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

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Abstract

The number of occurrences of an old phenomenon, expropriation of foreign-owned property, had peaked in the 1970s, and virtually every significant oil-producing developing country had nationalized its oil. Nationalization again was on the rise in the 2000s. Using novel data, this paper examines nationalization and its effect on productivity. First, we document historical global trends in expropriations, and examine the effect from the 1960s to the 1990s in a sample of oil-producing developing countries. We show that nationalization brings significant productivity losses. Then, we focus on Venezuela, presenting new extensive and detailed data. In Venezuela, productivity fell sharply immediately ahead of nationalization. We suggest a less-explored channel through which nationalization affects productivity: in anticipation of nationalization, producers reduce exploration, lower employment, and increase extraction. Guided by a quantitative dynamic partial equilibrium framework for nonrenewable resources disciplined by features of the Venezuelan data, we then examine the effect of nationalization on productivity. A comparison of the simulated and time series shows that the carefully calibrated model can explain 84 percent of the productivity pattern over 1961-1980 in the Venezuelan oil industry.

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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 between 1979 and the early 2000s. Following this process, a considerable amount of research was conducted supporting the proposition that privately-owned firms are more productive than otherwise-equivalent SOEs. 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).

The recent experience with expropriations has led to renewed interest in understanding expropriation of foreign direct investment in developing host countries. This paper attempts to provide a thorough analysis of the impact of this phenomenon by a novel, comprehensive dataset. In order to provide a careful, updated analysis, we start with investigating historical global trends in expropriations over 1922-2006. Our goal is to determine the periods, regions, and sectors in which expropriations have been widespread. We show that over half of the acts occurred during 1970-1976, that the extractive sector (including oil) is more vulnerable to forced divestment, and that expropriations are more common in Africa and Latin America. Motivated by these facts, we focus on the impact of oil industry expropriations on productivity in the 1970s in Latin America and Africa. Consistent with previous studies in the literature, we show that labor productivity relative to the U.S. declines following expropriation, and the losses range from 30 percent to 60 percent.

The Algerian and Venezuelan experiences provide initial insights with regard to possible explanations for the observed trend in productivity. Elimination of foreign workers and a fast-expanded domestic work force are common in both countries. Prior to expropriation, total employment, including foreign workers, shrank significantly. After expropriation, on the other hand, the lost foreign workers were replaced by domestic workers who were mostly

1 Megginson and Netter (2001).
2 Leading studies include La Porta and Lopez-de-Silanes (1999) [29]; Megginson, Nash, and Van-Randerborgh (1994) [34]; and Megginson and Netter (2001) [35].
3 Stroebel and van Benthem (2013). 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.
white-collar workers. In order to examine what can account for the impact of expropriation on productivity thoroughly, we then focus specifically on the case of Venezuela. We chose Venezuela, because it is one of the largest oil producers in the world, and a particular example of a remarkable decline in productivity following nationalization. In addition, we manually collect a unique dataset on the Venezuelan oil industry over a fifty years period, and also present novel evidence on world oil industry trends to see whether the Venezuelan trends were common to the industry at that time or not.

Venezuela fully nationalized its oil industry for the first time in 1975. By comparing annual time series data before and after nationalization, we show that production and productivity increased at a considerable rate until 1970. After that, a striking decline took place, which was particularly severe in the first five years after 1970. By 1985, production and productivity had declined by around 55 percent and 72 percent, respectively, compared to their levels in 1970. The total number of workers in the industry was stable until 1957, but this stability was replaced by a remarkable contraction between 1957 and 1975, where the total work force decreased by 49.4 percent (the number of domestic and foreign workers decreased by 43.7 percent and 90.9 percent, respectively). In line with the reduction in the labor force, exploration activity in the industry also began declining in 1957, which caused reserves to stagnate first and then decline. After nationalization, the percentage of foreigners in total employment stayed below 1 percent. The Venezuelan work force, on the other hand, expanded rapidly after nationalization. The contraction of 1957-1975 was replaced by a fast expansion, particularly in the number of white-collar workers. Likewise, exploration and reserves increased.

First, fast extraction before 1970 and the collapse right after 1970 are both striking. Together with declining exploration and falling employment which began well before nationalization, this behavior is likely to reflect short-run incentives under the fear of nationalization. Second, the industry couldn’t improve production and productivity despite the notable expansion in employment and increase in reserves during the post-nationalization period, which may result from a lack of a critical input in the production process that is not easy to substitute.

We argue that the regime change from dictatorship to democracy in 1957 induced in-
creasing expenditures in Venezuela, resulting in a temptation to increase the government share of multinational companies’ (MNCs) profits. This led to new tax laws, which progressively increased taxation. Moreover, new oil concessions were frozen during 1957-1958. These events induced an anticipated government takeover, and triggered the nationalization process, which began in 1970. We propose that the fast extraction, declining exploration, and the contraction in manpower prior to 1970 were driven by the news about the future nationalization.

The decline in the number of foreign workers began in 1957, and continued thereafter. The retarded recovery in production and productivity despite the expansion in the oil industry in the post-nationalization period, together with eliminated foreigners, motivate us to relate the role of a missing factor in production to the observed trends. So, we are led to a model where we distinguish between the two labor inputs, domestic and foreign workers. We provide evidence suggesting that foreign workers in the Venezuelan oil industry were high-skilled workers, representing key technical, professional, and managerial positions. Hence, low-skilled labor represent domestic workers, while high-skilled labor represent foreign workers in the model. Then, we hypothesize that if the available know-how in the industry was mainly supplied by foreigners, and their skills were complementary with the other factors of production, then nationalization would be costly, and cause a decline in the productivity of measured factors of production. We interpret this decline as “the missing input” of high-skilled workers in production.

The model section of the paper builds a dynamic partial equilibrium framework that incorporates the elements documented above. The production function in the model allows for imperfect substitutability across different labor inputs. In this dynamic framework, extraction depletes the resource, which can be maintained or increased by exploration. The industry takes prices and taxes as given, and decides on optimum exploration and production paths. The model allows us to assess the effects of anticipated changes under different timing assumptions, and suggests that foresight of several years distorts the effects under no foresight assumption. Nationalization is simply exogenously given and introduced as permanent foreseen shocks. Agents anticipate that nationalization would take place permanently via rising income taxes, elimination of foreign workers, and expansion of domestic workers.
We feed the actual income tax increases into the model, impose a gradually rising fixed
cost on foreign workers that results in gradual elimination of foreigners as in the data, and
subsidize post-nationalization wages paid to domestic workers. In anticipation of national-
ization, exploratory efforts fall, and extractive efforts increase. Production slightly increases
because reserves decline more than the increase in extractive efforts. As a result, prior to
nationalization, productivity increases due to significant decline in total number of work-
ers stemming from the decline in exploration efforts. By the realization of nationalization,
productivity falls and continues to do so after nationalization. Despite its simplicity, our
carefully calibrated model can explain the path of productivity quite well. A comparison of
the simulated and actual time series over the period 1961-1980 shows that our model can
account for 84 percent of the productivity pattern.

We document the impact of nationalization on industry performance and how it proceeds
in practice, and present a less-explored channel through which expropriation impacts produc-
tivity: in anticipation of expropriation, producers reduce exploration, decrease employment,
and increase extraction. We provide evidence supporting the suggested channel, and then
test the ability of this mechanism in explaining the Venezuelan experience by developing a
relatively simple but non-standard framework for non-renewable resources. Finally, we ex-
amine validity of a view suggesting that nationalization would allow expropriating country
to get to keep the whole, hence it would be better off. We quantify the impact of nationaliza-
tion on present discounted value of profits by calculating measured profits using simulated
data before and after nationalization. We find that measured profits shrank by more than
55 percent from 1961 to 1980. This implies that there is no support for this view within
Venezuelan oil industry.

Related Literature

This study contributes to several strands of the literature. First, Pindyck (1978) [42] has
extended the seminal work of Hotelling on the optimal exploitation of a resource from a fixed
reserve base to allow for exploration. We adopt his general framework. We use reserves as
a form of capital in extraction, as in Devarajan and Fisher (1982) [13], Yucel (1986) [54],
and Deacon (1993) [12], but different from the previous literature and motivated by the
observed trends, we represent exploratory and extractive efforts with different labor inputs, which are imperfect substitutes measured in efficiency units. This method allows us to test the proposed mechanism. In addition, we study the effects of taxation in resources under different beliefs about the future. When tax changes are unanticipated we obtain results in line with the literature. However, when tax changes are anticipated, opposite effects are obtained. Although the effects of taxes on a resource industry have been explored in the literature, the effects of anticipated tax changes have not yet been explored, as far as we know. In this context, our paper not only contributes to the taxation of resources literature, but also to the news shocks literature, by documenting an expropriation case in which news shocks have important policy implications. Relevant papers that examine tax effects under policy foresight are Yang (2005) [52] and House and Shapiro (2006) [21]. Yang studies the effects of tax changes under policy foreknowledge by simulating a standard neoclassical growth model and shows that anticipated changes in capital and labor taxes have opposite effects on macroeconomic variables. House and Shapiro, under perfect foresight, investigate the macroeconomic implications of the timing of tax cuts in the US introduced by President Bush in 2001 and 2003.

We present novel, unique evidence on the oil industry across the world, and in Venezuela over an episode of widespread expropriations. Our evidence on foreign workers suggests that foreign workers were in key positions and highly skilled. The specialized knowledge brought by foreign firms can be critical for industry operations, and removing them can be costly. This finding is related to a growing literature studying the impact of multinational activity in developing countries, which suggests that the presence of foreign firms can bring welfare gains, Antras, Garicano and Rossi-Hansberg (2006) [1]; Burstein and Monge-Naranjo (2009) [6]; and Eeckhout and Jovanovic (2010) [15].

To provide a better understanding of the policy, we evaluate a nationalization experience quantitatively where the parameters of the relevant functions represent the Venezuelan oil sector. To our knowledge, no research exists that explores nationalization in a quantitative manner, nor that attempts to explain a developing country experience as we undertake to.

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4 This impact 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) [39].
Existing studies mostly focus on the determinants of nationalization, or productivity impact of denationalization, or compare public ownership with private ownership. Examples include Megginson, Nash, and Van-Randerborgh (1994) [34]; La Porta and Lopez-de-Silanes (1999) [29]; Megginson and Netter (2001) [35]; Guriev et al (2009) [17]; Chang et al. (2010) [7]; and Stroebel and van Benthem (2013) [47].

James A. Schmitz Jr. presents industry-level analyses in which there is an exogenous change in competition, and productivity can be measured before and after the competitive change. For instance, Schmitz (2005) [45] finds that exogenous changes in the world steel market led to increased foreign competition for Great Lakes’ iron ore producers. These changes result in a 100 percent increase in labor productivity, which is explained by changes in work practices. Likewise, Schmitz and Teixeira (2004) [46] show that privatization of the Brazilian iron ore industry gives rise to productivity gains in newly privatized firms and existing private firms that have to compete with the new firms, and do so by eliminating restrictive work rules. In this paper, we follow a similar approach by presenting an industry case in which there is a large, exogenous policy change associated with significant losses in production and productivity.

Finally, this policy question has potential for further implications. When a resource is vitally important for a country’s economy and the country is unable to use its sources in alternative industries, then the impact of the policy on the industry can easily contribute to the performance of the aggregate economy. In this context, studying the effects of nationalization can help in understanding why some countries are development outliers. For instance, in Venezuela, the oil industry expanded quickly during that period until 1958, which coincided with a substantial expansion in the Venezuelan economy. Bello, Blyde, and Restuccia (2011) [3] show that GDP per capita relative to the US increased from 20 percent in 1920 to more than 90 percent in 1958, but then declined to reach about 30 percent in recent years. The authors find that capital accumulation and knowledge transfer account for the remarkable growth, and argue that openness of the oil sector to foreign investment contributes to expansion in the oil industry, resulting in overall expansion. The authors then

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5 When we examine real GDP per capita and oil production per capita, we observe that most of the time they move in the same direction.
show that a fall in total factor productivity and capital accumulation account for the subsequent collapse. They argue that government intervention can create misallocation, 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 Venezuela. Our analysis is in line with their arguments on the aggregate economy. To understand Venezuela’s development experience, which is critical in terms of the Latin American development problem, it is important to study the oil industry, particularly oil production.

The remainder of the paper is organized as follows: In Section 2, we present facts on the historical patterns of forced divestment across the world, and examine the impact of nationalization in a sample of oil-producing developing countries. In Section 3, we document the features of the Venezuelan oil industry. After describing the data, we explore main trends, discuss critical aspects of nationalization, and put forth our hypotheses in explaining the observed impact. In Section 4, we introduce our model. We present our quantitative analysis in Section 5, and conclude in Section 6.

2 Historical Trends in Expropriations and Their Impact on Productivity

First step in investigating the impact of expropriation on productivity is to determine the periods, regions, and sectors in which forced divestment has been widespread. For this purpose, we start with documenting the trends in expropriations across the world over 1922-2006.

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6 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.

7 1958 was a turning point not only in the aggregate economy but also in the Venezuelan oil industry. We believe the collapse of the industry was implicitly triggered by the events of 1958 (discussed in more detail later in this section) which consequently made nationalization inevitable.

8 Cole et al. (2005) [9] investigate the Latin American development problem, and find that barriers to competition, including limiting government policies, are a likely cause.

9 Kobrin (1980) [25] classifies forced divestment into four types: nationalization, intervention, forced sale, and contract renegotiation, and provide their descriptions in detail. In this paper, we use expropriation, forced divestment, and takeover interchangeably in return for forced divestment of foreign-owned property by the host government.
2.1 Trends: time, sector, and region

**Data:** The unit of analysis is an act.\(^{10}\) Our data set includes 703 acts occurred in 102 developing countries over the years 1922-2006. The data is primarily from Tomz and Wright (2008) \([49]\).\(^{11}\) Tomz and Wright (2008) \([49]\) construct a new data set on the occurrence of expropriation since the late 1920s. They consider a broad definition of expropriation following S. Kobrin, and gather data for the period 1929-1960. Then, they combine their newly collected data set with the existing inventories by Kobrin (1984) \([26]\) for the period 1960-1979, Minor (1994) \([38]\) for the period 1980-1991, and finally Hajzler (2007) \([18]\) for the period 1993-2004. Hajzler (2013) \([19]\) documents more recent expropriations covering the period 1989-2006. We combine Tomz and Wright (2008) \([49]\) data set with Hajzler (2013) \([19]\). Moreover, while examining expropriations in the oil industry, we put together the data provided by Kobrin (1984b) \([27]\) with the data provided by Guriev et al (2009) \([17]\), and use this combined data set for the investigation of the oil industry. Therefore, we present a set of facts for the occurrence of expropriation over an extensive period.\(^{12}\)

**Trends:** We find that over half of all the acts occurred from 1970 to 1976, very few expropriations took place in the 1980s and the 1990s, and expropriations were back in the 2000s, Figure 1. Second, extractive sector, in particular oil, is more vulnerable to forced divestment (Table 1). Third, forced divestment is more common in Africa and in Latin America (Table 2).\(^{13}\) Motivated by these facts, we will continue our analysis by focusing on the oil industry expropriations in Latin America and Africa in the 1970s.

The 1970s is a critical period in the oil industry. In particular, 1970-1976 is a period such that over 35 countries expropriated accounting for more than 70% of the 1970 world production.\(^{14}\) Although prior to 1970 almost all existing oil industries in developing coun-

\(^{10}\)An act is defined by Kobrin (1980) \([25]\), Kobrin (1984) \([26]\) as the involuntary divestment of any number of firms in an industry in a country in a given year.

\(^{11}\)We are grateful to Mark L. J. Wright for sharing their data.

\(^{12}\)The data set includes expropriations involving divestment of foreign direct investment. Kobrin (1984) \([26]\), Minor (1994) \([38]\), and Hajzler (2013) \([19]\) present analyses of expropriation trends in their studies. However, Tomz and Wright (2008) did not present such an analysis across 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. Hence, we examine the trends in expropriation acts historically over a long time period.

\(^{13}\)Appendix I.a presents figures, tables, and more discussion on the observed trends.

\(^{14}\)Kobrin (1984b) \([27]\), Williams (1975) \([50]\)
tries were operated by foreign firms, by 1976 virtually every major oil-exporting developing country expropriated its industry.\textsuperscript{15} Given the dominance of the industry in the developing host countries, forced divestment is attractive for increasing revenue, and the timing of expropriations confirms this opportunistic motive.\textsuperscript{16} Sovereignty over their own resources is another factor; and the foreign ownership is inconsistent with national control.\textsuperscript{17} However, government take-over can be very costly. It can result in significant losses in production and productivity, and contrary to the standard view, the consequence can be a wholly-owned sector by the state with much smaller output. In this context, we collect a unique data set to examine the impact of expropriations on productivity in the oil industry during the earliest possible period in which expropriations were most common.

2.2 The Impact of Oil Industry Expropriations on Productivity

\textbf{Data: } Crude oil production data is from British Petroleum Statistical Review of World Energy and OPEC historical data series. Employment data in petroleum refineries is from United Nations Industrial Development Organization (UNIDO) Statistics, and International Labour Organization (ILO) Report on Employment and Industrial Relations Issues in Oil Refining.\textsuperscript{18} We select the countries in our sample according to the following criteria: major oil producing countries that expropriated foreign-owned assets in the oil industry from late 1960s to 1970s.\textsuperscript{19}

We put expropriators into two categories: OPEC members, and non-OPEC members that produce more than 100,000 barrels per day. Sample countries include Algeria and

\textsuperscript{15}Prior to the 1970s, the exploration and development risks were requiring financial resources exceeding the capacity of host countries. Moreover, reserves were located in less-developed countries, but the major markets were in industrialized countries. The combination of large fixed costs and risk, the location of reserves, and geographical separation of consumption and production resulted in vertical integration. As developing countries’ income generated by oil grew, pressures of industrialization became more intense. This was 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 tilted the balance, and the host producers resolved the conflict through forced participation. For further discussion, see Kobrin (1984) [27].

\textsuperscript{16}Duncan (2006) [14], Guriev et al (2009) [17]

\textsuperscript{17}Kobrin (1984b) [27], Yergin (1991) [53]

\textsuperscript{18}We consider employment in petroleum refineries as a proxy for employment in the oil industry.

\textsuperscript{19}Sectoral employment data for oil-producing developing countries over the 1960s and the 1970s are not available for most of the cases. This prevented us from including several expropriations, such as Argentina or Nigeria, hence limited the size of our sample.
Venezuela as the OPEC members, and Colombia and Peru as the non-OPEC members.\textsuperscript{20} We include the U.S. as a benchmark for comparison.

**The Impact on Productivity:** Productivity is measured as oil production per worker (barrels per worker). For each country, using data described above, first we obtain labor productivity in the oil industry over the period 1962-1995. We plot corresponding figures in Appendix I.b.\textsuperscript{21} Second, labor productivity relative to the U.S. is obtained by dividing each country’s productivity by the productivity of the U.S. oil industry. Then, 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.\textsuperscript{22} Finally, for each case, we calculate five-year averages before and after expropriation excluding the value 100 at the time of expropriation. Table 3 presents pre- and post-expropriation relative labor productivity averages in the oil industry. We find that expropriation brings significant losses in productivity. The losses range from 30\% to 60\%. Figures show that productivity collapses before the policy is implemented, Figures 2-4.\textsuperscript{23} Formerly contracted oil employment expands after expropriation without accompanying recovery in production, hence, productivity keeps declining. \textsuperscript{24}

In the next subsection, we present more facts on the cases of Venezuela and Algeria to get insights with regard to the impact of expropriation.

\textsuperscript{20}In Peru, from late-1960s to mid-1970s, the government expropriated large number of enterprises. In 1975, foreign investment was called back, and in 1979 private companies could operate. Although foreign firms’ participation in new exploration was allowed, negotiations with the government was not easy. In 1985, after a dispute over taxes, re-nationalization took place. Data is available from 1979 until 1995 for the case of Peru, hence allowing us to examine the 1985 expropriation.

\textsuperscript{21}Figure 2, and left panels of Figure 3 and Figure 4. Red dotted lines indicate the year of expropriation.

\textsuperscript{22}Brogini (1973) [5], Kobrin (1984b) [27], Guriev et al (2009) [17]

\textsuperscript{23}Indeed, even for Algeria, this pattern is not irrelevant. Because, from 1967 until the mid-1970s, the country experiences a series of government take overs. This was in fact the case for many oil-producing developing countries during that period. Implementation of a series of government take overs or expropriation-like policies were common. So, the observed trend in productivity can be related to a series of expropriation-like or expropriation-triggering policies implemented beforehand in these countries leading to a drop in productivity prior to indicated expropriation date.

\textsuperscript{24}In the U.S. oil industry, on the other hand, the number of workers was stable in the 1970s that fell significantly in the 1980s resulting in a boost in productivity. From 1970 to 1975, productivity declined slightly, about 5\%, while from 1976 to 1985, it increased by around 30\%.
2.3 Exploring the Impact

*Algeria:* Algeria’s oil production began in 1958. It gained political independence in 1962. Sonatrach is the largest Algerian and African company and the 11th largest oil consortium in the world, which was founded on December 31, 1963. At the time, however, the Algerian state held only 4.5% of the exploration perimeters, while French interests were as high as 67.5%. After the Arab-Israeli War in June 1967, Algeria decided to nationalize the refining and distribution activities of Mobil and Esso, and Sonatrach signed an agreement with Getty Oil on October 19, 1968 receiving 51% of Getty Oil’s interests. So, we consider the year 1967 as the (benchmark) year of nationalization in Algeria in the oil industry. A series of government take-overs in the Algerian oil industry then followed until the mid-1970s.\(^{25}\) Left panel of Figure 3 presents production and labor productivity in the Algerian oil industry before and after nationalization, both are normalized to 100 in 1970. A contraction in the oil industry manpower starts prior to nationalization, which is reversed dramatically by nationalization, right panel of Figure 3. As output outpaced number of workers, productivity increased prior to nationalization. From 1962 to 1967, production doubled. After nationalization, however, production growth slowed down; and it could not get back to its continuous growth path until the 1980s. Hence, as number of workers outpaced production, measured labor productivity declined sharply in the post-nationalization period.

The changes in oil employment trends are remarkable during that period, which is documented by Brogini (1973) [5]. Prior to 1967, oil industry employment is mostly private. It begins to fall in 1966, while public sector employment starts increasing significantly. The share of public employees is 17% in total in 1965, which increases to about 70% in 1971. Another important trend we observe in Algerian oil industry is the change in the composition of the oil work force by nationality and by occupation, right panel of Figure 3 and Table 4. In 1962, 52.8% of manpower in the industry is foreign, which decreases to 21.2% in 1968, and by 1971 only about 5% of the total number of workers is foreign. In addition, foreigners in Algeria hold mostly managerial, professional, and technical positions. In 1962, 6.5% of total

\(^{25}\)1970, 1971, 1974, 1976 oil nationalizations, Guriev et al (2009) [17]. The country became a member of OPEC in 1969. However, as it experienced onward oil expropriations during the 1970s, we considered the country as an OPEC member, and 1967 as the benchmark year of expropriations.
workforce are managers and engineers, 98% of whom is foreign. Likewise, 33.8% of total manpower is technical mastery employees, of whom 87.5% is foreign. On the other hand, in 1971, 8.2% of total workforce are managers and engineers, 28.2% of whom is foreign; and about 60% of total manpower is technical mastery employees, only 4.4% of whom is foreign. This implies that nationalization in Algeria eliminates foreign workers from the industry who are mostly at managerial and technical positions, and brings a striking expansion in domestic manpower. Expansion in the domestic work force takes place mostly in skilled workers. In other words, high-profile foreign manpower is replaced by skilled domestic workers that are expanded by more than threefold. However, this remarkable expansion results in only a slight increase in production, but, a sharp drop in productivity.

Algeria experienced nationalist motives toward industrialization during the mid and late 1960s following political independence. Kobrin (1980) [25] discusses examples of wholesale taking of foreign-owned property following political-economic change over 1960-1976 including Algeria. He argues that in these cases take-overs result from a change in political-economic ideology and recent independence. 1967 crisis during Arab-Israeli war might have also played a role by bringing measures against American workers. Hence, elimination of foreign workers from the industry is likely to be closely related to these nationalist motives overall in the country.

**Venezuela:** The country nationalized its oil in 1975. The Reversion Law in 1971 mandated gradual transfer of all unexploited concession areas to government ownership, and the nationalization process was finalized by the end of 1975. Figure 4 left panel shows both production and labor productivity patterns during this period where we normalize the value in the year 1970 to 100. Prior to 1970, increasing production is accompanied by a contraction in the oil industry employment, hence productivity increases. However, by the beginning of the nationalization process, a striking decline in both production and productivity occurs. After nationalization, as declining production persists despite fast expanding employment falling productivity persists.

Figure 4 right panel presents domestic and foreign workers in the oil industry over 1948-
Similar to the case of Algeria, the number of workers starts declining prior to nationalization, foreign workers are eliminated, and replaced by domestic workers after nationalization. In Venezuela, elimination is more striking. In 1948, around 11% of the total manpower is foreign, 78% of whom are white-collar (WC) constituting 29% of total white-collar workers. The number of foreigners starts declining in 1957. At that time, 12% of the total work force is foreign, 83% of whom is white-collar making up 25% of total white-collar workers. By the time of nationalization, foreigners’ percentage in total decreases to 2.2%, of 95% is white-collar comprising only 4% of the total white-collar workers. After nationalization, until 1995, foreign employment in total employment never exceeded 0.85%. Venezuelan work force, on the other hand, expanded remarkably after nationalization. The substantial contraction during 1957-1975 is replaced by a fast expansion, which mostly takes place in white-collar workers. In 1948, domestic white-collar workers comprises only 20.3% of the total employment in the oil industry. Although there is a decline in the number of workers during 1957-1975, the percentage of Venezuelan WC workers in total work force increases from 30.9% to 51.8% due to the fact that contraction in blue-collar (BC) workers is stronger. After nationalization, expansion in BC workers is weaker, WC domestic workers become dominant in the industry and comprise up to 71% of the oil industry manpower. Even though the most important technical and managerial positions are held by foreigners prior to nationalization, who are paid much higher than domestic counterparts, in the post-nationalization period, these positions are assigned to Venezuelans.

Is this a common trend?: The elimination of foreign workers in Algeria and Venezuela is important not only because it is associated with nationalization but also it can account for the impact of nationalization on productivity. For instance, Saudi Arabian government starts increasing its interest in Aramco in the early 1970s and takes full control of Aramco by

26Source is Republic of Venezuela, Ministry of Mines and Hydrocarbons, Oil and Other Statistical Databooks.

27For the case of Algeria, independence (related political developments) is the main cause of expropriation, which is likely to create dislike against foreigners leading to elimination of foreigners from key roles. However, for Venezuela this is not the case, which we discuss in the following section. Although our theme is not the causes of expropriation, corresponding motives and taken actions can help us understand the mechanisms that drive the consequences.

28We will discuss why contraction starts back in the late 1950s, along with more data on the foreign workers in the Venezuelan oil industry in the following section.
However, Aramco partners continue to manage and operate Saudi Arabia’s oil fields with a foreign manpower constituting almost 50% of its workforce. But, during 1970-1980 we do not observe a decline in output, on the contrary, oil production increased remarkably in Saudi Arabia. Conversely, in Venezuela, where nationalization eliminates foreign workers to a larger extent, production declines by more than 40%. This implies that eliminating foreign expertise can have a role in explaining the impact of nationalization.

To sum up, we show that over half of all world expropriations occurred during the 1970s, they are more common in Africa and in Latin America, and oil is more vulnerable to forced divestment. Motivated by these facts, we focus on the oil industry expropriations in Latin America and Africa in the 1970s, and examine the impact of expropriation. We find that it brings significant losses in productivity. Our next question is why expropriation is associated with lower productivity. We present some evidence implying that eliminated foreign expertise can have a role. In order to investigate what can account for the impact of expropriation thoroughly, in the next section, we continue with narrowing our data analysis to one case. Our experiment will be the Venezuelan oil industry nationalization in 1975, for which we manually collect industry and micro data over a long time period.

3 The Venezuelan Oil Industry

Venezuela is one of the largest oil producer and exporter in the world, which experienced the first full-nationalization of its oil during 1971-1975. In this section, we will present the key patterns in the Venezuelan oil industry using a unique data set.

Data: Our data set dates from the early 1940s to 1995. Oil industry statistics are from the Republic of Venezuela, Ministry of Mines and Hydrocarbons, Oil and Other Statistical Databooks (MMH Databooks). From these databooks, we recorded annual industry-level time series data on various variables such as proved reserves, new reserves, completed wells, proved reserves, new reserves, completed wells,

29Luciani (1984) [30] argues that the former Aramco ownership distribution of equity capital is Exxon, Texaco, Chevron 30% each, and Mobil 10%.
31We do not have time series data on employment in the oil industry in Saudi Arabia. Because of that, we present production figures for the two OPEC members. They both experience nationalization during similar periods; one eliminated foreigners to a greater extent, and the other did not.
number of workers, wages and salaries, gross investment in fixed assets, royalties, income taxes, etc. We obtain GDP price deflator and exchange rate data from the Penn World Tables, which we use to convert nominal domestic values into constant U.S. dollars. For the Venezuelan aggregate economy, we use the Conference Board, Total Economy Database, and the Economic Commission for Latin America Database. We collected micro data on the composition of the workforce in the oil industry from Michelenia and Soublette (1976) [36], and Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census Database, 1987. Moreover, while investigating whether the main trends we observe are common to the industry at that time or not, we present evidence on the world oil industry trends from several publications, such as International Labor Organization, Programme of Industrial Activities, Chase Manhattan Bank, Energy Economics Division publications.

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, and since then fiscal revenues from oil have been the largest component of the government’s budget.

Production and Productivity: Figure 5 presents historical crude oil production and production per worker, in barrels and in barrels per worker, respectively. Both are normalized to 100 in 1970. Historical oil production figure, in the left panel, indicates two nationalization periods and a privatization period. This figure presents a striking decline in production during and following the two nationalization episodes as well as the positive impact of privatization in the 1990s.

Venezuelan oil industry productivity records over 1939 - 1995 are given in the right panel. On this figure, we also present the critical events via vertical colored lines, which will be discussed later in this section. Productivity captures the production path quite well. Until 1970, there is an upward trend in both production and productivity. However, this trend

is reversed in 1970 with a sharp decline by the beginning of the nationalization process. In 1985, ten years after nationalization, production is 45% of what it is in 1970, and it is 40% lower than its 1957 level. Similarly, and more strikingly, in 1985 productivity is only 28% of its level in 1970. It is important to note that the striking production decline in the Venezuelan oil industry is not due to an OPEC production cut. OPEC production quotas were agreed upon by each member during OPEC meetings, and the estimates have been reported only since 1982. In order to gain insight, however, we can compare production of OPEC with that of Venezuela during this period. Contrary to the Venezuelan case, not only OPEC production but also World production rose during the 1970s. For instance, Saudi Arabia increased its production more than 2.5 times, Table 5. In Mexico, one of the largest oil producer in Latin America that is not a member of OPEC, oil production more than quadrupled in the 1970s. In other words, Venezuela deviates from other big oil producers significantly with respect to production in the 1970s. In regard to pre-1970 period, Venezuelan oil output grew, but slower than the World or other big producers. During the 1960s, the World oil production more than doubled, and OPEC production almost tripled, while Venezuelan oil production increased by only 30%.

Employment: In Figure 7, we plot the total number of workers in the oil industry. Employment is stable during most of the 1950s. The contraction in the number of workers began in 1957, and continued until nationalization was finalized. The number of domestic workers and foreign workers decreased by about 43.7% and 90.9%, respectively, between the years 1957 and 1975. The contraction in foreign employment during this period is remarkable, which has been discussed in detail in the previous section. Figure 8 presents

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33In order to examine whether the loss in productivity is due to a total factor productivity (TFP) loss or due to a capital accumulation collapse, we perform a standard development accounting exercise. We decompose labor productivity into two components: TFP and physical capital per worker. By comparing pre- and post-nationalization averages for 10-years, we find that TFP can account more than 2/3 of the decline in labor productivity. Even though this simple framework doesn’t take into account all the factors that may contribute to oil production, it is useful in showing that declining labor productivity was mostly due to factors other than capital per worker. Note that we perform the same exercise by using reserves as the form of capital, which also gives us similar results.

34Production per operating well, which can be considered as a measure of productivity in the oil industry, also follows a similar pattern. Both production and productivity starts increasing in 1985. Cuddington and Moss (2001) [11] show that technology diffusions in exploration and development over 1966-1990 are concentrated in two periods: 1971-1972 and 1983-1984. Major advances, such as the applications of microcomputers, take place in the early 1980s. Hence, advances in computerization in the early 1980s can partly be responsible for the observed increasing productivity in post-1985 period.

35Venezuela is one of the founding members of OPEC in 1960.
this compositional change in a graph. In this figure, we decompose employment according to nationality and type of worker: blue-collar (laborer) and white-collar (employee). By the time the industry was nationalized, total employment had already dropped by half, and foreign workers’ percentage in total had decreased to 2.2%. In the post-nationalization period, foreign workers’ share in total employment fell below 1% and remained.

Venezuelan workers, on the other hand, expanded significantly after nationalization. During 1975-1979, the work force increased by about 10% each year. Contraction during the period 1957-1975 is replaced by a fast expansion, which mostly took place in white-collar workers, as discussed previously. Even though the number of domestic workers decreased during 1957-1975, the percentage of Venezuelan WC workers in total employment increased, because contraction in blue-collar workers was much stronger. In the post-nationalization period, expansion in BC workers is weaker, and WC domestic workers dominate the industry. In other words, composition of the work force changes after nationalization, which is likely to be a motive for replacing the high-profile of foreign workers. Ellner (1993) [16] points out that nationalization is committed to bring comprehensive worker gains in the Venezuelan oil industry from high revenue generated by OPEC price hikes; however, gaining the support of the workers for the policy can be another objective. We call this expansion taking place after the government take-over political favoritism.

As we did for production, we also investigate whether the observed trend in employment was common to the industry at that time or not. We find that Venezuela also deviates from the rest of the world with respect to employment, Figure 9. During the 1960s, the World oil employment was almost stable mostly due to stable oil prices, on the contrary, Venezuelan oil industry employment was significantly reduced. In the early 1970s, a noticeable expansion began across the World driven by increasing prices, while the Venezuelan employment didn’t start expanding until the end of 1975. After nationalization, expansion in employment didn’t slow down even in the early 1980s because of declining prices.

We also compare Venezuela with Mexico in Figure 6. As we can see, productivity captures production path quite well in both countries. However, they move in opposite directions. In

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36 The participation of oil employment in economy-wide employment increased by about 32.4% during 1975-1984.
37 Even though that increase was attributed largely to the new exploratory activity, Coronel (1983) [10] and Ellner (1993) [16] argue that the increase was also a sign of the failure of the state to maintain existing efficiency.
Mexico, employment almost doubled with production more than quadrupled resulting in a significant increase in productivity. On the other hand, in Venezuela, expanding manpower could not reverse declining production, and hence productivity falls even more. Randall (1989) [43] discusses the labor conditions in the oil industry in Mexico and in Venezuela, and argues that labor and work conditions are similar in both countries. In this context, assuming similar sectoral characteristics would not be unrealistic, which implies that the Venezuelan deviation is likely to be related to nationalization policy.

**Exploration and Capital Expenditures:** In Figure 10, we plot the total number of wells completed, and consider it as a proxy for exploration activity. In Venezuela, the number of wells drilled dropped sharply in 1957, and stayed low until 1975. Then we observe a drop in drilling activity starting from the early 1980s in Venezuela.

A series of detailed studies of the financial performance of a large number of petroleum companies is conducted by the Energy Division of the Chase Manhattan Bank over 1968-1982. In these studies, the combined operations of these companies are claimed to make up a major proportion of the worldwide activities of the petroleum industry. Therefore, the financial performance presented is indicating the experience of the overall industry. We present these total capital expenditure records of the World petroleum industry in Figure 11, left panel. During the late 1950s and the 1960s oil prices are stable, and hence capital expenditures are stable in the World petroleum industry. There is only one outlier in the sample, Venezuela. From 1958 to 1961, while capital expenses were stable in the rest of the World, they declined by more than 70% in Venezuela, which then remained stable until the year 1975. Capital expenditures started increasing across the World in the early 1970s, particularly in the Middle East. In Venezuela, however, the increase in capital investments accelerated with a lag, after nationalization. But, from 1975 to 1982, capital investments rose more than the rest of the World, they increased by more than ten-folds.\(^\text{38}\) That is, Venezuela joined the capital investment expansion the last, but it expanded the most in a seven years period. Another important aspect of capital investment pattern in Venezuela is

\(^\text{38}\)From 1975 to 1982, capital investments rose by almost three-folds in the U.S. and Canada, by almost four-folds in Africa, and rose by more than five-folds in the Middle East. Hence, the expansion in Venezuelan oil industry represents the highest expansion in the sample during 1975-1982.
the striking increase in exploration expenses relative to the rest of the World. Exploration expenses increased more than sixteen-folds from 1975 to 1982 in Venezuela, Figure 11, right panel, while in the U.S. and Canada around a three folds increase took place.\footnote{Chase Manhattan Bank, Energy Division \cite{8}. Over 1958-1982, exploration expenditures’ share in total capital expenditures is in between 2\% and 23\% across the world.}

A simple explanation for exploration activity and investments trends is that incentives to invest are high when earnings are expected to be high. Increase in prices in the early 1970s until the early 1980s is likely to be responsible for the capital expansion across the World. What we find prominent is the deviation of Venezuela from the rest of the World during several nationalization related episodes.

In the next subsection, we relate our main observations to the events that took place in the Venezuelan oil industry, and present our hypotheses. Then, in the next section, we present our model and quantitative analysis.

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

The beginning of the oil industry goes back to the 1910s in Venezuela. The oil industry was under the control of foreigners until the late 1930s, government control was minimal, and exports were dominated by oil. In 1943, through the new hydrocarbons law, greater participation of the government was introduced, which was a milestone in the Venezuelan oil industry. Before the law the main revenue tool was royalty tax, which was implemented at a low rate. By the law, income tax was introduced in exchange for additional years of exploitation and the promise of granting extensive new areas, Martinez (1989) \cite{33}. The principle of a 50-50 split in profits between the government and the multinational companies (MNCs) was also adopted, Mikesell (1984) \cite{37}. Manzano and Monaldi (2010) \cite{32} point out that by accepting the tax changes companies obtain a long-term planning horizon under a transparent tax regime. That is, the Law provides a mutual beneficial agreement. After the Law, taxes remained relatively stable. Hence, stable distributive rules with a long investment horizon led to expansion in the industry during 1943 - 1958.

In 1957/58, the dictatorship ended, and the democratic period began with the adoption
of a new constitution in 1961. A new regime requiring more spending with declining oil prices is likely to increase the government’s incentives to increase its take from the industry. The government increased its share from 50% to 65% unilaterally through increasing the income taxes significantly in 1958 via a decree, which argued to infuriate the foreign oil companies.\textsuperscript{40} Moreover, in 1958, “no more concession” policy is announced.\textsuperscript{41} Therefore, 1957/58 is the starting point of a major conflict between the government and the MNCs. As we indicate in our figures, 1957/58 coincides with the beginning of the contraction in the industry.\textsuperscript{42} Coronel (1983) [10] argues that the conditions of the policy, whose primary objective was to increase national control over the industry and increase government revenues, are severe, making profits almost impossible for the companies. His argument is in line with the activities of the Shell Oil Company, the second largest producer in Venezuela. Howarth and Jonker (2007) [23] emphasize that in the 1960s the Shell Group considered the conditions in Venezuela becoming insufficiently attractive for further exploration activities, and the Group started shifting their operations elsewhere. During 1958-1973, there was little exploration, and a consequent stagnation in reserves followed due to companies refraining from exploring and investing, because they couldn’t have eventual access to them, Coronel (1983) [10].

In the meantime, while additions to reserves were declining, production kept increasing. Figure 12 shows the ratio of production to reserve additions over time.\textsuperscript{43} Starting from 1958, annual additions to oil reserves were consistently declining. From early 1960s to late 1970s, annual reserve additions were lower than annual oil production. In other words, there was over-extraction. However, after nationalization, by means of remarkable efforts put by the state-owned industry in exploration and expansion, reserves increased. But, since production couldn’t be increased, there was under-extraction after the late 1970s.

In 1971, the Reversion Law was passed, which stated that all assets, plants, and equipment would be reverted to the nation. We assume that the nationalization process officially starts with this law. Note that, the law coincides with a sharp decline in productivity, see

\begin{footnotesize}
\begin{enumerate}
\item Manzano and Monaldi (2010) [32].
\item It means that the last oil concessions are granted.
\item Figure 7, Figure 8, Figure 10, and Figure 11.
\item In the figure, for smoothing purposes, we plot 5-year moving averages. The construction of our reserve additions series is presented in the Appendix II.b.
\end{enumerate}
\end{footnotesize}
The law also substantially changes the nature of monitoring in the industry. The Ministry of Mines and Hydrocarbons gains control, and the industry is co-managed with the MNCs, Coronel (1983) [10]. So, 1972-1975 is a transition period via co-management of the industry. New managerial power is likely to contribute inefficiency, because the ministry may not have enough experience regarding related organizational and managerial issues in the industry. Finally, all concessions were cancelled in 1975. That is, the oil industry is fully nationalized.\textsuperscript{44}

In 1957/58, the government’s participation starts to increase in a way that seems to make the Venezuelan oil industry unattractive. It has been argued that during the 1960s, the intention was not nationalization but making the arrangements in a way that allows the state to have more control. However, things appear to be precipitated by the “no more concession” policy, and higher and higher taxes. These events are likely to generate expectations that the government would eventually take control over the industry. This would motivate short-run incentives: lower investment and employment, explore little or none; hence, boost productivity in the short-run, but reduce productivity in the long-run. In fact, Figure 5 shows how fast production and productivity were rising just before 1970, and how much they collapsed right after.\textsuperscript{45} Increasing extraction prior to 1970 is also likely to tip the government to nationalize. Because, the government may have viewed it as their resources being looted by foreigners. Hence, fear of nationalization leading to no exploration and more extraction eventually can make nationalization inevitable. So, there is a possibility of a self-fulfilling nationalization. We argue that policies adopted during 1957-58 along with the unilateral tax increases are likely to generate expectations about

\textsuperscript{44}Petroleos de Venezuela, S.A. (PDVSA) was established to plan, coordinate, and control the activities of all the subsidiaries. In order to continue operations, technical and technological agreements were planned to be made with the MNCs. In addition, maintaining administrative structure of the companies after nationalization is another important goal.

\textsuperscript{45}This pattern reflects incentives, which can be explained simply as follows. Let’s suppose that there is 100 barrels of oil in the ground. Suppose that the oil company 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 would involve extracting the same amount each year. To be concrete, let’s say this rate is 10 barrels per year. So, under these conditions, the oil would be fully extracted in 10 years. Now, suppose that the oil company learns that its right to drill for oil will expire in 2 years because of nationalization. Then, it would face a different optimization problem. It must choose its extraction rate under the new assumption that the marginal cost of extraction in year 3 on is infinity. This should induce a shift in extraction toward periods in which the marginal cost is low and hence induce the company to increase extraction to a rate higher than 10 barrels per year in years 1 and 2. If so, the fear of nationalization would cause extraction to go up. What happens after nationalization? If the oil industry continues to act to minimize costs, it will choose an extraction rate that equalizes marginal cost in each period, which we have assumed is 10 barrels per year. So, extraction will go down from something more than 10 barrels per year to 10 barrels per year after nationalization.
nationalization, and following incidents such as continuing income tax increases are likely to lead to the implementation of an anticipated nationalization. So, we claim that news about the future is a candidate for explaining the observed productivity pattern.\(^\text{46}\)

Prior to the nationalization, exploratory activity and investment are low. Therefore, after nationalization, the industry’s goal is to expand: number of workers, capital expenditures, exploration increase significantly. However, in spite of all the efforts the nationalized industry put, production and productivity do not recover.\(^\text{47}\) We claim that this might be due to another challenge brought by anticipated nationalization: losing foreign workers. The number of foreign workers declines remarkably starting from 1957, Figure 8, and after nationalization their percentage in total workforce stays below 1%. This may imply a substantial loss in know-how if the available knowledge in the industry is dominated by the international firms.\(^\text{48}\)

We present evidence on the significant role of the foreign workers in the oil industry in Venezuela and in Algeria in the previous section, as well as we show how the composition of the workforce in the oil industry changed by nationalization. In addition to that, in Figure 13, we present the education level of foreign personnel employed in the Venezuelan oil industry. More than 70% of foreign manpower are university graduates or higher. Given the fact that in the same year the average year of total schooling is 2.65 for the same age group in Venezuela\(^\text{49}\), we can conclude that foreigners were comprising key highly skilled

\(^{46}\)Nationalization of the Venezuelan oil industry is argued to be established after intense negotiations with the foreign companies. The control of the industry was already in the hands of the state since 1971/72. So, negotiations focus 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) [10]. According to Martinez (1989) [33], compensation payments to former concessionaires and equity holders in 31st December 1975 was in total $1,342.28 million.

\(^{47}\)A transition from a period of stagnation to a period with significant expansion plans has also potential to create problems. It can bring production challenges as well as technological and political ones. The inflow of workers to manpower at a fast rate can cause problems in terms of both organization of activities and transfer of knowledge. This is likely to affect productivity negatively, in particular if the workers are inexperienced and need training. Moreover, the workers might not adapt themselves to the changing composition of the workforce. In addition, it has been argued that most of the foreign companies in Venezuela were not giving local managers considerable authority in the past, which can contribute to managerial problems in the nationalized industry, and hence efficiency loss. After nationalization, although total hours worked and total number of workers in the industry increased, annual hours per worker declined, which is accompanied by an increasing trend in real wages. It could be the case that firms were run differently after nationalization in order to increase employment. If a progressive tax structure is not available and the country’s main concern is to obtain national control over an important commodity, the government may prefer to take over, and distribute the revenues or profits as wages by hiring its own people. However, when the workers know that the government is overstaffing and there is a low probability of laying off workers, they are more likely to exert less effort.

\(^{48}\)In this context, overstaffing can indicate a substitution motive with less qualified local workers.

\(^{49}\)Barro and Lee (2010) [28].
workers in the industry and eliminating them is likely to bring know-how losses. If foreign skills are complementary with other factors of production, then nationalization would be costly. Lack of a critical factor in extraction can cause a continuing decline in production despite fast expanded domestic workers and increasing reserves.\textsuperscript{50}

However, it is also possible that the oil companies may have exploited the easy-to-extract reserves, and left the Venezuelans with the hard-to-extract fields. To explore, we investigate drilling activity in more detail. We group wells into three main categories according to LA-HEE well classification: (i) new field wildcat: drilling for a new field never productive before, (ii) exploratory wells: drilling for a new pool in already productive area, (iii) development and extension wells: drilling to exploit or develop a hydrocarbon accumulation discovered by previous drilling. So, development/extension wells are mainly designed to increase production from already discovered areas. In Figure 14, we present number of wells drilled by type. As can be seen, development wells constitute the highest portion of the drilled wells overall, particularly after nationalization. Drilling in an existent field or in a new pool in an already productive area is common and success rates are high, Figure 15. However, production did not increase, which imply that extraction became a challenge from existent productive fields for the nationalized industry. It is possible that prior to nationalization wells had been shut down. When they were restarted after nationalization, they were not as productive. In order to see whether the industry was successful in discovering new productive fields, we plot the number of new wildcats, Figure 16, which is consistently low until the late 1970s. Their number starts increasing in the late 1970s, but success rates are low. These imply that extracting oil from already productive areas and discovering new productive fields became more difficult, which can be due to loss of foreign know-how.

In the following section, we develop a model motivated by the observed trends in order to test to what extent anticipated nationalization can explain the impact on productivity.

\textsuperscript{50}So, we will focus on the hypothesis that the lack of foreign know-how can interfere with production due to the fact that the foreign workers who left were critical and their loss is likely to affect production badly. Perhaps, because it represents a loss in organizational capital.
4 Analytical Framework

The analytical framework we present adopts the general framework developed by Pindyck (1978) [42], and applied by Yucel (1986) [54] and Deacon (1993) [12].\footnote{Pindyck (1978) [42]'s model introduces exploration, and examines the impact of exploration on extraction costs and prices. Generally speaking, most of earlier models of nonrenewable resources aim to investigate the reserve and price dynamics under different assumptions.} The model is a dynamic partial equilibrium framework for nonrenewable resources. It describes exploration, extraction, and also taxation of resources, and our goal is to explain as much as possible with a simple model.

I assume competitive producers of a nonrenewable resource. 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. Average cost of production increases as reserves decline. Cost of exploration increases with exploration, and the marginal exploration cost increases as exploratory effort increases. To simplify, the model abstracts from uncertainty.

We will consider two common forms of taxation in natural resources: severance (royalty) taxes, i.e. taxes on production (extraction), and income taxes. These are common revenue sources for resource producing countries. Royalty taxes are levied on total sales, and income taxes are levied on total profits. In real world, taxes are not usually contingent on prices, production, or reserves. Therefore, here we also assume that the tax rates are not contingent on them. Taxes will play an important role in our analysis, because one component of introducing nationalization will be through income tax changes.

First, we will present technologies, then introduce the model.

4.1 Technologies

We regard extraction as a process combining reserves as a form of capital with different extractive efforts in order to produce the resource, oil in our case. In some earlier papers, re-
serves are also assumed to serve as a capital input.\textsuperscript{52} Despite this similarity, our technologies differ from them in several respects. In our model, the efforts participating in extraction and exploration are represented by different labor inputs that are measured in efficiency units. In extraction, reserve input is combined with labor inputs, and in exploration labor inputs that are imperfect complements generate additions to reserves. We construct the related labor inputs series by using novel oil industry employment data, which will be discussed later.\textsuperscript{53}

4.1.1 Extraction Technology

The production function we develop is different from the standard production function used in resource analysis. The alternative model is motivated by the key facts of the Venezuelan oil industry. We consider a production function with three inputs. This technology distinguishes between low skilled and high skilled labor, and takes reserves as the form of capital.\textsuperscript{54}

We take into account four categories of labor input: extractive low skilled & high skilled, and exploratory low skilled & high skilled.\textsuperscript{55} We assume that the skill level is exogenous, that is, individual’s skill level is not determined within the model.

Let’s denote the production (extraction) function with $O(\cdot)$. Reserves must enter into this technology in a certain way.\textsuperscript{56} In this context, the main characteristics of the production technology are as follows:

1. $O(\cdot)$ is a function of reserves, $R_t$, high skilled labor in extraction, $H_t$, and low skilled labor in extraction, $L_t$
2. $R_t = 0 \implies O(\cdot) = 0$
3. $\lim_{R \to 0} \frac{\partial O}{\partial R} = \infty$

2 implies that $R$ is an essential input. 3 shows how for low levels of $R$ marginal product of the input behaves. This enables us to eliminate corner solution for $R$, so that exhausting the resource in finite time is not allowed.

\textsuperscript{52}Among others, Devarajan and Fisher (1982) [13], Yucel (1986) [54], Deacon (1993) [12].
\textsuperscript{53}Data and construction are presented in detail in the Appendix.
\textsuperscript{54}Low skilled labor represent domestic workers and high skilled labor represent foreign workers.
\textsuperscript{55}Therefore, we consider not only a skill-level criterion but also an operational criterion.
\textsuperscript{56}Dasgupta and Heal (1974).
We will consider the class of production functions for which the elasticity of substitution is constant. Given this, 1 - 3 suggest that

\[ O(R_t, H_t, L_t) = \Gamma(H_t, L_t)R_t^\nu \]

where \(0 < \nu < 1\), and \(\Gamma(H_t, L_t)\) is \{homogenous of degree\} \(\leq (1 - \nu)\). We assume that \(O(R_t, H_t, L_t)\) is a non-increasing returns to scale Cobb-Douglas production function. We choose to represent \(\Gamma(H_t, L_t)\) by a CES functional form, so that low skilled and high skilled labor inputs interact in a particular way. That is, a production technology with a general nested CES functional form is considered, which allows for different substitutability across factors. It is formulated as follows:

\[ O(R_t, H_t, L_t) = R_t^\nu \left[ \mu(h_L L_t)^\sigma + (1 - \mu)(h_H H_t)^\sigma \right]^{\frac{1}{\sigma}} \]

where \(0 < \mu, \nu, \gamma < 1; \sigma \leq 1\); and \(\nu + \gamma \leq 1\). 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. \(h_L, h_H > 0\) 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 \([\mu(h_L L_t)^\sigma + (1 - \mu)(h_H H_t)^\sigma]^{\frac{1}{\sigma}}\). The second term is a CES aggregate over low skilled labor with share parameter \(\mu\), and high skilled labor with share parameter \(1 - \mu\). The parameters \(\nu\) and \(\gamma\) measure the shares of reserves and composite labor in income, respectively. The parameter \(\sigma\) governs the degree of substitutability between high skilled labor and low skilled labor.\(^{57}\)

Next, we will describe the exploration technology.

### 4.1.2 Exploration Technology

Output of exploratory activity is represented by the technology \(G(E_{lt}, E_{ht})\), where \(E_{lt}, E_{ht}\) are the low skilled and high skilled exploratory efforts, i.e. labor inputs participating in

\(^{57}\)\(\sigma\) being zero means Cobb-Douglas for the nested aggregate. The elasticity of substitution between low skilled labor and high skilled labor is \(\frac{1}{1-\sigma}\). Note that this definition holds only if all other input quantities are constant, Blackborby and Russell (1989) [4].
exploration, respectively. \( G(\cdot) \) is strictly increasing and strictly concave. Concavity implies that the marginal discoveries made by additional exploration diminish as exploration proceeds. So, \( G_k > 0 \), and \( G_{kk} < 0 \) for decreasing returns, where \( k = l, h \).

We choose the following Cobb-Douglas technology for exploration\(^{58}\)

\[
G(E_{lt}, E_{ht}) = (h_l E_{lt})^{\theta_1} (h_h E_{ht})^{\theta_2}
\]

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

### 4.2 Reserve Dynamics, and the Firm’s Problem

Reserves dynamics are governed by the following state equation:

\[
R_{t+1} = R_t - O(R_t, H_t, L_t) + G(E_{lt}, E_{ht}).
\]

The equation implies that 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, we will first consider the untaxed model. At each date \( t \), the producer seeks to solve

\[
v(S_t) = \max_{L_t, H_t, E_{lt}, E_{ht}, R_{t+1}} \{\Pi(\cdot) + \beta \mathbb{E}[v(S_{t+1})]\}
\]

subject to the constraints

\[
\Pi(\cdot) = P_t O(R_t, H_t, L_t) - (w_{lt} L_t + w_{ht} H_t) - (w_{lt} E_{lt} + w_{ht} E_{ht})
\]

\(^{58}\)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) [42] in section IV.
\[ R_{t+1} = R_t - O(R_t, H_t, L_t) + G(E_t, E_h) \]  

\[ O(R_t, H_t, L_t) = R_t^{\nu} \left[ \mu(h_L L_t)^\sigma + (1 - \mu)(h_H H_t)^\sigma \right]^{\frac{\bar{\sigma}}{\sigma}} \]

\[ G(E_t, E_h) = (h_t E_t)^{\theta_1} (h_h E_h)^{\theta_2} \]

where \( S_t := \{R_t, P_t, w_{it}\}, i = l, h, L, H \). Here, \( P \) is the real price of the commodity, and \( w_i \)'s are the real unit costs of different types of labor inputs. 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, hence exploration. As reserves decline both average cost of extraction and marginal extraction cost will increase. Hence, 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.

We denote marginal products by \( O_m \) and \( G_n \). Then, optimality conditions describing the solution of the model at time \( t \) are:

1. with respect to extractive efforts, \( m = H, L \)
   
   \[ P_t = \frac{w_{mt}}{O_{mt}} + \eta_t \]  

2. with respect to exploratory efforts, \( n = h, l \)
   
   \[ \eta_t = \frac{w_{nt}}{G_{nt}} \]  

3. intertemporal optimization condition

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

where \( \eta_t \) is the shadow value of an additional unit of reserves.

The first order condition for extractive efforts, equation (2), 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, $\eta_{t}$, is the change in the expected present value of future profits resulting from an additional unit of reserves, and it is always positive. If production costs rise fast as reserves decline, rent can fall, which implies that opportunity cost of extraction is decreasing due to declining resource use simply because costs rise. So, the resource will become less scarce.

Equation (3), the optimality condition for exploratory efforts, imply 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, 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), the dynamic intertemporal optimization equation, 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 that the additional unit of reserves generates next period plus the depreciated scarcity value in the next period.\(^60\)

In an untaxed environment, equations (1) through (4) govern the evolution of the variables $R_t, H_t, L_t, E_{l_t}, E_{h_t}, \eta_t$ taking exogenous variables $\{P_t, w_{L_t}, w_{H_t}, w_{l_t}, w_{h_t}\}$ as given.

We will introduce the two tax instruments mentioned earlier into the untaxed model, which will be baseline model and used in the quantitative analysis. The baseline model objective function is as follows:

$$\Pi(\cdot) = (1 - \tau_{\pi})[(1 - \tau_{r})P_tO(R_t, H_t, L_t) - w_{L_t}L_t - w_{H_t}H_t] - (1 - \tau_{\pi}c)(w_{l_t}E_{l_t} + w_{h_t}E_{h_t})$$

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

\(^59\)Also known as the resource rent at time $t$, $\eta_t$ summarizes what is sacrificed to obtain a unit of the resource. In other words, it represents the opportunity cost of extracting the resource.

\(^60\)Note that a unit of reserves has value. It can be extracted or left in the ground to the next period with a scarcity value $\eta_{t}$. The $(1 - O_{t+1})$ term on the right hand side of the equation (4) is like $(1 - \delta)$ in the euler equation of the neoclassical growth model, in other words $O_{H_{t+1}}$ here behaves like an endogenous depreciation rate. Once extracted at $t + 1$, tomorrow’s shadow value will be reduced by $O_{R_{t+1}}$.\(^{30}\)
The changes in taxes affect both production and exploration. An increase in severance tax reduces both extractive and exploratory efforts, equations (5) and (6). Size of the impact depends on the shares of the efforts 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. An income tax also decreases extraction and exploration efforts but to a lesser degree. This is because expensing assumptions imply that a significant amount of costs are deductible from taxable income. Therefore, 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 a decline in the opportunity cost of extraction today meaning higher extraction efforts but lower exploration efforts today. Equations (5) through (7) together with (1) govern the evolution of the variables \( R_t, H_t, L_t, E_{lt}, E_{ht}, \eta_t \) taking exogenous variables \( \{P_t, w_{Lt}, w_{Ht}, w_L, w_{ht}, \tau_{\pi t}, \tau_{rt}\} \) as given. Our quantitative results will depend on the parameters of these equations. In the following section, first we calibrate the model using Venezuelan data and then evaluate the impact of nationalization on productivity in the Venezuelan oil industry quantitatively.

5 Quantitative Analysis

In this section, we parametrize the model using the Venezuelan data and evaluate the impact of nationalization on production per worker in the oil industry. First, we describe what aspects of the data identify key parameters in the model. Then, we present baseline quantitative results.
5.1 Parameterization

We calibrate the model to the data for the Venezuelan oil industry. The data is annual time series. We assume that foreign workers are high skilled workers and domestic workers are low-skilled workers, and represent exploratory and extractive efforts by different types of labor. So, the related parameters are new. The parameters that we need to choose are the share of low-skilled extractive labor, $\mu$, the share of reserves, $\nu$, the share of composite labor, $\gamma$, the shares of low and high skilled exploratory labor, $\theta_1$ and $\theta_2$, and productivities of different labor inputs, $h_i$’s. We also need to assign values for the parameter governing the elasticity of substitution between high and low skilled extractive labor, $\sigma$, and the discount factor $\beta$.

We follow a similar approach used in Krusell, Ohanian, Rios-Rull, and Violante (2000) [28] while constructing our labor input and the corresponding wages series, which is explained in detail in the Appendix. Reserve additions data is constructed by following Pindyck (1978) [42], which will represent annual time series for $G(\cdot)$. For reserves and production, we use Venezuelan proven reserves and crude oil production, data respectively.

One period in the model is assumed to be a year in the data. The discount factor, $\beta$, is set at 0.90 to generate an 11% annual real interest rate. We set the elasticity of substitution parameter at $-0.5$, which imply complementarity between two types of extractive efforts.\(^{61}\)

The rest of the 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 $L, H, E_l, E_h$, and their corresponding wages. Reserve additions at the steady state is the pre-1960 average of the constructed $G(\cdot)$ series. $R$ at the steady state is set similarly. We assume that skilled workers are more productive than unskilled workers, and these productivities are constant over time. We target wage differences across different occupational groups by nationality in order to calibrate $h_i$’s, where $i = L, H, l, h$.

We set the ratio of unit extraction costs between low-skilled and high-skilled labor at 0.236 (the average $\frac{w_L}{w_H}$ ratio for the Venezuelan oil industry), and obtain $\mu = 0.679$. We

\(^{61}\)We argue that complementary high skilled and low skilled labor inputs can help capture the observed trends in productivity. For this purpose, $\sigma$ must be set at a value less than 0. Note that estimating a value for the elasticity of substitution between different factors of production is not possible due to data limitations.
jointly calibrate $\theta_1$ and $\theta_2$. We target the pre-1960 ratio of unit exploration costs between low-skilled and high-skilled labor and average reserve additions over the period 1948-1959 to choose these parameters, which results in setting the costs ratio at 0.82. The other two key parameters, $\nu$ and $\gamma$, are also jointly calibrated. We choose them so that production to reserves ratio is 0.39 and production is equal to the new reserves added.

We also need a value for $c$, the tax credit on exploration expenses. We calculate it following Deacon (1993) [12]. $c$ in my model 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.” Since we do not observe expensed drilling costs for the Venezuelan oil industry, we set $e$ at 0.45 as in Deacon (1993) [12]. During the period 1953-1957, the production to reserve ratio, $d$, is almost constant in the Venezuelan oil industry. So, we calculate $d$ as the average production to reserves ratio over 1953-1957. This allows $f = \frac{d}{r+1}$, where $r$ is the interest rate set at 11%. Hence, we obtain $c = 0.651$. The parameter values are summarized in Table 6.

5.2 Results

In this subsection, we study the impact of nationalization on exploration, production, and hence productivity, quantitatively.

As we have discussed in section 3, the conflict which took place in 1957/58 eventually gave rise to the realization of an anticipated nationalization. So, we choose 1961 to be the starting point to cover a 20 years period. We describe and introduce nationalization as follows: first, we assume that the agents in the economy anticipate in the year 1961 that the government will increase its participation through higher taxes permanently, which will be realized in the year 1970. We assume that the formal nationalization process starts in 1970, because later that year the Income Tax Law was amended, and the ministry co-managed the industry with the MNCs until the nationalization process was finalized in 1975. So, at time $t = 1$, which corresponds to the year 1961, the industry foresees a once-and-for-all change in income tax rates.

Second, we argue that the foreign workers became a missing factor in the industry. That is, nationalization brought elimination of foreign know-how. We impose a tax on wages paid
to foreign workers and gradually eliminate foreign workers by more than 70%.

Third, we introduce political favoritism as follows: we subsidize domestic workers after nationalization by subsidizing their wages by around 30%.

Before proceeding with the quantitative assessment of the impact of nationalization, we analyze effects of an increase in income tax under no foresight and foresight on model variables.⁶²

5.2.1 Impulse responses: increase in the income tax rate: anticipated vs. unanticipated

Figure 17 presents the impulse responses of a permanent income tax shock. Solid lines are the responses to an unanticipated permanent 50% exogenous rise in the income tax rate. The dashed lines are, on the other hand, the responses under 10-periods foresight.

News about the income tax increase realized at the beginning of time 11 arrives at the beginning of time 1. Before policy realization, the response of extraction is opposite. In response to anticipation of an increase in the income tax rate, extractive effort increases. However, exploratory effort decreases. The effect of an anticipated future increase in income tax on exploration and extraction can be understood by looking at the optimality conditions. The inter temporal first order condition implies that the future increase in the income tax rates should cause the shadow value of additional reserves to decline as soon as the policy is announced. The decline in the shadow value results in increasing the extractive efforts while inducing disincentive for exploration. Even though extractive efforts are increasing before the realization of the shock, lower reserves due to declining exploration prevent extraction from increasing. Hence, production only slightly increases and then stays almost stable. Note that exploratory efforts decline more than the increase in extractive efforts resulting in declining total employment. This implies increasing labor productivity, where labor productivity is measured as production per worker.⁶³

⁶²We present the impact of income tax increase due to the fact that during the period we will examine, only income tax rate was increased in Venezuela, the royalty rate was kept at its earlier level.

⁶³This may suggest a possible mis-measurement. Because, production takes into account exploratory effort only indirectly through its impact on reserves, but the productivity measure takes into account exploratory labor input directly through the total labor input component. However, in the data, total number of workers are not decomposed according to type of operation.
The unanticipated rise in the income tax rate is realized at time \( t = 1 \). The rise in income tax rate lowers both exploration and extraction. Decline in exploratory effort is more severe and its trend dominates the path of the total labor input, hence productivity immediately rise due to the sudden drop in total number of workers, but then decrease due to declining extraction which outweighs the decline in total labor input. However, labor productivity converges to a higher level in both cases. Note that the response after the policy realization is consistent with those to an unanticipated tax shock for extraction, however opposite for exploration. After realization of an unanticipated shock exploration falls immediately, but after the realization of an anticipated shock exploration increases first. The impact of the anticipated shock is driven by the change in the current shadow value which is determined by future expectation on taxes that is realized 10 periods in advance. On the other hand, for the case of unanticipated shock, the direct impact of higher income tax on current shadow value induces the impact on exploration.

In the long run, the overall impact of both anticipated and unanticipated tax shocks are similar. Hence, announcing the policy in the long run results in similar distortions. However, in the short run, from a policy making perspective, compared to a sudden increase in taxes announcement of the policy benefits the producers by allowing them to exert more extractive efforts and produce as much as they can before the policy is realized.

5.2.2 Nationalization

Nationalization is simply exogenously given: permanent foreseen shocks to income tax, number of foreign workers and number of domestic workers. Agents anticipate that income tax rate will increase and foreign workers will be eliminated permanently. News about nationalization realized at the beginning of 1970 arrives at the beginning of 1961. In addition, nationalization brings political favoritism, i.e. expansion in domestic employment, which will be realized at the beginning of 1975.

The income tax rate increases from 0.46 to 0.70 gradually in the data. We feed the actual tax increases into the model. Moreover, in the data, from 1960 to 1970, number of foreign workers fell by around 74%. In our simulation, we generate an equivalent decline in the
number of foreign workers via imposing an increasing fixed cost on their wages. Finally, we subsidize wages paid to domestic workers by around 30% after nationalization, which is the actual real wage rate increase observed in the data. Figure 18 shows actual data versus our simulated data. Table 7 presents how successful the model is in accounting for the impact of nationalization on productivity.

Figure 18 suggests that the simulated response to nationalization explains actual time series quite well despite simplicity of the model. Over 1961-1980, the proposed mechanism can account for 84% of the productivity pattern. Prior to nationalization, model can explain 93% of the data.

We also ask how steady state profits were affected by the nationalization policy. To do this, we calculate baseline profits in the old (initial) and new (end) steady states, normalize the old steady state profits to 100 and calculate the percentage change. Results are presented in Table 8. Nationalization is profits reducing, by 55.5%, due to declining production and exploration. Assume that in the initial steady state the profits were shared 50-50, which was the sharing policy between the Venezuelan government and MNCs after 1943. Hence, the government would get 50. But, it gets 44.5 in the new steady state, 11% less than what it gets in pre-nationalization period. This implies that the industry is worse off after nationalization: even though it gets the whole, what it gets is smaller.

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, implementation of nationalization is attractive because it can generate higher income or better income redistribution through the government’s exercising full control over the resource. However, these can come at the expense of a significant loss in productivity.

In this paper, we use new data to study nationalization thoroughly. First, we document historical trends in government take over. Then, we investigate its impact on productivity in the oil industry over a period when expropriations were widespread. Finally, we examine the Venezuelan oil industry nationalization in the 1970s: we document the impact of na-
tionalization on the industry performance, and how it proceeds in practice. In particular, we show that nationalization brings striking losses in production and productivity. We then present a less-explored channel through which nationalization impacts productivity. We argue that anticipated nationalization bringing lost foreign know-how can explain the impact of the policy by providing evidence on the proposed mechanism. Then, using macroeconomic tools, we test the ability of the proposed mechanism in explaining the Venezuelan experience quantitatively by developing a relatively simple but non-standard framework for non-renewable resources. Simulations of the calibrated model suggest that in anticipation of nationalization agents increase extractive efforts and lower exploratory efforts. This brings declining total employment due to exploratory labor declining more than the increase in extractive labor, and increasing productivity prior to nationalization. By realization of the policy, productivity starts declining. After nationalization, increasing domestic workers generates increasing reserves and hence higher output, but due to employment growth outpacing production growth, productivity continues declining. Despite its simplicity, our carefully calibrated model can explain the path of productivity quite well.

Future research may consider improving the model in several aspects to capture the real world better. First, we abstract from any kind of uncertainty, which may not be an ideal assumption due to highly uncertain nature of exploration. Second, our framework implicitly assumes that reserves are in the same quality. Declining quality of reserves can be a better representation. Third, we did not attempt to fully explain the post-1975 period. For this analysis, the objective of the firm is better to be different. In other words, developing two different problems for pre and post nationalization periods can help explain the path after nationalization better.

References


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APPENDIX I

a. Historical Trends in Expropriation Acts across the World

Figure 1 presents the trend in expropriation acts over time. In other words, it presents how frequently expropriations have occurred over time. We consider a three year moving average for smoothing purposes. Over half of the acts occurred during 1970-1976, and the acts made a peak during 1974-1975. This pattern is similar to the time trend presented by Kobrin, although our figure covers a longer time horizon with earlier and more recent expropriations. In the literature, this time-pattern has been attributed to national security concerns, changing commodity prices, or gaining independence.\(^\text{64}\) Kobrin (1980) \([25]\) argues that it is consistent with a secular bargaining power shift from investors to the host countries. In the 1970s, maintaining local-national ownership was important in terms of national security. Also, it was a period of relatively high commodity prices.\(^\text{65}\) Very few expropriations took place during the 1980s and early 1990s. In recent years, however, there has been an acceleration of expropriations again.

Vulnerability to forced divestment varies by sector. Table 1 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. In total, these sensitive sectors represent around 64% of all acts. Extractive sector represents around 41% by itself. Hajzler (2013) \([19]\) 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, these sectors are desired to be controlled by the government possibly because they dominate the economy and thereby making foreign ownership intolerable.

Table 2 shows the regional distribution of all acts. Africa and Latin America account for 39% and 30% of all acts, respectively. Middle East and Asia have lower shares, 16.4% and 15.3%, respectively.

\(^{65}\)Several motivations are discussed in the literature. For instance, Kobrin (1980) \([25]\) argues that benefits may not justify its costs due to change in investment or enterprise characteristics, hence expropriation may be an effective policy. Or, political pressures may develop whenever poor economic environment coincides with wealthy industries dominated by foreign-owned firms (scapegoat hypothesis).
Figure 1: Time Pattern of Expropriations in the World, 1922-2006

Table 1: Sectoral Distribution of Expropriation Acts in the World, 1922-2006

<table>
<thead>
<tr>
<th>% in total acts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Extractive</td>
<td>40.8</td>
</tr>
<tr>
<td>Agriculture</td>
<td>10.8</td>
</tr>
<tr>
<td>Mining</td>
<td>12</td>
</tr>
<tr>
<td>Petroleum</td>
<td>18</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>24.1</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>13</td>
</tr>
<tr>
<td>Banking and Insurance</td>
<td>10</td>
</tr>
<tr>
<td>Trade</td>
<td>4.3</td>
</tr>
<tr>
<td>Construction</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>5.8</td>
</tr>
</tbody>
</table>
Table 2: Regional Distribution of Expropriation Acts in the World, 1922-2006

<table>
<thead>
<tr>
<th>Region</th>
<th>% in total acts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>38.8</td>
</tr>
<tr>
<td>Latin America</td>
<td>29.5</td>
</tr>
<tr>
<td>Middle East</td>
<td>16.4</td>
</tr>
<tr>
<td>Asia</td>
<td>15.3</td>
</tr>
</tbody>
</table>

b. Impact of Expropriations on Productivity in the Oil Industry

Table 3: Labor Productivity relative to the U.S., 5-year averages

<table>
<thead>
<tr>
<th>Country</th>
<th>pre-expropriation</th>
<th>post-expropriation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>37.8</td>
<td>26.6</td>
</tr>
<tr>
<td>Colombia</td>
<td>194.4</td>
<td>77.5</td>
</tr>
<tr>
<td>Peru</td>
<td>158.5</td>
<td>74.5</td>
</tr>
<tr>
<td>Venezuela</td>
<td>130.9</td>
<td>86.4</td>
</tr>
</tbody>
</table>

* Productivity at the time of Expropriation = 100.
Figure 2: Oil Industry, Peru and Colombia

Peru, 1985 (year of expropriation) = 100

Colombia, 1974 (year of expropriation) = 100

Figure 3: Oil Industry, Algeria

1967 is the year of expropriation

0 2000 4000 6000 8000 10000 12000 14000 16000
Number of Workers
Foreign Workers
Algerian Workers
Figure 4: Oil Industry, Venezuela
Table 4: Algerian Oil Employment, by occupation and by nationality

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

Source: Brogini (1973) [5]
APPENDIX II

a. The Venezuelan Oil Industry Facts

Figure 5: Historical Production and Productivity in the Venezuelan Oil Industry

Table 5: Crude Oil Production, 1970-1980, Δ%

<table>
<thead>
<tr>
<th></th>
<th>Venezuela</th>
<th>Saudi Arabia</th>
<th>Mexico</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆%</td>
<td>- 41</td>
<td>+ 167</td>
<td>+ 337</td>
<td>+ 31</td>
</tr>
</tbody>
</table>

Sources: British Petroleum Statistical Review of World Energy
Figure 6: Venezuela vs. Mexico

Source: Randall (1989) [43], and British Petroleum Statistical Review of World Energy

Figure 7: Total Employment in the Venezuelan Oil Industry
Figure 8: Composition of the Work Force in the Venezuelan Oil Industry

(a) Venezuelan Work Force

(b) Foreign Work Force

(a) (b)
Figure 9: Employment Trends in the World

![Indices of Employment Trends](chart1.png)


Figure 10: Total Number of Wells Drilled, Venezuelan Oil Industry

![Number of Wells Drilled](chart2.png)
Figure 11: Capital Investments of the World Petroleum Industry

Source: Chase Manhattan Bank, Energy Division
Figure 12: Production to Reserve Additions Ratio
Figure 13: Education Level Distribution of the Foreign Personnel Employed in the Venezuelan Oil Industry, 1970

![Education Level Distribution Graph]

Source: Michelena and Soublette (1976) [36].

Figure 14: Number of Drilled Wells by Type

![Number of Wells Drilled by Type Graph]
Figure 15: Success Rates of Development and Exploratory Wells

![Graph showing success rates of development and exploratory wells over years 1960 to 1985. The graph displays two lines representing development and exploratory wells, with success rates fluctuating over time.]

Figure 16: New Field Drilling

![Graph showing number of new wildcat successful areas over years 1959 to 1986. The graph displays two bars representing total new wildcat and successful wildcat, with peaks and troughs indicating variations in drilling activity.]
b. Quantitative Analysis

Reserve Additions Data

Data source is the Republic of Venezuela, Ministry of Mines and Hydrocarbons, Petroleum Industry, Statistical Databooks (MMH Databooks). In our model, function $G(\cdot)$ represents new reserves. In the data, crude oil reserve additions consist of three components: new discoveries, extensions, and revisions, measured in millions of barrels.

We construct our annual data series for new reserves that will represent $G(\cdot)$ in the spirit of Pindyck (1978) [42]. He emphasizes that although new discoveries and extensions have a strong dependence on well drilling and cumulative reserve additions, revisions behave like a random process with a mean value several times the mean value of discoveries plus extensions. Hence, he obtains a constructed series by multiplying his data on discoveries plus extensions by the ratio of the mean value of reserve additions to the mean value of discoveries plus extensions. That is, he substitutes for annual revision its mean value in order to eliminate additional variance and possible negative discoveries. We follow the same procedure due to the fact that in our data revisions behave in a similar manner. Hence, we calculate new reserves as the multiplication of discoveries plus extensions with the ratio of the average reserve additions to the average value of discoveries plus extensions.

Labor Input Data

Collecting oil industry employment data over 1948-1995 is a challenging task. Data is not digitally available, and even for the U.S. there is limited historical data. The earliest industry level data available for the U.S. is for the year 1997. However, we are able to collect anecdotal evidence and statistical data that will help us constructing the labor input and corresponding wages series. Our main data sources are MMH Databooks, Michelena and Soublette (1976) [36], and Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census Databook for the year 1987. From 1948 to 1995, MMH databooks provide annual data on the 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. We converted them into millions of 1990 U.S.$ Michelena and Soublette (1976) [36] present occupational profile in the oil industry in Venezuela in 1974, and data on foreign personnel employed in the oil industry in 1970. Foreign employment data includes entity, age, education level, office held, experience in profession, and basic remuneration.

We construct the labor input series for extraction and exploration, and their corresponding wages in several steps following a similar approach used in Krusell, Ohanian, Rios-Rull, and Violante (2000) [28]. In the first step, we constructed three broad groups: (i) professionals, which includes three sub-categories: managers, administrative workers, technical workers; (ii) mid-level workers; and (iii) unskilled labor using the occupational profile of the oil industry in Venezuela in 1974. In the second step, we sort these groups into two categories: foreign and national. For this partition, we use data on occupations and education levels of foreign workers in the oil industry in Venezuela in 1970, and data on foreign and Venezuelan workers. In the third step, we classify these groups into extractive and exploratory skilled and unskilled labor. We construct total labor input measures for extractive workers: skilled and unskilled workers; exploratory: skilled and unskilled workers; and their corresponding wages. In order to aggregate group measures into these classes, first, we assume that groups are time-invariant. For instance, groups that belong to extractive skilled category are always the same. Second, the groups within a class are assumed to be perfect substitutes. We use the group wages in 1970 as the weights.
**Simulation Results**

Table 6: Parameterization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor ($\beta$)</td>
<td>0.90</td>
</tr>
<tr>
<td>Elasticity of substitution between extractive labor inputs ($\frac{1}{1-\sigma}$)</td>
<td>0.667</td>
</tr>
<tr>
<td>Tax credit ($c$)</td>
<td>0.651</td>
</tr>
<tr>
<td>Composite labor share in extraction ($\gamma$)</td>
<td>0.612</td>
</tr>
<tr>
<td>Share of unskilled labor in extraction ($\mu$)</td>
<td>0.679</td>
</tr>
<tr>
<td>Share of reserves ($\nu$)</td>
<td>0.214</td>
</tr>
<tr>
<td>Share of unskilled labor in exploration ($\theta_1$)</td>
<td>0.495</td>
</tr>
<tr>
<td>Share of skilled labor in exploration ($\theta_2$)</td>
<td>0.287</td>
</tr>
<tr>
<td>Productivity of extractive unskilled labor ($p_L$)</td>
<td>1.87</td>
</tr>
<tr>
<td>Productivity of extractive skilled labor ($p_H$)</td>
<td>9.12</td>
</tr>
<tr>
<td>Productivity of exploratory unskilled labor ($p_l$)</td>
<td>2.74</td>
</tr>
<tr>
<td>Productivity of exploratory skilled labor ($p_h$)</td>
<td>5.86</td>
</tr>
</tbody>
</table>
Figure 17: Impulse responses to income tax shock: Solid lines: responses to an unanticipated exogenous rise; dashed lines: responses to an anticipated exogenous rise, 10 periods foresight.
Figure 18: Actual versus Simulated Data

Table 7: Results: Accounting for the Impact of Nationalization on Productivity

<table>
<thead>
<tr>
<th>Period</th>
<th>Percentage Explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961 – 1980</td>
<td>84%</td>
</tr>
<tr>
<td>1961 – 1970</td>
<td>93%</td>
</tr>
<tr>
<td>1970 – 1980</td>
<td>77%</td>
</tr>
</tbody>
</table>
Table 8: Results: Profits

<table>
<thead>
<tr>
<th>Measured Profits</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre-nationalization</td>
<td>post-nationalization</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>44.5</td>
</tr>
</tbody>
</table>