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Productivity growth and international openness: Evidence from Latin American countries 1980-2006

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Abstract

In this study we examine productivity growth and their relationship with international openness in Latin American countries over the period 1980-2006. Overall results on productivity indicate a stagnation process for the entire period 1986-2006. The decomposition of productivity into *catching up* and technical change reveals that the first have a stagnation process and the latter worsening. Analyzing the relationship between productivity growth and international openness we find different patterns for both methodologies parametric (Arellano-Bond estimator) and nonparametric (GAM) and for both measures of international openness merchandise trade (% of GDP) and (export+imports)/GDP. In particular in a parametric way, although the shape is curvilinear for both models the relationship is positive inverted U-shaped in the first case and U-shaped in second.

Key words: Productivity growth, open economies, Non parametric regression, Panel data

JEL classification: C14, C61, F15, F43.

1. Introduction

Although productivity is not only determinant of economic growth and welfare, it does provide a measure of economic prosperity, standard of living and degree of competitiveness of a country. Productivity analysis can therefore provide valuable information about the effectiveness of economic policies and, thus, can provide a useful tool in helping design policies for improving economic development (Lall *et al*., 2002).

Focusing in the empirical literature about this issue, the classic work of Harrison (1996) draws together a variety of openness measures to test the association between openness and growth. Although the correlation across different types of openness is not always strong, there is generally a positive association between growth and different measures of openness. The strength of the association depends on whether the specification uses cross-section or panel data (which combines cross-section and time series). Harrison founds that for industrializing countries, (which have exhibited significant fluctuations in trade regimes over time), long-run averages may not serve as very meaningful indicators of policy.

Frankel *et al*. (1996) found a role for openness, particularly in explaining rapid growth among East Asian countries. This authors find that the effect of openness on growth is even stronger when corrects for the endogeneity of openness than in standard OLS estimates. The authors conclude with estimates of how much has been contributed to East Asian growth both by the exogenous or geographical component of openness and by the residual or policy component.

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Using a comparative data for 93 countries Edwards (1998) analyses the robustness of the relationship between openness and total factor productivity growth. Nine indexes of trade policy are used to investigate whether the evidence supports the view that total factor productivity growth is faster in more open economies. The results are robust to the use of openness indicator, estimation technique, time period and functional form, and suggest that more open countries experienced faster productivity growth.

According Greenaway *et al.* (2002) trade liberalization in developing countries over the last 20 years has often been implemented with the expectation of growth being stimulated; yet the evidence on its growth enhancing effects is mixed. The authors argue that problems with mis-specification and the diversity of liberalization indices used are in part responsible for the inconclusiveness. Using a dynamic panel framework and three different indicators of liberalization, the paper finds that liberalization does appear to impact upon growth, albeit with a lag. The evidence points to a J curve type response and this finding is robust to changes in specification, sample size and data period.

Yanikkaya (2003) demonstrates that trade liberalization does not have a simple and straightforward relationship with growth. The author uses two groups of trade openness measures. The regression results for numerous trade intensity ratios are mostly consistent with the existing literature. However, contrary to the conventional view on the growth effects of trade barriers, Yanikkaya's estimation results show that trade barriers are positively and, in most specifications, significantly associated with growth, especially for developing countries.

Alcala and Ciccone (2004) find that international trade has an economically significant and statistically robust positive effect on productivity. The authors also find a significantly positive aggregate scale effect. Their estimates control for proxies of institutional quality as well as geography and take into account the endogeneity of trade and institutional quality. Finally their analysis of the channels through which trade and scale affect productivity yields that they work through total factor productivity.

Baliamoune-Lutz and Ndikumana (2007) explore the argument that one of the causes for the limited growth effects of trade openness in Africa may be the weakness of institutions. Results from Arellano-Bond GMM estimations on panel data from African countries show that institutions play an important role in enhancing the growth effects of trade. Moreover, the authors find that the joint effect of institutions and trade has a U-shape, suggesting that as openness to trade reaches high levels, institutions play a critical role in harnessing the trade-led engine of growth.

Finnally in Wacziarg and Welch (2008) a new data set of on openness indicators and trade liberalization dates allows the 1995 Sachs and Warner study on the relationship between trade openness and economic growth to be extended to the 1990s. Analysis based on the new data set suggests that over the 1950–98 period, countries that liberalized their trade regimes experienced average annual growth rates that were about 1.5 percentage points higher than before liberalization. Liberalization raised the average trade to GDP ratio by roughly 5 percentage points, suggesting that trade policy liberalization did indeed raise the actual level of openness of liberalizers. However, these average effects mask large differences across countries.

In this context, the contribution of our study to the existing literature is twofold. On one hand we investigate the productivity growth in the 17 Latin American countries[1] (hereafter, LAC) to determinate the relative performance of the different countries within this economic region between 1980 and 2006. On the other hand, we investigate the link between trade liberalization and productivity growth.

[1] The region as a whole has experienced an unprecedented opening up to international trade since the mid-1980s (IDB, 1997; Morley *et al*., 1999; Paus et al., 2003). In this line, multinationals have embarked on or expanded manufacturing operations in Latin American in three broad categories: maquila (labor intensive assembly industries producing exclusively for export, primarily apparel and electronics), concentrated North of Panama; automobile assembly, concentrated in Mexico (for export) and Brazil and Argentine (for Mercosur); and natural resource processing (minerals and agro-industry) in South America, primarily for export (Reinhardt and Peres, 2000).

More specifically, based on recent World Bank data on variables aggregate productivity growth (GDP, Labor force, Gross capital in constant 2000US$) activity in Latin American, we evaluated de productivity growth, technical efficiency change and technology change. Also we study the relationship between trade opening and productivity growth. We use two possible ways to measure the degree of international openness; merchandise trade (% of GDP) and (export+imports)/GDP. Finally we use as control variables population, inflation rate and share of manufacturing and agriculture production as value added.

In addition, our study al presents substantial methodological differences to that existing literature, primarily attributable to the use of nonparametric techniques in the second-stage estimation of our study which overcome some drawbacks related to the models considered in the traditional two-stage studies. In this way, in line with (Illueca *et al*., 2009) one of the innovations of the present study is the consistent application of nonparametric techniques used for estimating the relationship between the productivity growth (as well as technical change and efficiency change) and international openness (which would make up the second-stage estimation). Also in relation to more traditional literature we use parametric methods using the Arellano-Bond GMM for relationship mentioned concepts with a set of control variables.

The results can be summarized in various ways. Overall results on productivity indicate a stagnation process for the entire period 1986-2006. The decomposition of productivity into *catching up*, or change in efficiency, and technical change reveals that the first have a stagnation process and the latter worsening. The analysis of the relationship between productivity growth and international openness we find different patterns for both methodologies parametric and nonparametric and for both measures of international openness. In particular in a parametric way, although the shape is curvilinear for both models the relationship is positive inverted U-shaped in the first case and U-shaped in second.

The remainder of the paper is organized as follows. Section 2 summarizes the theoretical background used in this work. Section 3 discusses data, variables, and methodology. In Section 4, we discuss our empirical findings. Finally Section 5 draws conclusions and implications.

2. Growth theories and International openness

2.1. Growth theories

As mention (Lall *et al.*, 2002), two theories have been proposed for explaining productivity growth in developed and developing countries. The first pertains to a general tendency for total factor productivity (TFP) or per capita income (Dorwrick and Nyugen, 1989) in low income countries to converge towards those of high income countries (Baumol, 1986; Baumol, Blackman and Wolff, 1989), while the second relates to the income per capita between low income and high income countries remaining more or less constant or even diverging (Arrow, 1962).

In testing the convergence theory, Baumol (1986) found a high inverse correlation between the production levels in a country and their growth rates. The doctrine of convergence is embedded in the philosophy of neoclassical growth theories, which are founded on diminishing returns to scale. The contrasting viewpoint that low and high income countries do not converge is related with the endogenous growth theories. This set of theories, originated from seminar work of Arrow (1962) and was developed further by Romer (1986, 1989) and Lucas (1988). Increasing returns to scale are generated from externalities associated with the acquisition of physical capital (e.g. technical) and human capital (knowledge) by individual and firms. According to endogenous growth theories, this accumulation contributes to increased productivity by others. As mention (Lall *et al.*, 2002) neither of these groups of growth theories explain currently observed situations in which the fastest growing countries are never the countries with the highest or lowest per capita incomes, or that some countries with relatively low per capita incomes tend to grow slower than countries with higher per capita income. Olson (1996) has suggested that such apparent inconsistencies are due to differences in policies, and economic and developmental institutions.

2.2. International openness

Empirical investigations of the trade-productivity relationship have produced conflicting results, especially regarding the precise channels which trade liberalization has affected the decisions of firms and their resulting productivity growth (Paus *et al.*, 2003). The aggregate studies as our that focus on the overall impact of trade liberalization on productivity growth find a positive and statistically significant relationship between productivity growth and trade openning (e.g., Edwards, 1998; Tybout and Westbrook, 1995). Others studies are skeptical of these findings (e.g., Tybout, 2000; Rodriguez and Rodrick 2001). The main criticism is included on the possible confusion of interpreting lower price-cost ratios as a sign of increased productivity rather than lowered mark-ups.

According to Romer (1994) the principal effect of trade restrictions is to reduce the supply of intermediate goods to an economy. Recognizing that this can have infra-marginal effects on productivity he argues that overlooking this effect leads to a several-fold under-estimate of the production penalty of protection. Romer's effect will show up in the data as a positive relationship between trade liberalization and productivity and one can think of further reasons why opening trade may give a one-off boost to productivity – e.g. competition stimulating technology adoption and adaptation, or the elimination of x-inefficiency.

As mention Winters (2004) over the 1990s the conviction that trade liberalization or openness was good for growth was fostered by some visible and well-promoted cross-country studies, e.g. Dollar (1992), Sachs and Warner (1995), Edwards (1998) and Frankel and Romer (1999). These, however, received, and by and large deserved, pretty severe criticism from Rodriguez and Rodrik (2001), who argue, inter alia, that their measures of openness are flawed and their econometrics weak.

Establishing an empirical link between liberal trade and growth faces at least four difficulties (for details see Winters, 2003). First, the definition of "openness". In the context of policy advice, it is most directly associated with a liberal trade regime (low tariffs, very few non-tariff barriers etc.) but in fact that is rarely the concept used in empirical work. Second, once one comes inside the boundary of near autarchy, measuring trade stances across countries is difficult. Third, causation is extremely difficult to establish. Does trade liberalization result in or, from, economic growth? Frankel and Romer (1999) and Irwin and Tervio (2002) address this problem by examining the effects of the component of openness that is independent of economic growth. The fourth complication is that for liberal trade policies to have a long-lived effect on growth almost certainly requires their combination with other good policies such as those that encourage investment, allow effective conflict resolution and promote human capital accumulation.

3. Methodology

This study will use nonparametric techniques to both: (1) estimate productivity growth of Latin American countries, along with its components, (2) test the existence of relation between international openness of Latin American countries and their productivity growth and (3) we use panel analysis to regress productivity growth and international openness with other control variables.

3.1. Methodology productivity growth for Latin American countries

We used the Malmquist productivity index to measure productivity growth in Latin American countries. Among many others, recent country studies employing the Malmquist productivity growth index include Färe *et al*. (1994), Llal *et al*. (2002), Krüger (2003), Yöruk and Zaim (2005) or Yöruk (2008). Based on the work of Caves *et al.* (1982), the Malmquist index was constructed as the ratio of two distance functions, each of which is a functional representation of a multiple-output, multiple-input technology that requires data on output and input quantities. The Malmquist index (henceforth MALM) attempts to establish whether a country has experienced productivity growth or decline between periods *t* and *t+1*. The index is constructed from distance functions, by exploiting the fact that the component distance functions are reciprocal to Farrell measures of technical inefficiency. Following Caves et al. (1982), the distance function in outputs of an individual in t regarding technology *t* (F^t) can be expressed as $D^t(x^t, y^t) = \inf\{\theta: (x^t, y^t/\theta)\}$, where $y^t \varepsilon \Re_+^M$ is the output vector for countries i (i=1,...,I), $x^t \varepsilon \Re_+^M$ is its input vector, and F^t is the technology period *t*. This distance function Dt is defined as the inverse maximum expansion to which the output vector in *t* (y^t) must be subject, given the input levels (x^t), in such a way that the observation is on frontier at period *t*. From these concepts, the MALM concept based on outputs to analyze productivity change between periods *t* and *t+1* is defined as:

$$MALM^t(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D^t(x^{t+1}, y^{t+1} \mid CRS)}{D^t(x^t, y^t \mid CRS)} \quad [1]$$

Where $D^t(x^{t+1}, y^{t+1} \mid CRS)$ and $D^t(x^t, y^t \mid CRS)$ are distance function to be estimated assuming a constant return to scale (CRS) technology. If $MALM^t > 1$, productivity for period *t+1* is higher than for period *t*. On the order hand, if $MALM^t < 1$ productivity has declined between periods *t* and *t+1*. Rewriting this mean enables us to decompose the Malmquist index of total factor productivity in a catching up –or efficiency change- effect and the effect of technical change:

$$MALM^t(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D^{t+1}(x^{t+1}, y^{t+1} \mid CRS)}{D^t(x^t, y^t \mid CRS)}$$

$$\times \underbrace{\left[\frac{D^t(x^{t+1}, y^{t+1} \mid CRS)}{D^{t+1}(x^{t+1}, y^{t+1} \mid CRS)} \times \frac{D^t(x^t, y^t \mid CRS)}{D^{t+1}(x^t, y^t \mid CRS)}\right]^{1/2}}_{Technical\_change} \quad (2)$$

The catching up effect, or relative efficiency change (*EFFCH*) between periods *t* and *t+1*, is represented by the first ratio, which will be greater than one if there has been a increase in efficiency- since we are taking the output oriented approach. Similarly, the term in square brackets measures technical change (*TECHCH*), or shifts of frontier between the two periods.

Following Färe *et al*. (1994) we can further decompose efficiency change into pure efficiency change (PECH) and scale efficiency change (SCH) so that equation 2 can be rewritten as:

$$MALM^{t}(x^{t+1}, y^{t+1}, x^{t}, y^{t}) = \frac{D^{t+1}(x^{t+1}, y^{t+1} \mid VRS)}{D^{t}(x^{t}, y^{t} \mid VRS)}$$

$$\underbrace{\frac{D^{t+1}(x^{t+1}, y^{t+1} \mid CRS)/D^{t+1}(x^{t+1}, y^{t+1} \mid VRS)}{D^{t}(x^{t}, y^{t} \mid CRS)/D^{t}(x^{t}, y^{t} \mid VRS)}}_{Scale\_efficiency\_change}$$

$$\times \underbrace{\left[\frac{D^{t}(x^{t+1}, y^{t+1} \mid CRS)}{D^{t+1}(x^{t+1}, y^{t+1} \mid CRS)} \times \frac{D^{t}(x^{t}, y^{t} \mid CRS)}{D^{t+1}(x^{t}, y^{t} \mid CRS)}\right]^{1/2}}_{Technical\_change} \qquad (3)$$

Where D^t (x^{t+1}, y^{t+1}| VRS) and D^t (x^t, y^t| VRS) are distance function to be estimated assuming a variable return to scale (VRS) technology. Thus, the EFFCH term refers to efficiency change calculated under CRS, whereas PECH is efficiency change calculated under VRS (Färe et al. 1994). We use Data Envelopment Analysis (DEA), which lies within the broad set of techniques that measure the efficiency of one DMU (Decision Making Unit) imposing a minimum number of assumptions both on the function to estimate and on the distribution of the indices of efficiency.

Our data on Latin American countries consist of a vector of inputs (x^t) and output (y^t) in our case one output of *I* country in both periods *t* and *t+1*:

$Z = \{(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}), i = 1,\ldots,I\}$, [4] Where x_i^t = ($x_{i1}^t,....,x_{i1n}^t$) ε $\Re_+^N$ and y_i^t = (y_{i1}^t) $\Re_+^M$ are the input and output corresponding to country *i*, *i =1,…,I*) in period t, respectively.

Both the production set and distances we may define from it are unknow. This applies to both period t and period t+1. Following Färe *et al.* (1994), for each country (*i =1,…,I*) we may consider a linear programming model as follows:

$$\left[\hat{D}_i^t(x_i^t, y_i^t \mid CRS)\right]^{-1} = \max\theta$$
$$\theta\, y_{im}^t \le \sum_{j=1}^{I} \lambda_j^t y_{jm}^t \qquad m = 1,...,M, \qquad [5]$$
$$\sum_{j=1}^{I} \lambda_j^t y_{jm}^t \le x_{in}^t \qquad n = 1,....,N,$$
$$\lambda_i^t \ge 0, \qquad i = 1,.....,I,$$

Where λ^t = ($\lambda_1^t,......,\lambda_1^t$) is a vector of weights forming a convex combination of observed countries relative to which the subject countries efficiency evaluated. Linear programming model (5) calculates the distances $D_i^t(x_i^t, y_i^t \mid CRS)$. Computing $D_i^{t+1}(x_i^{t+1}, y_i^{t+1} \mid CRS)$ is analogous to linear programming problem (5), where *t+1* is substituted by *t*.

3.2. Nonparametric regression

Nonparametric regression allows one to graphically observe how certain *Y* variable, in our case the productivity of Latin American countries and each components, is affected by changes in another variable *X*, in our case the international openness. The main advantage of this technique, as opposed to others such as linear or polynomial regression, lies in the fact that it does not impose any type of a priori relationship between the variable to be analyzed. We would estimate the mean response curve *m* from relationship:

$$MALM_i = m(X) + \varepsilon_i, \qquad i = 1,....,I$$

As mention Henderson and Simar (2005) nonparametric and semiparametric kernel methods are increasingly popular tools for statisticians/econometricians. Researchers have begun to gravitate towards nonparametric and semiparametric methods when there is little prior knowledge on specific (regression) functional forms or some known parametric specifications are deemed inadequate for the problem at hand. This often occurs when formal rejection of a parametric model yields no clues as to the direction in which to search for an improved parametric model. There are several approaches to estimations non parametric regression models local polynomial regression; smoothing splines, etc. (see Fox 2002). In particular, we used generalized additive model (GAM). This estimation procedure, introduced by Hastie and Tibshirani (1993), is based on the simple idea that a dependent variable can be explained by the sum of a finite number of unknown functions that depend on one or more explanatory variables.

3.3. Panel Data

We study the effect of international openness (*IO*) on the performance of country, that is, productivity growth (MALM). The general form of the regression specification we estimate is: *MALM* = *f* (*IO* + *others variables*). The relationship between competitive sources and performance were tested using panel regression analysis for the following reasons: First, because panel data suggests that countries are heterogenous and therefore do not run the risk of obtaining biased results. Second, because panel data gives more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency.

4. Data

The statistical source used for this analysis is the World Bank's World Development Indicators (WDI). This database provides more than 800 development indicators, with time series for 209 countries and 18 country groups from 1960 to 2007.

The study involved temporal observations (T=27) on the outputs and inputs for 17 countries in Latin America over the period 1980-2006[2]. As we mentioned in appendix

[2] At time of the study, data for periods after 1980 and beyond 2007 were not available for many countries.

(see table I), GDP, Labor force and Gross capital are in constant 2000US. As seen in table 1, growth in GDP decreases in annual average -1.0 percent per year over the entire 1980-2006 period our sample. Chile, Costa Rica and Dominican Republic have the highest positive average annual growth in GDP (1.1, 0.3 and 0.5 percent respectively). Evidence concerning the capital and labor shows in table 1 an increasing of 3.6 and 3.0 percent per year respectively.

Table 1- Average annual growth rates: Gross domestic product, Capital and Labor, 1980-2006

Country	Output(GDP)	Input(Capital)	Input(Labor)
Argentina	-0.017	0.033	0.025
Bolivia	-0.015	0.031	0.032
Brazil	-0.015	0.033	0.028
Chile	0.011	0.008	0.022
Costa Rica	0.003	0.075	0.036
Dominican Republic	0.005	0.048	0.029
Ecuador	-0.011	0.048	0.038
El Salvador	-0.015	0.016	0.022
Guatemala	-0.011	0.042	0.024
Honduras	-0.005	0.029	0.038
Mexico	-0.012	0.042	0.029
Nicaragua	-0.022	0.032	0.027
Panama	-0.001	0.034	0.033
Paraguay	-0.013	0.075	0.037
Peru	-0.013	0.005	0.035
Uruguay	-0.020	0.039	0.015
Venezuela, RB	-0.016	0.015	0.039
Mean	**-0.010**	**0.036**	**0.030**

Source: World Bank's World Development Indicators (2009), and author's calculations.

The lowest values of average capital are in Peru, Chile, Venezuela and El Salvador while the highest values are in Costa Rica and Paraguay. In relation with the lowest values of average Labor are in Uruguay, El Salvador and Chile while the highest value are in Venezuela, Ecuador and Paraguay.

5. Results

5.1 Productivity growth

The geometric averages of productivity growth (MALM), technological change (TECH) and technical efficiency change (EFFCH) under constant returns to scale (CRTS) are show in table 2 for period 1980-2006 and for periods 1980-1993 and 1993-2006 in table 3. Instead of presenting the disaggregated results for each year, a summary description of the average performance of all countries over the entire period was utilized. It should be noted that if the value of the Malmquist index (MALM) or any of its components is less than 1, this denotes deterioration in performance between any two adjacent years, whereas values greater than 1 denote improvements in the relevant performance. Also note that these measures capture performance relative to the best practice in the sample.

Table 2. Decomposition of Total Factor Productivity with scale effects: average annual changes

Country	Pure Tech. Change PECH	Scale Change SECH	Effciency Change EFFCH	Tech. Change TECHCH	Productivity Change MALM
Argentina	1.000	1.000	1.000	1.002	1.002
Bolivia	1.000	1.006	1.006	0.992	0.998
Brazil	1.000	1.007	1.007	1.003	1.010
Chile	0.994	1.003	0.997	1.014	1.011
Costa Rica	0.993	1.001	0.994	1.008	1.002
Dominican Republic	1.005	1.000	1.005	0.986	0.991
Ecuador	1.010	0.998	1.008	0.999	1.007
El Salvador	0.992	1.000	0.992	0.991	0.983
Guatemala	1.001	1.003	1.004	0.992	0.996
Honduras	1.000	1.002	1.002	0.994	0.995
Mexico	1.000	0.999	0.999	1.003	1.002
Nicaragua	1.000	1.000	1.000	0.992	0.992
Panama	1.000	0.992	0.992	1.005	0.997
Paraguay	1.024	0.995	1.020	1.002	1.022
Peru	0.989	1.002	0.991	0.995	0.986
Uruguay	1.004	1.004	1.007	1.010	1.018
Venezuela, RB	0.986	0.998	0.984	1.003	0.987
Mean	1.000	1.001	1.000	0.999	1.000

Source: World Bank's World Development Indicators (2009), and author's calculations.

Looking first at the bottom of Table 2, it is found that MALM (sixth column) value is equal to one indicating a process of stagnation over entire 1980–2006 period for the Latin American countries as a whole. On average, that stagnation can be ascribed to stagnation on catching up EFFCH=1.000 (fourth column) and worsening -0.1 percent at an average rate of technological change (TECH). Decomposing the efficiency change shows that the distancing from the efficient frontier the scale efficiency (SECH) shows a slight increase of 0.1% while pure technical efficiency (PECH) has a value equal to unity indicating stagnation (second and third column respectively)

Analyzing the productivity growth for each country, Table 2 shows some interesting results. First, eight countries showed positive productivity growth and nine showed a decline in productivity. Second, most of the countries experienced technical progress and gained in efficiency. Third, the productivity (MALM) improvements were almost entirely due to technical progress (TECH), and only one country Ecuador improved their efficiency (EFFCH).

More specifically, the productivity growth and its components do not have the same behavior patterns. On the one hand, in the Brazil, Paraguay and Uruguay MALM increased at an average rate of 1.0 %, 2.2%, 1.8% per annum, respectively, over the entire period 1980–2006. On average, these improvements were due to both technical progress (TECH) 0.3, 0.2 and 1.0 respectively and efficiency change (EFFCH) with improvements 0.7 % in Brazil and Uruguay and 2.0 % in Paraguay. On the other hand, improvements in MALM are due exclusively to improvements in TECH is the case of Argentina, Chile, Costa Rica and Mexico.

The worsening of the productivity growth is generally attributable to deterioration on TECH in six countries (Bolivia, Dominican R., Guatemala, Honduras and Nicaragua). In the case of Panama and Venezuela the origin of worsening is EFFCH. Finally for El Salvador and Peru the attributable to deterioration are both TECH and EFFCH.

Between the 1980-93 and 1993-06 periods (table 3), Latin American countries showed a deterioration and improvement in productivity growth (MALM) -0.3 and 0.2 percent respectively. While technological change is the attributable to improvements of MALM in period 1993/06, at the same time is the problem for deterioration MALM in period 1980/93

Table 3. Average productivity, technical efficiency and technological changes for the years 1980-93
and 1993-2006

	MALM			TECH			EFFCH		
Country	80-93	93-06	Change	80-93	93-06	Change	80-93	93-06	Change
Argentina	0.996	1	0.004	0.996	1.006	0.01	1	0.994	-0.006
Bolivia	0.984	0.996	0.012	0.977	1.005	0.028	1.006	0.991	-0.015
Brazil	1.021	1.029	0.008	1.001	1.006	0.005	1.020	1.022	0.002
Chile	0.999	1.007	0.008	1.015	1.006	-0.009	0.985	1.001	0.016
Costa Rica	0.999	1.004	0.005	1.008	1.007	-0.001	0.991	0.997	0.006
Dominican R.	0.985	0.996	0.011	0.974	0.998	0.024	1.012	0.998	-0.014
Ecuador	1.014	1.014	0	0.992	1.013	0.021	1.023	1.001	-0.022
El Salvador	0.971	0.966	-0.005	0.977	0.997	0.02	0.993	0.969	-0.024
Guatemala	0.995	0.999	0.004	0.978	0.999	0.021	1.017	1	-0.017
Honduras	0.983	0.995	0.012	0.981	1.005	0.024	1.002	0.99	-0.012
Mexico	1.005	1.007	0.002	1.007	1.007	0	0.999	1	0.001
Nicaragua	0.997	1	0.003	0.978	1.006	0.028	1.02	0.994	-0.026
Panama	0.981	0.986	0.005	0.998	1.006	0.008	0.983	0.98	-0.003
Paraguay	1.015	1.016	0.001	0.998	1.016	0.018	1.017	1	-0.017
Peru	0.983	0.989	0.006	0.985	1.006	0.021	0.998	0.984	-0.014
Uruguay	1.020	1.023	0.003	1.005	1.014	0.009	1.015	1.008	-0.007
Venezuela, RB	1.009	1.012	0.003	1.009	1.007	-0.002	1	1.005	0.005
Mean	**0.997**	**1.002**	**0.005**	**0.993**	**1.006**	**0.013**	**1.005**	**0.996**	**-0.009**
SD	**0.015**	**0.015**		**0.014**	**0.005**		**0.013**	**0.012**	

Source: World Bank's World Development Indicators (2009), and author's calculations.

Between the 1980-93 and 1993-06 period (table 3), thirty-five and forty-seven percent of the countries in sample showed improvement in productivity, the greatest gains being in Brazil, Uruguay and Paraguay. This improvement was accounted for mainly by the improvement in technology with the exception of Ecuador country where EFFCH is important.

5.2. Latin American performance and compatibility with growth theories and convergence process

In line with (Lall *et al*., 2002) to determine whether productivity growth in the Latin American is greater in lower or higher income countries, that is whether there was a pattern of productivity convergence (or productivity catching-up) in the Latin American, the productivity growth index is regressed against the difference in GDP per capita between the U.S. and each of 17 Latin American countries (USLAC) for the period between 1980 and 2006. The USLAC variable was calculated in the following manner:

$$USLAC_i = GDP_{US} - GDP_i; \qquad USLAC_i = \alpha + \sum_{1}^{17} \beta_o \, D\_countries + \varepsilon_i$$

Where GDP_i is the gross domestic product per capita of country. As mention (Lall *et al*., 2002) with the use of nonparametric methods it is possible to define the convergence theory in terms of technical efficiency. The convergence theory could be restated in the relationship between productivity and technical efficiency. This relationship would state that those countries that were near the production frontier would see a lower level of productivity growth than those that were farther away. Hence if the convergence theory helps, there would be a negative relationship between lagged technical efficiency and the next period's productivity level. The results in table 4 provide support for the theory of convergence in that the regression coefficient was statistically significant and negative.

Table 4. Relationship between productivity growth rate and GPD difference (USLAC)

	Coef. Est.	t value	
(Intercept)	53.01	60.212	**
TECH (lagged)	-1.71	-2.182	*

Bolivia	1.15	1.992	*
Brazil	6.56	11.388	**
Chile	9.59	16.634	**
Costa Rica	13.10	22.675	**
Dominican R.	16.60	28.76	**
Ecuador	18.30	31.805	**
El Salvador	20.20	34.984	**
Guatemala	24.00	41.64	**
Honduras	27.50	47.772	**
Mexico	32.40	56.281	**
Nicaragua	38.10	66.053	**
Panama	43.80	75.982	**
Paraguay	46.20	80.11	**
Peru	49.10	85.193	**
Uruguay	54.40	94.395	**
Venezuela, RB	58.90	102.262	**

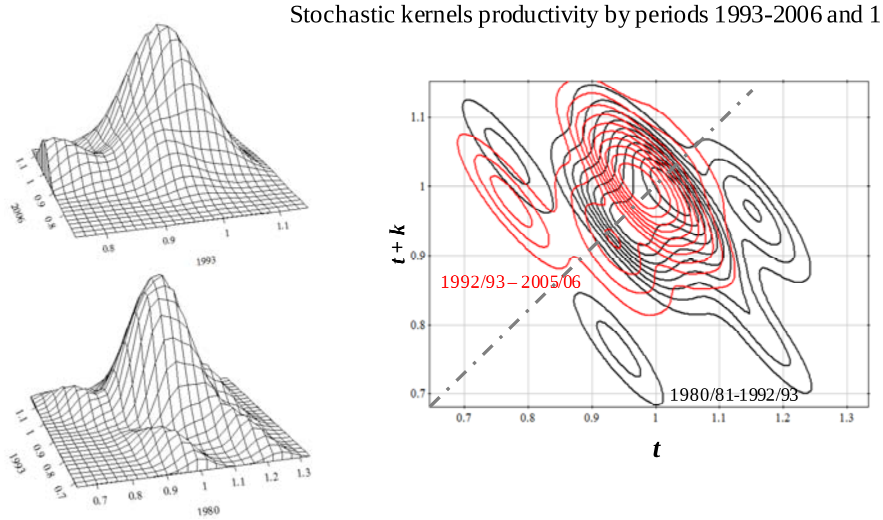
*,** significance at the 5 and 1 percent levels respectively
Omitted country Argentina; Anova test for country effect at 1 percent significance

Source: World Bank's World Development Indicators (2009), and author's calculations.

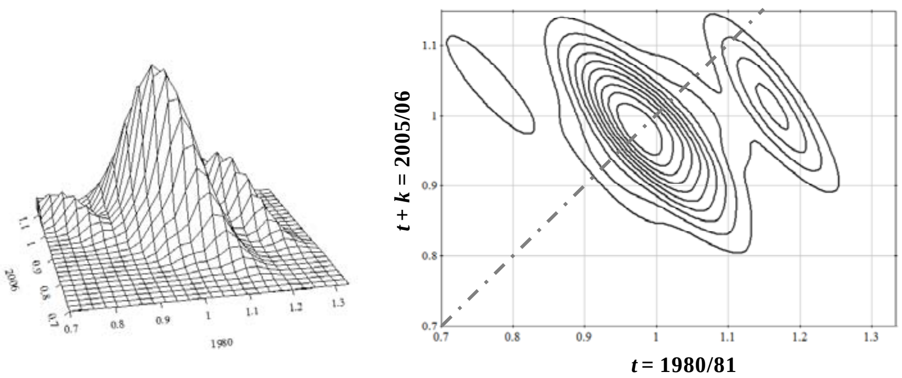
5.3. Dynamic perspective of the distribution of the productivity

The analysis up to this point is interesting to control the convergence process, but it does not say anything about the changes that may have occurred within the distribution itself. In order to capture this dynamism stochastic kernel estimations are used that consider the probability of moving between any two levels in the range of values. A stochastic kernel is therefore conceptually equivalent to a transition matrix with the number of intervals tending to infinity (Quah 1996). The stochastic kernel can be approximated by estimating the density function of the distribution at a particular time $t+k$, conditioned by the values corresponding to a previous time t. For this, a nonparametric estimation of the joint density function of the distribution at times t and $t + k$ is carried out. Figure 1 shows the stochastic kernels estimated from the efficiency for time periods of 13 years (t = 1980/81 and $t+k$ =1993/94), and (t =1993/94 and $t+k$ =2005/6) and 26 years (t =1980/81 and $t+k$ =2005/06) for Latin American countries.

Stochastic kernels productivity by periods 1993-2006 and 1980-1993



Stochastic kernels productivity by period 1980-2006



Source: World Bank's World Development Indicators (2009), and author's calculations.

Figure 1 Stochastic kernel for period and subperiods

The interpretation is straightforward: in the 3D part of these graphs on the left, the X-axis represents the productivity values in 1993 and 1980 for the top graph of Figure 1, the Y-axis represents the productivity values thirteen years later (in 2006 or 1993), while the Z-axis represents the density (or conditioned probability) of each point in the X–Y plane. Lines parallel to the year 2006 or 1993 show the probability of moving from the point considered on the X-axis to any other point on the Y-axis. Given that the probability mass for the two periods concentrates around the positive diagonal and separated from it above and below it can be concluded that the distribution is characterized by a same degree of persistence by also slight stratification. Nevertheless, comparing countries in the period 1980–2006 (see the bottom of Figures

1), countries sector presents some mobility. In other words, there is a certain distancing of the probabilistic mass from the diagonal.

An alternative way of analyzing this phenomenon is shown on the right-hand side of Figures 1, which shows the contour plots, representing cuts parallel to the base of the kernel (X–Y plane) at equidistant heights. Thus, the points are at an equal height and density. According to the contour plots in Figures 1 for two periods (see top graph) the probability mass of subperiod 1993-2006 (red lines) lies above the diagonal confirming an improvement of productivity over the period 1980-1993. Finally figure 1 shows for entirely period 1980-2006 two nucleus one is located over the diagonal, that is to say countries that not improvements its productivity and the second nuclei below the diagonal indicating that some countries worsen their productivity levels.

5.3. On the relationship between productivity and international openness

At least two major problems we find when explaining the effect of international openness on growth in productivity. The first relates to the difficulties of adequately measuring the degree of openness that was addressed in paragraph 2. The second refers to the most appropriate methodology for measuring the openness and productivity. As mention Winters (2004) the linear regression model, which is standard to this literature, is not well equipped to identify the necessity of variables rather than their additivity in the growth process. Brock and Durlauf (2001), in a fairly complex discussion of the statistician's concept of exchangeability, argue that growth theory is too open to be adequately tested with the economists' traditional regression tools.

Another important consideration is that the effect would be expected between openness and productivity. Many empirical studies have examined the role of openness on economic growth. Anikkaya (2003) makes an interesting review of the work to address these issues. From the literature reviewed from the classification into two groups (1) case studies of specific countries and (2) cross-country analyses, the author mentions that it is difficult to draw strong conclusions from them for at least three reasons: (i) they include only a handful of countries; (ii) they differ in the economic techniques employed; and (iii) researchers focused on different issues, specific to each of the respective countries (Edwards, 1993).

In specific field which forms part of this investigation, ie in cross-country literature, usually finds a positive relationship between measures of openness and growth. This positive association is then interpreted as evidence that openness to trade improves growth. Edwards (1993) reviews the most important studies published until the early 1990s and concludes that the most of these cross-country studies suffer serious problems in terms of endogeneity and measurement errors. In other studies the problems encountered are related to identify the direction of causality between openness and growth.

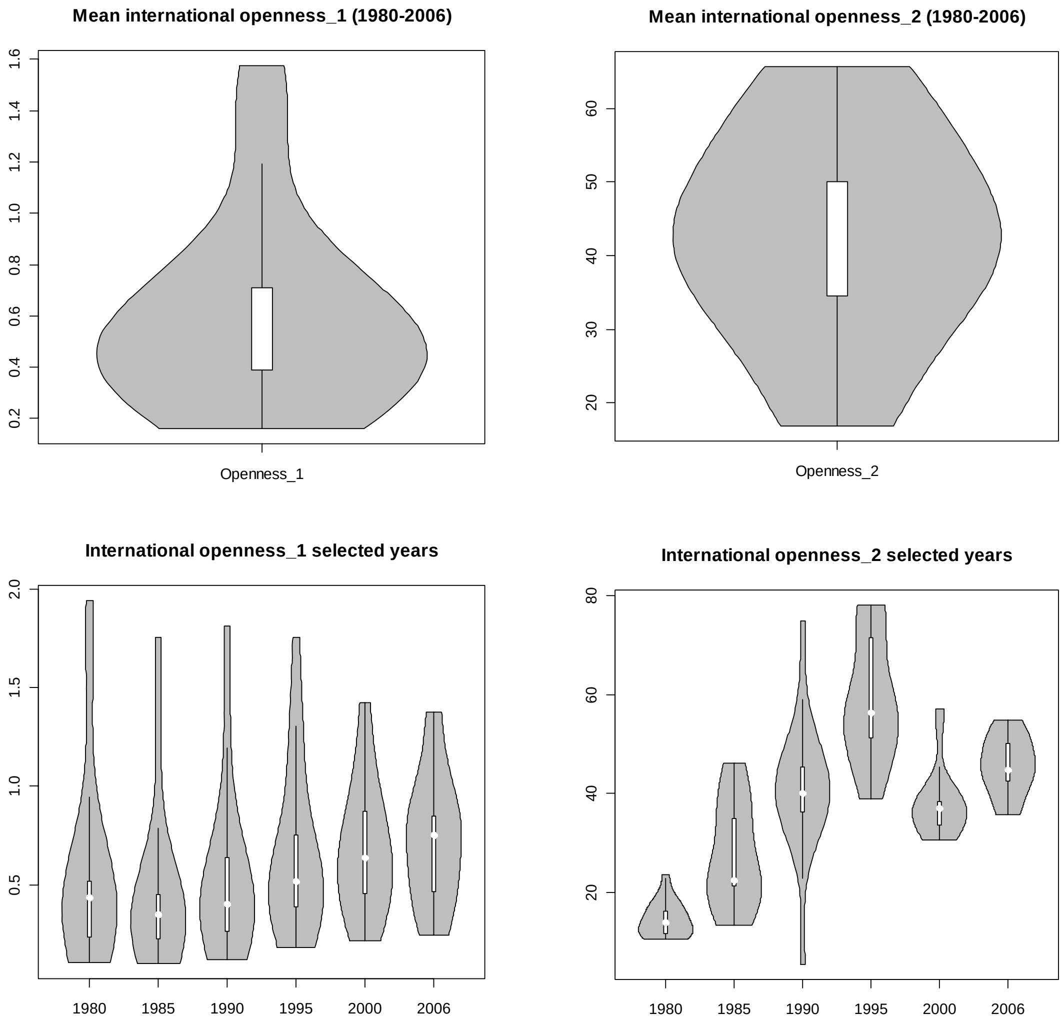
With these considerations in mind, we have raised the analysis of the relationship between openness and productivity growth in two stages. In the first one we made a descriptive analysis of the liberalization measures that we use and then fed compare these with the growth of productivity through nonparametric methods. In the second stage we propose a panel analysis in a complementary manner.

5.3.1. Descriptive analysis of international openness variable

As mention we use two variables to measure international openness trade: merchandise trade (% of GDP) and (export+imports)/GDP. We labeled this variables openness_1 and openness_2 respectively. Figure 2 shows the two variables in violin plots[3] that allows us to visualize the entire distribution using box plots and corresponding to mean productivity for countries by openness variables in selecting

[3] Violin plots are a mix between box plots and density functions estimated non parametrically via kernel smoothing, to reveal structure found within the data. Box plots show four main features of a variable: centre, spread, asymmetry and outliers. The density trace, which in the case of violin plots is duplicated for illustrating purposes, supplements this information by graphically showing the distributional characteristics of batches of data such as multi-modality. See Hintze and Nelson (1998).

years, which enables the features of the distributions to be detected more thoroughly. The white dot indicates the median and the black bar the first and third quartile.



Source: World Bank's World Development Indicators (2009), and author's calculations.
Figure 2. Mean and evolution of Openness in selected years

As shown in Figure 2, significant differences exist in the two variables. In relation to the graphs of the upper openness_1 variable has a significant mode in the lower middle range of values between 0.2 and 0.7 while openness_2 approaches a normal distribution.

Considering the evolution of the variables in selected years in the graphics on the bottom of Figure 2 shows also differences in both the range (openness_1 constant and variable openness_2) and the tendency of the distribution (increasing from 1985 in openness_1 and oscillating openness_2).

5.3.2. Nonparametric regression

Table 5 show the results significance of smooth terms in both nonparametric regression with openness_1 and openness_2.

Table 5 Statically significance for smooth parameters

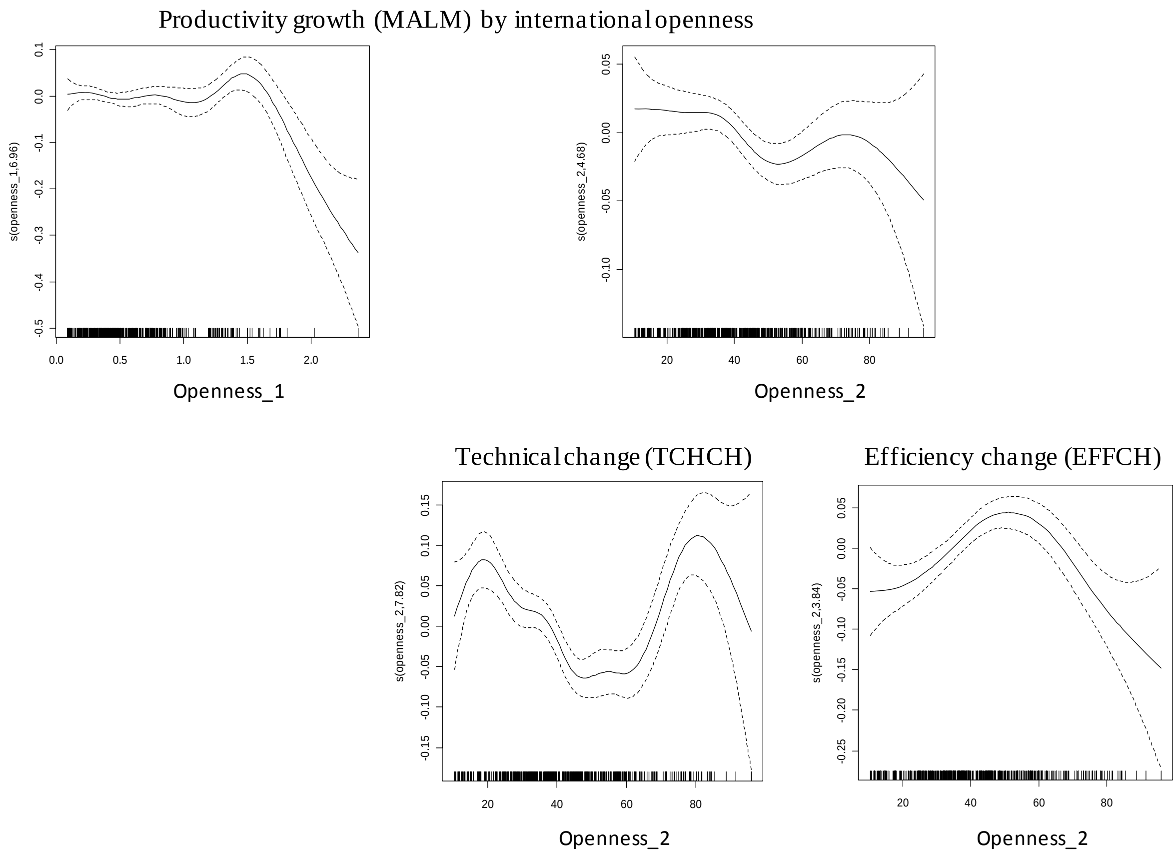
Variable	Model_1 Openness_1		Model_2 Openness_2	
MALM	4.175 (0.0001)	**	2.667 (0.0245)	*
R^2 adj.	0.0576		0.028	
TECHCH	1.651 (0.158)		10.88 (0.0000)	**
R^2 adj.	0.0113		0.159	
EFFCH	0.212 (0.661)		9.032 (0.0000)	**
R^2 adj.	0.0017		0.0732	

(*),(**) statically significance at 1 an 5 percent respectively

Source: World Bank's World Development Indicators (2009), and author's calculations.

For openness_1 the only significance at 1 % is productivity growth. In the case of openness_2 productivity growth and its components are all statically significance at 5 and 1 percent respectively.

The plot method for GAM produces the graphs showed in the figure 3, showing a point-wise 95 percent confidence envelope around de fit. As you can see the trend between productivity and openness 1 and 2 not have the same pattern (top figure). For openness 1, the downward trend in the final values is very pronounced. In relation to the components of MALM, technical change (TCHCH) and efficiency change (EFFCH) and its relationship to the degree of openness trajectories are antagonists, except in the final values as shown in the graphs at the bottom Figure 3.



Source: World Bank's World Development Indicators (2009), and author's calculations.

Figure 3 Partial-regression functions for additive regression of productivity growth and its components on openness_1 and openness_2. The broken lines give point-wise 95-percent confidence envelopes around the fit.

5.3.3. Panel data

The results obtained in the previous section gives an approximation to the relationship between openness and productivity growth. We now examine the same relationship but considering various control variables. We specify the following basic equation, where productivity growth depends on past productivity growth, international openness and others control variables:

$$LnMALM_{it} = \beta_0 + \beta_1 LnMALM_{it-1} + \beta_2 Inf_{it} + \beta_3 Pop_{it} + \beta_4 Sh\_Ag_{it} + \beta_5 Sh\_Man_{it} + \beta_6 Pop_{it} + \beta_7 Op_{it} (\#1 \text{ or } \#2) + c_{it} + \varepsilon_{it} \quad [4]$$

Where:

$LnMALM_{it}$: productivity growth (MALM)
$LnMALM_{it-1}$:lagged productivity growth (MALM)
Inf :inflation rate
Sh_Ag :share of agriculture (% GDP)
Sh_Man :share of agriculture (% GDP)
Pop :numbers of inhabitants
Op (#1 or #2) :international openness (export+impor/GDP) or merchandise trade (%GDP)
Time :time period 1981-2006

We include past productivity growth as an independent variable. If there is a trend effect, with past productivity growth perhaps indicating the ability to innovate, the coefficient on this variable will be positive. On the other hand, the coefficient may be negative if country innovation tends to be lumpy Paus *et. al* (2003). As mentioned and justified in the previous sections we use two variables to measure the degree of openness. It also includes variables to control the macroeconomic effects. To eliminate the country specific effects we first difference in equation (4). This leaves us with equation (5). We estimate using instrumental variables using the Arellano-Bond GMM estimator (Arellano and Bond, 1991).

$$LnMALM_{it} - LnMALM_{it-1} = \beta_0 + \beta_1 (LnMALM_{it-1} - LnMALM_{it-2}) + \beta_2 (Inf_{it} - Inf_{it-1}) + \beta_3 (LnPop_{it} - LnPop_{it-1}) + \beta_4 (Sh\_Ag_{it} - Sh\_Ag_{it-1}) + \beta_5 (Sh\_Man_{it} - Sh\_Man_{it-1}) + \beta_6 (Op_{it} - Op_{it-1}) + \varepsilon_{it} - \geq j_{it} \quad [5]$$

Table VI Arellano-Bond estimates of productivity growth model panel data 1980-2006: Dependent variable Productivity growth$_t$

Model #1				Model #2			
Variable	Coef. Est.	Std. Error		Variable	Coef. Est.	Std. Error	
LnMALM-1	5.5E-09	4.56E-10	***	LnMALM-1	6.08E-09	5.50E-10	***
Openness_1	2.50E-10	2.26E-11	***	Openness_2	-6.37E09	5.36E-10	***
Openness_1^2	-2.80E-12	1.98E-13	***	Openness_2^2	3.12E-09	3.05E-10	***
Inflation	1.70E-14	5.71E-	***	Inflation	1.11E-13	6.94E-	

		14				14	
Lpop	3.48E-08	1.69E-09	***	Lpop	2.36E-08	1.74E-09	***
S. of Agriculture	3.54E-10	2.37E-11	***	S. of Agriculture	4.20E-10	2.80E-11	***
S. of Manufacturing	-2.04E-11	2.09E-11		S. of Manufacturing	4.11E-11	2.41E-11	*
Wald test (p-value)	4.49E+18			Wald test (p-value)	3.11E+18		
Numbers of Obs.	372			Numbers of Obs.	372		

Note: Openness_1= % merchandise of GDP; Openness_2= (export+imports)/GDP
***,**,* Significant at the 99, 95 and 90 respectively. Standard errors in parentheses

Source: World Bank's World Development Indicators (2009), and author's calculations.

We estimated [5] to explore any factor-related differences in the determinants of productivity growth for both models of openness. The positive and significant coefficients on lagged productivity growth for both models provide support for ability to innovate. Similarly population and share of agriculture are positively related to productivity growth. Major differences are found in the different curvilinear relationship between productivity and openness. In the case of model 1, the relationship between productivity and openness (% merchandise of GDP) is inverted U-shape, whose maximum value is 44.64% and the average value in the analysis period is 42.39% (median 40.19%), which implies that a large number of countries by year of analysis is in trajectory growth, confirming a positive relationship.

With regard to model 2 ((imports + exports) / GDP) ratio is the ranking or the lowest point in 1.02 and the average 0.58 (median 0.46) therefore a considerable number of observations are on the downward trend, confirming a negative relationship between productivity and openness.

6. Summary and conclusions

In this study we examine productivity growth and their relationship with international openness in Latin American countries over the period 1980-2006. Overall results on productivity indicate a stagnation process for the entire period 1986-2006. The decomposition of productivity into *catching up,* and technical change reveals that the first have a stagnation process and the latter worsening. Analyzing the relationship between productivity growth and international openness we find different patterns for both methodologies parametric (Arellano-Bond estimator) and nonparametric (GAM) and for both measures of international openness merchandise trade (% of GDP) and (export+imports)/GDP. In particular in a parametric way, although the shape is curvilinear for both models the relationship is positive inverted U-shaped in the first case and U-shaped in second.

The positive relationship between productivity growth and international openness found in this work is in line with much of the literature as discussed in Anikkaya (2003). On the other hand the negative relationship has less empirical support. However, as mentioned Paus et al., (2003) authors such as Rodriguez and Rodrik (2001, p.24) puts it, "… no country has developed simply by opening itself up to foreign trade and investment. The trick has been to combine the opportunities offered by world markets with a domestic investment and institution-building strategy to stimulate the animal spirits of domestic entrepreneurs".

In this context, three conclusions from the results are worth emphasizing: First, the results suggest that Latin American countries need to reach a certain threshold of macroeconomic stability (low rates of inflation, etc.) in order to reap the benefits of the openness and trade in order to increase the economic growth. Second, the results confirm the advantage enjoyed by Latin American economies in terms of growth as illustrated by the positive association between population and real GDP growth. Third, the results also indicate that industrial activity will ultimately hurt growth as trade increases while agricultural activity helps the country to sustain growth.

Finally two issues have been highlighted by this paper as critical for future research. First, although the results of the two regressions reported in this paper suggest that the causality between openness and growth runs is positive and significant, the behavior of the shaped is different in both models (positive inverted U-shaped in the first case and U in second). Second, the different results which arise from the use of panel data suggest the importance of disentangling short-run from long-run effects without throwing away the information in annual data. Quah and Rauch (1990) have made a first attempt to disentangle the impact of cyclical from long-run effects of policies on growth in time series data. Apply Quah and Rauch's methodology to analyze their two openness measures used in this paper would be a useful exercise.

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Appendix

Table I Output and inputs variables.

Variable	Definition
Output: GDP[1] (constant 2000 US$)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.
Input 1: Gross fixed capital formation[2] (constant 2000 US$)	Gross fixed capital formation (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation. Data are in constant 2000 U.S. dollars.
Input 2: Labor force[3], total	Total labor force comprises people who meet the International Labour Organization definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general the labor force includes the armed forces, the unemployed and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector.

[1]International Finance Corporation's micro, small, and medium-size enterprises database (http://www.ifc.org/ifcext/sme.nsf/Content/Resources).
[2]World Bank national accounts data, and OECD National Accounts data files.
[3]International Labour Organization, using World Bank population estimates.

Source: World Bank's World Development Indicators (2009).

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