

Capital, Economic Growth and Relative Income Differences in Latin America

Oswaldo Lagares

University of York
Central Bank of the Dominican Republic

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- General slowdown of per capita relative income growth since the 1970's (Furtado, 1965, Arida, 1986).
- Technological disparities leading to differences in income growth and uneven-development in Latin America (Singer, 1950, Prebisch, 1959).
- Total factor productivity growth rather than capital accumulation may account for the vast majority of the observed differences on growth and development across countries (Easterly and Levine, 2001, Daude and Fernández-Arias, 2010, Pagés, 2010).
- However, some of the evidence suggest capital accumulation as an determinant of output growth (De Gregorio, 1992, Gutierrez, 2005, Astorga, 2010).

- Equipment investments, in particular imported machinery, are proposed to be the main drivers of output growth and productivity in developing economies (De Long and Summers, 1991, 1993).
- Endogenous growth: trade distortions and restrictions to the availability of foreign capital may be detrimental for long-run growth (Rebelo, 1991, Lee, 1993, 1995, Romer, 1994, Mazumdar, 2001).
- An interesting question is whether capital accumulation may account for the variety of growth experiences that we have observed across different income levels in Latin America.

Contribution

This paper examines the growth effects of domestic and imported capital on economic growth and relative income differences in 32 Latin American economies from 1960 to 2010:

1. Latin American countries may grow faster by acquiring capital imports in the form of machinery equipment capital.
2. Countries that invest relatively more in domestic equipment and non-equipment physical capital grows faster and reduce their relative income differences.
3. While capital imports drives faster economic growth, domestic capital is also a key determinant of higher relative income levels, therefore both sources of capital are needed to drive economic development towards the advanced economies living standards.
4. Surprisingly, we found an insignificant role of human capital in the growth process. The growth effects of secondary school education appears to be exhausted.

5. Our evidence suggests that countries which experienced a slowdown in economic growth were relatively richer in 1970 and invested relatively less in both domestic and imported capital.
6. We found a robust positive correlation between high productivity growth and the acquisition of machinery imports in Latin America.
7. We argue that the diversity of growth experiences across different income levels indicates that economic policies, trade patterns, endowments and the level of institutional development have played a determinant role in the growth and development performance of the region; potentially beyond those ascribed to total factor productivity growth.
8. We compile and present a new macroeconomic panel dataset for the 32 Latin American countries from 1960 to 2010, which includes more than fifteen growth determinants.

Methodology: theoretical foundation

- Builds on the endogenous growth theory proposed by Lee (1995), where in a two-sector open economy model with consumption and capital goods, Lee (1995) shows that a developing country may grow faster by acquiring capital imports from an advanced economy, provided these capital imports are relatively cheaper and are an imperfect substitute for domestic capital.
- In this type of endogenous growth theory, capital accumulation plays a key role in driving a faster growth performance across the transitional period towards the steady state. However, the model predicts the convergence of per capita income levels across countries.
- Through its effects on capital accumulation, trade restrictions and differences in economic policies may have a detrimental effect on long run growth (Rebelo, 1991, Lee, 1993).

Methodology: growth empirics

This paper investigate whether domestic and imported capital are key determinants of economic growth in Latin America. For this aim, we estimate the following dynamic panel growth equation:

$$\ln(y_{i,t}) - \ln(y_{i,t-1}) = \gamma \ln(y_{i,t-1}) + \beta k_{m,i,t} + \delta k_{d,i,t} + \iota h_{i,t} + \theta C'_{i,t} + T_t + I_i + \varepsilon_{i,t} \quad (1)$$

- where $\gamma = (\alpha - 1) \rightarrow \alpha = \gamma + 1$ and a conditional convergence process implies $\gamma < 0$; $y_{i,t}$ is real GDP per capital; $k_{m,i,t}$ denotes alternative specifications for capital imports; $k_{d,i,t}$ are alternative specifications for domestic physical capital; $h_{i,t}$ is domestic human capital; $C_{i,t}$ is a $(k \times 1)$ column vector of control variables with their respective $(k \times 1)$ vector of parameters; T_t and I_i are the respective period specific effects and time invariant country fixed effects.
- The panel dimensions are $i \in [1, \dots, 32]$ Latin America economies across $t \in (1, \dots, 10)$ five years averages.

Methodology: growth empirics

To examine the role of capital investments in relative income differences, we estimate the following relative income growth equation:

$$\ln \left(\frac{y_{i,t}}{y_{u,t}} \right) - \ln \left(\frac{y_{i,t-1}}{y_{u,t-1}} \right) = \phi \ln \left(\frac{y_{i,t-1}}{y_{u,t-1}} \right) + \beta k_{m,i,t} + \delta k_{d,i,t} + \iota h_{i,t} + \theta C'_{i,t} + T_t + l_i + \varepsilon_{i,t} \quad (2)$$

- where $\phi = (\lambda - 1) \rightarrow \lambda = \phi + 1$ and a conditional convergence process implies $\phi < 0$. $y_{i,t}$ is the PPP converted GDP per capita relative to the United States from Heston et al. (2012). The other variables follows the standard definitions defined previously; T_t and l_i are the respective period specific effects and time invariant country fixed effects.
- The panel dimensions are $i \in [1, \dots, 32]$ Latin America economies across $t \in (1, \dots, 10)$ five years averages.

Methodology: estimation procedure

1. Pooled OLS and within-group estimation following the exogeneity assumption of the regressors.
2. Two-stage least squares fixed-effects estimation following Schaffer (2010) programming.
3. Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) two-step system generalized method of moments estimation with Windmeijer (2005) finite sample corrections, small sample adjustments and Roodman (2009) collapsed instruments.

Methodology: data

- Data is structured in an unbalanced panel of 32 Latin America economies covering a fifty years period from 1960 to 2010.
- The major data sources for our study are the Penn World Tables, the World Development Indicators (WDI), the United Nations Comtrade database and the International Financial Statistics (IFS).
- For the construction of the domestic and imported capital series we extend the methodologies proposed by De Long and Summers (1991, 1993) and Lee (1995):
 - We define capital imports as the total value of electrical and non-electrical machinery equipment imports reported by the domestic economy as imported from the rest of the world, rather than those imported exclusively from developed countries.
 - Therefore, it follows that domestic physical capital results from the total value of investments or gross capital formation minus capital imports.
- We use standard controls for growth econometrics (Barro, 1991, De Gregorio, 1992, Acemoglu et al., 2001, Reinhart and Rogoff, 2009, Astorga, 2017)

Table 1.

Evidence on the growth effects of capital accumulation

| Dep. Var.: Real GDP Per Capita Growth | Pooled OLS estimator | | Within-groups estimator | Two-stage least-squares fixed-effects estimator | |
|--|--------------------------|---------------------------|---------------------------|---|-------------------------|
| | (1) | (2) | (3) | (4) | (5) |
| Period: 1960-2010 | | | | | |
| Initial real GDP per capita | -0.00814** (0.00339) | -0.00616 (0.00415) | -0.0461** (0.0178) | -0.0284 (0.0324) | -0.0150 (0.0232) |
| Capital imports | 0.000306 (0.000244) | 0.000821*** (0.000209) | 0.000677*** (0.000139) | 0.0000489 (0.000406) | 0.000772* (0.000438) |
| Domestic capital | 0.00156*** (0.000301) | 0.00145*** (0.000316) | 0.00114*** (0.000346) | 0.00209*** (0.000765) | 0.00104* (0.000546) |
| Human capital | 0.0119 (0.00812) | 0.0156 (0.0167) | 0.00561 (0.0190) | 0.0121 (0.0183) | 0.0285 (0.0214) |
| Investment share | 0.000390 (0.000315) | 0.000695 (0.000518) | 0.00185** (0.000671) | 0.000419 (0.00112) | 0.00141 (0.00124) |
| Population growth | -0.00314 (0.00257) | 0.000318 (0.00425) | -0.00228 (0.00445) | -0.0109 (0.00734) | -0.00906 (0.00749) |
| Government consumption | -0.0220*** (0.00638) | -0.0207** (0.00928) | 0.00468 (0.00730) | 0.00551 (0.0106) | 0.00174 (0.0103) |
| Lack of price stability | -0.0138*** (0.00437) | -0.0105* (0.00595) | -0.00825* (0.00429) | -0.0158** (0.00626) | -0.0121 (0.00798) |
| Macroeconomic crisis | -0.00741** (0.00315) | -0.00529 (0.00834) | -0.0149* (0.00807) | -0.00484 (0.0118) | -0.000369 (0.0163) |
| Trade Openness | | 0.00598 (0.00515) | -0.00550 (0.0117) | -0.0108 (0.0198) | -0.0166 (0.0232) |
| Initial secondary school enrolment lagged two periods (t-2) | | 0.00855 (0.0107) | 0.0217* (0.0120) | 0.00128 (0.0217) | |
| Constant | 0.104*** (0.0337) | 0.000808 (0.0582) | 0.303 (0.225) | | |
| Time effects | Yes | Yes | Yes | No | No |
| Country specific effects | No | No | Yes | Yes | Yes |
| Adjusted R-squared | 0.59 | 0.68 | 0.76 | 0.47 | 0.61 |
| F ² statistic | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Instrumental variables specification tests | | | | | |
| Kleibergen-Paap r^k LM statistic | | | | 0.23 | 0.31 |
| Kleibergen-Paap r^k Wald F statistic | | | | 1.42 | 4.75 |
| Hansen J statistic | | | | 0.81 | 0.13 |
| Endogeneity test | | | | 0.06 | 0.68 |
| Observations | 149 | 78 | 78 | 63 | 48 |
| Number of countries | 30 | 23 | 23 | | |

Table 2.

Domestic and imported capital effects on economic growth in Latin America

| Dep. Var.: Real GDP Per Capita Growth | Period: 1960-2010 | | | | |
|--|--------------------------|------------------------|--------------------------|-------------------------|--------------------------|
| | (1) | (2) | (3) | (4) | (5) |
| Initial real GDP per capita | -0.0124 (0.0127) | -0.00734 (0.0127) | -0.00611 (0.0133) | -0.0149 (0.0142) | -0.00976 (0.00817) |
| Capital imports | 0.000969** (0.000408) | 0.00106* (0.000611) | 0.00129*** (0.000441) | 0.000742* (0.000403) | 0.000824** (0.000337) |
| Domestic capital | 0.000388 (0.000871) | 0.000451 (0.00145) | 0.000881 (0.00125) | 0.000693 (0.000557) | 0.00161 (0.00139) |
| Human capital | 0.0546 (0.0366) | 0.0350 (0.0613) | 0.0265 (0.0427) | 0.0583 (0.0410) | 0.0467 (0.0572) |
| Investment share | 0.000673 (0.00126) | 0.00178 (0.00298) | 0.00131 (0.00245) | 0.000927 (0.00159) | 0.00150 (0.00166) |
| Population growth | -0.000786 (0.0114) | 0.00610 (0.0139) | 0.00590 (0.0118) | 0.000858 (0.00823) | 0.00611 (0.00835) |
| Government consumption | -0.00887 (0.0193) | -0.0180 (0.0200) | -0.0193 (0.0245) | -0.00699 (0.0163) | -0.0123 (0.0215) |
| Lack of price stability | 0.00181 (0.0107) | -0.00816 (0.0163) | -0.00536 (0.0121) | 0.000480 (0.0110) | -0.00471 (0.0193) |
| Macroeconomic crisis | -0.0241 (0.0153) | -0.00914 (0.0386) | -0.0112 (0.0300) | -0.0223 (0.0152) | -0.0118 (0.0193) |
| Imports of goods and services | | 0.00243 (0.0310) | 0.0101 (0.0363) | | |
| Trade openness | | | -0.00504 (0.0218) | -0.00444 (0.0138) | |
| Institutional development | | | | | 0.0132 (0.153) |
| Constant | -0.105 (0.115) | -0.0832 (0.260) | -0.0501 (0.191) | -0.0921 (0.125) | -0.117 (0.264) |
| <i>Specification Tests</i> | | | | | |
| i) F-statistic | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ii) Serial Correlation | | | | | |
| Arellano and Bond AR(2) | 0.39 | 0.76 | 0.46 | 0.25 | 0.56 |
| iii) Hansen J statistic for instruments validity | 0.72 | 0.58 | 0.62 | 0.75 | 0.60 |
| iv) Difference-in-Hansen Statistic | | | | | |
| Lagged growth instruments | 0.83 | 0.34 | 0.38 | 1.00 | 0.51 |
| System GMM instruments | 0.83 | 0.58 | 0.62 | 0.83 | 0.60 |
| Observations | 149 | 148 | 148 | 149 | 137 |
| Number of groups | 30 | 29 | 29 | 30 | 30 |
| Instrument count | 29 | 28 | 30 | 31 | 28 |

Results

- Latin American countries may grow faster by investing in capital imports.
- The estimated coefficients are relatively well stable across different specifications and econometric methods.
- Our measure of domestic capital is in many cases significantly correlated with higher growth. This finding cast doubts on Mazumdar (2001) hypothesis that domestic capital investments in developing countries appear to be detrimental for long term growth.
- As in Gutierrez (2005) we find insignificant effects of human capital in the region. Trade openness appears negatively correlated to economic growth as in Astorga (2010).
- Following the results of De Gregorio (1992), we find that macroeconomic stability and inflation are key determinants of economic growth in the region.

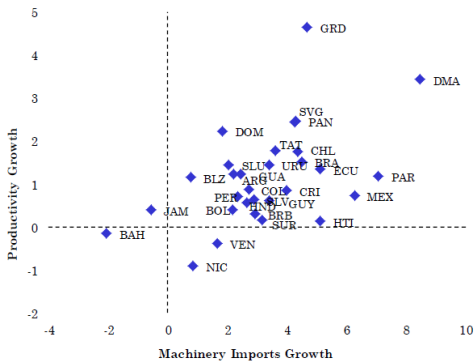


Fig 1. Productivity and machinery imports growth in Latin America, 1960-2010. Productivity growth is measure as the percentage growth rate in logarithmic differences of the real output per worker level. Source: Author construction based on data from the Penn World Tables and the UN Comtrade.

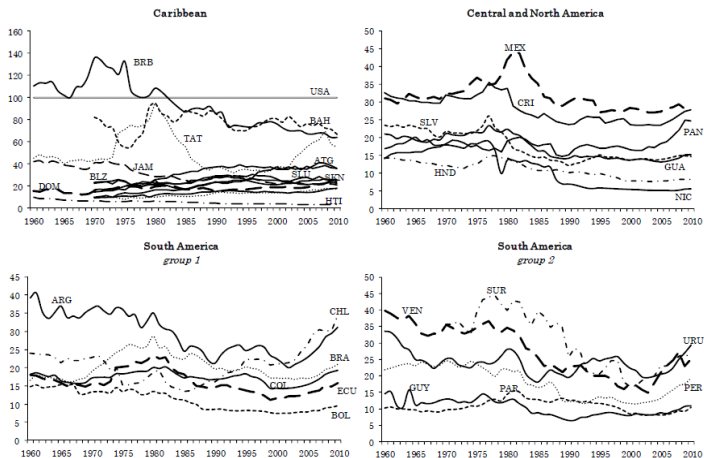


Fig 2. Relative income differences in Latin America, 1960-2010. Source: Author construction based on data from the Penn World Tables.

Table 3.

Domestic and imported capital effects on relative income growth in Latin America

| Dep. Var.: Relative Income Growth | Period: 1960-2010 | | | |
|--|--------------------------|-----------------------|--------------------------|-------------------------|
| | (1) | (2) | (3) | (4) |
| Initial relative income | -0.0181 (0.0169) | -0.0185 (0.0190) | -0.0121 (0.0206) | -0.0180 (0.0189) |
| Capital imports | 0.00127*** (0.000387) | 0.000454 (0.00158) | 0.000715** (0.000317) | 0.000966* (0.000480) |
| Domestic capital | 0.00243** (0.00108) | 0.00211 (0.00137) | 0.00187* (0.00109) | 0.00194 (0.00118) |
| Human capital | 0.0937 (0.0758) | 0.0803 (0.111) | 0.0872 (0.0538) | 0.0800 (0.0964) |
| Investment share | 0.00103 (0.00196) | 0.00168 (0.00165) | 0.000724 (0.00162) | 0.00148 (0.00175) |
| Population growth | 0.0141 (0.0116) | 0.0175 (0.0190) | 0.0118 (0.00911) | 0.0112 (0.0138) |
| Institutional development | 0.139 (0.124) | | 0.0704 (0.125) | 0.110 (0.149) |
| Government consumption | -0.00531 (0.0213) | -0.00312 (0.0329) | -0.0158 (0.0201) | -0.0159 (0.0170) |
| Lack of price stability | 0.0235 (0.0221) | 0.00694 (0.0294) | 0.0120 (0.0148) | 0.0161 (0.0286) |
| Macroeconomic crisis | -0.0323 (0.0245) | -0.0301 (0.0444) | -0.0288 (0.0204) | -0.0348 (0.0276) |
| Land size | | | 0.00253 (0.00518) | |
| Trade openness | | | | -0.0125 (0.0265) |
| Constant | -0.411 (0.341) | -0.328 (0.407) | -0.362* (0.210) | -0.266 (0.457) |
| <i>Specification Tests</i> | | | | |
| i) F-statistic | 0.00 | 0.00 | 0.00 | 0.00 |
| ii) Serial Correlation | | | | |
| Arellano and Bond AR(2) | 0.21 | 0.15 | 0.16 | 0.32 |
| iii) Hansen J statistic for instruments validity | 0.95 | 0.80 | 0.67 | 0.93 |
| iv) Difference-in-Hansen Statistic | | | | |
| Lagged growth instruments | 0.34 | 0.62 | 0.62 | 0.28 |
| System GMM Instruments | 0.95 | 0.80 | 0.67 | 0.93 |
| Observations | 137 | 148 | 137 | 137 |
| Number of groups | 30 | 30 | 30 | 30 |
| Instrument count | 28 | 26 | 30 | 30 |

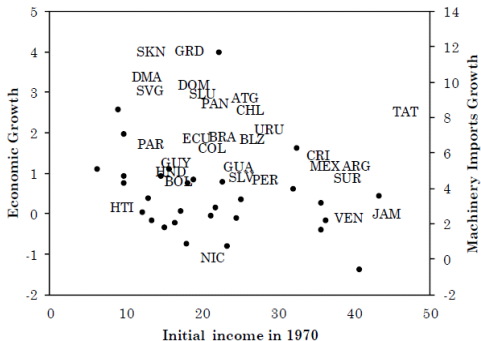


Fig 3. Convergence in Latin America. The countries name denotes the relationship between economic growth and initial income. Dot points represents the relationship between machinery imports and initial income. Source: Author construction based on data from the Penn World Tables and UN Commtrade.

Table 4.

Robustness: alternative specifications

| Dep. Var.: Real GDP Per Cápita Growth | Period: 1960-2010 | | | | |
|---|-----------------------|------------------------|-----------------------|-------------------------|--------------------------|
| | (1) | (2) | (3) | (4) | (5) |
| Initial real GDP per cápita | -0.0105 (0.0205) | -0.0149 (0.0120) | -0.00751 (0.0111) | -0.00852 (0.0192) | -0.00321 (0.0133) |
| Ratio of capital imports in investment | 0.0651 (0.184) | | | | |
| Capital imports | | 0.000755 (0.000452) | 0.00115 (0.00101) | 0.00115** (0.000474) | 0.00164*** (0.000591) |
| Domestic capital | | | 0.000623 (0.00170) | 0.000658 (0.000916) | 0.000331 (0.000747) |
| Human capital | 0.0779* (0.0416) | 0.0605* (0.0298) | 0.0311 (0.0738) | 0.0170 (0.0448) | 0.0573* (0.0328) |
| Investment share | 0.000929 (0.00104) | 0.000866 (0.000805) | 0.00184 (0.00214) | 0.00187 (0.00229) | 0.000921 (0.00204) |
| Population growth | 0.000145 (0.00948) | -0.000549 (0.00570) | 0.00306 (0.00915) | | 0.00269 (0.0140) |
| Government consumption | -0.0272 (0.0376) | -0.0113 (0.0161) | -0.0110 (0.0193) | -0.0144 (0.0225) | -0.00305 (0.0469) |
| Lack of price stability | -0.00199 (0.0168) | -0.000953 (0.0111) | -0.00245 (0.0207) | -0.00771 (0.0174) | -0.0324 (0.108) |
| Macroeconomic crisis | -0.0221 (0.0176) | -0.0208 (0.0162) | -0.0106 (0.0424) | -0.00788 (0.0322) | 0.00273 (0.0338) |
| Imports of goods and services | | | | 0.00176 (0.0305) | |
| Trade openness | | | | -0.00479 (0.0222) | -0.00831 (0.0319) |
| Tariffs | | | | | -0.000165 (0.00163) |
| Constant | -0.190 (0.235) | -0.106 (0.139) | -0.0749 (0.267) | 0.0231 (0.235) | -0.188 (0.214) |
| <i>Specification Tests</i> | | | | | |
| i) <i>F</i> -statistic | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ii) Serial Correlation | | | | | |
| Arellano and Bond AR(2) | 0.58 | 0.48 | 0.71 | 0.27 | 0.66 |
| iii) Hansen <i>J</i> statistic for instruments validity | 0.84 | 0.93 | 0.66 | 0.94 | 0.47 |
| iv) Difference-in-Hansen Statistic | | | | | |
| Lagged growth instruments | 1.00 | 0.87 | 0.75 | 0.38 | 0.68 |
| System GMM Instruments | 0.66 | 0.97 | 0.66 | 0.86 | 0.47 |
| Observations | 152 | 149 | 149 | 73 | 148 |
| Number of groups | 31 | 30 | 30 | 28 | 29 |
| Instrument count | 32 | 27 | 26 | 28 | 28 |

Results

- As in Furtado (1975) and Arida (1986), this paper finds a general slowdown in income growth since the late 1970's. This decline has persisted until beginnings of the 21st century.
- If technology is embodied in capital, we may explain the declines in growth rates as inadequate investments in domestic and imported capital, which may cause slow productivity growth: the capital-embodied technological change controversy (Denison, AER 1964, Hercowitz, JME 1998).
- As the Prebisch (1959) and Singer (1950) theory suggest, investments in capital imports appear not to be sufficient to drive economic development, which may explain our findings of significant growth effects of domestic capital investments at higher income levels.
- We argue that the level of institutional development is a key determinant of economic growth and development in Latin America.

Conclusion

- Domestic and imported capital imports are found to be key determinants of output and relative income growth in Latin America.
- We suggests international trade of capital is an important channel of embodied technology diffusion across countries, in particular across developing economies.
- However, our findings imply that a reliance on foreign capital and technologies may lead to differences in relative income levels and economic development, as those suggested by Singer (1950), Prebisch (1959), and later on Solow (2005).
- Developing countries should promote investments in domestic human and physical capital as well as domestic innovation and research in new technologies. These investments may prove beneficial for economic growth and development.