Human Capital, Innovation, and Productivity Growth: Tales from Latin America and Caribbean

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Abstract

Why have Latin American and Caribbean countries (LAC countries) not replicated Western economic success? We investigate the reasons behind the economic stagnation of LAC countries for the past four decades. We utilize a nonparametric Malmquist productivity index for relevant cross-country and over time productivity growth, technological change, and technical efficiency change comparisons. We document that productivity growth differences between LAC countries and Western countries can only partially be attributed to human capital differences. We argue that along with inefficient production, differences in civil, political, and economic policies and institutions are promising factors in explaining the long-run economic performance of LAC countries.

Keywords: Caribbean, Latin America, Institutions, Malmquist productivity index

JEL codes: N26, O40, P52

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1 Introduction

Over the past several decades, Latin American and Caribbean countries (hereafter, LAC countries) have faced significant development challenges including contracting productivity growth rates, high inflation, unemployment, skewed income distribution, and poverty. Along with the effects of various short-run crises, recent empirical research focuses on the long-standing economic stagnation of the region without giving much attention to comparative analysis of productivity growth trends and reasons behind the under-development of LAC countries. In this paper, we present a comparative analysis of LAC countries' growth trends for 1966-2000 period and investigate the effect of various factors on the long-run growth performance of the region.

We first compare long-run productivity growth performance of LAC countries with that of a peer group of European and North American countries[1] to provide a benchmark for what LAC countries could have possibly achieved over the last four decades of the century. Such a comparison makes sense since almost all of the LAC countries are populated by individuals of European descent who established the Western culture and economic success[2]. We show that almost all of the LAC countries perform unfavorably compared to North American and European countries in terms of their productivity growth rates. In light of this fact, we further investigate the reasons those could explain the poor economic growth performance of LAC countries.

Taking the United States as a benchmark country, we first document that human capital difference is not the primary factor in explaining the productivity growth differences between LAC countries and Western countries. This is because while LAC countries' relative human capital is

[1] Peer group of North American and European countries are as follows: United States, Canada, Austria, Belgium, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

[2] Our idea here follows that of Cole et al. (2005). Using a neoclassical growth framework, they compare long-run Latin American macroeconomic trends with a similar set of peer group of European and North American countries.

increasing over time, their relative labor productivity measured by GDP per worker is falling[3].

Recent literature in explaining the long-run growth dynamics gives a particular importance to institutions and provides well-established evidence that differences in institutional development among countries lead to sustained differences in economic outcomes. In a seminal paper, Hall and Jones (1999) argue that differences in capital accumulation and output per worker among countries are driven by differences in institutions and government policies, which they refer to as social infrastructure. Later, Acemoglu, Johnson, and Robinson (2001, 2002) and Easterly and Levine (2003) have all reached a consensus that the political institutions are the fundamental cause of economic growth. Lall et al. (2002) have also reached the same conclusion using a Malmquist productivity growth index, yet they fail to recognize that the institutional quality endogenously affect the productivity growth rates of different countries. Using various institutional quality measures, we investigate whether institutions can explain the poor economic performance of LAC countries compared to that of European and North American countries. After controlling for the endogeneity, we find strong evidence that civil, political and economic policies and institutions have significant and positive relationship with the productivity growth and also positively affect the technological change (innovation) within the sample countries. However, they have no significant effect on the technical efficiency change (adaptation of existing technologies) component of the productivity growth.

We utilize a Malmquist productivity index[4] computed by nonparametric linear programming methods for relevant cross-country and over-time comparisons. This index of total productivity growth and the method to compute it, data envelopment analysis, has several desirable features

[3] For comparison purposes, our approach for taking United States as a benchmark country in relevant comparisons follows Cole et al. (2005). They also conclude that human capital differences are not the primary factor in explaining Latin American TFP gap.

[4] Malmquist productivity index is first introduced by Caves et al. (1982). Later, Färe et al. (1994) show how this index can be computed using non-parametric linear programming methods.

compared to those of traditional growth accounting techniques. Most importantly, this index can be decomposed into two useful components, namely technological change and technical efficiency change. We report that innovation measured by the technological change component is the main source of productivity growth in European and North American countries. On the other hand, through international diffusion of knowledge, LAC countries use the opportunity to adopt the new technologies of Western countries and hence grow mostly due to the technical efficiency change.

The rest of this paper is organized as follows. A discussion of the main economic trends of LAC countries over the past several years is presented next to provide a background for our empirical analysis. In section three, we provide a discussion of the analytic framework and the construction of the Malmquist productivity growth index. In section four, we summarize the data and present our main findings. Section five is dedicated for the empirical investigation of the intuitional factors those could possibly explain the productivity differences between LAC and Western countries. Finally, section six concludes.

2 Relative macroeconomic trends in LAC countries

Most of the LAC countries are founded and populated by the individuals of European descent. Table 1 shows that most of the LAC countries widely adopted European culture, religion, and language. Spanish and English are among the native languages in both Latin America and the Caribbean. Almost 81% of Latin Americans are white or mixed-white along with 39% of Caribbeanians. In addition, 92% of Latin Americans and 66% of Caribbeanians are affiliated with a Western religion. These facts are consistent with those of Hoogvelt (2001). He argues that LAC countries experienced substantial European colonozation and immigration, and Western culture has had considerable impact on LAC countries. In most of the countries, European settlers nearly wiped out native cultures of the region. Therefore, following Cole et al. (2005), our basic assumption is that individuals of LAC countries share similar preferences compared with those of European and North American countries and have the same innate ability to innovate new technologies or to replicate existing technologies. Hence, a comparison of LAC countries to those of European and North American countries would provide a benchmark for what LAC countries could have possibly achieved over the last four decades of the century.

Table 2 presents the long-run trends for various macroeconomic indicators for the sample LAC countries and European and North American countries taking United States as a benchmark country. The mean GDP per capita in Latin America was 27% of the U.S level in 1966 and it fell from 23% of the U.S level in 1980 to 18% by 2000. Similarly, GDP per worker in Latin America fell from 34% of the U.S level in 1966 to 23% by 2000. Caribbean countries also lost substantial ground relative to the U.S during this period. The mean GDP per capita in Caribbean countries fell from 24% of the U.S level in 1966 to 21% by 2000. However, European countries increased their GDP per capita from 66% of the U.S level to 70% during the same period. In addition, mean GDP per worker in Europe increased from 65% of the U.S level in 1966 to 76% by 2000, although capital per worker decreased from 106% of the U.S level to 82% during the same period.

The comparison is even more striking if we consider individual countries. Argentina's GDP per capita was 53% of the U.S level in 1966 which was higher than Greece, Ireland, Portugal, and Spain. It fell to 35% of the U.S level from 1966 to 2000. During this time, Greece, Ireland, Portugal, and Spain all gained substantial ground and increased their GDP per capita above Argentinean level. Therefore, Table 2 shows the long-standing economic stagnation of LAC countries and their divergence from the rest of the Western countries.

Table 2 also implies that the economic stagnation of LAC countries cannot be attributed primarily to human capital differences between LAC countries and European and North American countries. The table reports that human capital in all LAC countries are catching up to the U.S level. Specifically, Latin America's relative human capital increased by 41% between 1966 and 2000, and Caribbean's increased by 47% compared to those of Europe's relative human capital, which increased by 11% and Canada's relative human capital, which increased by 6% during the same period. In line with Cole et al. (2005), we conclude that human capital differences between LAC countries and European and North American countries do not play the primary role in explaining the long-run economic performance of LAC countries. This is because while LAC countries' relative human capital is increasing over time, their relative labor productivity measured by GDP per worker is falling. We will later consider alternative factors retarding LAC countries' development process, in light of the conclusions of Hall and Jones (1999), Lall et al. (2002), Hendricks (2002), and Cole et al. (2005). That is, we will analyze the effect of inefficient production, institutions, and civil, economic, and political liberty on the long-run economic growth performance of LAC countries.

3 Malmquist index of productivity growth

Current literature offers two distinct methods to measure total factor productivity growth (TFP). The first method, also known as growth accounting, relies on the estimation of various production functions and is the standard measurement tool since Solow (1957). Growth accounting methodology relies on accounting for the contribution of the growth of the input factors of a country to the growth of its output. The residual part of the growth of output that cannot be accounted for measures TFP growth. Mankiw, Romer, and Weil (1992) and Islam (1995) are two recent and widely cited examples of cross-country studies using growth accounting techniques.

On the other hand, TFP growth can also be measured using methods that estimate frontier production functions. This methodology relies on constructing a best practice frontier using the data on inputs and outputs, then measuring distances of countries to the frontier constructed. In these methods, production frontier function can be estimated either parametrically or nonparametrically. Parametric method or so-called stochastic frontier analysis (SFA) requires the specification of the functional form of the production function and also relies on certain distributional assumptions. Gong and Sickles (1992) demonstrates that SFA yields biased results in small to medium sized samples.

In sharp contrast, using linear programming methods, the nonparametric approach and the method of data envelopment analysis (DEA) does not require any specific functional or distributional assumptions. However, independent of the methodology employed to calculate the distances of the sample countries from the best practice frontier constructed over the whole sample, TFP growth can be computed using the Malmquist productivity growth index.

Among many others, recent country studies employing the Malmquist productivity growth index include Färe et al. (1994), Krüger (2003), and Yörük and Zaim (2005). Färe et al. (1994) compute the TFP growth for 17 OECD countries from 1979 to 1988. They conclude that the main determinant of productivity growth in OECD countries is the technological change. Krüger (2003) apply this methodology to a sample of 87 countries for 1960-90 period. Employing hazardous by-products of production as undesirable outputs, Yörük and Zaim (2005) measure the TFP growth of OECD countries from 1983 to 1998.

The Malmquist productivity index has two main advantages when compared to those of growth accounting. First, this index can be decomposed into a technological change and technical efficiency change components accounting for innovation and catching-up respectively. Second, no price information on either inputs or outputs is necessary to compute this index. In this paper, we employed the DEA methodology and nonparametric approach to compute the Malmquist index, primarily because it relies on much weaker assumptions compared to SFA. Färe, Grosskopf, and Russell (1998) give a very complete survey on both the theory and the empirics of Malmquist indices; hence we will here provide a brief account of the essentials of the Malmquist index.

The theoretical foundation of Malmquist productivity growth index is based on the output distance function $D_o^t(x^t, y^t) = \inf\{x^t, (y^t/\theta) \in S^t\}$, which is defined with respect to the production technology such that $\{S^t = (x^t, y^t) : x^t \text{ can produce } y^t\}$[5]. Here, $y^t \in R_+^M$ refers to the vector of outputs produced at time t and $x^t \in R_+^N$ refers to the vector of inputs used in the production of outputs at time t. Given inputs, the output distance function measures the reciprocal of the maximal ray expansion of the observed outputs such that outputs are still feasible using the production technology S^t.

If the observed production is on the production frontier at time t, such as at point (x^t, y^t), then production is said to be technically efficient and $D_o^t(x^t, y^t) = 1$. On the other hand, if observed production is interior to the production frontier, production is said to be technically inefficient, and $D_o^t(x^t, y^t) < 1$. Hence, the output distance functions are the complete characterization of technology and the point $D_o^t(x^t, y^t) = 1$ represents the maximum production or the "best practice" as defined by Farrell (1957).

Caves et al. (1982) defines the Malmquist index as the ratio of two output distance functions, both of which are functional representations of a multiple-output and multiple-input technology that requires information on input and output quantities. Formally, the Malmquist index is defined as

$$M_o^t(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}. \tag{1}$$

[5] This production technology is defined in Shephard (1970).

It is also possible to break down the Malmquist index into technical efficiency change (catching-up) and technological change (innovation) components. Following Färe et al. (1994), the Malmquist index can be redefined as

$$M_o^{t+1}(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right]^{1/2} \tag{2}$$

where superscripts index two adjacent time periods. The ratio outside the brackets captures the change in technical efficiency between t and $t+1$, while the ratio inside the brackets captures the geometric mean of technological change relative to t and technological change relative to $t+1$.

In equation (2), $M_o^{t+1} > 1$ implies a productivity growth, whereas $M_o^{t+1} < 1$ implies deterioration in productivity over time. Similarly, technical efficiency change and technological change indices greater than one represent improvement in the respective measures, whereas values less than one represent deterioration in performance.

The Malmquist index can be constructed by solving following linear programming problem for any observation k':

$$\begin{gathered} (D_o^{t''}(x_{k'}^{t'}, y_{k'}^{t'}))^{-1} = \max \theta \\ s.t. \\ \textstyle\sum_{k=1}^{K} z_k y_{km}^{t'} \geq \theta y_{k'm}^{t'} \quad m = 1, ..., M \\ \textstyle\sum_{k=1}^{K} z_k x_{kn}^{t'} \leq x_{k'n}^{t'} \quad n = 1, ..., N \\ z_k \geq 0 \quad k = 1, ..., K \end{gathered} \tag{3}$$

where K indexes the number of cross-section units for each time period within the panel data, N represets the inputs, M indexes the outputs, and z_k is an intensity variable, which measures the weight of each cross-section unit within the sample group. The weight is then compared with any particular observation to determine the distance to the efficient frontier. This linear programming problem measures the output-based Farrell technical efficiency of observation k' relative to the reference technology at period t', i.e. $D_o^{t''}(x^{t'}, y^{t'})$, for all $(t', t'') \in \{(t,t), (t,t+1), (t+1,t), (t+1, t+1)\}$.

4 Data and results

In constructing the Malmquist productivity index, the resource constraint (inputs) consists of the net fixed standardized capital stock, labor force measured by the number of workers, and human capital stock accounted by the average years of schooling of adult population aged 25 and over. As an output, we take real GDP measured by purchasing parity adjusted in 1996 prices. Data on the capital stock, labor, and real GDP are drawn from a recent data set in Marquetti (2004). Barro and Lee (2001) is the source for human capital stock data[6]. The annual panel data set includes 20 Latin American and Caribbean countries and 18 European and North American countries. Time period considered is 35 years, from 1966 to 2000.

In the first three columns of Table 3, we report the mean annual changes in productivity growth, efficiency change, and technological change from 1966 to 2000. Except for United Kingdom and Portugal, all European and North American countries improved their productivity during the time period considered. On average, Italy, Finland, and Norway are the best performers. The main source of the productivity growth in European and North American countries is the technological change component, which increased annually by almost 0.6% in North America and 0.8% in Europe, while the technical efficiency change component actually decreased annually by 0.1% in North America but increased 0.5% in Europe.

In contrast, main source of the productivity growth in LAC countries is the efficiency change. On average, it increased annually by 0.1% in Latin American countries and 0.2% in Caribbean

[6]Barro and Lee (2001) provide this datum for every five years. Following Maudos, Pastor, and Serrano (1999) intermediate years have been estimated by interpolation.

countries, while technological change component decreased by 0.2% in Latin American countries but increased by 0.2% in Caribbean countries. Jamaica, Venezuela, Paraguay, Nicaragua, Mexico, Honduras, El Salvador, and Costa Rica are the LAC countries, in which productivity deterioration is observed. Ecuador is the best performer among LAC countries averaging 1.3% productivity growth per year.

In Table 3, we also report the cumulative Malmquist index and its components from 1966 to 2000 by sequential multiplication of improvements in each year. In terms of ranking and the productivity performance of the countries the results are virtually the same compared with the mean Malmquist index. The main component of long-run productivity growth in LAC countries appears to be the efficiency change while for European and North American countries, technological change remains to be the main component of the productivity growth. On average, for the time period considered, European countries improved their productivity by 55% while North American countries improved by 19.6%. On the other hand, Latin America's low TFP growth performance is clearly indicated by the 4.2% deterioration of the Malmquist index. However, Caribbean countries on average improved their productivity by 12%.

Figure 1 provides a clear exposition of long-run productivity performance of North American, European, Latin American and Caribbean countries. For expositional purposes, we normalize the Malmquist productivity growth index of all countries to unity for 1966. European productivity exhibits an upward trend from 1966 to 2000 with the exception of the periods 1974 to 1975, 1980 to 1983, and 1990 to 1993. North American productivity growth fluctuates over the time period considered. However, it trends upwards after 1983 with an exception of the period 1989 to 1991. Similarly, Caribbean TFP growth fluctuates over time but boosts after 1986. Recent stagnation periods in Caribbean region include 1991 to 1994 and 1996 to 1997. Finally, for Latin America, productivity growth declines until 1983 and then rises until 1994. However, a rapid decline after 1994 results an over all negative productivity growth performance for the region.

Hence, our main conclusion from our analysis in this section is that innovation is the main source of productivity growth in European and North American countries. On the other hand, LAC countries suffer from inefficient production and lack of innovation. However, through international diffusion of knowledge, they use the opportunity to replicate the new technologies produced and hence grow mostly due to adaptation, i.e., through technical efficiency change. In addition, human capital stock is an important factor in explaining the productivity growth[7], but it is not the key factor in understanding the long standing TFP growth gap between LAC countries and the rest of the Western region.

5 Policies, institutions, and growth

Since both LAC countries and European and North American countries share the same best practice frontier constructed over the whole sample, they have equal access to available technology and knowledge. Yet, considerable variation in the technological change, efficiency change, and productivity growth still exist among these countries. In this section, we will discuss how much of this variation can be accounted for by differences in country-level policies and institutions.

Following the earlier studies of the institutions and economic growth literature, we use two different proxies to account for the institutional quality, namely ICRG composite country risk ratings and the equally weighted average of political and civil liberty indices. Data for ICRG composite risk are taken from World Development Indicators (World Bank, 2004). This index was originally constructed by Political Risk Service Group based on 22 components of risk with three subcate-

[7] The inclusion of the human capital as an input to the DEA model is tested following Banker (1996). This test indicates that inclusion of human capital to the model is statistically significant at 1% level.

gories of risk namely political, financial and economic. In computing the index, political risk has the highest weight and includes many components accounting for government stability, socioeconomic conditions, corruption, law and order, democratic accountability, bureaucracy quality, internal and external conflicts, and military in politics.

On the other hand, Freedom House (2005) is the source for the civil and political liberty indices. Scores of individual countries in civil liberty index depend on various determinants of civil liberty including but not limited to freedom of expression and belief, associational and organizational rights, rule of law, and personal autonomy and individual rights. Political liberty index, on the other hand, is the proxy for political rights including right to vote, compete for public office, and elect representatives, who have a decisive impact on public policies.

In Table 4, we present mean ICRG composite risk ratings and the weighted average of civil and political liberty indices for our sample countries[8]. It is evident that European and North American countries have achieved a lot more in terms of civil and political liberty and political institutions compared to that of LAC countries with an exception of Greece and Spain. Costa Rica appears to be the best performer among LAC countries. Note that Costa Rica is a Central American success story. Although it is largely an agricultural country, it has recently expanded its economy to include technology and tourism sectors. The standard of living is relatively high and land ownership is widespread. In a similar manner, Trinidad Tobago is the best performer of the Caribbean region. It is one of the wealthiest countries in the Caribbean thanks to petroleum and natural gas production and processing. Its economy benefits from low inflation and a growing trade

[8] Our data for ICRG composite risk ratings cover the period from 1984 to 2000 while civil liberty index is available from 1972 to 2000. For a complete discussion of the construction of ICRG composite risk rating, see http://www.ICRGonline.com. For a complete discussion of the construction of the civil and political liberty index, see http://www.freedomhouse.org. Civil and political liberty indices were originally constructed with the values ranged from 1 to 7 with 1 being the most liberated. Values were transformed such that 7 became the most liberated and 1 the least liberated.

surplus[9]. In the light of the simple tabulations of Table 4, our hypothesis is that civil and political liberties, country-level policies, and institutional quality are positively associated with long-run productivity growth and the economic success of countries.

We start investigating the relationship between instutions and productivity growth using a panel regression framework. This methodology has an advantage of controlling the unobserved hetereogeity that is generated by country level differences and time. However, it yields biased estimates if instutional quality measures are still correlated with the error term after the heterogeity of time and country effects are controlled for. Our dependent variables are the Malmquist indices accounting for productivity growth, technological change, and efficiency change, respectively. Apart from the proxies for instutional quality, we use a set of control variables, such as GDP per worker, capital stock per worker, human capital, share of agriculture and manufacturing industries in GDP, population density, and inflation rate[10]. The estimation results for relying on fixed and random effects are reported in Table 5. Hausman test indicates that random effects is the appropriate estimation strategy when the dependent variable is the productivity growth measured by the Malmquist index. However, fixed effects are preferred when dependent variables are technological change and efficiency change. The most striking result is that the coefficient on human capital is insignificant in all regressions. This result is in line with our previous findings that human capital is not primary factor in LAC countries long-run economic stagnation. Furhermore, GDP per worker and share of manufacturing in GDP are positively, inflation rate is negatively associated not only with long-run productivity growth but also innovation and adaptation components of the Malmquist productivity growth index. The instutional quality measures do not have a significant effect on the productivity

[9] A detailed discussion of Costa Rica's and Trinidad Tobago's economic success is presented in CIA World Factbook (2005).

[10] The source of this data is World Bank Development Indicators (2004). Natural logarithm of inflation rate and GDP per worker is used in the estimations.

growth. Civil and political liberties, however, positively affect the technological change.

In Table 6, we investigate the relationship between instutional quality measures and productivity growth using an alternative methodology, which relies on identifying instruments. Our hypothesis in this analysis is that institutional quality is the only fundamental determinant of the long-run economic growth and technological change does not mean to omit the other determinants of growth such as inflation rate, share of manufacture and agriculture in GDP, and other characteristics of the economy. Following Hall and Jones (1999), we suggest that these variables are the outcomes, which are determined by the institutions, rather than being the determinants of the economic growth.

We use a set of instruments employed by Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2001, 2002). These are the extent to which the primary languages of Western Europe as spoken as first languages today and indigenous population density and settler mortality rate in 1500. Acemoglu, Johnson, and Robinson (2001, 2002) argues that the extent of settler mortality caused by the disease environment in colonies resulted in settler populations of differing sizes. Settler populations of smaller size tended to be more exploitative, and this was reflected in the institutions they created. Hence, indigenous population density and settler mortality rate are correlated with the Western influence on the countries that they conquered and colonized at the fifteenth century and proved to affect productivity growth only through intuitional quality measures[11]. Hall and Jones (1999) argues that Western countries adapted their own languages to the countries they colonized during the same period. Hence, this measure is also correlared with instutions and political liberty. We formally test the validity of these instruments using over identification tests[12].

[11]We use the log of settler mortality rate and population density in 1500 as in Acemoglu, Johnson, and Robinson (2001, 2002). See, Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2001, 2002) for a detailed discussion of the instruments.

[12]Note that since proposed instruments do not vary over time, we cannot account for the panel structure of the data. Hence, we estimate pooled OLS with appropriate instruments. This is the standart practice in the literature.

In Table 6, simple pooled OLS regressions show that intuitions as measured by two distinct proxy measures of instutions not only affect the productivity growth of the countries positively, but also positively and significantly affect the technological change component of the Malmquist index. On the other hand, they have no significant effect on the efficiency change component. This finding is consistent with our earlier findings that European and North American countries, thanks to their strong institutional quality, grow mostly due to the innovation of the new technologies. Alternative IV estimation also yields virtually the same results, but with some exceptions. Although the coefficient estimate of ICRG country risk ratings is still positive, it does not significantly affect the technological change. First stage F-tests and over identification tests imply that our instruments are valid in all cases except the 2SLS regression of ICRG ratings on the efficiency change component.

The elasticity parameters presented in Table 7 suggests that a one percentage point increase in the institutional quality as measured by the civil and political liberty index increases the productivity growth as measured by the Malmquist index by around 0.03 percentage points[13]. Similar results prevail if we instead consider the ICRG risk ratings as our preferred institutional quality measure. A one percentage point increase in this variable increases the productivity growth by around 0.04 percentage points. In addition, we report that a one percentage point increase in the institutional quality increases the technological change component by approximately 0.02 percentage points. These results imply that instutions and political liberty have a considerable impact on LAC countries' productivity growth trends through technological change.

[13]Note that, a one unit increase in the civil and political liberty index refers approximately to 14% increase in this index. Hence, a one unit increase in the civil and political liberty index increases the productivity growth by around $0.03 \times 14 = 0.42$ percentage points.

6 Conclusion

Using a nonparametric Malmquist productivity growth index, this study first measures productivity growth for LAC countries during the 1966-2000 period. Then it compares the results to those of a peer group of European and North American countries to provide a benchmark for what LAC countries could have possibly achieved over the last four decades of the century. We argue that our comparisons are relevant since almost all of the LAC countries are colonized and populated by individuals of European descent, who established the Western culture and economic success.

Our results indicate, on average, 55% productivity growth for Europe and 20% productivity growth for North America compared with that of 12% productivity growth of Caribbean and 4.2% productivity deterioration of Latin America for the time period considered. We report that LAC countries suffer from inefficient production and lack of innovation. However, through international diffusion of knowledge, they use the opportunity to replicate the new technologies produced and hence grow mostly due to adaptation. Hence, their productivity growth mostly comes from technical efficiency change rather than the technological change component of the Malmquist productivity growth index.

In a policy viewpoint, our study is the first that investigated the effect of institutions on economic growth and technological change, using a non-parametric measure of economic growth. We also explicitly recognize the endogeneity and measurement error of the institutional quality measures on the economic outcomes. We show that human capital difference is not the key factor in explaining poor productivity growth performance of LAC countries. However, our results suggest that institutional quality is an important determinant of long-run productivity growth.

In particular, we conclude that the policies related to improving economic freedom, civil rights, institutions, law and order, and other components of civil, economic, and political liberty positively contribute not only to the productivity growth, but also to the technological improvement of the countries.

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Tables

Table 1. Cultural, religious, and language characteristics of LAC countries

Country	Descent	Religion	Language
Latin America			
Argentina	97%	96%	Spanish, English, Italian, German, French
Bolivia	45%	95%	Spanish, Quechua, Aymara
Brazil	93%	80%	Portuguese, Spanish, English, French
Chile	95%	100%	Spanish
Colombia	92%	94%	Spanish
Costa Rica	94%	92%	Spanish, English
Ecuador	65%	92%	Spanish, Quecha
El Salvador	99%	83%	Spanish, Nahua
Guatemala	57%	90%	Spanish, Amerindian Languages
Honduras	91%	100%	Spanish, Amerindian Languages
Mexico	69%	95%	Spanish, Amerindian Languages
Nicaragua	84%	100%	Spanish, English, Indigeneous Languages
Panama	80%	100%	Spanish, English
Paraguay	95%	90%	Spanish, Guarani
Peru	52%	90%	Spanish, Quechua
Uruguay	88%	67%	Spanish, Portunol or Brazilero (Portuguese-Spanish mix)
Venezuela	89%	98%	Spanish, Indigeneous Languages
Mean	81%	92%	
Caribbean			
Dominican Rep.	89%	95%	Spanish
Jamaica	8%	65%	English
Trinidad&Tobago	20%	39%	English, Hindi, French, Spanish
Mean	39%	66%	

Source: CIA World Factbook (2005).
Notes:
i) Descent is the fraction of total population that is white or mixed-white.
ii) Religion is the fraction of total population affiliated with Western religions such as Christianity and Judaism.

Table 2. Main macroeconomic indicators of LAC, European and North American countries relative to U.S

	GDP per capita			GDP per worker			Capital per worker			Schooling		
Country	1966	1983	2000	1966	1983	2000	1966	1983	2000	1966	1983	2000
Latin America												
Argentina	0.525	0.425	0.349	0.559	0.576	0.398	0.672	0.671	0.300	0.571	0.568	0.693
Bolivia	0.182	0.125	0.083	0.227	0.195	0.106	0.185	0.106	0.051	0.409	0.349	0.452
Brazil	0.187	0.263	0.222	0.239	0.351	0.298	0.308	0.445	0.240	0.300	0.265	0.372
Chile	0.297	0.214	0.305	0.387	0.301	0.389	0.488	0.202	0.350	0.525	0.510	0.644
Colombia	0.183	0.196	0.166	0.252	0.303	0.178	0.194	0.181	0.104	0.297	0.345	0.409
Costa Rica	0.248	0.211	0.181	0.336	0.297	0.230	0.234	0.238	0.164	0.405	0.424	0.491
Ecuador	0.136	0.183	0.109	0.178	0.295	0.169	0.290	0.340	0.135	0.324	0.464	0.532
El Salvador	0.262	0.165	0.138	0.332	0.244	0.210	0.132	0.112	0.081	0.201	0.287	0.367
Guatemala	0.172	0.174	0.120	0.234	0.298	0.206	0.126	0.139	0.075	0.154	0.204	0.255
Honduras	0.118	0.106	0.063	0.160	0.175	0.099	0.101	0.097	0.080	0.179	0.260	0.333
Mexico	0.306	0.343	0.267	0.459	0.525	0.381	0.501	0.498	0.331	0.287	0.365	0.549
Nicaragua	0.247	0.148	0.054	0.336	0.240	0.084	0.192	0.144	0.058	0.250	0.259	0.361
Panama	0.207	0.260	0.187	0.257	0.370	0.246	0.263	0.358	0.268	0.452	0.517	0.645
Paraguay	0.165	0.209	0.150	0.210	0.308	0.162	0.087	0.201	0.098	0.357	0.404	0.469
Peru	0.282	0.203	0.140	0.387	0.317	0.156	0.773	0.335	0.141	0.348	0.470	0.598
Uruguay	0.374	0.296	0.297	0.389	0.371	0.328	0.359	0.359	0.180	0.520	0.527	0.592
Venezuela	0.620	0.336	0.197	0.867	0.487	0.275	0.932	0.597	0.198	0.274	0.437	0.458
Mean	0.265	0.227	0.178	0.342	0.333	0.230	0.343	0.295	0.168	0.344	0.391	0.484
Caribbean												
Dominican Rep.	0.116	0.146	0.162	0.174	0.247	0.251	0.098	0.164	0.134	0.255	0.307	0.422
Jamaica	0.216	0.158	0.116	0.230	0.170	0.113	0.359	0.180	0.109	0.280	0.332	0.426
Trinidad&Tobago	0.380	0.479	0.347	0.476	0.626	0.419	0.275	0.390	0.179	0.465	0.549	0.622
Mean	0.237	0.261	0.208	0.293	0.347	0.261	0.244	0.245	0.141	0.334	0.396	0.490
Europe												
Austria	0.604	0.759	0.737	0.567	0.806	0.784	0.889	1.150	0.960	0.740	0.706	0.718
Belgium	0.654	0.752	0.728	0.721	0.900	0.879	1.238	1.154	0.992	0.835	0.682	0.713
Denmark	0.914	0.868	0.818	0.806	0.788	0.787	1.244	1.024	0.850	0.945	0.790	0.824
Finland	0.610	0.765	0.732	0.541	0.740	0.755	1.003	1.068	0.782	0.633	0.687	0.828
France	0.685	0.804	0.705	0.651	0.857	0.761	0.962	1.131	0.888	0.626	0.602	0.683
Greece	0.416	0.516	0.448	0.438	0.659	0.546	0.695	1.027	0.548	0.534	0.576	0.695
Iceland	0.740	0.838	0.766	0.737	0.785	0.698	1.295	1.129	0.776	0.636	0.625	0.714
Ireland	0.393	0.476	0.806	0.424	0.619	1.008	0.388	0.611	0.766	0.691	0.658	0.736
Italy	0.584	0.719	0.670	0.608	0.895	0.836	1.160	1.186	0.902	0.519	0.474	0.571
Netherlands	0.720	0.737	0.749	0.838	0.908	0.809	1.398	1.221	0.850	0.639	0.694	0.754
Norway	0.656	0.807	0.832	0.673	0.809	0.837	1.498	1.451	1.095	0.686	0.708	0.968
Portugal	0.297	0.428	0.485	0.329	0.470	0.542	0.390	0.503	0.620	0.244	0.293	0.401
Spain	0.489	0.539	0.547	0.556	0.748	0.684	0.763	1.007	0.783	0.421	0.445	0.592
Sweden	0.832	0.811	0.727	0.764	0.784	0.704	1.251	0.938	0.693	0.814	0.791	0.927
Switzerland	1.166	1.028	0.813	1.029	1.009	0.735	2.047	1.516	1.003	0.803	0.845	0.848
United Kingdom	0.717	0.694	0.692	0.647	0.699	0.692	0.799	0.664	0.638	0.777	0.707	0.763
Mean	0.655	0.721	0.703	0.646	0.780	0.754	1.064	1.049	0.822	0.659	0.643	0.734
North America												
Canada	0.849	0.869	0.826	0.898	0.858	0.810	1.110	0.976	0.931	0.878	0.876	0.933
USA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Notes:
i) USA=1 for all figures.
ii) Schooling: Average years of schooling for adult population aged 25 and greater.

Table 3. Malmquist index and its decomposition

	Mean			Cumulative			
Country	Efficiency	Technological	Index	Efficiency	Technological	Index	Rank
Latin America							
Argentina	1.008	0.994	1.002	1.304	0.814	1.063	28
Bolivia	1.007	0.999	1.006	1.266	0.965	1.228	16
Brazil	1.008	0.995	1.003	1.320	0.835	1.109	24
Chile	1.008	0.998	1.005	1.297	0.923	1.194	20
Colombia	1.000	1.002	1.002	1.000	1.065	1.065	27
Costa Rica	0.997	1.002	0.999	0.896	1.089	0.974	31
Ecuador	1.013	0.999	1.013	1.557	0.981	1.529	9
El Salvador	0.999	0.996	0.995	0.964	0.883	0.851	34
Guatemala	1.001	1.004	1.004	1.018	1.129	1.149	23
Honduras	0.991	0.992	0.983	0.734	0.769	0.567	36
Mexico	1.003	0.994	0.997	1.100	0.814	0.896	33
Nicaragua	0.986	0.996	0.981	0.612	0.862	0.525	37
Panama	0.998	1.004	1.002	0.927	1.147	1.065	26
Paraguay	0.990	0.991	0.980	0.701	0.726	0.509	38
Peru	1.009	0.996	1.005	1.355	0.872	1.178	22
Uruguay	1.006	1.001	1.007	1.235	1.033	1.277	15
Venezuela	1.000	0.995	0.995	0.989	0.843	0.834	35
Mean	1.001	0.998	0.999	1.043	0.918	0.958	N/A
Caribbean							
Dominican Rep.	1.007	0.999	1.006	1.276	0.960	1.223	19
Jamaica	0.999	1.001	0.999	0.954	1.021	0.972	32
Trinidad&Tobago	1.000	1.005	1.005	1.000	1.183	1.183	21
Mean	1.002	1.002	1.003	1.068	1.050	1.120	N/A
North America							
Canada	0.998	1.005	1.003	0.943	1.173	1.103	25
USA	1.000	1.008	1.008	1.000	1.298	1.298	14
Mean	0.999	1.006	1.005	0.971	1.234	1.196	N/A
Europe							
Austria	1.007	1.013	1.020	1.269	1.537	1.952	4
Belgium	1.006	1.013	1.019	1.225	1.566	1.918	5
Denmark	1.000	1.011	1.010	0.983	1.433	1.408	12
Finland	1.011	1.011	1.022	1.468	1.436	2.104	2
France	1.007	1.011	1.018	1.251	1.465	1.834	6
Greece	1.010	1.004	1.015	1.429	1.165	1.658	7
Iceland	0.998	1.016	1.014	0.946	1.692	1.602	8
Ireland	1.007	1.004	1.012	1.276	1.156	1.478	10
Italy	1.012	1.013	1.025	1.495	1.535	2.290	1
Netherlands	1.002	1.009	1.011	1.071	1.367	1.466	11
Norway	1.007	1.015	1.022	1.250	1.670	2.083	3
Portugal	1.002	0.997	0.999	1.086	0.897	0.974	30
Spain	1.005	1.001	1.006	1.182	1.039	1.226	17
Sweden	1.004	1.006	1.010	1.132	1.228	1.390	13
Switzerland	0.991	1.015	1.006	0.732	1.669	1.224	18
United Kingdom	1.007	0.992	0.999	1.271	0.773	0.982	29
Mean	1.005	1.008	1.013	1.174	1.321	1.550	N/A

Notes:
i) Mean: Mean annual productivity growth, efficiency change, and technological change from 1966 to 2000. Cumulative: Cumulative productivity, efficiency change, and technological change from 1966 to 2000.
ii) Index: Malmquist productivity growth index. Efficiency: Efficiency change index. Technological: Technological change index.
iii) Geometric means are reported.

Table 4. Mean ICRG risk ratings and civil and political liberty index

	LAC Countries			European and North American Countries	
	ICRG risk rating	Civil and Political Liberty		ICRG risk rating	Civil and Political Liberty
Latin America			*Europe*		
Argentina	60.18	5.05	Austria	85.59	7.00
	(13.46)	(1.39)		(2.21)	(0.0)
Bolivia	54.56	4.86	Belgium	81.45	6.89
	(14.80)	(1.23)		(2.28)	(0.21)
Brazil	61.07	4.72	Denmark	84.70	7.00
	(5.07)	0.85		(2.37)	(0.0)
Chile	67.68	4.09	Finland	84.28	6.48
	(11.89)	(1.82)		(2.74)	(0.49)
Colombia	60.96	5.05	France	80.40	6.52
	(5.34)	(0.69)		(1.60)	(0.09)
Costa Rica	67.39	6.84	Greece	67.53	5.86
	(7.81)	(0.24)		(7.61)	(1.09)
Ecuador	56.55	4.93	Iceland	80.12	7.00
	(5.12)	(1.24)		(2.58)	(0.0)
El Salvador	55.45	4.71	Ireland	81.64	6.90
	(16.06)	(0.80)		(3.94)	(0.21)
Guatemala	53.93	4.07	Italy	78.21	6.57
	(12.04)	(0.94)		(2.94)	(0.32)
Honduras	52.86	4.74	Netherlands	87.43	7.00
	(7.45)	(0.86)		(1.81)	(0.0)
Mexico	66.39	4.38	Norway	87.71	7.00
	(6.55)	(0.39)		(2.26)	(0.0)
Nicaragua	43.11	3.76	Portugal	77.70	6.15
	(12.30)	(0.95)		(5.01)	(1.27)
Panama	60.58	3.86	Spain	76.09	5.86
	(9.18)	1.68		(3.34)	(1.39)
Paraguay	63.18	3.62	Sweden	83.69	6.98
	(9.03)	(0.95)		(2.29)	(0.09)
Peru	52.31	4.07	Switzerland	90.81	7.00
	(12.40)	(1.26)		(2.79)	(0.0)
Uruguay	66.78	4.93	United Kingdom	82.25	6.79
	(5.38)	(1.81)		(2.20)	(0.25)
Venezuela	64.99	5.81			
	(5.10)	(0.82)			
Caribbean			*North America*		
Dominican Rep.	59.62	5.52	Canada	83.84	7.00
	(10.63)	(0.56)		(1.50)	(0.0)
Jamaica	64.43	5.81	United States	84.01	7.00
	(8.16)	(0.36)		(1.89)	(0.0)
Trinidad&Tobago	65.52	6.38			
	(6.92)	(0.49)			

Notes:
i) Standard deviations are in parenthesis.
ii) ICRG risk rating: ICRG composite risk rating with 0=highest risk to 100=lowest (World Development Indicators, World Bank, 2004).
iii) Civil and political liberty: Computed as the weighted average of political liberty index and civil liberty index with 0=lowest to 7=highest (Freedom House, Freedom in the world, 2005).

Table 5. Determinants of Productivity growth, technological change, and efficiency change

	Independent Variables					
	Productivity Growth		Technological Change		Efficiency Change	
Independent Variables	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects	Random effects
Constant	0.591***	0.871***	0.745***	0.907***	0.838***	0.936***
	(0.181)	(0.049)	(0.127)	(0.033)	(0.176)	(0.046)
GDP per worker	0.131***	0.042***	0.083***	0.019***	0.049**	0.021**
	(0.021)	(0.009)	(0.015)	(0.006)	(0.021)	(0.009)
Capital stock per worker	-0.092***	-0.025***	-0.054***	-0.009**	-0.038**	-0.015**
	(0.017)	(0.007)	(0.012)	(0.005)	(0.017)	(0.006)
Human capital	-0.002	-0.001	-0.001	-0.000	-0.001	-0.001
	(0.007)	(0.001)	(0.005)	(0.001)	(0.007)	(0.001)
Share of manufacturing	0.002**	0.001***	-0.000	-0.000	0.002***	0.001***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Share of agriculture	0.002**	-0.001*	0.000	0.000	0.002**	-0.001**
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Population density×100	0.035	-0.004**	-0.031	-0.001	0.066*	-0.003
	(0.040)	(0.002)	(0.028)	(0.001)	(0.039)	(0.002)
Inflation rate	-0.010***	-0.004***	0.003**	-0.000	-0.010***	-0.004***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
ICRG Risk Rating×100	-0.035	-0.031	0.002	-0.021	-0.036	-0.010
	(0.036)	(0.026)	(0.025)	(0.018)	(0.034)	(0.024)
Civil and Political Liberty	0.003	0.003	0.004*	0.004**	-0.001	-0.001
	(0.003)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)
Hausman Test (p-value)	28.42	-	36.35	-	46.37	-
	(0.243)		(0.066)		(0.004)	
R^2	0.180	0.123	0.230	0.191	0.187	0.145
Number of Obs.	535	535	535	535	535	535

Notes:
i) Standard errors are in parenthesis.
ii) The sign *** indicates that the variable is statistically significant at 1% significance level. The sign ** indicates that the variable is statistically significant at 5% significance level. The sign * indicates that the variable is statistically significant at 10% significance level.
iii) Time effects are included in all regressions.

Table 6. Relationship between institutions and productivity growth, technological change, and efficiency change

	Productivity Growth			Technological Change (Innovation)			Effficiency Change (Adaptation)		
	OLS	2SLS	Over ID test (p-value)	OLS	2SLS	Over ID test (p-value)	OLS	2SLS	Over ID test (p-value)
Proxy for Instutions									
Civil and Political Liberty	0.003***	0.005*	0.290	0.004***	0.003	0.565	-0.0001	0.002	0.676
	(0.001)	(0.003)		(0.001)	(0.002)		(0.001)	(0.003)	
First stage R^2	0.015	0.164		0.038	0.165		0.001	0.164	
First stage F-test	16.35	41.67		43.34	41.67		0.98	41.67	
Number of Observations	1102	638		1102	638		1102	638	
Proxy for Instutions									
ICRG Country Risk Ratings	0.0002**	0.001*	0.247	0.0002**	0.0002	0.837	0.00004	0.0004	0.098
	(0.0001)	(0.000)		(0.0001)	(0.0002)		(0.0001)	(0.0003)	
First stage R^2	0.007	0.290		0.008	0.289		0.0003	0.290	
First stage F-test	4.90	50.29		5.61	50.29		0.20	50.29	
Number of Observations	646	374		646	374		646	374	

Notes:
i) Standard errors are in parenthesis.
ii) The sign *** indicates that the variable is statistically significant at 1% significance level. The sign ** indicates that the variable is statistically significant at 5% significance level. The sign * indicates that the variable is statistically significant at 10% significance level.
iii) All regressions include a constant.

Table 7. Coefficients of Elasticities under different specifications

	Productivity Growth		Technological Change		Efficiency Change	
Proxy for Instutions	OLS	2SLS	OLS	2SLS	OLS	2SLS
Civil and Political Liberty	0.019***	0.026*	0.023***	0.016	-0.005	0.008
	(0.005)	(0.016)	(0.003)	(0.011)	(0.005)	(0.015)
ICRG Country Risk Ratings	0.016**	0.037*	0.012**	0.011	0.003	0.025
	(0.007)	(0.021)	(0.005)	(0.014)	(0.007)	(0.019)

Notes:

i) Standard errors are in parenthesis.
ii) The sign *** indicates that the variable is statistically significant at 1% significance level. The sign ** indicates that the variable is statistically significant at 5% significance level. The sign * indicates that the variable is statistically significant at 10% significance level.

Figure 1. Long-run productivity growth trends