL)^{1-\alpha-\beta}$$

where Y represents output, K the stock of physical capital, A is the TFP index, and L is the number of employers in the economy. The total stock of human capital is the product of the average level of human capital, h, and the number of workers ($H = h \times L$).This production function can be rearranged as

$$\frac{Y}{L} = \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{H}{Y}\right)^{\frac{\beta}{1-\alpha-\beta}} A .$$

Assuming that rate of employment is constant in long-run, we proxy L with total population. Then, we rewrite the production function as

$$\frac{Y}{P} = \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{H}{Y}\right)^{\frac{\beta}{1-\alpha-\beta}} A .$$

We follow Nehru y Dhareshwar (1993) and use the perpetual inventory method with steady-state estimates of initial capital in the construction of K series; and we follow Mankiw et al. (1992) to compute the human capital intensity:

$$\frac{H}{Y} = \frac{I_H / Y}{n + g_{st} + \delta}$$

where I_H is the inversion in human capital, g_{st} is the steady-state growth rate of the country, n is the growth rate of the country's population, and δ is the rate at which human capital depreciate. I_H/Y is computed using

$$\frac{I_H}{Y} = \text{secondary school enrolment rate} \times \left[\frac{15-19 \text{ population}}{15-64 \text{ population}} \right]$$

which approximates the percentage of the working-age population that is in secondary school.

Then we estimate the production function re-expressed as rate of growth:

$$\frac{\Delta(Y/P)}{Y/P} = \gamma_1 \frac{\Delta(K/Y)}{K/Y} + \gamma_2 \frac{\Delta(H/Y)}{H/Y} + \frac{\Delta A}{A}$$

where $\gamma_1 = \alpha/(1-\alpha-\beta)$ and $\gamma_2 = \beta/(1-\alpha-\beta)$. Our estimating equation emerges by adding a random error to the last equation. This error term incorporates the effects of omitted variables. Classical regression analysis assumes that the omitted variables are independent of the included right-hand-side variables and are independently, identically distributed. We use fixed-effect panel data method for the estimation of the growth rate of product per capita equation. Then, we compute the rate of growth of TFP as:

$$\frac{\Delta A}{A} = \frac{\Delta(Y/P)}{Y/P} - \hat{\gamma}_1 \frac{\Delta(K/Y)}{K/Y} - \hat{\gamma}_2 \frac{\Delta(H/Y)}{H/Y}$$

The data sources that we used in the TFP estimation process were Nehru and Dhareshwar and World Bank for physical capital and population and United Nations Statistics Division for human capital. Our panel data cover the 1980 to 2005 time period (1981 to 2005 for any growth rate) for a sample of 87 countries in the full data set. The appendix lists the countries included in our sample.

The way to test for possible differences in technology consists in dividing the sample into groups of countries and re-estimate. We divide our sample into low-, middle-, and high-income countries based on real GDP per capita. The classification of each country is based on 1987 World Bank income per capita classification.

The results for the estimation of the production functions appear in table 1. Several noteworthy points emerge. The estimate for the full-panel data set yields the following results: The coefficients of the growth rate of physical and human capital intensity (i.e., 0.61 and 0.24) assign a value of 0.33 to the elasticity of output with respect to the physical capital stock and 0.13 to the elasticity of output with respect to the human capital stock. These two coefficients combine to generate the elasticity of output with respect to the labor force of 0.54. Starting with income categories, we find that the elasticity of output with respect to capital in high-income countries falls substantially below that in other countries: 0.18 while middle-income countries show 0.32 and low-

income countries 0.34. However, the high-income group' elasticity of output with respect to labor is similar to the middle-income group one (i.e., 0.64). This elasticity equals 0.49 for low-income countries.

Table 1
Estimation of growth rate of product per capita for all countries and for income groups

	All	Low	Middle	High
$\frac{\Delta(K/Y)}{K/Y}$	0,6087* (11,51)	0,7007* (6,42)	0,4995* (7,64)	0,2865* (2,63)
$\frac{\Delta(H/Y)}{H/Y}$	0,2470* (12,57)	0,3736* (10,95)	0,0713* (3,10)	0,2862* (3,21)
Constant	-0,0005 (-0,08)	-0,0560* (-3,52)	0,0053 (0,72)	0,0498* (4,03)
R2 within	0,1300	0,2730	0,0630	0,0272
N° obs	2261	571	1065	623
Countries	87	22	41	24

For details of the explanatory variables, see text. *t*-statistics between parentheses. * significant at 1% level, ** at 5% level, *** at 10% level

4. Determinants of TFP Growth

In this section, we examine the role of both domestic and external variables in influencing TFP growth rate. Our estimate proceeds with the following equation:

$$\Delta PTF/PTF = \beta_1 + \beta_2 OPE + \beta_3\{PIN, TAX, BMP\} + \beta_4 INF + \beta_5 IMR + \\ + \beta_6 NRA + \beta_7 CTF + \varepsilon \quad .$$

The essential variables are openness and political restrictiveness to world integration. *OPE* equals structural, mainly geographical, openness and we approximate it by the ratio of total trade (export + import) to GDP. The restrictiveness of the domestic policy to trade is approximated taking four alternative variables: (i) P-index (*PIN*); it represents the local price deviation from purchasing power parity. Larger deviations from purchasing power parity imply a more-restricted, less-open domestic economy. (ii) Customs duties over GDP (*TAX*); larger relevance of customs duties could imply two effects: A more-restricted economy (high tax, then high tax collection) or a more-dependent economy to the trade performance (low tax but high competitiveness, then high tax collection). We expect a negative sign if the first effect prevailed, but a positive sign in the other case because the variable could indirectly capture the effect of competitiveness on TFP growth. (iii) Black market premium (*BMP*) defined as the difference between the black market and the official exchange rates. Larger deviations from the official exchange rate imply a more-restricted domestic market of foreign currency and, then, a less-open domestic economy.

The control variables are (a) the inflation rate (*INF*) that captures the effects of the government's macroeconomic mismanagement on the domestic relative prices. We expect that economies with higher rates of inflation present more distorted the domestic prices, more uncertainty and less incentives to technological change; (b) the infant

mortality rate (*IMR*) as a proxy of human capital deficiency; (c) the primary production over GDP (*NRA*) that intent to capture the effects of the natural resources abundance on productivity performance. The specialization in the primary sector could result in a more-susceptible economy to the volatility of resource international prices. Finally, (d) the country's TFP over United States TFP that approximates to the closeness to the technological frontier taking US as benchmark (*CTF*). In accordance with the theoretical model, we expect negative signs for all of them.

The used data sources were the World Bank dataset, Penn World Tables, and our estimations of TFP levels for the calculation of *CTF*. The main sample corresponds to the years 1980-2004 for 87 countries. However, when data is not available, the study covers shorter periods[5]. Once again, we estimate the equation using the fixed-effects method. Table 2 reports the results for the estimation of the TFP growth rate for the pooled sample and for the three groups of countries taking differences in levels of development.

Starting with the effects of the external sector on the economy for the pooled sample, the variables related to trade show a generally positive effect on TFP growth rates. Openness exhibits a significant positive effect at different levels for all exercises. Greater openness enhances development through larger TFP growth.

The local price deviation from purchasing power parity displays a significant negative effect at the 1% level in the full sample. Here, larger deviations from purchasing power parity associate with lower rates of TFP growth. Taking in mind that the coefficient on this variable captures another aspect of the openness of the economy to trade, this result reinforces our finding on the OPE variable. The other political proxies report the wrong sign (TAX) or a very low significance (BMP).

For the domestic variables, inflation and human capital deficiency exert robust and significant negative effects, while the natural resource specialization effect and the technological closeness exert positive effects on TFP growth, albeit at different levels of significance.

Several noteworthy points emerge from the results by income categories. First, we find that openness loses its statistical significance in income sub-samples and it is not relevant for the low-income group of countries. However the combination of the geographical and political restriction to trade seems to maintain the negative effect on TFP growth for the other income groups, principally for the middle-income sub-sample.

Second, inflation and human capital deficiency exhibit coefficients with the right sign but with diverse levels of significance. There are great differences between countries.

[5] Regressions with TAX and BMP cover the years 1980-1999.

Table 2
Explaining TFP growth rate for all countries and for income groups of countries

	All	All	All	Low	Low	Low
OPE	0.0004* (2.55)	0.0003*** (1.52)	0.0004** (2.00)	0.0004 (0.34)	0.0003 (0.43)	0.0002 (0.36)
PIN	-0.0004* (-3.50)			-0.0007** (-1.74)		
TAX		0.0069** (2.24)			0.0014 (0.13)	
BMP			-0.0000**** (-1.43)			-0.0000**** (-1.44)
INF	-0.0254* (-3.78)	-0.0267* (-3.23)	-0.0256* (-3.04)	-0.0289 (-0.76)	-0.1189 (-1.28)	-0.0093 (-0.20)
IMR	-0.0010* (-3.78)	-0.0013* (-3.28)	-0.0011* (-2.95)	-0.0009*** (-1.49)	-0.0011 (-0.89)	-0.0009 (-1.04)
NRA	0.0023* (3.22)	0.0022*** (1.87)	0.0027* (2.85)	0.0027** (2.08)	0.0012 (0.46)	0.0023 (1.40)
CFT	0.3092** (1.85)	0.3149 (1.23)	0.5417** (2.32)	0.6690*** (1.85)	0.5908 (0.89)	1.0024**** (2.08)
Constant	-0.2424 (-1.74)	-0.2778 (-1.27)	-0.4650 (-2.39)	-0.4545 (1.74)	-0.3705 (0.13)	-0.6995 (-2.02)
R2 within	0.0315	0.0243	0.0216	0.0302	0.0192	0.0212
N° obs	2088	1349	1577	528	228	418
Countries	87	71	83	22	12	22

The dependent variable, in each case, is the growth rate of TFP. *t*-statistics between parentheses. For details of the other variables, see text. * significant at 1% level, ** at 5% level, *** at 10% level, **** at 15% level

Table 2 (continuation)
Explaining TFP growth rate for all countries and for income groups of countries

	Middle	Middle	Middle	High	High	High
OPE	0.0006* (2.94)	0.0004[1] (1.28)	0.0005*** (1.85)	-0.0001 (-0.69)	0.0004**** (1.56)	0.0015* (4.35)
PIN	-0.0002 (-1.13)			-0.0006* (3.83)		
TAX		0.0079** (2.07)			0.0072 (0.94)	
BMP			-0.0000 (-0.08)			0.0021[1] (1.30)
INF	-0.0268* (-3.80)	-0.0259* (-2.89)	-0.0285* (-3.29)	-0.0043 (-0.18)	-0.0188 (0.59)	-0.0489**** (-1.51)
IMR	-0.0009* (-2.84)	-0.0013* (-2.57)	-0.0010** (2.24)	-0.0058* (-4.49)	-0.0069* (-4.08)	-0.0091* (-6.38)
NRA	0.0029* (2.39)	0.0034* (1.97)	0.0037** (2.32)	0.0029 (1.07)	0.0063**** (1.52)	0.0159* (4.21)
CTF	0.1221 (0.54)	0.2637 (0.75)	0.1255 (0.39)	0.4788 (1.24)	-0.3767 (-0.72)	0.9388** (1.94)
Constant	-0.1255 (-0.66)	-0.2576 (-0.87)	-0.1429 (-0.53)	0.3495 (-0.96)	0.3788 (0.94)	-0.9866 (-2.10)
R2 within	0.0405	0.0342	0.0296	0.0602	0.0566	0.1509
N° obs	984	684	760	576	437	399
Countries	41	36	40	24	23	21

The dependent variable, in each case, is the growth rate of TFP. *t*-statistics between parentheses. For details of the other variables, see text. * significant at 1% level, ** at 5% level, *** at 10% level, **** at 15% level, [1] at 20% level

While inflation and human capital deficiency do not seem to be relevant for the low-income group, the first variable is essential only for the middle-income group and the second variable have a strong significance for middle and high-income group.

Finally, the positive effects of natural resources abundance and technological closeness are robust but only the second variable seems to be significant (but at the greater levels of significance) for the explanation of the TFP growth of the low-income group. In contrast, natural resources abundance is significant at 1% and 5% level depending of the regression model for the middle-income group, and technological closeness seems to be not relevant. Meanwhile, high-income group do not show convincing results.

A special commentary deserves CTF variable, that shows significant coefficients but the sign does not meet the expected one. The positive coefficients are only significant for the low-income countries, and two specifications for countries with higher income. This means that only very backward countries are benefited from technological spill-over[6] and there are signs of a "learning effect" in the process of technological absorption: relatively technological closeness is associated with better exploitation of the available technology. However, once the economy reached a certain technological level, the more relevant factor is not the "catch-up" term but the absorption rate, consequently, openness and political restrictiveness to trade.

5. Final considerations

We study the effects of openness –structural and political-, human capital and other control variables on TFP growth rate for a panel data set of developed and developing countries. We first estimate multiple sets of TFP based on an exercise of development accounting and the fixed-effect regression technique, involving output per worker, physical and human capital intensity. Then we classify countries along income and search for the possible differences in the relevance of the determinants of TFP growth, with special emphasis on variables reflecting trade orientation.

Our results show that a greater openness benefits TFP growth in general but not necessarily for specific classes of countries. In general, a higher openness, a lower inflation rate and a sufficient human capital associate with higher growth rate of TFP. Natural resources abundance seems to have a positive effect on TFP growth but this result deserve more attention in future researches. Finally, the negative effect of the closeness to the technological frontier seems to be defeated by the evidence.

The results for the full sample do not extend to the component income groups. Neither openness nor control variables seem to be relevant to the explanation of the technological performance of the low-income countries. In contrast, all variables are relevant to explain the technological performance en the middle-income group. Meanwhile, only openness and human capital deficiency maintain their significance for the high-income group.

Higher income group seems to benefit for the exposition to trade because it improves its absorption rate, and for the incorporation of human capital because it allow them to gain access to or to keep the innovation process.

[6] The 1980-2005 period average for the low-income contries' TFP levels was 68-70% of US TFP, 82-84% for the middle-income group and 98% for higher income group.

According with Miller and Upadhyay (2002), the results suggest that lumping countries at various levels of development together in an empirical growth study may not succeed in uncovering important policy implications. Moreover, our answer to the Rodriguez and Rodrik' question is that the evidence show that effectively trade restrictions operate differently in countries with development differences.

Appendix

1987 World Bank income per capita classification			
Low	*Middle*		*High*
Bangladesh	Algeria	Malta	Australia
China	Angola	Mauritius	Austria
Ethiopia	Argentina	Mexico	Belgium
Ghana	Bolivia	Morocco	Canada
Guyana	Brazil	Nicaragua	Denmark
Haiti	Cameroon	Panama	Finland
India	Chile	Paraguay	France
Indonesia	Colombia	Peru	Germany
Kenya	Costa Rica	Philippines	Iceland
Madagascar	Cote d'Ivoire	Portugal	Ireland
Malawi	Cyprus	Senegal	Israel
Mali	Dominican Republic	South Africa	Italy
Mozambique	Ecuador	Thailand	Japan
Nigeria	Egypt, Arab Rep.	Trinidad and Tobago	Kuwait
Pakistan	El Salvador	Tunisia	Luxembourg
Rwanda	Greece	Turkey	Netherlands
Sierra Leone	Guatemala	Uruguay	New Zealand
Sri Lanka	Honduras	Venezuela, RB	Norway
Sudan	Iran, Islamic Rep.	Zimbabwe	Singapore
Tanzania	Jordan		Spain
Uganda	Korea, Rep.		Sweden
Zambia	Malaysia		Switzerland
			United Kingdom
			United States

References

Edwards, S. (1989) "Openness, outward orientation, trade liberalization and economic performance in developing countries" NBER Working Paper Series, Cambridge.

Edwards, S. (1998) "Openness, productivity and growth: what do we really know?", Economic Journal, 108 (March), 383-398.

González, G. (2002) "Apertura, Orientación Comercial y Productividad Total de los Factores: La incidencia del nivel de desarrollo", Anales de la Asociación Argentina de Economía Política, XXXVII Reunión Anual. Argentina.

Hall, R. and C. Jones (1999) "Why do some countries produce so much more output per worker than others", Quarterly Journal of Economics, 114, 1, 83-116.

Klenow, P. and A. Rodriguez-Claire (1997) The Neoclassical Revival in Growth Economics: Has It Gone Too Far?, in Bernanke & Rotemberg (ed.) NBER MACROECONOMICS ANNUAL, Vol. 12, 73-102. MIT Press.

Mankiw, N. G., Romer D. & D. Weil (1992) "A contribution to the Empirics of Economic Growth", Quarterly Journal of Economics, 107, 2, 407-437.

Miller, S. and M. Upadhyay (2000) "The effects of openness, trade orientation, and human capital on total factor productivity", Journal of Development Economics, 63, 399-423.

Miller, S. and M. Upadhyay (2002) "Total factor productivity, human capital, and outward orientation: differences y stage of development and geographic regions" University of Nevada and Eastern Illinois University working paper.

Nehru, V and Dhareshwar, A, "A New Database on Physical Capital Stock: Sources, Methodology and Results", Revista de Analisis Economico Vol 8, Junio 1993

Rodríguez, F. and D. Rodrik (2000) "Trade policy and economic growth: a skeptic´s guide to the cross-national evidence", en Bernanke and Rogoff (eds.) NBER Macroeconomics Annual, Cambridge, Mass.: MIT Press.