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Capital, Economic Growth and Relative Income Differences in Latin America*

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Abstract

This paper examines the growth effects of imported and domestic capital in thirty two Latin America economies from 1960 to 2010. Disaggregated data on imported and domestic physical capital is compiled for each economy during the time horizon along with measures of human capital and other economic aggregates. Alternative growth econometric methods and instrumental variables procedures are then applied to control for economic policy, trade distortions and endowments effects. We find significant evidence that the acquisition of capital imports enhances economic growth and lessens relative income differences, particularly at lower income levels. We also find that relative income grows faster in countries that invest more on domestic capital. Our evidence show that countries which experienced a slowdown in economic growth were relatively richer in 1970, and acquired relatively less capital imports and domestic capital. Our findings indicate the existence of a positive correlation between higher productivity growth and the acquisition of capital imports in these countries. Capital accumulation is found to be a key driver of growth and development in Latin America.

JEL classification: F43, O11, O40

Keywords: Latin America, Capital accumulation, Economic growth, Relative income differences

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1 Introduction

The growth performance of the Latin America economies has resulted in slight improvements in living standards and modest income growth relative to those of the advance economies over the last fifty years. On average, the vast majority of these economies are below a quarter of the United State per capita income level, despite experiencing episodes of growth accelerations beyond those of the industrial leader. Historically, economic growth seems not to have resulted in substantial improvements in relative income levels.

Development theories for the region have predicted this disappointing evolution of income levels. The Prebisch-Singer theory suggests Latin America appears to suffer from technological disparities derived from a dependency to imported capital and foreign technologies which lead to differences in per capita in income growth and uneven development (Prebisch, 1950, Singer, 1950, Prebisch, 1959). Since the process of technology diffusion has been historically uneven, these economies specialize in the production of primary agricultural products instead of producing consumer durables, manufactured goods and machinery as in the advanced economies (Baer, 1962). Provided this is the case, the long run growth performance of these economies is expected to be inferior to that of the industrialized countries, therefore characterized by lower relative income levels, lower living standards, and a poor economic development[1].

To address the relative economic backwardness of their economies, at the start of the 1950's several Latin American governments implemented various programs of import substitution industrialization (ISI) to drive inward development. Curtailing imports may provide domestic producers with the necessary incentives to domestically produce the manufactured goods and consumer durables that were being imported from abroad. In that order, producers will seek to research and innovate in new technologies in order to increase domestic productivity, rather than relying on foreign capital and technology. However, while the ISI policies restricted the importation of final goods and unnecessary intermediate inputs, they promoted domestic production via facilitating the importation of key capital equipment and production inputs under preferential conditions (Baer, 1984)[2].

The economic imbalances created by the imports substitution policies lead to numerous crises and their general abandonment at the beginning of the 1980's. The governments of the region returned to an economic policy of outward development by export-led growth that was still fundamentally based on the production of primary products and limited manufactured goods (Franko, 2007). However, the export-led approach remained crucially dependable on imported inputs[3]. Rather than focusing on the structural reforms to address the dependency to imports, macroeconomic policy aimed at stabilizing economies plagued by current account deficits, high levels of external debt, high inflation and dual currency markets mainly derived from the sensitivity of output growth to imports. The complexity of

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[1] Latin America also seems to suffer from a poverty cycle of the type described by Nurkse (1952), where low income leads to a lower savings, lower investments, meagre capital accumulation and poor productivity growth.

[2] In an early study about the region's productivity, Bruton (1967) shows that productivity growth during ISI was primarily achieved by physical capital accumulation and using excess capacity rather than by domestic innovations in new technologies.

[3] In this line of research, Hummels et al. (2001) documents the increasing vertical specialization in international trade for a selected sample of OECD and developing countries from 1970 to 1990. By vertical specialization they refer to the increasing use of imported inputs in the production of the export goods.

the region growth process posed difficulties to the design of theoretical and empirical growth models to explain the inner dynamics of the growth process in these economies[4].

The existing literature on capital accumulation and economic growth has been divided in terms of what are the main sources of growth across countries, and what are the growth effects of capital accumulation. Neoclassical and endogenous growth theory holds the view that economies characterized by high levels of capital stocks should experience high income levels, however higher growth rates are either primarily achieved by exogenous technological change—as proposed by Solow (1956) and Swan (1956)—or by endogenous technological change and economic policy as proposed by Romer (1986) and Rebelo (1991). However, there is strong support in the literature for the notion that the growth process in developing countries, and in particular that of Latin America, is likely to be endogenous[5].

Embodied or disembodied technological change in capital has also been a controversy in the literature, although the evidence tends to favour the embodiment hypothesis (Denison, 1964, Hercowitz, 1998). Capital accumulation, and in particular imported physical capital, is suggested to be a key driver of productivity and growth in developing countries; being capital imports an important channel of embodied technology diffusion. In this line of research, De long and Summers (1991) finds strong support for technology embodied in machinery and equipment investment, and concludes that machinery investments drives faster productivity and economic growth in a sample of 61 countries from 1960 to 1985. In an extension of their previous work, De Long and Summers (1993) also finds that equipment investment—both domestic and imported equipment—drives faster growth in 88 developing and advanced economies over the period from 1960 to 1985.

The evidence seems to suggest that international trade of capital, and in particular that of machinery equipment, drives economic growth. This view generally implies that international trade of capital is a significant growth determinant. As Rodriguez and Rodrik (2001) argues, there are important debates on these issues, however we should not expect international trade of capital to be negatively associated with growth. In that order, Lee (1993) presents theoretical and empirical evidence indicating that trade distortions and restrictions to the availability of imported capital are detrimental for long term economic growth, particularly when the domestic production crucially requires domestic and imported inputs[6].

An important examination on the role of capital imports on economic growth in developing countries is that undertaken by Lee (1995) where by extending Rebelo (1991) two sector endogenous growth model to an open economy, it is shown that by using relatively more capital imports than domestic capital, the less developed countries experience a faster rate of per capita income growth. Lee (1995) then proceeds to examine 89 countries over the period from 1960 to 1985 finding that per capita income grow faster in countries that have increased their ratio of capital imports in investment.

While De Long and Summers (1991, 1993) and Lee (1993, 1995) holds the view that imported capital in the form of machinery equipment investments drives faster growth, they also suggests that domestic capital is beneficial for growth. However, their studies do not clearly distinguish specifically between domestic and imported capital, nor between equipment and non-equipment investments. Improving on these limitations, Mazumdar (2001) specifically disaggregated between imported and domestic equipment in 30

[4] For a discussion on these issues see Arida (1986).

[5] See, for example, the works of Romer (1994) and Franko (2007).

[6] Lee (1993) primarily use an open economy neoclassical growth model where restrictions and distortions to international trade decreases the growth rate of per capita income.

developing countries from 1965 to 1990, finding that imported machinery equipment drives faster growth, however investments in domestic equipment reduces the growth rate of per capita income. In addition, Mazumdar (2001) suggests that domestic and imported non-equipment capital has an insignificant role in the growth process of the less developed countries.

For the case of Latin America, the evidence on the role of imported and domestic physical capital on economic growth has been more controversial. The Prebisch-Singer theory and the structuralist approach to economic development view the creation of domestic capital and domestic production facilities as one of the main determinants of growth and development in the region (Singer, 1950, Prebisch, 1959, Furtado, 1965). On the contrary, others ascribe total factor productivity growth to be the primary source of long-run growth (De Gregorio, 1992, Daude and Fernández-Arias, 2010). In what follows we briefly summarize the primary evidence for the region.

Studying the growth process in 12 Latin American economies from 1950 to 1985, De Gregorio (1992) finds that total factor productivity growth is the main determinant of economic growth in the rapid growing economies of the region. In addition, investments in human and physical capital are found to be key growth drivers along with macroeconomic stability. On the issues of productivity growth—particularly that of productivity in manufacturing industries—Paus et al. (2003) finds that capital imports and trade liberalization were beneficial for productivity in 7 Latin American countries over the period from 1970 to 1998. Moreover, Paus (2004) show that the acquisition of capital imports have significant effects on productivity.

In a growth accounting exercise for 6 Latin American economies from 1960 to 2002, Gutierrez (2005) shows that machinery and equipment investments are the major growth drivers, however total factor productivity growth made the difference between a faster growth performance[7]. Solimano and Soto (2005) studied medium and long-run growth in Latin America during the last century, finding that there has been a general slowdown in economic growth rates since the 1980's. However, they attribute an important proportion of that slowdown in growth to declines in the rate of capital formation. In addition, their results show that productivity growth has actually declined in 7 out of the 12 Latin American economies under study.

Examining the growth process of the 6 largest Latin American economies over the last century, Astorga (2010) finds that human and physical capital accumulation are the key drivers of output per worker. Trade openness was found to be positively associated with higher growth via the investment channel, and macroeconomic instability was found to be detrimental for growth performance. On the contrary, in a study on productivity and factor accumulation in Latin America, Daude and Fernández-Arias (2010) finds that poor relative income growth in the region proceeds from slow productivity growth, being productivity at half of its expected potential, while capital accumulation does not primarily account for the region lack of convergence towards the advanced economies income and productivity levels.

The diversity and complexity of growth experiences across different income levels, and the lack of data availability for the vast majority of the Latin American economies, have make a comprehensive study of the growth process in the region a difficult endeavour[8]. Several of the studies for Latin America have relied on a limited sample of countries due to

[7] Gutierrez (2005) also documents that after the 1980's human capital has been an insignificant driver of economic growth in Latin America.

[8] Gutierrez (2005) recognized these difficulties.

data availability, whose results are expected to extend in a similar fashion to the other small developing countries in the region.

This paper contributes to existing studies on economic growth and development in Latin America by examining the growth effects of domestic and imported capital on economic growth and relative income difference in thirty-two Latin American countries over a period of fifty-years from 1960 to 2010. Our selection of countries can be considered one of the largest ever used in the existing literature to study growth performance in the region. This paper compiles a new macroeconomic panel dataset for all the countries during the time span of the data, with more than ten growth determinants which includes information on domestic and imported physical capital, human capital, economic policy indicators and other economic aggregates, thus facilitating the study of economic growth for the vast majority of the developing economies of Latin America.

Our aim is to uncover new evidence in order to provide answers to the key old questions related to the growth and development performance of the region: Are capital imports with embodied technologies the most significant drivers of economic growth and relative income levels? Have domestic physical and human capital played a major role in explaining the region's growth performance? Does capital accumulation explain the variety of growth experiences that we observe across different income levels? Is there a dependency of the growth process to capital imports of the type suggested by the Prebisch-Singer theory?

To define imported and domestic capital in Latin America, we extend and adapt the methodology proposed by Lee (1995). In that order, we disaggregate between changes in capital imports and domestic physical capital in a consistent procedure that can be applied to the developing economies of Latin America. Our domestic capital measure is defined by equipment and non-equipment capital, being capital imports primarily composed by machinery equipment.

Our methodology differs from that of De Long and Summers (1991, 1993), Lee (1995) and Mazumdar (2001) in three important directions. First, we consider machinery equipment imports reported by the domestic economy from the rest of the world; rather the ones reported as exclusively as imported from the OECD economies. In that order, our measure for capital imports accounts for international trade of capital between the developing countries of the region, and between these countries and the advanced economies. Second, our measure for domestic capital considers equipment and non-equipment capital that is domestically produced, rather than focusing only on domestically produced equipment. Third, our study essentially focus in the Latin American economies, therefore we seek to explain endogenous growth in these countries via the acquisition of domestic and imported capital given the Prebisch-Singer theory for economic development.

We propose two empirical growth models to examine the role of capital imports and domestic capital on economic growth and relative income differences. These empirical growth models builds on Lee (1995) theoretical contributions which show that trade distortions and restrictions to the availability of capital can be detrimental for long run economic growth. Our estimation procedure is based on a variety of different econometric methods and different specifications. In particular, we estimate our growth models using Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) two-step system generalized method of moments estimator following Roodman (2009a) programming with Windmeijer (2005) robust standard errors, small sample adjustments and collapsed instruments[9].

[9] This estimation procedure accounts for the endogeneity of the regressors, and our estimation results display stability and consistency across different alternative specifications.

The main empirical findings of this paper are as follows. First, countries in Latin America are able to grow faster by acquiring capital imports in the form of machinery equipment. Our findings indicate that not only machinery investments drive faster economic growth, but also that once endogenous interactions have been accounted for, the growth effects of domestic capital are insignificantly lower than those provided by machinery imports. There is a positive correlation between higher productivity growth rates and the acquisition of machinery imports in Latin America.

Second, countries that invest relatively more on domestic capital reduce faster their relative income differences. In other words, relative income to the Unites States grows faster in countries that invest relatively more on domestic equipment and non-equipment capital. Therefore, there is a significant role for domestic capital in reducing cross-country relative income differences in Latin America. While capital imports drives faster economic growth, domestic capital is a key determinant of higher relative income levels, therefore both sources of capital are needed to drive economic development towards advanced economies living standards.

Third, human capital appears to have insignificant effects in the Latin American growth process. Fourth our results indicate that countries which experienced a slowdown in growth rates where relatively richer in 1970, adopted less machinery imports, and did not invest enough in domestic capital. Fifth, the diversity of growth experiences across different income levels in Latin America suggests that economic policy, endowments, trade patterns and the level of institutional development have played a determinant role in the growth process.

The rest of the paper is organized as follow: Section 2 provides a discussion on development theories for Latin America and the role of capital accumulation in the growth process. Section 3 presents the growth models specifications, estimation procedures, and data methodologies. Section 4 discusses the main empirical findings. Section 5 discusses the robustness checks. Section 6 presents the conclusions and policy recommendations.

2 Latin American development theories and the role of physical capital accumulation

Growth performance in Latin America has been diverse across different income levels as macroeconomic policy has aimed at the stabilization of either the exchange rate or the price level. Common wisdom has traditionally implied that economic growth will improve living standards in these economies, thus resulting in long run convergence towards advance economies living standards.

Since the colonization period, countries in the region have relied on the importation of capital to augment production, covering a proportion of the acquisition costs either by debt or by increasing the exports of primary products (Franko, 2007). Such a dependency to imported capital is at the heart of a technological disparity at which these economies, due to a variety of structural factors, do not have the proper incentives to innovate but to depend on capital and technology created abroad. This is the essence of Singer (1950) and Prebisch (1959) technological disparities hypothesis.

A lower per capita income growth in the periphery results from technological disparities not only among the different sectors of production within the domestic economy, but also between the developing and the advanced economies. Since capital is primarily used in the production of the export good in the periphery, with a relatively lower share of capital being used in the other sectors of production, the rest of the economy is neglected to

backwardness due to their lower technological capabilities. The advanced economies by specializing in the production of manufactured goods are capital intensive, and have a higher level of technology than economies in the periphery which are specialized in the production and exportation of primary products that requires less technological capabilities. In that order, the observed differences in relative income levels. This is a process of uneven-development (Singer, 1950, Prebisch, 1959, Baer, 1962, Frankenhoff, 1962).

This process of uneven-development seems to be particularly reinforced by a pattern of trade where the Latin American economies specialize in the production of primary products, and the importation of manufactured goods and capital. Given this type of specialization—labour intensive developing countries versus capital intensive advance economies—emerge a pattern of declining terms of trade. Given the Engle Law, the export prices and the demand for primary products exports are relatively stable in the advanced economies. On the contrary, in the periphery, there is an inelastic demand for imports that leads to higher prices of imported manufactured goods and capital. In that order, there are stable export prices versus higher import prices, therefore the observed declining terms of trade. This process succinctly describes the Prebisch-Singer theory of declining terms of trade.

The less developed countries of Latin America seem particularly trapped in a "vicious cycle of poverty", where low income results in lower savings, lower investment, and hence lower capital accumulation and productivity (Nurkse, 1952). This cycle seems to be reinforced by the declining terms of trade, which implies increases in the costs of acquiring imported capital with embodied technologies that could help alleviate the technological disparity.

At the middle of the twentieth century, the proposed solution to address these issues in Latin America was to undertake various programs of import substitution industrialization (ISI). The objective of the ISI programs was to use the tools of economic policy, for example, overvalued exchange rates, tariffs, and import quotas, in order to restrict the importation of the final goods and services that were viewed as unnecessary for the industrialization project of these economies; while, at the same time, these programs gave subsidies and facilities to the importation of key capital goods and intermediate inputs of production for the key infant industries seen as important for industrialization (Baer, 1972).

The ISI strategies established few incentives for domestic innovation and productivity growth. ISI policies allowed the importation of key inputs of production at artificially lower relative prices under special conditions. In that order, domestic production became increasingly reliant on the use of imported inputs. While it was expected that domestic producers will innovate in new technologies thereby increasing their productivity and reducing the content of imported inputs in the production process, this final stage of the industrialization process did not occur to a large extent in these economies since domestic producers had access to low-cost capital to increase production. In a study of five Latin America economies from 1940 to 1964, Bruton (1967) documents that output growth in the region was primarily achieve by replacing existing capital and using excess capacity rather than by innovation and research in new technologies.

The several economic imbalances created by import substitution policies lead to severe macroeconomic crisis in these economies[10]. Given the low income capacity of the population

[10] Among these economic imbalances are the neglect of the export sector, distortions in the relative prices of capital, and a low labour absorption capacity in the production process (Baer, 1972, 1984).

there was a weak internal demand for the new domestically produced manufactured goods whose prices were relatively higher than similar ones produced abroad. In addition, the newly created industries were highly inefficient and with higher production costs than their counterparts in the advanced economies (Baer, 1984). In that order, the domestic imbalances created by the import substitution policies led to a slowdown in economic growth, inflation, dual currency markets and several crises as macroeconomic policy aimed primarily at the stabilization of the economy (Furtado, 1965, Arida, 1986)[11]. The general abandonment of ISI policies began to occur in the late 1970's, while during the 1980's there was a consensus in the region to return to a more oriented outward development approach by export-led growth.

The return to export-led growth was accompanied by a focus in competitiveness and the use of undervalued exchange rates to promote exports. However, these policies also failed to address the main structural features of these economies. Undervalued exchange rates increased the acquisition costs of capital imports thereby decreasing capital accumulation with the technologies embodied with it. Moreover, exports were still based on primary products which did not required higher technological capabilities, and therefore the countries practically return to the scenario described by the Prebisch-Singer theory[12].

During the 1990's the economies in the region advocated to financial and trade liberalization with an excessive focus on competitiveness. As Krugman (1994) suggests, macroeconomic policies that aim to enhance competitiveness are likely to result in poor growth performance. Despite the attempts to revive a sustainable economic growth through outward development via export-led growth, economic growth in the region remained fragile (Astorga, 2010).

Today the region appears to suffer from the same structural features described by the early development economists of Latin America: a high dependency to imported capital, poor domestic innovation in new technologies, and modest productivity and relative income growth which crucially depends on capital imports. Moreover, these structural characteristics of Latin America appear nowadays to extend to other world developing regions. Hummels et al. (2001) documented the increasing use of imported inputs in the production of export goods in a sample of 14 countries from 1970 to 1990. In addition, De Long and Summers (1991, 1993) show that the acquisition of machinery imports are the key drivers of productivity and economic growth in developing economies.

Despite the historical evidence that capital accumulation is a significant driver of productivity and output growth, there is disagreement in the existing literature with respect to the primary source of growth across countries. In a different line of research to the one presented previously, Easterly and Levine (2001) suggests that exogenous total factor productivity growth rather than capital accumulation is the major determinant of long-run economic growth in developing countries. In that order, for Latin America, Daude and Fernández-Arias (2010) and Pagés (2010) also suggest that total factor productivity growth instead of capital accumulation is the main driver of economic growth and development.

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[11] In our view, the main problems of ISI policies were that they restricted the importation of key capital goods and intermediate inputs of production for the sectors seen as unimportant for industrialization project, while artificially lowering the prices of imported capital and intermediate inputs of production for the key infant industries. In that order, the sectoral differences in the relative prices of capital perhaps exacerbated the technological disparities between the different sectors of production thereby failing to create the proper incentives for domestic innovation and productivity growth.

[12] See Franko (2007) for additional discussions on these issues.

To explain the evolution of international income levels across countries, Parente and Prescott (2005) have proposed a unified theory of economic development and a theory of relative efficiencies which shows that cross-country differences in economic policy may determine the countries choices of technology and the starting date of modern economic growth, thereby influencing long-run economic growth and development. This theory seems to account for the relative stagnation of Latin America income levels. In our view, economic policies in the region have restricted the use of imported capital across all sectors of production thereby limiting the use of foreign technologies that could be embodied in capital accumulation. At the same time, a reliance on imported capital has acted as a drag to innovation, productivity, and the development of domestic capital thereby inhibiting a sustainable economic growth and development.

These complex issues in the Latin America growth process signal that economic policies are an important determinant for long run growth. In addition, other factors such as institutions have been important in explaining the region growth performance. In that order, Acemoglu et al. (2001) suggests that the institutional heritage of the colonization in Latin America has been a key factor that may explain macroeconomic performance and long-run growth in the region. The level of institutional development has been a major indicator of the rule of law, macroeconomic stability and the security of property rights; factors that may contribute to innovation in new technologies. North (1989, 1991, 1994) has also suggested that institutions are vital for higher productivity and economic growth. Therefore, exogenous technological change in isolation, without capital accumulation, may not account for the evolution of income levels and long-run economic growth and development in Latin America.

There are few disagreements among economists that total factor productivity has played a major determinant role in the growth process of the Latin American economies. However, there are still vast controversies among economists whether technology is embodied or disembodied in capital accumulation[13]. Provided that capital imports contain embodied technologies, international trade of capital could be an important channel of technology diffusion among countries, and hence a major factor contributing to long-run growth.

In the next sections we turn to examine in detail the growth effects of domestic and imported capital in Latin America. Consistent with the growth and development theories for the region, we expect to find important evidence indicating that the acquisition of capital import is a significant driver of economic growth, and that capital accumulation, in addition to productivity, drives faster growth in the developing economies of Latin America.

3 Growth empirics

The empirical growth models presented in this section draws on the endogenous growth models proposed by Lee (1995) and Rebelo (1991). In a two-sector open economy with consumption and capital goods where the capital goods sector drive long run growth, Lee (1995) shows that a developing country may grow faster by importing relatively more capital, provided this imported capital is relatively cheaper and is an imperfect substitute for domestic capital. The foreign capital proceeds from an advance economy that is capital intensive, therefore the developing country grow relatively faster by importing the capital good and exporting the consumption goods, hence the corresponding convergence in living standards. The two-sector model characteristics are similar to those of Rebelo (1991), who

[13] See Denison (1964) and Hercowitz (1998).

considers an economy with a consumption good and a capital good sector where differences in resources lead to cross-country income differences and convergence in growth rates since these later ones are influenced by the preference and technology parameters.

An interesting feature of these types of endogenous growth models is that differences in resources and economic policies play an important role explaining the diversity of growth experiences across economies at different income levels. These are precisely the type of dynamics we viewed as important for Latin America. Failures to converge towards advanced economies living standards may be due to differences in development strategies, economic policies as well as endowments or total resources. In that order, growth is viewed as endogenous, that is, not entirely driven by exogenous technological change (Romer, 1986).

In this type of models capital is a key factor of production, and therefore capital accumulation plays a key role in driving faster growth across the transitional period towards the steady state[14]. In Lee (1995) open economy version of Rebelo (1991), imported capital is a key factor of production that also enhances the productivity of domestic capital. By importing relatively more capital from abroad, developing countries grows faster. In that order, higher taxes, import restrictions and quotas, dual currency markets and foreign exchange controls, by restricting the availability of imported capital may result in economic growth slowdowns. Therefore, trade distortions have a detrimental effect in long term economic growth (Lee, 1993).

There is significant and robust evidence indicating that a reduction in equipment investment, defined as electrical and non-electrical machinery, inhibit economic growth and productivity in developing countries (De Long and Summers, 1991, 1993)[15]. In that order, it is not surprising that imported inputs and machinery equipment has an important role in the production process of goods and services in the less developed countries. In fact, Hummels et al. (2001) documents the increasing use of imported inputs in the production of export goods[16]. It seems appropriate at this stage to specify a general definition for imported and domestic capital. Following Lee (1995), we define domestic capital as the value of total investment minus capital imports. We then proceed to define capital imports as equipment investments in electrical and non-electrical machinery reported by the domestic economy from the rest of the world. These imported machineries are expected to be key drivers of economic growth (De Long and Summers, 1991).

In recent years the literature has had a renewed interest in the cross-country evolution of relative income levels. There is an increasing interest on how relative income may influence individual's utility function and macroeconomic performance. For example, Clark et al. (2008) and Layard et al. (2009) provides the theoretical and empirical foundations to the introduction of relative income in the analysis of individuals utility function. In their empirical applications they use measures of relative income as an explanatory variable for a utility function in which the individual is concerned about the evolution of relative income levels. While in their study they use relative income as an explanatory variable, in this paper relative income is the dependent variable, and serves as proxy for relative income differences among the Latin American countries and the industrial leader.

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[14] In this type of models growth rates are conventionally equalized once the economy reaches the steady state.

[15] Note that capital imports are normally considered as imported machinery equipment.

[16] Currency depreciations and foreign exchange market distortions may increase the prices of imported goods and services. For a discussion, see Lee (1993), Lizondo and Montiel (1989).

The evolution of developing countries income and productivity levels relative to that of the United States as industrial leader has been a key indicator of efficiency in production, economic growth and development performance (Parente and Prescott, 2002, Durlauf et al., 2005, Daude and Fernández-Arias, 2010, Pagés, 2010). Moreover, traditionally, capital has played a key role in the explanation of per capita income differences across countries (Krueger, 1968). The understanding of the evolution of income levels in Latin America while accounting for capital accumulation and controlling for endowments effects, economic policies and macroeconomic conditions will allow policy makers to offer a meaningful economic advice to the region in order to achieve a sustainable economic growth and development.

3.1 Economic growth baseline specification

Our benchmark specification to estimate the growth effects of imported and domestic capital on economic growth in Latin America follows that of Lee (1995)[17]. However, our empirical approach extends that of Lee (1995) in three important directions. First, we specified a dynamic panel growth model to examine the growth effects of imported and domestic capital on economic growth. The Prebisch-Singer theory emphasize the important role of imported capital and foreign technologies in driving growth performance and explaining uneven-development in the region, therefore our interest in the growth effects of domestic and imported physical capital on economic growth in Latin America.

Second, we conduct a variety of different estimation procedures for growth econometrics in order to verify the validity of our results according to the dynamic panel estimation approaches outlined by Durlauf et al. (2005). Third, we employ an extended set of control regressors and alternative specifications. Fourth, our estimations essentially focus in the vast majority of the less developed and emerging market economies of Latin America. In that order, we estimate the following dynamic panel growth equation[18]:

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

where $y_{i,t}$ denotes the logarithm of real GDP per capita; $y_{i,t-1}$ is the initial real GDP per capita at the beginning of the period, where a negative coefficient value ($\gamma < 0$) for the initial GDP per capita implies the model is consistent with the conditional convergence hypothesis in growth theory[19]. $k_{m,i,t}$ is either the growth rate of capital imports or alternative measures for imported physical capital like the ratio of capital imports in investment; $k_{d,i,t}$ is the growth rate of domestic capital; $h_{i,t}$ is the initial level of secondary school enrolment or human capital as investments in education; $C'_{i,t}$ is a column vector of control variables, with θ as the corresponding column vector of control parameters; μ_t are the time period specific effects; l_i are time-invariant country specific effects, and $\varepsilon_{i,t}$ is the

[17] In a sample of 89 countries from 1960 to 1985, Lee (1995) estimated a cross-country growth regression using two-stage least squares to test the relationship between the ratio of capital imports in investment and economic growth. Note that Lee (1993, 1995) provides the theoretical endogenous growth models under which our empirical estimations are based. In these types of models, trade distortions and restrictions to the availability of capital imports may drag economic growth.

[18] See Barro (1991), Mankiw et al. (1992), Caselli et al. (1996), Bond et al. (2001) and Acemoglu (2009) for a discussion on the specifications of cross-country growth regressions.

[19] Under conditional convergence countries closer to their steady state experience a slowdown in economic growth (Barro and Sala-i-Martin, 1992).

country specific term. The panel dimensions are $l \in [1, \ldots, 32]$ economies across $T \in [1, \ldots, 10]$ five-year averages from 1960 to 2010.

Our primary selection of control variables includes the investment share, population growth, trade openness as measure for trade policies and trade distortions, inflation as a measure of lack of price stability and as an indicator of monetary policy, government consumption to control for fiscal policy, and a measure of macroeconomic crisis which accounts for periods of severe banking and currency crisis. These are normally standard choices for control regressors in growth econometrics[20]. In addition, we also account for the land size as a control for endowments, and tariffs rates and imports of goods and services in order to account for trade distortions and the level of total imports respectively. Furthermore, we also introduce a control for political instability and the level of institutional quality in the form of an institutional development variable. The time effects are introduced to capture common patterns of long run growth and exogenous shocks that may map to Latin American economies. The country specific effects serve as controls for time invariant unobserved heterogeneity, that is, omitted variables that are time invariant in these countries[21].

3.2 Relative income differences specification

We now address the relationship between relative income growth, capital imports and domestic capital. Following Parente and Prescott (2005), we study the evolution of income levels in Latin America relative to the United States as industrial leader. In addition, while the empirical application of Lee (1995) considered the growth rate of GDP per capita income as a measure for income growth, we extended their approach by considering relative income growth with respect to the United States. Our motivation to examine relative income levels in Latin America draws on the observation that relative income in the region has remained at a quarter of the United States income despite modest episodes of economic growth in these economies (Parente and Prescott, 2005). In that order, we seek to examine the importance of domestic and imported capital on the performance of relative income levels in Latin America.

The level of institutional development has been a key factor in the security of property rights, the rule of law and the maintenance of political stability in the Latin American economies. In this regard, North (1989, 1991, 1994) suggests that institutions are key drivers of productivity innovations and economic growth in developing countries. Moreover, Acemoglu at al. (2001) also suggest that institutional development has played a significant role on macroeconomic performance and economic development in Latin America. Therefore, in our estimation we incorporate an institutional development measure as a key explanatory variable of the evolution of relative income levels in Latin America.

Following the dynamic panel cross-country growth equation (3.1), we examine the growth effects of domestic and imported capital on relative income growth in the Latin American economies by estimating the equation:

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[20] A more detailed specification on the variables definitions and sources is given in the data methodologies section and Appendix B. See also Durlauf et al. (2005) for a literature survey on the different studies that use similar control variables, and their application on empirical growth research.

[21] See the data section of this paper for additional details on the selection of control regressors and the motivation to include these in our estimations.

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

where $\left(\frac{y_{i,t}}{y_{u,t}}\right)$ denotes the PPP converted real GDP per capita relative to the United States (Heston et al., 2012); $\left(\frac{y_{i,t-1}}{y_{u,t-1}}\right)$ is the initial relative income at the beginning of the period, where a negative coefficient $(\phi < 0)$ implies the conditional convergence hypothesis. $k_{m,i,t}$ is either the growth rate of capital imports or alternative measures for imported physical capital; $k_{d,i,t}$ is the corresponding growth rate of domestic capital or alternative measures for domestic physical capital; $h_{i,t}$ is the initial level of secondary school enrolment or human capital as investments in education; $X'_{i,t}$ is a column vector of control variables with θ as the corresponding column vector of control parameters; μ_t are the period specific effects; l_i are the time-invariant country specific effects, and $\varepsilon_{i,t}$ is the country specific term. The panel dimensions are $l \in [1, \ldots, 32]$ economies across $T \in [1, \ldots, 10]$ five-year averages from 1960 to 2010.

3.3 Data

In what follows we provide a description of our data structure, the economic relevance of the variables used in our estimations, and the motivation for their inclusion in our study. We also explain how our definitions may differ from those conventionally used in the literature[22].

Data is compiled for a panel of 32 Latin America economies. We filter out business cycle fluctuations by implementing five-year averages of the variables series, and the panel is unbalanced (Durlauf et al., 2005). Our data structure differs from others in the literature in two important aspects[23]: first, we use perhaps one of the most extensive samples of Latin American economies. Second, we use a significant time horizon since our sample period covers fifty years from 1960 to 2010. The major data sources for our study are the Penn World Tables, the World Development Indicators (WDI) and International Financial Statistics (IFS).

As dependent variables that proxy economic growth and relative income differences we use the growth rate of real GDP per capita, and the PPP converted GDP per capita relative to the United States, and data is obtained from Heston et al. (2012). Income is measure relative to the United States since it is the traditional benchmark as industrial leader (Parente and Prescott, 2005).

Initial real GDP per capita and initial secondary school enrolment ratios are introduced as control measures for the initial levels of physical and human capital stock (Barro, 1991, Barro and Sala-i-Martin, 1992, Mankiw et al., 1992, Levine and Zervos, 1996). We also

[22] Appendix B summarizes the variables definition and sources used in this paper. The term covariate and variable is used interchangeably.

[23] Most studies for the region focuses on the six largest economies in Latin America, or a selected sample of emerging market and developing countries. See, for example, the works of De Gregorio (1992), Gutierrez (2005), Astorga (2010), Daude and Fernández-Arias (2010).

include a measure for initial income relative to the United States as proxy for the initial level of income[24].

Following De Gregorio (1992) we control for government consumption and inflation. We introduce government consumption as share of GDP from World Bank (2013) as a control for fiscal policy. To account for monetary policy and inflationary spirals, we construct a measure that captures lack of price stability following the methodology proposed by Levy-Yeyati et al. (2010)[25].

There is substantial empirical evidence suggesting that the level of institutional development matters for macroeconomic performance in Latin America (Acemoglu et al., 2001). To address these concerns, we introduce a control for political instability in the form of institutional quality or institutional development.

Our institutional development measure proceeds from institutional constraints on the decision power of the executive (president) or veto points in these economies. The hypothesis being tested is that constraints on policy changes may bring security to investors and should be correlated to higher economic growth. We use data obtained from Henisz (2012) Political Constraint Index (POLCON). Controls for severe macroeconomic crisis in the form of systemic banking crisis and currency collapses are also included. Data on banking crisis proceeds from Reinhart and Rogoff (2009) and Laeven and Valencia (2012). We use Reinhart and Rogoff (2009) methodology to calculate currency crisis for each economy as a nominal currency depreciation greater than 30%.

We also include a variety of control regressors that are traditionally seen as key determinants of economic growth according to De Gregorio (1992), Lee (1995) and Astorga (2010). We include the investment share over GDP and population growth from the Penn World Tables, the land size (sq. km) as a proxy for endowments, and the tariff rates applied to all products in order to control for trade distortions. These latter ones are obtained from World Bank (2013).

A measure for real trade openness is also included to account for distortionary trade policies that may have a negative effect in the economy and hence may drag growth, especially if it is outward oriented. Since we are also accounting for the growth effects of capital imports, we need to control for the level of import capacity in these economies. In that order, following Lee (1995), we also control for the total level of goods and services imports, where data is obtained from the World Development Indicators.

One of the most important contributions presented in this paper is the examination of the growth effects of domestic and imported physical capital in Latin America. We now turn to explaining the methodologies we have used to disaggregate between changes in capital imports and domestic capital.

For the construction of the domestic and imported physical capital series for Latin America we extend the methodologies proposed by De Long and Summers (1991, 1993) and Lee (1995). According to the methodology proposed by Lee (1995), capital imports are defined as machinery exports from the OECD countries to the domestic economy. These may include exports of transport equipment. In a similar fashion, De Long and Summers (1991, 1993) consider as equipment investment those that proceeds from investments in transport equipment, electrical machinery and other nonelectrical machineries.

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[24] Initial values refer to the variable value at the beginning of each five year period. The secondary school enrolment rates are obtained from World Bank (2013). We decided to use the educational data from the World Bank since it includes a wider sample of Latin America countries.

[25] We compute lack of price stability measure as the logarithm of one plus the inflation rate.

To adapt Lee (1995) methodology to be implemented to the developing countries of Latin America, we proceed to define capital imports as the total value of imported machinery equipment from the rest of the world, therefore it follows that domestic physical capital results from the value of total investments minus capital imports. Our modified methodology differs from De Long and Summers (1991, 1993) and Lee (1995) in two important directions. First, we extend Lee (1995) definition of capital imports to include the importation of machinery (other than electric), and electrical machinery equipment reported by the domestic economy as imported from the rest of the world. Perhaps due to data availability at the time, Lee (1995) only considered as capital imports those machinery exports from the OECD to the domestic economy since these are more likely to be embodied with higher technologies that are key drivers for long term growth. We extend Lee's work by considering all imports from the rest of the world as having also some degree of embodied technologies that the country may use to improve its productivity potential and technological capabilities. Therefore in our definition of capital imports we include the imports of machinery equipment reported by the domestic economy to be obtained from the rest of the world.

Second, to avoid statistical inconsistencies, we not do include transport equipment in our capital imports measure. The concept of transport equipment includes automobiles, trains, aviation equipment and parts, whose value may well exceed those reported as total investment in GDP. In addition, it is likely that a considerable proportion of this transport equipment may be imported temporarily into the economy to be re-exported abroad after a period of time, or may simply be devoted for consumption or leisure transportation, hence not forming part of total investment and gross capital formation. To be more precise, in some countries in Latin America we find evidence that the value of total investment is relatively lower than the value of total imports in machinery and transport equipment, therefore the value of domestic physical capital could be negative[26].

It is important to bring an additional observation on why including transport equipment may bring additional statistical inconsistencies. Many of the countries in the region report statistics under different balance of payments (BOP) and system of national accounts manual (SNA)[27]. Hence many of them may classify some transport equipment as investment while others do not. This is one of the many reasons why in some of these economies the total values of imported machinery and transport equipment may well exceed those of total investment. Moreover, cross-country disaggregated national account data for the region is relatively scarce in order to perform an accounting decomposition on what types of capital are being considered as investment. Perhaps this is one of the main reasons why there is only a limited sample of Latin American countries in growth accounting exercises[28].

For these reasons, we proceed to abstract the capital imports analysis from that of transport equipment imports; although transport equipment is expected to be implicitly included in the total value of domestic physical capital. In that order, De Long and Summers (1993) also excluded from their analysis the investments on transport equipment since, according to their observations, these are likely to be influenced by demographic variables such as population growth and the rate of urbanization. Moreover, including

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[26] Recall that under Lee (1995) methodology domestic physical capital is calculated as total investment minus capital imports. Among the countries whose total imports value in machinery and transport equipment exceeds those of total investment are, for example, Panama and Uruguay.

[27] See the countries report by the World Bank (2013) and the International Monetary Fund.

[28] See, for example, Gutierrez (2005).

transport equipment imports in the total measure of imported capital may only strengthen the role of capital imports in the growth process; therefore our estimations may be regarded as conservative.

Our country level data on imported machinery equipment proceeds from U.N. Comtrade database[29]. In that order, we compile data on capital imports for each of the thirty-two Latin America economies, and disaggregate among changes in domestic and imported physical capital[30]. Given our procedure we have extended and adapted Lee (1995) methodology to be implemented to the wide diversity of developing and emerging market economies in Latin America[31].

3.4 Estimation procedure

The empirical growth models of Eq. (1) and Eq. (2) are commonly estimated either by cross-sectional analysis using pooled ordinary least squares and the fixed-effects (within-group) estimators, or by using instrumental variables estimation procedures to address the endogeneity of the growth determinants. Among the instrumental variables estimators, the most commonly used alternatives in growth econometrics are the two-stage least-squares, the first difference generalized method of moments (GMM) estimator, and the system GMM estimator[32].

The difference between these estimators relies primarily on the assumptions about the data generating process and the explanatory variables. The pooled OLS and the fixed-effects estimators require the exogeneity assumption of the regressors, that is, explanatory covariates are uncorrelated with the residual term. This implies, for example, that explanatory variables like government consumption and inflation has a unique identifiable effect in the economic growth rate, and there is no possibility for reverse causation or simultaneity that may be capture by the error term.

The pooled OLS does not incorporate country specific intercepts, while the fixed-effects estimation do control for time invariant unobserved heterogeneity. In dynamic panels, that is, where the dependent variable is included lagged one period as a repressor, the pooled OLS estimator may be biased upwards and inconsistent. In a similar fashion, the within-group estimator is likely to be downward bias. Moreover, since conventionally five-year averages of the variables time series are normally used in dynamic panel, in the context of small time periods and a large cross-section of countries, the pooled OLS and the fixed-effects estimators are prone to provide biased estimates about the coefficients (Durlauf et al., 2005).

Despite these shortcomings, these estimators are particularly useful when combined together to provide benchmark estimates of the coefficients when the variables are assumed to satisfy the exogeneity assumption. In our initial estimation strategy we impose the strong assumption of strict exogeneity among the regressors and the residual term.

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[29] We use the standard international trade classification revision 1, sections 7.1 and 7.2 which correspond to nonelectrical and electrical machinery. We find support for using data from revision 1 since it covers a longer time horizon than other revisions, therefore increasing our sample observations.

[30] Note that data on capital imports and domestic capital is calculated in constant per capita U.S. dollars in 2005. See appendix B for a detailed calculation of these variables.

[31] The complete dataset is available from the author upon request.

[32] For a comprehensive review on estimation procedures in growth econometrics see, for example, Durlauf et al. (2005). Note that random effects model do not suit growth regressions of this type since in random effects model the country effects are assumed unrelated to the explanatory variables, and this requirement is violated in dynamic panel growth models.

Therefore in the first stage of the estimation procedure we estimate Eq. (1) with the pooled OLS and the within-group estimator. Provided the equation adequately identify an important relationship among the regressors and the dependent variable our estimates should be stable across different specifications.

The reason for the pooled OLS and the fixed-effects estimator tendency to produce biased estimates in the context of dynamic panel growth regressions is due to the included lagged dependent variable as a regressors since it is expected to correlated with the fixed effects and the residual (Nickell, 1981). In addition, we should expect the explanatory variables to be endogenous in cross-country growth regressions. In other words, regressors may correlate with pasts and current realizations of the disturbance term. In that order, dynamic panel estimation procedures should correct for endogeneity and dynamic panel bias. An important line of attack to alleviate these issues is to implement an instrumental variables estimation approach.

In the second step of our estimation strategy, we estimate Eq. (1) using the two-stage least squares fixed-effects instrumental variable estimator (2SLS) following the programming proposed by Schaffer (2010). We test for the endogeneity among the lagged dependent variable and the capital measures. Namely, we estimate a variant of Eq. (1) where the lagged dependent variable, capital imports and domestic capital are assumed to be endogenous regressors. In order to verify the validity of our two-stage least-squares estimations we implement various instrumental variables specification tests. We use the Kleibergen-Paap *rk* LM underidentification test, where rejecting the null hypothesis implies that the estimated equation is identified (Kleibergen and Paap, 2006). The second test is a Kleibergen-Paap *rk* Wald F statistic for weak identification where this statistic is expected to be higher than Stock et al. (2002) critical values in order to reject the null of weak identification (Baum et al., 2003, Schaffer, 2010)[33].

To further examine instrument validity under the 2SLS approach, we implement the Hansen (1982) over-identification test under the null that the instruments used are uncorrelated with the error term, hence satisfying the orthogonality conditions and remaining valid instruments. Finally, we examine the endogeneity of the chosen regressors—the lagged dependent variable, capital imports and domestic capital—using a Durbin-Wu-Hausman endogeneity test under the null that the selected endogenous regressors can actually be treated as exogenous variables (Durbin, 1954, Wu, 1973, Hausman, 1978).

Important shortcoming of these types of instrumental variables estimators are as follow: first, not all the regressors can be specified as endogenous since we need to satisfy rank conditions, that is, the number of explanatory variables should exceed the number of instruments[34]. Second, it seems difficult to find strong external instruments outside those that may be available from the data generating process, and that can serve to expunge simultaneity from the specified endogenous regressors. Third, 2SLS seems to not perform well in the type of panel data structures that characterize growth regressions, that is, with a relatively small number of time periods and a large cross-section of countries.

Dynamic panel estimators for empirical growth models should produce consistent and efficient estimates in the context of small time periods and a large cross-section of countries while allowing endogenous regressors and controlling for individuals and time period

[33] Instruments may only be weakly correlated to the endogenous regressors, in which case there can be a bias that proceeds from weak identification. See Murray (2006) for a discussion on how to avoid and correct for potential weak or invalid instruments.

[34] See Heij et al. (2004) for an introduction to these issues.

specific effects. Such estimator in growth econometrics is proposed to be the system generalized method of moment estimator (Bond et al., 2001). The system GMM estimator estimate simultaneously two equations, one in first difference and another one in levels, from which appropriate instruments are selected from the data generating process according to the set of moment conditions derived from initial conditions and assumptions.

The first difference GMM estimator is proposed by Holtz-Eakin et al. (1988), Arellano and Bond (1991). This estimator uses lagged levels of the variables as instruments for an equation in first differences, and can be implemented using a one-step or two-step estimator[35]. The first difference transformation removes the time invariant unobserved heterogeneity thus alleviating omitted variables bias. However, in the context of small time periods and persistent time series—such as those that characterizes growth regressions—the first difference estimator has been found to perform poorly in simulations. The difference estimator shows a downward finite sample bias as lagged levels of the variables appears to be weak instruments for the regressors (Alonso-Borrego and Arellano, 1999).

Arellano and Bover (1995) proposed the use of lagged first differences to estimate an equation in levels, in addition to the use of lagged levels as instruments for an equation estimated in first differences. This system estimator is suggested to improve the consistency and efficiency of the estimations. Blundell and Bond (1998) outlined the initial conditions, assumptions and requirements under which this system GMM estimator outperforms the first difference estimator, and the estimators based on non-linear moment conditions[36]. The system estimator relies on the non-serial correlation assumption in the disturbance term, the fixed effects non-correlation with the regressor first differences, and the stationary requirements. These conditions are suitable for growth econometrics in the context of dynamic panels with short time periods and a relatively large cross-section of countries (Bond et al., 2001).

Finally, in the third stage of our estimation procedure, we estimate Eq. (1) and Eq. (2) using the Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) two-step system GMM estimator following Roodman (2009a) programming with Windmeijer (2005) robust standard errors, small sample adjustments and collapsed instruments[37]. Standard errors are robust to heteroskedasticity and autocorrelation within cross-sectional units.

For the system GMM estimator we impose the assumptions of the non- serial correlation of the idiosyncratic shock and the fixed effects, as well as the initial condition that the dependent variable is predetermined. We also assume that the explanatory variables are endogenous, in the sense of being correlated with current and past realization of the error term. Let us denote $Z_{i,t}$ as the *1 x k* vector of endogenous regressors. Following Arellano and Bond (1991), we use the following moment conditions for $t = 3, \ldots, 10$ *and* $a \geq 2$:

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[35] We use the two-step estimator since it is asymptotically more efficient than the one-step counterpart (Roodman, 2009a).

[36] For a detailed discussion on GMM estimators based on non-linear moment conditions see, for example, Ahn and Schmidt (1995).

[37] Windmeijer (2005) introduced a finite sample correction for the two-step GMM estimator to correct for the standard errors downward bias in small samples. To avoid instrument proliferation, Roodman (2009a) propose a restricted use of lags, as well as the use of collapsed instrument, that is, the use of one instrument per variable for each lag distance and zero for missing values, therefore allowing the instrument count to be linear in the time dimension. Small sample adjustments results in the t-test instead of the Z test for the variables, and when combined with collapsed instruments, it alleviates the bias that could be caused by many instruments (Roodman, 2009a).

$$E\left[y_{i,t-a}(\varepsilon_{i,t}-\varepsilon_{i,t-1})\right]=0 \tag{3}$$
$$E\left[(\tfrac{y_{i,t}}{y_{u,t}})(\epsilon_{i,t}-\epsilon_{i,t-1})\right]=0 \tag{4}$$
$$E\left[Z_{i,t}(\varepsilon_{i,t}-\varepsilon_{i,t-1})\right]=0 \tag{5}$$

The assumption that first differences of the covariates are uncorrelated with the time fixed effects results in the following additional moment conditions for the level equations instruments (Arellano and Bover, 1995, Blundell and Bond, 1998):

$$E\left[(y_{i,t-1}-y_{i,t-2})(l_i+\varepsilon_{i,t})\right]=0 \tag{6}$$
$$E\left[\left\{\left(\tfrac{y_{i,t-1}}{y_{u,t-1}}\right)-\left(\tfrac{y_{i,t-2}}{y_{u,t-2}}\right)\right\}(l_i+\epsilon_{i,t})\right]=0 \tag{7}$$
$$E\left[(Z_{i,t-1}-Z_{i,t-2})(l_i+\varepsilon_{i,t})\right]=0 \tag{8}$$

Recall that in our system GMM estimation procedure we have assumed the regressors to be endogenous. This assumption implies that we use second and further lagged levels of the variables as instruments for the first difference equation, in addition to lagged first differences of the variables as instruments for the levels equations. When an explanatory variable is assumed predetermined—the case of the lagged dependent variable—the first lagged level of the variable and contemporaneous lagged first differences are also available as instruments[38]. These conditions are important since the choice of lag is dictated by our assumptions about how regressors may potentially correlate with the disturbance term. For example, any weakly exogenous variable will likely become endogenous after the first difference transformation; therefore the next period lag is expected to be uncorrelated with the error term.

To ensure the validity of our instruments choice, we use the Hansen (1982) overidentification test under the null that the selected instruments are valid, hence remaining orthogonal to the error component. This *J* test can also be viewed as an specification test that shows whether the model is correctly identified and specified (Roodman, 2009a). In addition, we use the difference-in-Hansen statistics to verify the validity of each of the instruments subsets used in the first differences and the levels equations.

Since the validity of the system GMM estimation relies on the assumption that the residuals are serially uncorrelated, we also verify the validity of our instruments implementing the Arellano and Bond (1991) serial correlation test under the null of no serial correlation[39]. We also rely on the standard guidelines to restrict the instrument count to the number of cross sectional groups, as well, as to test different instrument counts and control set specifications.

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[38] See Roodman (2009a) for a review on the standard treatment and lag choices for predetermined and endogenous regressors in GMM estimations. Note that we could use additional lags as the moment conditions 3 to 8 suggests. However, to avoid over-fitting the regressors, we restrict our lag choice to the closest suitable lags.

[39] Recall that after the first difference transformation we should expect AR(1) serial correlation, therefore the Arellano and Bond (1991) serial correlation test looks for AR(2) serial correlation in the error component.

4 Empirical findings

The key questions to be address in this section are essentially the following: First, does the accumulation of physical and human capital leads to higher economic growth and lower relative income differences in Latin America? Second, is this capital endogenously or exogenously related to the growth rate? Third, which of these types of capital—domestic, imported or human capital—is essentially more growth enhancing, and alleviates more cross-country relative income differences in the region? These questions have no easy answers, however this paper brings substantial and robust evidence indicating that by adopting imported capital the Latin American countries grow faster and reduce their relative income gap with the industrial leader[40]. Our results suggest that capital imports are a major channel of technology diffusion between countries, therefore driving faster growth.

Recall that through this analysis the term capital is considered as a broad disaggregate measure that includes domestically produced capital, capital imported from the rest of the world, and domestic human capital. The adoption of this concept follows from the definitions of physical capital accumulation provided by Solow (1956), Swan (1956), Rebelo (1991) and Lee (1995), as well as to the concept of human capital developed by Schultz (1960, 1961), Becker (1962), and Lucas (1988).

The effects of technological change as an engine of growth is not explicitly modelled in these estimation, and it is left as the proportion of economic growth that cannot be explained by capital accumulation, economic policy and endowments. Part of this technological change, perhaps the most important one, may be seen as incorporated implicitly through productivity embodied in capital imports, as well as domestic productivity innovations embodied in the creation of domestic capital goods and domestic human capital accumulation (Hercowitz, 1998)[41].

Table 1 presents the preliminary evidence on the growth effects of capital accumulation under different econometric methods. We first assume the explanatory variables are exogenously correlated to the real GDP per capital growth rate. In that order, the first set of results in Table 1, that is regressions (1) and (2), are obtained via the Pooled OLS estimation of Eq. (1). While controlling for time specific effects to capture long run shocks that may affect these economies, this estimation method does not account for time invariant unobserved heterogeneity.

[40] By the industrial leader we refer to the United States (Parente and Prescott, 2005).

[41] Note that it could be misleading to assume that the error term of the estimations represents technological change. The residuals of these regressions may represent both the proportion growth that can be attributed to unexplained exogenous technological change, as well as possible omitted variables. By including a diversity of control regressors across different specifications omitted variable bias may be alleviated. However, these are not enough reasons to suggest that the residual denotes exogenous technological change. For a discussion on the alternative interpretations of residuals terms in cross-country growth regression see Durlauf et al. (2005).

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*	
Period: 1960-2010	(1)	(2)	(3)	(4)	(5)
Initial real GDP per capita	-0.00814**	-0.00616	-0.0461**	-0.0284	-0.0150
	(0.00339)	(0.00415)	(0.0178)	(0.0324)	(0.0232)
Capital imports	0.000306	0.000821***	0.000677***	0.0000489	0.000772*
machinery imports growth	(0.000244)	(0.000209)	(0.000139)	(0.000406)	(0.000438)
Domestic capital	0.00156***	0.00145***	0.00114***	0.00209***	0.00104*
domestic capital growth	(0.000301)	(0.000316)	(0.000346)	(0.000765)	(0.000546)
Human capital	0.0119	0.0156	0.00561	0.0121	0.0285
initial secondary school enrollment	(0.00812)	(0.0167)	(0.0190)	(0.0183)	(0.0214)
Investment share	0.000390	0.000695	0.00185**	0.000419	0.00141
	(0.000315)	(0.000518)	(0.000671)	(0.00112)	(0.00124)
Population growth	-0.00314	0.000318	-0.00228	-0.0109	-0.00906
	(0.00257)	(0.00425)	(0.00445)	(0.00734)	(0.00749)
Government consumption	-0.0220***	-0.0207**	0.00468	0.00551	0.00174
	(0.00638)	(0.00928)	(0.00730)	(0.0106)	(0.0103)
Lack of price stability	-0.0138***	-0.0105*	-0.00825*	-0.0158**	-0.0121
	(0.00437)	(0.00595)	(0.00429)	(0.00626)	(0.00798)
Macroeconomic crisis	-0.00741**	-0.00529	-0.0149*	-0.00484	-0.000369
banking and currency	(0.00315)	(0.00834)	(0.00807)	(0.0118)	(0.0163)
Trade Openess		0.00598	-0.00550	-0.0108	-0.0166
		(0.00515)	(0.0117)	(0.0198)	(0.0232)
Initial secondary school enrolment		0.00855	0.0217*	0.00128	
lagged two periods (t-2)		(0.0107)	(0.0120)	(0.0217)	
Constant	0.104***	0.000808	0.303		
	(0.0337)	(0.0582)	(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-statistic	0.00	0.00	0.00	0.00	0.00
Instrumental variables specification tests					
Kleibergen-Paap *rk* LM statistic				0.23	0.31
Kleibergen-Paap *rk* 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	16	15

Notes: Two-stage least-squares fixed-effects instrumental variable estimation following Schaffer (2010) programing. Estimation (4) considers the initial real GDP per capita, capital imports and domestic capital as endogenous regressors being instrumented by their lagged levels up to the third lag (initial GDP uses the second lag), in addition to the land size, institutional development and total imports of goods and services. Regression (5) considers only capital imports and domestic capital as endogenous regressors, these being instrumented by their lagged levels up to the third lag, in addition to the second lag of the initial school enrolment, the land size, institutional development and total imports of goods and services. Standard errors are given in parenthesis. The specifications tests report the p-values.

***Significant at 1%, **Significant at 5%, *Significant at 10%.

The results from the Pooled OLS estimation in regression (1) shows that capital imports have an insignificant effect in the growth process, being the growth effects of domestic capital more significantly conducive to output growth than human capital and capital imports. This initial finding suggests domestic capital as a main engine of growth. Our results show that controlling for a variety of economic policy variables and determinants of capital accumulation such as the investment share, population growth, government consumption, lack of price stability, macroeconomic crisis, trade openness among others, are important for growth modelling. It should also be noted here that the coefficient of initial real GDP per capita is negative and significant thus showing support for the conditional convergence hypothesis in Latin America, that is, economies closer to their steady state will experience a slowdown in economic growth rates (Barro and Sala-i-Martin, 1992, Caselli et al., 1996).

When in lagged values of human capital are included in estimation (2), the results presented in Table 1 show that capital imports and domestic capital have a significant effect on output growth. However the lagged measure of human capital appears statistically insignificant in the estimation[42]. It seems to be the case that lagged values of human capital interacts to enhance the productivity and the growth effects of the physical capital. These findings support Astorga (2010) who also finds that physical and human capital are important drivers of economic growth in Latin America

An initial shortcoming of this methodology is that previous estimates by Pooled OLS do not take into account unobserved heterogeneity and endogenous interactions. A first line of attack to alleviate the potential bias caused by unobserved time invariant heterogeneity in the estimates is to introduce country specific effects. This type of estimation is carried out with the within-group (fixed-effects) estimator in regression (3). When country fixed effects are included, the results confirms the growth enhancing effects of capital imports, domestic capital and human capital on economic growth.

The initial estimates suggest that domestic capital is more productive than both human capital and capital imports. Intuitively, a 1% increase in domestic capital is expected to yield a 0.11% faster economic growth in Latin America. The investment share of output also appears to be a major determinant in the growth process.

Note that the adjusted R-squared of these models is more that 50% of the economic growth rate. It implies that with this modelling we should be able to explain at least half of the region growth process. One of the main hypotheses handled in this paper is that capital imports are an important channel of technology diffusion between countries. Provided this is the case, and that a developing economy has a technological disparity of the type described by the Prebisch-Singer theory, we should expect capital imports to be more productive than domestic and human capital, allowing technology to be diffused from advanced economies to developing countries[43].

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[42] By estimation (2) it is meant regression 2 in Table 1. This terminology will be kept throughout the rest of the study. The choice of lags was determined from a System GMM perspective. Since human capital can be considered as a potential endogenous regressor, lagged levels of this variable dated $t-2$ are uncorrelated with the residual term.

[43] Note that productive means in this context that capital imports should enhance both productivity and economic growth. The assumption that higher productivity leads to higher economic growth is adopted throughout this paper. Prebisch (1959) suggested a technological disparity between advanced countries (the centre) and developing countries (as the periphery), in which the periphery have a lower technological state and depends from technology created in the centre to improve their economic growth and development.

A potential concern regarding the role of domestic capital in the growth process is that endogenous dynamics between the regressors and the residual terms may be influencing the results. To address these issues, regressions (4) and (5) in Table 1 presents the estimation results of Eq. (1) via the two-stage least-squares fixed effects estimator following the programming proposed by Schaffer (2010) for instrumental variables estimations. In that order, in regression (4) we allow for endogenous interactions between initial income, capital imports and domestic capital[44]. Our results indicate that after partially controlling for the potential endogeneity of these regressors, domestic capital still have a significant role in the growth process of the Latin American economies. These results may also be interpreted as suggesting that if technological change is embodied in domestic physical capital accumulation, then domestic innovations are an important engine of growth.

This estimation also detects significant endogeneity dynamics between initial real GDP per capita, capital imports and domestic capital with the error term. The endogeneity test indicates that at the 10% significance level we should reject the null that these regressors as a group should be treated as exogenous. The specification from regression (5) considers capital imports and domestic capital as the only endogenous regressors. After testing for this possibility, we can observe that capital imports and domestic capital have a significant role in the growth process.

Three important findings are derived from the results presented in Table 1. First, there are growth enhancing effects of capital imports and domestic capital robust to a variety of econometric assumptions. Second, the coefficient estimates are relatively well stable across different specifications. Third, domestic capital is an important driver of economic growth in Latin America. Fourth, the specification tests suggest the presence of endogeneity between some of the regressors and the residual term.

The specification tests from the two-stage least-squares regressions show that the instruments used in regressions (4) and (5) may not have accounted for all the endogenous interactions between the regressors and the error component. In addition, the instruments appear to be relatively weak and the specification seems under-identified[45]. To address these issues, a system generalized method of moments (System GMM) estimation approach is conducted and presented in the following subsection. The system GMM procedure allows the explanatory variables to follow an endogenous dynamic process, that is, they are correlated with current and past realizations of the error component.

4.1 The growth enhancing effects of capital accumulation in Latin America

In order to properly answer our key questions, we need an econometric approach that allows us to deal with endogeneity, omitted variables bias and potential measurement error. From this subsection onwards, the analysis is carried out using a system generalized method of moment's estimation (System GMM) approach. In particular, we implement the Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998)

[44] See the estimation table notes on how the endogenous regressors were instrumented.

[45] The Kleibergen and Paap (2006) *rk* Wald F statistic fail to reject the null of under-identification, and the Wald statistic of weak instruments is below Stock et al. (2002) critical values and the Stock et al. (2002) traditional threshold of 10. Moreover, when only subsets of covariates are considered as endogenous, the Hansen (1982) *J* statistic for instruments validity is very close to the 10% confidence rejection region. The struggle to find appropriate instruments to carry out 2SLS instrumental variables estimation motivates the use of system GMM estimations.

estimator following Roodman (2009a) programming[46]. All the estimations include Windmeijer (2005) finite sample correction, small sample adjustments, Roodman (2009b) collapsed instruments, and time specific effects. Under these specifications we should dramatically alleviate omitted variables bias, measurement error and simultaneity in the growth models (Bond et al., 2001).

The baseline equation being estimated is Eq. (1). The sample estimation period includes fifty years from 1960-2010. As previously discussed, the system GMM approach allows for the possibility that all the regressors are endogenously correlated with the error component. Strong support is found in the literature to control for endogeneity, omitted variables bias and measurement error using these types of specifications (Caselli et al., 1996, Blundell and Bond, 2000, Durlauf et al., 2005).

Table 2 presents the key findings concerning the growth effects of domestic and imported capital on economic growth in Latin America. After controlling for endogeneity among all the regressors, there are robust and significant growth effects of machinery imports in economic growth[47]. In other words, by adopting relatively more capital imports, countries in Latin America are able to grow faster. The growth effects of capital imports are also found to be relatively higher than those of domestic and human capital once endogenous interactions have been accounted for. These results coincide with the hypothesis that capital imports are an important channel of technology diffusion between countries. By importing machinery with embodied technologies developing countries grow faster.

The estimates are relatively well stable across a variety of different control regressor specifications. In the first set of estimations in Table 2, we control for main determinants of economic policy, the total imports of goods and services, and trade openness. After controlling for the level of total imports and real trade openness we can observe a higher effect of capital imports on economic growth. Intuitively, according to the results presented in regression (3), a 10% increase in capital imports should drive growth by 1.3%. Note here that the expected increase in growth is less than proportional to the increase in capital imports. This should be the expected result if we are willing to assume that there is a less than proportional embodied technology in these imports. There is no reason to believe countries are willing to incur in the adoption of foreign capital if this can be highly substituted, and is of unchanging quality as human and domestic capital.

Taking these estimates to the limit, if one is also willing to assume that physical and human capitals are perfect substitutes and of unchanging quality, one can incur in attribute the growth enhancing effects of capital imports only to embodied technological change. These estimates should be viewed in a wider perspective. By enhancing growth it should be the case that capital imports should be embodied with higher technology and of superior quality than human and domestic capital, since otherwise countries may be tempted to adopt the latter's to grow faster.

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[46] See Section 3 for additional details on the models assumptions, moment conditions and specification tests.

[47] Recall that Table 1 also shows that there are significant growth effects of capital imports if we adopt the assumption that the regressors are strictly exogenous.

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	-0.00734	-0.00611	-0.0149	-0.00976
	(0.0127)	(0.0127)	(0.0133)	(0.0142)	(0.00817)
Capital imports	0.000969**	0.00106*	0.00129***	0.000742*	0.000824**
machinery imports growth	(0.000408)	(0.000611)	(0.000441)	(0.000403)	(0.000337)
Domestic capital	0.000388	0.000451	0.000881	0.000693	0.00161
domestic capital growth	(0.000871)	(0.00145)	(0.00125)	(0.000557)	(0.00139)
Human capital	0.0546	0.0350	0.0265	0.0583	0.0467
initial secondary school enrollment	(0.0366)	(0.0613)	(0.0427)	(0.0410)	(0.0572)
Investment share	0.000673	0.00178	0.00131	0.000927	0.00150
	(0.00126)	(0.00298)	(0.00245)	(0.00159)	(0.00166)
Population growth	-0.000786	0.00610	0.00590	0.000858	0.00611
	(0.0114)	(0.0139)	(0.0118)	(0.00823)	(0.00835)
Government consumption	-0.00887	-0.0180	-0.0193	-0.00699	-0.0123
	(0.0193)	(0.0260)	(0.0245)	(0.0163)	(0.0215)
Lack of price stability	0.00181	-0.00816	-0.00536	0.000480	-0.00471
	(0.0107)	(0.0163)	(0.0121)	(0.0110)	(0.0193)
Macroeconomic crisis	-0.0241	-0.00914	-0.0112	-0.0223	-0.0118
banking and currency	(0.0153)	(0.0386)	(0.0360)	(0.0152)	(0.0193)
Imports of goods and services		0.00243	0.0101		
		(0.0310)	(0.0363)		
Trade openness			-0.00504	-0.00444	
			(0.0218)	(0.0138)	
Institutional development					0.0132
					(0.153)
Constant	-0.105	-0.0832	-0.0501	-0.0921	-0.117
	(0.115)	(0.260)	(0.191)	(0.125)	(0.264)
Specification Tests					
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

Notes: System GMM estimation following Roodman (2009a) programming for the two-step Arellano-Bover/Blundell-Bond estimator with Windmeijer (2005) finite sample corrections and period specific effects. Small sample adjustments with collapsed instruments have been performed in all the estimations. This table reports the t-test instead of the z-test and the F test instead of the Wald $\chi 2$ test for the general model. GMM instrumentation: All variables are treated as endogenous, except the initial output per worker which is assumed predetermined. Endogenous regressors use second lags for the difference equation and first lags for the levels equation. Predetermined variables use first lags for the difference equation and contemporaneous first differences for the levels equation. Estimation (4) uses an additional lag for the endogenous regressors in both equations. Standard errors are given in parenthesis. The specifications tests report the p-values.

***Significant at 1%, **Significant at 5%, *Significant at 10%.

After controlling for the level of institutional development as a proxy for market distortion, the rule of law and property rights, it seems to be the case that the growth effects of capital imports are also reinforced. A variety of specification tests show the results are robust, and instruments are valid and informative as we keep the instrument count as low as possible given the sample observations and number of countries as suggested by Roodman (2009b). The Arellano and Bond (1991) second order serial correlation statistics test fail to reject the null of no serial correlation among the error component, a key assumption in system GMM. The Hansen (1982) *J* test, and the difference-in-Hansen statistic, show the selected instruments are valid, while the stability of the coefficients across different model specifications indicates the estimates are relatively close to their true value.

The system GMM estimations fits quite well the data generating process. Figure 1 show the growth experience of a selected group of countries in the region, the *in-sample* estimates for the growth rate, along with the predicted growth series in response to a permanent shock in machinery imports[48]. Two observations seems particularly important given the model mechanics. First, countries grow faster with the importation of foreing physical capital. Second, there is a variety of growth experiences in the region with common patterns of business cycles across different income levels.

These results bring support to previous findings in the endogenous growth literature. For instance, Lee (1995) show in an endogenous growth framework similar to Rebelo (1991) that capital imports may result in higher long run growth rates, and possibly induce a faster convergence towards higher living standards. Under their theoretical and empirical model mechanics, trade restrictions may yield lower long run growth rates by restricting the availability of capital.

We can interpret our findings as suggesting that the importation of physical capital, regardless of its place of origin, may have growth enhancing effects. The key point to be emphasize here is that for this foreign capital to have growth effects—perhaps due to embodied technology—it do not need to be solely imported from the advanced economies. Since our measure for capital imports considers machinery imports reported by the domestic economy from the rest of the world, our findings suggests that capital imports from lower income trading partners could also have important growth effects in the domestic economy. If this would have not be the case, the estimation results will have shown an insignificant coefficient for capital imports. In that order, it appears to be the case that international trade of capital between the Latin American countries is as important as the expected one direction trade relationship from north to south.

[48] Selection was based on income group, country region and data availability.

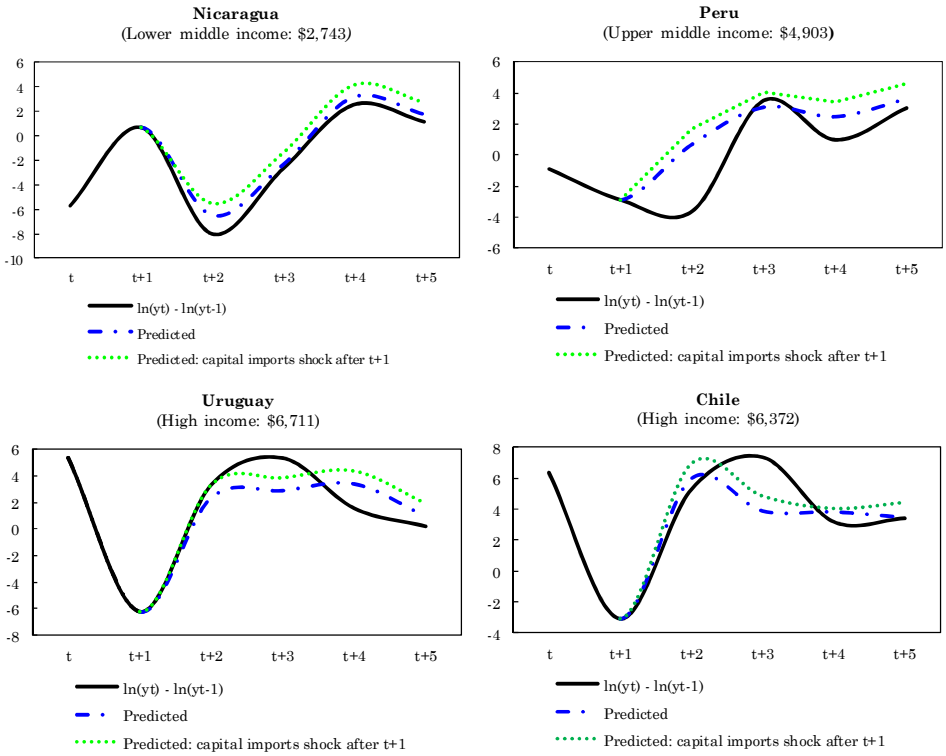

Fig 1. Economic growth response to capital imports shocks[49]. The left axis respresents the percentage growth rate of real GDP per capita[50]. Sample estimates are from regression (1) (Table 2), and the time span of the data is from 1975 to 2005 in "*t*" five-year averages.

These findings also seems plausible if we are willing to assume that each country, regardless of its level of development, is able to innovate in heterogeneous ways and in the same fashion as its trading counterparts, exporting abroad the fruits of their innovation. There is important evidence which suggests that historically capital have normally flown from advanced countries that are capital intensive to Latin America economies that can be considered labour intensive (Singer, 1950, Prebisch, 1959). However, a complete specialization of the type in which lower income countries specialize only in the production of labour intensive goods while higher income ones specialize only in the production of capital goods may not hold in the long run if we are willing to assume convergence in per capita income levels and technology of the type described by Barro and Sala-i-Martin (1992). By considering capital imports reported by the domestic economy from the rest of the world, our results indicate significant growth effects of capital imports through the trade of capital between developing countries, and between advanced economies and the less developed countries.

The international trade of capital between developing and emerging market economies is important. A significant proportion of machinery trade occurs in the South American region among *Mercosur* members and non-member countries, where Brazil is an important

[49] The shock is instrumented by a 10% permanent increase in capital imports after *t+1*.

[50] The level of per capita income is in constant U.S. Dollars in 2005, calculated by logarithmic differences. Data proceeds from Heston et al. (2012). The income level classification is based on the World Development Indicators.

exporter of capital to other Latin American economies. Actually, the data used in this research shows that Brazil is the second major trading partner among many South American countries, in addition to the United States. In other world regions such as Asia, China, Japan and South Korea, have been traditional exporters of capital goods to other economies in that region. However, whether capital imports contain embodied technologies that may improve long-rung growth has been the subject of embodiment controversy in the literature (Denison, 1964, Hercowitz, 1998).

The fact that countries with a higher capital stock, perhaps obtained through the importation of physical capital, may have higher capital to labour ratios and possibly different growth rates that may result in higher living standards seems to be supported by neoclassical and endogenous models of economic growth[51]. Once countries have reached a higher development stage we should expect these economies to benefit less by importing foreign capital, especially if this capital is embodied with relatively similar levels of technology as human and domestic capital. However, in the place of restrictions to the creation of new capital in the domestic economy these economies may well benefited from acquiring capital from abroad.

The observation that there seems to be a variety of growth experiences in the region with potential common patterns of business cycles is not surprising. The Latin America economies have been traditionally characterized by common structural and nominal rigidities, as well as common social and institutional constraints such as the lack of property rights and poor investment in sectors not seen as important for the government (i.e. the agricultural sector). These common issues have shape their growth and development experience (Franko, 2007). Nevertheless, the growth model presented in this paper seems to have fit quite well the data despite the variability in growth rates across different income levels.

On the role of capital imports in the production process, Hummels et al. (2001) finds significant evidence which suggests there have been increases in the share of imported inputs used in the production of export goods in advanced and developing countries. Our results can be reconciled with theirs as suggesting that machinery imports and imported input components have been significant drivers of economic growth in the developing economies of Latin America. In addition, it has been acknowledged in the literature the greater role of imported capital in the production of export goods and economic growth in the region (Singer, 1950).

Our results bring new evidence for Latin America, and establish new stylized facts for the region by extending and redefining previous findings in the literature. For instance, De Long and Summers (1991, 1993) show that machinery and equipment investments drives faster productivity and economic growth in advance and developing countries. In addition, our findings indicate that not only machinery investments drives faster economic growth, but also that once endogenous interaction have been accounted for, human and domestic capital drives faster growth but their growth effects are relatively lower to those provided by machinery imports.

[51] Acemoglu (2009) provides an outstanding treatment of these models assumptions and theoretical results, as well as their implications for modern growth research.

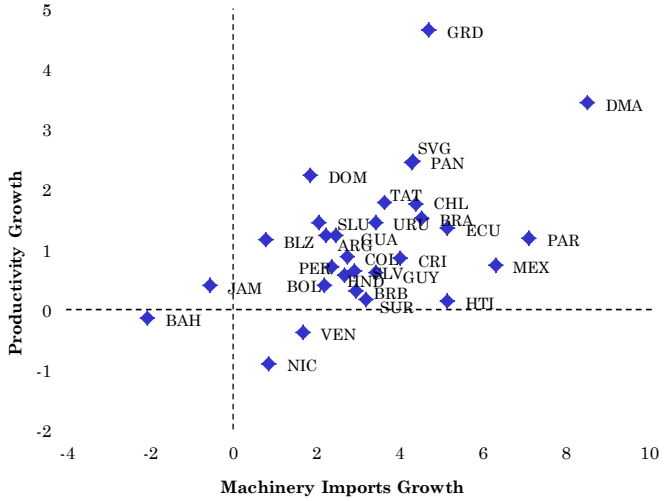

Fig 2. Productivity growth and machinery imports in Latin America, 1960-2010. Source: Author construction based on data from the Penn World Tables and the UN Comtrade[52].

As in Astorga (2010), our findings show the important role played by physical capital accumulation in the growth process of Latin America. Trade openness, population growth, government size and inflation appear to be negatively correlated with economic growth, while there are growth enhancing effects of higher investment and macroeconomic stability as those proposed by De Gregorio (1992). In addition to De Gregorio (1992) and Astorga (2010), however, our findings indicate an important but insignificant role of human capital in the growth process. Once simultaneity has been taken into consideration, our findings indicate that human capital is insignificantly related to faster growth. This result is in line with Gutierrez (2005) who also finds that secondary school enrolment rates as proxies for human capital are positive but insignificantly correlated with higher economic growth in Latin America since the 1980's.

Recently, total factor productivity has been suggested to be the main determinant of long term economic and productivity growth in Latin America (Solimano and Soto, 2005, Daude and Fernández-Arias, 2010, Pagés, 2010). Gutierrez (2005) supports the view that capital accumulation has been an important driver of growth (including capital imports with embodied technologies) however total factor productivity have been the key determinant between faster and slower growth rates experiences. Our findings are reconciled with theirs as suggesting capital imports as an important channel of technology diffusion between countries, driving faster technological change and economic growth.

Evidence from Figure 2 shows a positive correlation between higher productivity growth and machinery imports in Latin America during the last fifty years from 1960 to 2010. This relationship brings additional support to the widely held view that machinery imports may have embodied technologies that drive faster growth.

In what follows, we now turn to answer the question of whether by adopting capital imports countries can reduce their relative income differences. For the cross-country

[52] Productivity growth is measure as the percentage growth rate of the real GDP per capita in constant U.S. Dollars in 2005 by logarithmic differences. Data proceeds from Heston et al. (2012). For the definition of machinery imports see the data methodologies in Section 3.

income levels comparisons, the United States as industrial leader is proposed as the natural benchmark.

4.2 Capital accumulation and relative income differences

The evolution of per capita income levels in Latin America has been disappointing over the last fifty years. As of the end of 2010, a significant proportion of these countries, more precisely 16, has remain below a quarter of the United States income level. Many of these economies today are relatively worse off than in 1970 in terms of relative income to the industrial leader.

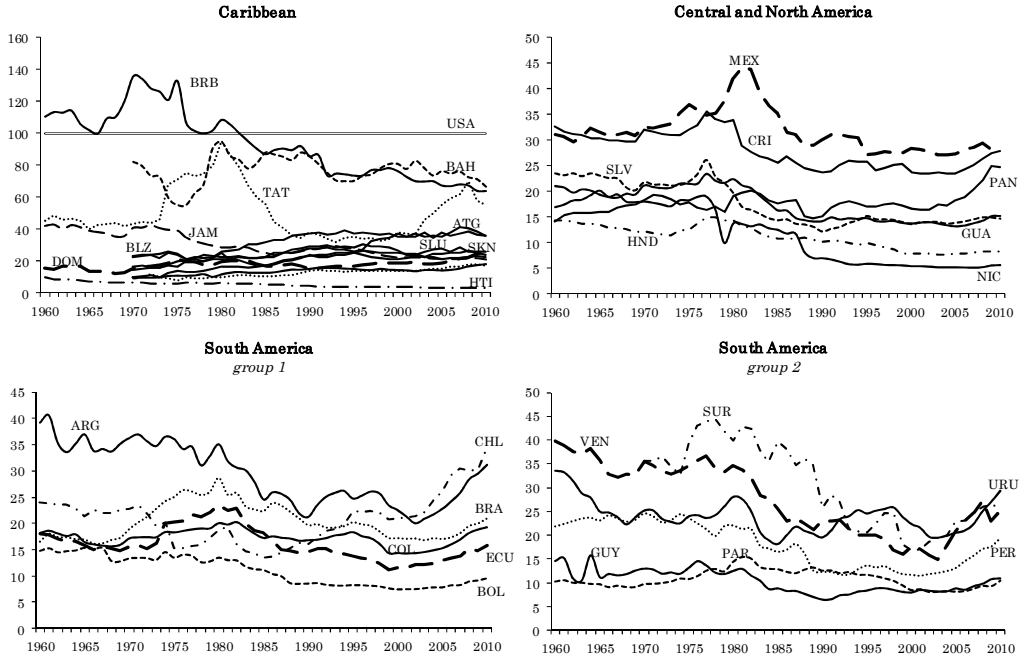

Fig 3. Relative income differences in Latin America, 1960-2010[53]. Income relative to the Unites States. Source: Author construction based on data from the Penn World Tables.

Figure 3 show the evolution of relative income levels in the region. A first striking observation is the downward cycle of income in the vast majority of these economies since the late 1970's, with a rapid period of catching up at the start of the twentieth first century. This downward phase coincides with the end of import substitution industrialization at the beginning of the 1980's, the debt crisis in the region during this decade, and the period of macroeconomic instability, high inflation and currency collapses during the late 1980's and the first half of the 1990's. The major top performers catching up to US income levels are located in the Caribbean, namely Grenada, St. Kitts and Nevis, Antigua and Barbuda[54].

[53] Data correspond to the PPP converted GDP per capita relative to the United States, G-K method (US=100). Data proceeds from Heston et al. (2012). See the country tables in Appendix A for the lists of countries and acronyms.

[54] Relative income performance was measure as the difference between the geometric average of relative incomes between 1970 and 2010, against initial income in 1970. The year 1970 was selected

We now address the questions on what has been the role of capital accumulation in the evolution of relative income levels in Latin America. What have been the key determinants of relative income growth in the region, and more importantly what have been the role played specifically by capital imports, human and domestic capital in the growth process of these countries? Table 3 summarizes the key findings for these questions. Surprisingly, once controlling for the level of institutional development as a proxy for the rule of law, property rights and market distortions, our results indicate that domestic capital, as oppose to capital imports is the key driver to faster relative income growth.

While capital imports is a significant driver of relative income growth, our findings indicate that it is the formation of domestic capital that drives a faster relative income growth towards the advanced economies living standards. Moreover, despite that human capital is shown to have insignificant effects on relative income growth, investments in education are positively correlated with higher relative income.

In Table 3, regressions (1) and (2), indicate it is critical to control for the level of institutional development to understand the growth enhancing effects of capital accumulation in Latin America. This result is not surprising since countries with weak institutions are normally plague with political and economic instability that harms innovation and investment in physical and human capital hence dragging economic growth.

Controlling for endowments and trade policies by introducing controls for the land size and real trade openness do not change our qualitative results. Countries in Latin America have substantial shares of land and are normally very high open economies. Controlling for trade openness, however, suggest that capital imports drives relative income growth in highly open economies.

The relative stability of our coefficient estimates suggests the system GMM approach has digested important endogenous relationships among the main growth determinants. In addition, our results indicate that higher investments and population growth insignificantly results in a higher relative income. This latter finding seems not to be abstracted from reality if we are willing to consider that an increase in population with a higher relative income may augment aggregate demand by increasing consumption, therefore driving economic growth. Actually, there is substantive evidence which suggest that one of the problems not considered by import substitution industrialization policies in Latin America was that countries did not have a sufficient strong internal demand to drive faster growth (Baer, 1972).

The fact that domestic capital drives a faster reduction in relative income differences is not striking. Solow (2005) suggests that after adopting similar technologies to the USA, some European countries have experienced a slowdown in growth. Our findings can be interpreted as suggesting that while it is plausible that the adoption of machinery imports drives faster economic growth in Latin America, it seems that the embodied technologies of these machineries maintain these economies in a relatively lower technological state, and dependency, from the industrial leader hence once the technological levels of these economies tend to equalize, so do tend to equalization the growth rates. This is precisely Prebisch (1959) technological disparity hypothesis. Hence the importance of innovation, imported and domestic capital formation to reduce relative income differences.

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as an initial year for this statistical comparison due to data availability, and to maximize the sample size for all the thirty-two countries under study.

Table 3.

Domestic and imported capital effects on relative income growth

Dep. Var.: Relative Income Growth	Period: 1960-2010			
	(1)	(2)	(3)	(4)
Initial relative income	-0.0181	-0.0185	-0.0121	-0.0180
	(0.0169)	(0.0190)	(0.0206)	(0.0189)
Capital imports	0.00127***	0.000454	0.000715**	0.000966*
machinery imports growth	(0.000387)	(0.00158)	(0.000317)	(0.000480)
Domestic capital	0.00243**	0.00211	0.00187*	0.00194
domestic capital growth	(0.00108)	(0.00137)	(0.00109)	(0.00118)
Human capital	0.0937	0.0803	0.0872	0.0800
initial secondary school enrollment	(0.0758)	(0.111)	(0.0538)	(0.0964)
Investment share	0.00103	0.00168	0.000724	0.00148
	(0.00196)	(0.00165)	(0.00162)	(0.00175)
Population growth	0.0141	0.0175	0.0118	0.0112
	(0.0116)	(0.0190)	(0.00911)	(0.0138)
Institutional development	0.139		0.0704	0.110
	(0.124)		(0.125)	(0.149)
Government consumption	-0.00531	-0.00312	-0.0158	-0.0159
	(0.0213)	(0.0329)	(0.0201)	(0.0170)
Lack of price stability	0.0235	0.00694	0.0120	0.0161
	(0.0221)	(0.0294)	(0.0148)	(0.0286)
Macroeconomic crisis	-0.0323	-0.0301	-0.0288	-0.0348
banking and currency	(0.0245)	(0.0444)	(0.0204)	(0.0276)
Land size			0.00253	
			(0.00518)	
Trade openness				-0.0125
				(0.0265)
Constant	-0.411	-0.328	-0.362*	-0.266
	(0.341)	(0.407)	(0.210)	(0.457)
Specification Tests				
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

Notes: System GMM estimation following Roodman (2009a) programming for the two-step Arellano-Bover/Blundell-Bond estimator with Windmeijer (2005) finite sample correction and period specific effects. Small sample adjustments with collapsed instruments have been performed in all the estimations. This table reports the t-test instead of the z-test and the F test instead of the Wald $\chi 2$ test for the general model. GMM instrumentation: All variables are treated as endogenous, except the initial relative income which is assumed predetermined. Endogenous regressors use second lags for the first difference equation and first lags for the levels equation. Predetermined variables use first lags for the difference equation and contemporaneous first differences for the levels equation. Standard errors are given in parenthesis. The specifications tests report the p-values.

***Significant at 1%, **Significant at 5%, *Significant at 10%.

Our findings in this section support the view that only through domestic capital formation, innovation and human capital; countries in Latin America are able to reduce faster their relative income differences. Should countries disregard capital imports for long term growth? No, these results show there are significant growth enhancing spillover effects from the adoption of machinery imports to increase the growth effects of human and domestic capital. Moreover, it is this growth enhancing effects of domestic capital to reduce relative income differences that may explain intra-regional trade of machinery imports between the Latin America economies.

The most plausible interpretation for our findings seems to be that given the technological disparities, countries in Latin America are able to grow faster by adopting machinery imports. Once technology levels are equalized, then human and domestic capital formation drive faster growth and reduce relative income differences. At a higher economic development level, countries may benefit from innovation and formation of domestic human and physical capital, being the later critical to sustain higher levels of living standards

The key role played by the economic policy variables and the level of institutional development in our findings brings new empirical support for Parente and Prescott (2005) theory of the evolution of international income levels. This theory builds on Hansen and Prescott (2002) who explain that countries transition from stagnation to modern economic growth once total factor productivity in the modern sector has achieved a critical value. It unifies it with Parente and Prescott (2002) theory of relative efficiencies which proposes differences in economic policies and institutions that restrict technology choices as key determinants of the observed cross-country income differences.

In our view, is important to reemphasize that technologies embodied in the adoption of machinery imports drives a faster growth in low income countries. Once these economies have reached a mature state of technology and development, then, human and domestic capital formation seems to drive a faster economic and relative income growth. Across this growth process, total factor productivity, capital imports, human and domestic capital, as well as the institutions and economic policy variables, interact in an endogenous fashion to drive growth and reinforce the effects.

Countries in Latin America seem to benefit from stable macroeconomic policies and sound institutions. It is not surprising that our results are sensitive to the inclusion of the level of institutional development for the growth effects of capital accumulation to be significant. As North (1989, 1994) has pointed out, weak institutions tend to be associated to with slow growth and poor productivity levels.

We should sympathize with Parente and Prescott (2005) view that one of main reasons for the failing of Latin America to catch up with living standards in the United Sates are trade restrictions and the slow adoption of efficient production practices. In that order, we present evidence which indicates that initially the less developed countries in the region can grow faster by acquiring capital imports.

Although relative income in most of the Latin American economies has been at a quarter of the United States income, there is evidence of conditional convergence in growth rates with persistent relative income difference. Countries that have had a higher relative income in 1970 have experience a slowdown in growth rates relative to those countries that had a lower initial income. In other words, countries relatively poorer have grown faster. Figure 4 show a negative relationship between initial relative income and economic growth. This evidence brings renewed support for the conditional convergence hypothesis of the type suggested by Barro (1991), Barro and Sala-i-Martin (1992) and Caselli et al. (1996).

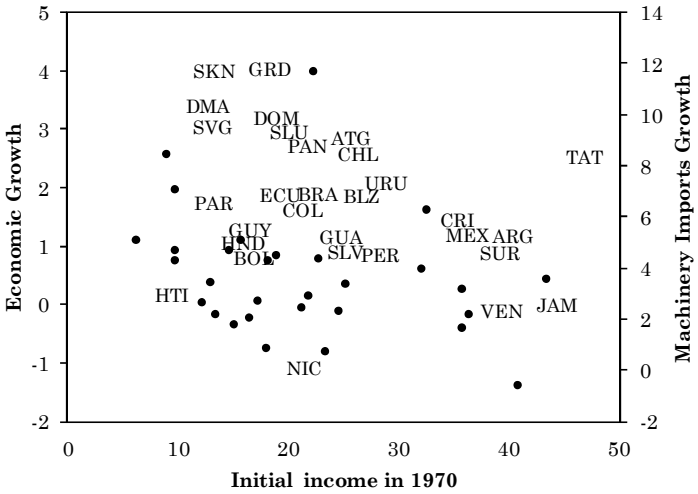

Fig 4. Convergence in Latin America[55]. Countries name represent the relationship between economic growth and intial income. Dot points represents the relationship between machinery imports and initial income. Source: Author construction based on data from the Penn World Tables and UN Commtrade,.

Figure 4 also seems to suggest that countries that have experienced a slowdown in growth, have adopted less machinery imports, and were relatively richer at the beginning. The diversity of growth experiences across different income levels in Latin America also suggest that economic policy, endowments, trade patterns and institutional development have also played a determinant role in the growth process.

When all these interactions are analysed in an endogenous fashion by the system GMM empirical growth model proposed in this paper, that is allowing for simultaneity among all the growth determinants and the residuals, substantial and robust evidence is found that these determinants have play an important role on economic and relative income growth, being the conditional convergence effect insignificantly negative. We interpret this finding as suggesting that poor growth performance is not systematically correlated with initial income.

Economic growth in Latin America seems to be nor totally independent of initial income, nor systematically correlated with it. Other factors have played a major role, among which we propose the technologies embodied in foreign physical capital in the form of investments in machinery imports. This analysis provides answers to the characteristics of relative income growth performance in the Latin America economies.

5 Robustness checks

This section now addresses a variety of robustness checks that have been performed to verify the validity of our results. We suggest the growth effects of physical and human

[55] For simplicity of the exposition Barbados and Bahamas are not shown in this graph. These countries had a ratio of relative income to the USA in the order of 135 and 82 percent, respectively, which values will be substantially to the right. The convergence relationship will not change if these values were included in the graph. Data uses the PPP Converted GDP per capita relative to the United States, G-K method (US=100). Data proceeds from Heston et al. (2012).

capital are relatively invariant to the choice of econometric methodology (see Table 1). When the exogeneity assumption is adopted both capital imports and domestic capital are suggested to drive faster growth. However, across economies at different income levels the growth effects of domestic capital are relatively higher than those of capital imports. Once we allow for simultaneity among the regressors and the residual term, a clearer relationship appears: capital imports drive faster growth across countries at all income levels, while domestic human and physical capital drive a faster relative income growth.

Correcting for simultaneity is important in growth econometrics for our estimates to be consistent, hence the preferred use of the system GMM estimation[56]. The estimated coefficients are relatively well stable across a variety of estimation assumptions, alternative instruments and choices of control variables.

Table 4 summarizes the results of a series of robustness checks to alternative specifications both in the choice of control regressors, alternative specifications and instrument count. When changes in domestic capital are not explicitly accounted for in the estimation, the growth effects of human capital are significantly higher (see regression 1 and 2 in Table 4)[57]. However, once we account for changes in domestic and imported physical capital, the growth effect of human capital turns out relatively insignificant. Our results indicate it is important to disaggregate between changes in capital imports and domestic capital.

An important set of results in these robustness checks indicate that the growth effects of capital imports are insignificantly related to higher growth when regressions do not control for changes in trade policies and trade distortions. For example, when controlling for tariff rates, real trade openness and the level of total imports in goods and services, the growth effects of capital imports turn up significant. Moreover, once trade openness and tariffs are incorporated together, the estimation results indicate that both capital imports and human capital are significant drivers of higher growth in Latin America. These results also hold if we adopt the exogeneity assumptions of the regressors.

Controlling for trade distortions in Latin America is important; hence our motivation to include whenever deemed appropriate controls for trade openness and tariffs rates[58]. Import substitution industrialization strategies (ISI) in Latin America relied heavily on the use of tariff rates and trade restrictions to promote inward development (Baer, 1984). Once these strategies were abandoned in the late 1980's in the search for outward oriented development (export-led growth), tariff and trade policies played a major role to restrict imports and encourage exports. Therefore, trade policies and restrictions have played a major role in the development process of the region.

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[56] Consistency implies the parameter estimate converge in probability to its true value (Heij et al., 2004).

[57] In regression (1) the ratio of capital imports in investment is defined as the ratio of machinery imports to total investment. See the data methodologies in Section 3 and the Appendix B for additional details.

[58] The main reason to not include a control for tariff rates in our baseline estimations is due to low data availability for the full sample of thirty-two countries (World Bank, 2013). However, given our limited data on tariffs, once these are incorporated the growth effects of capital imports turn up significantly higher. Hence our estimates are a conservative estimation of these effects.

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	-0.0149	-0.00751	-0.00852	-0.00321
	(0.0205)	(0.0120)	(0.0111)	(0.0192)	(0.0133)
Ratio of capital imports in investment	0.0651				
	(0.184)				
Capital imports		0.000755	0.00115	0.00115**	0.00164***
machinery imports growth		(0.000452)	(0.00101)	(0.000474)	(0.000591)
Domestic capital			0.000623	0.000658	0.000331
domestic capital growth			(0.00170)	(0.000916)	(0.000747)
Human capital	0.0779*	0.0605*	0.0311	0.0170	0.0573*
initial secondary school enrollment	(0.0416)	(0.0298)	(0.0738)	(0.0448)	(0.0328)
Investment share	0.000929	0.000866	0.00184	0.00187	0.000921
	(0.00104)	(0.000805)	(0.00214)	(0.00229)	(0.00204)
Population growth	0.000145	-0.000549	0.00306		0.00269
	(0.00948)	(0.00570)	(0.00915)		(0.0140)
Government consumption	-0.0272	-0.0113	-0.0110	-0.0144	-0.00305
	(0.0376)	(0.0161)	(0.0193)	(0.0225)	(0.0469)
Lack of price stability	-0.00199	-0.000953	-0.00245	-0.00771	-0.0324
	(0.0168)	(0.0111)	(0.0207)	(0.0174)	(0.108)
Macroeconomic crisis	-0.0221	-0.0208	-0.0106	-0.00788	0.00273
banking and currency	(0.0176)	(0.0162)	(0.0424)	(0.0322)	(0.0338)
Imports of goods and services				0.00176	
				(0.0305)	
Trade openness				-0.00479	-0.00831
				(0.0222)	(0.0319)
Tariffs					-0.000165
					(0.00163)
Constant	-0.190	-0.106	-0.0749	0.0231	-0.188
	(0.235)	(0.139)	(0.267)	(0.235)	(0.214)
Specification Tests					
i) *F*-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 *J* 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

Notes: System GMM estimation following Roodman (2009a) programming for the two-step Arellano-Bover/Blundell-Bond estimator with Windmeijer (2005) finite sample corrections and period specific effects. Small sample adjustments with collapsed instruments have been performed in all the estimations. This table reports the t-test instead of the z-test and the F test instead of the Wald $\chi 2$ test for the general model. GMM instrumentation: All variables are treated as endogenous, except the initial relative income which is assumed predetermined. Endogenous regressors use second lags for the first difference equation and first lags for the levels equation. Predetermined variables use first lags for the difference equation and contemporaneous first differences for the levels equation. Estimation (1) use an additional lag for both equations. Estimation (2) use an additional lag for initial output, domestic and imported capital. Standard errors are given in parenthesis. The specifications tests report the p-values.

***Significant at 1%, **Significant at 5%, *Significant at 10%.

Throughout our analysis we have control for periods of severe macroeconomic distress in the form of banking and currency crisis across all of our estimation. These crises are believed to be highly correlated with the growth rates in these economies and therefore are always included as controls. We have also found appropriate to control for fiscal policy in the form of government consumption, and for monetary policy in the form of a lack of price stability or inflation control. These controls have proven to be key determinants of growth in Latin America across a variety of estimation.

Our motivation to additionally include controls for the total investment share and population growth is that these have been traditional growth determinants in growth econometrics. By accounting for the population growth rate we are accounting for the economics of demographics, as we allow population dynamics to play a role explaining growth performance in the region: An increase in population with human capital may drive faster growth by augmenting the productivity of labour and raising consumer demand, while countries characterized by raising population with low human capital may experience a deterioration in living standard and augmenting poverty and inequality. Controlling for the investment share allow us to capture how much investments in physical capital these economies undertake, as more capital is usually related to increases in production, countries that do not invest enough on physical capital may find themselves relatively poorer and growing relative less than those who undertake higher investment programs.

We are not in favour of including additional control regressors in our estimations since it seems very likely that the instrument count will exceed the cross-sectional number of countries, hence decreasing the capacity of system GMM to digest endogeneity. We have chosen to select the most appropriate controls given our knowledge of the Latin America growth process and a number of studies in the literature closely related our research[59].

6 Conclusions

This paper examines the growth effects of domestic and imported capital in Latin America. We found that countries in the region are able to grow faster by acquiring capital imports. The benefits of acquiring imported physical capital appear to be larger in low income countries. At higher income levels, these economies may grow faster by accumulating domestic physical capital.

Capital imports are suggested to be an important channel of technology diffusion between advanced economies and developing countries. We found a strong correlation between higher productivity growth and the acquisition of electrical and nonelectrical machinery imports. Our findings supports the view that technological change requires capital investments in order drive economic growth (Hercowitz, 1998).

We offer a new interpretation for the general documented fact that since the 1980's there have been a growth slowdown in the vast majority of the small developing countries in Latin America, with a tendency towards a faster growth at the start of the twentieth first century. First, we present statistical evidence which shows that today the vast majority of these economies are below a quarter of the United States per capita income. Second, we find evidence that countries in Latin America who were initially richer in 1970 acquired less capital imports and not invested enough in domestic human and physical capital formation, therefore contributing to their growth slowdown. On the contrary, economies that were relatively poorer at the beginning, grew faster by acquiring machinery

[59] See the works of De Gregorio (1992), Astorga (2010), Paus et al. (2003), Paus (2004).

imports, however once their income levels improved, these did not invest enough in the development of domestic capital.

In terms of per capita income relative to the United States several countries in the region are today relatively worse off than in 1970. These economies appear to not have invested enough neither in capital imports nor in domestic human and physical capital. Without sufficient capital accumulation in the region, exogenous technological change seems to have failed to improve living standards.

The growth enhancing effects of capital accumulation are proposed to be as important as those provided by total factor productivity growth for these economies to grow faster. We do not generally advocate to the view that capital accumulation does not matter for long run growth, while growth and development is entirely driven by exogenous technological change. As Parente and Precott (2002) suggest, that view does not provide a meaningful economic policy advice. We advocate to the view that growth is endogenous, and hence affected by economic policies and institutional development of the type suggested by Rebelo (1991), Romer (1994), Lee (1995), North (1989, 1991, 1994) and Acemoglu et al. (2003).

Is important to mention that our findings do not suggest a total reliance on foreign technologies instead of domestic innovations to drive economic growth, as this will imply the same consequences for long run growth and development as those proposed by Singer (1950), Prebisch (1959) and Nurkse (1952). In the light of our findings, we suggest the following economic policy guidance for the region. First, deregulation of the international trade of capital and the dismount of import taxes and quotas for machinery imports and transport equipment. Second, sound fiscal and monetary policies that promote macroeconomic stability. Third, the development of institutional reforms that leads to maintain the security of property rights and the rule of law. Fourth, the creation of proper incentives for domestic innovation in new technologies via the development of licensing agreements and the creation of research grants for a wide variety of projects. Furthermore, these economies need to promote entrepreneurial activity by deregulating private monopolies and implementing anti-trust laws that promote competition and incentive the creation of efficient industries with lower production costs.

In our analysis human capital appears to have an insignificant effect on long run growth. Gutierrez (2005) has also found a similar result for the region. However, it would be misleading to suggest that human capital does not matter for economic growth. We interpret our findings as suggesting that these economies seems to have exhausted the benefits of secondary schooling education, or the quality of it is inferior to those of advance economies. Perhaps improvements in data for the proportion of the population with a university degree will strengthen the significance of human capital effect on economic growth in Latin America, as with the passage of time a vast proportion of the population have tended to complete secondary education.

The low income countries in the region need to invest relatively more in the acquisition of capital imports and foreign technologies, while improving human capital formation. These investments are necessary since these economies may lack the necessary means to promote domestic innovation. For the high income countries, efforts should be primarily devoted to improve the efficiency of domestic human and physical capital, as well as the creation of domestic technologies via domestic innovation. It seems plausible to suggest that domestic innovation in new technologies offer the most significant way to exceed the long run growth performance of the advance economies. A dependency to foreign technologies may only constraint relative income below that of industrialized nations.

There are several avenues for further research. A closer look needs to be taken at the relationship between human capital and economic growth in Latin America. Also, further

research should aim to disclose macroeconomic data at the national accounts level for the vast majority of these economies in order to facilitate the implementation of growth accounting exercise for the region. In another direction, in terms of monetary policy, it is not completely clear whether these economies in periods of relatively low inflation can achieve higher growth rates, relative to period were inflation was modest and growth rates exceeded potential. Finally, more research should be devoted to the understanding of the factors that could drag domestic innovation and research in new technologies in the developing countries of Latin America, and how these economies may reduce their dependency to imported capital.

Appendix A. List of Latin American countries

Central and North America

MEX	Mexico
CRI	Costa Rica
ECU	Ecuador
SLV	El Salvador
GUA	Guatemala
HND	Honduras
NIC	Nicaragua
PAN	Panama

South America

ARG	Argentina
BRA	Brazil
CHL	Chile
COL	Colombia
BOL	Bolivia
GUY	Guyana
PAR	Paraguay
PER	Peru
SUR	Suriname
URU	Uruguay
VEN	Venezuela

Caribbean

ATG	Antigua and Barbuda
BAH	The Bahamas
BRB	Barbados
BLZ	Belize
DMA	Dominica
DOM	Dominican Republic
GRD	Grenada
HTI	Haiti
JAM	Jamaica
SKN	St. Kitts and Nevis
SLU	St. Lucia
SVG	St. Vincent and the Grenadines
TAT	Trinidad and Tobago

Note: Country list based on the classification provided by the International Monetary Fund.

Appendix B. Variables definitions and sources

Variable	Definition	Source
Real GDP per capita	PPP Converted GDP Per Capita (Chain Series), at 2005 constant prices	Heston et al. (2012)
Real GDP per capita Growth	Growth Rate by Logarithmic Difference: $(\ln(y_t) - \ln(y_{t-1}))/5$	Author calculations using data from Heston et al. (2012)
Initial real GDP per capita	Initial logarithmic value of real GDP per capita at the start of the five year interval	Author calculations using data from Heston et al. (2012)
Relative income	PPP Converted GDP Per Capita Relative to the United States, G-K method, at current prices, [cgdp](US = 100)	Heston et al. (2012)
Initial income per capita	Logarithm of the variable level at the start of the period	Author calculations using Heston et al. (2012)
Capital imports as share of GDP	Real capital imports divided by real GDP per capita. Real capital imports are calculated as the ratio of machinery imports per capita to total investment PPP per capita at current prices x total investment PPP Converted GDP per capita at 2005 constant prices. Machinery imports per capita are machinery imports divided by total population. Total imports of machinery equipment at current prices proceeds from those reported by the domestic economy from the rest of the world. SITC revision 1. Sections 7.1 and 7.2., machinery other than electric plus electrical machinery	Author calculations based on Lee (1995) and UN Comtrade methodologies.
Real capital imports growth	Log difference of capital imports	Author calculations
Domestic capital as share of GDP	Real domestic capital divided by real GDP per capita. Total Investment PPP Converted GDP Per Capita at 2005 Constant Prices minus machinery imports PPP converted GDP per capita at 2005 constant prices.	Author calculations based on Lee (1995) methodology
Domestic capital growth rate	Log difference of capital imports	Author calculations
Ratio of capital imports in investment	Ratio of machinery imports per capita to total investment PPP Per Capita at current US$ dollars	Author calculations based on Lee (1995) methodology

Variable	Definition	Source
Investment share	Investment Share of PPP Converted GDP Per Capita at 2005 constant prices [rgdpl]	Heston et al. (2012)
Human capital	By educational attainment. School enrolment, secondary (% gross) (SE.SEC.ENRR).	World Bank (2013)
Population growth	Log difference of the population levels in thousands	Author calculations using data from Heston et al. (2012)
Land size	Land area (sq. km) (AG.LND.TOTL.K2)	World Bank (2013)
Tariff rate	Tariff rate, applied, simple mean, all products (%) (TM.TAX.MRCH.SM.AR.ZS)	World Bank (2013)
Institutional development	Veto Points referred to the extent of institutionalized constraints on the decision making powers of the chief executives, whether individuals or collectivities.	Henisz (2002)
Government consumption	General government final consumption expenditure (% of GDP) (NE.CON.GOVT.ZS)	World Bank (2013)
Lack of price stability	Logarithm of one plus the annual percentage change in the Consumer Price Index (2005 = 100) at the end of the year	Author calculations based on Levy-Yeyati et al. (2010) methodology
Banking crises	Number of years in banking crisis (banking crisis including systemic crisis) as a proportion of the total number of years within each panel period	Author calculations using data from Reinhart and Rogoff (2009) and Laeven and Valencia (2012)
Currency crises	Number of years in currency crisis as a proportion of the total number of years within each panel period. Currency crisis are defined as a nominal currency depreciation of at least 30%. Data on currency values are the official exchange rate (LCU per US$, period average) (PA.NUS.FCRF	Author calculations using data from World Bank (2013) based on Reinhart and Rogoff (2009) methodology
Macroeconomic crises	Number of years in banking and/or currency crisis as a proportion of the total number of years within each panel period.	Author calculations
Imports of goods and services	Imports of goods and services (% of GDP) (NE.IMP.GNFS.ZS)	World Bank (2013)
Trade openness	Openness at constant prices in 2005	Heston et al. (2012)

References

Acemoglu, D. (2009). *Introduction to Modern Economic Growth*. Princeton University Press.

Acemoglu, D., Johnson, S. and Robinson, J. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review,* 91(5), 1369-1401.

Acemoglu, D., Johnson, S., Robinson, J. and Thaicharoen, Y. (2003). Institutional causes, macroeconomic symptoms: volatility, crises and growth. *Journal of Monetary Economics,* 50(1), 49-123.

Ahn, S. C. and Schmidt, P. (1995). Efficient estimation of models for dynamic panel data. *Journal of Econometrics,* 68(1), 5-27.

Alonso-Borrego, C. and Arellano, M. (1999). Symmetrically normalized instrumental-variable estimation using panel data. *Journal of Business & Economic Statistics,* 17(1), 36-49.

Arellano, M. and Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies,* 58(2), 277-297.

Arellano, M. and Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics,* 68(1), 29-51.

Arida, P. (1986). Macroeconomic issues for Latin America. *Journal of Development Economics,* 22(1), 171-208.

Astorga, P. (2010). A century of economic growth in Latin America. *Journal of Development Economics,* 92(2), 232-243.

Baer, W. (1962). The Economics of Prebisch and ECLA. *Economic Development and Cultural Change,* 10(2), 169-182.

Baer, W. (1972). Import Substitution and Industrialization in Latin America: Experiences and Interpretations. *Latin American Research Review,* 7(1), 95-122.

Baer, W. (1984). Industrialization in Latin America: Successes and Failures. *The Journal of Economic Education,* 15(2), 124-135.

Barro, R. (1991). Economic Growth in a Cross Section of Countries. *Quarterly Journal of Economics,* 106(2), 407-443.

Barro, R. and Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy,* 100(2), 223-251.

Baum, C., Schaffer, M. and Stillman, S. (2003). Instrumental variables and GMM: Estimation and testing. *Stata Journal,* 3(1), 1-31.

Becker, G. S. (1962). Investment in Human Capital: A Theoretical Analysis. *Journal of Political Economy,* 70(5), 9-49.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics,* 87(1), 115-143.

Blundell, R. and Bond, S. (2000). GMM Estimation with persistent panel data: an application to production functions. *Econometric Reviews,* 19(3), 321-340.

Bond, S., Hoeffler, A. and Temple, J. (2001). GMM Estimation of Empirical Growth Models. *University of Oxford Nuffield College Economics Working Papers,* 2001-W21(September).

Bruton, H. (1967). Productivity Growth in Latin America. *The American Economic Review,* 57(5), 1099-1116.

Caselli, F., Esquivel, G. and Lefort, F. (1996). Reopening the convergence debate: A new look at cross-country growth empirics. *Journal of Economic Growth,* 1(3), 363-389.

Clark, A. E., Frijters, P. and Shields, M. A. (2008). Relative Income, Happiness, and Utility: An Explanation for the Easterlin Paradox and Other Puzzles. *Journal of Economic Literature,* 46(1), 95-144.

Daude, C. and Fernández-Arias, E. (2010). On the Role of Productivity and Factor Accumulation in Economic Development in Latin America and the Caribbean. *Inter-American Development Bank,* (IDB-WP-155).

De Gregorio, J. (1992). Economic Growth in Latin America. *Journal of Development Economics,* 39(1), 59-84.

De Long, J. B. and Summers, L. H. (1991). Equipment investment and economic growth. *The Quarterly Journal of Economics,* 106(2), 445-502.

De Long, J. B. and Summers, L. H. (1993). How strongly do developing economies benefit from equipment investment? *Journal of Monetary Economics,* 32(3), 395-415.

Denison, E. F. (1964). The Unimportance of the Embodied Question. *The American Economic Review,* 54(2), 90-94.

Durbin, J. (1954). Errors in Variables. *Revue de l'Institut International de Statistique / Review of the International Statistical Institute,* 22(1/3), 23-32.

Durlauf, S., Johnson, P. and Temple, J. (2005). Chapter 8 Growth Econometrics. In: Philippe, A. and Steven, N. D. eds. *Handbook of Economic Growth*. Vol. 1, Part A. Elsevier, pp. 555-677.

Easterly, W. and Levine, R. (2001). It's Not Factor Accumulation: Stylized Facts and Growth Models. *The World Bank Economic Review,* 15(2), 177-219.

Frankenhoff, C. A. (1962). The Prebisch Thesis: A Theory of Industrialism for Latin America. *Journal of Inter-American Studies,* 4(2), 185-206.

Franko, P. (2007). *The Puzzle of Latin American Economic Development*. Rowman & Littlefield.

Furtado, C. (1965). Development and stagnation in Latin America: A structuralist approach. *Studies in Comparative International Development,* 1(11), 159-175.

Gutierrez, M. A. (2005). *Economic Growth in Latin America: The Role of Investment And Other Growth Sources*. United Nations. Economic Commission for Latin America and the Caribbean. Economic Development Division.

Hansen, G. D. and Prescott, E. C. (2002). Malthus to Solow. *The American Economic Review,* 92(4), 1205-1217.

Hansen, L. P. (1982). Large Sample Properties of Generalized Method of Moments Estimators. *Econometrica,* 50(4), 1029-1054.

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica,* 46(6), 1251-1271.

Heij, C., De Boer, P., Franses, P. H., Kloek, T. and Van Dijk, H. K. (2004). *Econometric methods with applications in business and economics*. Oxford University Press.

Henisz, W. (2002). The Institutional Environment for Infrastructure Investment. *Industrial and Corporate Change,* 11(2), 355-389.

Henisz, W. (2012). *Political Constraint Index (POLCON) Dataset*

Hercowitz, Z. (1998). The 'embodiment' controversy: A review essay. *Journal of Monetary Economics,* 41(1), 217-224.

Heston, A., Summers, R. and Aten, B. (2012). *Penn World Table Version 7.1.* November 2012 ed. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

Holtz-Eakin, D., Newey, W. and Rosen, H. S. (1988). Estimating Vector Autoregressions with Panel Data. *Econometrica,* 56(6), 1371-1395.

Hummels, D., Ishii, J. and Yi, K.-M. (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics,* 54(1), 75-96.

Kleibergen, F. and Paap, R. (2006). Generalized reduced rank tests using the singular value decomposition. *Journal of Econometrics,* 133(1), 97-126.

Krueger, A. O. (1968). Factor Endowments and Per Capita Income Differences among Countries. *The Economic Journal,* 78(311), 641-659.

Krugman, P. (1994). Competitiveness: A Dangerous Obsession. *Foreign Affairs,* 73(2), 28-44.

Laeven, L. and Valencia, F. (2012). Systemic Banking Crises Database: An Update. *International Monetary Fund Working Papers,* No. 12/163.

Layard, R., Mayraz, G. and Nickell, S. (2009). Does relative income matter? Are the critics right? *CEP Discussion Paper,* No. 918. Centre for Economic Performance, London School of Economics and Political Science.

Lee, J.-W. (1993). International Trade, Distortions, and Long-Run Economic Growth. *Staff Papers - International Monetary Fund,* 40(2), 299-328.

Lee, J.-W. (1995). Capital goods imports and long-run growth. *Journal of Development Economics,* 48(1), 91-110.

Levine, R. and Zervos, S. (1996). Stock Market Development and Long-Run Growth. *The World Bank Economic Review,* 10(2), 323-339.

Levy-Yeyati, E., Sturzenegger, F. and Reggio, I. (2010). On the endogeneity of exchange rate regimes. *European Economic Review,* 54(5), 659-677.

Lizondo, J. S. and Montiel, P. J. (1989). Contractionary Devaluation in Developing Countries: An Analytical Overview. *Staff Papers - International Monetary Fund,* 36(1), 182-227.

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics,* 22(1), 3-42.

Mankiw, N. G., Romer, D. and Weil, D. N. (1992). A Contribution to the Empirics of Economic Growth. *The Quarterly Journal of Economics,* 107(2), 407-437.

Mazumdar, J. (2001). Imported machinery and growth in LDCs. *Journal of Development Economics,* 65(1), 209-224.

Murray, M. P. (2006). Avoiding Invalid Instruments and Coping with Weak Instruments. *The Journal of Economic Perspectives,* 20(4), 111-132.

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica,* 49(6), 1417-1426.

North, D. C. (1989). Institutions and economic growth: An historical introduction. *World Development,* 17(9), 1319-1332.

North, D. C. (1991). Institutions. *The Journal of Economic Perspectives,* 5(1), 97-112.

North, D. C. (1994). Economic Performance Through Time. *The American Economic Review,* 84(3), 359-368.

Nurkse, R. (1952). Some International Aspects of the Problem of Economic Development. *The American Economic Review,* 42(2), 571-583.

Pagés, C. (2010). *The Age of Productivity: Transforming Economies from the Bottom Up*. Palgrave Macmillan.

Parente, S. and Prescott, E. (2002). *Barriers to riches*. Vol. 3. Cambridge, MA: The MIT Press.

Parente, S. and Prescott, E. (2005). Chapter 21 A Unified Theory of the Evolution of International Income Levels. In: Philippe, A. and Steven, N. D. eds. *Handbook of Economic Growth*. Vol. 1, Part B. Elsevier, pp. 1371-1416.

Paus, E. (2004). Productivity Growth in Latin America: The Limits of Neoliberal Reforms. *World Development,* 32(3), 427-445.

Paus, E., Reinhardt, N. and Robinson, M. (2003). Trade Liberalization and Productivity Growth in Latin American Manufacturing, 1970-98. *The Journal of Policy Reform,* 6(1), 1-15.

Prebisch, R. (1950). *The economic development of Latin America and its principal problems*. Lake Success, NY: United Nations.

Prebisch, R. (1959). Commercial Policy in the Underdeveloped Countries. *The American Economic Review,* 49(2), 251-273.

Rebelo, S. (1991). Long-Run Policy Analysis and Long-Run Growth. *Journal of Political Economy,* 99(3), 500-521.

Reinhart, C. and Rogoff, K. (2009). *This Time is Different: Eight Centuries of Financial Folly*. Princeton University Press.

Rodriguez, F. and Rodrik, D. (2001). Trade policy and economic growth: a skeptic's guide to the cross-national evidence. In: *NBER Macroeconomics Annual 2000, Volume 15*. MIT PRess, pp. 261-338.

Romer, P. M. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy,* 94(5), 1002-1037.

Romer, P. M. (1994). The Origins of Endogenous Growth. *The Journal of Economic Perspectives,* 8(1), 3-22.

Roodman, D. (2009a). How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal,* 9(1), 86-136.

Roodman, D. (2009b). A note on the theme of too many instruments*. *Oxford Bulletin of Economics and Statistics,* 71(1), 135-158.

Schaffer, M. E. (2010). *XTIVREG2: Stata module to perform extended IV/2SLS, GMM and AC/HAC, LIML and k-class regression for panel data models*. S456501. Boston College Department of Economics.

Singer, H. (1950). The Distribution of Gains between Investing and Borrowing Countries. *The American Economic Review,* 40(2), 473-485.

Solimano, A. and Soto, R. (2005). *Economic growth in Latin America in the late 20th century: evidence and interpretation*. Vol. 33. United Nations Publications.

Solow, R. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics,* 70(1), 65-94.

Solow, R. (2005). Reflections on Growth Theory. In: Philippe, A. and Steven, N. D. eds. *Handbook of Economic Growth*. Vol. 1, Part A. Elsevier, pp. 3-10.

Stock, J. H., Wright, J. H. and Yogo, M. (2002). A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments. *Journal of Business & Economic Statistics,* 20(4), 518-529.

Swan, T. W. (1956). Economic Growth and Capital Accumulation. *Economic Record,* 32(2), 334-361.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics,* 126(1), 25-51.

World Bank (2013). *World Development Indicators (WDI) Database*.

Wu, D.-M. (1973). Alternative Tests of Independence between Stochastic Regressors and Disturbances. *Econometrica,* 41(4), 733-750.