



F U N D A Ç Ã O
GETULIO VARGAS

EPGE

Escola de Pós-Graduação
em Economia

Ensaio Econômico

Escola de

Pós-Graduação

em Economia

da Fundação

Getúlio Vargas

Nº 755

ISSN 0104-8910

Distortions in the Investment Goods Sector and Productivity Decline

Pedro Cavalcanti Ferreira, Samuel de Abreu Pessoa, Fernando A. Veloso

Agosto de 2014

URL: <http://hdl.handle.net/10438/11921>

Os artigos publicados são de inteira responsabilidade de seus autores. As opiniões neles emitidas não exprimem, necessariamente, o ponto de vista da Fundação Getulio Vargas.

ESCOLA DE PÓS-GRADUAÇÃO EM ECONOMIA

Diretor Geral: Rubens Penha Cysne

Vice-Diretor: Aloisio Araujo

Diretor de Ensino: Carlos Eugênio da Costa

Diretor de Pesquisa: Humberto Moreira

Vice-Diretores de Graduação: André Arruda Villela & Luis Henrique Bertolino Braidó

Cavalcanti Ferreira, Pedro

Distortions in the Investment Goods Sector
and Productivity Decline/ Pedro Cavalcanti Ferreira,
Samuel de Abreu Pessôa, Fernando A. Veloso - Rio de Janeiro :
FGV,EPGE, 2014

12p. - (Ensaio Econômico; 755)

Inclui bibliografia.

CDD-330

Distortions in the Investment Goods Sector and Productivity Decline ^{*}

Pedro Cavalcanti Ferreira[†] Samuel de Abreu Pessoa
Fernando A. Veloso

August 8, 2014

Abstract

We study the impact of distortions in the investment goods sector on aggregate total factor productivity (TFP). We develop a two-sector neo-classical growth model in which TFP in the capital goods sector relative to TFP in the consumption sector is inversely related to the price of investment relative to consumption, so that we use relative prices to measure TFP in the investment goods sector. The model is calibrated to Brazil and we find that distortions in the investment goods sector may explain most of the decline in Brazilian TFP relative to the United States since the mid-1970s.

1 Introduction

Between 1975 and 2000 there was a steep decline in Latin America total factor productivity (TFP) relative to the U.S. Specifically, TFP in Latin America declined from 88% of the U.S. TFP in 1975 to 54% in 2000.¹ In Brazil it fell from an average of 81% for the 1960-1975 period to 61%, on average, from 1990 to 2000.

At the same time, there was an increase in policy distortions in the investment sector of the region. In particular, some Latin American countries implemented import-substitution industrialization policies (ISI) in this sector in the 1970s. For instance, Brazil launched a major ISI program in the capital goods sector and initiated policies that culminated in an import ban on foreign produced computers as well as most computer components. There is strong evidence (Lee (1995) and Eaton and Kortum (2001)) that equipment imports affect TFP in developing countries. A second strand of distortionary policies

^{*}The authors acknowledge the financial support of CNPq-Brazil, Faperj and the INCT-EDEIS.

[†]Authors are from FGV/EPGE - Escola Brasileira de Economia e Finanças, FGV/IBRE and FGV/IBRE.

¹See Ferreira, Pessoa and Veloso (2013).

observed in several Latin American countries was a significant increase in the share of state-owned enterprises in the production of intermediate and capital goods.² As shown by Schmitz (2001), government production of investment goods reduces TFP and labor productivity.

In this paper we develop and calibrate a version of the two-sector neoclassical growth model to assess whether the introduction of distortions in the investment goods sector may explain the decline in TFP observed in Brazil relative to U.S. In this model, TFP in the capital goods sector relative to TFP in the consumption sector is inversely related to the price of investment relative to consumption. Therefore, we can use data on the relative price of investment to identify the investment-specific TFP level, employing the latter to estimate aggregate TFP. We find that this mechanism is able to explain most of the observed decline in TFP.

Our paper relates to Greenwood, Hercowitz and Krusell (1997) who used a price series for quality-adjusted equipment to investigate the role of investment-specific technological change in explaining postwar US growth. Restuccia and Urrutia (2001) and Hsieh and Klenow (2007) used data on the relative price of investment obtained from the Penn-World Table to analyze the implications of investment-specific TFP for international differences in investment and capital per worker. In contrast, this paper introduces a distortion to capital accumulation - a tax wedge - and focus on the impact of sectorial TFP changes on aggregate growth and capital accumulation, using data of a developing economy. Our paper is also related to Cole et al. (2005), that argued that competitive barriers may explain why TFP is low in Latin America relative to the United States, and to Bosworth and Collins (2003) and Loayza et al. (2005), which also documented a negative TFP growth rate in Latin America in the eighties.

The paper is organized as follows. Section 2 describes briefly the distortions introduced in the Brazilian investment goods sector in the 1970s. Section 3 presents a version of the two-sector neoclassical growth that will be used to quantify the impact of these distortions in aggregate TFP. Section 4 calibrates the model and presents the main results. Section 5 concludes.

2 Distortions in the Investment Goods Sector

In 1975, Brazil launched a major program of import-substitution in intermediate and capital goods called II *Plano Nacional de Desenvolvimento* (II PND). Tariffs on imported intermediate and capital goods were increased by as much as 30% to 100% of the value of the imports. For several goods, prior deposits became mandatory to receive import licenses, and several non-tariff barriers were created, including a negative import list known as "Annex C" and a more stringent application of the Law of National Substitute. As a consequence of the import-substitution policy, there was a sharp decline in the quantity of imported capital goods in Brazil after 1974. In 1985, real capital goods imports corresponded to only 19% of their quantity in 1974.

²Bulmer-Thomas (2003) presents evidence for Brazil and other Latin American countries.

Another dimension of II PND was a significant increase in government intervention in the domestic production of capital and intermediate goods. Two main mechanisms were used. First, there was a sharp increase in the amount of subsidies provided to domestic producers.³ In fact, for many years *Banco Nacional de Desenvolvimento Econômico* (BNDE), a very large public development bank, charged negative interest rates (e.g., the principal would only be corrected by 20% of inflation) on its main investment lines of credit.⁴ Second, several state-owned enterprises were created and there was an expansion in the production share of the existing government enterprises.

In 1984, Brazil adopted an import ban (zero quota policy) on foreign produced computers. After the policy was adopted, Brazilian computer prices were 70 to 100 percent above international prices. Moreover, domestic content laws required Brazilian computer makers to use domestically produced components.⁵

Figure 1 shows that between the mid-1970s and the late 1980s there was a sharp increase in the relative price of investment in Brazil.⁶ Specifically, between 1960 and 1975 the relative price of investment was low and nearly constant and it more than doubled since the mid-1970s. At the same time, aggregate total factor productivity falls sharply after 1980 in the country.

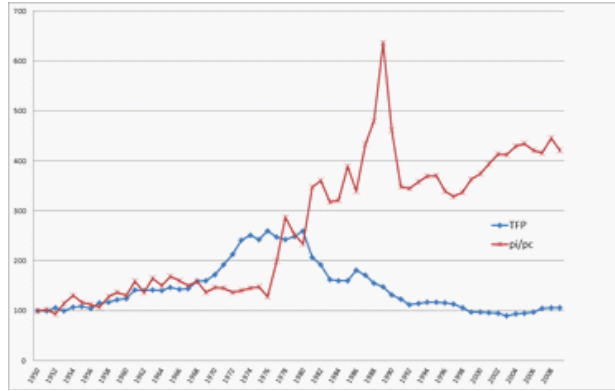


Figure 1: Relative Price of Investment (π_i/p_c) and Total Factor Productivity (TFP), 1950-2008.

3 The Model

In this section we present a simple version of the two-sector neoclassical growth model.⁷ Consider an economy inhabited by a representative household that

³See Bugarin et al. (2010).

⁴It is now called *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES).

⁵Luzio and Greenstein (1995) show that the abandonment of the import ban on computers in 1992 was associated with a large increase in productivity.

⁶Similar figures could be constructed for most Latin American countries. On average, the relative price of investment in the region went from 0.80 in 1960 to 1.3 in 1988.

⁷The model is similar to those presented in Restuccia and Urrutia (2001) and Hsieh and Klenow (2007).

solves the following problem:

$$Max \sum_{t=0}^{\infty} \tilde{\beta}^t \frac{\tilde{c}_t^{1-\sigma}}{1-\sigma} \quad (1)$$

$$s.t. \quad \tilde{c}_t + p_t \tilde{x}_t = [r_t - \tau_k (r_t - \delta p_t)] \tilde{k}_t + \tilde{w}_t + \tilde{\chi}_t \quad (2)$$

$$(1+g)(1+n) \tilde{k}_{t+1} = \tilde{x}_t + (1-\delta) \tilde{k}_t \quad (3)$$

where \tilde{c}_t is consumption per effective labor, \tilde{x}_t is investment per effective labor, p_t is the relative price of investment, \tilde{k}_t is capital per effective labor, r_t is the rental rate of capital, \tilde{w}_t is the wage rate per effective labor, $\tilde{\chi}_t$ is a lump sum transfer per effective labor, n is the growth rate of the labor force, g is the rate of technological progress, δ is the rate of capital depreciation, $\tilde{\beta} \equiv \beta(1+g)^{1-\sigma}(1+n)$ is the adjusted discount factor and τ_k is a tax rate on capital income. Each member of the household supplies inelastically one unit of labor.

The Euler equation is given by

$$(1+g)(1+n) p_t \tilde{c}_t^{-\sigma} = \tilde{\beta} \tilde{c}_{t+1}^{-\sigma} [(1-\tau_k) r_{t+1} + (1-\delta) p_{t+1} + \tau_k \delta p_{t+1}] \quad (4)$$

There are two sectors, the consumption goods sector and the investment goods sector. The technology for producing the consumption good C is given by:⁸

$$C = A_c K_c^\alpha \left((1+g)^t L_c h \right)^{1-\alpha} \quad (5)$$

where A_c is TFP in the consumption good sector, K_c and L_c are capital and labor devoted to the production of the consumption good and h is human capital per worker, which is assumed to be exogenous.

The technology for producing the investment good X is given by

$$X = A_x K_x^\alpha \left((1+g)^t L_x h \right)^{1-\alpha} \quad (6)$$

where A_x is investment-specific TFP and K_x and L_x are capital and labor devoted to the production of the investment good.

The problem of the firm in the consumption sector is given by:

$$\max \pi_c = C - w L_c - r K_c$$

The first-order conditions for the consumption sector firm are:

$$\alpha A_c \tilde{k}_c^{\alpha-1} h^{1-\alpha} = r \quad (7)$$

$$(1-\alpha)(1+g)^t A_c \tilde{k}_c^\alpha h^{1-\alpha} = w \quad (8)$$

where \tilde{k}_c is capital per effective labor in the consumption sector and w is the wage rate.

⁸We dropped the time subscript for convenience.

The problem of the firm in the investment sector is given by:

$$\max \pi_x = pX - wL_x - rK_x$$

and the first-order conditions for the investment sector firm are similar to (7) and (8).

In equilibrium, the marginal products of capital and labor are equated in the two sectors, implying that capital per effective labor is equated in both sectors. Consequently, the relative price of investment is given by:

$$p = \frac{A_c}{A_x} \quad (9)$$

and hence negatively related to TFP in the investment sector.

Let \tilde{k} and \tilde{k}_x be the economy-wide and investment sector capital per effective labor, respectively. Using $\tilde{k}_c = \tilde{k}_x = \tilde{k}$ and substituting (7) into (4), we obtain the steady state capital per effective labor:

$$\tilde{k} = \left[\frac{\alpha\beta(1-\tau_k)}{(1+g)^\sigma - \beta(1-\delta) - \beta\tau_k\delta} \right]^{\frac{1}{1-\alpha}} A_x^{\frac{1}{1-\alpha}} h \quad (10)$$

Substituting the expression above into the capital accumulation equation, we obtain the investment per effective labor, which can be substituted into the investment sector production function to obtain the steady state share of labor in the investment sector, η_x :

$$\eta_x = \frac{\alpha\beta(1-\tau_k)[(1+g)(1+n) - (1-\delta)]}{(1+g)^\sigma - \beta(1-\delta) - \beta\tau_k\delta}$$

where p^I is the relative price of investment in international prices. The steady state output per effective worker is:

$$\tilde{y} = TFP\tilde{P}\tilde{k}^\alpha h^{1-\alpha} \quad (11)$$

where detrended total factor productivity, $TFP\tilde{P} \equiv (TFP/(1+g)^{(1-\alpha)t})$, is given by

$$TFP\tilde{P} \equiv A_c(1-\eta_x) + p^I A_x \eta_x \quad (12)$$

where p^I is the relative price of investment in international prices.

4 Calibration and Results

Next we calibrate the model to explain the decline in average TFP and output per worker in Brazil relative to the U.S. between 1960-1975 and 1990-2000, which we interpret as steady states of the model.

To calibrate the model, we assume a capital share of $\alpha = 0.4$, following Gollin (2002) and we set $\delta = 0.05$. The rate of technological progress is estimated from

U.S. data in Penn World Table 7.0 (PWT) and set to 0.0153. We also assumed $\beta = 0.98$ and $\sigma = 1$. The value of n is obtained from the PWT.

The physical capital series is constructed with investment data in international prices from the PWT using the perpetual inventory method. As usual in the literature, we assume that all economies are in a balanced growth path at time zero and compute the initial capital stock, K_0 , according to the expression $K_0 = I_0 / [(1 + g)(1 + n) - (1 - \delta)]$, where I_0 is the initial investment expenditure, g is the rate of technological progress, n is the growth rate of the population and δ is the rate of capital depreciation.

Our human capital measure is based on Bils and Klenow (2000) and is given by:

$$h = \exp \phi(s) = \exp \left(\frac{\theta}{1 - \psi} s^{1 - \psi} \right), \quad (13)$$

where s stands for schooling. We measured s using average years of schooling of the population aged 15 years and over, taken from Barro and Lee (2010), interpolated (in levels) to fit an annual frequency. According to the calibration in Bils and Klenow (2000), we set $\psi = 0.58$ and $\theta = 0.32$.

Data on output per worker in international prices, on the price of investment relative to consumption and number of workers are also obtained from the PWT. We computed the value of aggregate TFP as the residual of an aggregate production function, using the observed values of output per worker and the constructed series of physical and human capital per worker.

We calibrate τ_k to match the observed average capital-output ratio in 1960-1975.⁹ In the baseline calibration we also keep the same value of τ_k in 1990-2000. In the formulas below, the superscript US denote U.S. variables and variables without the superscript refer to Brazil. We set $p^I = 1$, which is approximately the value of the relative price of investment in Western Europe.

We calibrate $\frac{A_c}{A_c^{US}}$ in 1960-1975 using (12), the observed average values of TFP , the computed values of η_x and η_x^{US} and the average relative prices of investment, p and p^{US} , in 1960-1975:

$$\frac{A_c}{A_c^{US}} = \left(\frac{TFP}{TFP^{US}} \right) \left(\frac{1 - \eta_x^{US} + \frac{\eta_x^{US}}{p^{US}}}{1 - \eta_x + \frac{\eta_x}{p}} \right) \quad (14)$$

We normalize $A_c^{US} = 1$. Given $\frac{A_c}{A_c^{US}}$, we then compute A_c . Using (9), the observed value of p and the computed value of A_c , we obtain A_x .

We assume that $\frac{A_c}{A_c^{US}}$ is constant between 1960-1975 and 1990-2000 and compute the variation in $\frac{A_x}{A_x^{US}}$ from the change in p between these periods. To compute relative TFP for the period 1990-2000, we use (12) and $TF\tilde{P} \equiv \frac{TFP}{(1+g)^{(1-\alpha)t}}$:

$$\frac{TFP}{TFP^{US}} = \frac{A_c (1 - \eta_x) + A_x \eta_x}{A_c^{US} (1 - \eta_x^{US}) + A_x^{US} \eta_x^{US}} \quad (15)$$

⁹This implies a value of $\tau_k = 0.90$.

We then compute the steady state values of k , y and the capital-output ratio κ .

The empirical evidence described in Section 2 suggests that the increase in the relative price of investment in Brazil may have resulted from a decline in TFP in the investment goods sector associated with the policy of import-substitution and government production of capital and intermediate goods. Based on the two-sector neoclassical growth model and the calibration procedure described above, we compute the investment-specific TFP decline based on the increase in the relative price of investment and estimate its implications for aggregate TFP, as well as for other variables, such as capital per worker, the capital-output ratio and output per worker. In the tables below, the notation \hat{z} denotes the value of variable z relative to the U.S. Let \hat{k} , $\hat{\kappa}$ and \hat{y} be the relative capital per worker, capital-output ratio and output per worker, respectively. Table 1 presents actual values of $TF\hat{P}$, \hat{k} , $\hat{\kappa}$ and \hat{y} for Brazil relative to the U.S. for the periods 1960-1975 and 1990-2000.¹⁰

Table 1: Brazil, Actual Values (USA=1)

period	$TF\hat{P}$	\hat{k}	$\hat{\kappa}$	\hat{y}
1960-1975	0.81	0.24	0.92	0.26
1990-2000	0.61	0.28	1.15	0.24

Relative TFP in Brazil declined from 0.81 for the period 1960-1975 to 0.61 for the period 1990-2000. At the same time, both the capital-labor ratio and capital-output ratio increased relative to the U.S., which is puzzling given the decline of productivity. The net result was a decline of relative output per worker in Brazil from 0.26 to 0.24.

Table 2 presents the predicted values for the period 1990-2000 obtained from the main calibration of the model, taking into account the increase in p between the two sub-periods.

Table 2: Brazil, Predicted Values (USA=1)

period	$TF\hat{P}$	\hat{k}	$\hat{\kappa}$	\hat{y}
1960-1975	0.81	0.24	0.92	0.26
1990-2000	0.64	0.05	0.37	0.13

Simulation: increase in p

The model can account for most of the TFP decline in Brazil between 1960-1975 and 1990-2000. However, the model predicts a sharp decline in relative capital per worker, capital-output and output per worker, which was not present in the data. This finding is because, everything else being constant, a decline of TFP in the capital goods sector increases the relative price of investment and thereby reduces the steady state capital stock and output.

Clearly, something was occurring in the Brazilian economy that was compensating for the lower TFP and our simulation is not capturing it. Note that the

¹⁰The relative human capital per worker in Brazil, not shown in Table 1, increased from 0.39 in 1960-1975 to 0.51 in 1990-2000.

restrictions to capital goods imports represented an increase of investment cost, and thus a reduction of the profits of many firms in the economy. To compensate the users of the now more expensive capital goods the government used public banks and agencies to subsidize investments. In other words, to compensate for one distortion - ISI of capital goods - the government introduced another in the opposite direction - subsidy of the purchases of these goods.¹¹

In our model this is equivalent to a reduction in τ_k . Hence, our assumption of a constant τ_k may be missing an important change in the Brazilian economy during this time period. To assess the robustness of our results, we thus compute the effects of a decline in investment-specific TFP in Brazil (as measured by the increase in the relative price of investment) on aggregate TFP and other variables using different values of τ_k . The results - predicted values for 1990-2000 - are presented in Table 3.

Table 3: Brazil, Predicted Values (USA=1)

τ_k	$TF\hat{P}$	\hat{k}	$\hat{\kappa}$	\hat{y}	r
0.90	0.64	0.05	0.37	0.13	30.5%
0.75	0.65	0.17	0.78	0.21	15.4%
0.54	0.67	0.33	1.16	0.28	10.5%

Simulation: increase in p and different values of τ_k

The first line of Table 3 corresponds to our baseline, which assumes a value of $\tau_k = 0.90$. Assuming that τ_k stays constant at 0.90, this implies a value of the real interest rate, r , equal to 30.5% for the period 1990-2000, which is implausibly high.¹² Assuming that $\tau_k = 0.75$, relative TFP changes very little, but there is a significant increase in the relative capital per worker, the capital-output ratio and output per worker. As a result, there is a sharp decline in the real interest rate to 15.4%. If we assume $\tau_k = 0.54$, relative TFP increases to 0.67, in comparison with the baseline value of 0.64. The overall match of the model improves further, as seen by comparing the results with the actual values in Table 1. The value of the interest rate declines to 10.5%, which is similar to the average real rate on government bonds in the 1990s.

Thus, if we allow the tax rate on capital income to fall in order to match the value of the real interest rate for the 1990-2000 period, the model not only accounts for most of the observed decline of TFP in Brazil, but it also matches very closely the behavior of capital and output per worker. In any case, the main finding is that the decline of TFP does not change much, regardless of the value of τ_k .

¹¹Bugarin et al. (2010) present evidence that subsidy to capital increased markedly in the period.

¹²The real interest rate is computed assuming that it is equal to the marginal productivity of capital, where the latter is given by $MPK = \frac{\alpha}{\kappa}$.

5 Conclusion

A calibrated version of the two-sector neoclassical growth model indicates that policy distortions that reduced TFP in the investment goods sector may explain a significant proportion of the decline of aggregate TFP in Brazil. Moreover, there are indications that the government compensated producers by subsidizing the acquisition of the less efficient domestic production of capital goods, which prevented a sharper decline in capital and output per worker, but did not prevent the collapse of TFP.

References

- [1] **Barro, R. and J. W. Lee, 2010.** "A New Data Set of Educational Attainment in the World, 1950-2010," NBER Working Paper #15902.
- [2] **Bils, M. and P. Klenow, 2000.** "Does Schooling Cause Growth?," *American Economic Review*, 90(5): 1160-1183.
- [3] **Bosworth, B. and S. Collins, 2003.** "The Empirics of Growth: An Update," *Brookings Papers on Economic Activity* 2: 113-179.
- [4] **Bugarin, M., Ellery Jr., R., Gomes, V. and A. Teixeira, 2010.** "From a Miracle to a Disaster: The Brazilian Economy in the Last Three Decades". *Brazilian Review of Econometrics* 30 (1), pp. 3-22.
- [5] **Bulmer-Thomas, V., 2003.** *The Economic History of Latin America Since Independence*. 2nd ed. Cambridge University Press.
- [6] **Cole, H. L., L. E. Ohanian, A. Riascos and J. A. Schmitz Jr., 2005.** "Latin America in the Rearview Mirror". *Journal of Monetary Economics*, 52: 69-107.
- [7] **Eaton, J. and S. Kortum, 2001.** "Trade in Capital Goods," *European Economic Review* 45, p. 1195-1235.
- [8] **Ferreira, P., Pessôa, S. and F. Veloso, 2013.** "On the Evolution of Total Factor Productivity in Latin America". *Economic Inquiry*, 51 (1), pp. 16-30.
- [9] **Gollin, D., 2002.** "Getting Income Shares Right," *Journal of Political Economy*, 110 (2), pp. 458-472.
- [10] **Greenwood, J. Hercovitz, Z. and P. Krusell, 1997.** "Long-Run Implications of Investment-Specific Technological Change," *American Economic Review*, 87(3), pp. 342-62.
- [11] **Hsieh, C. and P. Klenow, 2007.** "Relative Prices and Relative Prosperity". *American Economic Review* 97 (3), pp. 562-585.

- [12] **Lee, J., 1995.** "Capital Goods Imports and Long-Run Growth," *Journal of Development Economics* 48, pp. 91-110.
- [13] **Loayza, N., Fajnzylber, P. and C. Calderón, 2005.** *Economic Growth in Latin America and the Caribbean: Stylized Facts, Explanations, and Forecasts*. Washington, DC: The World Bank.
- [14] **Luzio, E. and S. Greenstein, 1995.** Measuring the Performance of a Protected Infant Industry: The Case of Brazilian Microcomputers". *Review of Economics and Statistics* 77, pp. 622-633.
- [15] **Restuccia, D. and C. Urrutia, 2001.** "Relative Prices and Investment Rates". *Journal of Monetary Economics* 47, pp. 93-121.
- [16] **Schmitz, J., 2001.** "Government Production of Investment Goods and Aggregate Labor Productivity", *Journal of Monetary Economics* 47, pp. 163-187.