THE TYRANNY OF NUMBERS, LINEAR MODELS, OR INVESTMENT PLANNING: Confronting Cuban and Singaporean Factor Accumulation and Technological Change

MANUEL MADRID-ARIS *
Florida International University
Department of Economics

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Abstract

This paper shows the role-played by physical capital accumulation in explaining the Cuban growth during the period 1962-1988. In addition, this paper analyzes the applicability of linear endogenous growth models in explaining the historical performance of the Cuban total factor productivity (TFP), investment, and human capital growth. Cuban economy performance for the period 1962-1988 is compared with the Singaporean economy performance indicators (Young, 1992, 1994). Then, Cuba's investment endogenity analysis is conducted to draw implications for applying linear growth models. Empirical evidence provided in this paper show that there is an obvious over-investment in the Cuban economy (as well in Singapore), which in the specific case of Cuba was it artificially forced by governmental interventionist policies which could have led to decreasing total factor productivity growth. Under an over-investment situation in a low presence of human capital such as that in Cuba and Singapore, economy performance can not be easily explained by linear endogenous growth models. Results suggest that TFP growth is maximized at a certain investment level, which seems to be directly linked to the human, technical and institutional capacity to absorb high levels of investment efficiency. The Cuban sectoral evidence from investment endogenity analysis suggests that linear growth model could be a tool in explaining the level of investment endogenity across economic sectors.

Comments are welcome: please send comment to inera@earthlink.net

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1. INTRODUCTION

At this moment, everyone would be wondering which is, if there any, the relationship between Singapore, a high income capitalist economy, and a low income centrally planned economy as Cuba. Obviously, at first sight for a non-economist there are no similarities, but, their historical factor accumulation and technological change performance shows that they have many factors in common, from which I will try to generate some general implications for growth models. Obviously, the simple empirical analysis presented here leaves a number of questions open fir further research.

This papers relies strongly on my own TFP and factor accumulation analysis of the Cuban economy, and in the data and the analytical framework provided by Alwyn Young, in his paper "A Tale of Two Cities: factor accumulation and technical change in Hong-Kong and Singapore", published in the Annual Macroeconomics of NBER in 1992 and the paper, "The Tyranny of the Numbers: Confronting the Statistical Realities of the East Asian Growth Experience," published in the *Quarterly Journal of Economics*.

It is widely known the importance of TFP growth over time. TFP growth measures the economic and technical efficiency in the process of transforming inputs or resources into products or final goods. The growth of an economy, or economic sector, is determined mainly by the rate of growth of its productive resources (especially labor and capital) and the rate of technological change or TFP growth. Thus, TFPs are important in explaining why some countries grow more rapidly than others or why some specific industries or sectors grow faster than others for a given period of time.[1] In addition, TFP is useful for the design of a country's "catching up" process, which involves economic policies directed to exploit some industries' or economic sectors' comparative advantage, and to keep the country competitive internationally (Nishimizu and Robinson, 1984). Therefore, the differential rate of sectoral TFP growth is a crucial determinant of the comparative advantage that could help growth and define structural economic adjustments in the medium- to long-run for a specific country.

The empirical literature on growth and technological change has accumulated a huge body of "stylized facts" about the contribution of TFP and factors input (labor and capital) to economic performance.[2] Most of the empirical studies of TFP show that increased investment and human capital are directly related with higher level of TFP.[3] On the other hand, theoretical linear endogenous growth models emphasize this relationship. This paper shows

[1] For an interesting comparative cross-country research on total factor productivity (TFP), which includes Korea, Japan, Turkey, and Yugoslavia, see Nishimizu and Robinson, 1984.

[2] For a critical survey about TFP, see Nelson (1981). For case studies applied to less-developed countries (LDCs), see Teitel and Westphal (1984), Ofer (1987), and Solimano (1996).

[3] Singapore is an exeption (Young, 1992).

that this relationship goes in the opposite way in Cuba. It is also shown that the Cuban economic growth during the period 1962-1988 was much like the Russian growth —it was mainly accomplished by massive, often wasteful capital accumulation, rather than productivity growth. In the Cuban economy there is no positive correlation between investment in human capital (better-educated labor force) and TFP growth performance. Cuba as well as Singapore presents decreasing TFP while human and physical investment was increased considerably over the same period.

This paper is organized as follows. The next section provides a brief review of the historical patterns of Cuban growth, factor accumulation, and human capital for the period 1962-1988. The third section contains the estimations of Cuba's aggregate and sectoral rate of technical progress or total factor productivity (TFP) growth during the period 1962-1988, using two different methodologies—the traditional methodology (Solow, 1957) and econometric methodology. The fourth section contains theoretical explanations of Cuban TFP growth results, such as technological change, embodiment in capital, and economies of scale analysis. The fifth section contains a comparative analysis between the Singaporean and Cuban economy. Implications for linear growth models that emphasize in factor accumulation are drawn. This section also contains an endogenity analysis of the Cuban investment using linear growth models, with the purpose of drawing some implications for growth models. The final section contains the conclusions.

2. BRIEF REVIEW OF CUBAN FACTOR ACCUMULATION AND LABOR FORCE STRUCTURE

2.1 Cuban Growth and Investment Indicators

Table 2.1 shows a summary of Cuban main macroeconomic indicators and the Soviet assistance received by Cuba during the period 1960-1988.

TABLE 2.1: Macroeconomic Indicators

Period	Economic Growth (%)	Income Per capita Growth	Investment as share of GMP	Total Soviet Assistance as share of GMP*	Exports as share of GMP	Imports as share of GMP
1960-1964	1.9	-0.2	0.14	0.08	0.15	0.19
1965-1969	3.6	1.7	0.19	0.07	0.14	0.21
1970-1974	10.0	8.2	0.17	0.07	0.18	0.23
1975-1979	3.4	2.2	0.28	0.18	0.34	0.40
1980-1984	5.7	5.1	0.30	0.33	0.44	0.52
1985-1988	1.3	0.3	0.31	n.a.	0.40	0.60
AVERAGE	4.4	3.2	0.23	0.15	0.28	0.36

Notes: Economic growth has been estimated with Gross Material Product (GMP) since statistics of Gross Social Product (GSP) are not as accurate as GMP (See Mesa-Lago and Perez-Lopez, *World Bank Staff Working Paper Number 770*, 1985).
*Total Soviet Assistance includes Soviet trade subsidies (sugar, petroleum and nickel) plus development aid (for further details, see, Central Intelligence Agency (CIA), Directorate of Intelligence, 1984, p. 40 and 1989, p. 39).

Source: Rodríguez (1990), Brundenius (1984), Mesa-Lago and Pérez-López (1985), CIA-Directorate of Intelligence (1984, 1989), Comité Estadístico Estatal (CEE)-Anuario Estadísticos de Cuba, several years, and author's estimations.

Cuba's gross material product (GMP)[4] was able to grow at a steady rate of 4.4% and per-capita income increased at an average rate of 3.2% during this period 1960-1988. Cuba greatly increased the rate of investment, which went from 15% in 1960 to 30% in 1988. Data from Table 1 shows that between 1960 and 1964, there was no increase in income per capita. On the other hand, during the period 1965-1988 income per capita increased at a considerable rate. Data show the Soviet assistance increased considerably over time. During the period 1960-64, soviet assistance was on average only 7% of GMP, but it increased to a level of 33% of GMP for the period 1980-1984. The amount of Soviet assistance was larger than the investments realized by the Cuban government for the period 1980-1984. In other words, during this period, it could be assumed that most of the investments realized by the Cuban government were realized by using capital coming from Soviet assistance.[5] Therefore, it could be inferred that the Cuban economy was losing its saving capacity.

The highest rate of economic growth (10%) was achieved in the period 1970-1974. Ironically, during this period, the Cuban investment rate was low (17%) and even decreased in this period from a level of 19% to a level of 17%. Additionally, the lowest rate of economic growth (1.3%) was during the period 1985-1988, when the highest rate of investment (31%) was observed. Looking at these figures, it seems that the Cuban economy was not able to absorb in an efficient way such a high level of investment.[6] It could be said that during the 1980s, investment was not allocated as efficiently as during the 1970s. Note that, if the rate of investment exceeds the country's technical, human and institutional capacity to allocate it in an efficient way, most of the investment goes to poorly managed projects. Thus, investment is not very productive and depreciates rapidly.

2.2 National Income and Social Investment

Table 2.2 shows a summary of Cuban investment in education and health, and its percentage of total income.

[4] The Cuban accounting system is different from the western concept of Gross National Product (GNP). Cuba uses the Soviet system of Global Social Product (GSP) and Gross Material Product (GMP), which is also called "gross product." For further explanation of the Cuban Accounting System, see Brundenius (1984), pp. 19-40, and Mesa-Lago and Perez-Lopez (1985).

[5] Note that in a centrally planned economy like Cuba, the investment is mainly realized by the government since there are no opportunities for private enterprises or for private investment.

[6] Miguel Figueras, the former Director of Planning of the Cuban Ministry of Industry, support this view. For further details, see Figueras, 1994.

TABLE 2.2: National Income and Social Investment (Education and Health)

YEAR	Investment in education as % of National Income(%)	Investment in health as % of National Income (%)
1960	3.2	2.0
1965	6.7	3.8
1970	10.0	6.2
1975	10.0	3.8
1980	13.6	4.5
1987	13.1	6.6

Source: Rodriguez, José. *Estrategia del Desarollo Económico de Cuba.* La Habana: Cuba, 1990, p. 218 and p. 293.

Evidence shows that investment in education increased considerable during the period 1960-1987. In 1960, it was only 3.2% of total national income, and increased to a level of 13.1% in 1987. Investment in health also increased considerably during this period. In 1990, investment in health represented only 2.0% of national income, and it increased to a level of 6.6% of national income by 1987**.**

2.3 Population Growth and Human Capital

Table 2.3 shows a summary of Cuban infant mortality and population growth during the period 1960-1989.

TABLE 2.3: Infant Mortality and Population Growth (%)

Period	Infant Mortality (per 1,000)	Population growth (percentage)
1960-1969	38.5	1.9 %
1970-1979	27.0	1.4 %
1980-1989	15.4	0.9 %

Source: Madrid-Aris (1997).

Cuban average rate of population growth in the 60s is 1.9%, in the 70's is 1.4%, and in the 80s is only 0.9%. These figures show the decreasing tendency of population growth in Cuba. At the same time that infant mortality was reduced considerable. The low rate of population growth could be explained by two factors, first, the emigration of Cuban people to other countries, and second by the fact that the birth rate was reduced. Both elements indicate that Cuba presents the lowest population growth rate in Latin America.

Table 2.4 contains data on enrollment per 1,000 habitants by educational levels in Cuba between 1958 and 1985. Since there is no accurate data concerning the rate of change of

education of the Cuban labor force, for purposes of discussion in this study, it is assumed that human capital changes at the same rate as enrollment rates changes.[7]

TABLE 2.4: Student Enrollment by Level of Education (per 1,000 habitants)

Year	Primary Education	Secondary Education	Higher Education	Other Education	**TOTAL ENROLLMENT**
1958	104.9	11.8	3.8	0	120.5
1970	193.4	24.9	4.1	32.4	254.8
1975	205.2	57.1	9.0	31.3	302.6
1980	164.2	110.0	15.7	6.8	296.7
1985	116.8	110.0	23.2	2.0	252.0

Note: For Cuba, secondary education includes technical schools. Other types of education include the worker farm educational program developed after the revolution.
Source: Madrid-Aris (2000).

Cuba considerably increased the rate of enrollment during the period 1959-1988. Data from Table 2.4 shows that human capital accumulation has been quite rapid in Cuba during the last 35 years. Without looking at economic variables such as the amount invested in education and the return on human capital creation, it could be concluded that the Cuban government was successful in achieving a very high rate of enrollment during this period.

2.5 Labor Force Structure

Note that centrally planned economies have an astonishing power to mobilize resources, especially labor. Hence, to understand growth in a centrally planned economy it is essential to understand how the labor structure changes through time under this type of regime. Empirical evidence shows that in the Soviet Union, the rapid rate of economic growth achieved under communism, especially during the 1950s and 1960s,[8] was mainly the result of the increased labor force and capital accumulation rather than technological change.[9] Table 2.5 shows the change in the labor force structure in Cuba from 1962 through 1988.

TABLE 2.5: Total and Sectoral Labor Force Structure (in percentage)

Year	Total Labor Force (as % of Total Population)	Productive Labor Force (as % of Total Population)	Industrial Labor Force (as % of Total Population)	Agriculture Labor Force (as % of Total Population)	Female Share of Total Labor Force (%)
1962	15	12	3.6	4.1	14
1970	23	18	4.9	7.6	18
1975	26	20	5.6	7.3	26
1982	28	21	6.1	6.5	35

[7] This approximation is assumed due to the lack of accurate and reliable data about graduation rates and its relation with the labor force.

[8] The average growth rate of the Soviet Union during 1950-1964 was 4.3%. The growth rate of the U.S. was only 2.2% for this period. For further details, see Bergson (1968).

[9] For further detail, see Krugman (1994) and Poznanski (1985).

1988	33	23	7.1	6.8	38

Note: Under GMP accounting system**,** the total labor is broken onto two categories, productive and unproductive labor force. For further see Soviet Accounting System.
Source: Comité Estadístico Estatal (CEE), Anuario Estadístico de Cuba, several years.

Data shows that the labor force increased considerably after the revolution. The labor force as percentage of total population surged from 15% in 1962 to 33% in 1988. Thus, over the past generation, the percentage of people entering the labor force doubled, but it obviously can not double again in the future.[10] Large portions of this new labor force were women, which more than doubled from 1962 to 1988. The analysis of TFP presented in the coming section clearly shows that increased labor inputs are directly correlated with the Cuban economic growth.

3. CUBAN TECHNOLOGICAL CHANGE

3.1 Review of TFP Growth Methodologies and their Applicability to a Centrally Planned Economy

Krugman's (1994) publication where he mentioned Kim and Lau's (1994) and Young's (1992, 1994) works, encouraged a debate regarding the validity of the TFP obtained under the application of different methodologies (indirect method--Solow, 1957, or econometric method). Subsequently, Harberger (1996) criticized the validity of some econometric estimation of TFPs due to multicollinearity problems. Lately, he proposed a third methodology to estimate TFP, which is the "two-deflator method."[11]

Harberger (1996, p.2) shows his preference for TFP estimates by using either the traditional growth-accounting methodology (Solow, 1957) or his two-deflator method instead of econometric estimation. It is clear that preference toward traditional methodology could not be extrapolated when estimating TFP growth for a centrally planned economy, since traditional methodology assumptions,[12] especially perfect competition, is could not be suitable to a centrally planned economy like Cuba. Thus, the validity (or lack) of each of these traditional assumptions affects the measurement of technical progress, and, therefore, its contribution to economic growth. Hence, under the absence of a multicollinearity problem, an econometric estimation of TFP could be a better way to estimate TFP growth as opposed to using traditional methodology.

[10] Labor force, as percentage of total population can not double again because today the labor force is already 33% of the total population. Doubling this figure means that 66% of the population would be part of the labor force. In reality this is not feasible, because to achieve that rate, it would mean that most of the women, old men, and children would have to be a part of the labor force.

[11] For further details about Harberger's criticism of econometric estimation of TFP, see Harberger (1990, 1996). For an explanation of his two-deflator method, see Harberger (1998). For an application of the two-deflator method to Mexico's manufacturing sector, see Torres (1997).

[12] The traditional assumptions are profit maximization with competitive labor and output markets (perfect competition), and constant returns to scale (CRTS), which implies that firms will set the return on capital equal to marginal product of the capital.

On this coming section, TFP using traditional methodology is estimated, and verified with econometric estimations. Econometric estimations can be found in the Appendix. Results show that the TFP estimations using traditional methodology are consistent with econometric results. Unfortunately, due to the lack of accurate and reliable data, it was not feasible to apply the two-deflator method to estimate TFP growth for Cuba.

3.2 Total Factor Productivity (TFP) Using Traditional Methodology

The starting point of growth accounting is the following aggregated production function.

$$Y_t = F(K_t, L_t, t) \quad (1)$$

$$Y_t = A(t)G(K_t, L_t) \quad (1')$$

Here *Yt, Kt,* and *Lt* are the quantities of aggregate real output, physical capital and labor, respectively, at time *t*, and *t* is an index of chronological time. The second equation (1') is the traditional neoclassical growth model, which is a specific case of the first one, since *A(t)* varies with time and independently of *K* and *L*. Technological change is by assumption disembodied, where a Hicks neutral technological change is assumed. This is the basic neoclassical Solow (1957) model for TFP growth estimation. By totally differentiating the production function (1'), and completing elasticities, the equation (1') can be written as follows:

$$\hat{Y} = \hat{A} + a_k * \hat{K} + b_l * \hat{L} \quad (2)$$

In equation (2) the sign (^) denotes for the rate of growth of the variable, and parameters a_k, b_l, are the elasticities of capital and labor with respect to output respectively. Finally, the term $\hat{A}$ is the residual, or the well-known neoclassical expression for exogenous technological change or total factor productivity growth (TFP). Discrete approximations of equation (2) can be written as,

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + a \frac{\Delta K}{K} + b \frac{\Delta L}{L} \quad (3)$$

Equation (3) is used to estimate Cuban TFP growth at the aggregated and sectoral level presented in the following sections.

3.3 Total Factor Productivity (TFP) Growth and Investment in the Cuban Economy.[13]

[13] This analysis includes all productive sectors. According to the Soviet National Accounting Systems, productive sectors include agriculture, industry, construction, transportation, communications, and commerce. Non-productive sectors include education, health, arts, personal services, finance and administration. Productive sectors accounts for more than 80% of total Cuban output for the period 1962-1988. Industry and agriculture accounts approximately 55% to 60% of the productive sectors output.

Applying equation (3), and using the aggregate rate of growth of productive factors (labor and capital), the sectoral factor shares, and the stock of capital time series,[14] TFP growth estimation are estimated for all productive sectors. Thus,

TABLE 3.1: TFP Growth Estimations and Investment for the Cuban Economy

	TFP growth (%)	Output Rate of Growth (%)	Rate of Growth of Investment (%)	Investment as percentage of GMP
1963-1970	1.0	4.4	3.2	18%
1971-1980	0.8	5.9	18.3	26%
1981-1988	-1.2	3.8	4.9	31%
AVERAGE (63-88)	0.2	4.5	9.3	25%

Note: For references about output and investment figures, see Table 2.1.

Results show that the Cuban rate of technological change (TFPs) decreased over time, achieving negative values after 1980. On the other hand, investment increased considerably from 18% of GMP in the period 1963-1970 to a level of 31% in the period 1981-1988. TFP results found are contrary to what any economist would expect and to what endogenous growth models would predict. Empirical estimations of TFP from capitalist economies show that an increase of investment, human capital, and a lower rate of population growth leads to higher TFP growth (Barro, 1991).[15] Hence, economists would have expected a higher rate of TFP growth for the Cuban economy given the increasing investment in physical and human capital creation, but the Cuban economy presents opposite results. The lack of TFP growth in Cuba is the result of some characteristics of centrally planned economies, such as lack of competitive forces and lack of incentives for innovation.

Based on previous estimations of TFP, the factors contributing to the aggregate economic growth are as follow:

TABLE 3.2: Factors Contributing to Growth for the Whole Economy

	Labor Contribution to Growth (%)	Capital Contribution to Growth (%)	TFP Contribution to Growth (%)	Investment as % of GMP	Subsidies as % of GMP*
1963-1970	25	53	22	18	7
1971-1980	17	70	13	26	15
1981-1988	38	99	-37	31	33**
AVERAGE (63-88)	26	70	4	25	

Notes:
*Subsidies figures estimated by the author (see Madrid-Aris, 1997, 2000).
** This figure represents the 1981-1984 average.

[14] For further explanation about the perpetual inventory methodology used to build the stock of capital time series, see, Madrid-Aris (1997).

[15] An exception is Young (1992, 1994). Young found similar productivity patterns for Singapore.

Table 3.2 shows that Cuba's average TFP contribution to economic growth for the period 1963-1988, was very low (only 4%) and the average contribution of capital to economic growth is very high (70%). From these results, it could be concluded that Cuba's economic growth has been basically driven by the increased investment. In addition, Cuba's economic growth during the period 1975-1988 is directly linked to the increased level of Soviet subsidies, which allowed the Cuban economy to achieve the high rate of investment observed during this period. In sum, the TFP growth results show that Cuba was not able to take advantage of the investment in human capital to gain some economic efficiency, especially during the 1980s.

TFP results suggest that central planning policies, and especially the New System of Economic Management and Planning (SDPE),[16] failed to achieve technological change. Note that the implementation of SDPE could have led to an even lower rate of growth of technological change. The failure of this Plan is even confirmed by Cuban officials who recognized the inefficiency of this plan (Zimbalist & Eckstein, 1987).

It seems that Cuba's low rate of technical progress may simply be due to an over-investment and to the absence of competitive pressure and economic incentives that provides motivation to maximize profits. The Cuban case of low contribution of TFP to economic growth seems to be a common pattern of the ex-socialist economies. Nishimizu and Robinson (1984) found that in Yugoslavia, almost all the industries derived their growth from increases in factors inputs, with zero or negative contribution from TFP growth. Bergson (1983) found that most of the Soviet growth was based on rapid growth in inputs (labor and capital). On the other hand, reality shows that Stalinist, and Castro planners as well, moved millions of workers, especially women, into the labor force. This research' results confirm Krugman's statement, that the special strength of the Soviet economies (centrally planned economies) was their ability to mobilize resources (especially labor), not their ability to use them efficiently (Krugman, 1994, p. 69).

3.4 Sectoral Total Factor Productivity Growth (TFP) and Investment

The sectoral analysis included only agriculture and industry. These two economic sectors represented approximately two thirds of the total GMP. More desagregation is not feasible, since under the Soviet national accounting system, the total output of productive sectors is aggregated into six categories (industry, agriculture, construction, transportation, communications, and commerce).

[16] The New System of Economic Management and Planning (SDPE) was introduced in the second half of the 1970s. It was modeled on Soviet economic reforms. This plan had different goals, among those; (1) to force enterprises on a self-financing basis; (2) to increase incentives to achieve a better rate of growth of productivity; and (3) to promote decentralization, organizational coherence, and efficiency (Zimbalist and Eckstein, 1987).

3.4.1 Total Factor Productivity and Investment for the Agricultural Sector

Applying equation (3) and using the rate of growth of agricultural productive factors (labor and capital) and the sectoral factor shares, the TFP estimates are as follows:

TABLE 3.3: TFP Growth and Investment for the Agricultural Sector

	Agricultural TFP	Rate of Growth of Agricultural Output (%)*	Rate of Growth of Agricultural Investment (%)*	Agricultural Investment as % of Agricultural GMP (%)*
1963-1970	-1.9	3.8	8.0	28%
1971-1980	-1.2	2.7	10.3	35%
1981-1988	-1.5	1.7	5.6	48%
AVERAGE	-1.5	2.7	8.1	37%

Notes:
*From Comité Estatal de Estadísticas (CEE), *Anuario Estadístico de Cuba*, several years and Rodriguez (1990).

As shown in Table 3.3, the agricultural sector experienced negative growth of TFP for the period 1963-1988. Therefore, it could be assumed that resources invested (especially capital) were not used efficiently in this economic sector. Cuban agricultural output growth was basically driven by expansion of inputs, especially investment, during the period 1963-1988. Note that the average investment rate (1963-1988) in the agricultural sector was extremely high (37%). It was three times higher than the industrial average investment rate (12%).

Most of the agricultural output was the result of increased investment, as result of increased Soviet subsidies given to Cuba during this period. It seems fair to say that the negative agricultural TFP reflects the low level of yields of Cuban agriculture.[17] It is also possible to conclude that the Cuban agricultural policies were inefficient in their attempt to force some technological change during the period 1963-1988. In sum, Cuba was not able to take advantage of the large amount of resources invested. The large investment destined to human capital creation; complemented with the high level of investment in physical capital, could have led to an increase in TFP growth, thus leading to an increase of agricultural output, but results are the opposite.

3.4.2 Total Factor Productivity Growth and Investment for the Industrial Sector

It is important to note that under the Cuban accounting system, the industrial sector includes several industries[18] (e.g., mining, electrical energy, oil, fuels, electrical machinery,

[17] During the last 40 years, the Cuban agricultural yields increased at a lower rate than the world average. Today, Cuba's average yields are less than 50% of those of developed economies. For further details, see Figueras (1994) and Food and Agricultural Organization, Annual Reports (1969, 1990).

[18] For further details, see Anuario Estadístico de Cuba (industrial production).

chemicals, paper products, wood products, construction products, food, textiles, glass, etc.). Applying equation (3) and using the rate of growth of industrial productive factors (labor and capital), the sectoral factor shares, and the stock of capital of the industrial sector, the industrial TFP growth estimates are as follows:

TABLE 3.4: TFP Growth Estimations for the Industrial Sector

	Industrial TFP	Rate of Growth of Industrial Output (%)*	Rate of Growth of Industrial Investment (%)*	Industrial Investment as percentage of Industrial GMP (%)*
1963-1970	1.4	5.2	13.2	6
1971-1980	0.7	5.5	25.6	11
1981-1988	-0.4	4.3	6.0	19
AVERAGE	0.6	4.7	15.0	12

Notes:
*From Comité Estatal de Estadísticas (CEE), *Anuario Estadístico de Cuba*, several years and Rodriguez (1990).

The overall industrial TFP growth achieved was moderate (0.6%) for the period of 1963-1980. The industrial sector presents negative TFP growth rate (-0.4%) for the period 1981-1988. Evidence shows that the average ratio of investment to output in the industrial sector was very low (12%) compared with the agricultural sector (37%). Industrial and agricultural TFP results from this research and investment data suggest that the right level of investment, and avoiding over-investment, could make workers more productive, thus achieving higher rates of technological change.

3.5 Summary of Factors Contributing to Economic Growth

For a better understanding of Cuban economic growth and its linkage with input factors (labor and capital), the factors contributing to economic growth have been estimated. Table 3.5 shows the contributions of factors to economic growth in percentage.

TABLE 3.5: Factors' Contributing to Aggregated and Sectoral Economic Growth

PERIOD	CONTRIBUTION OF FACTORS (as % of total economic growth)								
	All Economy (%)			Agriculture (%)			Industry (%)		
	Labor	Capital	TFP	Labor	Capital	TFP	Labor	Capital	TFP
1963-1970	25	53	22	30	120	-50	18	56	26
1971-1980	17	70	13	12	132	-44	19	67	14
1981-1988	38	99	-37	27	158	-85	36	73	-9
AVERAGE	26	70	4	23	133	-56	23	65	12

Previous tables show that for the agricultural sector, the average TFP growth is negative (-1.5%), and its contribution of TFP to output is negative (-56%) during the period of 1963-1988. In the industrial sector, at least the average TFP growth is positive, but it was moderate (0.6%), and its contribution to economic growth was very low (12%). In sum, the

Cuban governmental interventionist policy during 1975-1988 was accompanied by very low TFP performance. Previous results show that the industrial sector, which had a lower rate of investment, had the higher TFP growth and contribution to economic growth.

It seems an irony, because Cuba's industrial central planning development strategy was oriented toward getting resources from agriculture to develop an industrial base. But, reality shows that agriculture has been a big consumer of resources especially capital, without any positive result. Results shows that the creation by governments of institutional mechanisms to deal with inefficiencies may not always be an efficient way to force technological change. The Cuban decreasing TFP growth under factor accumulation is a confirmation of the low level of technical and allocative efficiency of a centrally planning system. Result from this research and other analysis of centrally planned economies confirm that the lack of allocative and technical efficiency is a common pattern of centrally planned economies as result of lack of competition and incentives.

4. FINDING THEORETICAL EXPLANATIONS OF CUBAN TECHNOLOGICAL CHANGE

This section presents some possible theoretical explanations of results previously obtained. Technological change embodiments in capital and economies of scales are evaluated.

4.1 Technological Change Embodiment in Capital Analysis

In a case of capital embodied technical change, the depreciation rate is endogenous, because the appearance of newer technologies can eliminate rents on older assets.[19] In the case of Cuba, it makes sense to analyze the effect of endogenous depreciation because Cuba received a large amount of machinery and equipment from the Soviet Union, which could have created a structural transformation in the economy, especially in the industrial sector.[20]

The rate of depreciation used to determine the stock of capital time series for the economy as a whole (all productive sectors) was considered constant equal to 4.5%. There could exist the possibility that Cuban depreciation estimate is inappropriate for an economy which experienced structural change. A higher depreciation rate implies that the capital stock accumulates more slowly, thus higher technological change can be observed. To test the

[19] For examples, see Solow (1959, 1962). For a formal model of technical progress embodied in capital, see Hulten (1992).

[20] After the revolution, a large amount of equipment and investment was mainly destined to mechanize the agricultural sector and to create an industrial base. Investment went to the development of new industries and expansion of existing industries, such as cement, fertilizers, electrical, and mining among others. For further details, see Figueras (1994), pp. 96-111.

effect of endogenous depreciation, TFPs were estimated using the methodology previously explained (equation 3), but using new stock of capital time series, which were constructed by increasing the depreciation rate to a level of 10%. Tables 4.1 and 4.2 show the new TFPs estimated and their contribution to economic growth.

TABLE 4.1: Rates of Growth of Factors for Different Depreciation Rates

	RATE OF GROWTH OF FACTORS (%)								
DEPRECIATION	Whole Economy (%)			Agriculture (%)			Industry (%)		
	Labor	Capital	TFP	Labor	Capital	TFP	Labor	Capital	TFP
Previous Results (4.5%)	2.3	5.8	0.20	1.3	6.7	-1.50	2.9	5.1	0.60
Depreciation of 10%	2.3	5.5	0.58	1.3	5.8	-0.97	2.9	3.8	1.26

TABLE 4.2: Factors Contributing to Economic Growth for Different Depreciation Rates

	CONTRIBUTION OF FACTORS (contribution as % of total economic growth)								
DEPRECIATION	Whole Economy (%)			Agriculture (%)			Industry (%)		
	Labor	Capital	TFP	Labor	Capital	TFP	Labor	Capital	TFP
Previous Results (4.5%)	26	70	4	23	133	-56	23	65	12
Depreciation of 10%	26	62	12	23	112	-36	23	50	27

The result show that increasing the rate of depreciation does not change the TFP patterns much, nor the TFPs' contribution to economic growth as a whole. A higher depreciation rate has some effect in the industrial sectors, since TFP contribution to economic growth increased from 12% to 27%. It is difficult to believe that average depreciation rate could be higher than 10%. Hence, the upper bound or "best scenario" would be that Cuban technological change contributed only 12% to the total output. In sum, an endogenous rate of depreciation does not provide much explanation about the low-level TFP growth observed during the period of 1963-1988 in Cuba, especially in the agricultural sector.

4.2 Economies of Scale Analysis

A Cobb-Douglas production function is used to analyze economies of scales. This analysis helps us to dispel whether the low TFP could be a result of the existence of decreasing return to scale or not.

$$Y_t = A \cdot K_t^{\,a} \cdot L_t^{\,b} \qquad (4)$$

Applying natural log to equation (4), we obtain a linear equation equal to:

$$\ln Y_t = \ln A + a \ln K_t + b \ln L_t + e \qquad (5)$$

Applying ordinary least square (OLS) to equation (5) and using time series data for the period 1962-1988, the results obtained are as follows:

Table 4.3: Economies of Scale Analysis--Regression Results (1962-1988)

	Dependent Variable: Log GMP		
	Agricultural Sector	Industrial Sector	All Productive Sectors
Ln A (constant)	2.814	-2.640	-3.851
	(4.03)	(-1.45)	(-3.28)
Coefficient α	0.368	0.714	0.528
	(13.2)	(3.49)	(18.34)
Coefficient β	0.096	0.378	0.536
	(1.52)	(1.39)	(4.57)
R^2	0.940	0.978	0.969
Number of Observations	27	27	27

Note: *t*-statistics in parenthesis

The econometric estimation of equation (5) could lead to a multicollinearity problem (Boskin and Lau, 1992; Harberger 1996). The data was tested for multicollinearity problems without finding serious problems, except in the agricultural sector.[21] On the other hand, the null hypothesis of the existence of CRTS for the industrial sector, and the Cuban economy as a whole, would not be rejected.[22] Previous results show the presence of CRTS in the whole productive sectors and industrial sector.

The elasticity with respect to capital obtained econometrically for all productive sectors is 0.528, value consistent with the capital-share coefficient from the national accounts (0.53). It is important to keep in mind that in the agricultural sector, where most of the investment was allocated by interventionist governmental policies, shows decreasing return to scale. Agricultural decreasing return to scales could be explained by the clear over-investment in this sector. Investment in this sector was 48% of GMP in the period 1981-1988, value considerably much larger than the normally rate of investment seen for this sector. In sum, economies of scale analysis provide at best, a partial explanation for the decreasing and low TFP growth found in the agricultural sector. Economies of scale analysis do not provide any answers to the decreasing TFP found in the Cuban industrial sector and in the all-productive sectors as a whole.

[21] A Belsley, Kuh, and Welch (1980) test of multicollinearity was conducted. In the Cuban economy (all productive sectors) and the industrial sector, there are no multicollinearity problems at all. The only regression that presents some multicollinearity problems is the agricultural sector.

[22] Hypotheses is not rejected at 95% confidence level.

5. INVESTMENT ENDOGENITY, TFP AND HUMAN CAPITAL IN CUBA AND SINGAPORE: implications for growth models

5.1 Growth models, numbers, human capital or investment planners ?

In this section, the implications of the results obtained in the previous section for endogenous growth models are discussed. It is important to note the results obtained in this study for Cuba are very similar to those found for Singapore (Young, 1992). Both countries experienced a considerable factor accumulation (human and physical capital) through time, especially in the last 30 years. Both, Singapore and Cuba's TFP growth is close to zero.

Cuban economy results previously obtained should help us to dispel or to complement Young's statement (Young, 1992, p.45-46) about that the early educational superiority of Hong-Kong labor combined with the higher rate of TFP provides evidence in favor of models of endogenous technical change that emphasize the supply of human capital as determining the ability of an economy to absorb new technologies (e.g. Romer, 1990). Thus Singaporean and Hong-Kong TFP results are *unfavorable toward linear growth models emphasizing on the accumulation of factor of production*. (e.g. Lucas, 1988, Romer, 1986). This is because linear growth model which emphasize the accumulation of human and physical capital, would predict that increased factors accumulation would tend to raise TFP growth. Table 5.1 and 5.2 shows Singapore and Cuba pattern of investment and TFP over time.

TABLE 5.1: Singapore Patterns of Investment and Factor Contribution to Growth

PERIOD	% of Labor Force with Higher Education	Investment as share of output	Rate of Investment Growth (%)	Capital Share of Total Output	Factor Contribution to Growth		
					Labor	Capital	TFP
1961-1965	1.8	0.15					
1966-1970	3.6	0.24	60.0 %	0.562	0.14	0.64	0.23
1971-1975	4.6	0.35	46.0 %	0.553	0.31	1.05	**-0.36**
1976-1980	6.0	0.34	-2.9 %	0.548	0.32	0.63	**0.05**
1981-1985	N.A.	0.39	14.7 %	0.491	0.42	0.78	**-0.20**
AVERAGE		**0.29**		**0.538**	**0.30**	**0.77**	**-0.07**

Source: Young (1992) and author's estimations.

TABLE 5.2: Cuban Patterns of Investment and Factor Contribution to Growth

PERIOD	% of Labor Force with Higher Education	Investment as share of output (I/GMP)	Rate of Investment Growth (%)	Capital Share of Total Output	Factor Contribution to Growth for all productive sectors		
					Labor	Capital	TFP
1963-1970	1.5	0.16		0.52	0.25	0.53	0.22
1971-1980	3.1	0.23	43.8 %	0.53	0.17	0.70	0.13
1981-1988	6.0	0.30	35.0 %	0.52	0.38	0.99	**-0.37**
AVERAGE		**0.23**		**0.53**	**0.26**	**0.70**	**0.04**

Source: Author's estimations.

There are some clear similarities between the Cuban and Singaporean economy, among those: (1) both countries increased their rate of investment from about 15% of output to over 30% in a period of 20 years; (2) both countries showed a very high average capital share of total output (around 52%); (3) both countries showed decreasing TFP over time and it was at the same time that investment and human capital was increasing; (4) both economies experienced zero or negative technological change (TFP) when the level investment was over 25% as share of output; (5) in both economies, the labor contribution to economic growth was about 30% and the capital contribution to economic growth is around 70%; (6) both countries presented very interventionist governments; thus, both countries attempted to industrialize their country by the creation of state companies;[23] (7) in both economies the rate of investment growth during the 60s and 70s is very high by any standard; (8) in both economies the proportion of the labor force with higher education is very low,[24] especially when the investment is increased during the 70s.

There are some crucial differences between these two economies that can be summarized as; (1) Singapore grew a much faster rate than Cuba during the period 1962-1989. For the period 1962-1988, in Singapore, the average GDP per-capita growth was 6.1%, whereas in Cuba was only 3.2%; (2) Cuba and Singapore present interventionist economies, but there is no doubt that the Singaporean government was much less interventionist than the Cuban.

Here, the crucial issue to be analyze is whether there is any problem with linear endogenous models that emphasize on factor accumulation or it these two economies could be considered as exceptions because of their high level of forced investment as result of interventionist government in the presence of a low initial level of human capital? Anyone after looking Cuba's and Singapore's aggregated results presented, could be tempted to argue that linear endogenous growth models are not a useful tool for explaining the growth in general. But, the empirical evidence presented in Tables 5.1 and 5.2 suggest that possibly a low TFP under factor accumulation could arise from a poor investment planning policy. In the case of Cuba and Singapore it seems unreasonable to force investment to rates over 30%, without having organizations, institutions, and especially human capital to allocate such high level of investment efficiently. Obviously, an over-investment condition can led to decreasing marginal product that could be reflected as a decreasing TFP growth.

It is clear that there is in over-investment situation in the Cuban agricultural, hence, decreasing TFP could be the result of poor investment allocation. The Cuban agricultural sector seems to reflect the Singapore case, since there were diminishing return to capital and negative TFP as result of an artificially forced over-investment situation. On the other hand,

[23] For further details about Singapore interventionist economic policies and public enterprises, see Young (1992).

[24] Today, in most developed countries the proportion of the labor force with higher education varies between 30 to 50% (e.g. in the USA is 46%). In developing countries this proportion varies between 1% and 20% (e.g. Indonesia: 2.3%, Thailand: 5.5%, Panama 7%, Chile: 9%, Argentina: 10%).

the Cuban industrial sector presents a positive TFP growth under a normal level of investment. This seems to reflect that the investment-human capital proportion was adequate. Thus, the industrial positive TFP can be interpret as a more efficient allocation of capital as result that less exogenity of capital investment and the right combination of capital and human capital. Therefore, the Cuban industrial sector seems to reflect a situation like Hong-Kong, which presented positive TFP under a reasonable level of investment (20%).

Assume, that in a country with an interventionist government, where there is a lack of human capital, technical capacity, and efficient institutions, the rate of investment is increased exogenously from a level of 15% to 30% in a very short period of time (10 to 15 years). It would be very likely that the TFP results would be very similar to those found in Cuba and Singapore. It seems that these types of specific cases or bad interventionist investment planning could lead to negative TFP and not be easily explained with linear endogenous growth models.

5.2 Cuban Investment Endogenity Analysis and Linear Growth Models

This section follows closely, the methodology that Young (1992) applied in his study to Singapore and Hong-Kong, with the purpose of analyzing Cuban results in the same context than Young's results. Table 5.3 presents time series regressions at aggregated and sectoral levels of log output per worker on a constant and the natural log of capital per worker.[25]

TABLE 5.3: Regression of Ln (Y/L) on Ln (K/L)

COUNTRY	Coefficient (B)	Standard Error	Grade	R2	Capital share coefficient
Hong-Kong	0.81	0.035	B		**0.42***
Netherlands	0.63	0.018	A		
Japan	0.58	0.010	A		
Taiwan	0.57	0.012	D		
Cuba (62-88)	**0.56**	**0.050**		**0.83**	**0.53**
China	0.53	0.050	D		
Korea	0.50	0.017	B		
Yugoslavia	0.50	0.044	B		
Singapore	**0.39**	**0.035**	**C**		**0.49***
Chile	0.36	0.087	C		
Costa Rica	0.36	0.040	C		
Cuba Industry (62-88)	**0.92**	**0.110**		**0.74**	**0.61**
Cuba Agriculture (62-88)	**0.28**	**0.062**		**0.44**	**0.52**

Notes: Coefficient B refers to the linear regression: Ln (Y/L) = C + B*Ln (K/L). Grades refer to the Summers and Heston quality rating. *Value from the mid-1980s (Young, 1992, p.36).
Source: Young (1992, pp. 48-49), and Cuban estimations from the author.

[25] Cuban results were obtained using the author's database.

As Young (1992, p. 47) notes, the large coefficient on capital (coefficient B) well in excess of capital share, can represent strong evidence in favor of linear growth models. However, if one believes in a concave neoclassical production function, then the large coefficient in the regression (coefficient B) could represent its correlation with the error term of the TFP, therefore, in that case investment is considered endogenous. *Young argues that results from Singapore suggest that of the constancy of the capital-output ratio and the large coefficient on capital in cross-national and country specific regressions are due to the endogenous response to capital accumulation to technical change, within the context of an otherwise concave production function.* Then, based on the empirical results, he concludes that simple linear endogenous growth model is not a useful means of thinking about the growth process (Young, 1992, p. 50 and p.60). The Cuban economy is the only one in the world that we can confidently assert that the capital stock increased exogenously,[26] hence, Cuba is the perfect case to be used to validate Young assumption.

Results show that the Cuban agricultural sector presents a lower coefficient (0.28) than the capital-output coefficient (0.52). The low coefficient of Cuba's agricultural sector is comparable to Singapore situation. On the other hand, the high coefficient of Cuba's industrial sector (0.92), which is much larger than the capital-output coefficient (0.61), is evidence in favor of linear models. Cuba's industrial TFP and factor accumulation, as well as the coefficient from Table 5.3, reflects the situation of Hong-Kong.

The industrial sector, capital stock could have increased more endogenously than the agricultural sector. In that case, Cuban interventionist policies should be lower in this sector compared with the agricultural sector. A lower level of investment in the industrial sector could be interpreted as less interventionist policies, therefore, investment in this sector could be considered endogenously. Thus, under a less interventionist policies, which did not led to an overinvestment situation, the industrial sector was able to achieve positive TFP growth. This suggests that in the industrial sector, the more endogenous investment was more efficiently allocated than the exogenous agricultural investment. The industrial coefficient from Table 5.3 is evidence in favor of linear models. The result for Cuba, as a whole, makes even more difficult to draw some final conclusions regarding linear growth models, since the coefficient on capital (0.56) is very close to the capital-share coefficient (0.53). *In sum, the industrial and agricultural sector results seem to suggest that linear models could explain level of endogenity of capital accumulation across sectoral levels within the country context.*

Looking at Young's results and from the present study results, the question that should be addressed is: Does the Cuban aggregated and sectoral results support Young's conclusions about linear growth models? Some feasible explanation from this study and Young (1992) research is that the use of "linear growth models" is not a very good tool for explaining growth in economies with a very high rate of investment forced by interventionist

[26] Exogenity refers that capital stock is increased by governmental interventionist policies. There is no doubt about the Cuban investment exogenity, since Young (1992) argues that in Singapore with a less interventionist government policies than Cuba, the capital stock can be considered exogenously (Young, 1992, p. 49).

policies under a low level of human capital. Therefore, maybe linear models should be limited to non-interventionist economies, and where investment is not force by governmental interventionist policies. However, results from this research seem to suggest that linear models can provide some insight at sectoral levels regarding the level of endogenity investment within a country. Obviously, much more empirical research is needed to support this point.

7. CONCLUSIONS

TFP analysis results show that Cuba's growth during 1963-1988 was almost entirely the result of capital accumulation rather than productivity gains. Decreasing TFP growth through the 1970s and 1980s, with increasing amount of subsidies received from Soviet Union during the same period, suggest that Soviet dependency and lack of competition created inefficiency in Cuba.

Conclusions from the analysis of Cuban TFP could be summarized as follows: (1) the results show that increasing the rate of depreciation does not change the TFP patterns much or TFPs' contribution to economic growth as a whole. In sum, an endogenous rate of depreciation or technological change embodiment in capital does not provide explanation about the low-level TFP growth during the period of 1963-1988 in Cuba; (2) The agricultural sector where most of the investment was allocated shows decreasing return to scale. Diminishing return could be explained by the over-investment in this sector, which was forced by poor investment planning policies. Therefore, economies of scale analysis provide at best, a partial explanation for the decreasing and low TFP growth found in the agricultural sector. Economies of scale analysis does not provide answers to the decreasing TFP found in the Cuban industrial sector and in the all productive sectors as a whole.

Results indicate that theoretical endogenous growth models, especially those that emphasize in factor accumulation, could not easily explain Cuba's economic performance. In Cuba's case, an increase of capital stock and human capital occurred at the same time as a decrease in the rate of technological change. Cuba's unique case could be partially explained by several factors, among the main one is the extreme inefficiency of the centrally planned investment policy in allocating resources (especially in human capital creation), which led to an overinvestment and the lack of competition. The over-investment situation in the agricultural sector led to decreasing returns to scale and negative TFP.

From this research, it appears that the use of linear growth for explaining the process of economic growth under an exogenous investment may be limited. Hence, in cases where there is over-investment, such as the Cuban and Singapore cases, linear growth model may not be an appropriate tool to explain the process of economic growth. TFP, human capital and investment evidence from Cuba and Singapore, suggest that there is an optimal combination of investment to human capital that maximizes technological change. The optimal level should be directly related to the country's technical capacity (infrastructure,

level of technology, research capacity, etc.), human capital, the efficiency of its institutions and markets. Investment over the optimal level leads to inefficiency in investment allocation, and to a reduction in the rate of technological change.

One important conclusion resulting from this work is that under a centrally planning resource allocation system (as the Cuban case), more investment does not lead to an increase in capital efficiency factor, and it could actually lead to diminishing return to scale. Thus, under an over-investment condition, such as the Cuban case, linear growth models should be used with caution, since it may not be an appropriate tool for explaining the process of economic growth. In addition, sectoral results imply that linear growth models can provide some insight at sectoral levels regarding different levels of endogenity investment within the country. Further studies of economies with high rate of investment, and contrasting similar patterns and institutions could help our understanding of the role of overinvestment, human capital accumulation, and economic growth, under interventionist policies and the applicability of linear growth models.

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APPENDIX 1:

A1: Econometric Estimation of Cuba Rate of Technological Change

With the purpose of avoiding the criticism about the use of traditional growth accounting methodology to estimate TFP growth in a centrally planned economy, where the strong assumption of perfect competition could not hold, TFP was estimated using econometric methodology, and compared with previous results. Results obtained in this section show that results obtained under the two methodologies are consistent.

Growth accounting can be conducted by subtracting from the residual the contribution stemming from increases of the inputs (especially human capital), as well as the contribution from research and development. With the purpose of comparison with previous TFP estimates where human capital adjustment was not considered, TFP will be estimated without considering human capital quality adjustment.

When TFPs are estimated econometrically, it is convenient to keep the assumption of constant returns to scale (CRTS) because it reduces the number of independent parameters to be estimated, and thereby, mitigates the possible multicollinearity among the data on capital and labor inputs and time (Boskin and Lau, 1992). From this paper analysis of economies of scale, it seems reasonable to keep the assumption of CRTS, especially for the Cuban economy and industrial sector. The right way of estimating technical progress econometrically is by including in the production function a term (terms) to capture the effect of technical progress through time, in order to allow technical progress to be non-linear over time. Thus, the following Hicks neutral equation will be estimated econometrically.

$$Y_t = A(t) f(K_t, L_t) = A_0 \cdot e^{rt} \cdot K_t^{\,a} \cdot L_t^{\,(1-a)} \qquad (1)$$

Then, in equation (4) the rate of technical progress or TFP is equal to:

$$\frac{\dot{A(t)}}{A} = \frac{e^{rt} \cdot r}{e^{rt}} = r \qquad (2)$$

Thus, applying natural log to equation (1) leads to equation (3) that will be used to estimated TFP growth econometrically.

$$\ln(Y_t / L_t) = \ln A + r \cdot t + a \ln(K_t / L_t) + e \qquad (3')$$

Econometric estimation of equation (3') is presented in Table A-1.

Table A-1: Econometric TFP Estimations (1962-1988)

	Ln of Output		
Variable	Agricultural Output	Industrial Output	Total Economy Output
ln A	-0.805	0.709	0.423
	(-6.03)	(1.141)	(2.69)
Coefficient r or TFP	-0.042	0.005	0.004
	(-9.34)	(1.245)	(1.48)
Coefficient α	0.944	.623	.456
	(11.88)	(2.35)	(5.16)
R^2	0.875	0.752	0.849
Number of observations	27	27	27

Econometric estimations show that TFP growth for industrial sector is 0.5%. The capital elasticity with respect to output obtained (0.456) for the Cuban economy, as a whole, is very close to that obtained indirectly using national accounts (0.53) and used in the indirect estimation of the TFP.

The average rate of technical progress during the period 1962-1988, obtained econometrically for the Cuban economy as a whole, is equal to 0.4%, which is exactly to that obtained using indirect methodology (0.4%). The TFP growth for industrial sector is 0.5%, value comparable with 0.6% obtained using the traditional methodology. In sum, econometric results confirm the validity of TFP obtained in the previously by using the traditional methodology.

Econometric estimations of TFP for the agricultural sector over the period 1962-1988 are much lower (-4.2%) than those obtained the traditional Solow methodology (-1.5%). This difference could be explained by the fact that the agricultural sector does not present constant return to scale. But, the main issue is that both estimations show that the agricultural sector presents a negative TFP growth for the period 1962-1988.