Productivity and Nationalization: Early Evidence and A Macroeconomic Analysis[†]

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Abstract

An old phenomenon, forced divestment of foreign-owned property (expropriation), was on the rise again in the 2000s. The number of expropriation occurrences across the world had peaked in the 1970s, and virtually every significant developing oil producer had nationalized its oil during this period. Using novel data, I investigate the impact of this phenomenon from the 1960s to the 1990s in a sample of oil producing developing countries, and focus especially on Venezuela for which I present extensive and detailed data. Nationalization brought considerable declines in productivity in the oil industries of the sample countries. Productivity fell by more than 70 percent in the Venezuelan oil industry. Despite enormous efforts put into expansion, it took Venezuelan's nationalized industry about 20 years to return to its early 1960s productivity levels. I find that news about the future (anticipation) and lost foreign know-how are promising in explaining the impact on productivity. Then, I develop a dynamic partial equilibrium framework for nonrenewable resources featured by imperfect substitutability between domestic and foreign workers to test my hypotheses. A comparison of the simulated and actual time series shows that the proposed mechanism can explain more than 85 percent of the productivity pattern over 1961-1980 in the Venezuelan oil industry.

Keywords: Nationalization, Productivity, Nonrenewable Resources, Oil, News, Policy Foresight

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1 Introduction

After their substantial rise in the 1970s, the importance of state-owned enterprises (SOEs) diminished following the large privatization programs of the 1980s and 1990s.[1] The SOE share of global GDP declined by more than 40 percent between 1979 and the early 2000s.[2] Following this process, a considerable amount of research was conducted supporting the proposition that privately-owned firms are more productive than otherwise-equivalent SOEs.[3] In recent years, however, the state ownership has been on the rise, again. The number of nationalizations has increased.[4]

Policies can have devastating impact on productivity which may result in economic failures. Cole, Ohanian, Riascos and Schmitz (2005) [3] examine Latin America's inability to catch-up the success of other Western economies, and find that labor productivity is the main reason. They argue that limiting government policies can explain productivity losses, and present supporting microeconomic evidence. They show that following nationalization productivity declines significantly, and discuss that eliminating international expertise can explain the loss in productivity. Restuccia (2008) [16], similarly, examines the failure of Latin American countries in catching up with the wealth of the U.S. He finds that low total factor productivity accounts for the difference in GDP per capita, and shows that removing policy barriers to productivity can increase long-run GDP per worker in Latin America.[5]

In the context of the development problem, examining the impact of forced divestment as a policy tool thoroughly is important, and its recent rise motivates a better understanding of the impact of nationalization.[6] This paper attempts to provide a thorough analysis of this phenomenon.

To provide a careful analysis, we start with investigating the trends in expropriations. Our goal is to determine the period, region, and sector that expropriations have been widespread. A historical time-series analysis of forced divestment acts show that over half of the acts occurred during 1970-1976, extractive sector (including oil) is more vulnerable to forced divestment, they

[1] The number of forced divestment acts increased significantly in the 1970s and peaked during 1974-1975.

[2] Megginson and Netter (2001).

[3] Leading studies include La Porta and Lopez-de-Silanes (1999); Megginson, Nash, and Van-Randerborgh (1994); and Megginson and Netter (2001).

[4] For example, Azerbaijan, Bolivia, Ecuador, Kazakhstan, Venezuela, and Argentina nationalized their oil sector. 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.

[5] As referred by Restuccia (2008) [16], we define development problem as the inability of catching up with the wealth of developed economies.

[6] Forced divestment of foreign-owned property is an old phenomenon. Among many other studies, Williams (1975) [21], Kobrin (1980) [9], Kobrin (1984b) [11], Minor (1994) [13], Tomz and Wright (2008) [20], Guriev et al (2009) [5] investigate different aspects of it, and could be useful for an interested reader.

are more common in Africa and Latin America, and nationalization is the most prevalent form of government taking. Motivated by these facts, we continue our analysis by focusing on the oil industry expropriations in the 1970s in Latin America and Africa. We examine both OPEC and non-OPEC members, and consider the U.S. as a benchmark. We find that relative labor productivity declines following nationalization, and the losses range from 25 percent to 55 percent.

The Algerian and Venezuelan experiences provide us insights with regard to possible explanations for the observed decline in productivity following nationalization. Using novel data we show that elimination of foreign workers and fast-expanded domestic work force are common in both countries. Prior to nationalization, total employment, including foreign workers, shrank significantly, which was contrary to the general world trends. After nationalization, the lost foreign workers were replaced by domestic workers, who were mostly white-collar workers. In order to examine what can account for the impact of nationalization on productivity thoroughly, we focus on the case of Venezuela. We chose Venezuela, because it is one of the largest oil producer in the world, a particular example of a remarkable decline in productivity following nationalization, and we manually collect a novel, comprehensive data set on the Venezuelan oil industry over a fifty years period. We also present new evidence on the world oil industry trends to see whether the Venezuelan trends were common to the industry at that time or not.

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, and was particularly severe in the first five years after 1970. By 1985, the 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 never exceeded 0.85 percent until 1995. The Venezuelan work force, on the other hand, expanded rapidly after nationalization. Contraction of 1957-1975 was replaced by a fast expansion, which mostly occurred in white-collar workers. Similarly, exploration and reserves increased.

These comparisons motivate the following questions: First, what caused the contraction in manpower and exploration in the late 1950s, which was a process that started well before na-

tionalization? Second, why couldn't the industry improve production and productivity despite the notable expansion in employment and increase in reserves during the post-nationalization period? We claim that the regime change from dictatorship to democracy in 1957 induced increasing expenditures, resulting in a temptation to increase the government share of multinational companies' (MNCs) profits. This led to new tax laws, which progressively increased taxation rate significantly. Moreover, new oil concessions were frozen. These events induced an anticipated government takeover, and triggered the nationalization process, which began in 1970. We propose that the industry contraction during the late 1950s and 1960s was caused by the news about the future nationalization.

The elimination of foreign workers began in 1957, and continued thereafter. The retarded recovery in production and productivity despite the expansion 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 novel evidence suggesting that foreigners are highly skilled workers, representing key technical, professional, and managerial positions. 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 would cause a decline in the productivity of measured factors of production. We interpret this decline as "the missing input" of highly skilled workers in production.

The model section of the paper builds a dynamic partial equilibrium framework that incorporates the elements we have 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 tax changes under different timing assumptions. Our baseline simulations suggest that foresight of several years distorts the tax effects under no foresight assumption. We introduce nationalization as follows: assume that nationalization is simply exogenously given, and modeled as a higher tax rate on income and a declining number of foreign workers. Our analysis attributes the increasing productivity prior to nationalization mostly to the declining efforts in exploration stemming from the anticipated changes. However, due to the dominating effect of lost foreign know-how over news about the future, extraction (production) declines. It is the declining number of foreign workers that offsets the rebound in the extractive effort due to

expected policy changes prior to nationalization. By the realization of nationalization, productivity falls and continues to do so. 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 more than 85 percent of the productivity pattern can be attributed to the proposed mechanism, mainly anticipation.

We document the impact of nationalization on industry performance, how it proceeds in practice, and present theories that can explain its impact, which have not been explored in the literature in the context of nationalization. We provide evidence supporting the suggested mechanisms, and then using macroeconomic tools, we test the ability of the proposed channels in explaining the Venezuelan experience by developing a relatively simple but non-standard framework for non-renewable resources. Finally, we ask whether the country is better off by nationalization or not. A common view is that nationalization is attractive because the country would expect to get the whole and hence be better off. We calculate measured profits using simulated data before and after nationalization to see whether this standard view holds or not. We find that although the country gets the whole pie, it becomes much smaller. Hence, it may not be better off.

Related Literature: This study contributes to several strands of the literature. First, James A. Schmitz Jr. presents industry-level analyses in which there is an exogenous change in competition, and where productivity can be measured before and after the competitive change. Schmitz (2005) [18] finds that exogenous changes in the world steel market led to increased foreign competition for Great Lakes' iron ore producers. These changes resulted in a 100 percent increase in labor productivity, which can be explained by changes in work practices. Likewise, Schmitz and Teixeira (2004) [19] show that privatization of the Brazilian iron ore industry gave rise to productivity gains in newly privatized firms and existing private firms that had to compete with the new firms, and did 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 and exogenous policy change associated with significant losses in production and productivity.

Second, Pindyck (1978) [52] 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) [32], Yucel (1986) [57], and Deacon (1993) [31], but different from the previous literature and motivated by the observed trends, we represent exploratory and extractive efforts with different labor

inputs, that are measured in efficiency units and imperfect substitutes. This method allows us to test the proposed channels. In addition, we study the effects of different taxes on exploration and production under different beliefs about the future. This imples that 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 studied, 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 a case in which news shocks have important policy implications. Relevant papers that examine tax effects under policy foresight are Yang (2005) [56] and House and Shapiro (2006) [37]. 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 provide novel evidence on the oil industry across the world, and in Venezuela. In particularly 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 due to lost foreign know-how, as explored here. 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); Burstein and Monge-Naranjo (2009); and Eeckhout and Jovanovic (2010)).[7]

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 a nationalization policy in a quantitative manner, nor that attempts to explain a developing country experience as we undertake to. 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); La Porta and Lopez-de-Silanes (1999); Megginson and Netter (2001); and Chang et al. (2010).

Finally, this policy question has potential for further implications. When a resource is vitally

[7] 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).

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 overall economy. Bello, Blyde, and Restuccia (2011) 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.[8] 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 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.[9] Our analysis is in line with their arguments about the aggregate economy in that we claim that foreign know-how and increasing government participation resulting in an anticipated takeover can explain the collapse of the oil industry.[10] And, to understand Venezuelas development experience, which is critical in terms of the Latin American development problem, it is important to study the oil industry, particularly oil production.[11]

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 countries. In Section 3, we document the features of the Venezuelan oil industry. After describing the data, we explore the 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 along with the calibration and simulation results in Section 5, and conclude in Section 6.

[8] When we examine real GDP per capita and oil production per capita, we observe that they move in the same direction, except for in the early 1960s and the mid-1970s, which can be explained by high oil prices and increasing participation of the government in industry affairs.

[9] 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.

[10] 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.

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

2 Historical Trends in Forced Divestment

To be able to investigate the impact of the policy thoroughly, first step is to determine the period, region, and sector in which forced divestment has been widespread.[12] For this purpose, we start with documenting the trends in expropriations across the world over 1922-2006.

2.1 Trends: time, sector, region, and type

Data: The unit of analysis is an act.[13] 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) [20].[14] Tomz and Wright (2008) [20] construct a new data set on the occurrence of expropriation since the late 1920s. They consider a broad definition of expropriation following Kobrin, and gather data for the period 1929-1960. Then, they combine their newly collected data set with the existing inventories by Kobrin (1984) [10] for the period 1960-1979, Minor (1994) [13] for the period 1980-1991, and finally Hajzler (2007) [6] for the period 1993-2004. Hajzler (2010) [7] documents more recent expropriations covering the period 1989-2006. We combine Tomz and Wright (2008) [20] data set with Hajzler (2010) [7]. Moreover, while examining nationalizations in the oil industry, we put together the data provided by Kobrin (1984b) [11] with the data provided by Guriev et al (2009) [5], 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.[15]

Trends: We find that over half of all the acts occurred from 1970 to 1976 (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). Finally, nationalization is consistently the most prevalent form of government taking (Table 3).[16] Motivated by these facts, we will continue our analysis by focusing on the oil industry expropriations in Latin America and

[12]Kobrin (1980) [9] 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.

[13]An act is defined by Kobrin (1980) [9], Kobrin (1984) [10] as the involuntary divestment of any number of firms in an industry in a country in a given year.

[14]We are deeply grateful to Mark L. J. Wright for sharing their data.

[15]The data set includes expropriations involving divestment of foreign direct investment. Kobrin (1984) [10], Minor (1994) [13], and Hajzler (2010) [7] present analyses of expropriation trends in their studies. However, Tomz and Wright (2008) did not present a trend 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 longer time period.

[16]Appendix I.a presents figures, tables, and more discussion on the observed trends.

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.[17] Although prior to 1970 almost all existing oil industries in developing countries were operated by foreign firms, by 1976 virtually every major oil-exporting developing country expropriated its industry, which is an important figure.[18] Given the dominance of the industry in the developing host countries, forced divestment is attractive for increasing revenue. Indeed, the timing of expropriations confirms this opportunistic motive.[19] Sovereignty over their own resources is another factor; and the foreign ownership is inconsistent with national control.[20] 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 with much smaller output. In this context, we collect a novel data set, most of which is manual, in order 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

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.[21] 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 mid-1970s.[22]

[17]Kobrin (1984b) [11], Williams (1975) [21]

[18]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) [11].

[19]Duncan (2006) [4], Guriev et al (2009) [5]

[20]Kobrin (1984b) [11], Yergin (1991) [23]

[21]We consider employment in petroleum refineries as a proxy for employment in the oil industry.

[22]Data availability is an important concern, which limits the size of our sample. Manually collecting employment data in the oil industry over 1960 - 1995 in oil-producing developing countries is a challenging task. Sectoral employment data across developing countries are not reported or do not exist for most of the developing countries over the 1960s and the 1970s, which prevent us from examining several cases, such as Argentina or Nigeria.

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 Venezuela as the OPEC members, and Colombia and Peru as the non-OPEC members.[23] We include USA as a benchmark for comparison.

The Impact on Productivity: Productivity is measured as oil production per worker. For each country, using data described above, first we obtain labor productivity over the period 1962-1995. We plot corresponding figures in Appendix I.b.[24] Second, labor productivity relative to the U.S. is obtained by dividing each country's productivity by the productivity of the U.S. 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.[25] Finally, for each case, we calculate five-year averages before and after expropriation excluding the value 100 at the time of expropriation. Table 4 presents the pre- and post-expropriation relative labor productivity averages. 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.[26] Formerly contracted oil employment expands remarkably after expropriation without accompanying recovery in production, hence, productivity keeps declining. On the other hand, the U.S., a non-expropriating efficient oil-producing country, has a stable pattern in the number of workers in the 1970s that is reduced significantly in the 1980s resulting in a boost in productivity, Figure 5.[27]

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

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[23] 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, not the earlier expropriations in the oil industry.

[24] Figure 2, and left panels of Figure 3 and Figure 4. Red dotted lines indicate the year of expropriation.

[25] Brogini (1973) [1], Kobrin (1984b) [11], Guriev et al (2009) [5]

[26] Indeed, even for Algeria, this pattern is not irrelevant. Because, from 1967 until the mid-1970s, the country experiences a series of government take over.

[27] In the U.S., from 1970 to 1975, productivity declines slightly, about 5%, while from 1976 to 1985, it increases by around 30%.

2.3 Exploring the impact on productivity

Algeria: Nationalization took place in 1967, and a series of government take-overs in the Algerian oil industry took place until the mid-1970s.[28] 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) [1]. 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 5. 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 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.[29]

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

[28] 1970, 1971, 1974, 1976 oil nationalizations, Guriev et al (2009) [5]. Note that the starting point of oil expropriations in Algeria is the year 1967, and 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.

[29] Algeria achieves political independence in 1962, and experiences nationalist motives toward industrialization during the mid and late 1960s. Kobrin (1980) [9] discusses examples of wholesale taking of foreign-owned property following political-economic change over 1960-1976. Among them Algeria was a case such that the take-overs resulted from a change in political-economic ideology and recent independence.

by more than threefold. However, this remarkable expansion results in only a slight increase in production, but, a sharp drop in productivity.

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 1948-1995.[30] 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.[31] 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.[32] 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

[30]Source is Republic of Venezuela, Ministry of Mines and Hydrocarbons, Oil and Other Statistical Databooks.

[31]For 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.

[32]We 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.

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 1980.[33] However, Aramco partners continue to manage and operate Saudi Arabia's oil fields with a foreign manpower constituting almost 50% of its workforce.[34] But, during 1970-1980 we do not observe a decline in output, on the contrary, oil production increases 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.[35]

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.

[33]Luciani (1984) [12] argues that the former Aramco ownership distribution of equity capital is Exxon, Texaco, Chevron 30% each, and Mobil 10%.

[34]Woodward (1988) [22], Olmedillo (1984) [51]

[35]We 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 eliminates foreigners to a greater extent, and the other does not. The facts we provide motivate us to examine the role of foreign workers in explaining the impact of nationalization.

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 we observe in the Venezuelan oil industry over a long time horizon including the nationalization period using a comprehensive and unique data set. Additionally, we will document main critical events in relation to the key stylized facts.

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 have recorded annual industry-level time series data on various variables such as proved reserves, new reserves, completed wells, 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, January 2011, and the Economic Commission for Latin America Database. We collect micro data on the composition of the workforce in the oil industry from Michelena and Soublette (1976) [54], and Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census Databook, 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 6 presents historical crude oil production and production per worker, in barrels and in barrels per worker, respectively. Both are normalized to 100 in the year 1970. Historical oil production figure, in the left panel, indicates two nationalization

periods and a privatization period.[36] This figure presents a striking pattern in production before and after nationalization for both incidents: increasing pattern is reversed just before nationalization, and the declining trend continues in the post-nationalization period. In this figure, another important pattern is the positive impact of privatization on production and productivity 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.[37] 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.[38] It is important to note that the striking production decline in the Venezuelan oil industry is not due to an OPEC production cut.[39] OPEC production quotas are agreed upon by each member during OPEC meetings, and the estimates have been reported 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 rise during the 1970s, Table 6.[40] For instance, Indonesia increases its production by 85%.[41] In Mexico, one of the largest oil producer in Latin America that is not a member of OPEC, oil production more than quadruples in the 1970s, Figure 7. 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 grows, but much slower than the World or other big producers. During the 1960s, the World oil production more

[36]Reopening of the industry, i.e. privatization, begins in the early 1990s. Chang et al (2010) [29] discuss the recent two events in Venezuela: 1991-1992 the reopening of the oil sector to foreigners after the 1975 nationalization, and 2001-2002 the beginning of a renegotiation process.

[37]In 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 $\frac{2}{3}$ 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.

[38]Production 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) [49] 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 be responsible for the observed increasing productivity in post-1985 period.

[39]Venezuela is one of the founding members of OPEC in 1960.

[40]Higher prices in the 1970s induce countries to increase production.

[41]Indonesia became a member of OPEC in 1962.

than doubles, and OPEC production almost triples, while Venezuelan oil production increases by only 30%.

Manpower: In Figure 8, 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 begins in 1957, and continues until nationalization is finalized. The number of domestic workers and foreign workers decrease 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 the previous section. Figure 9 presents us this compositional change in a graph. In this figure, we decompose the work force 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 stays below 1%.

Venezuelan workers, on the other hand, expanded significantly after nationalization. During 1975-1979, the work force increases by about 10% each year.[42] Contraction during the period 1957-1975 is replaced by a fast expansion, which mostly took place in white-collar workers, as discussed previously.[43] Even though the number of domestic workers decreases during 1957-1975, the percentage of Venezuelan WC workers in total employment increases, because contraction in blue-collar workers is 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 imply a possible motive for replacing the high-profile of foreign workers. Ellner (1993) [34] 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 is common to the industry at that time or not. We find that Venezuela also deviates from the rest of the world with respect to oil employment, Figure 10. During the 1960s, the World oil employment is almost stable mostly due to stable oil prices, on the contrary, Venezuelan oil industry employment is

[42]The participation of oil employment in economy-wide employment increased by about 32.4% during 1975-1984.

[43]Even though that increase was attributed largely to the new exploratory activity, Coronel (1983) [30] and Ellner (1993) [34] argue that the increase was also a sign of the failure of the state to maintain existing efficiency. In fact, by a simple accounting exercise, we show that there is a significant efficiency loss during nationalization process and afterwards.

significantly contracted. In the early 1970s, a noticeable expansion begins across the World driven by increasing prices, while the Venezuelan employment doesn't start expanding until the end of 1975.[44] After nationalization, expansion in employment doesn't slow down even in the early 1980s due to declining prices.

We compare Venezuela with Mexico in Figure 7. As we can see, productivity captures production path quite well in both countries. However, they move in opposite directions. In Mexico, employment almost doubles with production more than quadruples 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) [15] 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 deviation is likely to be related to the nationalization policy implemented in Venezuela.

Exploration and Capital Expenditures: In Figure 11, we plot the total number of wells completed, and consider it as a proxy for exploration activity. In Venezuela, drilled wells drop sharply in 1957, and stays low until 1975. In the U.S. we don't observe a sharp drop, rather there is a gradual decline. The number of wells drilled begins increasing in the early 1970s in the U.S., while the increase starts with a lag in Venezuela, after nationalization. Then we observe a drop in drilling activity starting from the early 1980s both in Venezuela and the U.S.

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 12. 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 our sample, Venezuela. From 1958 to 1961, while capital expenses are stable in the rest of the World, they decline by more than 70% in Venezuela, which then stay almost stable until the year 1975. Capital expenditures start increasing across the World in the early 1970s, particularly in the Middle East. In Venezuela, however, the increase in capital investments

[44]Mackay (1984) [42] shows that total manpower in the World petroleum industry rises by 44% from 1960 to 1980.

accelerates with a lag after nationalization. But, from 1975 to 1982, capital investments rise more than the rest of the World, increase by more than ten-folds.[45] That is, Venezuela joined the capital investment expansion the last, but it expands the most in a seven years period. Another important aspect of capital investment pattern in Venezuela is the striking increase in exploration expenses relative to the rest of the World. Exploration expenses increase more than sixteen-folds from 1975 to 1982, i.e. after nationalization, in Venezuela compared to around three-folds increase in the U.S. and Canada, about six-folds increase in the Middle East.[46]

A simple explanation for the trends we observe in exploration activity and capital investments is that incentives to explore and invest are high when earnings are expected to be high. Rising prices in the early 1970s until the early 1980s is likely to be responsible for the expansion across the World including Venezuela. However, what we find prominent is the deviation of Venezuela from the rest of the World during 1957-1958 and 1971-1975.

Now, in this section, as a final step, we relate our main observations to the events taking place in the Venezuelan oil industry, and present our hypotheses. Then, in the nest section, we present our model and test our hypotheses

3.2 Discussion: Events and Hypotheses

The beginning of the oil industry goes back to the 1910s in Venezuela. The oil industry is under the control of foreigners until the late 1930s, government control is minimal, and exports are dominated by oil. In 1943, through the new hydrocarbons law, greater participation of the government is introduced, which is 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 is introduced in exchange for additional years of exploitation and the promise of granting extensive new areas, Martinez (1989) [44]. The principle of a 50-50 split in profits between the government and the multinational companies (MNCs) is also adopted, Mikesell (1984) [47]. Manzano and Monaldi (2010) [43] 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 remain relatively stable. Hence, stable distributive rules with a long investment

[45]From 1975 to 1982, capital investments rise by almost three-folds in the U.S. and Canada, by almost four-folds in Africa, and rise by more than five-folds in the Middle East. Hence, the expansion in Venezuelan oil industry represents the highest expansion in the sample.

[46]Over 1958-1982, exploration expenditures' share in total capital expenditures is in between 2% and 23%, Chase Manhattan Bank, Energy Division [2].

horizon lead to expansion in the industry during 1943 - 1958, which can be seen in Figure 13 as well.

In 1957/58, the dictatorship ends, and the democratic period begins with the adoption of a new constitution in 1961. A new regime requiring more spending with declining oil prices increase the government's incentives to increase its take from the industry. The government increases its share from 50% to 65% unilaterally through increasing the income taxes significantly in 1958 via a decree, which infuriated the foreign oil companies according to Manzano and Monaldi (2010) [43]. Moreover, in 1958, "no more concession" policy is announced.[47] 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.[48] Coronel (1983) [30] argues that the conditions of the policy, whose primary objective is to obtain 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 as discussed in Howarth and Jonker (2007) [38]. They emphasize that in the 1960s the Shell Group considered the conditions in Venezuela insufficiently attractive for further exploration activities, and the Group started shifting their operations elsewhere. During 1958-1973, there is little exploration, and a consequent stagnation in reserves follows due to companies refraining from exploring and investing, because they couldn't have eventual access to them Coronel (1983) [30] argues.

In the meantime, while additions to reserves is declining, production is increasing fast. Figure 14 shows the ratio of production to reserve additions over time.[49] Starting from 1958, annual additions to oil reserves have been consistently declining. From early 1960s to late 1970s, annual reserve additions have been lower than annual oil production. In other words, there is over-extraction. However, after nationalization, by the remarkable efforts put by the state-owned industry in exploration and expansion, reserves are increasing. But, since production can't be increased, there is under-extraction since the late 1970s.

Recurrent fiscal deficit along with declining oil prices cause further increases in the income taxes in the oil industry to increase government revenues. In 1971, the Reversion Law is passed, which states that all assets, plants, and equipment would be reverted to the nation. We assume that the

[47]It means that the last oil concessions are granted.

[48]Figure 8, Figure 9, Figure 11, Figure 12, and Figure 13 in the appendix.

[49]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.

nationalization process officially starts with this law. Note that, the law coincides with a sharp decline in productivity, see Figure 6. 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) [30]. 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 the organizational and managerial issues in the industry. All concessions are cancelled in 1975. That is, the oil industry is fully nationalized.[50]

In 1957/58, the government's participation starts to increase[51] 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" decree, 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: extract more and explore little or none, hence, boosting productivity in the short-run, but lowering productivity in the longer-run. In fact, Figure 6 shows how fast production and productivity were rising just before 1970, and how much they collapsed right after.[52] The high extraction rate 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 aggressive extraction which eventually have made nationalization inevitable. So, there is a possibility of a self- fulfilling nationalization. We argue that the policy announced during 1957-58 along with the unilateral tax increase is likely to generate expectations about nationalization, and following increases in taxes lead to the implementation of an *anticipated* nationalization. We claim that

[50]Petroleos de Venezuela, S.A. (PDVSA) is established to plan, coordinate, and control the activities of all the subsidiaries. In order to continue operations, technical and technological agreements are planned to be made with the MNCs. Moreover, maintaining administrative structure of the companies after nationalization is another important goal.

[51]See Table 7.

[52]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.

news about the future is a candidate for explaining the observed productivity pattern.[53]

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 effort the nationalized industry put, production and productivity do not recover.[54] We claim that this might be due to another challenge: lost foreign workers. The number of foreign workers declines remarkably, Figure 9, and after nationalization their percentage in total work force stays below 1%. This may imply a substantial loss in know-how if the available knowledge in the industry was dominated by the international firms.[55]

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 work force in the oil industry changed by nationalization. We argue that nationalization eliminates foreign workers, which was not the case for Saudi Arabia. In addition to that, in Figure 15, 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[56], we can conclude that foreigners were comprising key highly skilled workers in the industry and eliminating them is likely to bring lost know-how. This can also create motives to replace high qualified foreign workers with significant amount of domestic workers. In this context, if foreign know-how is complementary with the other factors of production, then nationalization would be costly. Lack of a critical factor in extraction can cause the continuing decline in production despite fast expanded domestic workers

[53]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 trying to stay in the country. Article 15 of the law provides 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 is about $1,012,571,901.67, Coronel (1983) [30]. According to Martinez (1989) [44], compensation payments to former concessionaires and equity holders in 31st December 1975 is in total 1,342.28 million $.

[54]A transition from a period of stagnation to a period with significant expansion plans has 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, which can contribute to the managerial problems that occurred 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.

[55]In this context, overstaffing can indicate a substitution motive with less qualified local workers.

[56]Barro and Lee (2010) [40].

and reserves, which together with political favoritism would yield decreasing productivity. So, **losing foreign know-how** together with political favoritism can be good candidates in explaining the productivity pattern, especially in the post-nationalization period.

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.[57] However, it is also possible that the oil companies may have exploited the easy-to-extract reserves as much as possible, and left the Venezuelans with the hard-to-extract fields.[58] To rule out these kinds of stories, we investigate drilling activity in more detail. We group wells into three main categories according to LAHEE 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 16, 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 not only very common but also productive due to increasing success rates meaning that those wells are mostly productive, see Figure 18. Consequently, additions to reserves and proved reserves increase in the post-nationalization period. However, production did not increase, which imply that extraction became a challenge from existent productive fields for the nationalized industry. In addition, although the industry was able to add its reserves by developing existent productive fields, they were not able to discover new productive fields. Figure 17 shows the number of new wildcats, which is consistently low until the late 1970s. Their number starts increasing, but their success rates are lower. That is, newly discovered areas are mostly unproductive. These imply that extracting oil from already productive areas and discovering new fields that are productive have become more difficult with the 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 and lost foreign know-how can explain the impact of nationalization on productivity.

[57]Perhaps, because it represents a loss in organizational capital.

[58]This would be like a drop in TFP, and might also have contributed to the drop in output.

4 Model

The model we present adopts the general framework developed by Pindyck (1978) [52] which is then applied by Yucel (1986) [57], and Deacon (1993) [31]. The model is a dynamic partial equilibrium framework for nonrenewable resources. We assume that the industry takes prices and taxes as given, and chooses exploration and production paths to maximize the present value of profits.[59] Assume that the industry is composed of identical firms and there are no externalities. Hence, we can consider a representative firm exploiting the resource. 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, on the other hand, depletes reserves. To simplify, our model abstracts from uncertainty.

We will consider two common forms of taxation in natural resources: severance (royalty) taxes, i.e. taxes on production, and taxes on income. These are common revenue sources for resource producing countries. Royalty taxes are levied on total sales, and income taxes are levied on total private profits. In reality, 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 we will describe a permanent change in policy through changes in taxes.

First, we will describe our 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, reserves are also assumed to serve as a capital input.[60] Despite this similarity, our technologies differ from them in several respects. First of all, 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 that are imperfect substitutes, and in exploration labor inputs that are imperfect complements generate additions to reserves. We construct our labor inputs series by using our novel data on the oil industry manpower, which is presented in the Appendix. Secondly, we provide a quantitative analysis on the impact of nationalization on extraction and

[59] By assuming the industry is a price taker, we are not departing completely from the Venezuelan reality.
[60] Devarajan and Fisher (1982), Yucel (1986), Deacon (1993).

exploration through anticipated and unanticipated tax changes, which -to our knowledge- have not been addressed in the literature. Moreover, the parameters of the relevant functions represent the petroleum sector in Venezuela.

4.1.1 Extraction Technology

We develop a production function that differs from the standard production function used in resource analysis. The alternative model is motivated by the key facts of the Venezuelan oil industry. In previous sections, we show that a considerable expansion in the workforce and significant increase in exploration took place in the industry after nationalization. However, this did not lead to a recovery in production and productivity, they continued to decline. The recovery started ten years after nationalization.[61] Given the fact that in this period domestic workforce and reserves increased but foreigners, who were high-skilled personnel, were eliminated, the main missing factor to be considered would be foreign workers. These motivate the following hypothesis: If foreigners have skills that are complementary with the other factors of production, then their elimination would bring losses. In order to implement this theory, we develop a production function with three inputs. This technology distinguishes between skilled and unskilled labor, and takes reserves as the form of capital.

We consider four categories of labor input in our analysis: extractive skilled & unskilled (or less skilled), and exploratory skilled & unskilled.[62] We assume that the skill level is exogenous, that is, individual's skill level is not determined within the model. We will continue with describing the extraction technology first.

Let's denote the production function with $H(\cdot)$. Reserves must enter into this technology in a certain way.[63] In this context, the main characteristics of the production technology are as follows:

1. $H(\cdot)$ is a function of reserves, R_t, skilled labor in extraction, S_t, and unskilled labor in extraction, U_t
2. $R_t = 0 \implies H(\cdot) = 0$
3. $\lim_{R \to 0} \frac{\partial H}{\partial R} = \infty$

[61] Although time-to-build nature of exploration is likely to result in a later recovery (increase) in production, ten years seems to be a long period. Because, typically there is a three to at most seven years lag from beginning of exploratory expenditures to substantial production gains. Hence, we cannot directly attribute the late recovery to time-to-build nature of exploration. Moreover, technological innovations in early 1980s might contribute the increase in 1985.

[62] Therefore, we consider not only a skill-level criterion but also an operational criterion.

[63] Our discussion is in line with Dasgupta and Heal (1974).

(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 depletion of the resource in finite time is not allowed.

We will consider the class of production functions for which the elasticity of substitution is constant. Given this, (1) - (3) suggest that

$$H(R, S, U) = \Gamma(S, U)R^{\upsilon}$$

where $0 < \upsilon < 1$, and $\Gamma(S, U)$ is homogenous of degree $\leq (1 - \upsilon)$. In other words, we need a Cobb-Douglas technology. So, we assume that $H(R, S, U)$ is a non-increasing returns to scale Cobb-Douglas production function. We choose to represent $\Gamma(S, U)$ by a CES functional form, so that skilled and unskilled labor inputs would interact in a particular way. Hence, we consider a production technology with a general nested CES functional form, which allows for different substitutability across factors. It is formulated as follows:

$$H(U_t, S_t, R_t) = {R_t}^{\upsilon} \left[\mu(h_U U_t)^{\sigma} + (1 - \mu)(h_S S_t)^{\sigma}\right]^{\frac{\gamma}{\sigma}}$$

where $0 < \mu, \upsilon, \gamma < 1$; $\sigma \leq 1$; and $\upsilon + \gamma \leq 1$. The extractive efforts, U and S, 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. $h_U, h_S > 0$ 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 $[\mu(h_U U_t)^{\sigma} + (1 - \mu)(h_S S_t)^{\sigma}]^{\frac{1}{\sigma}}$. The second term is a CES aggregate over unskilled labor, U, with share parameter μ, and skilled labor, S, with share parameter $1 - \mu$. The parameters υ and γ measure the shares of reserves and composite labor in income, respectively. The parameter σ governs the degree of substitutability between unskilled labor and skilled labor, and hence key to our theory.[64]

Next, we describe the exploration technology.

[64] σ being zero means Cobb-Douglas for the nested aggregate. The elasticity of substitution between unskilled labor and skilled labor is $\frac{1}{1-\sigma}$. Note that this definition holds only if all other input quantities are constant, Blackborby and Russell (1989) [27].

4.1.2 Exploration Technology

Output of exploratory activity is represented by the technology $G(E_{u_t}, E_{s_t})$, where E_u, E_s are the unskilled and skilled exploratory efforts, i.e. labor inputs participating in exploration. $G(\cdot)$ is strictly increasing and strictly concave. Concavity implies that the marginal discoveries made by additional exploration diminish as exploration proceeds. So, $G_k > 0$, and $G_{kk} < 0$ for decreasing returns, where $k = u, s$.

We choose the following Cobb-Douglas technology for exploration: [65]

$$G(E_{u_t}, E_{s_t}) = (h_u E_{u_t})^{\theta_1} (h_s E_{s_t})^{\theta_2}$$

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

Given our technologies, now we present the model.

4.2 Reserve Dynamics, and the Firm's Problem

Reserves dynamics are governed by the following state equation:

$$R_{t+1} = R_t - H(U_t, S_t, R_t) + G(E_{u_t}, E_{s_t})$$

The equation implies that change in reserves depends on both how much effort you put into exploration, and how much you extract. Extraction lowers reserves while exploration increases them. The key underlying reason for exploration is to prevent extraction costs from becoming restrictive by enhancement of reserves.

At each date t, the producer seeks to solve

$$v(R_t, P_t, w_{U_t}, w_{S_t}, w_{u_t}, w_{s_t}, \tau_{r_t}, \tau_{\pi_t}) = \text{Max}\{\Pi(\cdot) + \beta \mathbb{E}[v(R_{t+1}, P_{t+1}, w_{U_{t+1}}, w_{S_{t+1}}, w_{u_{t+1}}, w_{s_{t+1}}, \tau_{rt+1}, \tau_{\pi t+1})]\}$$

[65] Cobb-Douglas exploration function has been used in the literature, Pindyck (1978), Yucel (1986), Barrett (1986), etc. 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. For the sake of simplicity, we suppress the additional argument.

subject to the constraints

$$\Pi(\cdot) = (1-\tau_{\pi_t})\left[(1-\tau_{r_t})P_t H(U_t, S_t, R_t) - w_{U_t}U_t - w_{S_t}S_t\right] - (1-\tau_{\pi_t}c)(w_{u_t}E_{u_t} + w_{s_t}E_{s_t})$$

$$R_{t+1} = R_t - H(U_t, S_t, R_t) + G(E_{u_t}, E_{s_t}) \tag{1}$$

$$H(U_t, S_t, R_t) = {R_t}^{\upsilon}\left[\mu(h_U U_t)^{\sigma} + (1-\mu)(h_S S_t)^{\sigma}\right]^{\frac{\gamma}{\sigma}}$$

$$G(E_{u_t}, E_{s_t}) = (h_u E_{u_t})^{\theta_1}(h_s E_{s_t})^{\theta_2}$$

Here, τ_π is the tax rate on income, τ_r is the royalty (severance) tax rate, and P is the real price of the commodity. w_i's are the real unit costs of different types of labor, where $i = U, S, u, s$. We allow for the producer to deduct c proportion of the exploration expenses from the tax bill.[66]

Denote the marginal products by H_i and G_j. Then, the optimality conditions describing the solution of the model are:

1. with respect to extractive efforts, $i = U, S$

$$(1-\tau_{\pi_t})(1-\tau_{r_t})P_t = (1-\tau_{\pi_t})\frac{w_{i_t}}{H_{i_t}} + \eta_t \tag{2}$$

2. with respect to exploratory efforts, $j = s, u$

$$\eta_t = (1-\tau_{\pi_t}c)\frac{w_{j_t}}{G_{j_t}} \tag{3}$$

3. intertemporal optimization condition

$$\eta_t = \beta\mathbb{E}\left[(1-\tau_{\pi_{t+1}})(1-\tau_{r_{t+1}})P_{t+1}H_{R_{t+1}} + \eta_{t+1}(1-H_{R_{t+1}})\right] \tag{4}$$

where η_t is the shadow value of an additional unit of reserves.

The first order conditions for extractive efforts, equation (2), yield that the marginal benefit of producing a unit of the resource at time t is equal to the marginal cost, marginal extraction cost plus the scarcity value of a unit of reserves in the ground. The scarcity value, η_t[67], is the expected present value of having one more unit of reserves in the next period. Equation (3), the

[66] In our specification, we abstract from the fact that the quality of deposits declines as production increases, that is extraction becomes more costly as reserves decline and low-cost reserves are exploited first. For instance, Solow and Wan (1976) develop a model with deposits differing in quality where the total reserves are fixed. One reason for our exclusion is insufficient data on costs.

[67] Also known as the resource rent at time t.

optimality condition for exploratory efforts, imply that the producer chooses optimal exploratory efforts so that the marginal exploration cost is equal to the marginal benefit from exploring, the resource rent. Finally, equation (4), the dynamic intertemporal optimization equation, governs the optimality condition between today and tomorrow.[68] Marginal value of a unit of reserves today is equal to the expected present value of the flow of income that an additional unit of reserves can generate next period plus the depreciated scarcity value.[69]

Equations (1) through (4) govern the evolution of the variables $R_t, U_t, S_t, E_{u_t}, E_{s_t}, \eta_t$ taking exogenous variables $\{P_t, w_{U_t}, w_{S_t}, w_{u_t}, w_{s_t}, \tau_{\pi_t}, \tau_{r_t}\}$ as given. Our quantitative results depend on the parameters of the functions. In the following section, first we will present our calibration, and then quantitative assessment of the impact of nationalization.

5 Quantitative Analysis

5.1 Calibration

We will calibrate the model to the data for the Venezuelan oil industry. The data is annual time series. Relative to standard models of resources, our approach has novel elements. We represent exploratory and extractive efforts by different types of labor, hence, the related parameters are new.

We follow a similar approach used in Krusell, Ohanian, Rios-Rull, and Violante (2000) [40] to construct 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) [52], which will represent annual time series for $G(\cdot)$. For reserves and production, we use 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, β, is set at 0.90 to generate an 11% annual real interest rate. The parameter governing the elasticity of substitution between skilled and unskilled labor in extraction is set at a baseline value, $\sigma = -0.5$. We argue that the complementary skilled labor, representing foreign workers, and unskilled labor, representing domestic workers, can help us explain the observed trends. For this purpose, σ must be set at a value less than 0, and we assume a baseline value of -0.5. We will consider a range of

[68] The so-called Euler Equation.

[69] Whether you extract it or not, reserves have value. They can be extracted or left to the next period with a scarcity value. $(1 - H_R)$ term on the right hand side is like $(1 - \delta)$ in the euler equation of the neoclassical growth model. That H_R behaves like an endogenous depreciation rate.

alternative values for σ in our experiments.

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 U, S, E_u, E_s, 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 $i = U, S, u, s$.

We set the ratio of extraction costs between unskilled and skilled labor at 1.7 (the average $\frac{w_U U}{w_S S}$ ratio for the Venezuelan oil industry), and obtain $\mu = 0.585$. We choose υ and γ so that production is equal to the new reserves added, and production to reserves ratio is 0.39. The pre-1960 ratio of exploration costs between unskilled and skilled labor is 1.726. Using this target along with the average reserve additions over the period 1948-1959, we obtain θ_1 and θ_2. The parameter values are summarized in Table 10.

For our quantitative analysis we also need to obtain c, the tax credit on exploration expenses. We calculate it following Deacon (1993) [31]. c in our 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." Following him, we set e at 0.45. During the period 1953-1957, the production to reserve ratio, d, is almost constant in the Venezuelan oil industry. We calculate d as the average production to reserves ratio over 1953-1957. This allows $f = \frac{d}{r+d}$, where r is the interest rate, which was set at 11%. Hence, we obtain $c = 0.651$.

5.2 Results

In this subsection, we study the impact of nationalization on exploration, production, and hence productivity, quantitatively. The model is solved using *Dynare*. The year 1959 is considered to be the steady state, and is chosen to be the starting point.

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. This is why we choose 1959 to be the starting point. We describe and introduce nationalization as follows: First, we assume that the agents in the economy anticipate in the year 1959 that the government will increase its participation through higher taxes permanently, which will be initially realized in the year 1970. We suppose

that the formal nationalization process starts in 1970, because later that year the Income Tax Law is amended, and the ministry co-managed the industry with the MNCs until the nationalization process is finalized in the year 1975. So, at time $t = 1$, which corresponds to the year 1959, the industry foresees a once-and-for-all change in tax rates. Table 7 summarizes the time path of marginal tax rates we feed in our simulations. Income tax increases gradually by abound 60%.

Second, we argue that the foreign workers have become a missing factor in the industry. That is, nationalization also has eliminated foreign know-how. We consider imposing a tax on wages paid to foreign workers and gradually eliminate foreign workers by more than 71%. We assume that the skilled labor input in both extraction and exploration in the model represent foreign workers. Then, we feed the actual number of extractive and exploratory foreign labor into the model.

Third, we introduce political favoritism as follows: we subsidize domestic workers by subsidizing their wages by around 24%. Hence, we attempt to provide a quantitative analysis by focusing on the tax rate increases, decline in the foreign labor input, and expansion in domestic workers.

Before proceeding with the quantitative assessment of the impact of nationalization, we first present dynamic effects of an increase in income tax and a decline in the number of skilled workers on the industry decisions under no foresight and foresight.[70] This enables us to understand how the proposed mechanisms work.

5.2.1 Baseline Simulations

Increase in the income tax rate

Figure 19 presents the impulse responses of a permanent income tax shock only. Solid lines are the responses to an unanticipated permanent 52% 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 would pro-

[70]We 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.

vide an incentive to increase the extractive efforts while induce 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 is stable. Note that exploratory efforts decline more than the increase in extractive efforts resulting in declining total labor input. This implies increasing labor productivity, where labor productivity is measured as total production divided by total labor input. But, this 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. In this sense, the increase in productivity seems puzzling, because we are expecting things to be more inefficient by an increase in income taxes.

Even though announcement of a higher tax on income seems to be harmless on extraction before it has been realized, both in terms of exploration and extraction it is costly, which is important from a policy making perspective. 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.

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 the long run, the overall impact of both anticipated and unanticipated tax shocks are similar. Hence, in terms of assessing policy, announcing a policy in the long run result in similar distortions. However, in the short run, announcement of the policy distorts exploration and extraction incentives significantly.

Losing foreign know-how

Figure 20 presents the impulse responses of a permanent foreign know-how shock only. Solid lines are the responses to an unanticipated permanent 70% exogenous decline in the number of

foreign workers. The dashed lines are, on the other hand, the responses under 10 periods foresight. In our setting, this change corresponds to a 70% decline in both E_s and S, both are assumed to be exogenous.

The unanticipated decline in the number of foreign workers is realized at time $t = 1$. The responses are similar to those to an unanticipated income tax increase. The only difference is that unlike a smooth decline in extraction, in response to the sudden drop in foreign workers, extraction also falls immediately.

News about elimination of foreign workers realized at the beginning of time 11 arrives at the beginning of time 1. The responses before policy realization are similar to those to an anticipated income tax shock. After policy realization, drop in extraction continues, and exploratory efforts increase only slightly.

In the long run, the overall impact of both anticipated and unanticipated lost foreign know-how are similar. However, in the shorter term, ignoring foresight seems to only leads to small impact on exploration and extraction.

5.2.2 Nationalization

We presented in Table 7 the average total government take in the Venezuelan oil industry. However, we do not have a clear description of the calculation if the take. We will assume that this take includes mainly royalty and income taxes.

Nationalization is simply exogenously given. In the early 1960s, the producer is anticipating a permanent increase in government take through higher income tax which has been realized in the year 1970. The income tax rate increased from 0.46 to 0.70, as we observe in the data. Moreover, expected nationalization brings elimination of foreign workers. 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 tax on their wages. In our experiment the decline for the ten-year period is around 71%. Figure 21 shows actual data versus our simulated data. Table 11 presents how successful the model is in accounting for the impact of nationalization on productivity.

Figure 21 suggests that the simulated response to nationalization explains actual time series quite well despite the simple structure of the model. Over 1961-1980, the proposed mechanism can account for more than 85% of the productivity pattern. Moreover, we run a counterfactual experiment and ask whether the nationalized industry is better off by nationalization or not. We calculate measured profits using simulated data, and find that they lost more than half of their

profits, Table 12. This implies that although the industry gets the whole by nationalizing, what they got is much 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. 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 industry. However, these can come at the expense of remarkable losses in productivity.

In this paper, we study the Venezuelan oil industry nationalization in 1975: we document the impact of nationalization on the industry performance, and how it proceeds in practice. After presenting the effects on general areas in the oil industry, we show that nationalization brings striking losses in production and productivity. We argue that anticipated nationalization and lost foreign know-how can explain the impact of the policy by providing evidence on the proposed channels. Then, using macroeconomic tools, we test the ability of the proposed channels in explaining the Venezuelan experience by developing a relatively simple but non-standard framework for non-renewable resources. Simulations of the calibrated model suggest that anticipation together with lost foreign know-how result in lower extraction and exploration, which brings declining total employment, but increasing measured productivity prior to nationalization. By realization of the policy, extraction declines, and decline in exploration weakens, hence productivity starts declining. The anticipated policy entails lost foreign know-how. They together can explain the path of productivity quite well given the simple structure of the model.

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 is not 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, which can be captured via a latent variable representing productivity of reserves whose growth rate is negative, or via the assumption that extraction becomes more costly as cumulative amount already extracted increases, as in Solow and Wan (1976) and Heal (1976). Third, we did not attempt to explain post-1975. For this analysis, the objective of the firm must be different. Developing two different problems for pre and post 1975 periods can help explain the paths after nationalization better.

Finally, developing a general equilibrium model with two sectors, resource and non-resource, can result in understanding how a government policy such as nationalization can contribute to the development problem of a resource rich country.

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APPENDIX I

a. Historical Trends in Expropriation Acts

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.[71] Kobrin (1980) [9] 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.[72] Almost no 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 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 (2010) [7] 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, they are desired to be controlled by the government possibly because they dominate the economy and thereby making foreign ownership intolerable.

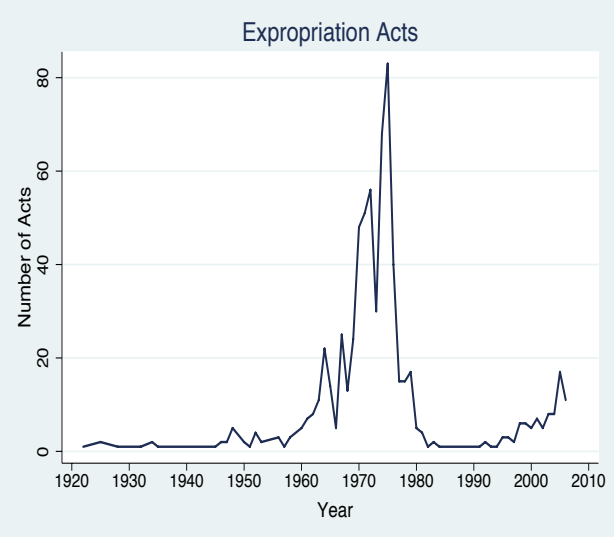
Table 2 shows the regional distribution of all acts. Africa and Latin America account for 39% and 30% of all acts, respectively. Middle East and Asia have lower shares, 16.4% and 15.3%, respectively. Finally, Table 3 indicates types of forced divestment over 1922-2006.[73] Nationalization is the most prevalent form of taking, 53% of all acts, which is followed by forced sale, 27% of all acts. Contract renegotiation accounts for 12% of all acts, and finally, intervention has a share of

[71] Kobrin (1980) [9], Hajzler (2010) [7], Tomz and Wright (2008) [20].

[72] Several motivations are discussed in the literature. For instance, Kobrin (1980) [9] 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).

[73] Note that 81.5% of the acts has been coded with the form of taking information.

Figure 1: Time Pattern of Expropriations



8% only. However, except nationalization, there is a significant shift in the form of taking across different periods. Contract renegotiation has become much more prevalent, and forced sale has become much less prevalent. Intervention has also become less common. However, nationalization is consistently the most prevalent form of taking.

Table 1: Sectoral Distribution of Acts

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

Table 2: Regional Distribution of Acts

	% in total acts
Africa	38.8
Latin America	29.5
Middle East	16.4
Asia	15.3

Table 3: Type of Taking

	% of Acts		
	1922-2006	1960-1979	1989-2006
Nationalization	53.23	52.99	54.55
Contract Ren.	12.04	8.04	34.09
Intervention	7.68	8.45	3.41
Forced Sale	27.05	30.52	7.95

b. Impact of Expropriations on Productivity in the Oil Industry

Table 4: Labor Productivity relative to the U.S.

	pre-nationalization	**post-nationalization***
Algeria	37.8	26.6
Colombia	194.4	77.5
Peru	158.5	74.5
Venezuela	130.9	86.4

* Productivity at the time of Nationalization = 100

Figure 2: Peru and Colombia

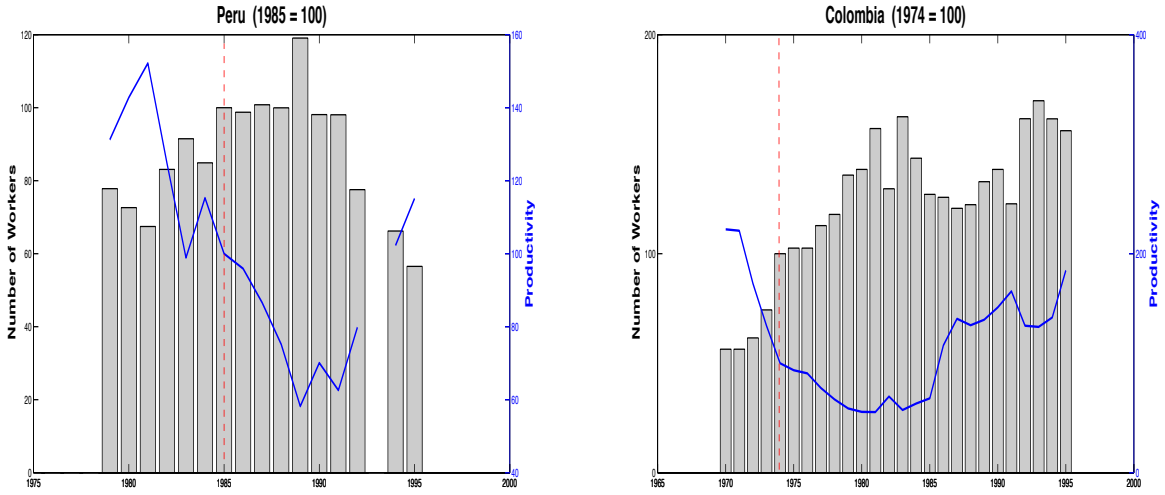


Figure 3: Algeria

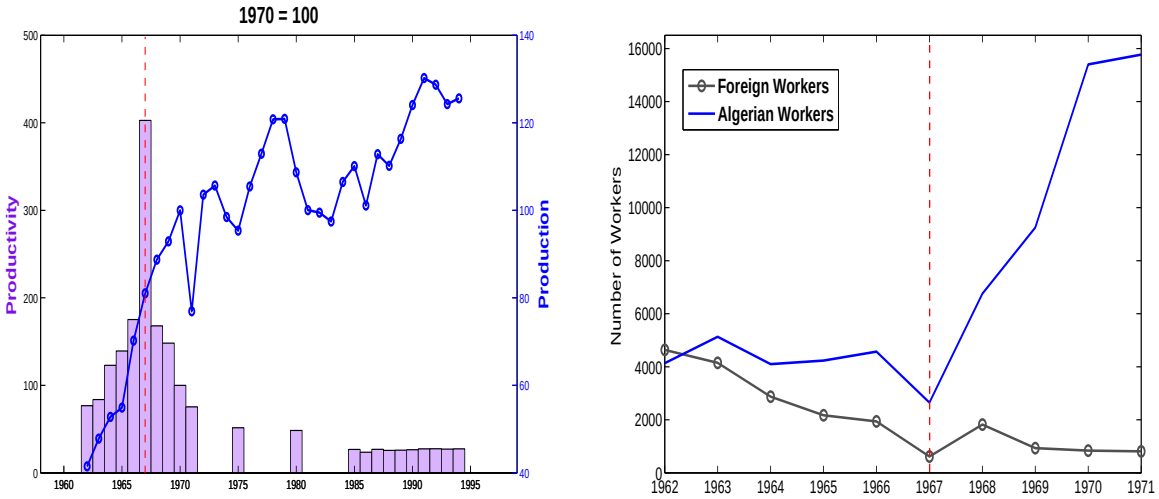


Figure 4: Venezuela

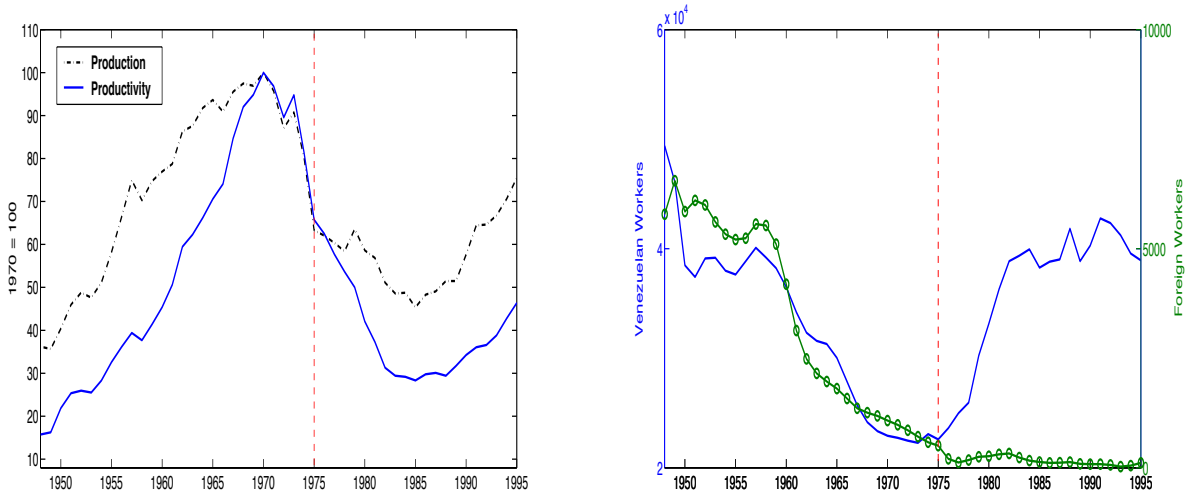


Figure 5: Number of Workers and Productivity in the U.S. oil industry

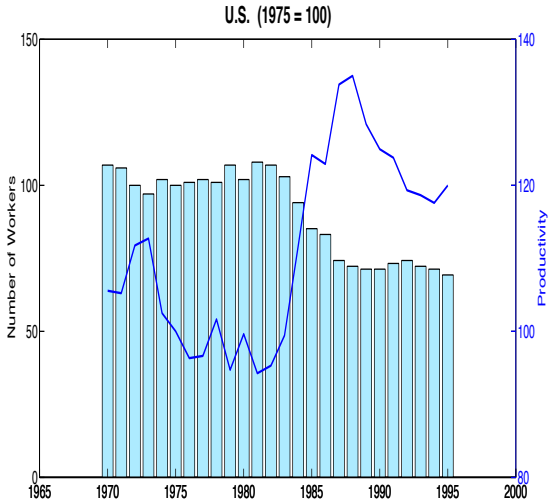


Table 5: Algerian Oil Employment, by occupation and by nationality

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

Source: Brogini (1973) [1]

APPENDIX II

a. The Venezuelan Oil Industry Facts

Figure 6: Historical Oil Production and Productivity

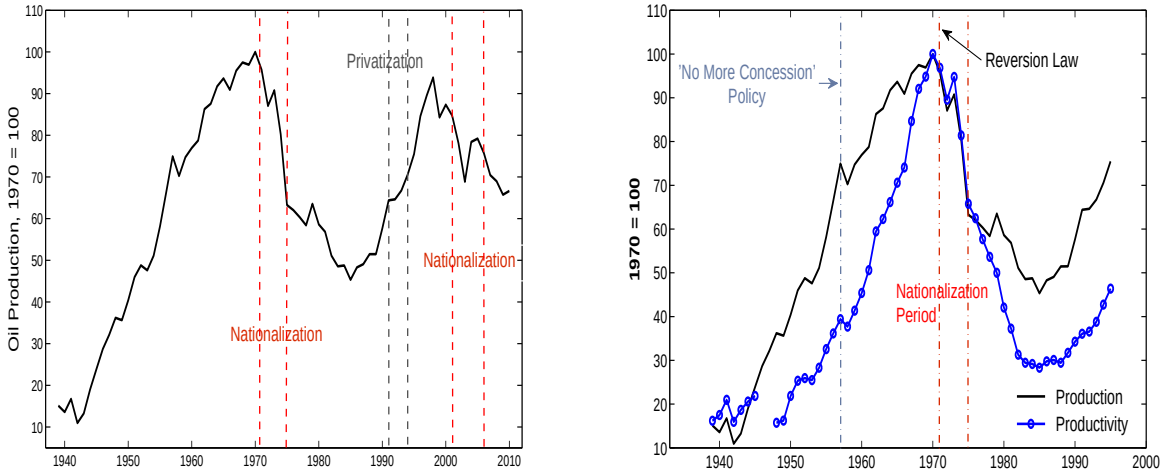
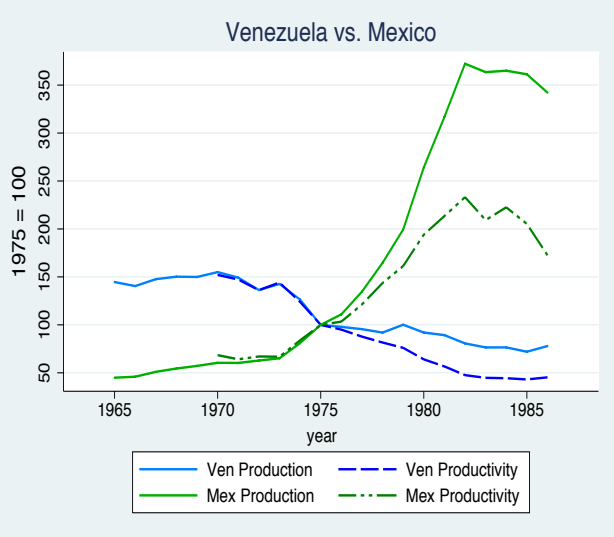


Table 6: Crude Oil Production, Δ%

	Total OPEC	**Total World**
1960-1970	+ 169.4	+ 115.2
	Venezuela	
	+ 30.3	
1970-1980	+ 14.8	+ 31.4
	Venezuela	
	- 40.7	

Sources: British Petroleum Statistical Review of World Energy, OPEC World Crude Oil Production

Figure 7: Venezuela vs. Mexico



Source: Randall (1989) [15], and British Petroleum Statistical Review of World Energy

Figure 8: Total Employment in the Venezuelan Oil Industry

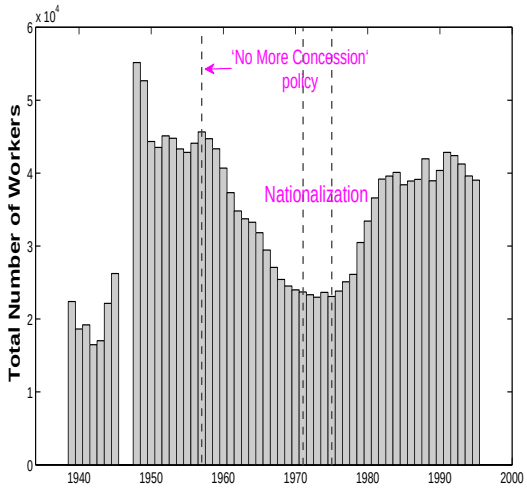
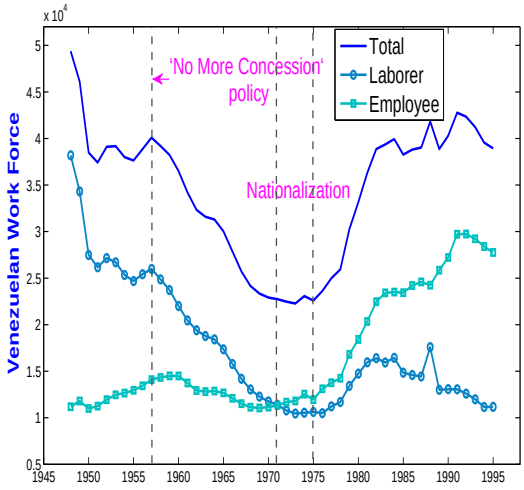
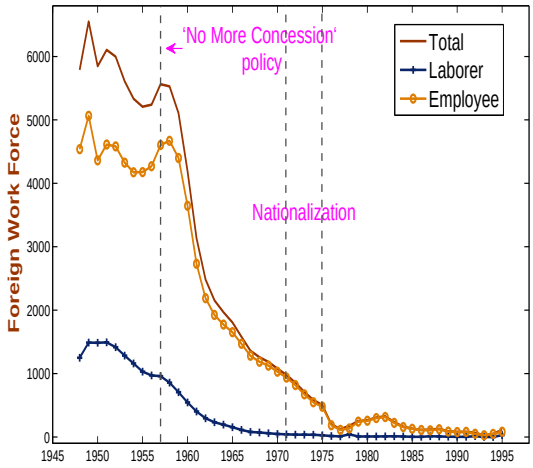


Figure 9: Composition of the Work Force in the Venezuelan Oil Industry

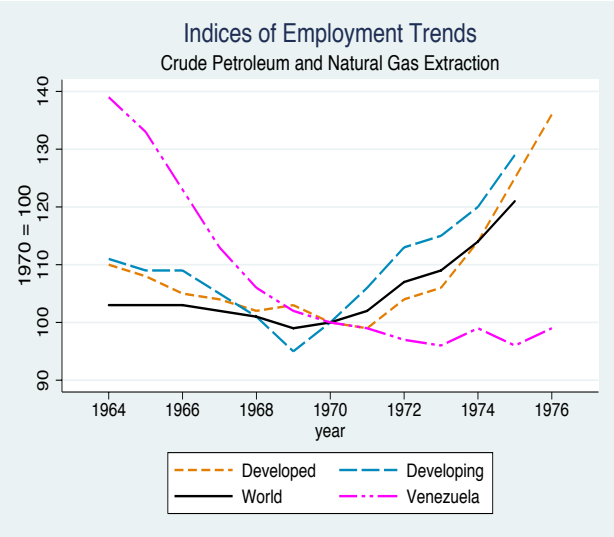


(a)



(b)

Figure 10: Employment Trends in the World



Source: General Report, Petroleum Committee, 1980, *International Labor Organization, Programme of Industrial Activities*. Developed Market Economies include Canada, USA, Europe (excluding centrally planned economies), Australia, Israel, Japan, New Zealand and Republic of South America. Developing Market Economies include Caribbean, Central and South America, Africa, Asian Middle East, East and Southeast Asia. World excludes Albania, China, Democratic People's Republic of Korea, Mongolia, Vietnam.

Figure 11: Total Number of Wells Drilled

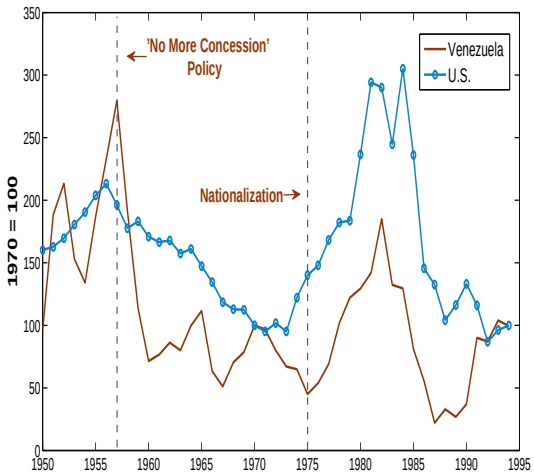
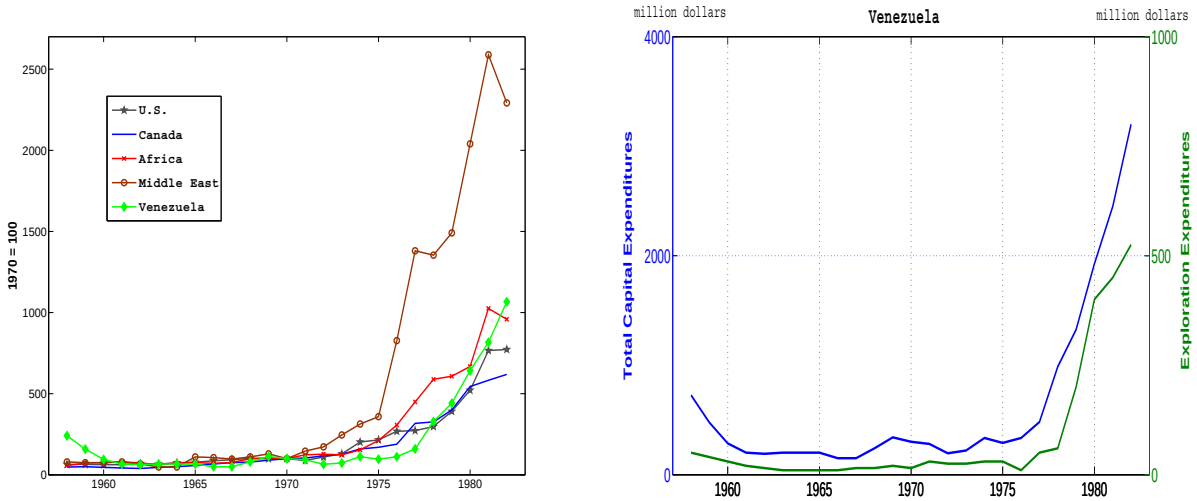


Figure 12: Capital Investments of the World Petroleum Industry



Source: Chase Manhattan Bank, Energy Division

Figure 13: Expansion in the Venezuelan Oil Industry during 1943-1957

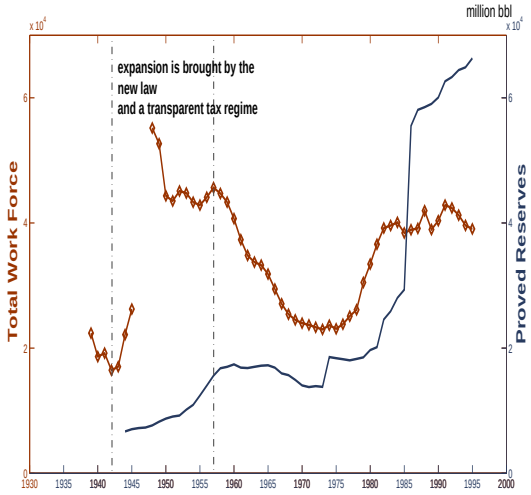


Table 7: Total Government Take in the Venezuelan Oil Industry

	1936-1942	1943-1957	1958	1974-1975
Percentage (%)[a]	39	50	65	94

[a] The percentages are representing the average total government take on oil companies' total profits, Martinez (1989) [44], Manzano and Monaldi (2010) [43].

Figure 14: Production to Reserve Additions Ratio

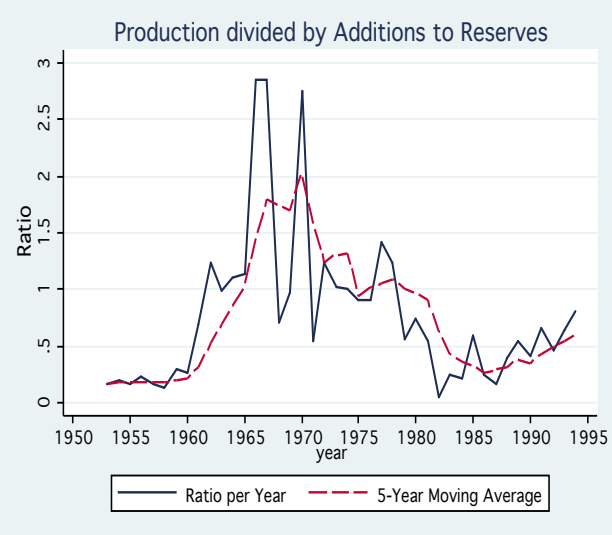
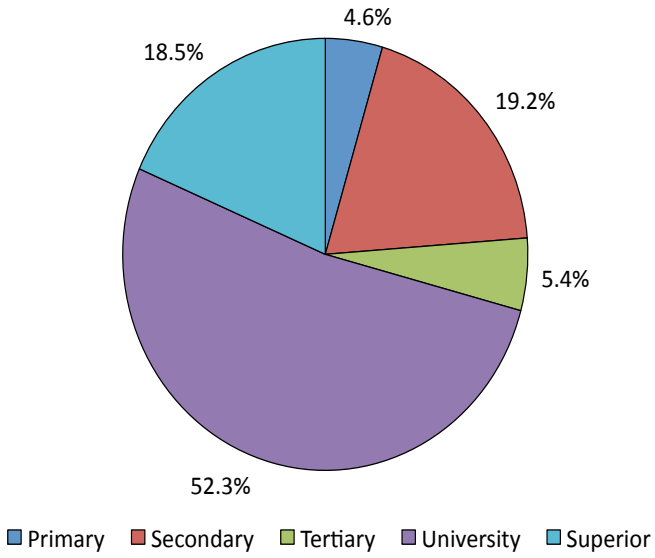


Figure 15: Education Level Distribution of the Foreign Personnel Employed in the Venezuelan Oil Industry, 1970



Source: Michelena and Soublette (1976) [54]

Figure 16: Number of Drilled Wells by Type

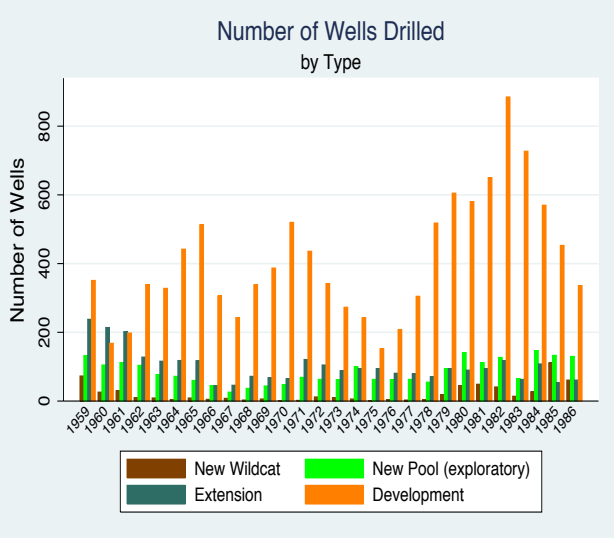


Figure 17: New Field Drilling

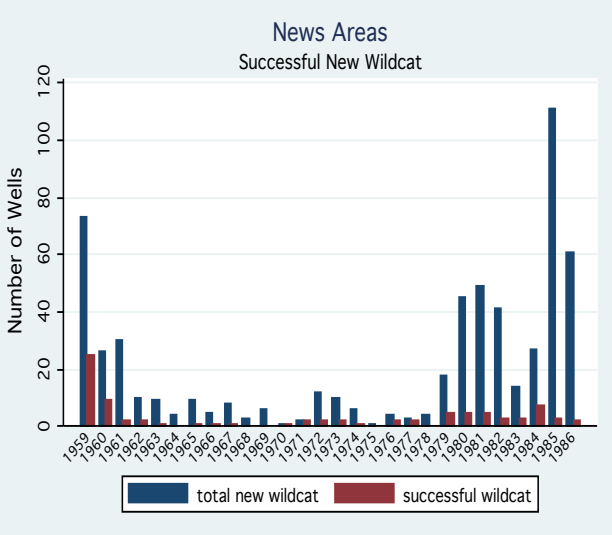
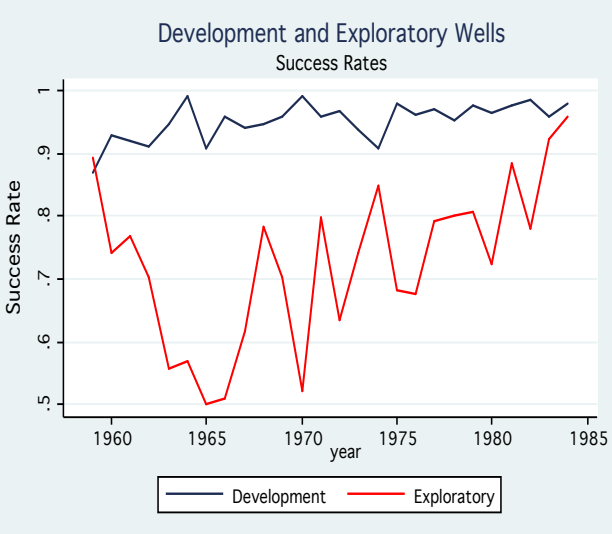


Figure 18: Success Rates of Development and Exploratory Wells



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) [52]. 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) [54], and Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census Databook for the year 1987.

For the years 1948-1995, 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, but we recorded them in millions of 1990 U.S.$. Michelena and Soublette (1976) [54] present the 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. 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 depending on 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 by MMH databooks. In the third step, we classify these groups into extractive and exploratory skilled and unskilled labor. We compute 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. Next, we describe how we construct the groups in more detail.

Construction of the Groups

MMH Databooks report only the total number of employees and laborers in the oil industry by their nationality, i.e. Venezuelan versus Foreign. They did not provide any further information on the demographic characteristics. So, we try to get evidence from other sources that can help us construct our labor input series. Michelena and Soublette (1976) [54] presents the occupational profile of the oil industry for the year 1974:

This table includes both oil and petrochemical industries. However, oil industry workers account for more than 76% of this profile, so we will use it as a proxy for the oil industry. Here, technologist is equivalent to a mid-level technical education graduate. "Others" in the last category includes secretaries, clerical and unskilled workers. We consider professionals as one broad group consisting managers, administrative workers, and technical workers where technical workers include technical, research, and others categories. Technologists and operators are regarded as mid-level workers, and finally, "others" in the last category are considered as unskilled workers. Assuming that this

Table 8: Occupational Profile, Venezuelan Oil Industry, 1974

Categories of Personnel	**% in Total Workers**
University Professionals	10
Management	1.13
Technical	6.13
Administration	1.94
Research	0.064
Others	0.74
Technologists	3.06
Opearators	25
Others	61.94

occupational distribution was true at any time t, using data on the total number of workers in the oil industry, we obtain three broad groups at time t.

We have the number of foreign workers in the oil industry by the office held, i.e. occupation, in 1970. First, we group them according to the above broad categories, and calculate the percentage distribution. Table 9 presents this distribution:

Table 9: Foreign Workers in the Oil Industry, 1970

Categories of Personnel	**Percentage (%)**
Professionals	70.6
Management	9.3
Technical	46.7
Administration	14.6
Mid-level	24
Unskilled	5.4

Under the assumption that this distribution holds at all times, we obtain the time series data for foreign workers in the industry by occupation. Then, given the distribution for the total employment, the rest of the workers are recorded as domestic professionals, domestic mid-level workers, and domestic unskilled workers.[74] Now, we have ten groups, foreign: professionals - management, technical, administration-, mid-level, and unskilled; and domestic: professionals -

[74]We eliminated the data points which create a discrepancy, that is the sum of foreign and domestic workers under our categorization do not add up to the total number of workers we have at the beginning, which might arise due to our assumptions.

management, technical, administration-, mid-level, and unskilled.

We have recorded real total wages paid to workers. No further information is provided in the databooks. We use anecdotal evidence on the wage differences between domestic and foreign workers in the Venezuelan oil industry, and foreign workers basic remuneration statistics in order to group real wage per worker into ten categories, which will then be used to construct total unskilled and skilled labor input and wage per worker.

Table 10: Calibration to the Venezuelan oil industry data

Parameter	**Value**
Discount factor (β)	0.90
Elasticity of substitution between extractive labor inputs ($\frac{1}{1-\sigma}$)	0.67
Composite labor share in extraction (γ)	0.61
Share of unskilled labor in extraction (μ)	0.585
Share of reserves (υ)	0.22
Share of unskilled labor in exploration (θ_1)	0.495
Share of skilled labor n exploration (θ_2)	0.287
Productivity of extractive unskilled labor (h_U)	1.87
Productivity of extractive skilled labor (h_S)	9.12
Productivity of exploratory unskilled labor (h_u)	2.74
Productivity of exploratory skilled labor (h_s)	5.86

Figure 19: 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

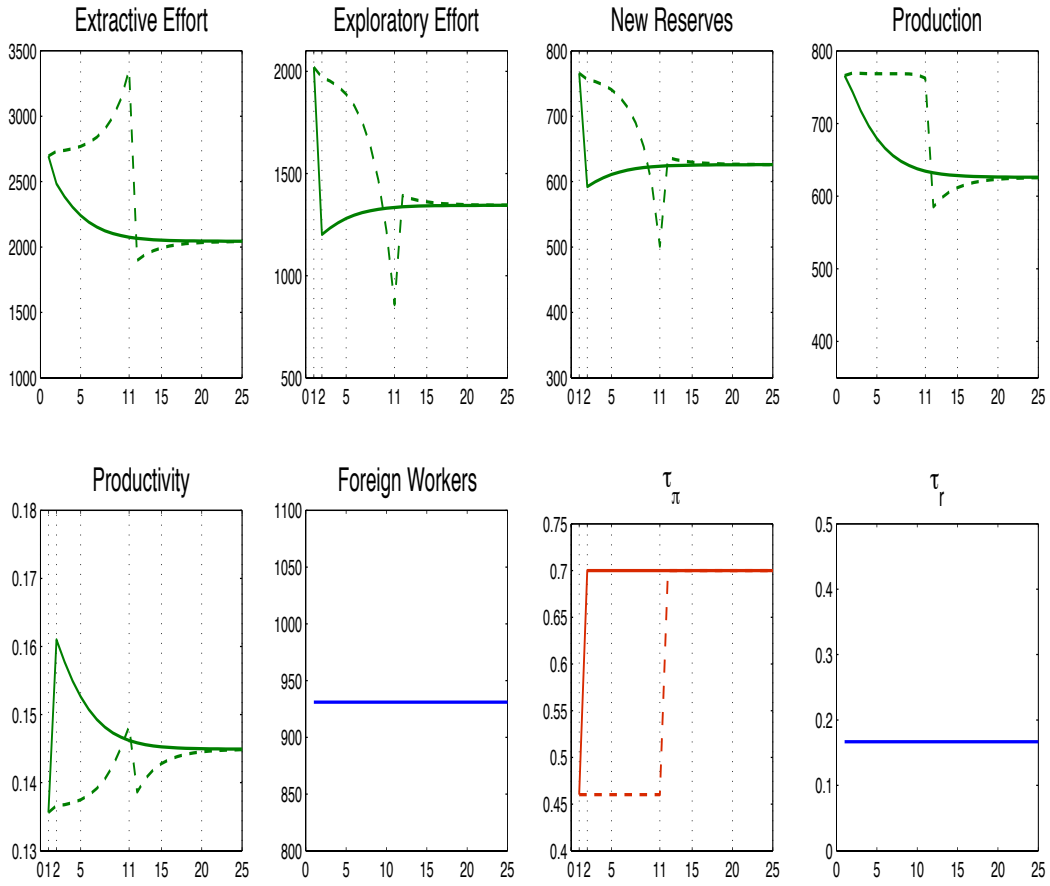


Figure 20: Impulse responses to know-how shock: Solid lines: responses to an unanticipated exogenous rise; dashed lines: responses to an anticipated exogenous rise, 10 periods foresight

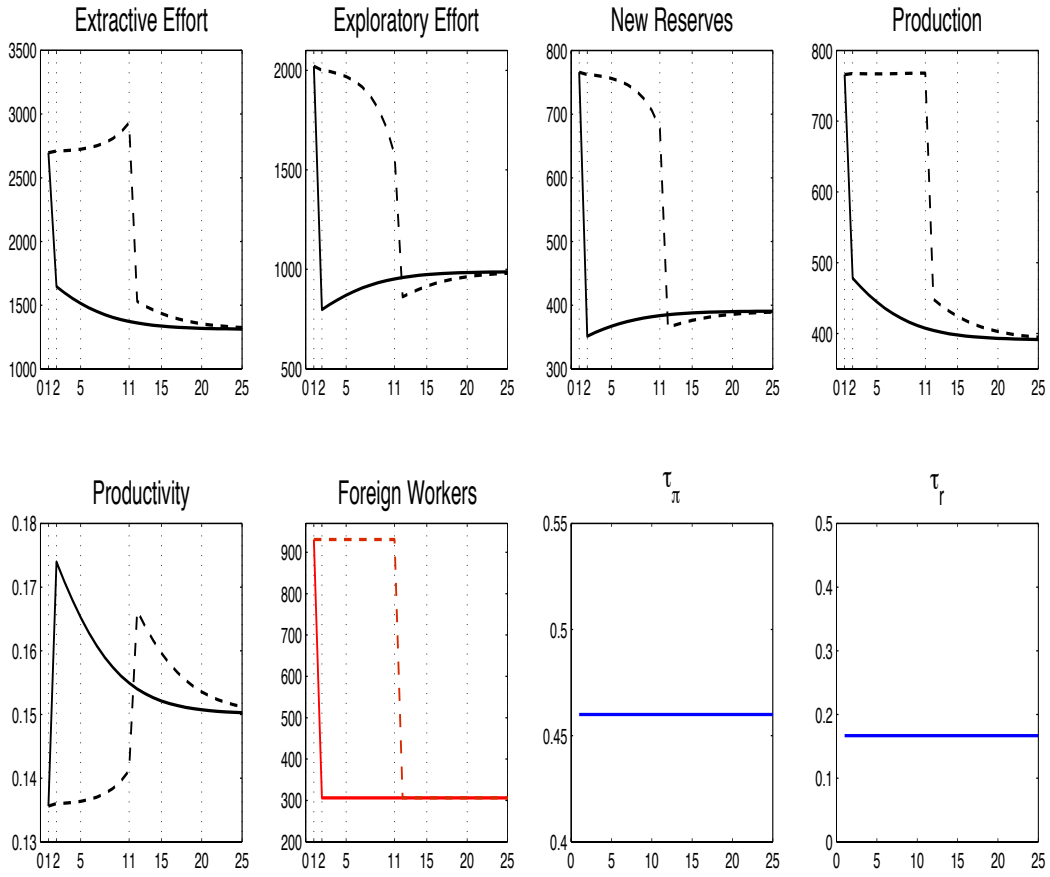


Figure 21: Actual versus Simulated Data

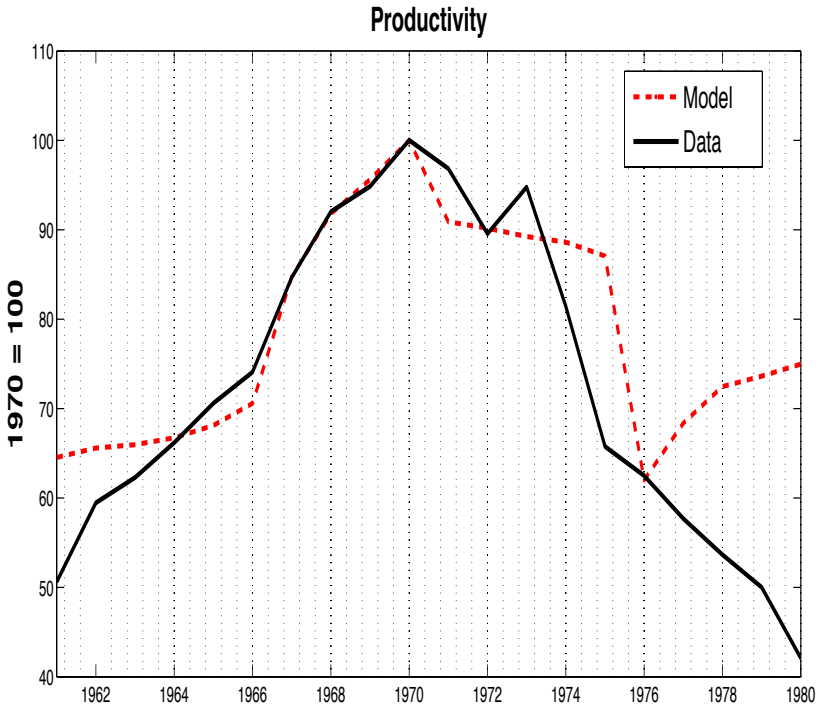


Table 11: Accounting for the Impact on Productivity

Period	$\Delta\%$ **Data**	$\Delta\%$ **Model**	**Percentage Explained**
$1961 - 1970$	+ 98	+ 55	56%
$1970 - 1975$	- 34	- 13	38%
$1975 - 1980$	- 36	- 14	39%

Table 12: Are they better off?

Measured Profits	
pre-nationalization	post-nationalization
100	48.3