

Sustainable Miracles: Protection and Competition in the Brazilian Oil Industry*

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Abstract

It is often suggested that competition improves productivity, however, the underlying support for this idea is surprisingly thin. This paper presents a case study examining the effects of a change in the competitive environment on productivity at the Petrobras, Brazil's state-owned oil company. Petrobras had a legal monopoly on production, refining, transportation and importation of oil in Brazil until it was removed in 1995. Even though Petrobras continues to have a *de facto* monopoly, the end of legal monopoly labor productivity growth rate more than doubled. A growth accounting of the industry shows that between 1980 and 1995 output growth rate (and productivity growth rate) is completely explained by the accumulation of capital, while Total Factor Productivity (TFP) did not grow. Between 1995 and 2004 labor productivity growth rate is completely explained by the growth rate of *TFP*. The results suggest that the threat of competition alone is sufficient to improve productivity. They also provide evidence that restricting competition help cause Brazil's depression of the 1980s.

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1 Introduction

It is often suggested that competition improves productivity. It is an idea at least as old as Adam Smith and is cited as support for a number of policy interventions including antitrust enforcement, deregulation of markets and privatization. Some economists have argued that restrictions on competition are an important source of differences in national income. (Parente and Prescott [18], Herrendorf and Teixeira [10])

Given its long pedigree, the underlying support for this idea is surprisingly thin. The theoretical literature is ambiguous. While some models predict increasing productivity in response to competition (For example, Holmes and Schmitz [9]), others predict the opposite. (For example, Martin [15] and Horn, Lang and Lundgren [9])

The empirical literature is also ambiguous. A number of authors have examined the data from public sector reforms such as privatization, deregulation of markets, and foreign competition. While many studies find improvements in productivity, some find the opposite. (See Megginson and Netter [16] for a survey.)

One challenge in testing this relationship is the measurement of competition. Common measures such as market share suffer from confounding influences. A firm may have a large market share because it is a very productive firm and can sell its output at a low price or because it has monopoly power. More direct measures such as markups require data on costs that are typically not available.

Another challenge is that reforms that increase competition are typically part of a comprehensive package, making it difficult to identify how competition affects productivity. For instance, a firm may be privatized at the same time as its markets are liberalized and trade barriers are reduced. Therefore, it is difficult to disentangle the effects of ownership change from those of market changes.

This paper presents a case study examining the effects of a change in the competitive environment on productivity at the Petrobras, Brazil's state-owned oil company. Petrobras had a legal monopoly on production, refining, transportation and importation of oil in Brazil until it was removed in 1995.

Using a case study allows us to avoid the issue to selecting a proxy for the degree

of competitiveness. This strategy has used to examine a number of instances when the competitive environment changed, including reduced trade barriers, deregulation, privatization (Schmitz and Teixeira [19]), and changes in technology (Galdon and Schmitz [8]).

We have selected a case that avoids disentangling the effects of multiple policy changes. The Petrobras reform was simply the removal of a legal monopoly and was not accompanied by any other changes. Ownership was not changed, nor are there plans to do so. Therefore, any changes in productivity cannot be attributed to other (direct) policy changes.

We find a large increase in labor productivity growth after 1995. Between 1980 and 1995 labor productivity grew at an annual average of 7 percent. Between 1995 and 2002 it grew at an annual average of 16.7 percent. Not only did growth more than double, the sources of the growth changed. All labor productivity growth prior to 1995 was due to capital accumulation (with no change in *TFP*) while all growth after 1995 was due to *TFP* growth (as capital stock fell).

These gains all the more impressive given how little competition Petrobras actually faced after losing its legal monopoly. It still maintains a dominant position. For example, Petrobras still has over 97% of Brazil's refining capacity. Its advantages as a large incumbent made it difficult for competitors to enter the market. Unlike previous studies where firms face a declining market as a result of competition, the *threat* of competition was sufficient to generate significant productivity gains.

The experience of Petrobras gives some insight into several areas of economics.

First, economists should be cautious when using market shares as an indicator of competitiveness. The prospect of competition resulted in changes in Petrobras's productivity. However, market concentration indicators changed very little. As a proxy for competition, they would have missed a shift in the competitive environment.

Second, privatization may not be required to improve the performance of public enterprises. There are no plans to privatize the company and it is unlikely to occur in the future given the political sensitivity of such a move. When privatization is not politically viable, increasing competition in the markets of state-owned firms can provide an avenue

for improving performance. The results lend support to the view that the competitive environment is an important determinant of productivity, regardless of ownership. (See Bartel and Harrison [1] for a discussion of the environment vs. ownership issue.)

Third, the results provide support for the idea that closing off competition in the 1970s contributed to Brazil's poor economic performance in the 1980s. Brazilian *TFP* began to fall after the government expanded state-owned enterprises (including Petrobras) and raised trade barriers during the 1970s as a strategy to keep the economy growing despite the recession that hit the main capitalist economies and the slowdown in the productivity growth rate.¹

2 The Oil Industry in Brazil

Since oil was discovered in Bahia in 1938 until the 1990s, the Brazilian oil industry has been characterized by increasing government intervention².

From 1938 to 1954, the government sought to develop the oil sector through private companies while serving as a regulator through the National Petroleum Council (henceforth CNP, from its Portuguese name). But the private sector did not show much interest since the reserves belonged to the CNP and there was no legislation to guaranteeing investors the benefits of exploration. In addition, the cost of extracting oil in Brazil was high compared to that of the Middle East.³

In 1954, the government created the state-owned monopoly Petrobras to explore, extract and refine petroleum. (Existing private refining companies were allowed to continue operating but could not expand.) This policy was part of a larger import substitution policy to develop the industrial sector (Kingstone [13]).

The monopoly power of Petrobras was extended to the import and export of oil in the 1963. Between the creation of Petrobras and 1970s, domestic prices were essentially equal to the international prices plus a Federal tax. In an attempt to shield the domestic

¹See Bugarin, et al. [2, 3].

²See Campos [4].

³See Ministerio das Minas e Energia [5] and Serour [20].

economy from the oil shocks, domestic prices became disconnected from international prices in 1977 and based on a measure of domestic production cost.

In 1988, the process of increasing government intervention reached its apex when Petrobras's monopoly rights were guaranteed in the new Brazilian constitution.

By the beginning of the 1990s, the process of privatization and deregulation in the Brazilian economy reached the oil sector. A constitutional amendment (Constitutional Amendment Number 9) approved by the Brazilian Congress in 1995 ended the monopoly rights of Petrobras over production, refining, importing and exporting. Though many other sectors were privatized, the Brazilian government did not propose privatizing Petrobras. The end of monopoly was the biggest concession that the government could manage to get from the Brazilian Congress⁴.

With the change in the Brazilian constitution, a new regulatory framework was set up for the oil sector. In September 1997, a new law was approved by the Congress allowing any firm to produce, transport, refine import and export petrol in Brazil. In 1998, two government decrees set up a regulatory structure in the sector and the National Energy Policy Council (CNPP) to advise on the norms and rules for the sector. It created the National Petroleum Agency (ANP henceforth) to regulate the sector. Finally, it set up auctions to sell the rights to extract oil in Brazil. In 1998, Petrobras were given the rights to the fields it has already started exploiting, keeping 7% of potential areas. This was called Round 0. In 1999, auctions began to sell exploitation rights for the remaining areas (Kingstone [13]).

3 Productivity at Petrobras

In this section we will analyze Petrobras's productivity performance in response to the loss of its legal monopoly.

Even though the change in the monopoly status of Petrobras happened in 1995, discussion of the policy change began earlier. When dating the beginning of a reform, the

⁴Kingstone [13] explains in detail how President Fernando Henrique Cardoso overcame opposition in the Congress to end the constitutional monopoly rights of Petrobras

date of the legal change may not be the most relevant date. Managers in the reformed industry may have anticipated the reform and introduced changes prior to the reform becoming official. (This is sometimes called the “announcement effect.”)

In a study of the impact of privatization in the Brazilian iron ore sector Schmitz and Teixeira [19] argue that 1989 should be set as the beginning of the reform. It was in 1989 that a new Brazilian president was elected promising to privatize and deregulate the economy to increase competition (Kingstone [13] and Velasco [12]).

We date the beginning of the reform in the oil industry as 1994. The policy to remove the monopoly originated with President Fernando Henrique Cardoso, who took office in January 1994. In January 1995, he sent an amendment to the Congress (Amendment #9) to eliminate Petrobras’s monopoly and Congress approved it in September 1995. Since discussion began before the amendment was sent to the Congress, we argue that 1994 is the year that the reform of Petrobras began.

In what follows, we will argue that the end of Petrobras’s monopoly rights and the threat of new competitors had a impact on its productivity performance. First, we will look at a measure of technological progress, total factor productivity (*TFP*), of Petrobras. *TFP* is computed using a Cobb-Douglas production function given by

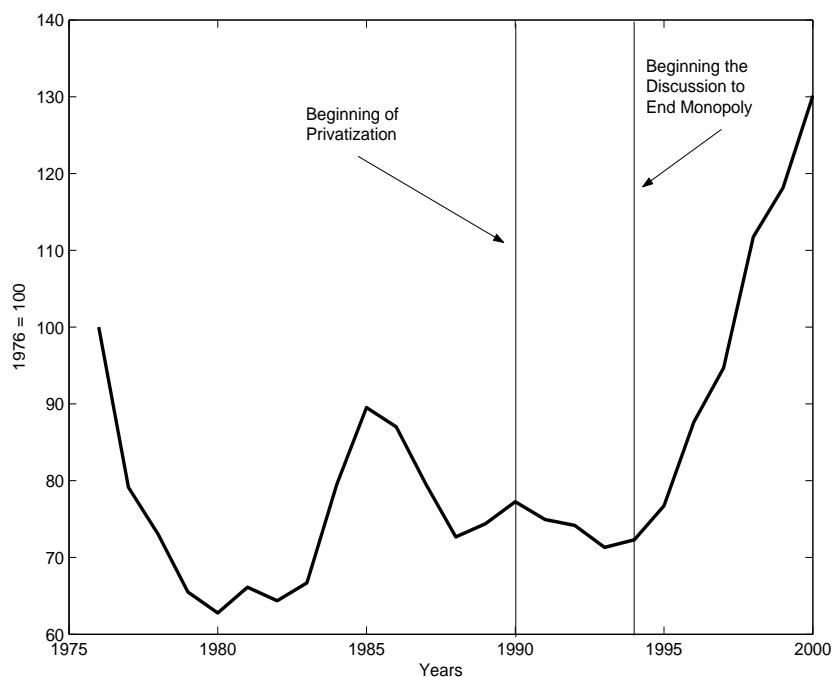
$$Y_t = A_t K_t^\theta M_t^\alpha N_t^{(1-\theta-\alpha)} \quad (1)$$

where K_t is the aggregate capital stock, M_t is the amount of material, N_t is the number of employees, θ is the capital share, α is the labor share and A_t is the total factor productivity (henceforth *TFP*).

Using the balance sheets of Petrobras and data available at the ANP we computed total amount of oil produced, the capital stock, the number of employees for each year and the labor share in the period 1976 and 2000. The average labor share in the period equal to 0.2 was used as the calibrated value of α . We did not have data for material so we use a proxy. We assume the total amount of material is a fixed proportion of the

number of wells. Behind this assumption is the idea that the amount of material used is defined by technology and therefore can not be easily substituted. Using data available for the United States we computed the share of capital equal to 0.45⁵ Therefore the share of material was set equal to 0.35.⁶ The results are showed in Figure 1

Figure 1: Total Factor Productivity of Petrobras, 1976-1999



The second half of the 1970s are characterized by a deep and abruptly fall in *TFP* of Petrobras. The *TFP* index falls from 100 in 1976 to 63 in 1980. This fall in *TFP* of Petrobras was in line with the fall in the aggregate Brazilian *TFP* (Bugarin, et al. [3]).

From 1980 until 1993 *TFP* shows no sustained gains. This period corresponds to the time Petrobras was a legal monopolist. In fact, its monopoly power was increased in this period. In 1988 Petrobras's monopoly rights became a constitutional guarantee rather than an ordinary law. On the other hand, from 1994 until 2000 *TFP* grows very fast. In five years *TFP* almost doubled, increased 82%. This is the period when a constitutional amendment abolished the monopoly rights of Petrobras, opening the sector to private

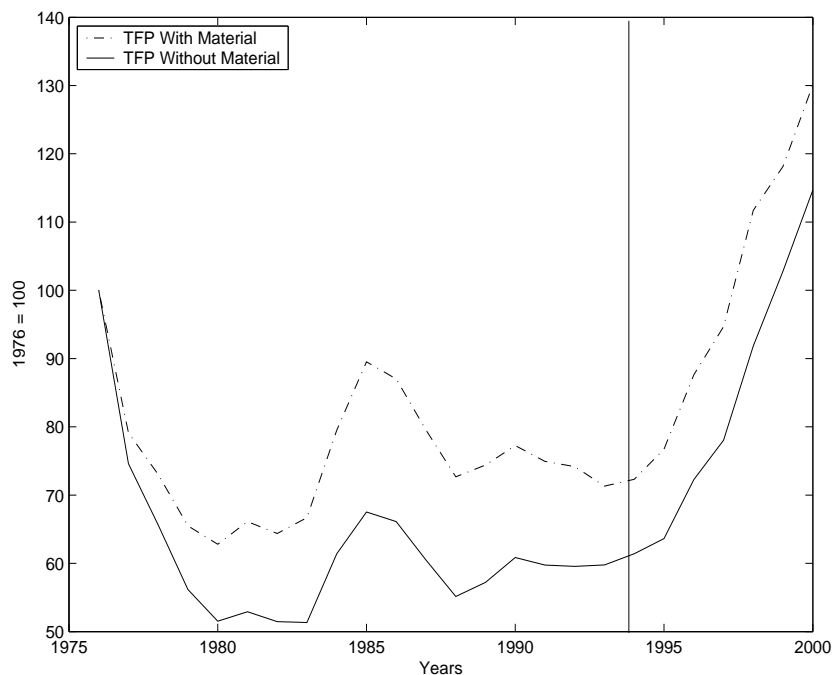
⁵We use the KLEM data set for Oil and Gas Extraction (Industry Group 4) described in Jorgenson and Stiroh [11]. The labor share for Petrobras was nearly identical to that of the United States.

⁶See the Appendix for details on the data

companies.

The results shown in Figure 1 could be driven by the assumption about materials. To check this possibility, we assumed that θ , the capital share in Equation 1, was equal to 0.8 and that material share was equal to zero. In this case we do not need to use any proxy for material. The results of TFP computed with and without materials in the production function are shown in Figure 2

Figure 2: Total Factor Productivity of Petrobras, 1976-1999



Excluding materials changes the magnitude of TFP's movements, but does not affect its pattern. In what follows, we will keep materials in the production function since we know from the U.S. data that material are a input in the oil sector.

The next step is to study the sources of growth of production and labor productivity (henceforth productivity). First we perform a growth accounting of growth rate of output. Logging Equation 1 and rearranging the terms we have:

$$[\log (Y_{t+s}) - \log (Y_t)] / s = [\log A_{t+s} - \log A_t] / s + \theta [\log (K_{t+s}) - \log (K_t)] / s + \quad (2)$$

$$\alpha [\log (M_{t+s}) - \log (M_t)] / s + (1 - \theta) [\log (N_{t+s}) - \log (N_t)] / s$$

The left hand side of Equation 3 gives us the contribution of technological progress, accumulation of capital, material and number of workers employed to output growth. As we said before, using a capital share of 0.45 and labor share equal to 0.2 the growth accounting in the two subperiods is given in Table 1.

Table 1 - Growth Accounting of Petrobras's Output(%)

Period	change in Y	due to TFP	due to K	due to M	due to N
1977-1993	8.0	-2.0	5.8	3.4	0.7
1994-2000	9.3	8.6	0.3	0.9	-0.5

The growth rate of output increased in the period without monopoly. But the major difference comes from the sources of growth in the two subperiods. In other words, the engine of growth changed. In the first period, output grew almost entirely due to increasing capital and materials. There is no technological progress. In fact technology regressed (see also Figure 1). This result is similar to the findings of Bugarin, et al. [3] for the aggregate Brazilian economy. They found that to keep the economy growing after the oil shocks of the 1970s the government encouraged capital accumulation, despite the lack of technological progress. To pursue the objective of keeping the growth rate of the Brazilian economy the government subsidized private companies and had SOEs, like Petrobras, increase investment. (We elaborate on this point below.).

In the second subperiod, the major source of growth was TFP . The growth rate of TFP increased a dramatically and it explains 93% of the growth rate of output.

We also perform a growth accounting of productivity (labor productivity). We divide Equation 1 by N_t than take logs and rearrange the terms to get

$$\begin{aligned} & \left[\log \left(\frac{Y_{t+s}}{N_{t+s}} \right) - \log \left(\frac{Y_t}{N_t} \right) \right] / s = [\log A_{t+s} - \log A_t] / s + \\ \theta & \left[\log \left(\frac{K_{t+s}}{N_{t+s}} \right) - \log \left(\frac{K_t}{N_t} \right) \right] / s \alpha \left[\log \left(\frac{M_{t+s}}{N_{t+s}} \right) - \log \left(\frac{M_t}{N_t} \right) \right] / s \end{aligned} \quad (3)$$

Using the same capital share and the share of material as specified above (θ equal to 0.45 and α equal to 0.35) we get the following results.

Table 2 - Growth Accounting of Petrobras's Labor Productivity (%)

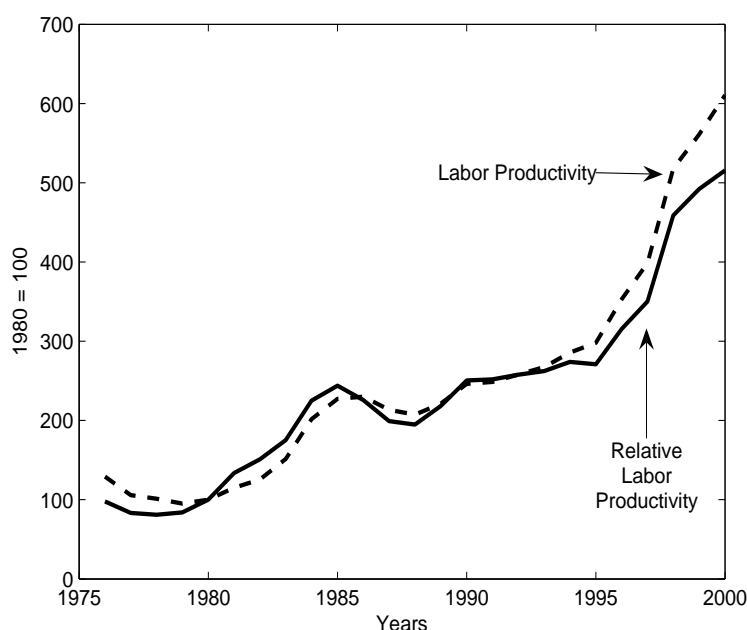
Period	change in Y/L	due to TFP	due to K/L	due to M/L
1977-1993	4.3	-2.0	4.1	2.2
1994-2000	11.8	8.6	1.4	1.8

Table 2 gives us a better idea of the engine of growth. First, we see that growth rate of productivity more than doubled after the end of monopoly. In the first subperiod, productivity grew almost completely due to an increases in K/N and M/N while TFP fell. In the second, TFP became the major source of growth.

Even though the increase of TFP started in 1994 (Figure 1) some other possibilities are open to explain this increase. One possibility is that technology advanced faster after 1994. To eliminate this possibility, we compare the Brazilian industry to that of the United States. Since we do not have enough data to compute TFP in the U.S. oil industry, we examine labor productivity. We compute the labor productivity of Petrobras relative to the U.S. labor productivity. If technology advanced faster after 1994 the relative productivity should not change since we would expect the United States industry to implement the new technology and experience the similar growth in the labor productivity.

Figure 3 plots two series. One is the labor productivity of Petrobras (Labor Productivity). The other is the labor productivity of Petrobras relative to the United States (Relative Labor Productivity). Both indices set to 100 in 1980. We analyze three subperiods. First, from 1977 until 1980 relative productivity is constant. Second, from 1980

Figure 3: Brazilian Labor Productivity Relative to the United States (1980=100), 1976-1999



until 1985 relative productivity increased going from 100 to 200. Third, from 1985 until 1993 relative productivity is constant. Finally, after 1994 when relative productivity grows quickly. Relative productivity more than doubled, going from 200 in 1995 to 500 in 1999.

To help us analyze these four subperiods, we recalculate Table 2 breaking it in smaller subperiods. The results are in Table 3.

Table 3 - Growth Accounting of Petrobras's Relative Labor Productivity (%)

Period	change in Y/N	due to TFP	due to K/N	due to M/N
1977-1980	-6.4	-11.6	5.7	-0.5
1981-1985	16.4	7.1	6.2	3.1
1986-1993	2.0	-2.8	2.0	2.9
1994-1999	11.8	8.6	1.4	1.8

In the first subperiod, relative productivity is constant. Labor productivity for both Petrobras and the United States decline. Recall from Table 3 that Petrobras's productivity did not fall as much as TFP because capital and materials growth compensated.

In the second subperiod, 1980-1993, relative productivity as well as TFP increased. The growth in the relative productivity is due to increasing productivity at Petrobras (the U.S. labor productivity is constant during this subperiod). There are two sources of growth. Both TFP and the K/N ratio increased. Even though TFP was growing rapidly, more than 75% of the growth of labor productivity is due to the rising K/L and M/N .

In the third subperiod, from 1986 until 1993, the United States's and Petrobras's productivity are growing at the same rate. Note that Petrobras's productivity is growing only due to rising K/N and M/N . TFP shows a negative growth rate. One possibility to explain this negative growth rate is the increase in barriers to entry in the oil sector. The new constitutional guarantee in 1988 reduced the amount of competition Petrobras's managers anticipated, since changing the constitution is more difficult than changing a law.

Finally, in the last subperiod from 1994 until 2000, relative productivity grows due to growth in the productivity of Petrobras (U.S. productivity is constant). As noted above, the main change with respect to the growth observed in the period 1980-1985 is the engine of growth. Between 1980 and 1985 the main source of growth is capital accumulation and material used per worker. After 1994, TFP is the main source of growth.

4 Competition and Productivity

In this section, we examine the implications of the results for relationship between competition and productivity. We argue that the results show that the *threat* of competition, even absent actual competition, can increase productivity. We discuss the implications of this finding for studying competition and designing reforms.

The reform we study is notable for how minimal it was compared to its effects. Even though Petrobras lost its *de jure* monopoly, *de facto* Petrobras is still a monopolist,

particularly in the refining and import sector⁷ (Palacios [17] and Lewis [14]).

There was very little entry into the oil extraction market. Table 4 shows the number of fields that Petrobras and other companies bought in each round that took place since 1998. The last column shows that share of all fields purchased over the period. Petrobras has at least an interest in nearly three quarters of new concessions. Even though the number of areas bought by other companies has increased, they have had little success discovering oil. According to Kingstone [13], this has been used as an indicator that Petrobras kept all the most promising areas in Round 0.

Table 4 - Purchase of Rights of Exploitation 1998/2004

	Measuring Entry – Number of Fields							<i>Share 98-04 (%)</i>
	1998	1999	2000	2001	2002	2003	2004	
Petrobras	96	1	0	7	3	85	57	<i>54.5</i>
Petrobras with others	0	6	11	7	5	0	50	<i>17.3</i>
Others	19	5	10	19	13	16	47	<i>28.2</i>
Total	115	12	21	33	21	101	154	<i>100</i>

Source: ANP

Petrobras also has nearly all the refining market. Table 5 shows the percentage of Petrobras in the total refining capacity between 1997 and 2003. Petrobras has 98% of the Brazilian installed capacity to refine oil during the entire period. The end of the monopoly did not affect Petrobras's share in the industry (even though refining is a specific sector of the industry, these figures do not change if we look at other sectors of the industry (production, export, import, distribution)⁸. See Lewis [14] and Ellsworth and Gibbs [7]).

⁷There is still barriers to entry and the sector is quite risky due to government intervention. For example, currently the Brazilian government is blocking a price increase in the domestic market in response to the high prices of oil in the international market.

⁸Maintaining control of exploration and refining gives Petrobras control of the gasoline market. There is little international trade in gasoline since it must be formulated to local standards, which prevents taking full advantage of economies of scale in transportation.

Table 5 - Share of the Installed Refining Capacity 1997/2003 (%)

Period	1997	1998	1999	2000	2001	2002	2003
Petrobras	98.7	98.7	98.5	98.6	98.6	98.3	98.4
Other Companies	1.3	1.3	1.5	1.4	1.4	1.7	1.6

Source: Anuario Estadístico (ANP).

An implication of the analysis is that economists should be cautious when using market shares as a indicator of competitiveness. The prospect of competition resulted in changes in Petrobras's productivity. However, market concentration indicators changed very little. As a proxy for competition, they would have missed a shift in the competitive environment.

One of the most popular indices of concentration of firms in an industry is the Herfindhal-Hirschman Index (HHI). It is given by the sum of the square of the market share of all companies in a given industry. It lies between zero and one, higher numbers indicating more concentration in the industry. Using the data in Table 5 we computed the HHI.

Even though we do not have data covering the period before 1997, when Petrobras was a monopolist, it could not be far from the numbers shown in Table 6 since the upper bound for HHI is one.⁹

Table 6 - Herfindhal-Hirschman Index (HHI) in the Refining Sector 1997/2003

Period	1997	1998	1999	2000	2001	2002	2003
HHI	0.97	0.97	0.97	0.97	0.97	0.97	0.97

The HHI was unchanged and showed a extremely concentrated market over the reform period. Using the HHI, one would conclude that the reform was a failure since Petrobras

⁹Since 1954, four private companies have operated in the refining sector. They were allowed to operate since they were operating prior to the creation of Petrobras (Serour [20])

did not cede any of its market share. However, it was successful in increasing productivity. Studies using market share data will miss threats of competition, which can have real effects.

Another implication is that privatization is not be required to improve the performance of public enterprises. There are no plans to privatize Petrobras and it is unlikely to occur in the future. Petrobras is one of a set of politically sensitive state enterprises, called the “Crown Jewels.” It is also a significant source of revenues for both state and Federal governments. The removal of the monopoly guarantee alone generated significant political conflict. (Kingstone [13])

The results lend support to the view that the competitive environment is an important determinant of productivity, regardless of ownership. In fact, many instances when only ownership was changed have not resulted in an improvement in performance. (Bartel and Harrison [1]) When privatization is not politically viable, increasing competition in the markets of state-owned firms can provide an avenue for improving performance.

5 Petrobras and the Brazilian Economy

In this section, we compare the sources of Petrobras’s productivity growth with those of the Brazilian economy. The experience of Petrobras is very similar to that of Brazil, suggesting that understanding Petrobras may provide insights into the aggregate economy.

To compare the results of Petrobras with the Brazilian economy, we report the growth accounting for the aggregate economy presented in Bugarin, et al. [3]. They use a capital share of 0.4 and real GDP per working age person as the measure of output. Labor input is hours worked. The results are reported in Table 7.

Table 7 - Growth Accounting of the Brazilian GDP per Working Age Person (%)

Period	change in Y/N	due to TFP	due to K/Y	due to H/N
1975-1980	2.27	-1.15	2.97	0.44
1981-1988	1.06	-1.63	1.22	1.47
1989-1992	-3.86	-5.41	3.08	-1.53
1993-1998	2.02	3.92	-0.41	-1.49

Source: Bugarin, et al. [3]

The performance of Petrobras closely follows that of the aggregate economy. During the second half of the 1970s, the 1980s until the beginning 1990s, the Brazilian economy grew only due to capital accumulation (K/Y on Table 7) which is also true of Petrobras.

Note that capital accumulation continued despite falling TFP, which suggests that the returns to capital were falling. During the period 1968-1974 the economy had grown rapidly, largely due to surging TFP growth. This period is often referred to as the “Brazilian Economic Miracle”. After 1974, TFP began to fall. The Brazilian government tried to maintain the economy’s growth rate by boosting the accumulation of capital (Bugarin, et al. [2, 3]).

To encourage capital accumulation, the Brazilian government acted on three fronts. First, it subsidized private investment by guaranteeing the rate of return. Second, it had SOEs maintain high investment rates even though TFP and the rate of return of capital were falling. Third, it increased protection from foreign firms by increasing barriers to international trade.

The Brazilian economy started recovering earlier than Petrobras. The main reason is that the reforms (privatization and trade liberalization) started earlier in other sectors (trade liberalization started in 1990 ending in 1994 and privatization started in 1990). The removal of Petrobras’s monopoly did not begin until 1994.

Bugarin, et al. [2, 3] argue that Brazil’s falling TFP in the 1970s was due to the closing off of competition through trade restrictions and expanding SOEs. The findings give support to this argument. While the study of a single industry, even a large one like oil, cannot definitely answer whether restricting competition reduced TFP, it suggests

that this is a fruitful avenue of inquiry.

6 Conclusion

It is often suggested that protection reduces efficiency. It is also argued that public enterprises are less efficient than private enterprises. The study of the end of monopoly of Petrobras that give us some insights into this topics.

First, some caution is necessary when using market shares as a indicator of competitiveness. As we saw just the threat of competition resulted in changes in Petrobras's productivity. However, market concentration indicators changed very little. As a proxy for competition, they would have missed a shift in the competitive environment.

Second, when privatization is not politically possible, increasing competition in the markets of state-owned firms can provide an alternative for improving performance. The evidence supports the view that the competitive environment is an important determinant of productivity, regardless of ownership.

Third, the results provide support for the idea that closing off competition in the 1970s contributed to Brazil's poor economic performance in the 1980s. Brazilian *TFP* began to fall after the government expanded state-owned enterprises (including Petrobras) and raised trade barriers during the 1970s as a strategy to keep the economy growing despite the recession that hit the main capitalist economies and the slowdown in the productivity growth rate.

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Data

The main source for Brazilian data is the Oil Report ('Relatório do Petróleo') from Ministry of Mines and Energy.

Oil production – thousands barrels per day:

1. Brazil: Oil Report, several years.
2. United States: Energy Information Administration, Annual Energy Review, 2001, p. 129.
3. World production, includes crude oil, shale oil, oil sands and NGLs (natural gas liquids - the liquid content of natural gas where this is recovered separately): BP Statistical Review of World Energy, June 2002.

Employment – oil and gas extraction, and oil and gas extraction services:

1. Brazil: Oil Report and RAIS. For details on RAIS see [6].
2. United States: Production and Service Jobs and Wells Drilled. U.S. Department of Labor, Bureau of Labor Statistics, National Employment, Hours, and Earnings (*www.bls.gov*). Oil and gas production (eeu10131001), and oil and gas services (eeu10138001).

Price – Dubai, oil spot crude price. US dollars per barrel. 1972-1985: Arabian Light; 1986-2001: Dubai. Sources: Brazilian Oil Report and BP Statistical Review of World Energy, June 2002.