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# Productivity, Nationalization, and the Role of “News”: Lessons from the 1970s

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# Productivity, Nationalization, and the Role of “News”: Lessons from the 1970s<sup>†</sup>

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## Abstract

Occurrences of an old phenomenon, the expropriation of foreign-owned property, peaked in the 1970s when virtually every significant oil-producing developing country nationalized its oil. Nationalization was again on the rise in the 2000s. Using novel data, this paper quantitatively evaluates the effects of nationalization. First, the paper finds significant productivity losses associated with nationalization in a sample of oil-producing countries. Venezuela in particular experienced a striking decline in productivity. Second, the paper presents a new channel through which nationalization affects productivity: specifically, it finds a long-term pre-announcement can result in higher extraction, lower exploration, and a shift in the composition of the workforce with a huge decline in highly skilled foreign workers. Guided by a quantitative dynamic partial equilibrium framework disciplined by features of the Venezuelan data, this paper then evaluates the effects of nationalization. A comparison of the simulated and time series data shows that the model can explain 80 percent of the productivity pattern over 1961-1980 in the Venezuelan oil industry. Counterfactual experiments suggest that the shift in the composition of the workforce is important in accounting for the productivity pattern. Furthermore, if nationalization had been sudden, long-run losses would have been lower.

**Keywords:** Productivity, nationalization, oil, news (policy foresight), foreign expertise

## 1 Introduction

After a substantial rise in the 1970s, the importance of state-owned enterprises (SOEs) diminished across the world in the 1980s and 1990s. The SOE share of global GDP declined by more than 40 percent from 1979 to the early 2000s.<sup>1</sup> Following this process, a considerable amount of research

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<sup>1</sup>Megginson and Netter (2001).

suggested privately owned firms were more productive than otherwise-equivalent SOEs.<sup>2</sup> But the sharp increase in oil prices from 2003 to 2008 brought back the old phenomenon. Expropriating countries include Algeria (2006), Bolivia (2006), China (2006), Ecuador (2007), Russia (2006, 2007), and Venezuela (2006, 2007).<sup>3</sup>

The recent experience with expropriations has led to renewed interest in understanding expropriation of foreign direct investment in developing host countries. Despite the long-standing interest, many theoretical studies have focused on the consequences or determinants of the old phenomenon. There has not been much quantitative work addressing the costs of expropriation. This paper helps fill this gap.

I present novel, comprehensive evidence on the costs facing the host country. The analysis begins with an overview of historical global trends in expropriations: over half of world expropriations occur during the 1970s, the extractive sector, in particular oil, is more vulnerable to expropriation, and that expropriation is more common in Africa and Latin America. Then, I investigate labor productivity declines associated with the oil expropriations of the 1960s, 1970s, and 1980s in Africa and Latin America and show that the declines in labor productivity relative to the U.S. range from 30 percent to 60 percent.

A more detailed analysis of the Algerian and Venezuelan experiences provides initial insights. Total oil employment, including foreign workers, gradually falls prior to nationalization, and post-nationalization increases are due entirely to an increase in domestic labor. To understand why nationalization is associated with lower productivity and to quantify the effects of nationalization on exploration and labor productivity, my laboratory is the 1975 oil nationalization of Venezuela. Venezuela is one of the largest oil producers in the world and a particular example of a remarkable decline in productivity following nationalization. In addition, I manually collect a unique dataset on the Venezuelan oil industry over a fifty-year period.<sup>4</sup>

Two key features of Venezuelan data are an increase in productivity before 1970 and a collapse right after- both are striking. The total number of workers in the industry was stable until 1957, but then significantly contracted from 1957 to 1975. Exploration activity also started declining in 1957, causing oil reserves to first stagnate and then decline. Increasing production, declining employment, and exploration well before nationalization may reflect short-run incentives under the fear of nationalization. I argue that the Venezuelan case involves a long-term pre-announcement leading not only to higher extraction and less exploration, but also to a huge decline in foreign workers, which I relate to another key feature in the data. The industry's production does not increase post-nationalization despite considerable increases in domestic employment and reserves.

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<sup>2</sup>Leading studies include La Porta and Lopez-de-Silanes (1999) [31], Megginson, Nash, and Van-Randerborgh (1994) [36], and Megginson and Netter (2001) [37].

<sup>3</sup>Stroebel and van Benthem (2013) [49]. In 2010, more than 75 percent of the world's oil supplies were controlled by state-owned (national) oil companies according to the Economist's, January 2012, Special report: State Capitalism.

<sup>4</sup>It is important to note that sectoral data availability is an issue for developing resource-rich countries during the period examined.

This may result from a lack of a critical input in the production process that is not easy to substitute: foreign workers.

As a result, in the model, I distinguish between domestic and foreign labor inputs. I provide evidence suggesting foreign workers in the Venezuelan oil industry are highly skilled, representing key technical, professional, and managerial positions. I hypothesize that if the available know-how in the industry is mainly supplied by foreign workers, and their skills are complementary with the other factors of production, then nationalization would be costly, causing a decline in the productivity of measured factors of production.

In the model section of the paper, I build a dynamic model of oil exploration and production in the spirit of Pindyck (1978) [43] that incorporates these elements. The production function in the model allows for imperfect substitutability across different labor inputs. Extraction depletes the resource, which can be maintained or increased by exploration. The industry takes prices, income, and royalty taxes as given, and decides on optimum exploration and production paths. Nationalization is simply exogenously given and anticipated. It has two components. First, agents anticipate that nationalization would increase income taxes permanently. Second, foreign labor would almost cease and there would be political favoritism.

My findings are as follows. In anticipation of nationalization, exploratory efforts fall and extractive efforts increase resulting in a decline in reserves and total employment but an increase in productivity prior to nationalization. Productivity increases mainly due to a significant decline in the total number of workers stemming from the decline in exploration efforts. By the realization of nationalization, however, productivity falls and continues to do so after nationalization. Despite its simplicity, my carefully calibrated model is able to explain the path of productivity quite well. A comparison of the simulated and actual time series over the period 1961-1980 shows that my model can account for 80 percent of the productivity path. I also quantify the effect of nationalization on present discounted value of profits using simulated data before and after nationalization. I find that nationalization reduces the industry's profits by 65 percent from 1961 to 1980. A commonly held view is that nationalization allows a resource-rich developing country to capture the profits which are no longer shared with the foreigners and thus become better off. I provide a different view. I empirically show in a number of cases that labor productivity falls enormously following expropriations, raising the question of whether expropriators are better off by expropriating. I show that even though the whole profits are captured, they are smaller.

To illustrate key factors accounting for the path of productivity and draw policy implications, I perform counterfactual experiments. First, I show that the shift in the composition of the workforce from foreign workers to domestic workers is a key factor in getting the path of productivity. Second, I show that political favoritism is costly for productivity but not as bad for profitability. Finally, I find that if nationalization had been sudden rather than anticipated, short-run costs would have been higher due to a sudden drop in activity. However, in the long run, sudden nationalization

appears to be less costly to the host country, as it yields higher post-nationalization profits.

## Related Literature

This study contributes to several strands of the literature. First, the questions addressed in this paper represent a novel contribution to the literature by filling the gap in quantitative evidence for costs of expropriation. To my knowledge, this paper is the first attempt to explain a resource-rich developing country's experience quantitatively. Existing studies mostly focus on the determinants of nationalization, or the effect of denationalization on productivity, or compare public ownership with private ownership. Examples include Megginson, Nash, and Van-Randerborgh (1994) [36], La Porta and Lopez-de-Silanes (1999) [31], Megginson and Netter (2001) [37], Guriev et al (2011) [20], Chang et al. (2010) [8], Stroebel and van Benthem (2013) [49], Hajzler (2014) [23].

I also present novel evidence suggesting foreign workers are highly skilled. The specialized knowledge brought by foreign firms can be critical for industry operations, and removing them can be costly. This is related to a growing literature studying the effect of multinational activity in developing countries, which suggests that the presence of foreign firms can bring welfare gains, Antras, Garicano and Rossi-Hansberg (2006) [2]; Burstein and Monge-Naranjo (2009) [7]; Eeckhout and Jovanovic (2010) [17]; Monge-Naranjo (2011) [41].<sup>5</sup>

In this paper, I examine an industry case in which large (exogenous) policy changes are associated with significant changes in production and productivity, similar to Schmitz and Teixeira (2004) [48] and Schmitz (2005) [47], and present a new mechanism to understand the effects.<sup>6</sup>

Finally, studying the effects of expropriation can help us understand why some countries are development outliers. Venezuela was one of the fastest growing economies in Latin America with an oil dominant economy, but then collapsed and has become a development failure. Thus, it is often cited as an illustration of resource curse, for instance Sachs and Warner (1999) [46].<sup>7</sup> To be more specific, the Venezuelan oil industry expanded until 1958, which coincided with a substantial expansion in the Venezuelan economy. Bello, Blyde, and Restuccia (2011) [4] show that GDP per capita relative to the United States increased significantly from 1920 to 1958, but then declined.<sup>8</sup> The authors find that capital accumulation and knowledge transfer account for the remarkable growth, which could be due to openness of the oil sector to foreign investment. They argue that government intervention can misallocate resources, leading to a fall in TFP and capital accumulation, and find that policy distortions are able to account for most of the decline observed in

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<sup>5</sup>This effect is not limited to static welfare gains. The presence of MNCs in a developing country can also affect the country's accumulation of know-how, yielding better exposure to it and improvements in welfare, Monge-Naranjo (2011) [41].

<sup>6</sup>The former study shows that privatization of the Brazilian iron ore industry raises productivity in newly privatized firms and existing private firms that have to compete with the new firms, and does so by eliminating restrictive work rules. The latter study finds that increased foreign competition for Great Lakes' iron ore producers resulting from exogenous changes in the world steel market increases labor productivity 100 percent.

<sup>7</sup>Therefore, among oil expropriators, as one of the largest oil producers in the world which fully nationalized its oil for the first time in the 1970s, Venezuela is an important case.

<sup>8</sup>Real GDP per capita and oil production per capita mostly move in the same direction.

Venezuela.<sup>9</sup> By the same token, Cole et al. (2005) [10] investigate the Latin American development problem and find that barriers to competition, including limiting government policies, are a likely cause. My analysis complements these studies. Understanding Venezuela’s development experience, which is critical in terms of the Latin American development problem, relies on understanding the evolution of the oil industry.

The remainder of the paper is organized as follows: Section 2 presents historical patterns of expropriations across the world, and examines the effects of nationalization in a sample of oil-producing developing countries. Section 3 documents the features of the Venezuelan oil industry. After describing the data, the section explores main trends in the oil industry, discusses critical aspects of Venezuelan nationalization, and puts forth my hypotheses. Section 4 introduces the model. The quantitative analysis is presented in Section 5, and Section 6 concludes.

## 2 Historical Trends in Expropriations and Their Effect on Productivity

The first step in investigating the effect of expropriation on productivity is to determine the period, sectors, and regions in which forced divestment have been widespread. For this purpose, I begin by documenting the trends in expropriations across the world over 1922-2006.<sup>10</sup>

### 2.1 World Historical Trends: over time, by sector and by region

More than half of the world expropriations occurred from 1970 to 1976; very few expropriations took place in the 1980s and the 1990s, and expropriations increased in the 2000s. The extractive sector, in particular oil, is more vulnerable to forced divestment. In addition, forced divestment is more common in Africa and in Latin America, accounting for about 39% and 30% of all acts, respectively.<sup>11</sup> Motivated by these facts, I focus on the oil industry expropriations in Latin America and Africa in the 1970s.

### 2.2 Expropriations in the Oil Industry

The 1970s were a critical period for the oil industry. From 1970 to 1976, expropriations by over 35 countries accounted for more than 70% of the 1970 world production.<sup>12</sup> Given the dominance

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<sup>9</sup>Similarly, Hausmann and Rodriguez (2006) assess the country’s performance from several perspectives. They argue that declining oil production, non-oil productivity and the inability to use resources in alternative industries are important factors in explaining the Venezuelan development failure.

<sup>10</sup>Kobrin (1980) [27] classifies forced divestment into four types: formal expropriation, intervention, forced sale, and contract renegotiation, and provides their descriptions in detail. In this paper, I use expropriation, nationalization, and takeover interchangeably in return for forced divestment of foreign-owned property by the host government. See the Appendix I.a for the data and a brief discussion on the observed trends.

<sup>11</sup>Middle East and Asia have lower shares, 16.4% and 15.3%, respectively.

<sup>12</sup>Kobrin (1984b) [29], Williams (1975) [54]. Prior to the 1970s, the exploration and development risks require financial resources exceeding the capacity of host countries. Moreover, reserves are located in less-developed countries, but the major

of the industry in the developing host countries’ economies, expropriation could be attractive for increasing revenue.<sup>13</sup> Sovereignty over their own resources is another factor; foreign ownership is inconsistent with national control.<sup>14</sup> However, government takeover can be costly irrespective of motivation. It can lower productivity significantly, and the consequence could be a wholly state-owned sector with much smaller output.

The focus of this paper is to investigate the effect of expropriation on productivity during the earliest possible period in which expropriations are most common, not why or how countries expropriate. My sample and empirical analysis are limited predominantly by the availability of oil industry data for oil-producing developing countries in the 1960s and the 1970s.

### 2.2.1 The Effect of Oil Industry Expropriations on Productivity

Productivity is measured as oil production per worker (barrels per worker). I obtain labor productivity in the oil industry over 1962-95 for each country. Then, I obtain labor productivity relative to the United States by dividing each country’s productivity by the productivity of the U.S. oil industry. The value at the time of expropriation for each country is normalized to 100. Algeria expropriated its oil industry in 1967, Venezuela in 1975, Colombia in 1974, and Peru in 1985.<sup>15</sup> Finally, for each case, I calculate five-year averages before and after expropriation, excluding the value 100 at the time of expropriation. Table 1 presents pre- and post-expropriation relative labor productivity averages for each country. I find that expropriation brings significant losses in productivity, ranging from 30% to 60%. Formerly contracted oil employment expands quickly following expropriation without an accompanying recovery in production; hence, productivity keeps declining. In the U.S. oil industry, on the other hand, the number of workers is stable in the 1970s but falls significantly in the 1980s, resulting in a boost in productivity.<sup>16</sup>

Table 1: Labor Productivity Relative to the United States (5-year averages)

	<b>Pre-expropriation</b>	<b>Post-expropriation</b>
<b>Algeria</b>	37.8	26.6
<b>Colombia</b>	194.4	77.5
<b>Peru</b>	158.5	74.5
<b>Venezuela</b>	130.9	86.4

Productivity at the time of Expropriation = 100

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markets are in industrialized countries. The combination of large fixed costs and risk, the location of reserves, and geographical separation of consumption and production result in vertical integration. As developing countries’ incomes generated by oil grow, pressures of industrialization become more intense. This is accompanied by a shift in bargaining power to the host countries as a result of the maturation of technology and transfer of skills through foreign-direct investment. Several other factors are also critical. Tightening of the market around 1970 tilt the balance, and the host producers resolve the conflict through forced participation. For further discussion, see Kobrin (1984) [29].

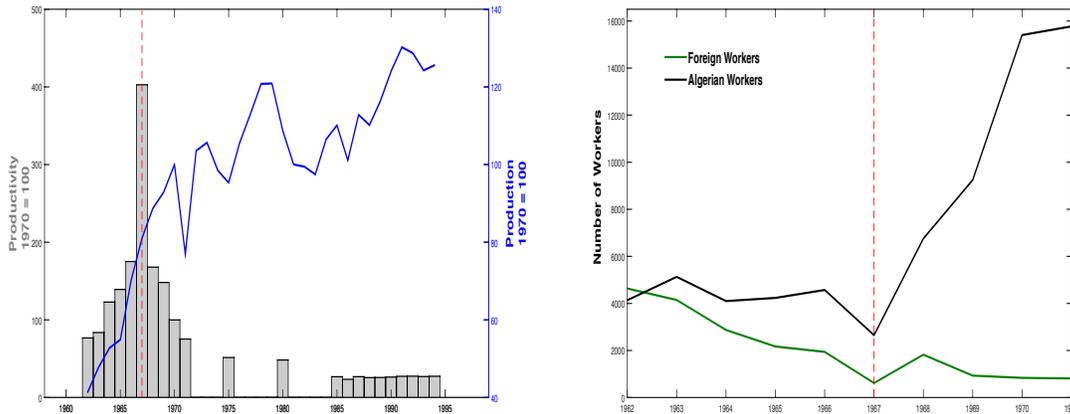
<sup>13</sup>The time pattern of expropriations confirms this opportunistic motive, Duncan (2006) [16], Guriev et al (2011) [20].

<sup>14</sup>Kobrin (1984b) [29], Yergin (1991) [56].

<sup>15</sup>Brogini (1973) [6], Kobrin (1984b) [29], Guriev et al (2011) [20].

<sup>16</sup>From 1970 to 1975, productivity declines slightly, about 5%, but from 1976 to 1985, it increases by around 30%.

Figure 1: Oil Industry, Algeria



To get some initial insights on the effect of expropriation, I first explore the Venezuelan and Algerian cases.

### 2.2.2 Exploring the cases of Algeria and Venezuela

Algeria began oil production in 1958 and gained political independence in 1962.<sup>17</sup> After the Arab-Israeli War in June 1967, Algeria nationalized the refining and distribution activities of Mobil and Esso.<sup>18</sup> Thus, I consider the year 1967 as the (benchmark) year of nationalization in the oil industry.<sup>19</sup> The left panel of Figure 1 presents production and labor productivity in the Algerian oil industry, both normalized to 100 in 1970. Red dashed vertical lines show the year of nationalization. The right panel of Figure 1 shows a decline in the oil industry employment prior to nationalization which is reversed dramatically following nationalization. Prior to nationalization, productivity increased as output outpaced the number of workers. Post-nationalization, however, production growth slowed down and didn't return to its pre-nationalization growth path until the mid-1980s. As the number of workers outpaced production, measured labor productivity declined sharply post-nationalization.

The right panel of Figure 1 shows the composition of the Algerian oil work force by nationality. In 1962, 53% of oil employment was foreign, decreasing to 5% in 1971. Moreover, foreigners held mostly managerial, professional, and technical positions. In 1962, around 7% of workers were managers and engineers, 98% of whom were foreign.<sup>20</sup> But in 1971, 8% of workers were managers

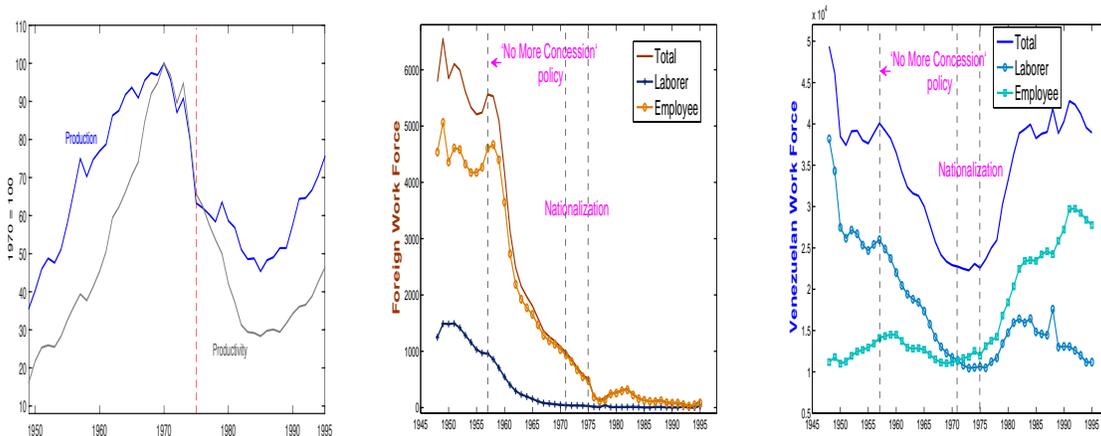
<sup>17</sup>Sonatrach, the largest Algerian and African company, was founded on December 31, 1963. At the time, the Algerian state held only 4.5% of the exploration perimeters, while French interests were as high as 67.5%.

<sup>18</sup>Sonatrach signed an agreement with Getty Oil in 1968 receiving 51% of Getty Oil's interests.

<sup>19</sup>A series of government takeovers in the Algerian oil industry then followed: 1970, 1971, 1974, 1976 oil nationalizations, Guriev et al (2011) [20]. The country became a member of OPEC in 1969. However, as it expropriated during the 1970s, I consider the country an OPEC member in my sample, and 1967 the benchmark year of expropriations.

<sup>20</sup>See Appendix I.b for details.

Figure 2: Oil Industry, Venezuela



and engineers, and only 28% of them were foreign. Nationalization in the Algerian oil industry appears to have reduced the number of foreign workers who were mostly employed in managerial and technical positions. However, nationalization also brought a striking expansion in domestic employment, particularly in managerial and technical occupations. Foreign workers were replaced by domestic workers of similar occupations but the increase in domestic workers was more than threefold. This remarkable expansion resulted in a slight increase in production and a sharp drop in productivity even though oil production in the country was in its early stages and thus expected to grow faster.

Another striking case is the 1975 nationalization of Venezuela’s oil industry. In Venezuela, the Reversion Law mandated gradual transfer of all unexploited concession areas to government ownership in 1971, and the nationalization process was finalized by the end of 1975. The left panel of Figure 2 shows both production and labor productivity patterns during this period, normalized to 100 in the year 1970. Prior to 1970, increasing production was accompanied by declining employment, resulting in productivity increases. However, by the beginning of the nationalization process, both production and productivity declined markedly. Post-nationalization, declining production and quickly expanding employment led productivity to fall further.

The mid and right panels of Figure 2 present foreign and domestic workers in the oil industry over 1948-95 disaggregated by type.<sup>21</sup> Similar to Algeria, the number of workers started declining prior to nationalization. Post-nationalization foreign workers were replaced by domestic workers.<sup>22</sup>

<sup>21</sup>Source is Republic of Venezuela, Ministry of Mines and Hydrocarbons, Oil and Other Statistical Databooks.

<sup>22</sup>Although my theme is not the causes of expropriation, possible motives can be highlighted here. Algerian takeover appears to have resulted from a change in political-economic ideology and independence, Kobrin (1980) [27]. 1967 crisis during Arab-Israeli war might have also played a role by bringing measures against American workers in the country. In this regard, reducing the number of foreign workers in the industry might be related to nationalist motives in the country. For Venezuela, however,

In Venezuela, the decline in foreign workers is even more striking. In 1948, around 11% of total workers were foreign, 78% of whom were white-collar (employees),<sup>23</sup> constituting 29% of total white-collar workers. The number of foreigners began declining in 1957. At that time, 12% of the total work force were foreign, 83% of whom were white-collar, making up 25% of total white-collar workers. By the time of nationalization, the percentage of foreign workers decreased to around 2%, 95% of whom were white-collar comprising only 4% of total white-collar workers. After nationalization, the share of foreign employment in total employment never exceeded 1%. On the other hand, post-nationalization, Venezuelan employment, particularly white-collar employment, expanded markedly. Moreover, even though the most important technical and managerial positions were held by foreigners prior to nationalization, who were paid much higher than domestic counterparts, these positions were assigned to Venezuelans after nationalization.<sup>24</sup>

The changing composition of the work force and the decline in the number of foreign workers holding key positions in the Algerian and Venezuelan oil industries following nationalization can help us understand why nationalization is associated with lower productivity. A natural question to ask is whether their experiences are common among expropriators or not. The Saudi Arabian government, for example, started increasing its interest in Aramco in the early 1970s and took full control of Aramco by 1980.<sup>25</sup> However, Aramco partners continued to manage and operate Saudi Arabia's oil fields with foreign workers constituting almost 50% of the workforce.<sup>26</sup> During 1970-1980, oil production increased by 167% in Saudi Arabia. Conversely, in Venezuela, where nationalization nearly eliminated foreign employment, production declined by more than 40%.<sup>27</sup>

In the next section, I explore how the industry evolved in the wake of nationalization further by narrowing the analysis to the 1975 Venezuelan oil industry nationalization and comparing it with the world trends.

### 3 The Venezuelan Oil Industry

Venezuela is one of the largest oil producers in the world. It fully nationalized its oil for the first time in 1975. This section presents the key patterns in the Venezuelan oil industry and across the world using a unique, manually collected data set described in Appendix II.a.

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such motives are not present.

<sup>23</sup>In PDVSA databooks, total employment is disaggregated into employees and laborers by nationality. I assume that employees represent white-collar (WC) workers and laborers represent blue-collar (BC) workers.

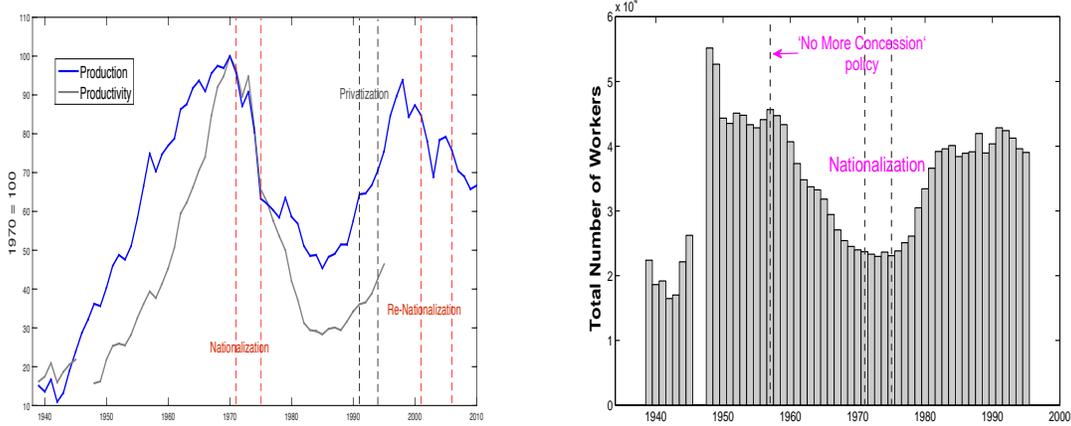
<sup>24</sup>Michelena, Agustin, and Soublotte (1976) [38].

<sup>25</sup>The former Aramco ownership distribution of equity capital was Exxon, Texaco, Chevron 30% each, and Mobil 10%, Luciani (1984) [32].

<sup>26</sup>Woodward (1988) [55], Olmedillo (1984) [42].

<sup>27</sup>I do not have time series data on employment in the oil industry in Saudi Arabia. Hence, I present production figures for the two OPEC members. They both experienced nationalization, one nearly eliminated foreign workers and the other did not.

Figure 3: Historical Production, Productivity, and Employment in the Venezuelan Oil Industry



### 3.1 Key Patterns in the Oil Industry

Oil production began in Venezuela in the early 20th century. The country became the largest oil exporter in the world in the 1930s: since then, fiscal revenues from oil have been the largest component of the government’s budget. The left panel of Figure 3 presents the country’s historical crude oil production (in barrels) and production per worker (in barrels per worker). Two nationalization episodes and a privatization episode are indicated.<sup>28</sup> The nationalization episodes are associated with production declines, but privatization has a positive effect.

The left panel of Figure 3 also presents productivity records over 1939-95. Productivity in the oil industry captures the production path quite well. Until 1970, both production and productivity trended upward. By the beginning of the nationalization process, the trend reversed sharply. In 1985, ten years after nationalization, production and productivity were 45% and 28% of their levels in 1970.<sup>29</sup> Both began increasing in 1985.<sup>30</sup>

It is important to note that the striking decline in oil production is not due to an OPEC production cut.<sup>31</sup> OPEC production increased by more than 14% in the 1970s. For instance, a member country, Indonesia, increased its production by 85%.<sup>32</sup> World production also increased

<sup>28</sup>Chang et al (2010) [8] explore reopening of the oil sector to foreigners in the early 1990s and re-nationalization of the industry in the early 2000s.

<sup>29</sup>Production per operating well which can also be considered a measure of productivity in the oil industry follows a similar path.

<sup>30</sup>Cuddington and Moss (2001) [12] show that technology diffusions in exploration and development over 1966-90 are concentrated in two periods: 1971-72 and 1983-84. Major advances, such as applications of microcomputers, take place in the early 1980s. Thus, increasing productivity in the post-1985 period can partly be due to the advances in technology in the early 1980s.

<sup>31</sup>Venezuela is one of the founding members of OPEC in 1960. OPEC production quotas have been agreed upon by members during OPEC meetings but estimates have been reported since 1982. During the 1970s and 1980s, OPEC production restrictions took place. In 1973-74, mostly Arab oil producers restricted output. From 1979 to 1985, Saudi Arabia, Libya, and Kuwait implemented the greatest percentage cutbacks, and countries like Indonesia, Nigeria, and Venezuela were among those least willing to cut production, Gately (1986) [19].

<sup>32</sup>British Petroleum Statistical Review of World Energy.

by around 31%. Mexico, a large non-OPEC producer in Latin America, more than quadrupled its oil production in the 1970s. This implies that Venezuela deviated from other large oil-producing nations significantly in the 1970s.

The right panel of Figure 3 plots historical oil employment. Employment was relatively stable during most of the 1950s. It began declining in 1957 and continued to decline until the early 1970s. The substantial contraction from 1957 to 1975 was then followed by a fast expansion: Venezuelan oil employment increased by about 10% each year from 1975 to 1979. Likewise, the share of oil employment in economy-wide employment increased by about 32.4% from 1975 to 1984. Although that increase can be attributed largely to new exploratory activity, Coronel (1983) [11] and Ellner (1993) [18] argue that it can also be considered a sign of the state's failure to maintain efficiency. Another distinctive feature of the employment data is the compositional change presented earlier. I call the increase in domestic employment following the government take-over *political favoritism*.

The left panel of Figure 4 shows that the path of Venezuelan oil employment from the mid-1960s to the mid-1970s is overall different from oil employment trends across the world. During the 1960s, world oil employment was relatively stable likely due to stable oil prices. In the early 1970s, rising prices supported oil employment across the world. Likewise, in Mexico, employment in the oil industry almost doubled and production more than quadrupled, resulting in an increase in productivity in the 1970s (Figure 4, right panel). Indeed, productivity captures production paths quite well in both Venezuela and Mexico, though they move in opposite directions.<sup>33</sup>

I also present total capital expenditure records of the world petroleum industry.<sup>34</sup> During the late 1950s and 1960s, capital expenditures in the world petroleum industry were stable with the exception of Venezuela in the late 1950s (Figure 5, left panel). From 1958 to 1961, capital expenses were stable in the rest of the world, but declined by more than 70% in Venezuela and then remained stable until 1975. Capital expenditures took off across the world in the early 1970s, particularly in the Middle East. In Venezuela, however, investment began increasing with a lag after nationalization. From 1975 to 1982, investment increased much more than the rest of the world, by more than ten-fold.<sup>35</sup> In other words, Venezuela joined the capital investment expansion last, but expanded its investment most in a seven-year period. Another important aspect of the capital spending pattern in Venezuela is the striking increase in exploration expenses relative to the rest of the world. Exploration expenses increased more than sixteen-fold from 1975 to 1982 in Venezuela (Figure 5, right panel), while the U.S. and Canada only saw a three-fold increase.<sup>36</sup> In

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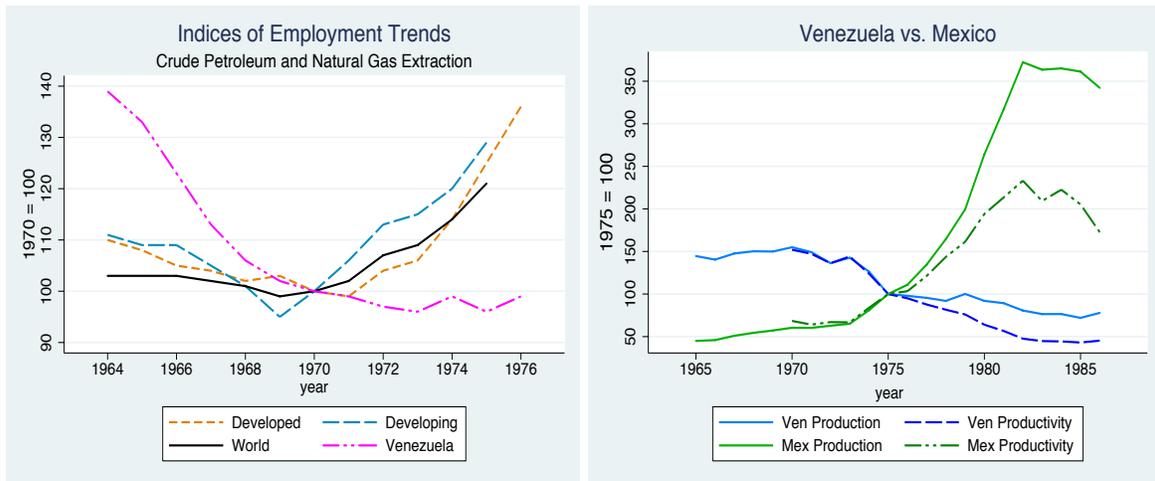
<sup>33</sup>Randall (1989) [44] argues that labor and work conditions in the oil industry in Mexico and Venezuela are similar. In this context, it would not be unrealistic to assume their sectoral characteristics are similar, implying that Venezuela's deviation is likely to be driven by nationalization.

<sup>34</sup>Source is a series of detailed studies of the financial performance of a large number of petroleum companies by the Energy Division of the Chase Manhattan Bank over 1968-82. In these studies, the combined operations of these companies make up a major proportion of the worldwide activities of the petroleum industry. Therefore, the financial performance presented shows the experience of the overall industry.

<sup>35</sup>From 1975 to 1982, capital investments increased by almost three-fold in the U.S. and Canada, by almost four-fold in Africa, and by more than five-fold in the Middle East.

<sup>36</sup>Chase Manhattan Bank, Energy Division [9]. From 1958 to 1982, the share of exploration expenditures in total capital

Figure 4: Oil Industry Employment



**Left Panel:** Source (Developed, Developing, and World Markets): *General Report, Petroleum Committee, 1980, International Labor Organization, Programme of Industrial Activities*. Developed Market Economies include Canada, USA, Europe (excluding centrally planned economies), Australia, Israel, Japan, New Zealand and Republic of South America; Developing Market Economies include Caribbean, Central and South America, Africa, Asian Middle East, East and Southeast Asia; World excludes Albania, China, Democratic People’s Republic of Korea, Mongolia, Vietnam. Source (Venezuela): *Republic of Venezuela, Ministry of Mines and Hydrocarbons, Petroleum Industry, Statistical Databooks*. **Right Panel:** Source: *Randall (1989) [44], and British Petroleum Statistical Review of World Energy*.

relation, the total number of wells completed in the Venezuelan oil sector, which can be considered a proxy for exploration activity, dropped sharply in 1957, and stayed low until 1975.<sup>37</sup> However, after nationalization, drilling activity more than quadrupled.<sup>38</sup>

When earnings are expected to be high, incentives to hire, invest, and explore are also high. Increasing prices from the early 1970s to the early 1980s are likely to be responsible for the expansion in the oil industry across the world. What I find prominent is the deviation of the Venezuelan oil industry from the rest of the world starting from the late 1950s until the mid-1970s.

### 3.2 Events and Policies Adopted in the Venezuelan Oil Industry and Discussion

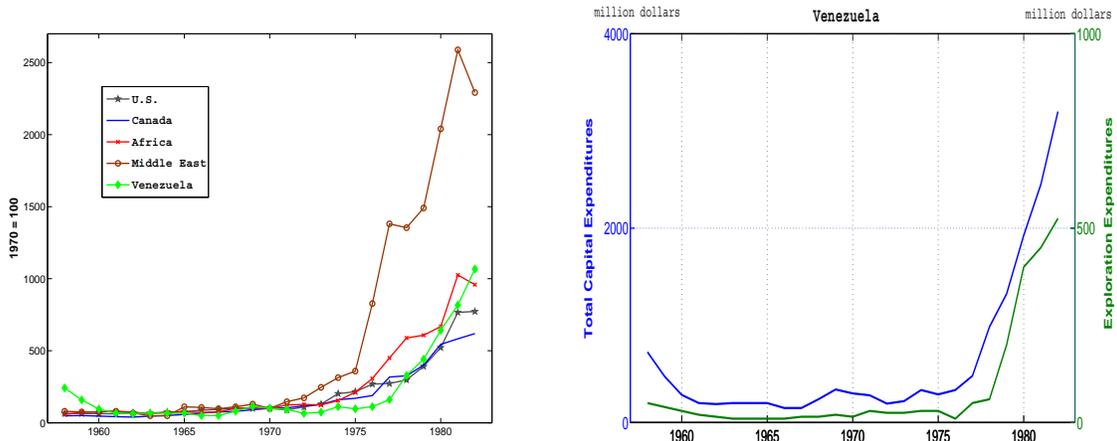
Government control of the Venezuelan oil industry was minimal until the late 1930s. In 1943, a new hydrocarbons law introduced greater government participation, and was considered a milestone for the Venezuelan oil industry. Before the law, the government’s main revenue tool was royalty taxes implemented at low rates. The 1943 hydrocarbons law introduced income taxes in exchange for additional years of exploitation and the promise of granting extensive new areas, Martinez (1989) [35]. A 50-50 split in profits between the government and the multinational companies

expenditures ranged between 2% and 23% across the world.

<sup>37</sup>Figures on exploration activity in the Venezuelan oil sector are available upon request.

<sup>38</sup>While the number of wells drilled decreased by 53% from 1971 to 1975 in Venezuela, U.S. drilling activity increased due to higher oil prices (the Energy Information Administration, U.S. crude oil exploratory and developmental wells drilled). From 1975 to 1982, U.S. drilling activity continued to rise, though not as much as the drilling activity in Venezuela.

Figure 5: Capital Investments of the World Petroleum Industry



Source: Chase Manhattan Bank, Energy Division, 1968 - 1982

(MNCs) was also adopted, Mikesell (1984) [39]. Manzano and Monaldi (2010) [34] argue that by accepting these tax changes, companies obtained a long-term planning horizon under a transparent tax regime. After the law, taxes remained relatively stable. Hence, stable distributive rules with a long investment horizon led an expansion in the industry from 1943 to 1958.

In 1957/58, the dictatorship ended, and the democratic regime began with the adoption of a new constitution in 1961. A new regime can increase spending, and when oil prices are relatively stable it can make higher government take more attractive. Indeed, the Venezuelan government increased its share in profits from 50% to 65% unilaterally through a significant rise in income taxes via a decree in 1958. This action is argued to have infuriated MNCs, Manzano and Monaldi (2010) [34]. Moreover, in 1958, the “no more concession” policy was announced meaning the last oil concessions were granted. Therefore, 1957/58 was the starting point of a major conflict between the government and the MNCs, which coincided with the beginning of a contraction in the industry. Coronel (1983) [11] argues that the conditions of the policy, whose primary objective is to increase national control over the industry and increase government revenues, are severe, making profits almost impossible for the companies. In line with this, in the 1960s, Shell Oil Company, the second largest producer in Venezuela, began shifting its operations elsewhere, Howarth and Jonker (2007) [25]. The government take increased from more than 65% in the 1960s to about 90% in the early 1970s, Manzano and Monaldi (2010) [34]. And, from the late 1950s to the mid-1970s, exploration was low. Additions to reserves declined and reserves stagnated soon after. Indeed, from the early 1960s to the mid-1970s, annual reserve additions were lower than annual oil production, suggesting over-extraction. After nationalization, although reserves increased, production did not, implying under-extraction.

In 1971, the Reversion Law was passed stating that all assets, plants, and equipment belonging to concessionaires would be reverted to the nation upon the expiration of the concession. Therefore, I assume that the formal nationalization process started with the Reversion Law, which coincided with a sharp decline in productivity.<sup>39</sup> The law also changed the nature of monitoring in the industry, because the Ministry of Mines and Hydrocarbons gained control and co-managed the industry with the MNCs until all concessions were cancelled and the industry was fully nationalized in 1975.

My interpretation of the facts documented in the previous section in the light of these events is as follows. In the late 1950s, the government's participation starts increasing in such a way that it makes the Venezuelan oil industry unattractive for MNCs. "No more concession" policy and the following tax increases are likely to generate expectations that the government would eventually take over the industry. This would motivate short-run incentives: increase extraction, lower employment, lower exploration; boost productivity in the short-run, but reduce productivity in the longer-run.<sup>40</sup> Increasing extraction is also likely to tip the government to nationalize. Because, the government may have viewed it as their resources being looted by MNCs.<sup>41</sup>

After nationalization, the state-owned industry's goal was to expand. However, production and productivity did not recover. I argue that this could be due to another challenge brought by the anticipated nationalization: lost foreign know-how. Figure 6 presents the education level of foreign personnel employed in the Venezuelan oil industry and shows that more than 70% of foreign workers are university graduates or higher. Given that in the same year, the average year of total schooling is only 2.65 for the same age group in Venezuela, Barro and Lee (2013) [3], I can conclude that foreigners comprise key, highly skilled workers in the industry and their departure is likely to bring significant know-how losses. In particular, if foreign skills are critical in extraction and complementary with other factors of production, then nationalization could be costly. Lack of a critical factor in extraction can cause production to continue to decline despite quickly increasing

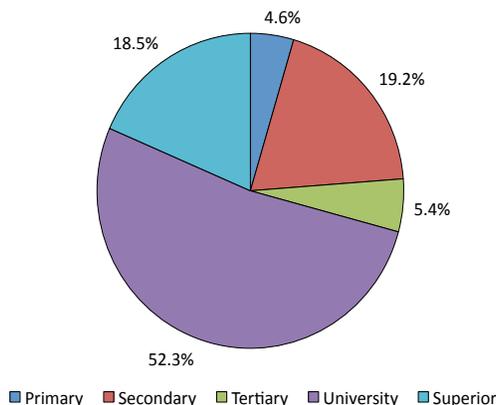
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<sup>39</sup>Nationalization of the Venezuelan oil industry is argued to be established after intense negotiations with MNCs. To some extent, the control of the industry had already been in the hands of the state since 1971/72. So, negotiations focused on establishing the amount and type of compensation rather than trying to stay in the country. Article 15 of the law provided the mechanisms of compensation in detail: "the amount of compensation of the expropriated assets cannot be higher than the net value covering properties, plants, and equipment ...," and the actual compensation was about \$1,012,571,901.67, Coronel (1983) [11]. According to Martinez (1989) [35], compensation payments to former concessionaires and equity holders on 31st of December in 1975 was in total \$1,342.28 million.

<sup>40</sup>This can be explained simply as follows. Let's suppose that there is 100 barrels of oil in the ground and that the industry is not worried about nationalization. Then, it will choose to extract oil at a rate such that the marginal cost of extraction in each of the future periods is equalized. Assuming marginal costs don't rise with a fall in reserves (and other factor prices are anticipated to remain constant), this will involve extracting the same amount each period. To be concrete, suppose that this rate is 10 barrels per year. So, under these conditions, oil will be fully extracted in 10 periods. But, if the industry expects that its right to drill and produce will expire in 2 periods because of an upcoming nationalization, then, it must choose its extraction rate under the new assumption that the marginal cost of extraction in period 3 on is infinity. This should induce a shift in extraction toward periods in which the marginal cost is low, and hence induce the industry to increase extraction to a rate higher than 10 barrels per period in periods 1 and 2. As a result, the fear of nationalization would cause extraction to go up.

<sup>41</sup>Hence, fear of nationalization could eventually make nationalization inevitable. So, there is a possibility of a self-fulfilling nationalization.

Figure 6: Education Level Distribution of the Foreign Personnel Employed in the Venezuelan Oil Industry, 1970



Source: Michelena, Agustin, and Soubllette (1976) [38].

domestic employment and increasing reserves.<sup>42</sup> My narrative of the Venezuelan case involves a long-term pre-announcement with a response of not only less exploration and higher extraction, but also a huge decline in the number of foreign workers.

In the following section, I develop a partial equilibrium framework to evaluate how the proposed mechanism can account for the key features of the Venezuelan data.

## 4 Model

The analytical framework I present adopts the general framework developed by Pindyck (1978) [43] and applied by Yucel (1986) [57] and Deacon (1993) [14]. Pindyck (1978) [43] has extended the seminal work of Hotelling (1931) [24] on the optimal exploitation of a resource from a fixed reserve base to allow for exploration, and examines the impact of exploration on extraction costs and prices. I modify his framework by introducing production technologies with different substitution elasticities between different types of labor in the exploration and extraction of oil.

<sup>42</sup>MNCs may have exploited easy-to-extract reserves and left the Venezuelan oil industry with hard-to-extract fields. To explore this possibility, I examine drilling activity in more detail. I group wells into three main categories according to LAHEE well classification: (i) new field wildcat drilled for a new field never productive before, (ii) exploratory wells drilled for a new pool in already productive area, (iii) development and extension wells drilled to exploit or develop a hydrocarbon accumulation discovered by previous drilling. So, development/extension wells are drilled to increase production from already discovered areas. I find that development wells constituted the highest portion of completed wells in the Venezuelan oil industry from 1959 to 1986 with high success rates. The number of development wells was the lowest in 1975 and increased markedly post nationalization. Drilling in a new pool in an already productive area was also common with increasing success rates. Given that production did not increase post nationalization, this suggests that extracting oil from existent productive fields became a challenge for the nationalized industry. It could be that prior to nationalization wells were shut down and when they were restarted after nationalization, they were not as productive. Moreover, to see whether the nationalized industry was successful in discovering new productive fields, I examine the number of new wildcats. The number of new wildcats declined from 73 in 1959 to 1 in 1970 and stayed low overall until the late 1970s. Even though it increased from 4 in 1978 to 111 in 1985, success rates were low. In 1959, there were 73 new wildcats 25 of which were successful. In 1985, there were 111 new wildcats but only 4 of them were successful. This implies that discovering new productive fields also became increasingly difficult post-nationalization.

I assume competitive producers of a nonrenewable resource.<sup>43</sup> The producers, taking prices and taxes as exogenously given, choose exploration and production paths to maximize the present value of profits. Reserves, which serve as a form of capital to support production, can be maintained or increased through exploration, even though returns to exploration decrease as discoveries increase. Production (extraction), on the other hand, depletes reserves. The average cost of production increases as reserves decline, and the marginal cost of exploration increases as exploratory effort increases.

I consider two forms of taxation in natural resources: severance (royalty) taxes and income taxes.<sup>44</sup> These are common revenue sources for resource-producing countries including Venezuela. Royalty taxes are levied on total sales, and income taxes are levied on total profits. As in Rigobon (2010) [45], I assume that tax rates are not contingent to prices, production, or reserves.<sup>45</sup>

Extractive and exploratory efforts are represented by different labor inputs measured in efficiency units. I consider a nationality (or skill-level) criterion and an operational criterion and assume four categories of labor input: extractive foreign and domestic labor and exploratory foreign and domestic labor. Extraction is a process combining reserves as a form of capital with extractive efforts to produce the resource- oil in my case.<sup>46</sup> In exploration, labor inputs that are imperfect complements generate additions to reserves.

Extraction of oil is represented by a three-factor production function denoted by  $O(\cdot)$  such that

1.  $O(\cdot)$  is a function of reserves,  $R_t$ , foreign labor in extraction,  $F_t$ , and domestic labor in extraction,  $D_t$ .
2.  $R_t = 0 \implies O(\cdot) = 0$  implying that  $R$  is an essential input.<sup>47</sup>
3.  $\lim_{R \rightarrow 0} \frac{\partial O}{\partial R} = \infty$  so that exhausting the resource in finite time is not allowed.

I consider the class of production functions for which the elasticity of substitution is constant. Given this, 1 - 3 suggest

$$O(R_t, F_t, D_t) = \Gamma(F_t, D_t)R_t^v$$

where  $0 < v < 1$ , and  $\Gamma(F_t, D_t)$  is homogenous of degree  $\leq (1 - v)$ . I assume that  $O(R_t, F_t, D_t)$  is a non-increasing returns to scale Cobb-Douglas production function, and choose to represent  $\Gamma(F_t, D_t)$  by a CES functional form, so that foreign and domestic labor inputs interact in a particular way. It is formulated as follows:

$$O(R_t, F_t, D_t) = R_t^v [\mu(s_D D_t)^\sigma + (1 - \mu)(s_F F_t)^\sigma]^{\frac{\gamma}{\sigma}}$$

---

<sup>43</sup>By assuming competitive producers, I am not departing from the Venezuelan reality.

<sup>44</sup>The sequences of tax rates are viewed parametrically. To simplify the analysis, I assume perfect foresight.

<sup>45</sup>This is how most of the contracts in oil-producing developing countries were specified during the period examined.

<sup>46</sup>In some earlier papers, reserves are also assumed to serve as a capital input. Among others, Devarajan and Fisher (1982) [15], Yucel (1986) [57], Deacon (1993) [14].

<sup>47</sup>Dasgupta and Heal (1974) [13].

where  $0 < \mu, v, \gamma < 1$ ;  $\sigma \leq 1$ ; and  $v + \gamma \leq 1$ . The extractive efforts are measured in efficiency units. Each input type is a product of the number of workers and a productivity index, which is assumed to be constant.  $s_D, s_F > 0$  are the corresponding productivity parameters. The technology is a non-increasing returns to scale Cobb-Douglas function in two inputs: reserves,  $R_t$ , and a compound term  $[\mu(s_D D_t)^\sigma + (1 - \mu)(s_F F_t)^\sigma]^{\frac{1}{\sigma}}$ . The second term is a CES aggregate over domestic labor with share parameter  $\mu$ , and foreign labor with share parameter  $1 - \mu$ . The parameters  $v$  and  $\gamma$  measure the shares of reserves and composite labor in income, respectively. The parameter  $\sigma$  governs the degree of substitutability between foreign labor and domestic labor.<sup>48</sup>

Output of exploratory activity is represented by technology  $G(d_t, f_t)$ , where  $d_t, f_t$  are the domestic and foreign exploratory efforts, i.e. labor inputs participating in exploration.  $G(\cdot)$  is strictly increasing and strictly concave. Concavity implies that the marginal discoveries made by additional exploration diminish as exploration proceeds. I choose the following Cobb-Douglas technology for exploration.<sup>49</sup>

$$G(d_t, f_t) = (s_d d_t)^{\theta_1} (s_f f_t)^{\theta_2}$$

where  $0 < \theta_1 + \theta_2 < 1$ . Similar to the extractive efforts, the exploratory labor inputs are also measured in efficiency units such that  $s_d > 0$  and  $s_f > 0$  are the corresponding productivity parameters.

Reserve dynamics are governed by the following state equation:

$$R_{t+1} = R_t - O(R_t, F_t, D_t) + G(d_t, f_t).$$

The change in reserves depends on how much effort is put into exploration and how much is extracted. Extraction lowers reserves, while exploration adds to them. The key underlying reason for exploration is to prevent extraction costs from becoming restrictive by enhancement of reserves.

To discuss the basic dynamics, I first consider the untaxed model. At each date  $t$ , the producer seeks to solve

$$v(S_t) = \max_{D_t, F_t, d_t, f_t, R_{t+1}} \{\Pi(\cdot) + \beta \mathbb{E}[v(S_{t+1})]\}$$

subject to the constraints

$$\Pi(\cdot) = P_t O(R_t, F_t, D_t) - (w_{D_t} D_t + w_{F_t} F_t) - (w_{d_t} d_t + w_{f_t} f_t)$$

$$R_{t+1} = R_t - O(R_t, F_t, D_t) + G(d_t, f_t) \tag{1}$$

---

<sup>48</sup> $\sigma$  being zero means Cobb-Douglas for the nested aggregate. The elasticity of substitution between foreign labor and domestic labor is  $\frac{1}{1-\sigma}$ . Note that this definition holds only if all other input quantities are constant, Blackborby and Russell (1989) [5].

<sup>49</sup>In general, the output of exploratory activity is assumed to depend not only on exploratory effort, but also on the stock of cumulative discoveries over time such that returns from exploration decline as cumulative discoveries increase. For the sake of simplicity and to investigate transitional dynamics, I suppress the additional argument and assume that production can go on indefinitely. This case is also presented in Pindyck (1978) [43] section IV.

$$O(R_t, F_t, D_t) = R_t^\nu [\mu(s_D D_t)^\sigma + (1 - \mu)(s_F F_t)^\sigma]^{\frac{\gamma}{\sigma}}$$

$$G(d_t, f_t) = (s_d d_t)^{\theta_1} (s_f f_t)^{\theta_2}$$

where  $S_t := \{R_t, P_t, w_{k_t}\}$ ,  $k = d, f, D, F$ . Here,  $P$  is the real price of the commodity, and  $w_i$ 's are the real unit costs of different types of labor. Although the cost of production is a function of extractive efforts and exogenous costs of efforts, it depends on current production, which is affected by reserves and thus by exploration. As reserves decline, both the average cost of extraction and the marginal extraction cost will increase. As a result, building up more reserves via exploration will decrease the cost of production, so exploration can be postponed when reserves are large. The intertemporal tradeoff in exploration involves balancing gains from reduced exploration costs due to postponed exploration with the loss from increased production costs because of lower reserves.

Marginal products are denoted by  $O_i$  and  $G_j$ . Then optimality conditions describing the solution of the model at time  $t$  are:

extractive efforts,  $i = D, F$

$$P_t = \frac{w_{i_t}}{O_{i_t}} + \eta_t \quad (2)$$

exploratory efforts,  $j = d, f$

$$\eta_t = \frac{w_{j_t}}{G_{j_t}} \quad (3)$$

reserves

$$\eta_t = \beta \mathbb{E} [P_{t+1} O_{R_{t+1}} + \eta_{t+1} (1 - O_{R_{t+1}})] \quad (4)$$

where  $\eta_t$  is the shadow value of an additional unit of reserves. The first order condition for extractive efforts yields that price is equal to the marginal extraction cost plus the scarcity value of a unit of reserves in the ground. The scarcity value,  $\eta_t$ <sup>50</sup>, is the change in the expected present value of future profits resulting from an additional unit of reserves and is always positive. If production costs rise as reserves decline, rent could fall, which implies that the opportunity cost of extraction is decreasing due to declining resource use. Thus, the resource will become less scarce. Equation (3) implies that the producer chooses optimal exploratory efforts so that the resource rent equals marginal exploration cost. That is, the shadow value of a unit added to reserves is equal to the cost of adding a unit via exploration. Here, the marginal explorations cost is the ratio of the additional cost and the additional exploration associated with one more unit of exploratory effort. Finally, equation (4) governs the optimality condition between today and tomorrow. The scarcity value of a unit of reserves in the ground today is equal to the expected present value of the flow of income

<sup>50</sup>Also known as the resource rent at time  $t$ ,  $\eta_t$  summarizes what is sacrificed to obtain a unit of the resource, i.e. the opportunity cost of extracting the resource.

that the additional unit of reserves generates next period plus the depreciated scarcity value in the next period.<sup>51</sup> In an untaxed environment, equations (1) through (4) govern the evolution of the variables  $R_t, F_t, D_t, d_t, f_t, \eta_t$  taking exogenous variables  $\{P_t, w_{D_t}, w_{F_t}, w_{d_t}, w_{f_t}\}$  as given.

I introduce taxes below, which will be my baseline model used in the quantitative analysis:

$$\Pi(\cdot) = (1 - \tau_{\pi_t})\{(1 - \tau_{r_t})P_t O(R_t, F_t, D_t) - w_{D_t}D_t - w_{F_t}F_t\} - (1 - \tau_{\pi_t}c)(w_{d_t}d_t + w_{f_t}f_t)$$

where  $\tau_{\pi}$  is the tax rate on income and  $\tau_r$  is the royalty tax rate. I allow for the producer to deduct  $c$  proportion of the exploration expenses from the tax bill. The tax-adjusted optimality conditions are

$$(1 - \tau_{\pi_t})(1 - \tau_{r_t})P_t = (1 - \tau_{\pi_t})\frac{w_{i_t}}{O_{i_t}} + \eta_t \quad (5)$$

$$\eta_t = (1 - \tau_{\pi_t}c)\frac{w_{j_t}}{G_{j_t}} \quad (6)$$

$$\eta_t = \beta\mathbb{E}[(1 - \tau_{\pi_{t+1}})(1 - \tau_{r_{t+1}})P_{t+1}O_{R_{t+1}} + \eta_{t+1}(1 - O_{R_{t+1}})] \quad (7)$$

The changes in tax rates affect both exploration and production. An increase in severance taxes reduces extractive and exploratory efforts, and the size of the reduction depends on the shares of the labor inputs and the elasticity of substitution. Lower exploratory efforts result in lower reserve additions and hence lower reserves. Lower reserves and lower extractive efforts result in lower output. The effect on output per worker, however, is ambiguous and depends on whether the decline in output dominates the decline in total effective labor. An income tax also decreases extraction and exploration efforts but to a lesser degree, as the expensing assumption implies that a certain proportion of the costs are deductible from taxable income. Therefore, as the effective tax rate on return to marginal exploration is low, so is the distortionary impact. Equation (7) shows how expected future changes in taxes affect exploration and extractive efforts. An increase in expected future taxes causes the opportunity cost of extraction today to decline, which makes extraction more attractive today but exploration less attractive.

Expropriation can be considered a form of (higher) taxation on producers: higher royalty and/or higher income taxes. Thus, its effect will depend on the composition of the taxation and whether it is anticipated or not.

## 5 Quantitative Analysis

Prior to conducting experiments of interest, I calibrate the model using the Venezuelan data. First, I describe what aspects of the data identify key parameters in the model. Then, I present baseline

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<sup>51</sup>Each unit of reserves has value, it can be extracted or left in the ground to the next period with a scarcity value  $\eta$ .  $(1 - O_{R_{t+1}})$  term on the right hand side of the equation (4) is similar to  $(1 - \delta)$  in the euler equation of the neoclassical growth model. That is,  $O_{R_{t+1}}$  here behaves like an endogenous depreciation rate. Once extracted at  $t + 1$ , tomorrow's shadow value will be reduced by  $O_{R_{t+1}}$ .

quantitative results. Finally, counterfactuals and sensitivity analysis are presented.

## 5.1 Calibration and Impulse Responses

To calibrate the model parameters, I match the steady state of the model to the features of the Venezuelan oil industry for the pre-1960 period. One period in the model is assumed to be a year in the data. The discount factor,  $\beta$ , is set to 0.90, which delivers a steady-state annualized real interest of about 11 percent. The elasticity of substitution parameter,  $\sigma$ , is set to  $-0.5$ , so that domestic and foreign labor in extraction are complements.<sup>52</sup>

I follow a similar approach used in Krusell, Ohanian, Rios-Rull, and Violante (2000) [30] to construct my labor input series and the corresponding wages series, which are explained in detail in Appendix II.b. Reserve additions data is constructed by following Pindyck (1978) [43] and also explained in Appendix II.b. For reserves and production, I use Venezuelan proven reserves and crude oil production data, respectively.

The parameters that I need to choose are  $\mu$ , the share of domestic extractive labor;  $v$ , the share of reserves;  $\gamma$ , the share of composite labor in production; the shares of domestic and foreign labor in exploration,  $\theta_1$  and  $\theta_2$ ; and productivities of different labor inputs,  $s_D, s_F, s_d, s_f$ . These parameters are calibrated from the steady state model, where tax rates are set at zero. Constructed pre-1960 data averages are used for the steady-state values of  $D, F, d, f$ , and their corresponding wages.  $G(\cdot)$  at the steady state is the pre-1960 average of the constructed reserve additions series. The steady-state value of  $R$  is set similarly. Productivities are constant over time. I target wage differences across different occupational groups by nationality in order to calibrate  $s_D, s_F, s_d, s_f$ .

I target the ratio of the domestic labor share and foreign labor share in extraction expenditures to calibrate  $\mu$  and obtain 0.68 (the average  $\frac{w_D}{w_F}$  ratio for the Venezuelan oil industry is 0.405). I jointly calibrate  $\theta_1$  and  $\theta_2$ . I target average pre-1960 ratio of domestic and foreign shares in exploration expenditures as well as average reserve additions over the period 1948-59 to choose these parameters, resulting in setting the exploration costs ratio to 1.56. The other two parameters,  $v$  and  $\gamma$ , are also jointly calibrated. I choose them so that the oil production to reserves ratio is 0.39, and production is equal to the new reserve additions.

I also need a value for  $c$ , the tax credit on exploration expenses. I calculate it following Deacon (1993) [14]. In my model,  $c$  is equivalent to the term  $(e + (1 - e)f)$  in his formulation, where  $e$  is the “fraction of drilling costs expensed for tax purposes,” and  $f$  is the “present value of cost depletion deductions per unit of depletable expense.” Following Deacon (1993) [14], I set  $e$  to 0.45. During the period 1953-57, the production to reserves ratio,  $d$ , is almost constant in the Venezuelan oil industry. Thus, I calculate  $d$  as the average production to reserves ratio over 1953-57. This allows  $f = \frac{d}{r+d}$ , where  $r$  is the real interest rate. Hence, I obtain  $c = 0.651$ . The parameter values are

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<sup>52</sup>Estimating a value for the elasticity of substitution parameter is not possible due to data limitations on skill premium. I hypothesize that complementary domestic and foreign labor inputs can help explain the observed path of productivity. Thus,  $\sigma$  must be set at a value  $\leq 0$ . As a baseline value, I consider  $-0.5$  and then conduct sensitivity analysis.

Table 2:

Parameter	Symbol	Value
Discount factor	$\beta$	0.90
Elasticity of substitution between extractive labor inputs	$\frac{1}{1-\sigma}$	0.667
Tax credit	$c$	0.651
Composite labor share in extraction	$\gamma$	0.675
Share of domestic labor in extraction	$\mu$	0.68
Share of reserves	$v$	0.113
Share of domestic labor in exploration	$\theta_1$	0.51
Share of foreign labor in exploration	$\theta_2$	0.32
Productivity of extractive domestic labor	$s_D$	3.6
Productivity of extractive foreign labor	$s_F$	7.66
Productivity of exploratory domestic labor	$s_d$	3
Productivity of exploratory foreign labor	$s_f$	6.39

summarized in Table 2.

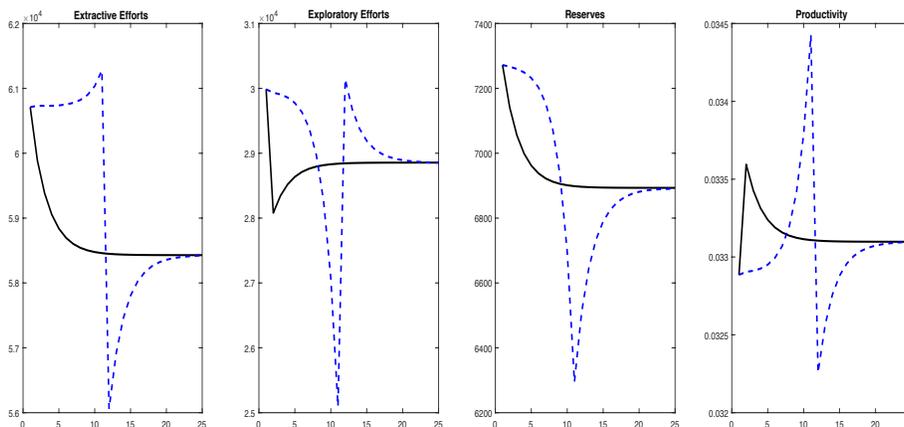
To gain insight on the role of anticipated tax increases, I first examine the effects of a higher income tax under foresight and no foresight assumptions.<sup>53</sup> Figure 7 presents impulse responses of a permanent income tax shock. Solid lines are the responses to an unanticipated (sudden) permanent 50% rise in the income tax rate. The dashed lines are the responses to the same tax increase with 10 periods of foresight. That is, news about the income tax increase which would materialize at the beginning of time 11 arrives at the beginning of time 1. In response to the anticipated income tax increase, extractive efforts increase. However, exploratory efforts decrease because the expected future increase in the income tax rate causes the shadow value of an additional unit of reserves to decline, increasing extractive efforts while disincentivizing exploration. Lower reserves due to decreasing exploration put downward pressure on production. As a result, despite increasing extractive efforts, production only slightly increases and then stays relatively stable until the shock is realized. Exploratory efforts decline more than the increase in extractive efforts, resulting in declining total employment. So, production per effective worker (productivity) increases prior to the realization of the shock. Once the shock is realized, the sharp decline in extraction yields a sharp drop in productivity.

A sudden (unanticipated) rise in the income tax rate materializes immediately at time  $t = 1$ , lowering both exploration and extraction efforts. However, the overall declines in these efforts upon realization of the shock are not as large as in the foresight-assumed case. The decline in exploratory efforts is sharp, and its path dominates the path of the total labor input. Therefore, there is a sudden rise in productivity followed by a decline. In both cases, labor productivity converges to a slightly higher level.

In the long run, anticipated and sudden (tax) policy changes result in similar distortions. But

<sup>53</sup>I only consider the effects of an income tax increase due to the fact that during the period examined, only income tax rates increased in the Venezuelan oil industry, royalty rates were unchanged.

Figure 7: Impulse responses to an income tax shock: Solid lines: responses to an unanticipated exogenous rise; dashed lines: responses to an anticipated exogenous rise, 10 periods foresight



in the short run, an anticipated change appears to benefit oil producers by allowing them to exert more extractive efforts to increase or maintain production, but appears to hurt the host country by lowering exploration.

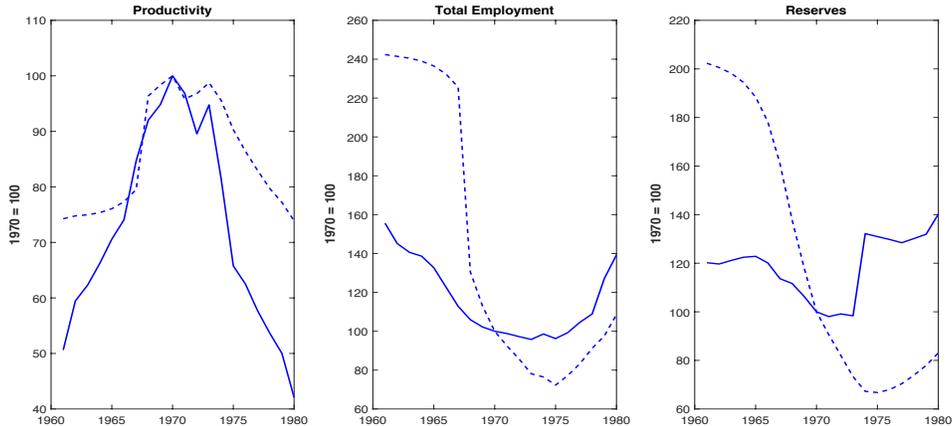
## 5.2 Nationalization

This subsection derives quantitative implications of nationalization in the Venezuelan oil industry. The initial period in the model refers to the year 1961, and I cover a 20-year period. Nationalization is simply exogenously given and introduced via permanent foreseen shocks. The agents in the economy anticipate that in the year 1961, the government will introduce nationalization permanently, which will be realized at the beginning of 1968. This is because the average government take in the Venezuelan oil industry started accelerating in 1968, Manzano and Monaldi (2010) [34]. Later, in 1970-71, the Income Tax Law was amended and the ministry co-managed the oil industry with the MNCs until the nationalization process was finalized in 1975.

Nationalization has two components. First, agents anticipate that the government will increase its participation through higher income taxes. PDVSA Databooks present Petroleum Industry Effective Rates of Income Tax and Manzano and Monaldi (2010) [34] present Royalty Tax Rates. From the early 1940s to 1975, royalty rates stayed the same. From the early 1960s to the late 1960s, income tax rates were also relatively stable. They began increasing in 1967-68 and peaked in 1975.<sup>54</sup> The income tax rates increased from 0.46 in 1961 to 0.70 in 1975 in the data. I assume

<sup>54</sup>I have data on effective income tax rates beginning in 1964. The average government take presented by Manzano and Monaldi (2010) [34] (in their Figure 3) was stable in the early 1960s. So, I assume that the income tax rates from 1961 to 1963 are the same as the 1964 income tax rate.

Figure 8: Data (solid) and Baseline Model (dash)



royalty tax rate stay the same and feed the actual annual income tax rate increases into the model.

The second component of nationalization is labor market distortion. This component has two dimensions. First, foreign labor becomes a missing factor- foreign labor distortion. In the data, from 1961 to 1975, the number of foreign workers fell by 84%. I generate declines in the number of foreign workers that match the path of foreign labor data by imposing increasing taxes on foreign wages. More specifically, I make it more and more costly to hire foreign workers to generate data equivalent declines from 1961 to 1968 and from 1968 to 1975.<sup>55</sup> Second, political favoritism. I model the post-nationalization expansion of domestic employment, domestic labor distortion, as a subsidy on domestic wages ( $s_d$ ). Total real wages in the Venezuelan oil industry were relatively stable from 1967 to 1972. Then, they increased, and from 1976 to 1983 they were relatively stable again. Between these two episodes, real wages increased by about 30% and, oil employment reversed its declining trend in 1973. From 1974 to 1980, the annual growth rate of real wages averaged at 4%. So, in the model, I assume  $s_d = 0$  from 1961 to 1973, set it to 4% in 1974, and assume it will continue increasing by 4% every year until it reaches 30%.<sup>56</sup>

Figure 8 displays the behavior of productivity, total employment, and reserves in the baseline model during the 1961-80 period relative to the actual Venezuelan time series. The values in the year 1970 are normalized to 100. Total employment is in effective units, and productivity is oil production per effective worker. The simple, carefully calibrated model economy is consistent with some key features of the data. The model generates qualitatively similar paths for labor and reserves, particularly for productivity. Specifically, the model generates a decline in total labor and

<sup>55</sup>I generate an average of 56% (data: 60%) decline from 1961 to 1968, an average of 58% (data:60%) decline from 1968 to 1975 and an average of 81% (data: 84%) decline from 1961 to 1975.

<sup>56</sup>In my view, changes in oil prices are not a major factor in explaining the trends in the Venezuelan oil industry as I discussed in section 3. Thus, I assume that  $p$  stays at its initial steady-state value.

Table 3: Profits

	Pre-nationalization	Post-nationalization
A. Baseline model	100	35
B. Model with domestic and foreign labor distortions only	100	42
C. Model with foreign labor distortion only	100	29
D. Unanticipated nationalization	100	43

reserves until the early 1970s and then an increase. The proposed mechanism can account for about 90% and 80% of the productivity path during 1961-70 and 1961-80, respectively. One difference is that in the post-nationalization model, productivity does not fall by more than one would expect. This deviation between data and model reflects the interaction between labor market distortions introduced by expropriation and the complementarity assumption between domestic and foreign labor in extraction. Foreign labor distortion, along with increasing income taxes, result in declining extractive and exploratory efforts, lowering total employment until 1973. Exploratory labor starts rising in 1973 due to domestic labor subsidy, but stronger foreign labor distortion prevents domestic extractive labor from rising due to complementarity until the end of 1975. Foreign labor distortion weakens in the post-nationalization period, and expansionary domestic labor distortion (subsidy) causes extractive efforts to rise. Increasing extractive efforts prevent productivity from falling by more, and labor productivity converges to a level only slightly below its 1961 level.

To evaluate the cost of the policy, I also calculate profits of the industry at the old (initial) and new (end) steady states, and normalize the old steady-state profits to 100. Panel A of Table 3 presents measured profits for the baseline model.<sup>57</sup> Nationalization reduces the industry's profits significantly by 65%. For a moment, let's assume that in the pre-nationalization period, profits are shared 50-50 between the Venezuelan government and the MNCs, which is the sharing policy introduced by the 1943 Hydrocarbons Law. In this case, the government would get 50% of profits, instead it gets only 35% in the new steady-state, 30% less than in the pre-nationalization period. This suggests that the industry is worse off after nationalization: though the whole profits are captured, they are smaller.

### 5.3 Assessing Nationalization

#### 5.3.1 Deconstructing the roles of labor distortion

To investigate the role of labor market distortions in driving the labor productivity pattern, I conduct further experiments. First, I simulate the model with distortions to domestic and foreign

<sup>57</sup>Post-nationalization profits take into consideration the associated labor taxes and subsidies.

labor, and fix the income tax rate at its 1961 level. The solid lines in Figure 9 show the paths of productivity, labor, and reserves for the baseline model, and the dashed lines show the results for the model with labor distortions. An anticipated increase in income taxes by itself does not alter labor productivity much. More significant to the path of labor productivity is the anticipated shift in the composition of the workforce from foreign workers to domestic workers. Not surprisingly, in the absence of increasing income taxes, the industry's profits are higher in the post-nationalization period than the baseline, Panel B of Table 3.

Political favoritism is common following a government take-over of a resource-rich developing country. As a second experiment, to examine the role of political favoritism, I simulate the model with only foreign labor distortion. The income tax rate is still fixed at its 1961 level and there is no political favoritism, that is, the domestic labor subsidy is zero. Now, the model fails to replicate the decline in labor productivity and increase in labor and reserves post-nationalization (Figure 9, diamond-lines). Production continues to decline due to low reserves and low extractive efforts post-1975, but so does total effective labor. As a result, labor productivity is relatively stable after 1975, and converges to a significantly higher level than the initial steady state. Without political favoritism, however, the industry's profits decline further, Panel C of Table 3. This implies that favoring domestic workers is very costly for productivity but not as bad for profits in the industry, Panel B versus Panel C of Table 3.

### 5.3.2 Sudden nationalization

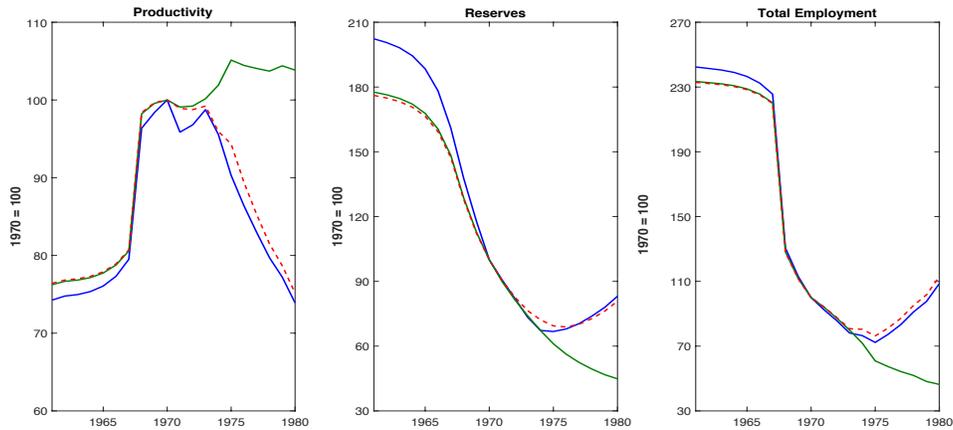
How would output per worker and profits upon nationalization change if the policy change had been sudden? I simulate the model with permanent unforeseen shocks. Upon a sudden policy change, total labor falls sharply, and stays low. Reserves also decline, but more gradually, and stay low. As a result, there is a sudden loss in production and a sudden increase in labor productivity which then drops and converges to a level slightly higher than the initial steady state, at odds with the data. Still, industry profits decline less than the baseline case, by 57%, Panel D of Table 3.

These counterfactuals imply that not taking into account labor market distortions or the anticipatory nature of nationalization understates the performance of the model in accounting for the productivity pattern over 1961-80. An anticipated nationalization that brings only higher income taxes has limited distortionary effects. However, nationalization that causes a shift in the composition of the work force results in significant losses. The cost is detrimental particularly in the short run, when nationalization is sudden due to a sudden drop in activity; in the long run sudden nationalization appears to be less costly to the host country than an anticipated nationalization.

### 5.3.3 Sensitivity analysis

I also perform sensitivity analysis for the elasticity of substitution between foreign and domestic labor inputs in production, ( $\sigma$ ), the parameter I were not able to pin down solely on the basis

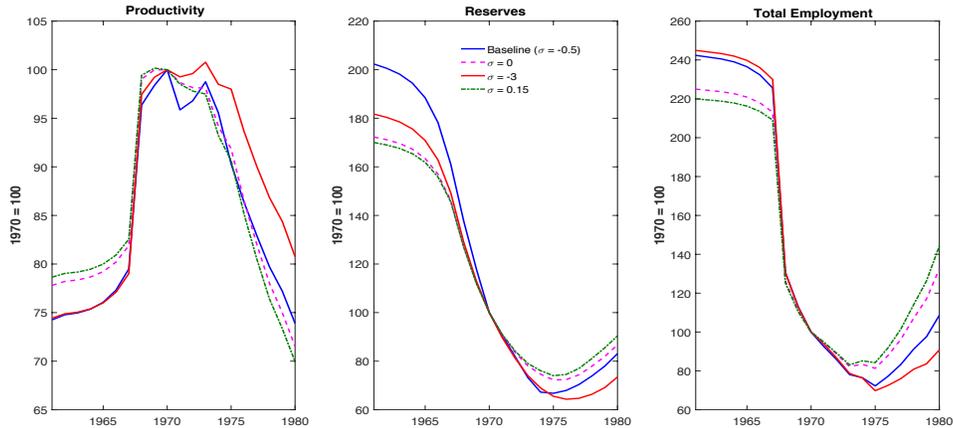
Figure 9: Baseline Model (solid blue), Model with Labor Distortions (dash red), Model with only Foreign Labor Distortion (solid green)



of simple steady state moments. In the baseline calibration,  $\sigma$  is set at  $-0.5$  so that foreign and domestic labor would be complements. I pick a much smaller elasticity of substitution,  $\sigma = -3$ , Cobb-Douglas technology i.e.  $\sigma = 0$ , and a higher elasticity of substitution,  $\sigma = 0.15$ , than the baseline value. For each of these cases, I recalibrate the model.

With  $\sigma = 0$  and  $\sigma = 0.15$ , the model predicts lower post-nationalization productivity and higher post-nationalization employment and reserves, fitting post-nationalization data better. However, there is a trade-off. In the post-nationalization period production increases, at odds with the data, due to the model being more responsive to domestic labor distortion driven by substitutability. As a result, post-nationalization profits are higher than the baseline. On the other hand, with stronger complementarity,  $\sigma = -3$ , loss of foreign skills limits the increase in employment and reserves, production stays low, and productivity is higher post-nationalization. As the degree of complementarity increases, it becomes more costly to the host country in terms of production and profits, but can be less costly in terms of productivity compared to the baseline. This exercise suggests that foreign and domestic labor in Venezuelan oil extraction are not easy to substitute and the degree of complementarity between the two is important for the path of productivity.

Figure 10: Model with different elasticities of substitution, 1970 = 100



## 6 Conclusion

Encouraged by revenue windfalls due to price hikes or the desire to gain control over a vitally important commodity, a significant number of developing countries have instituted nationalization several times in the history. From the point of view of a resource-rich country, implementing nationalization can be attractive due by generating higher revenue or better redistributing income through the government’s full control over the resource. However, nationalization can come at the expense of significant loss in productivity and profits.

In this paper, I use novel data to study the effects of nationalization quantitatively. First, I document historical trends in government take-over. Then, I investigate its effect on productivity in the oil industry over a period when expropriations are widespread and show that nationalization brings significant losses in productivity. Finally, I examine the Venezuelan oil industry’s nationalization to understand why nationalization is associated with lower productivity. The Venezuelan case is important and presents an example of a striking decline in productivity following nationalization. I document the effect of nationalization on the industry’s performance and show how it proceeds in practice. I argue that the Venezuelan case involved a long-term pre-announcement and that the response was not only higher extraction and lower exploration, but also a change in the composition of the workforce with a huge decline in foreign experts. I provide evidence on the proposed new mechanism and then use macroeconomic tools to test the ability of my theory in explaining the Venezuelan experience quantitatively. My simple, carefully calibrated model can explain the path of productivity quite well.

I also perform counterfactual experiments to illustrate key factors accounting for the path of productivity and draw policy implications. I show that the shift in the composition of the workforce from foreign workers to domestic workers is a key factor in productivity’s path. I find that political

favoritism is very costly for productivity but not as costly for profitability. Finally, I find that if nationalization had been sudden rather than anticipated, short-run costs would have been higher due to a sudden drop in activity. However, in the long run, sudden nationalization appears to be less costly to the host country.

Future research may consider improving the model in several aspects to capture the real world better. First, I abstract from any kind of uncertainty, which may not be an ideal assumption in particular due to the highly uncertain nature of exploration. Second, my framework implicitly assumes that reserves are of the same quality. A better representation would allow reserves to decline in quality. Third, a different objective function for the nationalized industry can help explain the post-1975 episode better.

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## APPENDIX I

### a. Historical Trends in Expropriation Acts across the World

**Data:** The unit of analysis is an act.<sup>58</sup> my data set includes 703 acts that occurred in 102 developing countries over 1922-2006. The data is primarily from Tomz and Wright (2010) [51].<sup>59</sup> They construct a new data set on occurrences of expropriation from 1900 to 1960 by considering a broad definition of expropriation following S. Kobrin. Then, they combine their newly collected data set with the existing inventories by Kobrin (1984) [28] for the period 1960-1979, Minor (1994) [40] for the period 1980-1991, and finally Hajzler (2007) [21] for the period 1993-2004. I combine Tomz and Wright (2010)'s [51] data set with Hajzler (2012)'s [22], which covers 2004-2006. Moreover, while examining expropriations in the oil industry, I combine the data provided by Kobrin (1984b) [29] with the data provided by Guriev et al (2011) [20], and use this combined data set to investigate the oil industry. Therefore, I present a set of facts for the occurrence of expropriation over an extensive period.<sup>60</sup>

**Trends:** Over half of the acts occurred during 1970-1976, and the acts peaked during 1974-75.<sup>61</sup> This pattern is similar to the time trend presented by Kobrin, although my figure covers a longer time horizon including earlier and more recent expropriations. In the literature, this time-pattern has been attributed to national security concerns, changing commodity prices, or gaining independence.<sup>62</sup> Kobrin (1980) [27] argues that it is also consistent with a secular bargaining power shift from investors to the host countries. In the 1970s, maintaining local-national ownership is important in terms of national security. Also, the late 1970s are a period of relatively high commodity prices.<sup>63</sup> Vulnerability to forced divestment varies by sector. Table 4 presents sectoral distribution of acts as a percentage in total acts during 1922-2006. Not surprisingly, investments in natural resources, infrastructure, and banking & insurance are more vulnerable to expropriation than others. In total, these sensitive sectors account for around 64% of all acts. The extractive sector alone accounts for around 41%. Hajzler (2014) [23] argues possible reasons for extractive sector being more vulnerable to forced divestment, such as widespread sunk costs, volatile prices, relatively easy technologies to operate, and national security concerns. In general, governments

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<sup>58</sup>An act is defined by Kobrin (1980) [27], Kobrin (1984) [28] as the involuntary divestment of any number of firms in an industry in a country in a given year.

<sup>59</sup>I am grateful to Mark L. J. Wright for sharing their data.

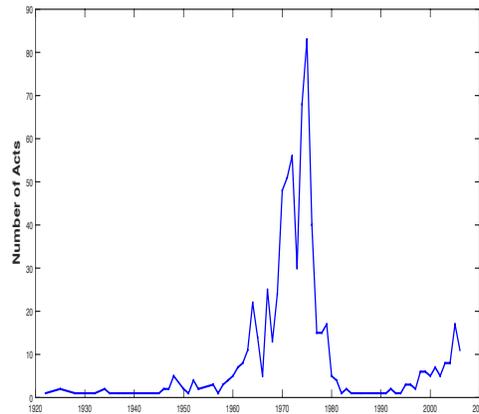
<sup>60</sup>The data set includes expropriations involving divestment of foreign direct investment. Kobrin (1984) [28], Minor (1994) [40], and Hajzler (2012) [22] present analyses of expropriation trends in their studies. However, Tomz and Wright (2010) [51] do not present such an analysis of expropriations. They only show the number & proportion of countries in the world that expropriated and/or defaulted over 1929-2004 while examining the impact of default and expropriation on foreign investment.

<sup>61</sup>Figure presents the total number of expropriation acts over time, i.e. how frequently expropriations occurred over time. I consider a three-year moving average for smoothing purposes.

<sup>62</sup>Kobrin (1980) [27], Hajzler (2014) [23], Tomz and Wright (2010) [51].

<sup>63</sup>Several other motivations are discussed in the literature. For instance, political pressures may develop whenever a poor economic environment coincides with wealthy industries dominated by foreign-owned firms (scapegoat hypothesis).

Figure 11: Time Pattern of Expropriations in the World, 1922-2006



prefer to control these sectors, possibly because the sectors dominate their economies and thereby make foreign ownership intolerable.

Table 4: Sectoral Distribution of Expropriation Acts in the World, 1922-2006

	% of total acts
Total Extractive	40.8
Agriculture	10.8
Mining	12
Petroleum	18
Manufacturing	24.1
Infrastructure	13
Banking and Insurance	10
Trade	4.3
Construction	2
Other	5.8

## b. Effect of Expropriations on Productivity in the Oil Industry

**Data:** Crude oil production data are from British Petroleum Statistical Review of World Energy and OPEC historical data series. Employment data in petroleum refineries are from United Nations Industrial Development Organization (UNIDO) Statistics, and International Labour Organization (ILO) Report on Employment and Industrial Relations Issues in Oil Refining.<sup>64</sup> The countries in my sample are major oil-producing countries that expropriated foreign-owned assets in the oil industry from the late 1960s to the 1970s.<sup>65</sup> My sample countries include Algeria and

<sup>64</sup>I consider employment in petroleum refineries as a proxy for employment in the oil industry.

<sup>65</sup>Sectoral employment data for oil-producing developing countries in the 1960s and the 1970s are not available for most of the cases. This prevents me from including several other expropriations, such as Argentina or Nigeria, thus limiting the size of my sample.

Table 5: Algerian Oil Employment, by occupation and nationality

<b>Occupation</b>	<b>1962</b>	<b>1966</b>	<b>1971</b>
<b>Algerians</b>			
managers and engineers	9	82	970
technical mastery employees	370	1718	9382
workers	3757	2772	5420
<b>Foreigners</b>			
managers and engineers	562	413	381
technical mastery employees	2590	1242	431
workers	1482	286	0

Source: Brogini (1973) [6]

Venezuela (OPEC members), and Colombia and Peru (non-OPEC members producing more than 100,000 barrels per day).<sup>66</sup> I include the United States as a benchmark for comparison.

Algerian oil employment data presented in the right panel of Figure 1 is from Brogini (1973) [6]. Table 5 presents the oil employment by occupation and nationality. In addition, prior to 1967, oil industry employment was mostly private. It began to fall in 1966, while public sector employment began to increase significantly. The share of public employees was 17% in 1965, increasing to about 70% in 1971.

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<sup>66</sup>Data are only available from 1979 to 1995 for the case of Peru, allowing us to examine the 1985 expropriation.

## APPENDIX II

### a. Oil Industry Facts

**Data:** My data set covers the early 1940s to 1995. Venezuelan oil industry statistics are from the Republic of Venezuela, Ministry of Mines and Hydrocarbons, Oil and Other Statistical Databooks (MMH Databooks). Annual industry-level time series data on various variables, such as proved reserves, new reserves, completed wells, number of workers, wages and salaries, gross investment in fixed assets, royalties, income taxes, etc., are recored from these databooks. Micro data on the composition of the labor in the oil industry are obtained from Michelena, Agustin, and Soubllette (1976) [38] and Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census Databook, 1987. Evidence on world oil industry trends are obtained from several publications by the International Labor Organization, the Programme of Industrial Activities; Chase Manhattan Bank, Energy Economics Division publications, and others mentioned in the text. GDP price deflator and exchange rate data are obtained from the Penn World Tables used to convert nominal domestic values into constant U.S. dollars. For the Venezuelan aggregate economy, the Conference Board, Total Economy Database, and the Economic Commission for Latin America Database are used.

### b. Quantitative Analysis

#### *Reserve Additions Data*

The source of my data is MMH Databooks for the years 1953-1994. In the data, new reserves in a given year consist of three components: discoveries, extensions, and revisions, in millions of barrels.

New discoveries in existing fields, discoveries of new fields, and extensions of existing fields rely heavily on well drilling. However, revisions occur more or less randomly and are not the result of well drilling. Revisions include corrections in reserves estimates; hence, they historically show highly erratic movements. For instance, the mean value of revisions is more than two times the mean value of discoveries plus extensions in the Venezuelan data, and the volatility of revisions is much higher than than the volatility of other components. Because of these factors, Pindyck (1978) [43] constructs series for reserve additions by multiplying data on discoveries plus extensions by the ratio of the mean value of reserve additions to the mean value of discoveries plus extensions.<sup>67</sup> I construct reserve additions data series representing the  $G(\cdot)$  variable in the model by following Pindyck's approach.

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<sup>67</sup>That is,  $reserve\ additions := (discoveries + extentions) * \frac{average(discoveries+extentions+revisions)}{average(discoveries+extentions)}$ .

## *Labor Input Data*

To construct the labor input and corresponding wages series, demographic characteristics of workers in the oil industry are needed. As oil industry employment data over 1948-95 is very limited and not digitally available (even for the United States historical data is quite limited), I manually collect data and anecdotal evidence on oil industry employment that allow us to construct these series.

From 1948 to 1995, MMH Databooks present annual data on the total number of workers and earnings in the petroleum industry in Venezuela. Earnings are annual total wages and salaries charged to operations in current million Bolivares. I convert them into millions of 1990 U.S.\$.

Michelena, Agustin, and Soubllette (1976) [38] present occupational profiles in the petroleum industry in Venezuela for the year 1974, and detail data on foreign personnel employed in the oil industry in 1970.

I construct the labor input series for extraction and exploration and their corresponding wages in several steps following an approach similar to Krusell, Ohanian, Rios-Rull, and Violante (2000) [30]. In the first step, several hundred demographic groups are recorded and these few hundred groups are sorted into three categories: (i) professionals, which includes three sub-categories: managers, administrative workers, technical workers; (ii) mid-level workers; and (iii) unskilled labor. In the second step, I sort these groups into two categories: foreign and national. In the third step, I classify these groups into extractive and exploratory and construct total labor input measures for extractive foreign and domestic workers, exploratory foreign and domestic workers, and their corresponding wages. To aggregate group measures into these classes, I first assume that groups are time-invariant. For instance, groups that belong to the extractive skilled category are always the same. Second, groups within a class are assumed to be perfect substitutes. I use the group wages in 1970 as the weights.

Next, I describe how these groups are constructed, what criteria are used, and how the group variables are aggregated to construct the measures of extractive and exploratory foreign and domestic labor input and wages used in this paper.

### **Individual Variables and Construction of Groups**

I record demographic characteristics of each foreign individual employed in the Venezuelan petroleum industry in 1970 by company in different federal states. Individual variables include age, education level (branch and number of years), office held (i.e. occupation), years of experience in the profession, and basic remuneration. I have these variables for several hundreds of different offices across different companies. To group these few hundred occupations into broader categories, I use the profile presented in Table 6 as a benchmark. This table presents the occupational profile in the

Table 6: Occupational Profile, Petroleum Industry, Venezuela

Categories of Personnel	Percentage (%)
University Professionals	10
Management	1.13
Technical	6.13
Administration	1.94
Research	0.064
Others	0.74
Technologists	3.06
Operators	25
Others	61.94

Source: Michelena, Agustin, and Soubllette (1976) [38].

Venezuelan Oil Industry in 1974, which includes both oil and petrochemical industries.<sup>68</sup> However, oil industry workers account for more than 76% of this profile, so I use it as a benchmark for the oil industry in Venezuela. Here, “Others” in the University Professionals category includes lawyers, doctors, sociologists, educators and other professionals. Technologist is equivalent to a mid-level technical education graduate. And “Others” in the last category consists of secretaries, clerical and unskilled workers. Given this profile, I define three groups: professionals, mid-level workers, and unskilled workers. **Professionals** include managers, administrative workers, and technical workers, where technical workers include technical, research, and others categories. Technologists and operators are regarded as **mid-level workers**, and finally, “Others” in the last category are considered **unskilled workers**. I assume that this occupational profile of the Venezuelan oil industry represents the industry at any time  $t$ .

Given these definitions, I group my records of foreign workers (707 individuals are recorded) according to their education level (Primary, Secondary, Tertiary, University, Superior) and occupation (office held, job title), and obtain an occupational profile for foreigners, which is presented in Table 7.<sup>69</sup>

Table 7: Occupational Profile of Foreign Workers in the Venezuelan Oil Industry

	Percentage (%)
Professionals	70.6
Technical	46.7
Management	9.3
Administrative	14.6
Mid-level	24
Unskilled	5.4

The percentage distribution presented in Table 6 is assumed to represent the oil industry’s occupational profile in Venezuela. The occupational distribution calculated and presented in Table

<sup>68</sup>The occupational profile of the industry in 1974 is not an ideal representation for pre-nationalization period, but this is the only data I could obtain for the whole industry.

<sup>69</sup>I consider an education-based criterion and an occupation criterion explained above, and thus assume that professionals have at least a university degree, mid-level workers have tertiary, technical, or secondary education, and unskilled workers have a primary or secondary education.

7 is assumed to represent foreign workers' profile in the Venezuelan oil industry.

MMH Databooks report four categories of labor in the Venezuelan oil industry from 1948 to 1995: domestic employees, domestic laborers, foreign employees, and foreign laborers.<sup>70</sup> In the second step, using total domestic and foreign labor data and the occupational profiles presented above, I construct time series data for the number of professionals, mid-level workers, and unskilled workers by nationality.<sup>71</sup>

MMH Databooks only report total wages paid in the oil industry. To construct corresponding wage series for different occupational groups by nationality, in addition to total wages paid, I use individual remuneration data for foreign workers employed in the oil industry from Michelena, Agustin, and Soubllette (1976) [38], and also use evidence from Tennessee (1979) [50]. First, I calculate average basic remuneration for foreign managers, administrative workers, technical workers, mid-level workers, and unskilled workers. I find that among foreigners, mid-level workers and administrative workers were paid similarly, about 2.5 times an unskilled worker's salary; technical workers were paid around 20% higher than mid-level workers; and managers, as expected, were paid the highest, more than double the mid-level worker's salary. These suggest a *skill-premium* in the range of 2.5 and 5.8 across different occupational groups. I assume that these represent the Venezuelan oil industry *skill-premium*.

Table 8: Salaries of Venezuelan and Foreign Workers in the Petroleum Industry, in Bolívares, 1932-1935

Profession	Daily Wage of a Foreigner	Daily Wage of a Venezuelan
Tool Pusher	42.50	18
Driller	42.75	18
Welder	35.75	14
Drawer	32.50	15
Derrick-man	32.50	16
Mechanic	32.00	16
Clerk	22.75	15

Source: Michelena, Agustin, and Soubllette (1976) [38].

Tennessee (1979) [50] argues that during the structuring of the oil industry in Venezuela, the recruitment was done abroad, leaving Venezuelan nationals in occupations lower in the hierarchical order largely due to the regime in Venezuela and the very low educational level of the population. Moreover, he claims that since the beginning of the oil industry, domestic workers did not have the same opportunity to achieve better positions or the same wage treatment as foreign workers and that disparities in wage levels were maintained throughout the development of the oil industry. So, not surprisingly, there is a *nationality-premium* in the Venezuelan oil industry. For instance,

<sup>70</sup>Databooks neither provide definitions of employee versus laborer, nor do they provide any further demographic information.

<sup>71</sup>I have a few negative data points in the two constructed series, domestic management and domestic administrative workers, prior to 1959. This implies that my assumptions on occupational profiles resulted in exceeding numbers of foreign managers and administratives for some years, so, I have made the following correction. I calculate average numbers of domestic managers and domestic administratives (using constructed positive values) prior to 1960, and replace negative values in the two series with these averages. Then, I adjust related entries in foreign managers and foreign administratives series.

over 1959-70, the average annual salary of a foreign employee was 62.071 bolivars, while for a Venezuelan employee, it was 27.110, Tennessee (1979) [50]. This implies a ratio of 2.3 between average foreign salary and average domestic salary in the Venezuelan oil industry. Table 8 also presents a *nationality-premium* not so different from that ratio during 1932-35. The disparity between wages across different occupations range between 1.5 and 2.6. I assume that professions presented in Table 8 except “Clerk” are mid-level jobs, and considered the average differential across these jobs to represent *nationality-premium* for mid-level workers in the Venezuelan oil industry, which is 2.25.<sup>72</sup> I assume “Clerk” represents unskilled jobs, so the *nationality-premium* for unskilled workers is equal to  $\frac{22.75}{15} = 1.52$ . Finally, for technical workers, administratives, and managers, I assumed a *nationality-premium* of 2.3 following Tennessee (1979) [50].

Table 9: Relative Wages in the Venezuelan Oil Industry

<b>category</b>	<b><i>nationality-premium</i> (np)</b>	<b><i>skill-premium</i> (sp)</b>
Management (m)	2.3	5.78
Technical (tech)	2.3	3.13
Administrative (a)	2.3	2.51
Mid-level (mid)	2.25	2.58
Unskilled (u)	1.52	1

Table 9 summarizes the relative wages of domestic and foreign workers in each category in the second column and wages in each category relative to the unskilled category in the third column. Then, I obtain the labor income of domestic unskilled workers as

$$w_{du,t} = \frac{W_t}{\sum_{i \in \{d,f\}} \sum_{j \in \{u, mid, a, tech, m\}} n_{ij,t} sp_{ij} np_{ij}}$$

where  $W$  is total real wages,  $n$  is number of workers,  $i$  shows nationality, and  $j$  shows occupational category.  $sp$  is skill-premium such that  $sp_{dj} = sp_{fj}$  presented in the third column of Table 9 with  $sp_{iu} = 1$  for all  $i, j$ .  $np$  is nationality-premium such that  $np_{fj}$ 's are presented in the second column of Table 9 and that  $np_{dj} = 1$  for all  $j$ . Domestic wages for other categories,  $j \in \{mid, a, tech, m\}$ , are

$$w_{dj,t} = w_{du,t} sp_{dj}.$$

Hence, I have wage series for each domestic occupational group. Multiplying wages of domestic workers in each category by corresponding *nationality-premium* parameter, I then obtain wage series for each foreign occupational group, i.e.

$$w_{fj,t} = w_{dj,t} np_{dj}$$

<sup>72</sup>That is  $\frac{wage_{foreign}}{wage_{domestic}} = 2.25$  for mid-level workers.

for all  $j$ . Now, I have labor input and wage series for different occupational groups by nationality, i.e. foreign and domestic.

### Aggregation of Groups into Exploration and Production

I aggregate occupational categories into broad classes of extraction and exploration and obtain measures of labor inputs and their wages. In doing so, I assume that broad classes of exploration and production (extraction) include all five occupational groups and this partition is time invariant. That is, both exploration and extraction classes include occupational groups  $\{u, mid, a, tech, m\}$ . To aggregate groups into these two classes, I also assume that groups within a class are perfect substitutes, i.e. they simply add. For the aggregation, I use adjusted group wages of 1970 as weights. Then, the total labor input (in number of workers) for the two classes is

$$N_{ik,t} = \sum_{j \in \{u, mid, a, tech, m\}} (\mu_{k,t} n_{ij,t}) \bar{w}_{ij,70}$$

where  $t$  represents the year;  $i = d, f$ ;  $k = e, p$  represents exploration or production;  $\mu_k$  is the share of  $k$  in total employment explained below;  $\bar{w}_{ij,70} = \frac{w_{ij,70}}{\text{average}(w_{dj,70}, w_{fj,70})}$  so that it would be unitless and an appropriate skill index. The wages are therefore

$$W_{ik,t} = \frac{\sum_{j \in \{u, mid, a, tech, m\}} (\mu_{k,t} n_{ij,t}) (\zeta_{k,t} w_{ij,t})}{N_{ik,t}}$$

where  $\zeta_{k,t}$  represents the wage differential between exploration and production segments in the oil industry.

my data on occupations in the Venezuelan oil industry do not provide enough information on the segments of the industry in which the individuals were employed. To get estimates for the shares of production and drilling and exploration workers in total oil industry employment, I use U.S. Census of Mineral Industries 1958 [52] and 1987 [53] publications and the American Petroleum Institute (API) 1975 Data Book [1].<sup>73</sup> Using the data available from these sources, I obtain the following shares of oil and gas extraction employment in production and drilling and exploration for the years 1958 and 1972:

	production	drilling & exploration
1958	0.63	0.37
1972	0.57	0.43

<sup>73</sup>U.S. Census of Mineral Industries 1958 [52] provides employment statistics for the U.S. oil and gas extraction sector (SIC 13) and its subsectors: crude petroleum and natural gas (SIC 131), natural gas liquids (SIC 132), and oil and gas field services (SIC138) for the year 1958. U.S. Census of Mineral Industries 1987 [53] provides statistics for the subsector oil and gas field services (SIC 138) for the years 1972, 1977, 1982, 1987. API (1975) [1] provides statistics for the oil and gas extraction sector for the years 1965-74.

I consider the 1958 shares as a proxy for the Venezuelan oil industry prior to 1961 ( $\mu_{p,t} = 0.63, \mu_{e,t} = 0.37$  where  $t \leq 1960$ ), and the 1972 shares as a proxy for the Venezuelan oil industry for post-1960 ( $\mu_{p,t} = 0.57, \mu_{e,t} = 0.43$  where  $t > 1960$ ). Similarly, using payroll data reported in U.S. Census of Mineral Industries 1958 [52], I calculate the wage ratio between production and exploration workers as 1.2. That is, production workers are paid 20 percent higher than exploration workers ( $\zeta_{p,t} = 1.2, \zeta_{e,t} = 1$ ).