CROSS SECTIONAL STUDY OF GROWTH IN DEVELOPED AND DEVELOPING COUNTRIES: AN ANALYSIS OF THE ENDOGENEITY OF HUMAN CAPITAL AND INCOME INEQUALITY

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Luiz A. de Paula

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To the Graduate Council:

I am submitting herewith a dissertation written by Luiz A. de Paula entitled "Cross Sectional Study of Growth in Developed and Developing Countries: An Analysis of the Endogeneity of Human Capital and Income Inequality." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

Gregory K. Pompelli, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor
and Dean of The Graduate School

DEDICATION

This dissertation is dedicated to my wife

Marúzia Helena Ribeiro Almeida de Paula

and my daughter

Luiza Almeida de Paula

whose love and patience were fundamental to this achievement,

and to my parents

Raimundo Antônio de Paula

and

Maria Elsa Maciel de Paula

who have always encouraged me to pursue high education.

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ABSTRACT

In the 1950s economic growth was hypothesized to be a function of the saving rate and the capital-output ratio. The higher the saving rate, the higher the rate of output growth till steady state reached. As a result, income inequality was thought to promote growth because of the high marginal propensity to save of the rich.

In the 1960s and the 1970s economic growth models recognized that technical progress was necessary to provide permanent growth. In these models variables such as the saving rate, technology, population growth, and the depreciation rate were considered exogenous.

More recently, economic growth models have endogenized some of the variables previously considered exogenous in an attempt better to explain economic growth. These studies known as endogenous growth models consider the effects of human capital as well as income inequality and other variables to provide a more complete view of economic growth.

This study extends endogenous growth theory by combining agricultural development with the endogenous growth models. The formulation used in this study extends single-equation models of Persson and Tabellini (1994) and Alesina and Rodrik (1994). Instead of a tradeoff, the joint effects of growth and distribution are used to measure economic development. The role of agriculture is examined and land tenure patterns are used to better understand the forces that enable a country to grow over time and to determine why output per capita varies across countries. The data are from

Summers and Heston (1988), Barro and Wolf (1989), Alesina and Rodrik (1994), and the World Bank. Forty-one developed and developing countries are included in the sample.

The model developed in this study was specified as a system of simultaneous equations, thus per capita growth rate, human capital, and income concentration were jointly determined. The results indicate that greater income concentration reduces economic growth. This supports the idea that growth and income distribution go together. In addition, land ownership concentration was found to reduce human capital and increase income inequality, which constrained growth rates. Therefore, these results support findings of Persson and Tabellini (1994) and Alesina and Rodrik (1994) and improve their models by endogenizing human capital and income concentration.

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CHAPTER I

INTRODUCTION

Background of the Problem

The first model of permanent economic growth was formulated by Solow (1956). This model represents a significant improvement in capital accumulation theory. It gives the evidence for the indefinite increase in output per worker determined by technical progress. Nevertheless, this model treats technology, the saving rate, and population growth as exogenous variables. Thus, it does not answer what causes technological progress and why some countries use different technology than others.

Traditional growth studies ignored critical factors that are interconnected with the dynamics of growth. Most conventional approaches emphasize the analysis of physical capital as the only determinant of per capita output growth neglecting the effects of other factors such as human capital and institutions. In addition to technological change, institutional change also determines subsequent growth. Early models are usually static and fail to incorporate the distributional impacts of growth into the dynamic process. The exogeneity of some key variables and the neglect of those critical factors are the main criticisms from the endogenous growth theory which attempts to explain the determinants of those variables which neoclassical models treated as exogenous.

This new approach to growth that emerged from the 1980s emphasizes that "economic growth is an endogenous outcome of the economic system, not the result of forces that impinge from outside" (Romer, 1994). Endogenous growth theorists have stressed the endogeneity of technology, which is provided by entrepreneurial decisions (Romer, 1986; Lucas, 1988); the importance of human capital for growth in income (Becker, Murphy, and Tamura, 1990; Mankiw, Romer, and Weil, 1992; and others); and the convergence hypothesis (Barro, 1991; Mankiw, Romer, and Weil, 1992) among other basic questions left unexplained by the neoclassical model.

The endogenous growth theory is an alternative view to the early growth thinking but it fails to take into account the agrarian question and the concentration of income in less developed countries (LDCs). Indeed, the neglect of income distribution is not a new phenomenon. Chenery et al. (1974) point out that the rapid growth of the 1960s and 1970s in LDCs led to increasing inequalities. The Kuznets's inverted-U hypothesis[1] came under criticism and the reformists suggested a reorientation of policy in order to face the problem of economic concentration.

Following the resurgence of studies on economic growth, Chang (1994) reviews the trade-off between income equality and economic growth. The author analyzes the actual direction of causality and concludes that income inequality has a negative effect on growth. However, he suggests that the result should be analyzed carefully by considering

[1] Kuznets (1955) hypothesis states that income inequality increases in the first stages of growth and then decreases in the late stages.

the "theories that focus on the relation between economics and politics and . . . the role of imperfect financial markets."

By analyzing the relationship between economics and politics, given by the level of taxation and voting, Alesina and Rodrik (1994) formulate a model that describes how factor endowment inequality is negatively correlated with growth. Although they give an important contribution to the endogenous-theory literature, they fail to explain the determinants of human capital and income inequality, and the role of land ownership concentration in the growth process.

Statement of the Problem and Justification

Even though some recent endogenous growth models have dealt with distributional issues, this study examines that their empirical specifications could be improved in order to better describe the relationship between growth and some of its determinants such as human capital and income inequality. Therefore, this study is concerned with the following questions:

1. What are the effects of the concentration of income and land ownership on economic growth?
2. What are the determinants of human capital and income inequality?

It seems reasonable that a theory of growth takes into consideration the agricultural sector which often is the main sector of the economy in less developed countries. Agricultural activity in LDCs has its peculiarities because of structural constraints of the traditional agriculture (Ghatak and Ingersent, 1984). When constraints such as land ownership concentration and illiteracy are not recognized both growth and development tend to fail. Therefore, development strategies need to consider the development of the agricultural sector simultaneously with industrialization.

Despite the evolution of the endogenous growth theory, some endogenous determinants of growth are still taken exogenously. Indeed, the most recent studies of Persson and Tabellini (1994) and Alesina and Rodrik (1994) recognize this weakness and even suggest future research to endogenize income inequality.

Research Objectives

The main objective of this study is to investigate the relationship between economic growth and income inequality and human capital. Unlike the mainstream growth theory, it considers the reverse relation in which income distribution explains growth. Also, it treats human capital and income inequality as endogenous variables explained by land ownership concentration and other relevant variables. According to Griffin (1976), "the distribution of income in the agricultural sector and the standard of living of the majority of the rural population are greatly affected by the degree of land concentration. Indeed, in not a few countries, the only way quickly to increase the well-being of the poor would be through a redistribution of landed wealth. . . ." Therefore, the specific objectives include:

1. to test the effect of income inequality on growth;

2. to examine the endogeneity of human capital and income inequality; and

3. to test the influence of land ownership concentration on human capital and income inequality.

This research expects to contribute to the investigation of sources and permanence of poverty in LDCs by approaching the problem from a holistic view by giving more importance to other determinants of growth that are often not considered in the literature. In particular, the constraint of land ownership concentration. This study is a variation of recent papers that deal with the theory of endogenous growth. It attempts to contribute to this debate by making clear the distinction between growth and development and specifying a joint determination of growth, human capital, and income inequality.

The plan of the study is as follows: Chapter II focuses on a historical analysis of development thought, models of economic growth, human capital, income distribution, and the importance of agriculture and institutions in developing economies; Chapter III states the hypotheses and describes the model and the data; Chapter IV presents and discusses the results; and Chapter V presents the conclusions and policy implications.

CHAPTER II

LITERATURE REVIEW

The Evolution of Development Thought

Economic development was established as a branch of economics after World War II. The Keynesian contribution to macroeconomic analysis and postwar political order transformations were the basis for the development theory formulation. Even though Keynes dealt with fluctuations in developed economies, his view of an active government intervention was followed by some economists to formulate their approaches to structural problems in developing countries. The analysis of development is often characterized by two different views: the orthodox and the heterodox development thoughts. It is essential to go back to the basis of development theory to understand both points of view.

Capital Accumulation and Industrialization Strategy

The idea of capital accumulation and industrialization prevails in the early development thought. According to its supporters, the lack of capital resources is an obstacle to increase output which becomes a barrier to growth. For instance, the Harrod-Domar model[2]

[2] Harrod (1939) and Domar (1946).

described the conception of allocation of part of national income to new investment representing net addition to capital stock. This model can be simplified as follows:[3] capital-output ratio, $K/Y = a$, is the amount of capital necessary to produce one unit of output (or GNP). The saving ratio, s, is a fixed proportion of national output (or income), $S = sY$, and investment is defined as the change in capital stock, $I = \Delta K$. Since capital-output ratio is constant,

$$\frac{K}{Y} = a \quad or \quad Y = \frac{1}{a}K \quad and \quad \Delta Y = \frac{1}{a}\Delta K. \tag{2.1}$$

That is, a rise in output is determined by an increasing in capital. Therefore, $\Delta K/\Delta Y$ is the marginal capital-output coefficient which equals the constant average ratio.

Given that $S = I$, this can be rewritten as $S = sY = a\Delta Y = \Delta K = I$. Note that sY equals $a\Delta Y$. After some manipulations

$$\frac{s}{K/Y} = \frac{\Delta Y}{Y}, \tag{2.2}$$

where $\Delta Y/Y$ is the rate of growth of GNP. However, this model is extremely mechanical because it just considers the rate of investment as the determinant of economic growth. The calculation of the rate of growth is given by the national savings ratio to the national capital-output ratio. This is clearly a misinterpretation of Keynesian theory. Harrod-Domar model borrows Keynes conception to explain the mechanism of increasing savings to generate investment toward growth. Nevertheless, that conception focuses on developed countries (DCs) which face depression problems and aim to growth without inflation.

[3] Todaro (1989) and Leite (1983).

Rostow (1952) defines the process of economic growth as an evolution from a traditional society to the age of mass consumption. His conception of stages of growth accentuates the "take-off" as a momentum in which the society is transformed in such a way that economic growth follows as a natural consequence. As intermediate stages, he also points out the preconditions for "take-off" and its following maturity. This model is supposed to be applied in any country qualified as underdeveloped. Therefore, the vicious circle of poverty can be broken and transformed in a virtuous circle.

Rostow (1952) states that the "take-off" needs an increase in the rate of investment from 5 percent to 10 percent of national income; creation of a leading manufacturing sector; and social, political, and institutional changes in order to lead this transformation. He assumes that capital should be mobilized not only from domestic sources but also from foreign investors. The idea of capital formation is implicitly included as a precondition. The criteria of capital-output ratio and investment-ratio require both a raise in investment rate and a rapid increase in the leading manufacturing sector. Indeed, "in most underdeveloped countries, net capital formation is not as high as 5% of the national income, even when foreign investment is included" (Oman and Wignaraja, 1991).

Many debates and criticisms were raised concerning Rostow thesis. Todaro (1989) shows the economic logic of the Harrod-Domar-Rostow approach and points out the increase in the proportion of national income saved as a fundamental "trick" of the economic growth. However, the lack of capital in LDCs leads to a savings gap which is supposed to be overwhelmed by the massive transfer of capital from DCs. Nevertheless, the mechanism of savings and investment is a necessary condition for acceleration economic growth but it is not sufficient by itself. The capital constraint in underdeveloped countries is a reality but the lack of infrastructure is also an obstacle to growth which was not the case observed in Europe during post-war reconstruction. Therefore, the "linear-stage theory" is an attempt of economists from industrialized countries to formulate a development theory for poor countries. When this concern appeared after World War II, those economists based their knowledge to analyze this problem on the experience of the Marshall Plan applied in Europe.

The analysis of the problems of development motivated the rise of other models and points of view. Rosenstein-Rodan (1943) emphasizes industrialization as way of development in depressed areas. This approach is called "big-push" which means the creation of a strong industrial sector with different industries producing the bulk of wage goods and generating external economies. The complementarity of these industries contributes to expanding the market and stimulating private investment with less risk. Nurkse (1953) points out the vicious circle of poverty in terms of the market size as a constraint to development. He believes that the circle can be broken and a country can achieve development through "balanced growth." On the other hand, Hirschman (1958) suggests that instead of a plain strategy, the alternative way of "unbalanced growth" would stimulate the more active sectors which would pull the more passive ones forward. The industry with the greatest number of linkages will provide the "forward and backward linkages" to move the economy toward growth.

The early orthodox development thinking relies basically on capital formation and industrialization. None of the approaches is concerned about the distribution of income and the role of the agriculture in development. Indeed, these models should be defined as traditional models of economic growth. "Development was seen primarily as a matter of 'economic growth,' and secondarily as a problem of securing social changes necessarily associated with growth" (Streeten, 1979).

Heterodox Approach: Structuralism and Dependency

The transformations after World War II and the Keynesian analysis of the state intervention led to creation of the heterodox development thought mainly produced in LDCs (Oman and Wignaraja, 1991). This view also focuses on industrialization but in an opposite way comparing with the orthodox view. In particular, the structuralist school opposes the historical growth process defined as "outward-oriented." The center-periphery paradigm divides the world into two poles in which underdeveloped countries (the periphery) are characterized by subsistence agriculture, coexisting with some modern structures, and exports that are limited to primary products with no diversification. The developed countries (the center) present modern production techniques throughout the whole diversified economy.

As a member of the structuralist school, Prebisch (1962) argues against the neoclassical idea that the forces of the international market will share the benefits with

LDCs. Unlike DCs, the "periphery" has not been reached by those benefits because of the low income elasticities of demand for primary products and the deterioration of terms of trade. He concludes that LDCs should industrialize themselves to obtain the benefits of technology. The concept of "outward-oriented growth" should be changed to "inward-oriented growth" which is well known as import-substituting industrialization (ISI). Thus, different from Rosenstein-Rodan (1943) and Nurkse (1953), Prebisch (1962) concepts do not defend underdeveloped countries as an appendix of the modern industrial center. This evidence represents an important step in the evolution of economic development thought because it means a benchmark of an alternative conception of development created in developing countries. For instance, the structuralism views the problem of unemployment in LDCs as structural, i.e., as a problem of underdevelopment instead of a temporary problem as would be the case of a crisis under the great depression of the 1930s.

The structuralists initially also neglected agriculture since the priority was given to "import substitution of manufactured goods rather than to production of agricultural exports" (Eicher and Staatz, 1990). In the 1960s, U.N. Economic Commission for Latin America (ECLA)'s policies shifted towards social issues[4] and the analysis of obstacles in the agricultural sector such as the structure of production, land ownership and tenancy, and pre-capitalist social values that should be transformed in order to contribute to economic development. "The agrarian-reform proposals emphasized the need not only to transform the structures of land ownership and tenancy but also to stimulate production

[4] Health and education services, housing, employment creation, and training programs.

through technical assistance, credit supports and appropriate price policies" (Oman and Wignaraja, 1991).

In the mid-1960s the dependency school emerged with a more radical interpretation of the development process. Although three different currents[5] are usually mentioned in studies of this school of thought, a general definition of dependency is provided by dos Santos (1970): "Dependence is a conditioning situation in which the economies of one group of countries are conditioned by the development and expansion of others. A relationship of interdependence between two or more economies or between such economies and the world trading system becomes a dependent relationship when some countries can expand through self-impulsion while others, being in a dependent position, can only expand as a reflection of the dominant countries, which may have positive or negative effects on their immediate development." Even though those currents differ in essence, they all agree that dependency tends to benefit the local elites in developing countries. Foreign investment in capital-intensive industry favor the higher income groups increasing the "disparities in income distribution" (Oman and Wignaraja, 1991).

Unlike the early development thought, the dependency approach gives a significant role to agricultural and rural development. One of the main arguments of the dependency school was the stagnation of traditional agriculture due to the preservation of backward

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[5] According to Oman and Wignaraja (1991): (1) Celso Furtado and Osvaldo Sunkel; (2) Paul Baran, A. Gunder Frank, and Teodomiro dos Santos; and (3) F. Henrique Cardoso and Enzo Faletto.

agrarian structures.[6] "[T]he economic and political system was dominated by an alliance between a new national elite based on the monopolization of trade and industrial relations with the center and the older, socially and politically powerful agrarian elite" (Hayami and Ruttan, 1985). In the particular case of Latin America, Hayami and Ruttan (1985) discusses the roots of historical rural poverty.[7] At the "international level," the dependence between the periphery and the center is responsible for underdevelopment of the former. At the "sectoral level," the relationship between the capital-intensive industry and labor-intensive industry and agriculture leads to strengthen the subjugation of the subsistence sector. At the "social level," the production relations between landlords and agricultural laborers result in undervalued labor and food.

The heterodox development thinking seems to give much attention to the structural problems and social issues that are typical of developing countries. In contrast to the early development theories, the agrarian question is viewed as fundamental to understand the pattern of development. "The growth-stages theories attempt to explain the process of transformation from a primarily agrarian to an industrial economy. . . . The dependency perspective attempts to explain why the periphery remains trapped in a backward agrarian state. In the dependency view incorporation of rural areas into the market is the source of marginalization - it perpetuates rather than erodes dualism" (Hayami and Ruttan, 1985).

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[6] "Agrarian structure is characterized by a system of social relations (modes of production and their corresponding social class composition) and a system of land tenure (ownership and usufruct of land and water by farm sizes)" (de Janvry, 1981a).

[7] Based on de Janvry (1981b).

Models of Economic Growth

The Neoclassical Economic Growth Theory

The neoclassical model of economic growth formulated by Solow (1956) specifies the output of a single composite commodity as a function of two factors of production, the community stocks of capital, $K(t)$, and labor, $L(t)$. Market-clearing conditions assume full employment of labor force and capital. The output, $Y(t)$, is equal to the amount of output supplied and the amount of labor input is equal to the amount of labor that workers wish to sell. The aggregate production function is defined as

$$Y = F(K, L). \tag{2.3}$$

Since the model is concerned with per capita output, the production function will assume constant returns to scale (CRS). That is, an increase in K and L by the factor z will increase the output by the same proportion. Setting $z = 1/L$,

$$Y/L = F(K/L, 1), \tag{2.4}$$

now output per worker, $y = Y/L$, is a function of capital per worker, $k = K/L$. Therefore, the model can be rewritten as

$$y = f(k). \tag{2.5}$$

The CRS production function has the property that output per worker depends only on the amount of capital per worker. Also, the model assumes diminishing returns to capital.

Thus, a country with small capital stock will have a higher marginal productivity of capital which leads to a higher profitability of capital than a country with large capital stock.

Solow assumes that saving is a constant fraction of output (or national income), $sY(t)$, exogenously taken by the model. If S is gross saving, then

$$sY = S = I = dK/dt, \tag{2.6}$$

where I is gross investment. Therefore,

$$\text{saving} = sy = I/L = \text{investment}, \tag{2.7}$$

expressed into a per worker form. Notice that investment is determined by saving in the market-clearing model.

The evolution of the capital stock per unit of labor is defined as

$$\dot{k} = sf(k) - \delta k \tag{2.8}$$

where $\dot{k} = dk/dt$ is net investment per worker, $sf(k)$ is gross investment, δ is the depreciation rate, and δk is depreciation. The steady state is defined at $\dot{k} = 0$. Therefore, at the steady state, $sf(k) = \delta k$. Gross investment has to exceed depreciation in order to have any net addition to capital stock. Suppose that the initial situation is defined at a low level of capital per worker k where $sf(k) > \delta k \Rightarrow \dot{k} > 0$. The amount of capital per worker is relatively small and in particular, saving exceeds depreciation. Capital per worker rate will rise up to the steady state k^* where investment is equal to depreciation. Thus, at the steady state, the addition to capital stock is zero. Further, that k rises is important to output per worker because y increases with a move to the right along the investment curve.

As the capital to labor ratio goes up, more investment is needed because the capital stock is wearing out. Therefore, the economy needs more to replace it. The higher the capital stock, the greater the amount of depreciation. Since δ is a constant, δk will be a straight line. As k rises, part of the output per worker goes up. Since the amount of saving is a constant fraction of the amount of the output per worker, saving goes up as $(Y/L)s$. However, this is not a straight line because as Y/L rises, output rises but at a diminishing rate. Consequently, multiplying that ratio by a constant s gives a curve $sf(k)$. The slope diminishes as k rises.

Considering a country which is initially at k_1* and s_1. If the saving rate goes up to s_2, it will shift that curve up. For any level of k, people now will save a larger fraction of the output, s_2. This amount will be available for investment. Then investment will rise and, given δ, the capital to labor ratio goes up. Since the new steady-state $s_2f(k) = \delta k_2$ will be higher, the ratio of output per worker y_2* will be higher considering the country's production function. Notice that the rate of growth is higher only temporarily. This occurs because depreciation also is higher. Part of the new investment must be used to replace the portion of capital that is wearing out. Once the economy reaches y_2*, there will be no further gains in growth. Hence, higher saving is not an answer to the desire of achieving permanent economic growth. Economic growth is only temporary and moves the economy from one equilibrium to the next equilibrium. Certainly Solow model is an improvement on those models such as Harrod-Domar's that just considered capital accumulation and the saving rate. It shows that a higher saving rate is not enough to achieve permanent long-run economic growth and that other variables should be considered.

So far this analysis has been considering that the growth rate of labor force, g_L, is equal to zero. Now considering population growth, the model becomes

$$\dot{k} = sf(k) - \delta k - g_L k \tag{2.9}$$

or

$$\dot{k} = sf(k) - (\delta + g_L)k. \tag{2.10}$$

Since the growth rate of labor force is positive, the economy needs an amount of investment not only to replace the depreciated capital but also to provide new workers with capital. Notice that in Solow model, g_L is exogenous. Like depreciation, the model does not explain the rate of population growth.

Without technical progress the model predicts that, in the steady state,

$$\frac{dY/dt}{Y} = \frac{dK/dt}{K} = \frac{dL/dt}{L}, \tag{2.11}$$

which means that output grows at the same rate as capital and labor. Therefore, output per person is not growing or $\dot{y} = 0$. However, the evidence based on the U.S. economy shows that

$\frac{dY/dt}{Y} > 0$, i.e., the rate of growth of Y per unit of time is positive, and

$\frac{dY/dt}{Y} > \frac{dL/dt}{L}$, i.e., output goes up faster than labor which implies that Y/L increases. Capital investment can no longer be the reason for this additional output growth because capital stock is increasing at the same rate as labor force. That is, since there is no increase in K/L, then Y/L should stay constant.

In order to provide an explanation of how it is possible for output per worker to rise over time, Solow introduces technical progress in his model

$$Y = F(K, E) \tag{2.12}$$

or

$$Y/E = F(K/E), \tag{2.13}$$

where E is the number of effective units of labor, $E = L\xi$, and ξ stands for the effectiveness of labor (productivity of labor) which grows at rate λ. The increase in knowledge raises the productivity of labor. Now even in the steady-state there will be growth. Investment is needed not only to replace depreciated capital and to provide new workers with capital, but also to allow for the increase in labor productivity. Thus, in the steady state

$$sf(K/E) = (\delta + g_L + \lambda)\, K/E, \tag{2.14}$$

where $(\dot{K/E})$ and $(\dot{Y/E})$ are zero but $\dot{y}$ is positive because $\lambda > 0$. The effective labor is growing faster than the raw labor force. Therefore, the amount of output per worker is increasing. The rate of growth λ is in fact the rate of technical progress. Notice that Y also grows by the magnitude $(g_L + \lambda)$. This would be the equivalent to the long-run rate of growth of GDP. Since g_L is positive, then total output grows faster than the output per worker.

Solow model gives an explanation for the indefinite increase in the output per worker. Technical change is the hero in Solow model. Nevertheless, in addition to s, δ, and g_L, his model treats technology as exogenous. So it does not answer what causes technological progress and why some countries use different technology than others. Thus, if a LDC wished to raise its growth rate, the model will tell it that the country will need technical progress. However, if the country's policy makers asked what could they do to have that technology, the model would answer that it is exogenous. This is the main criticism from the endogenous growth theory. It attempts to explain the determinants of λ and the other exogenous variables.

Endogenous Growth Theory

Endogenous growth theory views growth as result of internal forces that work within the market system. Technological change is not disembodied of the entrepreneurial decision and does not depend only on scientific discoveries. The allocation of resources is governed by a motivating set of forces that drives the economy. Maximization of profits is the motivating force in the Romer model (1990). "The existence of capital markets in which entrepreneurial assets can be bought and sold induces investment in technical innovations, which mainly benefits future generations, simply as a result of self-interest"

(Ehrlich, 1990). Market incentives play an important role in economic growth through price signals.

It is clear that physical capital accumulation by itself is not sufficient to achieve economic growth because of depreciation and population growth. Endogenous growth models consider knowledge as the catalyst to increase productivity either in the form of human capital or in the process of technological innovation. The endowment of human capital is necessary to the adoption of innovative techniques.

Mankiw, Romer, and Weil (1992) analyze the empirics of economic growth in a recent cross-country study. Their hypothesis states that Solow model failed to predict the magnitudes of the effects of savings and population growth. Since Solow model just considered physical capital, they conclude that the exclusion of human capital in that model leads to an overestimation of the influence of the saving rate and population growth. They assume a Cobb-Douglas production function at time t:

$$Y(t) = K(t)^{\alpha}(A(t)L(t))^{1-\alpha} \qquad 0 < \alpha < 1, \tag{2.15}$$

where A is the level of technology, $A(t)L(t)$ is the effective units of labor, and α and $1-\alpha$ are the shares of income received by capital and labor, respectively.

Introducing the saving rate, s, as a constant fraction of output, the evolution of the capital stock per unit of labor, $\dot{k} = dk/dt$, is given by the following equation:

$$\begin{aligned} \dot{k} &= sy - (\delta + g_L + \lambda)k \\ &= sk^{\alpha} - (\delta + g_L + \lambda)k, \end{aligned} \tag{2.16}$$

where $y = Y/L$, $k = K/L$, δ is the rate of depreciation, g_L is growth rate of labor force, λ is technical progress, and $(g_L + \lambda)$ is the growth rate of the effective units of labor. The steady state is defined as follows:

$$sk^{*\alpha} = (\delta + g_L + \lambda)k^*, \tag{2.17}$$

or

$$k^* = [s/(\delta + g_L + \lambda)]^{1/(1-\alpha)}. \tag{2.18}$$

Substituting (2.18) into (2.15) and taking logs, the model becomes

$$\ln(Y/L) = a + \frac{\alpha}{1-\alpha}\ln(s) - \frac{\alpha}{1-\alpha}\ln(\delta + g_L + \lambda) + \varepsilon \tag{2.19}$$

where a is a constant equal to $\ln A(0) - \varepsilon$, and ε is a country-specific shock.

To test the prediction of Solow model, Mankiw, Romer, and Weil (1992) estimate the basic specification, equation (2.19), with ordinary least squares (OLS). The annual data are from Summers and Heston (1988) and the World Bank, and cover the period from 1960 to 1985:

$$\ln(y) = \underset{(1.55)}{5.36} + \underset{(0.17)}{1.31}\ln(I/Y) - \underset{(0.53)}{2.01}\ln(\delta + g_L + \lambda) \tag{2.20}$$

where $s = I/Y$ and the figures in parentheses are standard errors. Following the assumptions of Solow model, their study assumes that technology and depreciation are considered the same for all countries.[8] Thus, g_L is the second variable in the right-hand side of the equation (2.20).

[8] Although technology can be transferred from one country to another, each country develops its own technology and nothing guarantees that they will be the same. Also, the rate of depreciation is supposed to vary according to the quality of the physical capital. Therefore, that is not a reasonable assumption. Nevertheless, Mankiw, Romer and Weil (1992) assume that $(\delta + \lambda) = 0.05$ and conclude that "changes in this assumption have little effect on the estimates."

The parameter estimates are significantly different from zero and the signs are correctly predicted. Solow model rightly expects that an increase in the saving rate will lead to an increase in output per worker. Also, an increase in labor force will lead to a decrease in output per worker. Nevertheless, the coefficient estimates for physical capital and for the growth of labor force are considered too high. The share of income received by capital was expected to be one third according to historical data. Therefore, the estimated coefficient for ln(*I/Y*) was expected to be one half (Mankiw, Romer, and Weil, 1992).

To overcome this weakness, Mankiw, Romer, and Weil's (1992) study introduces human-capital accumulation to the previous model:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} (A(t)L(t))^{1-\alpha-\beta}, \tag{2.21}$$

where H is human capital, α is physical capital's share of income, β is human capital's share of income, and $1\text{-}\alpha\text{-}\beta$ is effective labor's share of income. The OLS estimation of the augmented Solow model gives the following equation:

$$\ln(y) = \underset{(1.19)}{7.81} + \underset{(0.15)}{0.70}\ln(I/Y) - \underset{(0.40)}{1.50}\ln(\delta + g_L + \lambda) + \underset{(0.10)}{0.73}\ln SCHOOL \tag{2.22}$$

where the figures in parentheses are standard errors. The proxy for human capital is the fraction of eligible population enrolled in secondary school, *SCHOOL*. The coefficient estimate for *SCHOOL* is statistically significant and has the correct sign. This means that accumulation of human capital contributes to subsequent growth. Also, this alternative specification gives a lower coefficient for physical capital as was expected.

Mankiw, Romer, and Weil (1992) conclude that the addition of human capital to the Solow model improves its performance. They suggest that future research should relax Solow model assumptions allowing the exogenous variables to vary across countries. They "expect that differences in tax policies, education policies, tastes for children, and political stability will end up among the ultimate determinants of cross-country differences" (Mankiw, Romer, and Weil, 1992).

Another specification was designed to test the predictions of the convergence hypothesis which states that countries with low initial per capita GDP grow faster than rich countries:

$$\dot{y} = a_0 + a_1 \ln y_{60}, \tag{2.23}$$

where the dependent variable is the change in the log of income per capita over the period 1960 to 1985, and y_{60} is the income per capita in 1960. The estimated equation for the unconditional convergence in a sample of 75 countries is

$$\dot{y} = \underset{(0.43)}{0.59} - \underset{(0.05)}{0.004} \ln y_{60}. \tag{2.24}$$

Considering the standard errors in parentheses, the estimated coefficient is not significant. This means that even though initial income per capita is negatively related to the growth rate, the model does not support the convergence hypothesis. In addition, the adjusted R-square is -0.01.

But the Solow model predicts conditional convergence. That is, after controlling for the determinants of the steady state (equilibrium). Introducing the measures of the rates of investment, I/Y, and population growth, g_L, Mankiw, Romer, and Weil (1992) estimated the conditional convergence:

$$\dot{y} = \underset{(0.86)}{2.23} - \underset{(0.06)}{0.23} \ln y_{60} + \underset{(0.10)}{0.64} \ln(I/Y) - \underset{(0.31)}{0.46} \ln(\delta + g_L + \lambda), \tag{2.25}$$

where the figures in parentheses are standard errors and the adjusted R-square is 0.35. The estimated coefficient of initial income per capita becomes significantly negative, as predicted by conditional convergence. Also, the estimate for the saving rate is positively related to growth as shown before. The estimated coefficient for population growth is not significant in this specification.

Adding the measure of human capital improves the fit of the regression and the significance of the variables:

$$\dot{y} = \underset{(0.91)}{3.69} - \underset{(0.07)}{0.37} \ln y_{60} + \underset{(0.10)}{0.54} \ln(I/Y) - \underset{(0.28)}{0.55} \ln(n + g + \delta) + \underset{(0.08)}{0.27} \ln(SCHOOL), \tag{2.26}$$

where the figures in parentheses are standard errors and the adjusted R-square is 0.43. These results mean that poor countries grow faster than the rich ones if the rate of investment, population growth, and human capital do not vary across countries. That is, convergence is conditional on the saving rate, population growth, and human capital. Note that the saving rate and population growth are among those variables that determine the steady state in Solow model. The results of this paper give not only the evidence of the conditional convergence but also the relevance of human capital in economic growth.

Barro (1991) also states that the neoclassical growth theory may have ignored the role of human capital. His paper raises the question of the negative relation between growth and the initial GDP level. Since poor countries have small capital stock, they can generate higher marginal productivity of that factor if *K/L* has diminishing returns. Those countries will take advantage of technology, but there is no empirical evidence[9] that they will catch the per capita income levels of the rich ones. Unless other determinants are considered, the convergence hypothesis will be inconsistent. Barro's hypothesis states that the factor that supports conditional convergence is the given level of human capital. That is, a poor country will grow faster than a rich country only if the level of human capital in the former is higher than it would be given its income level.

The data for Barro's study are from the Penn World Table of national accounts (Summers and Heston, 1988), the United Nations, the World Bank, Barro and Wolf (1989) data set, and other sources. The basic model presents fourteen different specifications of OLS regressions for growth rates of per capita real GDP from 1960 to 1985 in a cross section of 98 countries.

The basic results are related to the regression of the growth rate of real per capita GDP from 1960 to 1985 (*GR6085*) against the 1960 value of real per capita GDP (*GDP60*); secondary-school enrollment rate (*SEC60*); primary-school enrollment rate (*PRIM60*); the average from 1970 to 1985 of the ratio of real government consumption (exclusive of defense and education) to real GDP (g^c/y); number of revolutions and coups per year (*REV*); number of assassinations per million population per year (*ASSASS*); and the magnitude of the deviation of the 1960 purchasing-power-parity value for the

[9] Note that Barro's (1991) paper was written before Mankiw, Romer, and Weil (1992) have provided empirical evidence of (conditional) convergence.

investment deflator (U.S. = 1.0) from the sample mean (*PPI60DEV*). The first estimated equation is described as follows:

$$GR6085 = \underset{(0.0066)}{0.0302} - \underset{(0.0012)}{0.0075}GDP60 + \underset{(0.0079)}{0.0305}SEC60 + \underset{(0.0056)}{0.0250}PRIM60$$

$$- \underset{(0.028)}{0.119}g^{c}/y - \underset{(0.0063)}{0.0195}REV - \underset{(0.0155)}{0.0333}ASSASS - \underset{(0.0053)}{0.0143}PPI60DEV, \qquad (2.27)$$

where the figures in parentheses are standard errors of coefficient estimates.

Barro (1991) emphasizes the analysis on the effects of initial GDP (*GDP60*) and human capital (proxies: *PRIM60* and *SEC60*) on per capita growth (*GR6085*). The results show that the estimated coefficient of initial GDP is significantly negative holding constant the other variables. This finding agrees with the conditional convergence in which higher initial GDP leads to lower growth rates. Also, with the other variables held constant, the regressions show that per capita growth is positively related to human capital. Barro's regression 2 (not shown) considers the same variables in equation (2.27) and introduces the square of GDP60. Its estimated coefficient is marginally significant and positive which means that convergence becomes weak as per capita GDP rises. (Convergence holds for values of *GDP60* below $10,800).

The strong positive correlation (0.77) between *GDP60* and human capital helps to explain the neoclassical conditional convergence. Increases in initial GDP are negatively related to subsequent growth only if human capital is held constant. On the other hand, increases in the level of human capital are positively related to subsequent growth when initial per capita GDP is held constant. Japan, Korea, and Taiwan are shown as examples of countries with high initial levels of human capital relative to initial GDP per capita.

Countries in sub-Sahara Africa such as Ethiopia, Sudan, and Senegal are examples that relatively low levels of initial human capital lead to reduced growth rates. In general, oil-exporting countries (Algeria, Gabon, Indonesia, Nigeria, Iran, and Venezuela) present high values of initial GDP relative to human capital which lead to reduced growth rates, except for Gabon for which the high growth rate could be explained by higher initial human capital.

Considering measurement error in initial GDP, which could result in negative correlation between future growth rates and the starting levels, Barro (1991) tested a particular specification with the growth rate of GDP from 1970 to 1985 (*GR7085*). The estimated coefficients remained statistically significant which means that measurement errors (or business-cycle effects) are not important if they only persist for ten years.

Recall that the proxies *PRIM60* and *SEC60* are expected to measure the stock of human capital. To avoid the problem that those variables could have estimated the flow of investment[10] in human capital, the author uses other measures in different specifications introducing the following explanatory variables: *PRIM50*; *SEC50*; *PRIM70*; *SEC70*; adult literacy rate in 1960 (*LIT60*); and student-teacher ratio in primary and secondary schools in 1960, *STTEAPRI* and *STTEASEC*, respectively. By adding the 1950 values of school-enrollment rates the model tries to capture the differences in stocks of human capital. Nevertheless, the estimated coefficients for the 1950 variables are not statistically

[10] It is implicit that high investment in human capital could reflect high investment in rapid growth of GDP as a whole.

significant. The same results come out when the 1970 values are added instead of the 1950 values.

Student-teacher ratios were used to measure the differences in the quality of education. Only the estimated coefficient for primary education is significantly negative. Considering that the higher the student-teacher ratio, the lower the level of education is, this result implies a lower initial stock of human capital. The estimated coefficient for *LIT60* is significantly positive only when the student-teacher ratios are excluded from the model. Despite the attractiveness of this variable in measuring the stock of human capital, the author points out the inconsistent way in which adult literacy is measured across countries.

Four different specifications were used to analyze the relationship between fertility and initial GDP and human capital. The variables *FERT* (total fertility rate measured by the average of 1965 and 1985 children per woman) and *FERTNET* (*FERT* x [1 - *MORT04*], where *MORT04* stands for mortality rate for age 0 through 4 , average of 1965 and 1985) were regressed against *GDP60*; *SEC60*; *PRIM60*; *REV*; *ASSASS*; *PPI60DEV*; *MORT04*; and g^c/y. The estimated coefficient for human capital is significantly negative when the dependent variable is *FERTNET*.[11] That is, more human capital is associated with lower net fertility, as in Becker, Murphy, and Tamura (1990). The coefficient for initial GDP is not significant. When *FERT* is regressed against all variables the estimated coefficient of *MORT04* is significantly positive. That is, gross fertility is positively related

[11] Of course not regressed against *MORT04*.

to child mortality. Also, the growth rate of population from 1960 to 1985 (*GPOP6085*) is negatively related to initial GDP and human capital.

Two variations of the model were used to analyze the hypothesis that per capita growth and the investment ratio move together. First, with the average from 1970 to 1985 of the ratio of real private domestic investment to real GDP (i^{priv}/y) as the dependent variable, the estimated coefficient for human capital is significantly positive. That is, an increase in the initial stock of human capital tends to increase the investment ratio, as predicted by Becker, Murphy, and Tamura (1990). The estimated coefficient of initial GDP is significantly negative which is consistent with the convergence hypothesis. If i/y, the average from 1960 to 1985 of the ratio of private plus public domestic investment to real GDP, is used as dependent variable the results are broadly similar to the first regression.

Recall that Barro's study treats per capita growth, fertility, and investment as endogenous variables in separated regressions. The endogenous growth theory predicts that per capita growth is positively related to investment and negatively related to fertility. With *GR6085* as dependent variable, the estimated coefficients for i/y and *FERTNET* are significantly positive and negative, respectively.

Using the basic specification and introducing the exogenous variables g^i/i (average from 1970 to 1985 of the ratio of real public domestic investment to real domestic investment (private plus public) and g^i/y (average from 1970 to 1985 of the ratio of real public domestic investment to real GDP), Barro analyzes the effects of government expenditures. The results show a negative association between the ratio of real government consumption expenditure to real GDP (g^c/y coefficient) and growth even with investment ratio held constant. It seems that government consumption introduces distortions through high taxes and no offsetting stimulus to private investment. However, Garrison and Lee (1995) find the coefficient for the ratio of government consumption expenditures to GDP to be positive but not significant in a study on the effect of macroeconomic variables on growth rates.

Political instability was analyzed by introducing the variables *REV* and *ASSASS*. Both per capita growth and investment ratios are negatively associated with these proxies for political instability. Barro concludes that *REV* and *ASSASS* affect growth and investment through the adverse influence on property rights.

Different economic systems were analyzed by introducing the dummy variables *SOC* (socialist economic system), and *MIXED* (mixed free enterprise/socialistic economic system) in the growth equation. Only the estimated coefficient for *SOC* is negatively significant. The author considers that the subjective division of these economic system and the reduced number of socialist countries in the sample contributed to results not very reliable.

Barro's study considers the purchasing-power-parity (PPP) numbers for investment goods in order to measure the effects of market distortions. The estimated coefficient of *PPI60DEV* (the magnitude of the deviation of the PPP value for the investment deflator (U.S. = 1.0) from the sample mean) is significantly negative when the model is regressed for per capita growth. This means that an increase in *PPPI60* deviation leads to a reduction in the per capita growth. The author considers these results as preliminary and suggests further research with alternative measures of government-induced price distortions.

To test the common view that countries in Africa or Latin America have poor growth performance, the author introduced the variables *AFRICA* (dummy variable for sub-Sahara Africa) and *LAT.AMER* (dummy variable for Latin America). The estimated coefficients of *AFRICA* and *LAT.AMER* are significantly negative when the dependent variable is *GR6085* and significantly positive when the dependent variable is *FERTNET*. For the investment ratios equation, the estimates are not statistically significant. However, those significantly negative effects on growth appear even when investment and fertility are held constant. The author concludes that the adverse effects on growth "do not result from the unexplained behavior of the investment ratio or fertility. . . . Thus, it appears that something is also missing to explain the typically weak growth performance in Latin America" (Barro, 1991).

Although endogenous growth theory is an improvement on the Solow model, it fails to include the problem of income concentration in the growth process. Following recent studies on the theory of endogenous growth and the theory of endogenous policy, Persson and Tabellini (1994) formulate a model that analyzes the effect of income distribution on economic growth. Income inequality is hypothesized to be harmful for growth. The authors state that the incentives for investment depend on "the ability of individuals to appropriate the fruits of their efforts, which in turn crucially hinges on what tax policies and regulatory policies are adopted. In a society where distributional conflict is more important, political decisions are likely to result in policies that allow less private appropriation and therefore less accumulation and less growth" (Persson and Tabellini, 1994).

The data used by Persson and Tabellini (1994) are from Summers and Heston (1988), the World Bank, the Organization for Economic Cooperation and Development, and some other sources. The empirical results from a cross section of 56 countries in a sample containing postwar evidence are given by

$$GROWTH = \underset{(-2.359)}{-\,2.589} - \underset{(-3.070)}{0.00052}GDP + \underset{(4.432)}{0.041}PSCHOOL + \underset{(2.350)}{0.189}MIDDLE, \quad (2.28)$$

where *GROWTH* is the 1960-85 average annual growth rate of the per capita GDP, *GDP* is the level of 1960 real GDP per capita, *PSCHOOL* is the primary school enrollment ratio, *MIDDLE* is the share of the national income earned by the middle 20 percent of the population, and the figures in parentheses are t statistics.

All coefficients estimated by OLS are statistically significant and have the expected sign. The coefficient for *MIDDLE* is positive, as expected. This result indicates that an increase in the share of the national income accruing to the middle class by 1 percent will increase the real per capita growth rate by 0.189. The negative sign of *GDP* coefficient implies that countries with low initial GDP grew faster than the rich countries.[12] The

[12] This is result provides evidence of the convergence hypothesis discussed before in this section.

positive sign of *PSCHOOL* coefficient means that countries with advanced educational systems grew faster during the 1960-85 period.

To test the effect of income equality given the nature of the political regime, the same model was estimated based on two different samples: one sample of democratic countries and other sample of nondemocracies. The results support the hypothesis that initial income equality has a positive effect on subsequent growth only in democratic countries since the coefficient for *MIDDLE* was not significant for nondemocracies.

In addition to those specifications, Persson and Tabellini (1994) examine the effects of income inequality on growth in a historical sample of nine developed countries. The data cover the period from 1830 to 1985 which is divided into subperiods of 20 years of growth. That is, the dependent variable per capita growth rate, *GROWTH*, is constructed as the average growth rate for each 20-year episode. OLS estimation provided the following results:

$$GROWTH = \underset{(6.899)}{6.456} - \underset{(-3.963)}{6.409}INCSH - \underset{(-2.778)}{1.728}GDPGAP \qquad (2.29)$$

where *INCSH* is the share in personal income of the top 20 percent of the population, *GDPGAP* is the ratio between per capita GDP and the highest level of GDP per capita in the sample, and the figures in parentheses are *t*-values. The significant and negative coefficient for *INCSH* indicates that a higher income inequality decreases growth. *GDPGAP* coefficient is significant and negative which gives the evidence of convergence.

The authors conclude that "inequality is harmful for growth, because it leads to policies that do not protect property rights and do not allow full private appropriation of returns from investment" (Persson and Tabellini, 1994). Since their model takes income distribution as given, they suggest that future research should endogenize growth and income inequality.

Chang (1994) also analyzes the relationship between income equality and growth. His model raises the question of the tradeoff between income equality and economic growth. Comparing old (Kuznets, 1955) and recent (Adelman and Robinson, 1989; Persson and Tabellini, 1994) studies on this subject matter, he debates the actual direction of causality: Does growth increase income equality or vice versa? Based on the model formulated by Persson and Tabellini (1994), Chang's model stresses the roles of the control variables *GDP* (the level of 1960 real GDP per capita) and *PSCHOOL* (the primary school enrollment ratio) in the investigation of the growth-equality relation.

First, he takes the data from Persson and Tabellini's data set and plots income growth (*GROWTH*) against income distribution (*MIDDLE*), *GROWTH* = *f*(*MIDDLE*), and shows a positive, but weak association between these two variables. Then he replicates Persson and Tabellini's model (equation 2.28) and concludes that the augmented model improves the fit of the regression. Also, the dependent variable *GROWTH* after controlling for the effect of initial GDP and education is more responsive to *MIDDLE* than it was before in the simple regression. These results repeat initial findings from Alesina and Rodrik (1994).

However, Chang (1994) points out that the empirical correlation between those two variables is not enough to conclude that income equality boosts growth. Indeed, empirical evidence also showed that economic growth generates greater equality. This "observational equivalence" is only solved when the direction of causality is defined. Therefore, he suggests future studies to formulate theoretical models of the growth-equality link based on politicoeconomic theories and financial imperfection theories.

Persson and Tabellini's politicoeconomic model (1994) of decision on tax and transfers via majority rule is helpful to explain the role of inequality in growth through a country's political situation. If the majority is poor, they will vote for more redistribution. This implies an increase in taxation which discourages investment. On the other hand, a wealthier majority will imply lower tax and faster growth. Eventually, redistribution will create a wealthier majority which will reduce taxes resulting in more investment and faster growth. Persson and Tabellini's model and others (Alesina and Rodrik, 1994) assumes that wealth distribution is exogenous and the direction of causality is from equality to growth (unlike Kuznets). However, Chang (1994) suggests that income distribution should be treated as endogenous.

In Alesina and Perotti (1994), the link between inequality and growth is not through fiscal policy. They state that inequality causes "political instability," which reduces investment and the growth rate. Nevertheless, their measure of "political instability" is too vague from the standpoint of economics. Despite this fact, their approach seems promising.

According to Chang (1994), financial imperfections theories consider that the initial distribution of wealth is crucial for determining the growth rate. These theories assume market imperfections such as the uneven access to credit and that a high-growth project requires some set-up cost. Chang reviews models that analyzes the relation between initial endowment and the level of education. Assuming that all parents leave bequests to their children, the ones with larger bequest will be able to pay for higher education (set-up cost) and their income will grow faster. This represents the market imperfection: only those can afford to pay for education. Therefore, the greater the number of (initial) wealthier families, the greater the overall growth rate.

Chang (1994) suggests specific public policies for reducing borrowing market imperfections and income inequality with subsequent higher growth rate. Models of financial imperfections also are promising to explain the growth-equality link. Indeed, the two theoretical approaches analyzed here are important tools to help to explain the positive association between income equality and economic growth.

The endogenous growth theory also fails to include the problem of land ownership concentration in developing countries. The skewed distribution of ownership of this important asset leads to market distortions in which small-, medium-, and large-scale farmers will not face the same input prices. The reason is due to the fact that the small-scale farmers do not have access to certain inputs as the medium- and large-scale ones do. According to Grabowsky (1979), "the privileged access to sources of credit allows the large farmers to purchase fertilizers, pesticides, and tractors at lower prices than small farmers. . . ."

The difference in relative prices is certainly crucial to determine the pattern of technology innovations but it is not the whole story. Recall that production efficiency in resource allocation is defined under the conditions of Pareto optimality. Also, the first fundamental theorem of welfare economics says that all competitive general equilibrium is Pareto optimum (Varian, 1992). However, the competitive market determines a particular Pareto optimum "given a particular initial distribution of factor ownership. But if one changes the distribution of ownership, a new competitive equilibrium and thus a new Pareto optimum is reached. . . . The relative value of products depends on income distribution, which depends, in turn, on factor ownership" (Just et al., 1982).

Alesina and Rodrik (1994) analyze the distributive politics taking into account the concentration of asset ownership. Their study is an extension of the endogenous theory analysis in which they introduce the effects of income and land ownership concentration. To test the theoretical model they focus on redistributive policies, such as taxation, minimum wage laws, and trade restriction, which introduce distortions and reduce growth. According to them, it is impossible to construct reasonable measures for different countries. Instead of redistributive policies, the empirical model emphasizes on the distribution of resources.

The hypothesis of Alesina and Rodrik's study is that initial inequality has a negative effect on long-term growth. The model uses concentration of income and land ownership, measured by Gini coefficients,[13] as proxies for wealth concentration. "Land is

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[13] Gini coefficient is a measure of (usually) income concentration. It ranges from 0 (perfect equality) to 1 (perfect inequality).

only one component of wealth, and thus the Gini coefficient of land ownership is only a very imperfect proxy of a true measure of wealth distribution. . . . Since only Gini coefficients are available for land, we restrict the presentation of results to Gini coefficients for income as well" (Alesina and Rodrik, 1994).

Since Alesina and Rodrik's study covers the time period for long-run growth from 1960 to 1985, the initial inequality in income and land ownership should be measured at the beginning of the time horizon for growth, i.e., in 1960. However, data limitations led the authors to use Gini coefficients for land measured between 1952 and 1964, and Gini coefficients for income measured between 1956 and 1977. Since many of the data for income Gini coefficients are measured in the 1960s and some in the 1970s, two stage least square (TSLS) regression was run to deal with the reverse causation from growth to income distribution. That is, the first stage of the regression was run instrumenting[14] for the Gini coefficient for income, and then the second stage used the estimated value as regressor in an OLS regression. Also, the simultaneity was dealt with by running OLS regressions for the period 1970-85.

Following the recent endogenous growth literature (Barro, 1991), the regressions also include the initial level of per capita income and the primary school enrollment rate as explanatory variables.[15] Most of the data are from Barro and Wolf (1989) data set and

[14] The instruments for *GINI60* are: *GDP*60, *PRIM*60, literacy rate in 1960, infant mortality in 1965, secondary enrollment in 1960, fertility in 1965, and an Africa dummy.

[15] To test the convergence hypothesis and the human capital effect, respectively.

Summers and Heston (1988). Equation (4) from Alesina and Rodrik (1994) based on a sample of 70 countries shows the results of the TSLS regression for the period 1960-85:

$$\underset{}{GR6085} = \underset{(2.93)}{6.48} - \underset{(-3.47)}{0.58}GDP60 + \underset{(3.75)}{3.70}PRIM60 - \underset{(-3.12)}{12.93}GINI60 \tag{2.30}$$

where *GR*6085 is the average per capita growth rate over 1960-85, *PRIM*60 is per capita GDP level in 1960, *GINI*60 is the Gini coefficient for income, and *t* statistics are in parentheses. Alesina and Rodrik's (1994) equation (6) based on a sample of 41 countries shows the results when the Gini coefficient of land distribution inequality, *GINILND*, is introduced:

$$GR6085 = \underset{(4.69)}{6.22} - \underset{(-3.25)}{0.38}GDP60 + \underset{(2.66)}{2.66}PRIM60 - \underset{(-1.82)}{3.47}GINI60 - \underset{(-4.38)}{5.23}GINILND. \tag{2.31}$$

According to the results, income and land ownership inequality are negatively related to growth. The estimated parameters for *GINI*60 and *GINILND* are significantly negative when entered either alone or together. Unlike Persson and Tabellini's model, the estimated coefficient of a dummy variable for democracies is not significant. Thus, the model rejects the hypothesis that the relationship between inequality and growth is different in democracies and nondemocracies. "The difference in the result arises mostly because of different data sets on inequality, and to a lesser extend from some differences in specification and definition of democracies" (Alesina and Rodrik, 1994).

The study also repeats some growth regressions for 1970-1985. This may be a more relevant time period since many of the income Gini's are measured during the 1960s and some in the 1970s. The results are even stronger. "Our results imply that countries that experienced a land reform in the aftermath of World War II and hence reduced the inequality in land ownership should have had higher growth than countries with no land reform. This argument is often mentioned in the literature on economic development as one explanation for the successful experience of several Asian countries, such as Japan, South Korea, or Taiwan, compared with the less stellar performance of most Latin American countries" (Alesina and Rodrik, 1994). The basic conclusion of the model is that inequality will generally harm growth. The authors suggest future extensions of their model including the study of the conditions that predetermine the distribution of assets and the reverse relation between distribution and growth.

Table 2.1 presents key characteristics of some endogenous growth studies reviewed in details in this section. The studies are summarized by the type of model, empirical technique, variables, and the sign of estimated coefficients.

Human Capital, Income Distribution, and Growth

This section reaffirms the importance of the relationship between economic growth and two likely endogenous determinants: human capital and income inequality. Most of the papers reviewed in the previous section highlighted the significance of those variables. Becker, Murphy, and Tamura (1990) raise the question that the increase in the level of human capital implies higher rates of investment in both human and physical capital which leads to higher growth rates. According to them, accumulation of human capital is the essence of economic growth. "Crucial to our analysis is the assumption that rates of

Table 2.1. Summary of key characteristics of some studies reviewed

Author	Model	Empirical Techique	Economic Factor	Sign	Socioeconomic Factor	Sign	Politicoeconomic Factor	Sign
Mankiw, Romer, and Weil (1992)	Single-equation	OLS	Per capita GDP Physical capital Labor force	(-) (+) (-)	Human capital	(+)		
Barro (1991)	Single-equation	OLS	Physical capital Per capita GDP Government consumption	(+) (-) (-)	Human capital	(+)	Political instability Market price distortions	(-) (-)
Persson and Tabellini (1994)	Single-equation	OLS and TSLS[a]	Per capita GDP	(-)	Human capital Income equality	(+) (+)	Democracy dummy	(+)
Chang (1994)	Single-equation	OLS	Per capita GDP	(-)	Human capital Income equality	(+) (+)		
Alesina and Rodrik (1994)	Single-equation	OLS and TSLS[a]	Per capita GDP	(-)	Human capital Income inequality Land ownership inequality	(+) (-) (-)	Democracy dummy	—[b]

Notes: The signs in parentheses show the direction of the relation between growth and its determinants.
The dependent variable is per capita GDP growth.
[a] TSLS regressions were used to for correcting reverse causation by instrumenting the income inequality variable.
[b] Not statistically significant.

returns on investments in human capital rise rather than decline as the stock of human capital increases, at least until the stock becomes large" (Becker, Murphy, and Tamura, 1990). They based this assumption on the evidence that the production of human capital uses education and other skilled inputs intensively.

Their theoretical model assumes a negative correlation between human capital and fertility. One of the two stable steady states is defined when the stock of human capital, H, is low (or zero) and fertility rate, (n), is high. The second steady-state occurs when human capital is high and fertility is low. Considering the relationship between human capital per worker at time $t + 1(H_{t+1})$ and human capital at time $t(H_t)$, the authors analyze those two situations. The discount rate on future consumption, $[a(n)]^{-1}$, is greater than the rate of return on investment in human capital, $R_h(H)$, when $H = 0$.[16] This happens because the degree of altruism per child, $a(n)$, is negatively correlated to fertility, (n), which is high given that the cost of bearing and rearing children is low when H is low. Thus,

$$[a(n)]^{-1} > R_h, \qquad \text{for } H = 0, \tag{2.32}$$

which is required for the steady-state since "the economy does not want to invest when there is no human capital. Moreover, the steady state is locally stable, for the inequality must continue to hold for small positive values of H" (Becker, Murphy, and Tamura, 1990).

[16] They assume that "that higher fertility of the present generation increases the discount on per capita future consumption in the intertemporal utility functions that guide consumption and other decisions" (Becker, Murphy, and Tamura, 1990).

Since the rate of human capital monotonically increases as H increases and the high cost of bearing and rearing children reduces its demand, the second steady-state when H is sufficiently large is defined as

$$[a(n^*)]^{-1} = R_h(H^*), \tag{2.33}$$

where n^* and H^* are steady-state levels of human capital and fertility rate, respectively. Incorporating physical capital, K, with the usual assumption of diminishing returns, the model becomes:

$$[a(n_u)]^{-1} = R_k \tag{2.34}$$

when $H = 0$, $K = K_u$, and R_k is the rate of return on investment in physical capital. At $H = H^*$, K is expected to be larger than at $H = 0$. According to Becker, Murphy, and Tamura (1990), these two stable steady states are related to undeveloped and developed economies, respectively. At the lower one, per capita income levels are low, human and physical capital amounts are small, and birth rates are high. The higher one, on the other hand, has higher per capita incomes, larger amounts of both human and physical capital per capita, and lower birth rates. Human capital is considered more important than physical capital in the process of growth because human capital increases with H and physical capital decreases with K.

The relationship between growth and fertility is described by production functions of human capital, consumption, and fertility. Endogenous fertility is determined by the opportunity cost of rearing children and the effect of family size on the discount rate of future consumption. It was shown that high fertility implies low human capital. Theoretical and empirical studies have provided evidence that an increase in human capital raises per capita income. Since fertility affects human capital negatively, small families and large human capital (and perhaps physical capital) are expected to increase the level of income per capita.

Finally, the authors suggest further research to understand why growth rates differ among countries and regions, and why the growth leaders differ along the history. They suggest that their "analysis appears to highlight important variables in growth and development: investments in human capital, choices over family size and birth rates, interactions between human capital and physical capital, the existence of several stable steady-state equilibria, and the crucial role of luck and past" (Becker, Murphy, and Tamura, 1990).

Income inequality is the other determinant of growth that deserves to be studied in more details. Adelman and Robinson (1989) provide a comprehensive review of the literature on income distribution and growth. The rapid growth after World War II in DCs led Western economists to believe that the same pattern could occur in LDCs. However, the traditional institutions and structural constraints in developing countries turned out to be a barrier to growth. "It was assumed that growth would affect the poorest in contemporary developing countries as it affected those in developed countries during the twentieth century, when conditions of the poor did improve. This assumption implicitly ignored the major institutional reforms (e.g. development of labor unions and welfare legislation) introduced at great social cost in developed countries since the turn of the century" (Adelman and Robinson, 1989). According to them, many reasons are given to explain the failures in achieving growth with income distribution, such as the alliance between the local elites and the international capital, the deterioration in the terms of trade, and corrupt governments and incentives to benefit particular regions inside the countries (dualism).

At the end of the 1960s it was clear that the pattern of development via capital formation and industrialization was reducing employment opportunities because of the incentives to the adoption of capital-intensive technology. In addition to the increase in the wage-rental ratio due to physical capital subsidization, the very simple transfer of technology from DCs did not take into account the need for labor-intensive technology in developing countries. Also, the industrial sector was not able to absorb the labor surplus from rural-urban migration and rapid population growth.

Masses of unskilled (or uneducated) rural workers migrated from the agricultural sector and became part of an urban traditional sector which is plenty of petty economic activities such as domestic services, handicrafts, and informal businesses on the streets. This informal sector can be characterized by very low capital-labor ratios, low-income, and lack of human capital formation (Cole and Sanders, 1985). Indeed, this is a dynamic sector in which a large number of people in Third World countries have the opportunity to get a job and make money. Nevertheless, even if most migrants found employment in the urban subsistence sector, this would not change the income inequality. "For most countries, the distribution of income had deteriorated as a consequence of growth, and social and political participation bore little relationship to economic growth" (Adelman and Robinson, 1989). This evidence shifted the focus of the research and policy agenda towards growth with redistribution strategies in the late 1970s.

However, the oil crisis and the huge foreign debt contributed to divert the focus from distribution and poverty issues during the 1970s and 1980s. In addition, the neoclassical resurgence (Oman and Wignaraja, 1991) led some policy makers to believe that prices would regulate the free market in developing countries as they did in the growth process of DCs. The strategy of structural adjustment applied by the World Bank and the International Monetary Fund (IMF) in many LDCs is an example of this resurgence. That strategy requires the countries to open the economy, privatize state companies, cut government deficit spending, and downgrade the role of government policy (Adelman and Robinson, 1989).

This new orthodoxy criticizes the developing countries by saying that they neglect the lessons of the developed world. That is, they should encourage private initiative and let markets do their jobs. Nevertheless, this orientation has worsened income distribution and declined growth in those countries where it has been applied (Oman and Wignaraja, 1991).

A classic reference for the relationship between income inequality and income per capita is Kuznets (1955). Kuznets's inverted-U hypothesis states that inequality is expected to increase in the early stages of growth, reach a peak, and then decrease in the late stages. This proposition has been either confirmed or refuted in many studies in the literature on growth and development (for details, see Meier, 1984; Adelman and Robinson, 1989; Birdsall, Ross, and Sabot, 1995; Ram, 1995).

The Agricultural Sector and Institutional Change

Among the orthodox thinkers, another group appeared during the 1950s and 1960s shifting the focus of the analysis from the industry and inter-industry relations to the inter-sector analysis which also considers the agricultural sector (Lewis, 1954; Ranis and Fei, 1961). Since the early development thought used to neglect agriculture, Ranis and Fei paper has a positive impact in terms of giving the real importance to the agricultural sector. Industrialization can only be part of the development process which should include agricultural modernization and institutional changes such as land tenure system reform. In other words, industrialization and agricultural development should occur simultaneously.

However, those orthodox models stimulated enormous theoretical and empirical debate in the literature. Perhaps the most significant criticism to those models is the evidence that they focus on the agricultural sector only as a source of resources for the industry. "In short, what these models do not include is a mechanism of development of the agricultural sector as such" (Oman and Wignaraja, 1991).

An important contribution for switching the growth analysis towards the agricultural sector was given by Johnston and Mellor (1961). The "interrelated strategy", differs from the philosophy of 1950s approach in terms of the role of agriculture and the government. "They argue that far from playing a passive role in development, agriculture could make five important contributions to the structural transformation of the Third World economies: it could provide labor, capital, foreign exchange, and food to a growing industrial sector and could supply a market for domestically produced industrial goods" (Eicher and Staatz, 1990). They believe that the agricultural sector, in particular the huge segment of small-scale farmers, should be the focus of financial and human capital investment in order to contribute to economic development. This unimodal strategy[17] is capable of integrating diverse actions such as employment creation, wage goods production, and increasing demand for food.

This review has considered both the neoclassical and the endogenous theories of growth for the entire economy in previous sections. Hayami and Ruttan (1985) approach of agricultural development introduced the endogenous view in the agricultural sector even before the rise of the new endogenous growth theory. The hypothesis of induced innovations considers that the difference in the prices of the factors of production has influence in technological change. The decline in the prices of land and machinery, relative to wages, motivated the substitution of machinery for labor in the United States. In the case of Japan, land supply was inelastic and its price increased relatively to wages. Thus, the decline of the price of fertilizers with respect to the price of land was exploited through biological technology. The improvement in agriculture in the United States and

[17] This is called unimodal strategy because it focuses on scale-neutral innovations which are expected to be adopted by small-scale farmers.

Japan from 1880 to 1980 was better understood when analyzed as a dynamic process of substitution of inputs as response to their relative prices.

However, Grabowsky (1979) points out that the distribution of wealth and income is not taken into account in Hayami and Ruttan model. In most LDCs land ownership is highly concentrated. Thus, the large-scale farmers have the economic and political power to influence the type of agricultural research and other policies that the government should take. "The ideal solution would be, of course, to implement extensive land reforms which would reduce the power large landowners have had in affecting the direction of research in less developed nations" (Grabowsky, 1979).

Indeed, this question can be better understood under the theoretical framework of institutions and institutional change. "Institutions are the humanly devised constraints that structure political, economic, and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights.) . . . Institutions provide the incentive structure of an economy; as that structure evolves, it shapes the direction of economic change towards growth, stagnation, or decline" (North, 1991a).

Since institutions are incentive structure of an economy, they influence individual choices. North (1991b) refers to Mankiw, Romer, and Weil (1992) findings and concludes that if the saving rate or human capital in a country increases by 1 percent, its GDP per worker increases by about 1 percent since the saving rate, schooling, and population growth explain almost 80 percent of the variation in income per capita in that model.

Therefore, all countries should just follow that prescription "and they will all be rich — why not if there are such a high payoff? It is the institutional framework that determines the payoffs. Poor countries are poor because the payoffs do not reward productive activity" (North, 1991b).

In order to understand why the contrasting results of North American and Latin American histories, North (1991a) digs deep into the original institutional frameworks of those regions and their evolution. English colonies were created under the following circumstances: struggle between Parliament and the Crown; religious and political diversity; unambiguous development in the direction of increasing local political control; and secure property rights for the colonists. British tax imposition along with other policies produced violent reactions which ended up in political and social transformations and the subsequent creation of the United States. On the other hand, Spanish (and Portuguese) colonies were created when the Parliament power was declining; the Crown centralized the control over the country and the Spanish colonies; uniform religious and bureaucratic administration were established; and traditional landed elite struggled for control of the bureaucratic machinery. Independence maintained the centralized bureaucratic control mainly because only few basic institutions were transformed.

Despite the common ideological influences, the divergent paths defined by England and Spain have not converged. "In the former, an institutional framework has evolved that permits complex impersonal exchange necessary to political stability as well as to capture the potential economic benefits of modern technology. In the latter, 'personalistic' relationships are still the key to much of the political and economic exchange. They are the consequence of an evolving institutional framework that has produced erratic economic growth in Latin America, but neither political nor economic stability, nor realization of the potential of modern technology" (North, 1991a).

In particular, the institutional framework of the rural economy seems to be an obstacle to growth. According to de Janvry and Sadoulet (1989), one of the most important institutions in agriculture is the land tenure system. Agrarian structure in Latin America has been characterized by the concentration of land ownership which led to a contradictory situation in the agriculture sector. That is, on the one hand, there is a significant number of individuals who depend upon agricultural activities but they have neither the opportunity to till the land nor to get a job. On the other hand, there is a great deal of idle agricultural land on the hands of medium- and large-scale farmers. Modernization strategy in the 1960s focused on medium- and large-scale farmers who were supposed to adopt innovation faster than the small-scale ones and accelerate the supply response as result of government incentives. "Modernization of the medium and large farms, however, created economic and political power among these farmers which allowed them to gain (or reinforce their) privileged access to the state" (de Janvry and Sadoulet, 1989).

Therefore, induced innovation without changing the economic, political, and social structure benefits the ones who have the power. Following Grabowsky's (1979) interpretation of Hayami and Ruttan model, the large-scale farmers press the research toward their interest. Thus, the benefits of the innovation are not shared by the small-scale farmers.

The initial endowment of land in the beginning of a country (*the basic institutional framework*) determines the pattern of land distribution and policy decisions for that country. In this case, land ownership redistribution through a program of land reform (*an institutional change*) is a necessary condition to decrease inequalities. The impacts of such program can be evaluated by the positive results in terms of agrarian structure modernization, increasing agricultural productivity, employment creation, income distribution, and improvement in human capital.

CHAPTER III

THE MODEL AND DATA

Hypotheses

This chapter presents the hypotheses and describes the proposed model and data. The hypotheses are presented in very simple statements and followed by theoretical and empirical support. The hypotheses are stated as follows:

1. there is a negative association between income inequality and economic growth;

2. there is a negative association between land ownership concentration and human capital; and

3. there is a positive association between land ownership concentration and income inequality.

The first working hypothesis states that the greater the inequality in income, the lower the rate of growth. Theoretical and empirical support for this hypothesis is derived from Alesina and Perotti's (1994), Persson and Tabellini's (1994), and Alesina and Rodrik's (1994) politicoeconomic studies, and Murphy, Shleifer, and Vishny's (1989) purely economic study. Alesina and Perotti (1994) point out that income inequality depresses investment because of political and economic instability. In addition, inequality is expected to discourage investment since "political decisions produce economic policies that tax investment and growth-promoting activities in order to redistribute income." (Persson and Tabellini, 1994). In the economic channel, taxes will reduce investment in human capital and growth. In the political channel, a poor majority of voters will approve more taxation and therefore reduce investment.

Also, the major results in Alesina and Rodrik (1994) provide evidence that inequality of income increases the rate of taxation and decreases the growth rate. Their arguments are summarized by Alesina and Perotti (1994): the relative share of labor endowment and capital endowment is monotonically related to income distribution. Proportional taxation of capital income is used to finance public investment. An increase in taxes reduces private appropriation of returns from capital investment. This will discourage investment and reduce growth. "The political mechanism is that the higher the proportion of capital income in an individual's total income (or, equivalently, the higher the individual's total income), the higher the price the individual has to pay for the benefits of public investment and therefore the lower the individual's preferred tax rate" (Alesina and Perotti, 1994). Again, the poor median voter will prefer high tax rates which reduce investment and growth.

Since the investment variable is included in most specifications of the proposed model in this study, another channel by which income inequality affects economic growth is considered. Murphy, Shleifer, and Vishny (1989) point out that income inequality reduces the size of domestic demand and therefore the potential for industrialization. "When domestic markets are small and world trade is not free and costless, firms may not be able to generate enough sales to make adoption of increasing returns technologies profitable, and hence industrialization is stalled" (Murphy, Shleifer, and Vishny, 1989).

The second working hypothesis states that land ownership concentration affects human capital inversely. Two studies on human capital and growth provide theoretical support for this hypothesis: Barro (1991) suggests that the exogeneity of some of the explanatory variables in his model could be questioned, and Lee, Liu, and Wang (1994) found that a model with endogenous human capital was more "suitable for studying the economic development of Taiwan because of its special emphasis on education." In addition, this hypothesis recognizes that the landless and the small-scale farmers, which are the majority in LDCs, will not have access to education because of lack of endowment.

The third working hypothesis states that there is a significant positive correlation between land ownership concentration and income inequality. Ahluwalia (1974) theorizes that agricultural land should be included as one of the determinants of income inequality. Empirical support is drawn from Bourguignon's (1994) study, which uses land equality as an instrumental variable to construct his income distribution variable.

The Econometric Model

An ideal model of economic development would consider both economic and social indicators. Monetary and non-monetary indexes would measure economic growth and human welfare, respectively. Indeed, this would be better named socioeconomic development. The empirical specification of such a model could describe the effects of developmental policies and entrepreneurial decisions on economic growth and the well-being of the people. This would require a huge system of equations to measure the correlation between many explanatory variables and the socioeconomic indicators. Nevertheless, there is no consensus among economists about the appropriateness of non-economic indexes. Most importantly, the limitations of the data rule out such a model for both cross-country studies and for a particular country analysis in the context of this research. Thus, this study will follow the direction of the current literature and will adapt the model to the closest approximation.

The origins of most empirical specifications of growth models can be traced to Solow's 1956 model. Subsequent attempts to adapt and enhance the Solow model include Barro (1991); Mankiw, Romer, and Weil (1992); Persson and Tabellini (1994); Chang (1994); and Alesina and Rodrik (1994). Barro's and Mankiw, Romer, and Weil's specifications test the convergence hypothesis of the Solow model and show the evidence of the conditional convergence. The results of the augmented Solow model constructed by Mankiw, Romer, and Weil (1992) give the relevance of human capital in economic growth as it was analyzed in the literature review. Therefore, those specifications give the basis for the proposed model in this study. Also, recent studies on income inequality and growth such as Persson and Tabellini's (1994) and Chang's (1994) revive the discussion of distributional issues which are incorporated in the specification proposed here as an attempt to capture the actual role of those variables.

Alesina and Rodrik's (1994) contribution to the endogenous-growth theory was the incorporation of factor-ownership concentration. Indeed, this seems to be the first study to consider the role of the rural sector on endogenous growth, even though the choice of inequality in land ownership as a proxy of wealth distribution was made because of lack of data. Nevertheless, the actual role of land ownership concentration is still missing. In addition to this, none of the endogenous-growth models consider human capital as an endogenous variable in a cross section of developed and developing countries. These findings influenced the decision to modify the traditional single-equation models and specify a second equation in which human capital is hypothesized to be explained by inequality in land ownership among other variables.[18]

Modern research on income distribution is historically related to the Kuznets study (1955). Based on the theories of economic growth from the fifties, Kuznets established the well-known inverted-U hypothesis to explain the pattern of income distribution in a growing economy. Since the working population is expected to move from the traditional agricultural sector to the modern industrial sector (Lewis, 1954), the high inequality of the intermediate period will decrease as time passes. His approach assumes that income distribution is endogenous and growth is exogenous. "The behavior of income distribution is viewed as endogenous — that is, explained by the theory as an outcome of the development process. In contrast, growth is treated as exogenous, not explained by the theory and, in particular, not affected by income distribution. Because growth affects

[18] Bourguigon (1994) treats human capital as endogenous in a sample of developing countries only.

income distribution but not vice versa, economists say that causality in Kuznets's theory runs one way, from growth to income distribution" (Chang, 1994). Based on this result, one cannot justify redistributive policies as a way of achieving growth.

Although the Kuznets hypothesis has been largely debated (Adelman and Robinson, 1989), most subsequent studies neglected the issue of income distribution perhaps because of some inconclusive empirical tests of the inverted-U curve. Also, many economists were focusing on the short-run effects of the business cycle and on the debate about rational expectations that was in evidence during the last two decades. Since the models for analyzing fluctuations and rational expectations were based on the behavior of a representative individual and a representative firm, these assumptions turned the attention to the microeconomic foundations for a stronger macroeconomic approach (Chang, 1994).

This study not only emphasizes the importance of income distribution, but also introduces a third equation in which the distribution of income is considered endogenous. The proposed model is defined as follows:

$$GROWTH = f\,(GDP60, INV, PSCHOOL, INC) \tag{3.1}$$

$$PSCHOOL = g\,(LAND, GDP60, RURPOP, INC) \tag{3.2}$$

$$INC = h\,(LAND, GDP60, AGRISH, GR5560, POPGR, PSCHOOL), \tag{3.3}$$

where *GROWTH* is the growth rate of real per capita GDP, *GDP60* is the initial GDP per capita, *INV* is the investment rate, *PSCHOOL* is primary-school enrollment rate, *INC* is

Gini coefficient of income inequality, *LAND* is Gini coefficient of land distribution inequality, *RURPOP* is the proportion of rural population, *AGRISH* is the share of agriculture in GDP, *GR5560* is the growth rate of real per capita GDP from 1955 to 1960, and *POPGR* is the rate of growth of population. Two continent dummies, *ASIA* and *LATAM,* will be added to the *GROWTH* equation to test the potential effect of land reform on growth. Additional description of the variables is given in Table 3.1.

This study suspects that some empirical endogenous-growth models face serious problems of estimation. The single-equation specifications in which the growth rate is regressed on human capital and income distribution do not consider the endogeneity of these two variables. This may be result of misunderstanding of the real situation of the agrarian economies that characterizes the developing countries. In general, land ownership concentration is related to idle land (Griffin, 1976). That is, this characteristic leads not only to problems of inequality but also to inefficient allocation of resources because both labor and land are underutilized.

Moreover, land is the main collateral that enables farmers to have access to credit which can lead to technology innovation with increase in productivity resulting in less income inequality. The endowment of plots of land large enough to allow farmers to be part of the agricultural market can enable them to have access to information, progress, and be concerned about the education of their children and themselves resulting in a higher level of human capital. Therefore, the concentration of land ownership and other

Table 3.1. Definition of the variables and data sources

Variable	Definition	Source
GROWTH	Growth rate of real per capita GDP from 1960 to 1985	*GROWTH* is taken from Alesina and Rodrik (1994), who in turn took from Barro and Wolf (1989)
GDP60	1960 value of real per capita GDP	*GDP60* is taken from Alesina and Rodrik (1994), who in turn took from Barro and Wolf (1989)
INV	The average share of real investment (public and private) in real GDP	*INV* is taken from Barro and Wolf (1989)
PSCHOOL	Primary-school enrollment rate	*PSCHOOL* is taken from Alesina and Rodrik (1994), who in turn took from Barro and Wolf (1989)
INC	Gini coefficient of income inequality, measured close to 1960	*INC* is taken from Alesina and Rodrik (1994)
LAND	Gini coefficient of land distribution inequality, measured close to 1960	*LAND* is taken from Alesina and Rodrik (1994)
RURPOP	Percentage of rural population in 1960	*RURPOP* is computed from the World Bank (1980)
AGRISH	The share of agriculture in GDP in 1960	*AGRISH* is computed from the World Bank (1980)
GR5560	Growth rate of real per capita GDP from 1955 to 1960	*GR5560* is computed from Summers and Heston (1988)
POPGR	The rate of growth of population from 1950 to 1960	*POPGR* is taken from Barro and Wolf (1989)
ASIA	Asia dummy	*ASIA* equals 1 for Asian countries
LATAM	Latin America dummy	*LATAM* equals 1 for Latin American countries

constraints in the agricultural sector play a very important role in explaining the effects of income distribution and human capital on economic growth.

This assumption led to the introduction of the two additional equations in the traditional model. Note that even Equation (3.1) differs in some way from the endogenous models reviewed before (see details in Table 2.1). While Mankiw, Romer, and Weil's model says nothing about income distribution, Alesina and Rodrik's model introduces income distribution but does not consider the investment rate. According to Alesina and Perotti (1994), income inequality discourages investment. "A large group of impoverished citizens, facing a small and very rich group of well-off individuals, is likely to become dissatisfied with the existing socioeconomic status quo and demand radical changes. As a result, mass violence and illegal seizure of power are more likely the more unequal the distribution of income is" (Alesina and Perotti, 1994). Thus, this study expects that the proposed model will be more complete by considering those variables.

Equation (3.2) says that human capital is a function of land ownership concentration and other variables such as income concentration which determines the low demand for education. Following Lee, Liu, and Wang (1994) the model considers the initial level of output which facilitates and makes the accumulation of human capital possible.

Equation (3.3) follows Ahluwalia (1974) in considering that the concentration of income is a function of the level of per capita GDP, the share of agriculture in GDP, the rate of growth of income, and population growth. Ahluwalia (1974) recognizes that his study has "not considered a number of potential explanatory variables which can be identified a priori. The most important of these is the concentration of wealth (including agricultural land) and mechanisms perpetuating this concentration pattern" (emphasis added). Thus, the proposed model does treat land ownership concentration as an explanatory variable in Equation (3.3). Human capital is also included in the right-hand side of that equation following the works of Bourguignon (1994) and Ahluwalia (1974).

Since the proposed model is specified as a system of simultaneous equations, the endogenous regressors are correlated with the disturbance errors. An appropriate method of estimation will be applied in order to correct for the simultaneous-equation bias.

Definition of the Variables

The variable *GROWTH* represents the growth rate of per capita real GDP from 1960 to 1985 for a sample of developed and developing countries and is taken from Barro an d Wolf (1989). *GDP60* is the 1960 level of real per capita GDP also taken from Barro and Wolf (1989). This variable is included here to account for conditional convergence and to test its relationship with human capital and income concentration. Initial GDP is expected to be negatively related to both growth and income concentration, and positively related to human capital. Physical capital is represented by the average ratio of real domestic investment (private plus public) to real GDP, *INV*, which is expected to have a positive effect on growth.

Primary school enrollment ratio, *PSCHOOL*, is the proxy for human capital.[19] This proxy is constructed as the ratio of total students enrolled in primary education to the number of individuals in primary-school age (6-11 years). This variable is introduced by Mankiw, Romer, and Weil (1992) in the augmented Solow model to stress the role of human capital in economic growth. According to Barro (1991), human capital is the key variable in various endogenous-growth models. Countries with greater stock of human capital will grow faster because of their more rapid rate of technology adoption. Also, the increase in the level of human capital will increase growth rates through higher rate of investment in both human and physical capital (Becker, Murphy, and Tamura, 1990). Therefore, the model expects a positive relationship between growth and human capital.

Gini coefficients of income inequality, *INC*, and land distribution inequality, *LAND*, represent measures of concentration. Gini coefficient is a measure derived from a box-diagram that describes the relationship between percentage of income (vertical axis) and percentage of income recipients (horizontal axis). If each *a* percent of the income is distributed to *a* percent of the population and any percentage of the population always receives equal percentage of the income, then the graphical representation would be a positively sloped straight line with 45 degrees at the origin which is called the line of complete equality. The curve of perfect inequality would be represented by an inverted-L with a right angle at the lower-right corner. This is the case in which only one individual

[19] The level of education is chosen as proxy to capture the average basic skills. Using this proxy may lead to loss of a great deal of inequality in schooling distribution because the rural sector has little high school and next to no university resources. Therefore, the study will also test secondary school enrollment ratio as proxy for human capital.

holds 100 percent of the income. A curve drawn between the line of complete equality and the curve of perfect inequality is named Lorenz curve. An area enclosed by the straight line and the Lorenz curve is know as the area of concentration. Thus, Gini coefficient is defined as the ratio of the concentration area to the triangular area under the line of complete equality. The coefficient equals 0 when the equality is perfect and 1 in the case of complete inequality. Hence, the model expects negative effects of both variables.

RURPOP represents the percentage of rural population and is expected to be inversely related to human capital. One of the characteristics of developing countries is a large proportion of rural population with low level of formal education. *AGRISH* is the share of agriculture in 1960 total GDP that is expected to capture the positive effect of traditional production structure on income concentration. *GR5560* is the growth rate of per capita real GDP from 1955 to 1960, i.e., during the five years preceding. This time period was chosen in order to examine the impact of short-term growth on income inequality. This variable is expected to have a negative effect on income inequality. The rate of growth of population from 1950 to 1960, *POPGR*, is expected to be positively related to income inequality. "A high rate of population growth may perpetuate a labor surplus situation, holding back a rise in real wages that might otherwise occur" (Ahluwalia, 1974).

Finally, *ASIA* and *LATAM* are two dummy variables for Asia and Latin America, respectively. Following Barro (1991) these variables are included to test whether the model fully explains the characteristics of the countries in those continents. In other words, those dummies are expected to be not significant if the nature of being in Asia and Latin America is already explained by the other determinants.

Data Sources

The data for this study are from Summer and Heston's (1988) Penn World Table of international comparisons, Barro and Wolf (1989) data set, Alesina and Rodrik (1994), and the World Bank (1980). The sample consists of 41 developed and developing countries. The endogenous growth rate was measured from 1960 to 1985 following recent studies to facilitate comparisons. In addition, those years are considered the period of rapid growth in many developing countries.

Population growth and the previous growth rate are measured in the ten and five years preceding the beginning of the time horizon for growth, respectively. Gini coefficients for income and land are measured close to 1960 given the limitations of data (see Alesina and Rodrik (1994) for details). All remaining variables required data for the initial moment which was defined as the year of 1960. Although the sources provide data on most variables for 118 countries, the sample size was restricted by the availability of data for income inequality and land ownership concentration.

CHAPTER IV

RESULTS

The Basic Model

The theoretical discussion raised the concern that traditional single-equation models of economic growth may not adequately represent relationships among variables, some of which may be simultaneously determined. Economic growth data are always products of existing economic systems, which involve simultaneous influences among variables including current and past values of some variables. As a result models of these systems need to utilize a simultaneous estimation structure.

The economic growth model described in Chapter III can be written as follows:

$$GROWTH_j = \alpha_0 + \alpha_1 GDP60_j + \alpha_2 INV_j + \alpha_3 PSCHOOL_j + \alpha_4 INC_j + u_{1j} \quad (4.1)$$

$$PSCHOOL_j = \beta_0 + \beta_1 LAND_j + \beta_2 GDP60_j + \beta_3 RURPOP_j + \beta_4 INC_j + u_{2j} \quad (4.2)$$

$$INC_j = \gamma_0 + \gamma_1 LAND_j + \gamma_2 GDP60_j + \gamma_3 AGRISH_j + \gamma_4 GR5560_j + \gamma_5 POPGR_j + \gamma_6 PSCHOOL_j + u_{3j} \quad (4.3)$$

where $u_{1j}, \ldots, u_{3j}$, are the disturbance terms, and j represents the observations, $j = 1, \ldots,$ J. All disturbance terms are assumed to have the following structure:

$$E[u_{1j}] = E[u_{2j}] = E[u_{3j}] = 0, \quad (4.4)$$

and

$$E[u_{mj}u_{nj}] = \sigma_{mn} \qquad \text{for} \qquad m, n = 1, \ldots, \text{M equations.} \quad (4.5)$$

Also, the structural form of the system can be written in matrix notation:

$$\mathbf{B_0 y}_j = \mathbf{\Gamma x}_j + \mathbf{u}_j, \tag{4.6}$$

where $\mathbf{y}_j = (GROWTH_j\ PSCHOOL_j\ INC_j)'$, $\mathbf{x}_j = (GDP60_j\ INV_j\ LAND_j\ RURPOP_j\ AGRISH_j\ GR5560_j\ POPGR_j)'$, $\mathbf{u}_j = (u_{1j}\ u_{2j}\ u_{3j})'$, $\mathbf{B_0}$ is the matrix of coefficients of the endogenous variables, and $\mathbf{\Gamma}$ is the matrix of coefficients of the exogenous-predetermined variables. Therefore, the assumptions become:

$$E[\mathbf{u}_m] = \mathbf{0}, \tag{4.7}$$

$$E[\mathbf{u}_m\mathbf{u}_m'] = \sigma_{mm}\mathbf{I}_J = \sigma_m^2\mathbf{I}_J = \Sigma \qquad \text{for} \qquad m = 1, \ldots, \text{M}, \tag{4.8}$$

and

$$E[\mathbf{u}_m\mathbf{u}_n'] = \sigma_{mn}\mathbf{I}_J \qquad \text{for } m \neq n \qquad \text{and} \qquad m, n = 1, \ldots, \text{M}. \tag{4.9}$$

The variance-covariance matrix of the structural disturbances Σ is assumed to be symmetric and positive semidefinite. The reduced form of the system is described as

$$\mathbf{y}_j = \mathbf{\Pi x}_j + \mathbf{v}_j, \tag{4.10}$$

where

$$\mathbf{v}_j = \mathbf{B_0}^{-1}\mathbf{u}_j, \tag{4.11}$$

and the variance-covariance matrix of the reduced-form disturbances is Ω. Substituting Equation (4.10) into Equation (4.6) and after some matrix manipulation,

$$\mathbf{B_0\Pi} = \mathbf{-\Gamma}. \tag{4.12}$$

The relationship between the structural- and the reduced-form parameters is given by

$$\mathbf{\Pi} = \mathbf{-B_0}^{-1}\mathbf{\Gamma} \tag{4.13}$$

and

$$\Omega = \mathbf{B_0}^{-1}\Sigma(\mathbf{B_0}')^{-1}. \quad (4.14)$$

These are the relations used to establish identifiability of the equations.

The Problem of Identification

A structural parameter is considered identified if it can be uniquely derived from the reduced parameters. A system is not identified if any of its equations is not identified. In general, in order to be identified, the number of endogenous regressors in the equation *m* cannot exceed the number of predetermined variables excluded from that equation. A practical rule for identification is given by the following: the number of exogenous variables excluded from the *m*th equation must be greater than or equal to the number of endogenous variables included in that equation minus one (Kennedy, 1992). If the equality (inequality) holds, the equation will be just identified (over-identified). This is called the order condition for the identification.

In the growth equation (4.1), five exogenous variables are excluded which is greater than the three endogenous variables included in the equation minus one. Therefore, this equation is over-identified. In the human capital equation (4.2), four exogenous variables are excluded which is greater than the two endogenous variables included minus one. Therefore, the human capital equation is over-identified. Finally, in the income concentration equation (4.3), two exogenous variables are excluded which is greater than the two endogenous variables included minus one. Therefore, the income concentration equation is over-identified.

Nevertheless, the order condition is only a necessary, but not a sufficient condition for identification because there is no guarantee that the equations are independent of each other (Pindyck and Rubinfield, 1991). The rank condition is sufficient to ensure unique values of the structural parameters derived from the reduced-form parameters. Since each equation has its own exogenous variable, the sufficient condition is also satisfied.[20] Given that the conditions hold for each equation and all equations are over-identified, then in the absence of additional restrictions the whole system is over-identified.

To test the restrictions that over-identify the model this study used a Lagrange Multiplier procedure (Greene, 1993). Over-identifying restrictions mean that the *m*th equation has omitted one or more exogenous variables when it could have included them and remained identified. For instance, that the human capital equation (4.2) is over-identified means that INV_j, $AGRISH_j$, $GR5560_j$, and $POPGR_j$ were excluded from that equation when identification required that only one of those variables were omitted. The sample size times the uncentered *R*-square, JR^2, equals 1.8368 in equation (4.2) which is less than the critical value for a Chi-square at 0.05 significance level with degrees of freedom equal to the number of exogenous variables in the system minus the number of right-hand side variables in that equation[21]. Therefore, the test failed to reject the null hypothesis that the over-identifying restrictions on that equation are correct. However, the test showed that the over-identified restrictions on equations (4.1) and (4.3) are not correct, i.e., it rejected the hypothesis of over-identifying restrictions on those equations.

[20] "There is a rule of thumb that is sometimes useful in checking the rank and order conditions of a model: If every equation has its own predetermined variable, the entire model is identified" (Greene, 1993).

[21] $\chi^2_{(7-4)} = 7.82$.

According to Greene (1993), this could be a problem of misspecification. Indeed, Kennedy (1992) stresses that those tests "usually reject the over-identifying restrictions, casting doubt on the identifying restrictions since the over-identifying restrictions cannot be separated from the identifying restrictions. A skeptic may use this fact to explain why economists seldom undertake such tests".

Empirical Evidence

Among the single-equation estimation methods, the OLS estimator is ruled out because it is biased and the indirect least squares (ILS) cannot be used in the presence of over-identified equations. Two-stage least squares (2SLS) estimator is the usual alternative for estimating the parameters in over-identified systems. However, 2SLS is a "limited information" method because it only utilizes information from the particular equation being estimated. A "full information" method such as three-stage least squares (3SLS) is capable of incorporating all of the available information in the system. If the variance-covariance matrix of the structural disturbances is diagonal, then 3SLS is asymptotically equivalent to 2SLS.

The equation (4.10) was estimated using 2SLS for a sample of 41 countries which are listed in the Appendix. To compare the 2SLS estimator with a "full information" method, the model was also estimated by using 3SLS. The standard errors for the latter parameter estimates are either less than or equal to those estimated for the former, as expected. Although the values of the parameter estimates are similar in the two methods, the improvement in terms of efficiency led to the choice of the 3SLS estimator. If the covariances between equations' disturbances were zero, i.e., if the disturbances were contemporaneously uncorrelated, then there would be no advantage to use 3SLS. In other words, the advantage of 3SLS over 2SLS in capturing the information coming from the other equations is none if there is no disturbance correlation across equations.[22]

The 3SLS estimation of the System I, equation (4.10), is reported in Table 4.1. The system *R*-square is 0.8481 which shows that the equations fit the data rather well. The Chi-square statistic for the Breusch-Pagan Lagrange Multiplier test is 5.0351 with 3 degrees of freedom. This result suggests that the test fails to reject the null hypothesis of diagonal covariance matrix (White, 1993). The Wald test that all the slope coefficients equal zero has a Chi-square of 77.279 with 14 degrees of freedom which rejects the null hypothesis. The 3SLS estimates of the System I coincide with the expected signs. The estimated coefficient for *INC* in the *GROWTH* equation is negative and statistically significant at the 1 percent level which means that income concentration has a inverse effect on growth, as it was hypothesized. The coefficient for *LAND* in the *PSCHOOL* equation is negative and significant supporting the hypothesis that land ownership concentration affects human capital inversely. Finally, the coefficient for *LAND* in the INC equation is significant which means that land ownership concentration is positively related to income inequality.

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[22] Note that the estimation of equation (4.10) will provide reduced coefficients Π. Since the system is over-identified, there is no guarantee that each structural parameters Γ will be uniquely derived. However, the solution of the equation (4.13) determining Π in terms of $\mathbf{B}_0$ and Γ gives $\alpha_0 = \pi_{11}$, $\alpha_1 = \pi_{21}$, $\alpha_0 = \pi_{31}$, and the other structural parameters have more than one solution. By imposing restrictions that some coefficients are not significantly different from zero, other structural parameters are retrieved: $\beta_0 = \pi_{12}$, $\beta_1 = \pi_{42}$, $\beta_3 = \pi_{52}$, $\gamma_3 = \pi_{62}$, and $\gamma_5 = \pi_{83}$.

Table 4.1. Estimation of the basic model - system I

Variable	Estimate	Standard Error	*t*-value
(1) Dependent Variable: *GROWTH*			
Constant	0.0190	0.0164	1.1590
GDP60	-0.0060*	0.0014	-4.2401
INV	0.1620*	0.0321	5.0511
PSCHOOL	0.0171	0.0194	0.8834
INC	-0.0603*	0.0226	-2.6641
(2) Dependent Variable: *PSCHOOL*			
Constant	0.8886*	0.2524	3.5210
LAND	-0.6908*	0.2788	-2.4774
GDP60	0.0411***	0.0233	1.7637
RURPOP	-0.6811*	0.2596	-2.6237
INC	1.5651**	0.6689	2.3398
(3) Dependent Variable: *INC*			
Constant	0.3676*	0.1237	2.8880
LAND	0.2312*	0.0935	2.4713
GDP60	-0.4731×10^{-4}	0.0143	-0.0033
AGRISH	0.2105×10^{-5}*	0.6631×10^{-6}	3.1752
GR5560	0.7938×10^{-6}	0.8378×10^{-6}	0.9475
POPGR	2.4254	1.6849	1.4395
PSCHOOL	-0.1181	0.1504	-0.7851
Number of observations = 41			
System R^2 = 0.8481			
Breusch-Pagan Test = 5.0351			
Wald Test = 77.279			

Notes: * denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, and *** denotes significance at the 10 percent level.

In general, the other results of estimating the parameters support the model. The convergence hypothesis is confirmed by the negative and strongly significant effect of the initial level of GDP, *GDP60* coefficient, in the *GROWTH* equation. Also, the estimated coefficient for *INV* is positive and significant, which indicates that higher investment ratios lead to faster growth. The proxy for human capital, *PSCHOOL*, is not significant. Persson and Tabellini (1994) found similar results when they introduced an investment variable and schooling variable together. The schooling variable lost significance and had wrong sign in their growth equation.

In the *PSCHOOL* equation, the most important result is the confirmation of the endogeneity of human capital. In addition to the negative sign and the significance of *LAND*, the initial level of GDP, *GDP60*, and the percentage of rural population, *RURPOP*, have significant parameter estimates. The positive sign of *GDP60* means that, on average, countries with high initial levels of GDP in 1960 had higher levels of human capital. The negative sign on *RURPOP* coefficient indicates that the greater the percentage of rural population, the lower the level of education. *INC* coefficient is significant, but has the wrong sign (positive). The model may not have adequately incorporated inequality in schooling distribution by using primary school enrollment as a proxy for human capital. The likelihood of finding primary schools even in remote rural areas of developing countries is higher than the likelihood of finding secondary schools and university resources. Indeed, the sign of the income concentration coefficient, *INC*, may be wrong only when evaluating its effect on primary-school enrollment ratio as a proxy for human capital. In other words, income concentration may be negatively related to secondary school or higher education, but positively related to primary education. As a result, a specification including secondary-school enrollment ratio will be tested later.

The estimation of the income concentration equation showed a mix of expected and contradictory results. The positive and significant sign on *LAND* coefficient provides a striking result: land ownership concentration affects income concentration directly. This finding may be interpreted as evidence of the importance of the land occupation pattern. Those countries with historically skewed land occupation patterns and countries that did not promote land redistribution are typically countries with high indices of income concentration. The coefficient for *GDP60*, the measure of GDP in 1960, was not significant. Indeed, this result may reflect that income concentration is directly related to per capita income in the early stages of development and inversely related as the economy grows. In other words, this result may be an evidence of the inverted-U hypothesis discussed in Chapters II and III. Based on Ahluwalia (1974), a further examination of this hypothesis will be tested using a quadratic model in logarithm of per capita GDP.

The positive and significant sign on *AGRISH* coefficient in the *INC* equation gives an evidence that the higher the share of agriculture in GDP, the higher the concentration of income, as predicted by the model. This finding supports the idea that the existence of a significant traditional sector contributes to reduce growth through the persistence of income inequality. The coefficient for *GR5560* is insignificant. A negative sign was expected in order to reject the hypothesis that growth and distribution are incompatible goals. However, this result could reflect cyclical movements of per capita income. The coefficient for *POPGR* is not significant. This result is similar to those found by Ahluwalia

(1974) for the income shares of the top 20 percent and the middle 40 percent in which "the coefficient on this population variable is not significant . . . indicating that there is no clear pattern as to whether the poor benefit at the expense of the rich or middle." On the other hand, he found a negative and significant (at the 5 percent level) effect of population growth on the income share of the lowest 40 percent. *PSCHOOL* coefficient was not significant. Again, this finding is also similar to the results in Ahluwalia (1974). Therefore, secondary-school enrollment may be a better proxy for human capital.

Sensitivity Analysis

In order to evaluate some of the weaknesses of the model, mostly because of data limitations, other specifications were analyzed. All new formulations were based either on previous studies related to growth or on the development economics theory. Persson and Tabellini (1994) show that the human capital variable loses significance when entered together with the investment variable. Barro's (1991) results suggest a positive relationship between human capital and investment. The estimated coefficients on the human capital variables in Barro (1991) became smaller when they entered together with the investment variable in the growth equation. Indeed, the parameter estimate for the secondary-school enrollment ratio became not only smaller but also insignificant. The other proxy for human capital, primary-school enrollment ratio, remained significant but its coefficient became smaller.

Alesina and Rodrik (1994) did not include investment in their regressions because they took investment as endogenous variable in their model. In Mankiw, Romer, and Weil's (1994) model investment and human capital entered together to test the convergence hypothesis and both were significant and had the correct sign. However, they used the fraction of the population aged 12 to 17 enrolled in secondary school which is different from the proxy used in this study.

Estimation without the Investment Variable

A variation of the model without the investment variable was tested:

$$GROWTH_j = \alpha_0 + \alpha_1 GDP60_j + \alpha_2 PSCHOOL_j + \alpha_3 INC_j + u_{1j} \quad (4.15)$$

$$PSCHOOL_j = \beta_0 + \beta_1 LAND_j + \beta_2 GDP60_j + \beta_3 RURPOP_j + \beta_4 INC_j + u_{2j} \quad (4.16)$$

$$INC_j = \gamma_0 + \gamma_1 LAND_j + \gamma_2 GDP60_j + \gamma_3 AGRISH_j + \gamma_4 GR5560_j + \gamma_5 POPGR_j + \gamma_6 PSCHOOL_j + u_{3j} \quad (4.17)$$

It is worth noting that this system is also identified. The results of the new model called System II are shown in Table 4.2. The system R-square is 0.5573. The Breusch-Pagan Lagrange Multiplier test fails to reject the null hypothesis of homoscedasticity (Chi-square equals 7.4584 with 3 degrees of freedom). The null hypothesis that all the slope coefficients are zero is rejected since the Chi-square statistic equals 33.407 with 13 degrees of freedom.

The main changes are related to the human capital variable, as expected. The coefficient for *PSCHOOL* became significant in both the *GROWTH* and the *INC*

Table 4.2. Results without investment - system II

Variable	Estimate	Standard Error	*t*-value
(1) Dependent Variable: *GROWTH*			
Constant	0.0301	0.0261	1.1530
GDP60	-0.0063*	0.0021	-3.0162
PSCHOOL	0.0482***	0.0260	1.8569
INC	-0.0912*	0.0354	-2.5788
(2) Dependent Variable: *PSCHOOL*			
Constant	1.1196*	0.2173	5.1520
LAND	-0.7502*	0.2669	-2.8106
GDP60	0.0391***	0.0218	1.7984
RURPOP	-0.6616*	0.2519	-2.6263
INC	1.3282***	0.6985	1.9015
(3) Dependent Variable: *INC*			
Constant	0.6669***	0.3776	1.7660
LAND	0.2189***	0.1155	1.8951
GDP60	0.0218	0.0202	1.0796
AGRISH	0.2699 x 10^{-5}*	0.8521 x 10^{-6}	3.1676
GR5560	0.1454 x 10^{-6}	0.1043 x 10^{-5}	0.1394
POPGR	2.5972	2.1311	1.2187
PSCHOOL	-0.4242***	0.2249	-1.8865
Number of observations = 41			
System R^2 = 0.5573			
Breusch-Pagan Test = 7.4584			
Wald Test = 33.407			

Notes: * denotes significance at the 1 percent level and *** denotes significance at the 10 percent level.

equations. This finding is supportive of the results found in Persson and Tabellini (1994) and Barro (1991), and represents an improvement of the model. The coefficient for initial level of per capita GDP, *GDP60*, is again significant and affects growth negatively. This result provides evidence to support the convergence hypothesis. Income concentration coefficient, *INC*, is also significant and has negative effect on growth. The estimated *PSCHOOL* equation remained basically the same. The coefficient estimates for *LAND*, *GDP60*, and *RURPOP* are all significant and have the correct sign. Also, the coefficient for *INC* is significant but has wrong sign.

Land ownership concentration coefficient, *LAND*, is significant and has the expected positive sign in the *INC* equation. That is, the higher the concentration of land ownership, the higher the concentration of income. The coefficient for the share of agriculture in GDP, *AGRISH*, also affects *INC* positively. The estimated coefficient for growth of per capita GDP from 1955 to 1960, *GR5560*, is again not significant. The coefficient estimate for population growth rate, *POPGR*, is not significant. Finally, the coefficient estimate for *GDP60* is again not significant.

Therefore, the new specification results are mixed. On the one hand, the significance of the variable human capital represents an improvement of the model. On the other hand, that one variable loses significance and another variable has wrong sign represents a weakness of the modified specification. Furthermore, although there is theoretical support to omit the investment variable, the decision of dropping one variable introduces a bias into the estimation. Since the coefficient for the investment variable was not zero, "omitting a relevant variable causes estimate of the parameters of the remaining variables to be biased (unless some of these remaining variables are uncorrelated with the omitted variable, in which case their parameter estimates remain unbiased)" (Kennedy, 1992).

Results with Secondary School

It was stated in the analysis of the System I, equations (4.1), (4.2), and (4.3), that the chosen proxy for human capital, primary-school enrollment ratio, might not be appropriate to that model. Since the choice of primary schooling may disguise inequality in income distribution, it was suggested the use of a higher education measure as proxy for human capital. This new specification is called System III and is described as follows:

$$GROWTH_j = \alpha_0 + \alpha_1 GDP60_j + \alpha_2 INV_j + \alpha_3 \boldsymbol{SSCHOOL}_j + \alpha_4 INC_j + u_{1j} \quad (4.18)$$

$$\boldsymbol{SSCHOOL}_j = \beta_0 + \beta_1 LAND_j + \beta_2 GDP60_j + \beta_3 RURPOP_j + \beta_4 INC_j + u_{2j} \quad (4.19)$$

$$INC_j = \gamma_0 + \gamma_1 LAND_j + \gamma_2 GDP60_j + \gamma_3 AGRISH_j + \gamma_4 GR5560_j + \gamma_5 POPGR_j + \gamma_6 \boldsymbol{SSCHOOL}_j + u_{3j} \quad (4.20)$$

This regression repeats all variables from System I except the human capital variable which is now the ratio of total students enrolled in secondary education to estimated number of individuals in the age bracket 12-17 years, *SSCHOOL*. Table 4.3 presents estimates of System III.

The system R-square equals 0.9508 which means that the regression provides a good fit. The Breusch-Pagan Lagrange Multiplier test has a Chi-square of 17.857 with 3 degrees of freedom which rejects the hypothesis of diagonal covariance matrix. The Chi-

Table 4.3. Results with secondary school - system III

Variable	Estimate	Standard Error	*t*-value
(1) Dependent Variable: *GROWTH*			
Constant	-0.0051	0.0198	-0.2581
GDP60	-0.0093*	0.0026	-3.6241
INV	0.1174**	0.0580	2.0228
SSCHOOL	0.0680***	0.0393	1.7311
INC	0.0172	0.0472	0.3648
(2) Dependent Variable: *SSCHOOL*			
Constant	0.7570*	0.1487	5.0910
LAND	-0.6054*	0.1549	-3.9088
GDP60	0.0686*	0.0132	5.1787
RURPOP	-0.3176**	0.1390	-2.2843
INC	-0.0849	0.3817	-0.2224
(3) Dependent Variable: *INC*			
Constant	0.3805*	0.1277	2.9800
LAND	0.1416	0.1235	1.1461
GDP60	0.0087	0.0183	0.4734
AGRISH	0.1885×10^{-5}*	0.6413×10^{-6}	2.9399
GR5560	0.1060×10^{-5}	0.8376×10^{-6}	1.2656
POPGR	1.6436	2.1121	0.7782
SSCHOOL	-0.1981	0.2090	-0.9476
Number of observations = 41			
System R^2 = 0.9508			
Breusch-Pagan Test = 17.857			
Wald Test = 123.46			

Notes: * denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, and *** denotes significance at the 10 percent level.

square for the Wald test equals 123.46 with 14 degrees of freedom which rejects the hypothesis that all the slope coefficients are zero. The most important result of this new specification is the significance of the human capital variable, *SSCHOOL*, in the *GROWTH* equation. This finding confirms the questions raised in the analysis of the previous specifications. That is, secondary-school enrollment ratio seems to be a better proxy for human capital, as expected.

Nevertheless, the estimated coefficient for income concentration, *INC*, became not significant in both the *GROWTH* and the *SSCHOOL* equations. If the coefficient for *INC* were significant in the *SSCHOOL* equation, then the negative sign would mean that the more concentrated the income, the lower the level of human capital measured by secondary education. The other coefficient estimates in both the *GROWTH* and the *SSCHOOL* equations are similar to those estimated in the System I.

The estimation of the income inequality equation, *INC*, seems to be the main weakness of the System III. Five out of six variables have either insignificant parameter estimates or wrong sign. The estimated coefficient for land ownership concentration, *LAND*, became not significant even at the 10 percent level. *GDP60* coefficient is again not significant and now has wrong (positive) sign. The coefficient for population growth rate, *POPGR*, is not significant. Indeed, the finding for population growth is similar to the results found by Ahluwalia (1974), as it was stressed in the discussion of the System I. *AGRISH* coefficient is the only significant one in the *INC* equation. That is, the greater the share of agriculture in GDP, the higher the level of income concentration. The coefficient for the rate of growth of per capita GDP from 1955 to 1960, *GR5560*, is again not significant. Unlike the results in the growth equation, the estimated coefficient for human capital, *SSCHOOL*, is not statistically different from zero in the income inequality equation. Therefore, the expectation that secondary education measure would improve the fit of the regression was only partially correct. It is worth noting that the secondary-school enrollment ratio is more significant in explaining income concentration than primary-school enrollment ratio in Ahluwalia (1974).

Given the importance of human capital in this study, a different way of constructing this variable was tried. Following Persson and Tabellini (1994), arbitrary weights were given to the measures for primary- and secondary-school enrollment ratios. Since the weights should increase with the level of schooling, a new variable, *PRIMSEC*, was defined and constructed as 0.3 x *PSCHOOL* + 0.7 x *SSCHOOL*. Although the estimated coefficient for the human capital variable is a little larger than that one in System I, it is still not significant.

Estimation with Asia and Latin America Dummy Variables

Barro (1991) included continent dummy variables in his model to examine if the nature of being in those continents was already explained by the other variables. Thus, the coefficients for the dummy variables were expected to be insignificant in the growth equation. However, "the finding of significant coefficients on these dummies indicates that some regularities are missing from the model" (Barro, 1991). The proposed model in this study suggests that some characteristics of the agricultural sector in those countries are still missing.

One of the theoretical foundations of all models investigated in this chapter is the importance of land ownership concentration on economic growth. The empirical findings in the previous specifications of this paper give evidence on two linkages: from land ownership concentration to human capital and income inequality; and from human capital and income inequality to growth. It was stated in Chapter II that the way of land occupation in the beginning of a country would determine the pattern of land distribution for future generations. This pattern could be broken if a program of land redistribution took place in that country.

Therefore, two continent dummy variables were included into the *GROWTH* equation of the System I in order to test whether the growth performances of countries in those continents were still unexplained. This study expects insignificant coefficients on Asian and Latin American dummies since the agricultural characteristics are now considered.[23] The new specification, System IV, is given by the following:

$$GROWTH_j = \alpha_0 + \alpha_1 GDP60_j + \alpha_2 INV_j + \alpha_3 PSCHOOL_j + \alpha_4 INC_j + \alpha_5 \mathbf{ASIA}_j + \alpha_6 \mathbf{LATAM}_j + u_{1j} \quad (4.21)$$

$$PSCHOOL_j = \beta_0 + \beta_1 LAND_j + \beta_2 GDP60_j + \beta_3 RURPOP_j + \beta_4 INC_j + u_{2j} \quad (4.22)$$

$$INC_j = \gamma_0 + \gamma_1 LAND_j + \gamma_2 GDP60_j + \gamma_3 AGRISH_j + \gamma_4 GR5560_j + \gamma_5 POPGR_j + \gamma_6 PSCHOOL_j + u_{3j} \quad (4.23)$$

[23] Barro's (1991) continent dummies are Latin America and Africa.

The dummy variable *ASIA* equals one for Asian countries in the sample and is expected to have a positive sign since most of those countries promoted land reform. The dummy variable *LATAM* equals one for Latin American countries for which is expected a negative sign representing the lack of land reform. "Asian countries had land reform; Latin American countries did not" (Alesina and Rodrik, 1994). That is, in countries such as Japan, South Korea, and Taiwan, land redistribution contributed to high growth rates. (In addition, Asian countries have high saving rates and investment in human capital.) On the other hand, the lack of land reform in Latin American countries kept the inequality in land ownership and lowered growth.

Table 4.4 shows that the variables *ASIA* and *LATAM* entered not significantly in the System IV. This result provide evidence that the growth performance of Asian and Latin American countries are already explained by the explanatory variables in the System I. The System IV R-square is 0.9105. The Breusch-Pagan Lagrange Multiplier test rejects the null hypothesis of homoscedasticity (Chi-square equals 12.865 with 3 degrees of freedom). The null hypothesis that all the slope coefficients are zero is rejected since the Wald test gives a Chi-square statistic equal to 98.970 with 16 degrees of freedom.

The coefficient estimates for *GDP60* and *INV* in the *GROWTH* equation are significant and have the correct signs. *PSCHOOL* coefficient in this regression is not significant even at the 10 percent level (0.0238, t-value = 1.2758). Moreover, the coefficient for *INC* became not significant. All coefficient estimates in the human capital equation, *LAND*, *GDP60*, *RURPOP*, and *INC*, are significant. Except for the *INC* coefficient, all the others have the correct signs. The estimated coefficients for *LAND* and

Table 4.4. Results with dummy variables for Asia and Latin America - system IV

Variable	Estimate	Standard Error	*t*-value
(1) Dependent Variable: *GROWTH*			
Constant	-0.0026	0.0191	-0.1367
GDP60	-0.0051*	0.0014	-3.6991
INV	0.1332*	0.0345	3.8647
PSCHOOL	0.0238	0.0187	1.2758
INC	-0.0184	0.0286	-0.6430
ASIA	0.0080	0.0053	1.5235
LATAM	-0.0057	0.0042	-1.3455
(2) Dependent Variable: *PSCHOOL*			
Constant	0.6435*	0.2454	2.6220
LAND	-0.7245*	0.2766	-2.6195
GDP60	0.0546**	0.0235	2.3184
RURPOP	-0.5925**	0.2574	-2.3013
INC	1.9669*	0.6125	3.2112
(3) Dependent Variable: *INC*			
Constant	0.2382***	0.1175	2.0280
LAND	0.2494*	0.0933	2.6738
GDP60	-0.0155	0.0131	-1.1827
AGRISH	0.1365×10^{-5}**	0.6164×10^{-6}	2.2144
GR5560	0.7875×10^{-6}	0.7546×10^{-6}	1.0436
POPGR	1.7781	1.5219	1.1683
PSCHOOL	0.0718	0.1330	0.5396
Number of observations = 41			
System R^2 = 0.9105			
Breusch-Pagan Test = 12.865			
Wald Test = 98.970			

Notes: * denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, and *** denotes significance at the 10 percent level.

AGRISH in the income concentration equation are significant and have the correct signs. Nevertheless, the coefficients for *GDP60*, *GR5560*, *POPGR*, and *PSCHOOL* are not significant.

Testing the Inverted-U Hypothesis

The estimated coefficients for *GDP60*, the measure of GDP in 1960, were never significant in previous regressions for income concentration, *INC*. It was stated before that this result might reflect different relationships between income inequality and per capita income according to the stage of development. This could give an evidence of the Kuznets's inverted-U hypothesis in which income inequality increases in the first stages of growth and then decreases in the late stages.[24] Following Ahluwalia (1974), this study tested that hypothesis by taking the logarithm of per capita GDP, ln*GDP60*, and introducing the square of the logarithm of per capita GDP, $\ln^2 GDP60$. The quadratic equation in logarithm and the *GROWTH* and *PSCHOOL* equations, System V, are described as follows:

$$GROWTH_j = \alpha_0 + \alpha_1 GDP60_j + \alpha_2 INV_j + \alpha_3 PSCHOOL_j + \alpha_4 INC_j + u_{1j} \quad (4.24)$$

$$PSCHOOL_j = \beta_0 + \beta_1 LAND_j + \beta_2 GDP60_j + \beta_3 RURPOP_j + \beta_4 INC_j + u_{2j} \quad (4.25)$$

$$INC_j = \gamma_0 + \gamma_1 LAND_j + \gamma_2 \ln \boldsymbol{GDP60}_j + \gamma_3 \ln^2 \boldsymbol{GDP60}_j + \gamma_4 AGRISH_j + \gamma_5 GR5560_j + \gamma_6 POPGR_j + \gamma_7 PSCHOOL_j + u_{3j} \quad (4.26)$$

[24] This hypothesis refers to secular effect of economic growth on income inequality.

The results of this estimation are shown in Table 4.5. They are surprisingly good since most coefficient estimates became significant. Also, the system *R*-square equals 0.86, the Breusch-Pagan test equals 4.025, and the Wald test equals 80.609 which show a good fit, homoscedasticity, and non-zero slope coefficients, respectively. Most importantly, the estimated *INC* equation provided the best fit comparing with the previous specifications. Except for *GR5560*, *POPGR*, and $\ln^2$*GDP60* coefficients, all other estimates were significant at the 10 percent level and some of them at the 1 percent level. The estimated coefficient for $\ln^2$*GDP60* is almost significant at the 10 percent level. That the coefficients for *LAND* and *AGRISH* are significant is only a replication of the other specifications. But now the estimated parameter for the proxy for human capital, *PSCHOOL*, is also significant and has the expected (negative) sign which means that the accumulation of human capital reduces income inequality.

Unlike previous specifications in this paper in which the estimated parameters for the initial level of GDP, *GDP60*, were not significant, the coefficient for ln*GDP60* is significant and has the expected sign in the System V. The positive sign of the ln*GDP60* coefficient and the negative and almost significant coefficient for $\ln^2$*GDP60* may indicate a weak inverted U-shaped relationship. Again, this result is in accord with the findings in Ahluwalia (1974). According to Adelman and Robinson (1989), all studies on the inverted-U hypothesis "agree on one descriptive result: the initial phase of the development process, during which a mostly agrarian economy starts industrialization, is necessarily marked by substantial increases in the inequality of the distribution of income. . . . But there is controversy whether a decrease in inequality with development is inevitable

Table 4.5. Estimates from the system with a quadratic equation in logarithm of per capita GDP - system V

Variable	Estimate	Standard Error	*t*-value
(1) Dependent Variable: *GROWTH*			
Constant	0.0094	0.0156	0.6001
GDP60	-0.0068*	0.0013	-5.1569
INV	0.1501*	0.0307	4.8923
PSCHOOL	0.0318***	0.0166	1.9160
INC	-0.0578*	0.0222	-2.6029
(2) Dependent Variable: *PSCHOOL*			
Constant	1.0467*	0.2333	4.4860
LAND	-0.5606**	0.2435	-2.3023
GDP60	0.0374***	0.0216	1.7307
RURPOP	-0.6022*	0.2305	-2.6132
INC	0.9593***	0.5561	1.7248
(3) Dependent Variable: *INC*			
Constant	0.5283*	0.1348	3.9200
LAND	0.1615***	0.0981	1.6468
ln*GDP60*	0.0792***	0.0431	1.8369
$\ln^2$*GDP60*	-0.0366	0.0240	-1.5274
AGRISH	0.2471×10^{-5}*	0.6545×10^{-6}	3.7759
GR5560	0.1126×10^{-5}	0.8632×10^{-6}	1.3049
POPGR	2.5464	1.7476	1.4571
PSCHOOL	-0.2598***	0.1371	-1.8947
Number of observations = 41			
System R^2 = 0.86			
Breusch-Pagan Test = 4.025			
Wald Test = 80.609			

Notes: * denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, and *** denotes significance at the 10 percent level.

(the U-hypothesis) or a matter of policy choice (the J-hypothesis)."[25] Further, since the coefficient for *GR5560* is not significant, there is no conclusive result about the short-run impact of growth on income concentration.

The estimated coefficients in the *GROWTH* equation are all significant and have the correct signs. In particular, the coefficient for *PSCHOOL* became significant which means that human capital affects growth positively. The regression for *PSCHOOL* equation also presented significance in all coefficients. The coefficient for *INC* has a positive sign instead of the expected negative sign. Again, this result may be losing a lot of inequality in schooling distribution since the proxy for human capital is primary-school enrollment ratio.

[25] The J-hypothesis refers to the evidence that "in the phase of development represented by the most developed third of developing countries, policy choices determine whether an improvement in the share of income accruing to the poorest does or does not occur. The cross-country relationship can be either U-shaped or J-shaped" (Adelman and Robinson, 1989).

CHAPTER V

CONCLUSIONS

Theoretical Background

The influence of the agricultural sector in the economy has been changing with the evolution of the modern societies. Obviously the agricultural sector is no longer the dominant economic sector in the industrial countries and not even in many developing countries. Although its activity continued generally the same, i.e., crop and livestock production, its role has shifted to become a source of food and labor force in the process of development. Neoclassical economists correctly predicted this process of changing but they incorrectly generalized when they turned some empirical evidence into a linear theory of development.

The neglect of agriculture has already been pointed out in Chapter II. Also, it was stressed the great evolution of the growth theory when the role of technological progress was considered (Solow, 1956). The availability of data across countries (Summers and Heston, 1988) and the emergence of the endogenous growth theory (Romer, 1986; Lucas, 1988) in the late 1980s allowed the economists and other scientists to improve their knowledge about economic development. The recent literature on growth (Barro, 1991; Mankiw, Romer, and Weil, 1992) has some models that describe the macroeconomic relations rather well. Indeed, several new studies on economic growth (Persson and

Tabellini, 1994; Alesina and Rodrik, 1994; Chang, 1994) even include concepts proper to economic development such as income distribution.

Although the tradeoff between growth and distribution has always been debated (Adelman and Robinson, 1989) and lately reconsidered (Birdsall, Ross, and Sabot, 1995), the historical sources of inequality of income and low rates of growth seem to be misconceived. This study intended to contribute to the understanding of the true nature of this subject matter. Firstly, the traditional models were rewritten to take into account the simultaneous effect of several variables. Secondly, the roles of some variables such as human capital and income concentration were redefined. Finally, the variables land ownership concentration, share of agriculture in GDP, and percentage of rural population were introduced in order to infer the significance of the agricultural sector.

One could argue that agriculture is already included in the national accounts figures. This is true, but the problem in consideration are not the figures by themselves. This study tried to establish that the pattern of land occupation in each country determined the modes of production and the system of land tenure which in turn influenced the long-run growth. These structural characteristics are diluted in the macroeconomic indicators because they only measure the aggregate values of some variables and the average of the others. For instance, a country with high per capita income could have low consumption level because of the high income concentration. Also, the level of investment could be low because of economic and political instability generated by inequalities. Further, some political reasons could prevent the access to education resulting in low skilled labor which is likely to affect the growth rates. Nonetheless, the usual macroeconomic framework disguises this reality.

The theoretical model followed the concept that economic development is a result of economic growth with distribution. In this sense, some ideas from the structural approach were incorporated and some current models from the endogenous growth theory were adapted. The model was tested in a sample including 41 developed and developing countries. The time period of the analysis is from 1960 to 1985.

Results and Policy Implications

The 3SLS estimations gave impressive results. The specification of the model as a system of simultaneous equations improved the description of the process of growth and distribution. By endogenizing the variables human capital and income inequality, this study improved the performance of models such as Persson and Tabellini (1994) and Alesina and Rodrik (1994). Overall, this evidence contributes to the theory of endogenous growth in attempting to explain some variables which neoclassical models took as exogenous.

The results of this study supported previous evidence of the negative effect of income inequality on economic growth (Persson and Tabellini, 1994; Alesina and Rodrik, 1994). Most importantly, the results confirmed the prediction of the role of land tenure in economic development. The estimated coefficients for land ownership concentration, *LAND*, were always significant helping to explain the rate of growth throughout human capital and income concentration. Also, the insignificant effects of the dummy variables

ASIA and *LATAM* on growth confirmed the expectations about the role of land reform in the process of development.

These findings may question the idea that land reform is a "dead policy" for the 1990s (Eicher and Staatz, 1990). Land reform would be a dead topic according to the neoclassical recipe for development. That is, the agricultural labor surplus should move to the modern urban sector and the competitive market would allocate all factors optimally. Therefore, there would be no need for employment creation in the agricultural sector. However, this linear theory neglects the fact that in some development processes the transformation of the agriculture in a commercialized sector fails to keep pace with the industrialization of the urban sector.[26] Consequently, the labor surplus is barely absorbed and the contradictions between modernization and poverty are widened. According to North (1991b), most economists are missing the "way to integrate institutional analysis into economic theory."

A comprehensive program of agrarian reform remains as a necessary strategy for development in the 1990s. Such a program must include not only land redistribution, but also all sort of complementary measures in order to create efficient small and medium farms. Thus, land reform accompanied by technological innovations may be appropriate policies for increasing agricultural production, assuring self-employment in agriculture, and contributing to overall growth.

Furthermore, a development program has to consider "an alternative, or at least a complementary, engine of growth to the 'technological change' that serves this purpose in

[26] See Ranis and Fei (1961).

the Solow model . . ." (Lucas, 1988). Human capital is the completing engine suggested by the endogenous growth literature (Barro, 1991; Mankiw, Romer, and Weil, 1992; Lucas, 1988) and confirmed by this study. The emphasis on education in order to increase the potential for technological improvements was essential to the transformation of traditional economies such as Taiwan and South Korea (Lee, Liu, and Wang, 1994; Lucas, 1993; Birdsall, Ross, and Sabot, 1995). Although sometimes the estimated coefficients for the proxies for human capital, *PSCHOOL* and *SSCHOOL*, were not significant in the current study, in general they were in accord with the findings in various endogenous growth models. That is, the results provided evidence that human capital accumulation contributes to growth. Also, at least one of the specifications of the model, System II, indicated a significantly negative relation between income concentration and human capital, as expected. Finally, the regressions for both *PSCHOOL* and *SSCHOOL* equations implied that human capital was correctly treated as endogenous variable, as hypothesized by this study.

The relationship between economic growth and income inequality was established by the estimated *GROWTH* equation. However, "[f]or purposes of policy it is more important to consider what determines the patterns of concentration in income and to what extent they can be influenced through government policy" (Ahluwalia, 1974). The regressions for the *INC* equations showed the determinants of income inequality. Again, land ownership concentration, *LAND*, played a significant role in explaining the concentration of income along with *AGRISH* and *PSCHOOL*. These indicators can reflect characteristics of backward agrarian societies in which a great deal of the economic activity remains in the agriculture with highly concentrated land ownership and surplus labor. That is, countries with high land ownership concentration, large share of agriculture in GDP, high population growth rate, and low education level have high income inequality. In addition to *LAND* and *PSCHOOL* that can be influenced by the policies discussed above, high fertility can be influenced by policies such as adequate education (Becker, Murphy, and Tamura, 1990) and family planning.

The insignificance of the coefficient estimate for *GDP60* in most specifications of the *INC* equation cast doubt on its construction. By considering a quadratic in logarithm functional form for that equation, a weak evidence of the inverted-U hypothesis was implied. On the other hand, the negative coefficient for *INC* in the *GROWTH* equation indicated that income concentration is harmful for economic growth. These apparently contradictory results should be analyzed carefully and seen as an alert to hasty conclusions on whether a tradeoff between growth and equality exists or not.

The current study provided evidence that income inequality reduces growth and this result is in accord with the findings in Persson and Tabellini (1994), Chang (1994), and Alesina and Rodrik (1994). However, this result by itself is not enough to reject the inverted-U hypothesis, as Birdsall, Ross, and Sabot (1995) suggest. Like Persson and Tabellini (1994), this study establishes empirical evidence that low income inequality (*INC*) helps the *change* in income (*GROWTH*), while the inverted-U hypothesis relates income inequality (*INC*) to the *level* of income (log of *GDP60*).[27] Moreover, the

[27] Persson and Tabellini (1994) state that their results "remain valid both in the presence and in the absence of a Kuznets curve."

coefficient for *GR5560* was never significant which fails to establish a short-term relationship between income concentration and the change in income.

Limitations and Suggestions

The main limitations are related to data availability, the choice of proxies, and the model specification. According to the preliminary results, the model could be improved if some variables were redefined. In particular, this applied very well to the proxy for human capital. The redefinition of this variable was done in the section on sensitivity analysis. However, the efforts to reconstruct that variable were only partially successful. Perhaps the effects of technical education and university resources are still being missed.

The limitation of data also created difficulties in constructing some variables. For instance, the previous population growth rate was supposed to be measured from 1950 to 1960, but for some countries the data only cover the time period from 1955 to 1960. This could be the reason for the insignificance of the *POPGR* coefficient in different specifications. Indeed, the main constraint was data availability for the Gini coefficients for income and land ownership inequality. Although the Penn World Table (Summers and Heston, 1988) and the Barro and Wolf (1989) data set provided information for more than 100 countries on all other variables, the data for the two indexes of concentration cover only 41 countries. Data from all or most countries could improve the model since the sample selected may have produced some degree of bias in the results. Also, the insignificance of some variables may be related to the small sample size.

The test for overidentifying restrictions suggested that some predetermined variables could have been omitted from two of the equations in the basic model. Therefore, the results recommend further adjustments in the model to eventually suit the purposes of this study.

Perhaps longitudinal or panel studies will be able to incorporate the dynamics of growth and the concentration of income and land ownership. Also, the use of current data will enable the analysis of the growth process during the last half of the 1980s and the first years of the 1990s. The application of more recent data may alter the results given the rapid growth in some countries during that period. Finally, further research in a specific economy using survey information may provide basis for government actions toward economic development.

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APPENDIX

APPENDIX

Country	*GROWTH*	*GDP60*	*INV*	*PSCHOOL*	*SSCHOOL*	*INC*	*LAND*	*RURPOP*	*AGRISH*	*GR5560*	*POPGR*
Argentina	0.004810	3.091	0.25340	0.98	0.32	0.44	0.870	0.26	0.17		0.01543
Australia	0.021400	5.182	0.31600	1.03	0.51	0.32	0.880	0.19	0.12	0.01495	0.02208
Brazil	0.035181	1.313	0.22900	0.95	0.11	0.53	0.850	0.54	0.16	0.03467	0.03190
Colombia	0.026400	1.344	0.18040	0.77	0.12	0.57	0.860	0.52	0.34	-0.00471	0.03016
Costa Rica	0.018600	1.663	0.14710	0.96	0.21	0.50	0.780	0.63	0.26	0.01524	0.03723
Germany	0.028800	5.217	0.28580	1.33	0.53	0.39	0.670	0.23	0.06	0.04882	0.01028
Denmark	0.027400	5.491	0.26610	1.03	0.65	0.39	0.460	0.26	0.11	0.04138	0.00698
Dominican Republic	0.024300	0.956	0.17180	0.98	0.07	0.49	0.800	0.70	0.27	0.02117	0.03066
Ecuador	0.029500	1.143	0.24420	0.83	0.12	0.68	0.860	0.66	0.33	0.01171	0.02864
Egypt	0.034900	0.496	0.16330	0.66	0.16	0.42	0.670	0.62	0.30	0.02717	0.02304
El Salvador	0.004820	1.062	0.08040	0.80	0.11	0.40	0.830	0.62	0.32	0.00787	0.02788
Spain	0.039000	2.425	0.17740	1.10	0.23	0.39	0.800	0.43	0.21	0.01839	0.00872
Finland	0.032700	4.073	0.36910	0.97	0.74	0.47	0.350	0.62	0.18	0.03084	0.00994
United Kingdom	0.022200	4.970	0.18440	0.95	0.67	0.35	0.730	0.14	0.04	0.01600	0.00376
Guatemala	0.009500	1.268	0.08810	0.45	0.07	0.30	0.860	0.67		0.02358	0.02877
Honduras	0.007890	0.748	0.13850	0.67	0.08	0.62	0.760	0.77	0.37	0.01212	0.03217
India	0.013700	0.533	0.16820	0.61	0.20	0.42	0.520	0.82	0.50	0.02431	0.01642
Iran	0.030300	1.839	0.18470	0.41	0.12	0.46	0.630	0.66	0.17	0.09199	0.01265
Iraq	0.004290	2.527	0.16230	0.65	0.19	0.63	0.882	0.57	0.29	0.03297	0.02897
Jamaica	0.006340	1.472	0.20640	0.82	0.43	0.63	0.770	0.66	0.10	0.05520	0.01092
Japan	0.05760	2.239	0.36000	1.03	0.74	0.40	0.470	0.38	0.13	0.06947	0.01172

APPENDIX
(cont.)

Country	*GROWTH*	*GDP60*	*INV*	*PSCHOOL*	*SCHOOL*	*INC*	*LAND*	*RURPOP*	*AGRISH*	*GR5560*	*POPGR*
Kenya	0.009630	0.470	0.17450	0.47	0.02	0.64	0.690	0.93	0.38	0.01319	0.02057
South Korea	0.059500	0.690	0.22370	0.94	0.27	0.34	0.390	0.72	0.40	0.00588	0.03044
Mexico	0.024600	2.157	0.19590	0.80	0.11	0.53	0.690	0.49	0.16	0.02485	0.03162
Malaysia	0.045200	1.103	0.23240	0.96	0.19	0.42	0.470	0.75	0.37	0.01841	0.02906
Netherlands	0.026500	4.690	0.25860	1.05	0.58	0.44	0.580	0.20	0.09	0.02669	0.01265
Norway	0.037000	5.001	0.29190	1.18	0.53	0.39	0.680	0.68	0.09	0.02290	0.00920
New Zealand	0.014500	5.571	0.22540	1.08	0.73	0.31	0.740	0.24		0.03883	0.02153
Pakistan	0.029000	0.558	0.12230	0.30	0.11	0.36	0.650	0.78	0.46	0.02599	0.01712
Panama	0.033700	1.255	0.26190	0.96	0.29	0.57	0.740	0.59	0.23	0.02618	0.02791
Peru	0.008230	1.721	0.12060	0.83	0.15	0.59	0.930	0.54	0.26	0.02735	0.01875
Philippines	0.017700	0.874	0.14930	0.95	0.26	0.45	0.530	0.70	0.26	0.02901	0.02685
Sweden	0.026200	5.149	0.24530	0.98	0.55	0.41	0.510	0.27	0.07	0.02708	0.00641
Taiwan	0.056781	0.866	0.20730	0.96	0.27	0.31	0.460	0.42	0.28	0.11349	0.03598
Thailand	0.040600	0.688	0.18080	0.83	0.12	0.41	0.460	0.87	0.40	0.05754	0.02447
Trinidad & Tobago	0.013600	4.904	0.20430	0.78	0.22	0.54	0.690	0.78	0.08	0.08607	0.02673
Turkey	0.028100	1.255	0.20210	0.75	0.14	0.56	0.590	0.70	0.41	0.02063	0.02753
Uruguay	0.002270	3.271	0.11850	1.11	0.37	0.43	0.830	0.20	0.19	-0.01484	0.01446
United States	0.021200	7.380	0.21180	1.18	0.86	0.39	0.710	0.33	0.04	0.00372	0.01696
Venezuela	-0.016100	5.308	0.11450	1.00	0.21	0.54	0.910	0.33	0.06	0.02557	0.03774
South Africa	0.015700	2.627	0.21670	0.89	0.15	0.58	0.700	0.53	0.12	0.00689	0.02715

VITA

Luiz Antônio Maciel de Paula was born in Icó, Ceará, Brazil on March 15, 1960. He attended primary school in Lima Campos (Ceará) and graduated from secondary school in December, 1978 in Fortaleza, the capital of Ceará. He entered the Federal University of Ceará the following year and received the degree of Bachelor in Science in Agronomy in December, 1985. After he worked for three years in a research and training center, he reentered the Federal University of Ceará in March, 1989 and received a Master of Science degree in Rural Economics in July, 1991. In August, 1991, he entered The University of Tennessee, Knoxville and in May, 1996 received the Doctor of Philosophy degree in Agricultural Economics.