ECONOMIC GROWTH:

PANEL DATA EVIDENCE FROM LATIN AMERICA

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This paper is concerned with the impacts of various growth determinants on the per capita growth rate in Latin America. The choice of explanatory variables is based on the framework proposed by Barro and Sala-i-Martin (1999). Panel data technique is used to estimate the growth regression using data on seventeen Latin American countries from 1952 to 2000.

The regression results show evidence of conditional convergence among the countries studied, pointing to the need for an upward shift in the steady-state level of the region. The results indicate that per capita growth in Latin America increases with an increase of the life expectancy, openness and investment. On the other hand, the initial level of GDP per capita, government spending and the polity score are found to be negatively related to the per capita growth rate. A puzzling finding is that schooling is not a significant determinant for growth in Latin America.
To Juninho, for his support and essential help and guidance.

To my parents, Maria de Fatima and Walter, for the unrestricted love and encouragement.
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CHAPTER 1. Introduction

One of the main characteristics of modern economies is the large difference in per capita income among countries. The literature presents a large number of studies on cross-country analysis of economic growth. The development of powerful computational techniques and data sets has allowed researchers to carry out empirical analysis of growth and why it happens (or, more revealingly, does not happen). A common technique in this analysis has been cross-section regressions in which national economic performance, typically growth in per capita product, has been used as the dependent variable.

The differences in per capita income and in its evolution over time can be determined by a set of explanatory variables. An analysis of the determinants of economic growth, which this paper will present, can thus shed light on the causes of the large gap in growth rates across countries.

Economic growth has been the object of numerous theoretical and empirical projects. Growth models help to explain the mechanisms of growth, and empirical studies use concrete data to produce insights from real economies’ growth experiences. Economic growth can be modeled in a variety of ways, and the choice of control variables to use is largely up to the taste of the researcher. Modeling growth is, to a great extent, an ad-hoc task. Although theories, such as the Solow model and new growth theories (endogenous growth) exist and are often used as frameworks for growth studies, most of the researchers propose individual models that slightly, or sometimes deeply, modify the original models according to their particular intuition on growth and its determinants.
Understanding the characteristics and determinants of economic growth requires an empirical framework that can be applied to both individual and groups of countries over a relatively long period. Growth regressions provide this framework enabling researchers to explore the channels through which various determinants influence growth. There is a core set of explanatory variables that has been shown to be consistently related to economic growth and, therefore, other variables should be examined conditional on the inclusion of this core set. This study restricts its attention to estimations based on a set of conditioning variables, at the same period.

In their study of economic growth, Barro and Sala-i-Martin (1999) proposed the use of two types of variables: control (or environmental) variables, and state variables. Control variables account for the economic environment of the country and include variables such as public expenditure on education as a ratio of the gross domestic product (GDP), the ratio of real gross domestic investment to real GDP, the ratio of government consumption to GDP, the black market premium on foreign exchange, a measure of political stability, and the growth rate of the terms of trade. State variables describe endowments of resources within a country. Barro proposed the use of initial stock of physical capital and initial stock of human capital as state variables.

Another formulation, adopted by Mankiw, Romer, and Weil (1992) and by Klenow and Rodriguez-Clare (1997), specifies human capital (education) as an independent factor in the growth process, one that can augment labor, physical capital, and Total Factor Productivity (henceforth TFP). The relationship with TFP reflects the view that an educated work force is better able to implement new technologies and to generate ideas for improving efficiency. Mankiw, Romer, and Weil (1992) and Barro
and Sala-i-Martin (1999) found a significant positive association between cross-country differences in the initial endowment of education and subsequent rates of growth.

Latin America has been considered an under-performer in regard to growth rates, particularly in the last two decades. This paper explores some factors that influenced the performance of per capita income growth rates over the second half of the last century in Latin America. Using panel data techniques, it analyzes the determinants of economic growth for seventeen Latin American countries. This research has particular interest in finding the effects of the human capital variable on the per capita growth rates in Latin America and in verifying the conditional convergence hypothesis.

The model proposed in this paper uses some of the growth determinants suggested by Barro (Barro and Sala-i-Martin, 1999 and Barro, 1997). Stock of physical capital and stock of human capital are used as state variables. As environmental variables, it uses the ratio of real gross domestic investment to real GDP, the ratio of government consumption to GDP, openness in constant prices, the growth rate of population, and a polity measure.

Previously mentioned studies (Barro and Sala-i-Martin; Mankiw, Romer, and Weil) have attempted to gauge the differential impact of variables such as human capital and investment on the performance of fast and slow growing economies. These studies use cross-section data in which each country has only one observation. This paper analyzes the determinants of per capita income growth by employing the technique of panel data estimation, which seems to consider more information than what is available from time series variations within each country.

The remainder of the paper is organized as follows. The next section provides some insights into the major trends in the Latin American economies from 1950 to 2000.
Chapter 2 presents a survey of the literature on economic growth and its determinants, including the concept of conditional convergence. Chapter 3 presents the methodology, a description of the data sets used in this paper, and introduces the estimated model. Chapter 4 analyzes the results and discusses suggestions for future research. The last chapter concludes by recapitulating the results.

**Background on Latin American Economic History from 1950 to 2000**

Following is a general overview of the main aspects of the Latin American economic history from 1950 to 2000.

**The Import Substitution Industrialization (ISI) Model**

In response to the adverse effects of the Great Depression in 1929, governments throughout Latin America began actively promoting industrialization in order to both increase production and reduce reliance on imported manufactures (import substitution industrialization, or ISI). These policies represented a “turning inward,” away from international markets, to generate domestic development and growth. The ISI model proved to be economically successful from the 1930s-1960s. The fundamentals of such a system were to produce manufactured goods that were previously imported from Europe and the United States (Hirschman, 1968). Proponents of the ISI model sought protectionist measures in order to revitalize their economies but in doing so capital controls were also set in place that restricted the inflow of foreign investment. Strategies that supported industrialization included various policy mixes of trade tariffs and quotas,
exchange rate regimes, price and market distribution controls, direct subsidies, and the establishment of government enterprises (Triner, 2003).

As the ISI model further progressed, it began to produce negative effects on the Latin American economies. The success of the ISI model depended on capital goods that were now too expensive to import because of protective policies implemented in the initial phases of the ISI model. Investment was dumped into machines and capital goods causing a decline in the need for manual labor. The economic situation of Latin America thus became contentious as the unemployment rate increased and purchasing power decreased.

**Stabilization Reform**

As the success of the ISI model deteriorated, military authoritarian regimes became the form of government throughout Latin America. An increased resistance toward organized labor and cuts in federal spending, as part of the stabilization programs, dominated the political economy of many Latin American countries. In fact, stabilization programs became the typical strategy of military government control over national economies. These militaristic regimes, also referred to as bureaucratic authoritarian governments, aimed to stimulate economic growth by consolidating ties with international economic forces. Though these authoritarian regimes aimed to promote economic growth through economic policies of stabilization and world market access, such governments were perceived as politically unstable. High capital controls from the previous economic regimes and the lack of credibility discouraged investors to send
monies to the Latin American region. Therefore, access to external financial resources remained limited.

**Debt-led Growth**

Aside from efforts in establishing credit and relations with international creditors such as the United States, European banks, the World Bank and the International Monetary Fund (IMF), the 1970s brought about a change in which international private liquidity increased and the economic growth of Latin America became dependent on external financing. External financing during the 1970s was heavily provided in the form of recycled petrodollars.

A rise in oil prices during the early part of the 1970s allowed for the recycling of petrodollars that began to enter Latin America. Middle Eastern countries unable to spend the profits earned from the increase in world oil prices invested their "petrodollars" in international banks, particularly those in the United States and Europe. In turn these banks sought to lend or re-invest this money out to capital starved but credit worthy clients at profitable interest rates. The Latin American countries quickly assumed the role of credit worthy and profitable clients.

**The Lost Decade - 1980s Debt Crisis**

As borrowing and lending to these countries increased, so did their debt. The increased external financing further plunged the region of Latin America into a decade long economic crisis in the 1980s. Mexico’s announcement in 1982 that it was unable to meet its payments was the pre-condition, setting the stage for the region’s economic
collapse of the 1980s. This era is often referred to as the “lost decade”. Capital flows turned into capital flight and in the later part of 1982 and early 1983 countries began to lose access to international financial capital markets.

**The Era of Neoliberalism**

Between 1982 and 1989, Latin American governments pursued deals to reduce their debt with private creditors. The IMF and the World Bank imposed strict terms of conditionality on Latin American borrowers in order to relieve them from debt burdens. The structural reforms set forth by international institutions such as the IMF were referred to as neoliberal ideas.

Neoliberalism included reforms such as macro-adjustment through the promotion of freer market economies implementing lower barriers to trade and investment. Structural reforms of domestic economic policy called for a reduced government role and for efforts to reduce inflation. The international lending institutions would then finance countries that agreed on these terms of conditionality.

The smaller countries of Latin America were the first to implement neoliberal policies during the 1970s (Argentina and Chile). The Mexican and Brazilian governments did not implement neoliberal reforms until the late 1980s and mid-1990s respectively. A region once characterized by high inflation now began to experience a significant drop in inflation by the early 1990s. In 1989, closing the decade of economic crisis, inflation was at an astounding 130%, but by 1994 it had dropped to 14%. This dramatic drop in inflation allowed for international investors to start looking towards Latin America again.
Pro-market economic reform throughout the Latin American region in the context of neoliberalism is reflective of the new attitude towards the inflow of external capital. Unlike the restrictive laws of the 1970s, that discouraged foreign investment through capital controls, liberal policies of the 1980s have encouraged capital inflows. Foreign investment was greatly reduced during the first half of the decade due to the increased country risk associated with the debt crises and the region’s impaired prospects for growth. But shortly after the debt crises, many Latin American countries began implementing policies to liberalize trade and investment so that by the end of the decade such reforms proved successful as the inflows of capital returned to the region.

More recently, a number of bilateral trade agreements and free trade areas have started to gain importance in Latin America. Examples are the NAFTA (North American Free Trade Agreement), formed by Mexico, USA and Canada in 1994; and Mercosur, formed by Brazil, Argentina, Uruguay and Paraguay in 1991, which also has Bolivia, Chile, Colombia, Ecuador, Peru, and Venezuela as associate members.
CHAPTER 2. Literature Review

For most economists, the natural starting point for understanding economic growth is the one-sector neoclassical growth model developed by Solow (1956) and by Swan (1956). The model is very simple and assumes neoclassical constant returns in two factors, capital and labor, with each factor exhibiting diminishing marginal productivity. The economy is perfectly competitive and is driven by an exogenous savings rate and by exogenous labor force (and population) growth.

Both Solow and Swan understood the model to be “unrealistic” in the sense that it abstracted from important considerations. However, this model served as the central building block for a very large subsequent empirical and theoretical literature.

The central mechanism by which per capita economic growth occurs in the Solow-Swan model is through increases in the amount of capital per worker, or ‘capital deepening’. The associated ‘prediction’ of the model is that, along transition paths towards a steady-state, high per capita output growth would be associated with high investment rates relative to labor force and population growth rates which would tend to raise the capital per labor ratio. In addition, other things equal, growth rates should be negatively correlated with initial per capita output. This follows because low initial per capita output arises purely from low capital to labor ratios (assuming, in the neoclassical tradition, that all countries have access to the same aggregate production function). If capital per labor ratios are low, the marginal productivity of investment is high, and a given investment rate should give rise to faster growth of per capita output. Thus, convergence in the data should be observed, with the poorer countries converging on wealthier countries.
Solow’s growth theory asks the question: What are the determinants of sustainable growth of real income per person in an isolated economy producing a single product? This simple model assumes that the state of technology does not change over time, that the labor does not grow and capital stock does not depreciate.

The original Solow-Swan model considers saving rate, the growth rate of population, and the position of the production function as the determinants of a country’s steady-state level of per capita income. The extended Solow-type neoclassical growth model emphasizes investment rate, population growth, and human capital as important factors that determine the long-run potential level of income (Mankiw, Romer, and Weil, 1992).

Following is an excerpt from Barro and Sala-i-Martin (1999) on the concepts of absolute and conditional convergence:

“The hypothesis that poor economies tend to grow faster per capita than rich ones—without conditioning on any other characteristics of economies—is referred to as absolute convergence. This hypothesis receives only mixed reviews when confronted with data on groups of economies...This hypothesis fares better empirically if we examine a more homogeneous group of economies...We can accommodate the theory to the empirical observations on convergence if we allow for heterogeneity across economies, in particular, if we drop the assumption that all economies have the same parameters, and therefore, the same steady-state positions. If the steady states differ, then we have to modify the analysis to consider a concept of conditional convergence. The main idea is that an economy grows faster the further it is from its own steady-state value.” (pp. 26 – 30)

Robert Barro (1991) used an extended version of the neoclassical growth model of Solow (1956), which also includes human capital as an explanatory variable, as a

1 The concept of a single steady state in convergence theory has mostly been replaced by the idea of multiple equilibriums.
testing ground to study the determinants of growth in a cross-section of countries. Empirical findings of Barro demonstrate that for a given starting level of real per capita GDP, the growth rate is enhanced by higher initial schooling and life expectancy, lower fertility, lower government consumption, better maintenance of rule of law, low inflation and improvements in the terms of trade. For given values of these and other variables, growth is negatively related to the initial level of real per capita GDP. Political freedom has only a weak effect on growth but there is some indication of a non-linear relation.

In the initial phase, growth in developing countries is hindered primarily by the lack of basic economic foundations such as institutions and services. Growth in these less developed countries demands considerable investments in social and economic overheads. This is the initial phase of the process of development, where the government of an under-developed country is required to create the basic economic foundation for development by direct investment in social and economic infrastructure. According to Barro, initial per capita GDP is substantially negatively related to subsequent per capita growth. Per capita growth is positively related to the proxies for the initial human capital, holding fixed the starting level of real per capita GDP and the other variables.

Following empirical researches undertaken by Barro and Lee (1994), Barro (1997), and Barro and Sala-i-Martin (1999) also take human capital, institutions, and policy factors to be important determinants of long-run per capita income.

Mankiw, Romer, and Weil (1992) investigate the capacity of Solow’s model to explain the level of relative variation in per capita income across countries and suggest that the differences can be well described using an augmented Solow model that accounts for accumulation of both physical and human capital. The inclusion of human capital in
the original Solow model is justified by the observation that the effects of saving and population growth alone on income are too large. After adding a proxy for human capital accumulation as an extra explanatory variable in the cross-country regressions, the authors find that human capital is correlated to saving and population growth; and also that the inclusion of this variable lowers the estimated effects of saving and population growth to about the values predicted by the augmented Solow model. Mankiw, Romer, and Weil also suggest that variations in tax policies, education policies, family size references, and political stability may account for observed variations on exogenous variables in the Solow model.

Recently, the profusion of remarkable advances in econometric methods has generated a new set of empirical tests for economic growth theories. In keeping with this trend, an important contribution was made by Islam (1995), whose paper reports estimates for the parameters of a neoclassical model in a panel data approach. In this case, the author admits on leveling effects for individual countries as heterogeneous fixed intercepts in a dynamic panel. Although Mankiw, Romer, and Weil (1992) findings allow us to conclude that human capital performs an important role in the production function, Islam (1995) reaches an opposite conclusion, once a country’s specific technological progress is introduced into the model.

Dobson and Ramlogan (2002) studied income convergence in Latin America, analyzing a panel of nineteen countries from 1970 to 1998, without controlling for human capital. Their results offer little evidence of income convergence in the region, which suggest a need for regional development policies in order to reduce the income inequalities.
Panel data, also called cross-sectional time series data, are repeated observations on the same set of cross-section units. Two types of information are represented in cross-sectional time-series data: the cross-sectional information, reflected in the differences between subjects, and the time-series or within-subject information, reflected in the changes within subjects over time. Panel data regression techniques allow researchers to take advantage of these different types of information.

Although it is possible to use ordinary multiple regression techniques on panel data, they may not be optimal. The estimates of coefficients derived from regression may be subject to omitted variable bias - a problem that arises when there is some unknown variable or variables that cannot be controlled for that affect the dependent variable. With panel data, it is possible to control for some types of omitted variables even without observing them, by observing changes in the dependent variable over time. This controls for omitted variables that differ between cases but are constant over time. It is also possible to use panel data to control for omitted variables that vary over time but are constant between cases. A panel dataset should have data on \( n \) cases, over \( t \) time periods, for a total of \( n \times t \) observations.

The Pooled OLS Estimator

The simplest case of using longitudinal data arises from ignoring the panel structure of the data. Once the data is organized by decision units, the model can be written as

\[
y = X\beta + e
\]  

(1)
The simplicity of this model comes from the assumption about the error term: it is assumed that $e \approx N(0, \sigma^2) iid^2$. That is, for a given $X$, there is no serial correlation between observations and, furthermore, errors are not heteroskedastic. Put differently, one assumes that an individual’s observations over time are observations from different individuals. Such approach might be reasonable, for example, in cases when the size of cross-sectional samples is too small. However, ignoring the panel structure of the data by assuming that the error terms are $iid$ leads to results that are not appropriate in many cases. Still, as the assumptions about the disturbance meet those of the classic linear regression model, efficient estimation can be achieved using OLS.

Despite its potential biases, pooled OLS estimation will be used in this paper, similarly to other applied studies, as a starting point for the empirical analyses. Its results will be compared to results from models that are better suited for the analysis of panel data. The three models considered here are the random effects estimator, the fixed effects estimator as well as the Hausman-Taylor instrumental variables estimator. These are presented next.

**Fixed and Random Effects Models**

Consider the following model:

$$y_{it} = X_{it} \beta + \epsilon_{it}$$  \hspace{1cm} (2)

also consider that the error term has the following structure:

\footnote{iid \sim independent and identically distributed. In other words, knowing the value of the error term does not tell you anything about the other variables in the model (the distribution of the error term is orthogonal to the distribution of the other variables), and observations of the error term are uncorrelated with each other (i.e., no autocorrelation). In addition, $e$ is normally distributed with $E(e) = 0$ (the error term $e$ has a zero mean), and a constant variance $\sigma^2$ (no heteroskedasticity).}
where it is assumed that $\eta_{it}$ is uncorrelated with $X_{it}$. The first term of the decomposition, $\alpha_i$, is called an individual-specific effect; and the second part, $\eta_{it}$, corresponds to the common stochastic error term in, for example, classical linear regression models. In this formulation, the first part, $\alpha_i$, varies across individuals or the cross section unit (in the case of this paper, countries) but is constant across time; this part may or may not be correlated with explanatory variables. The second part, $\eta_{it}$, varies arbitrarily across time and countries. This formulation is the simplest way of capturing the notion that two observations from the same country will be more “like” each other than observations from two different countries.

The crucial assumption that distinguishes the fixed effects model from the random effects model is whether $\alpha_i$ may or may not be correlated with the set of explanatory variables, $X_{it}$:

1) Random effects model: $\alpha_i$ is uncorrelated with $X_{it}$.

2) Fixed effects model: $\alpha_i$ is correlated with $X_{it}$.

That is, in the fixed effects model, the $\alpha_i$ are assumed to be $n$ unknown parameters that are to be estimated, while in the random effects case, the $\alpha_i$ are treated as drawings from a distribution with mean $\mu$ and variance $\sigma^2_{\alpha}$ which are independent from the explanatory variables in $X_{it}$. As will be shown later in this chapter, the Hausman-Taylor instrumental variable estimator provides an alternative to this ‘all or nothing’ approach regarding the correlation between the $X_{it}$ and $\alpha_i$. 
**Random Effects**

The random effects model has the following structure:

\[
y_{it} = X_{it} \beta + \varepsilon_{it}
\]  

(4)

where \( \varepsilon_{it} = \alpha_i + \eta_{it} \).

The main assumption that differentiates this model from the fixed effects model is that the time-invariant country-specific effect \( \alpha_i \) is uncorrelated with \( X_{it} \).

It is useful to be more explicit about the two parts of the error term:

\[
E[\eta_{it} | X] = E[\alpha_i | X] = 0;
\]

\[
E[\eta_{it}^2 | X] = \sigma^2_{\eta};
\]

\[
E[\alpha_i^2 | X] = \sigma^2_{\alpha};
\]

\[
E[\eta_{it} \alpha_i | X] = 0, \text{ for all } i, t, \text{ and } j;
\]

\[
E[\alpha_i \alpha_j | X] = 0, \text{ for } i \neq j.
\]

In essence, the random effects model is one way to deal with the fact that \( T \) observations on \( n \) countries are not the same as observations on \( nT \) different countries. The model is then calculated by first, deriving an estimator of the covariance matrix of the error term, and second, using this covariance structure in the estimator of \( \beta \).

If the variance components \( \sigma^2_{\eta} \) and \( \sigma^2_{\alpha} \) are known, GLS estimation can be applied without difficulty. However, this typically is not the case and estimates of the unknown variances are needed. Consistent estimators can be derived as the appropriately modified sum of squared errors from two different estimators, the so-called *between estimator* and the *within estimator*. 
**Fixed Effects**

In contrast to the random effects case, the crucial assumption in the fixed effects model is that \( \text{cov}(\mathbf{X}_i, \alpha_i) \neq 0 \). The model must therefore be estimated conditionally on the presence of the fixed effects. Rewriting the model in (4) gives:

\[
y_{it} = \mathbf{X}_i \beta + \alpha_i + \eta_{it}
\]

where the \( \alpha_i \) are unknown parameters to be estimated. However, consistent estimates of these additional parameters cannot be obtained. Although we cannot estimate \( \alpha_i \) consistently, we can estimate the remaining parameters consistently.

To do so, the regression that is to be run is

\[
y = \mathbf{X} \beta + \mathbf{D} \alpha + \eta
\]

where, \( \mathbf{D} \) is the matrix that collects \( n \) dummy variables corresponding to each individual. Premultiplying the data by

\[
\mathbf{M}_D = (\mathbf{I} - \mathbf{D}'(\mathbf{D}'\mathbf{D})^{-1}\mathbf{D})
\]

the resulting within estimator is

\[
\hat{\beta}_w = (\mathbf{X}'\mathbf{M}_D\mathbf{X})^{-1}\mathbf{X}'\mathbf{M}_D\mathbf{y}
\]

The particular advantage of the fixed effects model is the removal of the individual-specific heterogeneity, which can be shown by a ‘deviations-from-means’ approach.

Consider

\[
\bar{y}_i = \bar{\mathbf{X}}_i \bar{\beta} + \alpha_i + \bar{\eta}_i
\]

As the mean of the individual fixed effect \( \alpha_i \) for individual \( i \) is \( \alpha_i \), Eqs. (5) and (8) can be differenced. This yields

\[
y_{it} - \bar{y}_i = (\mathbf{X}_{it} - \bar{\mathbf{X}}_i) \beta + (\eta_{it} - \bar{\eta}_i)
\]
While unobservable heterogeneity is accounted for, there is a potential drawback insofar that the within estimator uses only the variation within an individual’s set of observations. This might be problematic when there are time-invariant explaining variables.

Summing up, the last two estimators presented, the random effects estimator and the fixed effects estimator, both are models designed to handle the specific structure of longitudinal or panel data. That is, unobservable individual heterogeneity is taken into account by both models. The distinction between the two models is whether the individual-specific time-invariant effects are correlated with the regressors or not. Furthermore, given that the random effects model is valid, the fixed effects estimator still produces consistent estimates of the identifiable parameters. As it often might be unlikely to believe that the individual-specific effects are uncorrelated with the relevant covariates, it is appealing to prefer the fixed effects estimator to the random effects estimator. However, it has to be noted that there are also perils relying on the fixed effects model only.

First, as pointed out, time-invariant variables cannot be used. Furthermore, measurement error in $X$ and endogenous changes in $X$ might lead to biased results also with the fixed effects estimator. As a consequence, neither random effects nor fixed effects estimation might be appropriate and other, more sophisticated models, like instrumental variable (IV) estimation or Generalized Method of Moments (GMM) estimator should be applied.

As some of the explanatory variables used in the model presented in this paper are supposed to be endogenous, the random effects and fixed effects models are used here for comparison purpose only. The final regression is estimated using a more sophisticated
model, the Hausman-Taylor IV estimation, which will be described in the following section.\(^3\)

**The Hausman-Taylor Model**

Hausman and Taylor (1981) suggest an alternative that combines the beneficial aspects of both the random-effects and fixed-effects estimators. The major shortcoming of the random-effects model is the assumption that the included explanatory variables are uncorrelated with the error term. The Hausman-Taylor method is an instrumental-variable technique\(^4\) that uses only information already contained in the model to eliminate the correlation between country specific effects and the error term. Unlike the fixed effects estimator, this approach does not necessitate the elimination of time-invariant explanatory variables.

The Hausman-Taylor instrumental variable (HT-IV) method is an extension of the random-effects estimator. The main assumption of the Hausman-Taylor method is that the explanatory variables that are correlated with \(\alpha_i\) can be identified. In particular, they consider a model of the form:

\[
y_{it} = X_{it}\beta + Z_i\gamma + \alpha_i + \eta_{it} \tag{10}
\]

where the \(Z_i\) are time-invariant covariates. In this formulation, all individual effects that are denoted as \(Z_i\) are observed. As in the previous panel models, unobservable individual effects are contained in the person-specific random term, \(\alpha_i\). Hausman and Taylor

---

\(^3\) GMM is another alternative.

\(^4\) The technique of instrumental variables is commonly used in regression analysis when the standard assumption that the explanatory variables are uncorrelated with the unexplained component fails. In this case ordinary linear regression will not provide consistent estimates. However, if an instrument is available, consistent estimates may still be obtained. An instrument is a variable that does not itself belong in the regression, that is correlated with the explanatory variable, and that is uncorrelated with the error term.
suggested to split $X$ and $Z$ into two sets of variables: $X = [X_1; X_2]$ and $Z = [Z_1; Z_2]$. $X_1$ is $n \times k_1$, $X_2$ is $n \times k_2$, $Z_1$ is $n \times g_1$, $Z_2$ is $n \times g_2$ and $n = NT$.

The model is then

$$y_{it} = X_{1i} \beta_1 + X_{2i} \beta_2 + Z_{1i} \gamma_1 + Z_{2i} \gamma_2 + \alpha_i + \eta_{it} \quad (11)$$

The distinguishing feature of this model is found in the assumptions on the correlation between the individual-specific effect, $\alpha_i$, and the sets of time-varying and time-invariant regressors. In particular, four sets of observed variables are defined in this model:

- $X_{1i}$ is $k_1$ variables that are time-varying and uncorrelated with $\alpha_i$,
- $Z_{1i}$ is $g_1$ variables that are time-invariant and uncorrelated with $\alpha_i$,
- $X_{2i}$ is $k_2$ variables that are time-varying and correlated with $\alpha_i$,
- $Z_{2i}$ is $g_2$ variables that are time-invariant and correlated with $\alpha_i$.

The presence of $X_{2i}$ and $Z_{2i}$ is the cause of bias in the random-effects estimator. The strategy proposed by Hausman and Taylor (1981) is to use information already contained in the model to instrument for the problematic variables, $X_{2i}$ and $Z_{2i}$. Hausman and Taylor propose an instrumental variable approach where the following variables are used as instruments: $X_{1it}$, $Z_{li}$, $X_{2it} - \overline{X}_{2it}$ and $\overline{X}_{1it}$. That is, the exogenous variables, i.e. the variables that are uncorrelated with $\alpha_i$, serve as their own instruments. The time-varying endogenous variables, $X_{2it}$, are instrumented by the deviation from individual means $(X_{2it} - \overline{X}_{2it})$, the time-invariant endogenous variables, $Z_{2i}$, are instrumented by the individual average of $X_{1it}$ $(\overline{X}_{1it})$. The selection of the variables that should be included in
\( \mathbf{X}_{2i} \) and \( \mathbf{Z}_{2i} \) is not obvious. Hausman and Taylor (1981) base their selection on economic intuition, this paper bases the choice of variables on the framework proposed by Barro and Sala-i-Martin (1999).

The Hausman-Taylor instrumental variables estimator is always consistent and efficient. Furthermore, a strong advantage of this approach is that no external instruments have to be used.

**Choosing between Fixed Effects, Random Effects and Hausman-Taylor**

The generally accepted way of choosing between fixed and random effects is running a Hausman (1978) test. Furthermore, the Hausman test can also be used for the decision on whether the HT-IV estimator is the more appropriate estimator to apply to the data.

The Hausman test tests the null hypothesis that the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator. If they are (insignificant P-value, \( \text{Prob} > \chi^2 \) larger than .05) then it is safe to use random effects. If one gets a significant P-value, however, one should use fixed effects. This same logic applies when using the Hausman test to decide between the fixed effects model and the Hausman-Taylor estimator. In this second case, the Hausman test tests the null hypothesis that the coefficients estimated by the efficient HT-IV estimator are the same as the ones estimated by the consistent fixed effects estimator. If they are (insignificant P-value), then the HT-IV estimator is consistent and efficient, and the fixed effects estimator is consistent, though less efficient.
Statistically, fixed effects are always a reasonable thing to do with panel data (they always give consistent results) but they may not be the most efficient model to run. Random effects will give you better P-values as they are a more efficient estimator, so you should run random effects if it is statistically justifiable to do so. The Hausman-Taylor estimator is consistent and efficient, being usually the best choice when compared to both fixed and random effects estimators.

The Hausman test checks a more efficient model against a less efficient but consistent model to make sure that the more efficient model also gives consistent results.

**Example**

In order to illustrate the methodology concepts, a simple regression example will be presented. Suppose that there is an economic model that considers a country’s growth rate as being defined by the amount of education its population have and the total savings of the country. This model also predicts that the growth rate should increase if the amount of education and savings increase. Suppose one has data on education and savings for the period 1970-2000 for three different countries and he wants to test if the empirical data supports the predictions of this model. This researcher would use regression analysis to quantify the type of causal relationship among these three variables. The growth rate is the dependent variable and education and savings are the independent variables. The regression model would look like:

$$\text{GDP}_{it} = C + \alpha \text{EDU}_{it} + \beta \text{SAV}_{it} + E_i$$  \hspace{1cm} (12)

where $\text{GDP}_{it}$ is the value of the per capita growth rate of country $i$ at time $t$ (where $i$ varies from 1 to 3 and $t$ varies from 1970 to 2000), $C$ is the constant term, $\text{EDU}_{it}$
is the average years of schooling country $i$ has at year $t$, $SAV_i$ is the total savings of country $i$ at year $t$, and $E$ is the random error term, a proxy for all the uncertain factors that may also affect the per capita growth rate of a country. EDU and SAV are the exogenous variables, and $\alpha$ and $\beta$ are the regression coefficients and reflect the partial effect of the education and savings variables respectively, holding the effects of the other independent variable constant.

In order to use the pooled OLS estimator, one would have to assume that past values of the error term do not influence its current value (no autocorrelation). It would also be necessary to assume that the independent variables, education and savings, are not affected by variations of the error term. But in making these assumptions the panel structure of the data is being ignored. As stated earlier, the researcher here has data for three different countries, so it is unreasonable to believe that there is no unobservable heterogeneity in data due to the individual characteristics of each country. Therefore, the pooled OLS method is not suitable to estimate this model.

According to the theories described above, it is known that the error term of a panel data model has two parts, one that is uncorrelated with the other independent variables, and one, which we are mostly interested in, that is called the individual-specific effect. The individual-specific effect characterizes the cross-sectional properties of the panel-data as it captures the variations that exist in the data that are related to the fact that it has information about three different countries, and not only one, and that does not vary over time. The size of the country or cultural elements, for example, can be considered an individual-specific effect. There are two conventional methods researchers may use to estimate the model once the need to control for the country-specific effects is identified,
the random effects and the fixed effects models. The random effects estimator should be used if one assumes that there is no correlation between the country-specific effects and the independent variables, education and savings, in other words, this method should be used only if it is assumed that education and savings are not influenced by any characteristics of the specific country that was not explicitly defined in the model. As this is a very strong assumption, most empirical researches prefer to use the fixed effects method. This second method is used when the country-specific effects might be correlated with the explanatory variables. The fixed effects method is always consistent, but might not be the most efficient method if the random effects method is suitable for the data. In order to help researchers choose between these two methods, a common test to run is the Hausman test. Given a model and data in which fixed effects estimation would be appropriate, the Hausman test tests whether random effects estimation would be almost as good. In a fixed-effects kind of case, the Hausman test is a test of \( H_0: \) that random effects would be consistent and efficient (note that fixed effects would certainly be consistent). The result of the test is a vector of dimension \( k \) (dim(b)) which will be distributed chi-square(k). So if the Hausman test statistic is large, the hypothesis that random-effects is consistent and efficient is rejected and therefore one must use fixed-effects. If the statistic is small, this hypothesis is not rejected and it is safe to use the more efficient random-effects estimator.

Now let’s suppose that the savings variable is influenced by variations of the per capita growth rate – it is endogenous. This is a reasonable hypothesis, as people tend to save more as their earnings increase. This endogeneity problem will cause bias in the regression results if it is not properly corrected. In order to correct the endogeneity
problem that underlines the individual-specific effect, one may use a third estimator, the Hausman-Taylor instrumental variables method. This method allows us to use information already contained in the model to instrument for the problematic variable-savings. Now two methods were found to correct the country-specific effects in the model, the fixed-effects estimator and the Hausman-Taylor IV estimator. In order to choose which of these two estimators will be used in analyzing the final results, a second Hausman test needs to be run. Now the $H_0$ hypothesis is that the Hausman-Taylor method is consistent and efficient. If $\chi^2$ is small enough so that the $\text{Prob}>\chi^2$ is statistically insignificant (P-value >0.5), then the Hausman-Taylor method is not only consistent but it is also more efficient than the fixed-effects method.

This example tried to illustrate a simple problem that could be modeled using panel data techniques and how to choose the best method to estimate this model.

**Data Set**

The data set on GDP per capita growth rates, population growth, openness in constant prices, government consumption share of real GDP, and investment share of real GDP were obtained from the Penn World Tables Version 6.1\(^5\) (Heston, Summer and Aten, 2002). The data set on years of schooling came from the Barro-Lee\(^6\) data set (Barro and Lee, 2000). The polity score data was obtained from the Polity IV Project Data Set from the Centre for International Development and Conflict Management (CIDCM) at the University of Maryland\(^7\) (Marshall and Jaggers, 2002). The data on life expectancy

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\(^5\) Pen World Table 6.1 data set can be found online at: http://pwt.econ.upenn.edu/php_site/pwt61_form.php

\(^6\) Barro-Lee data set can be found online at: http://www.cid.harvard.edu/ciddata/ciddata.html

\(^7\) Polity data set can be found online at : http://www.cidcm.umd.edu/inscr/polity
was obtained from the Statistics and Economic Projections Division of the United Nations Economic Commission for Latin America and the Caribbean (ECLAC)\(^8\). The data covers the period from 1952 to 2000 for a set of seventeen Latin American countries\(^9\).

In order to provide a better idea of the data used in this paper, three tables of descriptive statistics were created. Table 1 summarizes the complete dataset. In table 2, the data is summarized by decade and a summary of the whole period is calculated in the end. Table 3 presents the descriptive statistics of the data for each country. Based on the descriptive statistics, one can see that the per capita growth rates for the Latin American countries included in this study are very irregular. Although these countries had an average annual per capita growth rate of 1.3% from 1952 to 2000, the growth rates actually varied between a minimum of -24.7% and a maximum of 18.5%. The huge gap between the lower and upper bounds of the per capita growth rate clearly demonstrates the level of economic instability in the region. It is also noticeable that even though the per capita GDP value increased 80% from 1052 to 2000, the average per capita GDP in 2000 is still at a very low level, US$ 5,757.

The data also shows that the region has made great improvement in its life expectancy and schooling levels. The life expectancy in the region grew from an average of 54 years in the 1950s to 70 years in the 1990s. The level of schooling increased from an average of 3.5 years in the 1950s to 5.9 years in the 1990s. The region also saw a large increase in its openness to trade level, the total exports plus imports as a percentage of the

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\(^8\) ECLAC / CEPAL Database of social indicators for Latin America and the Caribbean can be found online at: http://www.eclac.cl/badeinso

\(^9\) Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela.
GDP grew from an average initial value of 38% in 1952 to 65% in 2000, demonstrating the effects of the trade liberalization policies implemented in the region since the late 1980s. It is also possible to see an increase in the government expenditure rates from the beginning of the 1970s until the 1980s, with a subsequent reduction in the 1990s, which demonstrates the increased implementation of neoliberal policies in the region. The investment level still has not fully recuperated from the sharp decrease it experienced in the 1980s. Even though the region saw an almost 40% increase in the investment rate in the 1990s, the average investment rate in 2000 still is 0.3% lower than it was in 1952. The variable that presented the most distinguished increase in its level is the polity score, from an average level of −1 (the score goes from −10 to 10) in 1952, it increased to an average 7.6 score in 2000. The −2.2 average polity score in the 1970s portrays the spread of authoritarian governments in the region in this period.

**Estimated Model**

The Hausman-Taylor instrumental variables estimator is used here to assess the impact of a set of growth determinants on the per-capita income growth rates for seventeen Latin American countries in the period 1952-2000. This paper also presents the results from polled OLS, fixed effects and random effects estimations.

Some of the explanatory variables in the model proposed in this paper are assumed to be endogenously determined\(^\text{10}\). Endogenous variables are a problem because the growth determinants might be being determined by the growth rate itself,

\(^{10}\) In an economic model, an endogenous change is one that comes from inside the model and is explained by the model itself. An endogenous explanatory variable will lead to bias in the estimate of the regression parameter associated with this variable.
characterizing a system of simultaneous equations. In order to simplify the estimation problem, a model with only one equation using instrumental variables is proposed. The instrumental variables estimator uses the relationship between the potentially endogenous explanatory variable and an additional variable, called the “instrument”, to tease out any exogenous variation actually present in the potentially endogenous variable.

Based on the above assumption and supported by the Hausman test results, the Hausman-Taylor instrumental variables method is considered to be more adequate than random effects or fixed effects. The HT-IV model is also used to verify the conditional convergence hypothesis.

The proposed model uses the growth rate of real per capita GDP as the dependent variable. The lagged levels of physical and human capital are the state variables. Due to the availability of data, the level of real per capita GDP is used as a proxy for stock of physical capital. For stock of human capital, the database on school attainment constructed by Barro and Lee (2000) is used. The control variables used are the population growth rate, life expectancy, the ratio of real gross domestic investment to real GDP, the ratio of government consumption to GDP, openness in constant prices (as a proxy for movements in the terms of trade), and a measure of democracy. It is assumed here that the disturbance term is not autocorrelated, in other words, the error term has no “memory”, it does not relate to its previous values in time.
Therefore, using the Hausman-Taylor model, this paper estimates the following equation\(^\text{11}\):

\[
y_{it} = c + \beta_1 \log(Y_{it-1}) + \beta_2 h_{it-1} + \beta_3 pop_{it} + \beta_4 \log(life_{it}) + \beta_5 o_{it} + \beta_6 g_{it} + \beta_7 i_{it} + \beta_8 pol_{it} + u_{it}
\]

where,

- \(y_{it}\) is the growth rate of real per capita GDP;
- \(c\) is a constant;
- \(Y_{it-1}\) is the first lag of the level of real per capita GDP;
- \(h_{it-1}\) is the first lag of the level of education in years of schooling;
- \(pop_{it}\) is the population growth rate;
- \(life_{it}\) is the life expectancy;
- \(o_{it}\) is openness in constant prices (total trade as % of GDP);
- \(g_{it}\) is the ratio of government consumption to GDP;
- \(i_{it}\) is the real gross domestic investment to real GDP;
- \(pol_{it}\) is the polity score, a measure of democracy; and
- \(u_{it}\) are the exogenous disturbances.

\(^{11}\) Note that the proposed model is not autoregressive. The dependent variable is the per capita GDP growth rate and one of the explanatory variables is the log of the first lag of the level of per capita GDP, what differs from the lag of the growth rate of per capita GDP.
CHAPTER 4. Results

This paper presents the pooled OLS, fixed-effects, random-effects, and Hausman-Taylor estimation (table 4) of the proposed growth model and provides substantial evidence that the Hausman-Taylor estimator is the superior choice in this setting.

The regression tries to quantify how much the explanatory variables impact the growth rate of per capita GDP for the seventeen countries studied. This paper investigates, for instance, if an increase in the average years of schooling of the population causes the growth rate to increase, decrease, or even if education has no significant impact on growth at all. Another research objective is to verify if the studied countries are converging to their steady-state. For example, Latin America, with a few exceptions, has been an under-performer in terms of growth, meaning that the countries in this region are growing at a slower rate than the world average. If it is found that the countries in Latin America are converging, it means that their per capita income is tending to the equilibrium, which is not a good sign, as the equilibrium would be at a low income level.

The results from the pooled OLS estimator are presented in table 4. Due to the presence of unobservable individual heterogeneity, the pooled OLS estimator is biased. After estimating the proposed model using the fixed and random effects methods, a Hausman test is performed comparing both estimators (table 5). The test compares the results of the fixed-effects estimator, which is always consistent, with the results of the random-effects estimator, which is more efficient, to verify if the later would also be able to yield consistent results. A Hausman test statistic of 36.05 shows that the random effects estimator is inconsistent, implying that there is correlation between the included
variables and the error term, and therefore the fixed-effects estimator is a better choice than the random-effects estimator.

In addition, based on the assumption that endogeneity problems are present in the data, a Hausman-Taylor estimator is calculated and an additional Hausman test is conducted using the fixed-effects and the Hausman-Taylor methods to determine if the instrumental variable technique has eliminated the correlation that plagued the random-effects estimator (table 5). It is found that the correlation has been removed and therefore, from the two alternatives considered here, the Hausman-Taylor estimator is the better choice. That is, the problematic correlation between variables included in the model and the individual component of the error term that introduced bias into the random-effects estimator has been removed through the use of instrumental variables. The instrumental-variable technique controls for the possible simultaneity problem when the control variables are endogenously determined.

In using the HT-IV estimator, the following time-varying variables are considered to be exogenous and can therefore be used as their own instruments: schooling ($h_{it-1}$), life expectancy ($\log(life_{it})$), population growth ($pop_{it}$), openness ($o_{it}$), and the polity score ($pol_{it}$). The following variables are also time-varying, but they are considered to be endogenously determined and therefore are instrumented by the deviation from their individual means ($X_{2t} - \bar{X}_{2t}$): the initial level of per capita GDP ($Y_{it-1}$), government consumption ($g_{it}$), and the investment rate ($i_{it}$).

Table 4 contains the Hausman-Taylor regression results for the growth rate of real per capita GDP for a panel of seventeen Latin American countries in the period of 1952 to 2000. The model seems to be well adjusted with exception of the schooling and
population growth variables. The model is re-estimated without the population growth variable and the coefficients of the other variables do not change significantly. This result can be explained by the fact that the dependent variable is the \textit{per capita} growth rate, which already takes population growth into account. The schooling variable was expected to be positively related to the per capita growth rate, but one can note that this variable is negative and statistically equal to zero in all regressions. One possible explanation is that there is not enough variation in the sample since the dataset on schooling used in this paper (Barro and Lee, 2000) measures this variable at a five-year interval.

A discussion of the regression results for each of the explanatory variables included in the proposed model follows\textsuperscript{12}.

\textbf{Initial level of per capita GDP.} The variable \(\log(Y_{it-1})\) is the log of the first lag of the level of real per capita GDP, and it is instrumented by the deviation from individual means. The estimated coefficient on \(\log(Y_{it-1})\), -0.0335 (s.e. 0.0075), shows the conditional convergence that has been reported in various studies, such as Barro (1991) and Mankiw, Romer, and Weil (1992). The convergence is conditional in that it predicts higher growth in response to lower starting GDP per person only if the other explanatory variables (some of which are highly correlated with GDP per person) are held constant. The intuition behind the negative coefficient is that the per capita income level of the studied countries is approaching the steady-state. Taking into consideration that most of the countries in this region are poor and have been growing at comparatively low rates, one can assume that the steady-state of these countries can also be considered to be at a

\textsuperscript{12} With the exception of population growth, which is considered to be already accounted for in the per capita GDP variable.
lower level than average and the fact that the results indicate that per capita income in this region is approaching this level may not be considered a good prospect. A solution to this problem would be to move the steady-state to a higher level, which would need a rise in the savings per worker ratio.

**Initial level of educational attainment.** The variable $h_{it-1}$ is the first lag of the level of education. The educational attainment variable is measured in years of schooling and is available in five-year intervals. The missing values were calculated using the growth rate between the adjacent figures. Since this variable is pre-determined, it enters as its own instrument in the regression. A negative, although highly insignificant relation between the school attainment variable and subsequent growth was found. The insignificance of the estimated coefficient (-0.0023, s.e. 0.0024) implies the lack of a role for school attainment in the determination of growth. This result is surprising, especially since previous studies (Barro, 1991 and Barro and Sala-i-Martin, 1999) have found strong positive correlations between these two variables in cross-section data. The lack of enough variation in the data is a possible explanation for this result.

**Life expectancy.** The life expectancy data set used in this paper is available in five-year intervals. Due to this limitation, the data was interpolated based on its growth rate between each two adjacent values. The variable is then entered in the form $\log(\text{life expectancy})$ and is used as its own instrument. The estimated coefficient is 0.0442 (s.e. 0.024), and it is significant at the 10% level. The result means that an increase in life expectancy causes an increase in the growth rate. An explanation for this positive
correlation between life expectancy and growth is that a population with higher life expectancy work for more years, thus the economy has a larger stock of productive working age population per capita than before, furthermore, this larger cohort of workers works and earns income, and since they now expect to live longer, they might save more for their old age. In addition, a longer life expectancy might also be signaling better health and work conditions, which, by its turn, might imply better productivity.

**Openness.** The openness variable \((o_d)\) is calculated as the total trade (exports plus imports) as a percentage of GDP in constant prices. This variable is viewed as exogenous and enters as its own instrument. The estimated coefficient of this variable is 0.00024 (s.e. 0.00011), what implies that although a significant positive relation exists between openness and growth, it is of small magnitude. The concept of openness suggests that economies benefit from international trade. In addition, trade and contact with foreign enterprises provide access to knowledge of new products and production styles, either through technology embodied in imports or through foreign direct investment. High trade restrictions tend to produce exchange rate appreciations and inflation in the non-tradable sector. As a consequence, producers of tradable goods and services are discriminated and economies become more vulnerable to external shocks. Moreover, trade protection creates interest groups that lobby for maintaining and extending these and similar government interventions. ISI-critics suspect that trade restrictions encourage or initiate broad-based rent-seeking behavior and corruption, which act as a drag on growth.
**Government consumption.** The government consumption variable \((g_{it})\) is the ratio of government consumption to GDP. The estimated coefficient of \(g_{it}\) is -0.0015 (s.e. 0.0003), meaning that the government consumption variable has a significantly negative impact on growth. A possible explanation for this result is that higher public spending undermines economic growth by transferring additional resources from the productive sector of the economy to government, which uses them less efficiently. Another possible problem is that government spending requires costly financing choices. The federal government cannot spend money without first taking that money from someone. All of the options used to finance government spending have adverse consequences. Taxes discourage productive behavior, borrowing consumes capital that otherwise would be available for private investment and, in extreme cases, may lead to higher interest rates. Inflation debases a nation’s currency, causing widespread economic distortion.

**Investment ratio.** The investment ratio variable \((i_{it})\) is the ratio of real gross domestic investment to real GDP. The estimated coefficient on investment rate is positive and highly significant, 0.0017 (s.e. 0.0003), meaning that investment has a strong positive relation to growth. Higher investment promotes higher growth by allowing firms to increase production of consumer goods and services in future time periods.

**Polity score.** The polity score \((pol_{it})\) is a measure of democracy provided by the Polity IV Project Data Set from the Centre for International Development and Conflict Management (CIDCM) at the University of Maryland. The polity scale ranges from +10 (strongly democratic) to -10 (strongly autocratic). The estimated coefficient is negative.
and significant at the 5% significance level, -0.0006 (s.e. 0.0003). This might be explained by the period of high growth and low political freedom experienced by a number of Latin American countries from the 1960s to the 1980s.

**Suggestions for Further Study**

Empirical studies of the determinants of economic growth suggest numerous additional explanatory variables. The framework used here captures some important growth determinants but other variables may also have a strong connection to growth performance. Some of these variables, such as the human development index (HDI), were not included in the regressions due mainly to the lack of available data for the period studied in this paper.

Another important additional variable is the quality of education. The schooling variable considered in the regressions refers to the quantity of education, as measured by years of schooling, rather than its quality. The main issue in assessing the quality of education in a cross-country setting is finding internationally comparable measures of the performance of students, especially for developing and underdeveloped countries.

A third variable that might have a correlation with growth and was not included in the model proposed here due to data availability is income distribution. The most widely used measure of inequality is the GINI coefficient from the UNDP World Income Inequality Database (WIID). The effects of income distribution on growth are expected to be negative. It was not possible to include the GINI coefficient as an explanatory variable in the regression because this index was not available for the whole period studied here.
CHAPTER 5. Conclusion

Per capita growth rates vary significantly across countries and are systematically related to a set of quantifiable explanatory variables. One element of this set is a net convergence term, the positive effect on growth when the initial level of real per capita GDP is low relative to the starting amount of human capital in the forms of educational attainment and life expectancy. The results from the panel data regression using a Hausman-Taylor model show evidence of conditional convergence among the seventeen Latin American countries studied, as revealed by the negative sign of the initial level of per capita GDP. This result implies that these countries are converging to their steady state, the point of equilibrium of growth levels that a country tends to reach. Although the steady-state level was not estimated due to the small size of the sample, it is known that this point of equilibrium is related to the level of income, and as the level of income in Latin America is considerably lower than the income of developed countries, the results indicate that this region is converging to a low income level.

In addition, a significant relation between schooling and growth could not be found. What the empirical data suggests is that educational attainment is not a significant determinant for growth in Latin America. This result is not intuitive but might be explained by the economic policy put in place by most of the countries in this region over the last fifty years, which had a strong top-down approach and little focus on improving the human capital. Another, more technical, explanation might be the small variation in the data sample.

The variables found to be positively related to economic growth in Latin America are life expectancy, openness, and the investment ratio. The positive relation between life
expectancy and growth can be explained by the fact that life expectancy might be a proxy for features other than good health that reflect desirable performance of a society.

The finding that an increase in the openness to trade level increases the per capita growth rate corroborates the liberalization policies put in practice in Latin America in the last decades. This analysis also applies to the positive correlation between investment and growth as major reforms have been made in legislation governing trade and investment aiming at increasing these two factors.

On the other hand, growth declines with increases in the government consumption and in the level of democracy. The negative relation between government consumption and growth might be explained by the fact that higher government consumption leads to lower growth by shifting resources from productive activities and distorting private decisions. And the fact that higher levels of democracy seems to lead to lower levels of growth in Latin America can be related to the periods of strong growth under authoritarian governments that this region experienced.

The model proposed here seems to be well adjusted, with the important exception of the schooling variable. Based on most empirical and theoretical literature, one would expect the educational attainment variable to be positively related to growth. However, the model was not able to capture this relationship in the empirical data. As stated earlier, this might be explained by the small number of observations in the time series data, what hinders the inference power of the statistical method.

Latin America is heavily dependent on external markets to sustain its growth, and the time frame covered by this research has seen a large number of external shocks that greatly affected the economic performance of this region. One conclusion that can be
made from the results presented here is that growth in Latin America has not been carried out through the channels that tend to make it a sustainable experience, such as increased level of education. Moreover, the negative, although weak, link between democracy and growth shows that non-democratic governments were able to achieve some economic growth, at least in the short term. The conclusion that the countries in Latin America are reaching their steady-state should raise major concern due to the low income level of this region. This result points out the need to implement institutional changes in order to effect an upward shift in the steady-state, and consequently in the living standard of this region.
References


## Appendix

Table 1: Summary of the Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDPpc growth rate</td>
<td>1.33%</td>
<td>4.47%</td>
<td>-24.68%</td>
<td>18.54%</td>
</tr>
<tr>
<td>Population growth</td>
<td>2.46%</td>
<td>0.79%</td>
<td>-1.25%</td>
<td>5.27%</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>63.1</td>
<td>8.2</td>
<td>41</td>
<td>78.1</td>
</tr>
<tr>
<td>Openness</td>
<td>44.63%</td>
<td>28.52%</td>
<td>6.42%</td>
<td>175.1%</td>
</tr>
<tr>
<td>Gov. consumption (% of GDP)</td>
<td>18.50%</td>
<td>7.10%</td>
<td>3.08%</td>
<td>66.02%</td>
</tr>
<tr>
<td>Investment (% of GDP)</td>
<td>14.62%</td>
<td>6.49%</td>
<td>-3.46%</td>
<td>46.28%</td>
</tr>
<tr>
<td>Years of schooling</td>
<td>4.5</td>
<td>1.6</td>
<td>1.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Polity score</td>
<td>1.6</td>
<td>6.5</td>
<td>-9</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: Total number of observation is 833= 17 countries * 49 years (1952 to 2000).
Table 2: Data Summarized by Decade

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>3322.8</td>
<td>1.3%</td>
<td>54.1</td>
<td>3.5</td>
<td>38.7</td>
<td>16.6</td>
<td>15.6</td>
<td>-0.5</td>
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<td>Cum growth (%)</td>
<td>8.9</td>
<td>-66.4</td>
<td>7.2</td>
<td>3.0</td>
<td>3.9</td>
<td>4.9</td>
<td>-1.0</td>
<td>1.8</td>
</tr>
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</table>
Table 3: Descriptive Statistics by Country

| Country   | GDP per capita (Min) | GDP per capita (Max) | GDP per capita (Mean) | GDP per capita (Median) | GDP per capita (Std. Dev.) | Life Exp. (Min) | Life Exp. (Max) | Life Exp. (Mean) | Life Exp. (Median) | Life Exp. (Std. Dev.) | Openness (Min) | Openness (Max) | Openness (Mean) | Openness (Median) | Openness (Std. Dev.) | Gov. Consump. (Min) | Gov. Consump. (Max) | Gov. Consump. (Mean) | Gov. Consump. (Median) | Gov. Consump. (Std. Dev.) | Investment (Min) | Investment (Max) | Investment (Mean) | Investment (Median) | Investment (Std. Dev.) | Years of Schooling (Min) | Years of Schooling (Max) | Years of Schooling (Mean) | Years of Schooling (Median) | Polity score (Min) | Polity score (Max) | Polity score (Mean) | Polity score (Median) | Polity score (Std. Dev.) |
|-----------|---------------------|---------------------|----------------------|------------------------|--------------------------|---------------------------|----------------|----------------|----------------|----------------|------------------|----------------|----------------|----------------|----------------|------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|--|
Table 3: continued.

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<th>Gov. Consump. (% of GDP)</th>
<th>Investment (% of GDP)</th>
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<td>-12.73</td>
<td>66.7</td>
<td>14.07</td>
<td>13.59</td>
<td>8.43</td>
<td>5.13</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>9.68</td>
<td>75.2</td>
<td>45.38</td>
<td>23.18</td>
<td>19.95</td>
<td>7.56</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>1.06</td>
<td>70.5</td>
<td>24.39</td>
<td>17.99</td>
<td>12.09</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.05</td>
<td>69.9</td>
<td>21.84</td>
<td>18.23</td>
<td>11.64</td>
<td>6.16</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>4.86</td>
<td>2.5</td>
<td>9.41</td>
<td>2.65</td>
<td>2.95</td>
<td>0.77</td>
</tr>
<tr>
<td><strong>Uruguay</strong></td>
<td>Min</td>
<td>-8.77</td>
<td>56.4</td>
<td>36.24</td>
<td>5.82</td>
<td>7.61</td>
<td>2.64</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>8.57</td>
<td>72.8</td>
<td>94.60</td>
<td>17.41</td>
<td>30.98</td>
<td>6.69</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.12</td>
<td>66.8</td>
<td>66.17</td>
<td>11.85</td>
<td>17.72</td>
<td>4.29</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>0.08</td>
<td>67.9</td>
<td>66.06</td>
<td>13.83</td>
<td>15.98</td>
<td>3.63</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>4.30</td>
<td>4.9</td>
<td>14.92</td>
<td>3.87</td>
<td>5.71</td>
<td>1.41</td>
</tr>
</tbody>
</table>
Table 4: Regression Results

<table>
<thead>
<tr>
<th></th>
<th>Pooled OLS</th>
<th>Random-Effects</th>
<th>Fixed-Effects</th>
<th>Hausman-Taylor IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita growth</td>
<td>-0.0248 *</td>
<td>-0.0225 *</td>
<td>-0.03355 *</td>
<td>-0.03355 *</td>
</tr>
<tr>
<td>rate (t-1)</td>
<td>(0.0052)</td>
<td>(0.0059)</td>
<td>(0.00762)</td>
<td>(0.00754)</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>0.0606 *</td>
<td>0.0545 *</td>
<td>0.04422 **</td>
<td>0.04422 **</td>
</tr>
<tr>
<td></td>
<td>(0.0186)</td>
<td>(0.0205)</td>
<td>(0.02458)</td>
<td>(0.02433)</td>
</tr>
<tr>
<td>Openness</td>
<td>-0.00009</td>
<td>-0.00006</td>
<td>0.00024 *</td>
<td>0.00024 *</td>
</tr>
<tr>
<td></td>
<td>(0.00006)</td>
<td>(0.00007)</td>
<td>(0.000119)</td>
<td>(0.000118)</td>
</tr>
<tr>
<td>Gov. consumption (% of GDP)</td>
<td>-0.0009 *</td>
<td>-0.00113 *</td>
<td>-0.00160 *</td>
<td>-0.00160 *</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.00026)</td>
<td>(0.000313)</td>
<td>(0.000309)</td>
</tr>
<tr>
<td>Investment (% of GDP)</td>
<td>0.0019 *</td>
<td>0.00196 *</td>
<td>0.00172 *</td>
<td>0.00172 *</td>
</tr>
<tr>
<td></td>
<td>(0.00025)</td>
<td>(0.00028)</td>
<td>(0.000367)</td>
<td>(0.000363)</td>
</tr>
<tr>
<td>Years of schooling (t-1)</td>
<td>-0.0033 *</td>
<td>-0.00311 **</td>
<td>-0.00231</td>
<td>-0.00231</td>
</tr>
<tr>
<td></td>
<td>(0.0015)</td>
<td>(0.00178)</td>
<td>(0.002521)</td>
<td>(0.002495)</td>
</tr>
<tr>
<td>Polity score</td>
<td>-0.0005 *</td>
<td>-0.00052 **</td>
<td>-0.00065 *</td>
<td>-0.00065 *</td>
</tr>
<tr>
<td></td>
<td>(0.00025)</td>
<td>(0.00028)</td>
<td>(0.000322)</td>
<td>(0.000319)</td>
</tr>
<tr>
<td>Population growth</td>
<td>-0.3238</td>
<td>-0.27447</td>
<td>0.01823</td>
<td>0.01823</td>
</tr>
<tr>
<td></td>
<td>(0.2676)</td>
<td>(0.29191)</td>
<td>(0.345117)</td>
<td>(0.341543)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0498</td>
<td>-0.00865</td>
<td>0.11389</td>
<td>(dropped)</td>
</tr>
<tr>
<td></td>
<td>(0.0610)</td>
<td>(0.06975)</td>
<td>(0.09308)</td>
<td></td>
</tr>
</tbody>
</table>

Note: (*) Statistically significant at the 5% significance level.
     (**) Statistically significant at the 10% significance level.
Table 5: Hausman Tests Results

<table>
<thead>
<tr>
<th>Test</th>
<th>Chi 2</th>
<th>Prob &gt; Chi 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-Effects vs. Random-Effects</td>
<td>36.05</td>
<td>0.00</td>
<td>Rejects $H_0$</td>
</tr>
<tr>
<td>Fixed-Effects vs. Hausman-Taylor IV</td>
<td>0.00</td>
<td>1.00</td>
<td>Does not reject $H_0$</td>
</tr>
</tbody>
</table>

Note: $H_0$: difference in coefficients not systematic.