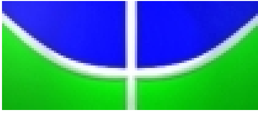

Universidade de Brasília
Departamento de Economia

Série Textos para Discussão

Long Run Implications of the Brazilian Capital Stock and Income Estimates

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TEXTO PARA DISCUSSÃO Nº 278

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Long run implications of the Brazilian capital stock and income estimates*

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Abstract

The present study aims to analyze the empirical as well as theoretical implications related to the possible inconsistencies between the Brazilian capital stock estimate and its associated investment decision. Based on empirical evidences it is shown that the common practice of using the country's accumulated (depreciated) fixed capital formation data as a proxy for the capital stock generates a set of incompatible facts with dynamic models built on balanced growth and on aggregate production functions. Moreover, a related issued on the Brazilian capital income is brought about into the analysis. According to the country's National Accounts, the participation of capital income reaches about half of the aggregate income which is a very high share compared to international data. It is shown that this problem can also be solved using alternative methods that generates a more suitable capital stock series to be used in recursive equilibrium models. Finally, the long run impacts of using the proposed capital stock series is studied using a modified basic growth model calibrated to reproduce some Brazilian empirical facts.

Journal of Economic Literature Classification Code: E13, E2, E32
Key Words: Growth model, stock of capital, capital share

1 Introduction

The capital stock constitutes one of the key variables to study economic growth and cycles. Nevertheless there is no consensus on the definition as well as the method to measure its value. In less developed countries as Brazil the problem is aggravated due to the lack of official data on capital stock.

Generally, in the macroeconomic literature, the lack of capital series data is solved using the perpetual inventory method (PIM), namely through the accumulation of depreciated investment.[1] Nonetheless, this method presents some theoretical as well as measurement problems.

¿From the theoretical point of view, the PIM assumes that the value of capital must be equal to the value of the associated investment decision. However, Hicks (1995) and more recently Prichett (2000) argue that this assumption need not be true. On the other side, from a measurement point of view, the above method requires some parameter values which are not easily observable as the values on the depreciation rate and the initial stock of capital. Another problem is based on the implicit assumption of the PIM according to which the entire value assigned to investment turns out to be next period's capital stock. This cannot be the case if part of the resources allocated into investment is wasted. This could be aftem the case, in particular for public investment, for subsidized private investment, or whenever due to technological reasons the associated capital to an investment is not fully operational, as it is the case with capital vintage models.[2] Moreover, relative price changes can also change the capital stock value, as in the example presented by Prichett (2000) of a reduction of import barriers to capital goods.

Indirectly associated with the above measurement problem, the capital income participation in aggregated income comes naturally out. Similarly to the capital stock measurement problem, shortcomings related to its quantification are more accentuated for less developed countries. Young (1995) and Gollin (1998) pointed out that this measure is rather confusing in less developed countries. In particular, the later observes that this parameter value can vary from 20% to 80% among different countries. This measurement problem generates, in turn, serious limitations for the economic growth analysis. As Young (1995) argues, in terms of total factor productivity (TFP), the economic performance analysis can be completely different depending on the used value for the capital income participation in aggregate income.

The present study aims to introduce a friction into the dynamics of cap-

[1] For a careful estimation of the capital stock series based on the PIM refer to Morandi (1998).

[2] For this consideration refer to Parente (1994).

ital stock accumulation, assuming that part of the current investment does not turn into capital next period. In other word, it is assumed that the value of the current capital stock does not correspond to the value of the last period investment. With this redefined law of motion for capital accumulation, a recursive general equilibrium model is used to quantitatively asses the long run implications of the existence of a waste associated to the investment decision of the economy. Furthermore, the quantitative impact on steady state equilibrium derived from the utilization of an alternative capital stock series will be discussed. To this end, alternative imputation methods, proposed by Young (1995) and Gollin (1998), to derive the capital income share into aggregate income will be introduced.

The present study is organized as follows. Section 2 presents the theoretical as well as empirical justification to introduce a waste factor into the capital accumulation dynamics for the Brazilian economy. Section 3 describes the model economy and the recursive equilibrium definition to be numerically computed. Section 4 explains the calibration of the model economy to mimic some of the Brazilian economic empirical facts. Section 5 analyzes the long run behavior of the model economy. Finally, Section 6 concludes pointing out some suggestions for future research.

2 Stock of capital and investment

The issue of the capital stock measurement of a given economy has important consequences on the macroeconomic analysis. When dealing with this question, Hicks (1974) defined two different ways to measure the value of capital. The first one regards the acquisition cost as the value of the capital stock available in the economy and, the second one defines it as the sum of all goods that could be produce in the future using that capital.[3]

Hence, the practice of evaluating the capital stock as the accumulated sum of depreciated investment is clearly associated to the materialist view for the emphasis is given to the cost associated to produce the capital good regardless of the value of future goods it could produce. Moreover, the same author presented an example of the problem associated with this view taken from Hayek: a machine can be used to produce a given good which is very trendy in a given year but is not so next year, so at the end of its utilization this capital good remains intact. In this example, the materialist view considers the value of the machine in the second period to be defined as its value in

[3]Hicks named the former view as "materialist" and the later as "fundist", for the first one regards the capital input as a physical good and the second as a fund to finance the production of future goods.

the previous year subtracting the corresponding depreciation value,[4] whereas according to the second view the machine would not have any value in the second period for it would not be used to produce any future good.

A way to conciliate both approaches is to consider investment as a result of an optimal decision such that its cost equals the present value of future goods the associated capital stock could produce. So that, with this hypothesis in hand, the practice of using the accumulated investment as proxy for the capital stock value could be justified. Therefore, changes in the capital accumulation rule will be needed such that the two views could be simultaneously taken into consideration.

However, before introducing the alterations in the capital accumulation rule, the question on the non-optimal investment decision has to be dealt with. There are at least one important reason to believe that the cost of a given investment decision would be different to the present value of the future goods the associated capital stock could produce. The argument, as suggested by Prichett (2000), is based on the idea that not all agents in the economy, in particular the government sector, behave optimally trying to maximize the return from its investment decision.

In order to justify the application of the above line of argument in particular for Brazil, some empirical studies could be mentioned. In particular, Cândido Júnior (2001) argues that public expenses in the country are not productive. Defining an efficient public resource allocation as such that the generated public good equals the associated social benefit, the author concludes that the Brazilian public expenses are not efficiently used. Moreover, this study shows that the productivity of the Brazilian public sector is only about 60% the productivity of the private sector. Thus, this study clearly shows that the Brazilian public sector does not observe optimality conditions when deciding on public expenses. If the government is not an optimizing agent it turns out to be quiet hard to assume the same agent will be optimizing when taking public investment decisions.

Moreover, as Brazilian public investment reaches about 14% of total investment for the period 1970-1998, distortions in public investment decisions have had important sector wise as well as macroeconomic implications. An extreme example of this sub-optimal public investment can be easily observed in the country from huge public projects that were never finish, or were finish and never used, as the so-called “iron-rail-road”, the nuclear power generator in Rio de Janeiro, and the “trans-amazonian” route among others. Other forms of waste in public investment can also be easily observed in public

[4] This is exactly the procedure adopted when evaluating the capital as the accumulated sum of depreciated investment.

projects that takes much more time than originally planned or in over valued projects. This argument should be also applied to the investments financed with public funds, trough public and private enterprises as well, associated with special development agencies as the former Brazilian SUDAN and SUDENE.

However, it is possible that a difference between the investment value and the present value of its flow of returns can also arise when markets are not competitive. Gollin, Parente and Rogerson (2000) argue that, for instance, the presence of barriers to entry can artificially push up the investment cost or relative price of capital goods. This could also be the case when high import tariffs are applied to capital goods or monopoly power to use a given technology is aonsidered. Parente and Prescott (2000) based on data from the Penn World Tables show that the relative price of investment goods to consumption goods are substantially high in poorer countries. In order to take into account this friction, the former authors used a capital accumulation rule where part of the investment is lost.[5]

Along with the above arguments to justify the proposed alteration in the method used to construct the estimated capital stock series for the Brazilian economy, the observed empirical evidences of the country appears to be even stronger to point out the inconsistency in the capital stock series. The increase in the capital output ratio, specially after 1974, suggested by some authors as Morandi (1998) among others, could not be consistent with various facts observed during the same period. Namely, with the fact that the rate of investment also showed a remarkable increase. Figure 1 below shows the behavior of the Brazilian capital output ratio for the period 1950-1998. The proposed interpretation of this seemingly inconsistency is that the increase in investment did not turn out into new productive capital stock for the economy, reflecting only an accounting increase of the capital output ratio. For if this increasing investment were turned out in fact into capital stock, the rate of increase of capital supply higher than the rate of labor supply would have led into a reduction of the productivity of capital due to the law of decreasing returns and, consequently, to a reduction of capital income and to an increase of real wages. Neither of these expected outcomes cannot be supported by the Brazilian empirical evidence of the period. According to Ferreira and Rossi (1999) the economy presented an increase in total factor productivity only from 1990.

The proposed approach tries to solve this problem assuming that part of

[5]Despite of the different motivation as well as aim of the analysis, the present study also introduces the modified capital accumulation rule in the model similar to the one proposed by Gollin, Parente and Rogerson (2000), in order to capture the waste associated to the Brazilian aggregate investment decision.

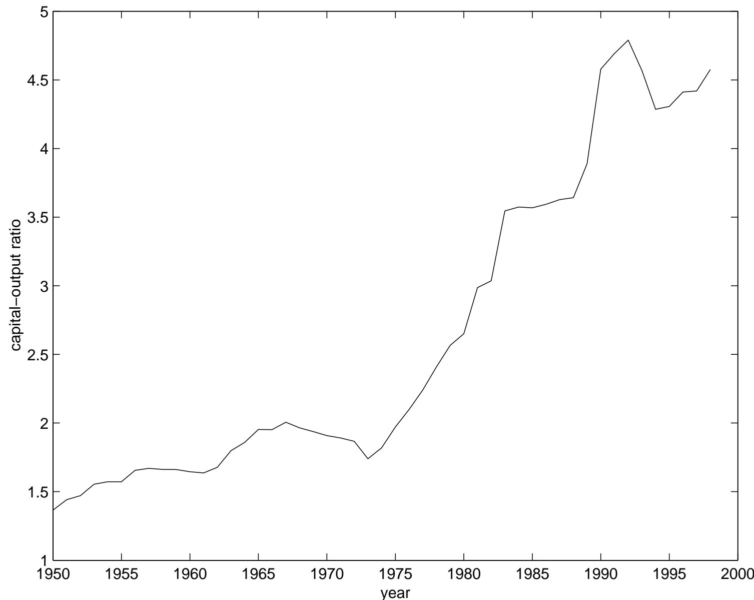

Figure 1: Capital-output ratio series (Brazil 1950 – 1998)

the current investment does not turn into capital next period, regardless of the reasons behind this dynamics which could be attributed to corruption, low government productivity and/or existence of entry barriers. Taking into account the existence of this waste in the investment decision, the model will not produce an increasing capital output ratio as the data plotted in Figure 1 above shows. Formally, the following capital accumulation law will be introduced into the model economy:

$$K_{t+1} = (1-\delta)K_t + \frac{1}{\phi}I_t \tag{1}$$

where K represents the aggregated capital stock, δ the depreciation rate, ϕ a parameter related to the waste and I the aggregate investment defined as the sum of gross fixed capital formation and consumption of durable goods.[6]

As an example of a possible implication of the existence of a waste in the investment, consider the wealth output relation for the Brazilian economy in 1970 of approximately 2.2 which is compatible with the values reported by IPEADATA and by Morandi (1998). Taking a depreciation rate of 10% and a rate of population growth and per capita GDP of 2% and 2.6% respectively as

[6]The series of consumption of durable goods for the Brazilian economy were obtained from Ellery, Gomes and Sachida (2000).

reported in the National Accounts statistics, the following algorithm can be implemented in order to obtain a rate of waste for the Brazilian economy.

1. Give an arbitrary initial investment capital relation.
2. According to the modified law of motion for capital accumulation given above, at steady state the waste rate ϕ will be given by:

$$\phi = \frac{I/K}{\delta + (1+x)(1+n) - 1} \tag{2}$$

   where x and n represent the growth rate of per capita GDP and the population growth rate respectively.

3. With the above value for the parameter ϕ compute the capital stock series.
4. Compute the investment/capital ratio using the above obtained series of capital stock. If this value is equal to the initially given relation stop the algorithm. Otherwise, continue with the second step.

Using this algorithm the obtained value for the parameter ϕ is 1.26 implying an investment waste of approximately 20.6%[7]. According to this modified rule, the mean capital output ratio turns out to be 1.8, reaching its maximum value of 2.17 in 1990 and 1991 which were exceptionally poor years in terms of the country's GDP performance due to the "Plano Collor" policies. If these two exceptional years were excluded, the mean value of the capital output ratio goes down to 1.75. Figure 2 below depicts the obtained capital output ratio series together with the original series reported in Figure 1 above.

Figure 2 shows the same declining pattern for both series during the early 1970s. This pattern could be accentuated using the proposed algorithm due to a possible over estimation of the waste parameter for the period 1970-1973[8]. For the remaining years, the relative stability of the obtained capital output ratio series compared to the original series turns out to be apparent.

The obtained stable capital output ratio is crucial to apply macroeconomic models to study the performance of real economies due to the fact that it constitutes a key hypothesis for the majority of models dealing with steady state equilibrium or with constant growth rates for the main aggregate

[7] $1-(1/1.26)=0.2063$.

[8] A time varying estimation of the parameter could solve this problem, but this extension will be left as a future exercise.

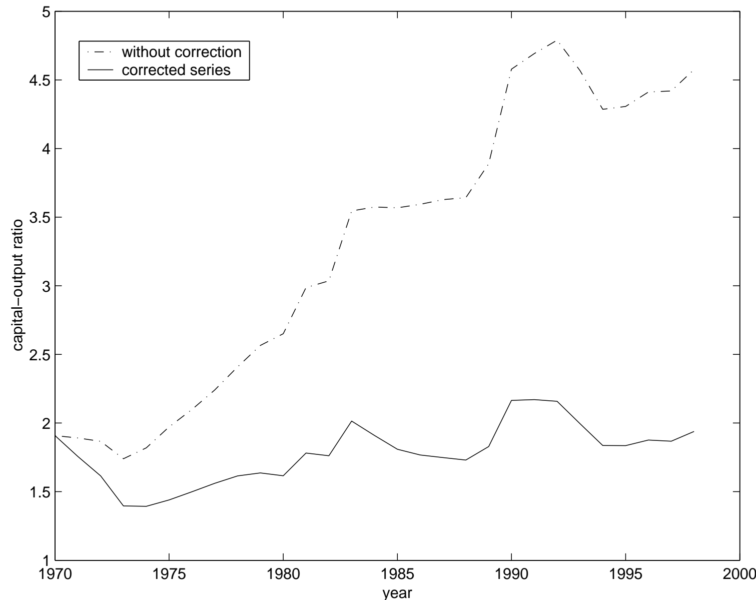

Figure 2: New capital-output ratio series with waste

variables. Otherwise, if the existence of a waste in investment is not considered, the only possible way to conciliate the observed increasing Brazilian investment with a stable capital output ratio would be to assume an extremely high capital stock depreciation rate.[9]

2.1 Transitional dynamics

The argument presented above is based on the assumption that the economy is at its steady state. However, it could be argued that the Brazilian economy could had being undergoing a dynamics of transition towards a more capital intensive steady state, hence, justifying the increasing capital output ratio.

In order to incorporate the transition, equation (1) should be expressed in unit of efficiency as:

$$(1+\eta)(1+\gamma)k_{t+1} = (1-\delta)k_t + \frac{1}{\phi}i_t \tag{3}$$

where η represents the population growth rate, γ the per capita aggregate output growth rate, δ the depreciation rate, k_t the capital stock at time t

[9]Ellery Jr, Gomes and Sachsida (2002) suggest a depreciation rate as high as 17% to obtain a stable capital output ratio for the Brazilian evidence on increasing investment during the same considered period.

and i_t time t investment. For an economy in a balanced growth path, the parameter γ represents the rate of growth of per capita aggregate product and of per capita capital stock as well. Whereas for an economy in transition the rate of growth of per capita output is different to the productivity growth rate, the later being one of the components of the former.[10]

In a balanced growth path, the variables measured in efficiency units do not grow for they are at steady state. This fact was taken into consideration when the algorithm with a waste in investment was developed, for it was assumed $k_t = k_{t+1}$ in equation (3). This assumption does not hold for an economy in transition. Therefore, the rate of growth of per capita capital stock measured in efficiency units, i.e. k_{t+1}/k_t, needs to be determined. This implies that the rate of per capita output need to be expressed as the sum of the productivity growth rate and the growth rate induced by the increase in per capita capital stock.

The above decomposition can be implemented trough a growth accounting exercise, using a particular aggregate production function. To this end, the following Cobb-Douglas production function is assumed to characterized the available technology.

$$Y_t = f(K_t, A_t H_t) = K_t^{\theta}((1+\gamma)^t H_t)^{(1-\theta)} \tag{4}$$

where Y_t refers to time t output, H_t time t labor[11] and θ the capital participation parameter.

Expressing the above equation in per capita units the following equation is obtained.

$$\hat{y}_t = A_t^{(1-\theta)} \hat{k}_t^{\theta} = (1+\gamma)^{t(1-\theta)} \hat{k}_t^{\theta} \tag{4'}$$

and taking logarithms it is possible to express the rate of growth of per capita output Γ_{haty_t} as the weighted sum of the rate of labor augmenting

productivity growth Γ_A and the rate of per capita capital stock growth $\Gamma_{\hat{k}_t}$.

$$\Gamma_{\hat{y}} = (1-\theta)\Gamma_A + \theta\Gamma_{\hat{k}} \tag{5}$$

where $\Gamma_{\hat{y}}$ is the growth rate of per-capita output, Γ_A the growth rate of labor-augmented productivity, and $\Gamma_{\hat{k}}$ the growth rate of per-capita capital. According to the Brazilian National Accounts $\Gamma_{\hat{y}_t}$ is 2.6% per year for the time period 1947-1998. Hence, leaving one equation with two unknowns. To solve this problem, we assume the growth rate of U.S. TFP as proxy to

[10] The other components refer to the contribution of factors, capital and labor inputs, to the product's growth.

[11] In this study this variable is assumed to be equal to the population.

Brazilian TFP, i.e. it is assumed that the Brazilian productivity grows at a same rate of the American aggregate productivity at the maximum.[12]

According to Penn World Table, the American productivity growth rate, in terms of per capita output, is 1.7% in the Post-War period. Then, for the standard view, this can be the higher rate to the Brazilian TFP. In other words, it is assumed that the Brazilian productivity grows at a same rate of the leader.[13] With these parameters values the rate of growth of the per capita capital stock is computed as shown below:[14]

$$\Gamma_{\hat{k}} = \frac{1}{\theta}\left[\Gamma_{\hat{y}} - (1-\theta)\Gamma_A\right] = \frac{1}{0{,}35}\left[2{,}60\% - 1{,}70\%\right] = 2{,}00\%$$

Then, since by definition $k_t = K/AH = k/A$, the rate of growth of per capita capital in terms of efficiency units can be derived as:

$$\Gamma_{k_t} = \Gamma_{\hat{k}_t} - \Gamma_A = 0.30\%$$

and, with the above value in hand, the parameter related to the waste in investment can be obtained in turn using equation (3) above, i.e.

$$\phi = \frac{I/K}{\delta + (1+x)(1+n)(1+\Gamma_k) - 1} \tag{6}$$

and using this equation instead of equation (2) in the proposed algorithm, the corresponding series for the capital stock output ratio along the transition dynamics can be obtained.

Figure 3 below shows the obtained series depicting in solid line the behavior of the capital output ratio during the transition dynamics and in dashed line the series computed at steady state. Comparing both series we can observe that when the possibility of the Brazilian economy being in its transition dynamics is considered, the capital output ratio increases but remains lower than for the economy without any investment waste. The former presents an average ratio of 1.91, with a maximum value of 2.36 and an associated investment waste of approximately 13.4%, i.e. $\phi = 1.15$.

Summing up, the obtained results of this section suggest that, even taking into consideration the possibility that the Brazilian economy was undergoing

[12]This assumption means that the Brazilian economy can undergo a transition dynamics towards a rich economy only by means of capital accumulation. This assumption is the traditional view that the transitional dynamics can only use capital accumulation (see King and Rebelo, 1993), and diverge from the recent literature where the catching up relies on the productivity side – see for example Parente and Prescott (2000), and Lucas (2002).

[13]This assumption is equivalent to assume that the American economy is in steady state.

[14]The value of the parameter θ will be discussed below in Section 4.1.

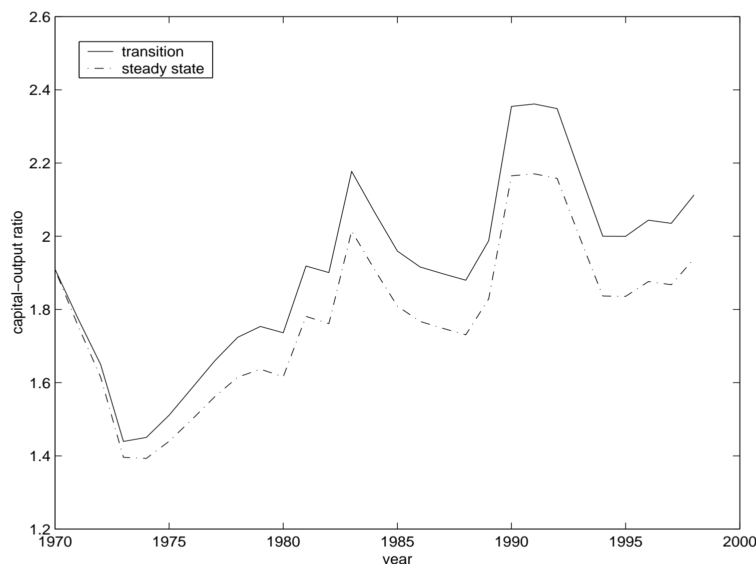

Figure 3: Capital-output ratio series – transition and steady state

a transition phase during the considered period, the observed increase in the capital output ratio appears to be inconsistent with a theoretically expected result. In other words, the introduction of the assumption on the existence of a waste in the aggregate investment seems to be successful in explaining the discrepancy between the observed data and the analytically expected result.

The next section will introduce an extended basic growth model, introducing the waste factor into the law of motion for capital accumulation of the artificial economy. Then, the impact of this assumption on the steady state (long run) recursive general equilibrium properties of the main aggregated series generated by the model economy will be evaluated following Cooley and Prescott (1995).

3 The model

The model economy consists of a large number of identical agents and firms participating in perfectly competitive factors, capital and labor, and single good markets. Hence, the model is a standard growth model, where population grows at a rate given by η and productivity is assumed to grow at a rate given by γ. Therefore, in equilibrium, aggregate variables grow at a rate given by $(1+\eta)(1+\gamma)$. Herein, all considered variables will be measured in

units of labor, such that the corresponding dynamic programming problem can be properly defined.

However, the artificial economy differs from the standard model in regard to the capital stock accumulation rule. The modified law of motion explicitly considers the assumption of a waste of a fraction of the investment optimally decided by the agents. Taking into account this friction, the problems of the representative agent and firm, and the definition of the recursive equilibrium for the model economy will be next described.

3.1 The representative agent's problem

The identical agents will be modeled as in the standard growth model, so that in every period the representative agent (RA) will choose how much to consume and to save for next period.

Furthermore, the RA has preferences over stochastic sequences of consumption and leisure characterized by the equation below.

$$U = E\left\{\sum_{t=0}^{\infty} \beta^t (1+\eta)^t u(c_t, l_t)\right\} \tag{7}$$

where c_t represents time t consumption, β the intertemporal discount factor, l_t time t leisure, and $u(.)$ the instantaneous utility function assumed to take the explicit form $u(c,l) = ln(c_t) + aln(h)$ and, in every period t, the RA faces a budget constraint given by:

$$c_t + i_t = w_t h_t + r_t k_t \tag{8}$$

such that all time t available income given by the sum of current labor income and capital income, i.e. $w_t h_t + r_t k_t$, will be entirely allocated into current consumption c_t and investment i_t. The RH is also time restricted such that in every period the allocation of time between work, h_t, and leisure, l_t, must be equal to the total available time, i.e. $h_t + l_t = 1$.

Therefore, the RA problem can be summarized as to maximize his/her expected discounted utility (7) over a stochastic sequence of consumption and leisure, subject to the per period budget and time constraint (8), given the initial capital stock and the (modified) dynamics of capital accumulation:

$$(1+\eta)(1+\gamma)k_{t+1} = (1-\delta)k_t + \frac{1}{\phi} i_t \tag{9}$$

where δ denotes the depreciation rate, and $\phi > 1$ a constant related to the waste of resources allocated to investment. This equation means that if i_t

units of current production is allocated into investment only i_t/ϕ units will turn out capital stock next period. Therefore, the magnitude of the waste will be given by $(1-(1/\phi))$.

3.2 Technology

The constant return to scale technology available to the representative firm (RF) is characterized by the following production function:

$$Y_t = z_t f(k_t, A_t h_t) = z_t (1+\gamma)^{(1-\theta)t} k_t^{\theta} h_t^{1-\theta} \tag{10}$$

where k_t denotes the employed capital stock pre worker at time t, h_t worked hours by labor input, A_t a labor augmenting technical progress and, z_t a random variable capturing the exogenous shock to time t production which evolves according to the following rule.

$$z_{t+1} = 1 - \rho + \rho z_t + \varepsilon_t \tag{11}$$

where ϵ_t denotes time t innovation component of the stochastic process, normal, independent and identically distributed with zero mean and finite constant variance σ_{ε}^2.

The competitive firms choose optimally the quantity of capital and labor at every period, such that profits are maximized setting their respective marginal products to their returns given in the competitive markets of labor and capital, i.e.

$$w_t = z_t(1+\gamma)^{(1-\theta)}(1-\theta)K^{\theta}H_t^{-\theta} \quad \text{and} \quad r_t = z_t(1+\gamma)^{(1-\theta)}\theta K_t^{\theta-1}H_t^{1-\theta} \tag{12}$$

3.3 Dynamic Programming Problem and Recursive Competitive Equilibrium (RCE)

With the above RA and RF characterization in hand, the following Bellman equation describes the dynamic problem faced by the agents of the model economy.

$$V(z,k,K) = \max_{\{h,k'\}} \{u(c, 1-h) + \beta(1+\eta)EV(z',k',K')\} \tag{13}$$

subject to (8), given the law of motion of the state variables (11) and (9) and the initial capital stock available in the economy. Then, we can define the recursive competitive equilibrium as follows.

Definition (*Equilibrium*): A recursive competitive is a value function $V(z,k,K)$; a set of decision rules: $c(z,k,K)$, $h(z,k,K)$ and $i(z,k,K)$; a set of decision rules: $C(z,K)$, $H(z,K)$ and $I(z,K)$; and factor prices function $w(z,K)$ e $r(z,K)$, such that these functions satisfy:

1. the household's problem, (13):

$$V(k,z) = \max_{\{h,k'\}} \{u(c, 1-h) + \beta(1+\eta)EV(k',z')\}$$

   subject to (8), given (11), (9), and k_0.
2. the firm's problem, (12)
3. the consistency of individual and aggregate decisions, i.e., $Nc(z,k,K) = C(z,K)$; $Nh(z,k,K) = H(z,K)$ e $Ni(z,k,K) = I(z,K)$, where N is the number of individuals.
4. the aggregate resource constraint:

$$C(z,K) + I(z,K) = Y(z,K)$$

In order to numerically compute the above defined RCE a linear quadratic approximation of the return function around the steady state was implemented following Hansen and Prescott (1995) and Ljungqvist and Sargent (2000, chap. 4).

4 Calibration

The calibration of the artificial economy followed Cooley and Prescott (1995). Thus, the parameter values were set in such a way that the model economy could reproduce, at steady state, the main facts observed in the Brazilian economy. Therefore, the characterization of the Brazilian economy at steady state with a waste of investment is needed.

To proceed with this characterization, the below modified first order condition corresponding to the maximization problem (13) is used.[15]

$$\begin{gathered} \frac{\phi(1+\gamma)(1+\eta)}{c_{t+1}} = \frac{\beta(1+\eta)\left[\theta k_{t+1}^{\theta-1} h_{t+1}^{(1-\theta)}\right]}{c_{t+1}} \\ \frac{(1-\theta)k_t^{\theta} h_t^{-\theta}}{k_t^{\theta} h_t^{1-\theta} - \phi k_t[(1+\gamma)(1+\eta)-(1-\delta)]} = \frac{a}{1-h_t} \end{gathered} \tag{14}$$

[15] for a detailed justification of the choices for the specific utility and production functions used in the model refer to Ellery, Gomes and Sachsida (2002).

The corresponding equations used for calibration purposes were obtained from (14) and the capital stock accumulation rule (9) evaluated at steady state such that:

$$\frac{\phi(1+\gamma)}{\beta} - \phi(1-\delta) = \theta\frac{y}{k}$$

$$(1-\theta)\frac{y}{c} = \frac{ah}{1-h} \tag{15}$$

$$i = \phi\left[(1+\gamma)(1+\eta) - (1-\delta)\right]$$

The above three equations allowed, in turn, to set the discount parameter value β, the value for the elasticity of substitution between consumption and labor a and, the waste of investment parameter value ϕ, all of them as function of the other remaining parameters.

The deprecation rate δ and its relationship with the waste parameter ϕ were discussed in Section 2 above and will be again described in Section 5 below. The value for δ will be set at 10% for the benchmark case, hence implying a value of $\phi = 1.26$. The parameter value corresponding to the capital income participation in aggregate income θ will be carefully discussed below. The other two values needed for the calibration procedure are the population growth rate, η, and the rate of growth of per capita GDP, γ. Based on the National Account statistics, these parameters' values were set at 2% and 2.6% respectively which are the approximate values observed for the Brazilian economy for the period 1947-1998.

Finally, the model economy should be able to reproduce the capital output ratio, corrected by the investment waste, of approximately 1.8 as well as the worked hours h_t. According to PNAD[16] data h_t is approximately 0.31, meaning that a typical Brazilian worker allocates approximately one third of his/her available time to market labor activities.[17]

Given the above defined values, the complete determination of all parameters values needed for calibration depends solely on the value of the capital income participation in aggregate income, θ. The next subsection will be devoted to carefully describe the problems associated to the measurement of this parameter for the Brazilian economy.

4.1 Capital and labor income participation in aggregate income

A significant part of dynamic macroeconomic studies applied to the Brazilian economy assume that the capital income participates with about 50% of

[16]Pesquisa Nacional de Amostra Domiciliar (National Household Survey).

[17]See Ellery Jr, Gomes and Sachsida (2002) for further details.

aggregate income[18]. However, as showed by Gollin (1998) and Parente and Prescott (2000), this share is too high compared to international standards which is about 30%. Therefore, naturally emerges the question of why the capital income participation in Brazil is so high.

In fact, different country's official National Accounts data show a great variability in regard to this parameter value, from 20% up to 80%. Gollin (1998) suggests that this measurement discrepancy arises from a common national account procedure, specially in poorer countries, which treats the self-employment remuneration as capital income. The author bases his argument pointing out that the capital income share measurement problem is associated to the practice of measuring the share of labor income in aggregate income as the ratio between the "employment remuneration" and the "national product" and, the former constitutes in fact a poor measure of labor income, specially in those countries, for it does not take into account the self-employment remuneration which is accounted, as residual, as capital income. For instance, for countries as Ghana, Bangladesh and Nigeria, the percentage of self-employed workers in manufacturing accounts up to 80% of total employed workers, whereas for the USA this number is approximately 2%.

Based on the above line of argument, the author suggests three alternative procedures in order to correct the above usual measurement procedure of labor income participation for the self-employment income. The first one, from now on named G1, consists of treating the operational surplus of non-incorporated private enterprises as labor income. The second G2 divides this non-incorporated income by the ratio between the employment compensation and the aggregate income. The third alternative procedure G3 imputes the employment compensation to all self-employed workers.[19]

Furthermore, the same author shows that with the commonly used procedure the average labor income participation among different countries reaches 0.479, with a standard deviation of 0.135. Whereas applying his proposed methods, the average labor income participation increases to 0.745 (G1), 0.675 (G2) and 0.654 (G3) and the respective standard deviations decrease down to 0.087 (G1), 0.089 (G2) and 0.103 (G3) respectively.

The measures of the Brazilian average labor income participation in aggregate income for the period 1990-1998, obtained through the usual procedure (Naive) and the (G1), (G2) and (G3) procedures proposed by Gollin (1998) were computed and the results are shown in Table (1). This Ta-

[18]See for instance Barreto and Oliveira (1995), Ferreira and Arajo (1999) and Gomes, Ellery and Sachsida (2000).

[19]i.e. ((employment compensation/employed workers) working age population)/GDP.

ble clearly shows that the average labor income participation in aggregate income increases from 0.47 (Naive) to 0.55 (G1), to 0.5 (G2) and to 0.53 (G3).[20] Comparing these results with the ones obtained by Gollin (1998), which suggest an increase in labor income participation up to 0.7 approximately, two questions can be formulated, (i) Does not the Brazilian economy behave as the others? (ii) Are the Gollin's procedures suitable to measure the Brazilian labor income participation?

It is important to point out that the main concern of Gollin was to produce an efficient method to be used in comparative, cross-section studies among different countries. The same author suggests that perhaps a better method would be Young's (1995) based on micro-data evidences, though it could be only applied to a few number of countries. Young's method imputes worker's wages to self-employed and employers, according to their respective production sector, gender, age and education.

In fact, Gollin's (G3) and Young's procedures are similar in terms of the motivation. Both of them imputes the average wage to the self-employed worker. Along this line of argument, if these procedures are to be applied for the Brazilian economy a crucial factor must be observed in addition. The average labor compensation for the Brazilian employed workers was R$ 5,480,00 in 1998 according to the National Accounts data, however, the imputation of this income to self-employed workers cannot be suitable due to the fact that, as studied by Barros, Henriques and Mendona (2001), the country's aggregate income distribution is highly concentrated. Empirical evidences from PNAD 1998 data show that the annual average remuneration of employees (R$ 6,024) is similar to the average income of self-employed workers (R$ 5, 268) but much lower than the employers' remuneration (R$ 20,736). Therefore, the imputation of the average wage to the self-employed can clearly bias the labor income participation in aggregate income.

Aiming to capture the income of self-employed workers and employers, the above PNAD 1998 information is used to compute the average income of those different type of workers. First, a weighted (by the number of workers) average income of those two type of workers were computed. Second, the ratio of this number and the average income of employees were calculated for 1992, 1993, 1995 and 1998, imputing the corresponding average income of these years for 1990, 1991 and 1994. The obtained value of 1.26 clearly suggests that the Brazilian total labor income is in fact 26% higher than the share shown in the country's National Accounts.

With the above information, a corrective factor of 1.26 were applied to the officially reported total labor income and, dividing this number by the

[20]Data from PEA/PNAD and National Accounts were used in this procedure.

total number of employed workers, the mean value of per worker labor income were obtained. Finally, the share of labor income in aggregate income was obtained multiplying this corrected average labor income by the economically active population and dividing this result by the country's aggregate value added. The obtained result of 0.67 is also introduced in the last column of Table1 under the DR (difference in remuneration) denomination.

Two characteristics on the obtained labor share derived from the above estimation procedure are noteworthy. From a quantitative point of view, the obtained measure is highly similar to the average international evidence of 0.7 presented by Gollin (1998). Furthermore, the obtained estimates are rather stable along the considered period, contrary to the commonly used (Naive) estimates which present a declining tendency along the same period. The later aspect is crucial from a theoretical point of view, for the new stable estimates on labor income share can, in turn, empirically support the utilization of an aggregate Cobb-Douglas production function for the artificial economy.

Table 1: Labor share, 1990-1998

	Naive	G1	G2	G3	DR
Média Part. Trab.	0,47	0,55	0,50	0,53	0,67

Setting the labor income share, based on the alternative procedures described above - (Naive),(G1), (G2), (G3) and (DR) shown in Table 1- allows to assign the corresponding values to the capital income share parameter, θ, the discount factor, β, and the elasticity of substitution between consumption and labor, a. Table 2 below shows the calibrated values for this set of parameters, recalling that the depreciation rate was set to 10%, the investment waste factor to 1.26, the population growth rate to 2% and, the rate of growth of labor productivity to 2%.

Table 2: Calibration

	Naive	G1	G2	G3	DR
θ	0,53	0,45	0,50	0,47	0,33
β	0,9050	0,9341	0,9157	0,9266	0,9813
a	1,96	1,83	1,67	1,77	2,28

5 Long run implications

With the above described calibration of the model economy in hand, the long run implications of the assumption on the existence of a waste factor

on the optimal investment decision are analyzed. Hence, the effects of this assumption on the steady state is studied.

To this end, following the suggestion of Parente and Prescott (2000) per capita income[21] associated at the steady state equilibrium with a given investment waste, ϕ, are compared to each other rather than comparing the associated growth rates.

Before evaluating the long run impacts of the existence of a waste in investment resources, it is important to mention the implications of changing the value of capital income share on aggregate income, θ. It was argued, in the previous section, how the measurement problems present in the National Accounts leads to an overestimation of this share relative to the labor income share in aggregate income. Alternative procedures to deal with this problem were proposed and, for each of them a corrresponding value for the parameter θ was derived.

In terms of the set up of the model, higher values of θ are related to higher values of the capital stock and to smaller values for the worked hours. Since the calibration of the model imposes the worked hours be approximately one third of the available time, i.e. $h = 0.31$, the effect on the dynamics of capital accumulation will be the only relevant impact of changing the value of the parameter θ.

Therefore, higher values for this parameter would simply imply higher values of per capita income in the artificial economy. Figure 4 below sketches this relationship taking values for θ between 0.33 and 0.53.

This figure shows a strictly and monotonically increasing relationship between the capital income share parameter value and the other variables of the model. Hence, it was chosen to fix an intermediate value for the former parameter, i.e. $\phi = 0.45$, corresponding to the value obtained with the (G1) procedure, and compute the steady state RCE for different values of the investment waste factor ϕ.

Recall that in Section 2 above, the relation between the depreciation rate, δ, and the investment waste factor, ϕ, was carefully discussed, showing that for each value for the former it is possible to obtain a value for the later such that a stable capital output relationship could be derived. The same method was implemented in this section in order to attribute the values for

[21] According to the authors, "...we came to the conclusion that relative income levels rather than growth rates are key to understanding the problem of development..."

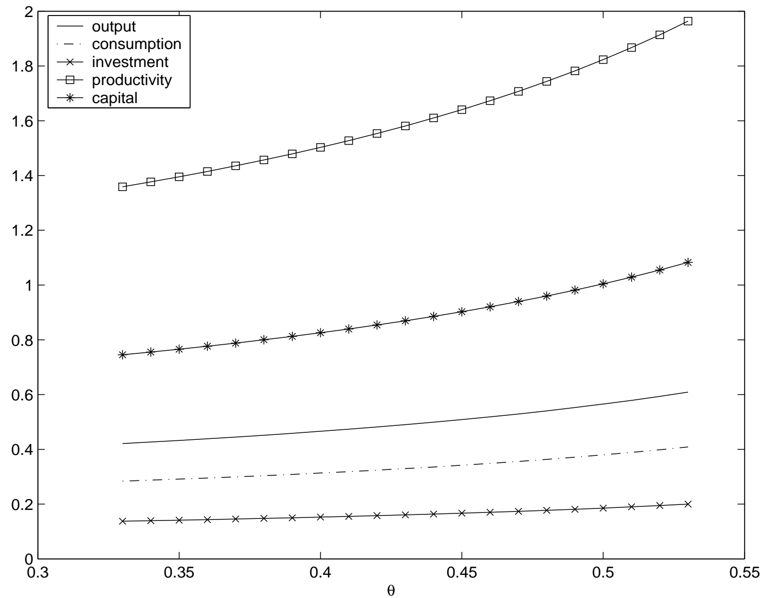

Figure 4: Effects of θ over the steady state

the parameter ϕ consistent with a depreciation rate between 4% and 12.5%. Table 3 below presents the results of this computation.

Table 3: Values of ϕ and δ

δ	ϕ	δ	ϕ	δ	ϕ
4,0%	2,28	7,0%	1,64	10,0%	1,26
4,5%	2,14	7,5%	1,56	10,5%	1,22
5,0%	2,02	8,0%	1,49	11,0%	1,18
5,5%	1,91	8,5%	1,43	11,5%	1,13
6,0%	1,81	9,0%	1,37	12,0%	1,09
6,5%	1,72	9,5%	1,32	12,5%	1,06

The above values, consistent with a stable capital output ratio, allowed to quantify the changes in per capita income, at steady state, as a result of the existence of a waste of resources optimally allocated to investment. The simulation results indicates that the long run per capita income of the artificial economy calibrated for the Brazilian economy could be 20% higher with a waste of 5.66%, i.e. $\phi = 1.06$, than for an economy with a waste of 56%, i.e. $\phi = 2.28$. Figure 5 below illustrates the long run per capita income of the model economy for each considered ϕ value. As expected, this figure

shows that the higher this parameter value or, equivalently, the higher the waste $(1 - (1/\phi))$ of resources allocated to investment, the lower will be the resulting per capita income at steady state.

Another performed exercise aimed to compare the steady state equilibrium of an economy calibrated with $\beta = 0.9341$, $\theta = 0.45$, $\delta = 0.10$, $a = 1.8336$, $\gamma = 0.026$, $\eta = 0.02$ with a waste of $\phi = 1.26$ with the one obtained for an economy without any waste of resources, i.e. $\phi = 1$. This simulation shows that with an investment waste of approximately 20.63%, causes a reduction of 20% in per capita income and, the capital output ratio shrinks from 2.2 to 1.8 at the steady state.

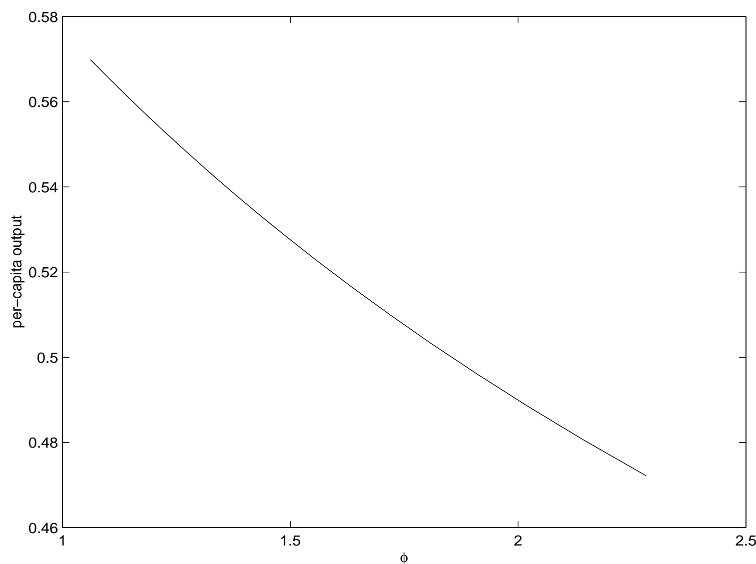

Figure 5: Impact of ϕ on per-capita income at steady state

The analysis of this section suggests that, for a model economy calibrated to reproduce the main empirical facts of the Brazilian economy including an also observable friction into the dynamics of capital accumulation, given by a waste of 20.63% on investment resources, could cause, at steady state, a reduction of per capita income as deep as 20% at steady state.

Although this effect appears to be insufficient to fully explain the differences in per capita income among Brazil and other more developed countries[22], clearly suggest the relevance of the proposed argument in order to

[22]In fact it would be inappropriate to justify the underdevelopment of any economy solely based on the existence of a waste of investment resources.

(partially) identify the causes of a lower per capita income in the country compared to more developed economies.

6 Conclusion

This study aimed to explicitly introduce a friction given by the presence of a waste in the capital accumulation process and analyze its long run effects on the performance of the economy.

The above hypothesis was empirically justified, for looking at the Brazilian data (in particular the capital output ratio series) the presence of an investment waste in the Brazilian economy turned out to be apparent.

Comparing this facts with the theory allowed us to observe that without the introduction of this assumption, the implementation of balanced growth models as well as of steady state models would be impossible for the Brazilian economy.

Thus, the utilization of aggregate models to an economy where the capital stock growth rate is higher than the ones of other variables, in particular aggregate output and effective labor growth rates, was questioned. The introduction of the proposed assumption conciliated the theoretical requirements and the observed facts in the Brazilian economy.

Then, the effects of such an assumption on the economy were analyzed by means of numerical simulations of a standard growth model calibrated for the Brazilian economy taking different possible values for the waste factor. The low run analysis suggested that the presence of an investment waste could be responsible for a reduction of as much as 20% in per capita income.

Finally, it is worthy to point out the need to further study the public and private composition of the Brazilian investment series. The country's public sector investment crucial roll on the growth experience needs to be evaluated taking into account the suggestion of some studies which shows the waste of public investment to be higher than of the private sector.

Along this line of argument, the set up of a two sector model in which one of the sectors presents a higher waste, due for instance to the presence of monopoly rights, and explicitly considering the resource allocation mechanism for investment financing, such as taxes and/or subsidies, could improve the understanding of the impact of such a waste on the short and long run economic performance of the Brazilian economy.

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