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PRODUCTIVITY, NATIONALIZATION, AND THE ROLE OF "NEWS": LESSONS FROM THE 1970S

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

Keywords: Productivity, Nationalization, Oil, News (Policy Foresight), Foreign Expertise

1. INTRODUCTION

After a substantial rise in the 1970s, the importance of state-owned enterprises (SOEs) diminished across the world in the 1980s and 1990s. The SOE share of global GDP declined by more than 40% from 1979 to the early 2000s [Megginson and Netter (2001)]. Following this process, a considerable amount of research

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suggested privately owned firms were more productive than otherwise-equivalent SOEs.[1] But the sharp increase in oil prices from 2003 to 2008 brought back the old phenomenon. Expropriating countries include Algeria (2006), Bolivia (2006), China (2006), Ecuador (2007), Russia (2006, 2007), and Venezuela (2006, 2007). [2]

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

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

A more detailed analysis of the Algerian and Venezuelan experiences provides initial insights. Total oil employment, including foreign workers, gradually falls prior to nationalization, and post-nationalization increases are due entirely to an increase in domestic labor. To understand why nationalization is associated with lower productivity and to quantify the effects of nationalization on exploration and labor productivity, my laboratory is the 1975 oil nationalization of Venezuela. Venezuela is one of the largest oil producers in the world and a particular example of a remarkable decline in productivity following nationalization. In addition, I manually collect a unique data set on the Venezuelan oil industry over a 50-year period.[3]

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

As a result, in the model, I distinguish between domestic and foreign labor inputs. I provide evidence suggesting foreign workers in the Venezuelan oil

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industry are highly skilled, representing key technical, professional, and managerial positions. I hypothesize that if the available know-how in the industry is mainly supplied by foreign workers, and their skills are complementary with the other factors of production, then nationalization would be costly, causing a decline in the productivity of measured factors of production.

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

My findings are as follows. In anticipation of nationalization, exploratory efforts fall and extractive efforts increase resulting in a decline in reserves and total employment, but an increase in productivity prior to nationalization. Productivity increases mainly due to a significant decline in the total number of workers stemming from the decline in exploration efforts. By the realization of nationalization, however, productivity falls and continues to do so after nationalization. Despite its simplicity, my carefully calibrated model is able to explain the path of productivity quite well. A comparison of the simulated and actual time series over the period 1961–1980 shows that the model can account for about 80% of the productivity path. I also quantify the effect of nationalization on present discounted value of profits using simulated data before and after nationalization. I find that nationalization reduces the industry's profits by more than 70% from 1961 to 1980. A commonly held view is that nationalization allows a resource-rich developing country to capture the profits which are no longer shared with the foreigners and thus become better off. I provide a different view. I empirically show in a number of cases that labor productivity falls enormously following expropriations, raising the question of whether expropriators are better off by expropriating. I show that even though the whole profits are captured, they are smaller.

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

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1.1. Related Literature

This study contributes to several strands of the literature. First, the questions addressed in this paper represent a novel contribution to the literature by filling the gap in quantitative evidence for costs of expropriation. To my knowledge, this paper is the first attempt to explain a resource-rich developing country's experience quantitatively. Existing studies mostly focus on the determinants of nationalization, or the effect of denationalization on productivity, or compare public ownership with private ownership. Examples include Megginson et al. (1994), La Porta and Lopez-de-Silanes (1999), Megginson and Netter (2001), Guriev et al. (2011), Stroebel and Van Benthem (2013), Hajzler (2014), and Chang et al. (2018).

I also present novel evidence suggesting foreign workers are highly skilled. The specialized knowledge brought by foreign firms can be critical for industry operations, and removing them can be costly. This is related to a growing literature studying the effect of multinational activity in developing countries, which suggests that the presence of foreign firms can bring welfare gains [Antras et al. (2006), Burstein and Monge-Naranjo (2009), Eeckhout and Jovanovic (2010), and Monge-Naranjo (2011)].[4]

In this paper, I examine an industry case in which large (exogenous) policy changes are associated with significant changes in production and productivity, similar to Schmitz and Teixeira (2004) and Schmitz (2005), and present a new mechanism to understand the effects.[5]

Finally, studying the effects of expropriation can help us understand why some countries are development outliers. Venezuela was one of the fastest growing economies in Latin America with an oil-dominant economy, but then collapsed and has become a development failure. Thus, it is often cited as an illustration of the resource curse, for instance Sachs and Warner (1999).[6] To be more specific, the Venezuelan oil industry expanded until 1958, which coincided with a substantial expansion in the Venezuelan economy. Bello et al. (2011) show that GDP per capita relative to the USA increased significantly from 1920 to 1958, but then declined.[7] The authors find that capital accumulation and knowledge transfer account for the remarkable growth, which could be due to openness of the oil sector to foreign investment. They argue that government intervention can misallocate resources, leading to a fall in total factor productivity (TFP) and capital accumulation, and find that policy distortions are able to account for most of the decline observed in Venezuela.[8] By the same token, Cole et al. (2005) investigate the Latin American development problem and find that barriers to competition, including limiting government policies, are a likely cause. My analysis complements these studies. Understanding Venezuela's development experience, which is critical in terms of the Latin American development problem, relies on understanding the evolution of the oil industry.

The remainder of the paper is organized as follows: Section 2 presents historical patterns of expropriations across the world and examines the effects of

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nationalization in a sample of oil-producing developing countries. Section 3 documents the features of the Venezuelan oil industry. After describing the data, the section explores main trends in the oil industry, discusses critical aspects of Venezuelan nationalization, and puts forth my hypotheses. Section 4 introduces the model. The quantitative analysis is presented in Section 5, and Section 6 concludes.

2. HISTORICAL TRENDS IN EXPROPRIATIONS AND THEIR EFFECT ON PRODUCTIVITY

The first step in investigating the effect of expropriation on productivity is to determine the period, sectors, and regions in which forced divestment has been widespread. For this purpose, I begin by documenting the trends in expropriations across the world over 1922–2006.[9]

2.1. World Historical Trends: Over Time, by Sector, and by Region

More than half of the world expropriations occurred from 1970 to 1976; very few expropriations took place in the 1980s and the 1990s; expropriations increased in the 2000s. The extractive sector, in particular oil, is more vulnerable to forced divestment. In addition, forced divestment is more common in Africa and Latin America, accounting for about 39% and 30% of all acts, respectively.[10] Motivated by these facts, I focus on the oil industry expropriations in Latin America and Africa in the 1970s.

2.2. Expropriations in the Oil Industry

The 1970s were a critical period for the oil industry. From 1970 to 1976, expropriations by over 35 countries accounted for more than 70% of the 1970 world production [Kobrin (1984b) and Williams (1975)]. Given the dominance of the industry in the developing host countries' economies, expropriation could be attractive for increasing revenue.[11] Sovereignty over their own resources is another factor; foreign ownership is inconsistent with national control [Kobrin (1984b) and Yergin (1991)]. However, government takeover can be costly irrespective of motivation. It can lower productivity significantly, and the consequence could be a wholly state-owned sector with much smaller output.

The focus of this paper is to investigate the effect of expropriation on productivity during the earliest possible period in which expropriations are most common, regardless of why or how countries expropriate. My sample and empirical analysis are limited predominantly by the availability of oil industry data for oil-producing developing countries in the 1960s and the 1970s.

2.2.1. The effect of oil industry expropriations on productivity. Productivity is measured as oil production per worker (barrels per worker). I calculate labor

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TABLE 1. Labor productivity relative to the USA (5-year averages)

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

Notes: Productivity at the time of expropriation = 100.

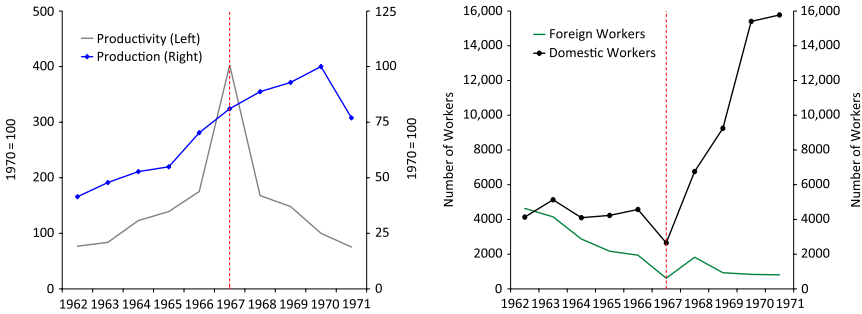

FIGURE 1. Oil industry, Algeria.

productivity in the oil industry over 1962–1995 for each country. Then, I obtain labor productivity relative to the USA by dividing each country's productivity by the productivity of the USA oil industry. The value at the time of expropriation for each country is normalized to 100. Algeria expropriated its oil industry in 1967, Venezuela in 1975, Colombia in 1974, and Peru in 1985 [Brogini (1973), Kobrin (1984b), and Guriev et al. (2011)]. Finally, for each case, I calculate 5-year averages before and after expropriation, excluding the value 100 at the time of expropriation. Table 1 presents pre- and post-expropriation relative labor productivity averages for each country. I find that expropriation brings significant losses in productivity, ranging from 30% to 60%. Formerly contracted oil employment expands quickly following expropriation without an accompanying recovery in production; hence, productivity keeps declining. In the US oil industry, on the other hand, the number of workers is stable in the 1970s but falls significantly in the 1980s, resulting in a boost in productivity.[12]

To get some initial insights into the effects of expropriation, next, I explore the Venezuelan and Algerian cases.

2.2.2. Exploring the cases of Algeria and Venezuela. Algeria began oil production in 1958 and gained political independence in 1962.[13] After the Arab-Israeli War in June 1967, Algeria nationalized the refining and distribution activities of Mobil and Esso.[14] Thus, I consider the year 1967 as the (benchmark) year of nationalization in the oil industry.[15] The left panel of Figure 1 presents production

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and labor productivity in the Algerian oil industry, both normalized to 100 in 1970. The right panel shows the composition of the Algerian oil workforce by nationality. Dashed vertical lines show the year of nationalization. The left panel shows that prior to nationalization, productivity increased as output outpaced the number of workers. Post-nationalization, however, production growth slowed down and did not return to its pre-nationalization growth path until the mid-1980s. As the number of workers outpaced production, measured labor productivity declined sharply post-nationalization and stayed low.

The right panel shows a decline in the oil industry employment prior to nationalization which is reversed dramatically following nationalization. Fifty-three percent of oil employment was foreign in 1962, decreasing to 5% in 1971. Moreover, foreigners held mostly managerial, professional, and technical positions. In 1962, around 7% of workers were managers and engineers, 98% of whom were foreign.[16] But, in 1971, 8% of workers were managers and engineers, and only 28% of them were foreign. Nationalization in the Algerian oil industry appears to have reduced the number of foreign workers who were mostly employed in managerial and technical positions. However, nationalization also brought a striking expansion in domestic employment, particularly in managerial and technical occupations. Foreign workers were replaced by domestic workers of similar occupations but the increase in domestic workers was more than threefold. This remarkable expansion resulted in a slight increase in production and a sharp drop in productivity even though oil production in the country was in its early stages and thus expected to grow faster.

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

The middle panel of Figure 2 presents the total number of foreign and domestic workers in the Venezuelan oil industry over 1948–1995.[17] The right panel shows foreign and domestic breakdown for employees, that is, white-collar (WC) or skilled workers. Similar to Algeria, the number of workers started declining prior to nationalization. Post-nationalization, foreign workers were replaced by domestic workers.[18] In Venezuela, the decline in foreign workers is even more striking. In 1948, around 11% of total workers were foreign, 78% of whom were WC (employees), constituting 29% of total WC workers.[19] The number of foreigners began declining in 1957. At that time, 12% of the total workforce were foreign, 83% of whom were WC, making up 25% of total WC workers. By the time of nationalization, the percentage of foreign workers decreased to around 2%, 95%

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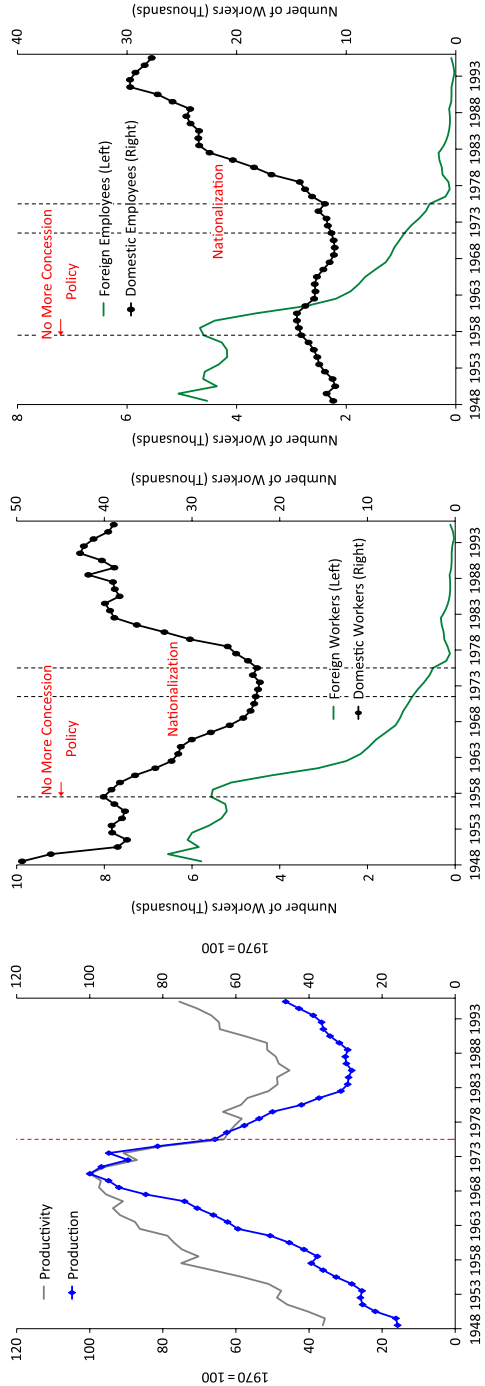

FIGURE 2. Oil industry, Venezuela.

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of whom were WC comprising only 4% of total WC workers. After nationalization, the share of foreign employment in total employment never exceeded 1%. On the other hand, Venezuelan employment, particularly WC employment, expanded markedly post-nationalization. Moreover, even though the most important technical and managerial positions were held by foreigners prior to nationalization, who were paid much higher than their domestic counterparts, these positions were assigned to Venezuelans after nationalization [Michelena et al. (1976)].

The changing composition of the workforce and the decline in the number of foreign workers holding key positions in the Algerian and Venezuelan oil industries following nationalization can help us understand why nationalization is associated with lower productivity. A natural question to ask is whether their experiences are common among expropriators or not. The Saudi Arabian government, for example, started increasing its interest in Aramco in the early 1970s and took full control of Aramco by 1980.[20] However, Aramco partners continued to manage and operate Saudi Arabia's oil fields with foreign workers constituting almost 50% of the workforce [Woodward (1988) and Olmedillo (1984)]. During 1970–1980, oil production increased by 167% in Saudi Arabia. Conversely, in Venezuela, where nationalization nearly eliminated foreign employment, production declined by more than 40%.[21]

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

3. THE VENEZUELAN OIL INDUSTRY

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

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. The left panel of Figure 3 presents the country's historical crude oil production (in barrels) and production per worker (in barrels per worker). Two nationalization episodes and a privatization episode are indicated.[22] The nationalization episodes are associated with production declines, but privatization has a positive effect.

The left panel of Figure 3 also presents productivity records over 1939–1995. Productivity in the oil industry captures the production path quite well. Until 1970, both production and productivity trended upward. By the beginning of the nationalization process, the trend reversed sharply. In 1985, 10 years after

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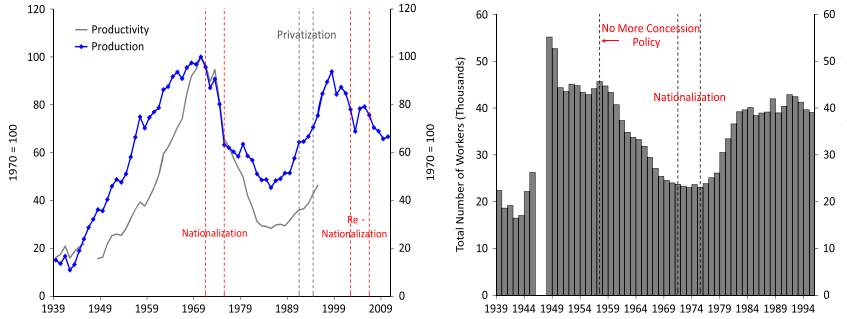

FIGURE 3. Historical production, productivity, and employment in the Venezuelan oil industry.

nationalization, production and productivity were 45% and 28% of their levels in 1970, respectively.[23] Both began increasing in 1985.[24]

It is important to note that the striking decline in oil production is not due to an OPEC production cut.[25] OPEC production increased by more than 14% in the 1970s. For instance, a member country, Indonesia, increased its production by 85%.[26] World production also increased by around 31%. Mexico, a large non-OPEC producer in Latin America, more than quadrupled its oil production in the 1970s. This implies that Venezuela deviated from other large oil-producing nations significantly in the 1970s.

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

The left panel of Figure 4 shows that the path of Venezuelan oil employment from the mid-1960s to the mid-1970s is overall different from the oil employment trends across the world. During the 1960s, world oil employment was relatively stable likely due to stable oil prices. In the early 1970s, rising prices supported oil employment across the world. Likewise, in Mexico, employment in the oil industry almost doubled and production more than quadrupled, resulting in an increase in productivity in the 1970s (Figure 4, right panel). Indeed, productivity captures production paths quite well in both Venezuela and Mexico, though they move in opposite directions.[27]

I also present total capital expenditure records of the world petroleum industry.[28] During the late 1950s and 1960s, capital expenditures in the world

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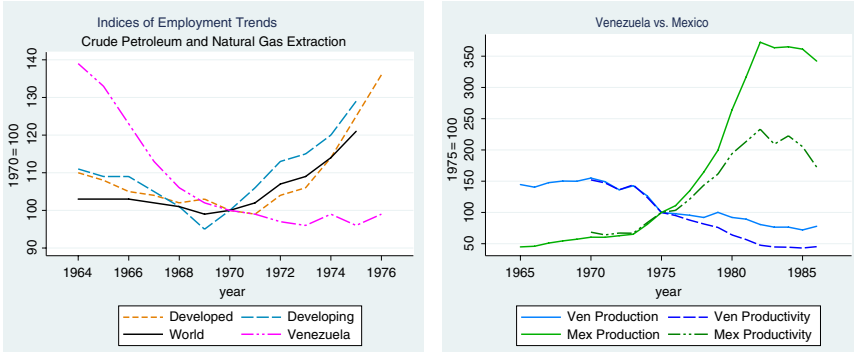

FIGURE 4. Oil industry employment. **Left panel:** Source (Developed, Developing, and World Markets): *General Report, Petroleum Committee, 1980, International Labor Organization, Programme of Industrial Activities.* Developed Market Economies include Canada, USA, Europe (excluding centrally planned economies), Australia, Israel, Japan, New Zealand, and Republic of South America; Developing Market Economies include Caribbean, Central and South America, Africa, Asian Middle East, East and Southeast Asia; World excludes Albania, China, Democratic People's Republic of Korea, Mongolia, and Vietnam. Source (Venezuela): *Republic of Venezuela, Ministry of Mines and Hydrocarbons, Petroleum Industry, Statistical Databooks.* **Right panel:** *Source*: *Randall (1989), and British Petroleum Statistical Review of World Energy.*

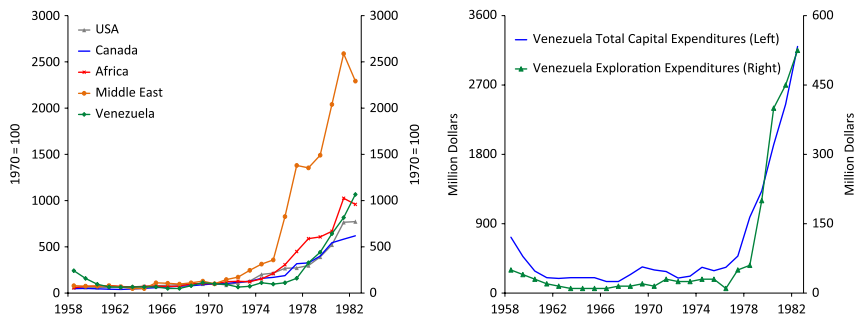

FIGURE 5. Capital investments of the world petroleum industry.
Source: Chase Manhattan Bank, Energy Division, 1968–1982.

petroleum industry were stable with the exception of Venezuela in the late 1950s (Figure 5, left panel). From 1958 to 1961, capital expenses were stable in the rest of the world, but declined by more than 70% in Venezuela and then remained stable until 1975. Capital expenditures took off across the world in the early 1970s, particularly in the Middle East. In Venezuela, however, investment began increasing with a lag after nationalization. From 1975 to 1982, investment increased much more than the rest of the world, by more than 10-fold.[29] In other words, Venezuela joined the capital investment expansion last, but expanded its investment most. Another important aspect of the capital spending pattern in

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Venezuela is the striking increase in exploration expenses relative to the rest of the world. Exploration expenses increased more than 16-fold from 1975 to 1982 in Venezuela (Figure 5, right panel), while the USA and Canada only saw a three-fold increase.[30] In relation to that, the total number of wells completed in the Venezuelan oil sector, which can be considered a proxy for exploration activity, dropped sharply in 1957 and stayed low until 1975. However, after nationalization, drilling activity more than quadrupled.[31]

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

3.2. Discussion: Events, Attitude, and Policies Adopted in the Venezuelan Oil Industry

Government control of the Venezuelan oil industry was minimal until the late 1930s. In 1943, a new hydrocarbons law introduced greater government participation and was considered a milestone for the Venezuelan oil industry. Before the law, the government's main revenue tool was royalty taxes implemented at low rates. The 1943 hydrocarbons law introduced income taxes in exchange for additional years of exploitation and the promise of granting extensive new areas [Martinez (1989)]. A 50−50 split in profits between the government and the multinational companies (MNCs) was also adopted [Mikesell (1984)]. Manzano and Monaldi (2010) argue that by accepting these tax changes, companies obtained a long-term planning horizon under a transparent tax regime. After the law, taxes remained relatively stable. As a result, stable distributive rules with a long investment horizon led an expansion in the industry from 1943 to 1958.

In 1957/1958, the dictatorship ended, and the democratic regime began with the adoption of a new constitution in 1961. A new regime could increase spending, and when oil prices are relatively stable it could make higher government take more attractive. Indeed, the Venezuelan government increased its share in profits from 50% to 65% unilaterally through a significant rise in income taxes via a decree in 1958. This action is argued to have infuriated MNCs [Manzano and Monaldi (2010)]. Moreover, in 1958, the "no more concession" policy was announced meaning the last oil concessions were granted. Coronel (1983) argues that the conditions of the policy, whose primary objective is to increase national control over the industry and increase government revenues, are severe, making profits almost impossible for the companies. The government take increased from more than 65% in the 1960s to about 90% in the early 1970s [Manzano and Monaldi (2010)]. The oil companies saw these policies as an end to the profitability of working in Venezuela and ceased almost all exploration activities and began shifting their assets outside the country [Coronel (1983), Olmedillo (1984), and Ellner (1993)]. For instance, Howarth and Jonker (2007) note that, in the 1960s,

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Shell Oil Company, the second largest producer in Venezuela, considered the conditions in Venezuela unattractive and began shifting its operations elsewhere. This is in accordance with the capital expenses data presented in Figure 5. Therefore, 1957/1958 was the starting point of a major conflict between the government and the MNCs, which coincided with the beginning of a contraction in the industry presented earlier. For example, the post-1957 decline in the number of workers, in particular the decline in the number of foreign workers, is striking (Figure 2). Moreover, from the late 1950s to the mid-1970s, the data show that exploration was low. Additions to reserves declined and reserves stagnated soon after. In fact, from the early 1960s to the mid-1970s, annual reserve additions were lower than annual oil production, suggesting over-extraction. After nationalization, although reserves increased, production did not, implying under-extraction.

In 1971, the Reversion Law was passed stating that all assets, plants, and equipment belonging to concessionaires would be reverted to the nation upon the expiration of the concession. It gave the government almost total control of the oil industry, which coincided with a sharp decline in productivity.[32] Therefore, I assume that the formal nationalization process started with the Reversion Law. The law also changed the nature of monitoring in the industry, because the Ministry of Mines and Hydrocarbons gained control and co-managed the industry with the MNCs until all concessions were cancelled and the industry was fully nationalized in 1975.

My interpretation of the facts documented in the light of these events is as follows. In the late 1950s, the government's participation starts increasing in such a way that it makes the Venezuelan oil industry unattractive for MNCs. "No more concession" policy and the following tax increases are likely to generate expectations that the government would eventually take over the industry. This would motivate short-run incentives: increase extraction, lower employment, lower exploration, and boost productivity in the short run, but reduce productivity in the longer run.[33] Increasing extraction is also likely to tip the government to nationalize, because the government may have viewed it as their resources being looted by MNCs.[34]

One aspect of my interpretation is that foreign labor is likely to become a missing factor due to policies, attitude, or steps taken by the government which can be regarded as government restrictions on foreign activity. After nationalization, the state-owned industry's goal was to expand, and there seems to be a desire to replace foreign workers with domestic workers. Olmedillo (1984) points out that in contrast to other nationalization examples, foreign workers in Venezuela were removed and replaced with the next qualified Venezuelans. This "venezuelization", as Bye (1979) calls it, is also supported by Coronel (1983), who notes a speech by President Perez in 1974 calling for management of new oil companies to be run by Venezuelans. Pushing out foreign personnel, who were mainly in high-level positions, was not something that was common to nationalization experiences (Olmedillo (1984)), also noted earlier in Section 2. Even though proportionally most of the Venezuelan oil industry jobs were held by domestic labor, high-level positions were mostly held by foreigners, and there were

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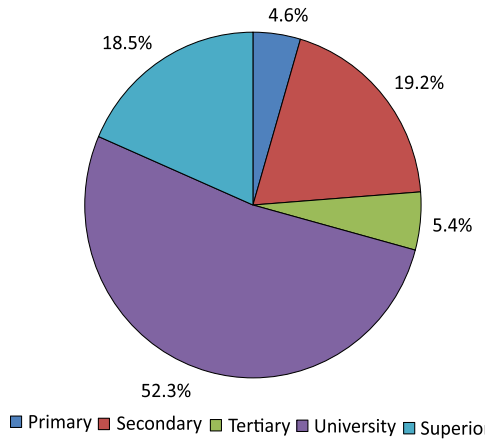

FIGURE 6. Education-level distribution of the foreign personnel employed in the Venezuelan oil industry, 1970.
Source: Michelena et al. (1976).

limited domestic employees hired into these positions before the 1970s [Gall (1975) and Aitken and Harrison (1999)]. Domestic employees were not hired into these positions, partly because there were not enough trained domestic employees to fill these positions [Coronel (1983)]. Despite all these issues, foreigners were still removed in favor of the next qualified domestic employees. To support the need for trained domestic labor, Venezuela started putting workers in foreign universities and began training programs after nationalization [Coronel (1983) and Olmedillo (1984)]. However, production and productivity did not recover (Figure 2). I argue that this could be due to foreign labor becoming a missing factor and the resulting *lost foreign know-how*.

Figure 6 presents the education level of foreign personnel employed in the Venezuelan oil industry and shows that more than 70% of foreign workers are university graduates or higher. In the same year, the average year of total schooling is only 2.65 for the same age group in Venezuela [Barro and Lee (2013)]. So, along with the anecdotal evidence presented, I can conclude that foreigners comprise key, highly skilled workers in the industry, and their departure is likely to bring significant know-how losses. In particular, if foreign skills are critical in extraction and complementary with other factors of production, then nationalization could be costly. Lack of a critical factor in extraction can cause production to continue to decline despite quickly increasing domestic employment and increasing reserves.[35] My narrative of the Venezuelan case involves a long-term pre-announcement with a huge decline in the number of foreign workers resulting in less exploration and higher extraction.

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

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4. MODEL

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

I assume competitive producers of a non-renewable resource.[36] The producers, taking prices and taxes as exogenously given, choose exploration and production paths to maximize the present value of profits. Reserves, which serve as a form of capital to support production, can be maintained or increased through exploration, even though returns to exploration decrease as discoveries increase. Production (extraction), on the other hand, depletes reserves. The average cost of production increases as reserves decline, and the marginal cost of exploration increases as exploratory effort increases.

I consider two forms of taxation in natural resources: severance (royalty) taxes and income taxes.[37] These are common revenue sources for resource-producing countries including Venezuela. Royalty taxes are levied on total sales, and income taxes are levied on total profits. As in Rigobon (2010), I assume that tax rates are not contingent on prices, production, or reserves.[38]

Extractive and exploratory efforts are represented by different labor inputs measured in efficiency units. I consider a nationality (or skill-level) criterion and an operational criterion and assume four categories of labor input: extractive foreign and domestic labor and exploratory foreign and domestic labor. Extraction is a process combining reserves as a form of capital with extractive efforts to produce the resource, oil in my case.[39] In exploration, labor inputs that are imperfect complements generate additions to reserves.

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

1. $O(\cdot)$ is a function of reserves, R_t, foreign labor in extraction, F_t, and domestic labor in extraction, D_t.
2. $R_t = 0 \implies O(\cdot) = 0$ implying that R is an essential input [Dasgupta and Heal (1974)].
3. $\lim_{R\to 0} \frac{\partial O}{\partial R} = \infty$ so that exhausting the resource in finite time is not allowed.

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

$$O(R_t, F_t, D_t) = \Gamma(F_t, D_t) R_t^{\upsilon},$$

where $0 < \upsilon < 1$, and $\Gamma(F_t, D_t)$ is homogenous of degree $\leq (1 - \upsilon)$. I assume that $O(R_t, F_t, D_t)$ is a non-increasing return to scale Cobb–Douglas production

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function, and choose to represent $\Gamma(F_t, D_t)$ by a CES functional form, so that foreign and domestic labor inputs interact in a particular way. It is formulated as follows:

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

where $0 < \mu, \upsilon, \gamma < 1$; $\sigma \leq 1$; and $\upsilon + \gamma \leq 1$. Each labor input type is a product of the number of workers and a productivity index, which is assumed to be constant. $s_D, s_F > 0$ are the corresponding productivity parameters. The technology is a non-increasing return to scale Cobb–Douglas function in two inputs: reserves, R_t, and a compound term $[\mu(s_D D_t)^{\sigma} + (1-\mu)(s_F F_t)^{\sigma}]^{\frac{1}{\sigma}}$. The second term is a constant elasticity of substitution (CES) aggregate over domestic labor with share parameter μ and foreign labor 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 foreign labor and domestic labor.[40]

Output of exploratory activity is represented by technology $G(d_t, f_t)$, where d_t, f_t are the domestic and foreign exploratory efforts, that is, labor inputs participating in exploration. $G(\cdot)$ is strictly increasing and strictly concave. Concavity implies that the marginal discoveries made by additional exploration diminish as exploration proceeds. I choose the following Cobb–Douglas technology for exploration[41]:

$$G(d_t, f_t) = (s_d d_t)^{\theta_1}(s_f f_t)^{\theta_2}, \tag{2}$$

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

Reserve dynamics are governed by the following state equation:

$$R_{t+1} = R_t - O(R_t, F_t, D_t) + G(d_t, f_t). \tag{3}$$

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

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

$$v(S_t) = \max_{D_t, F_t, d_t, f_t, R_{t+1}} \{\Pi(\cdot) + \beta \mathbb{E}[v(S_{t+1})]\}, \tag{4}$$

subject to the constraints

$$\begin{aligned} \Pi(\cdot) &= P_t O(R_t, F_t, D_t) - (w_{D_t} D_t + w_{F_t} F_t) - (w_{d_t} d_t + w_{f_t} f_t) \\ R_{t+1} &= R_t - O(R_t, F_t, D_t) + G(d_t, f_t) \\ O(R_t, F_t, D_t) &= R_t^{\upsilon}\left[\mu(s_D D_t)^{\sigma} + (1-\mu)(s_F F_t)^{\sigma}\right]^{\frac{\gamma}{\sigma}} \\ G(d_t, f_t) &= (s_d d_t)^{\theta_1}(s_f f_t)^{\theta_2}, \end{aligned} \tag{5}$$

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

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

$$\text{extractive efforts, } i = D, F$$

$$P_t = \frac{w_{i_t}}{O_{i_t}} + \eta_{t,} \tag{6}$$

$$\text{exploratory efforts, } j = d, f$$

$$\eta_t = \frac{w_{j_t}}{G_{j_t}} \tag{7}$$

$$\text{reserves}$$

$$\eta_t = \beta \mathbb{E}\left[P_{t+1} O_{R_{t+1}} + \eta_{t+1}(1 - O_{R_{t+1}})\right], \tag{8}$$

where η_t is the shadow value of an additional unit of reserves. The first-order condition for extractive efforts yields that price is equal to the marginal extraction cost plus the scarcity value of a unit of reserves in the ground. The scarcity value, η_t, is the change in the expected present value of future profits resulting from an additional unit of reserves and is always positive.[42] If production costs rise as reserves decline, rent could fall, which implies that the opportunity cost of extraction is decreasing due to declining resource use. Thus, the resource will become less scarce. Equation (7) implies that the producer chooses optimal exploratory efforts so that the resource rent equals marginal exploration cost. That is, the shadow value of a unit added to reserves is equal to the cost of adding a unit via exploration. Here, the marginal exploration cost is the ratio of the additional cost and the additional exploration associated with one more unit of exploratory effort. Finally, equation (8) governs the optimality condition between today and tomorrow. The scarcity value of a unit of reserves in the ground today is equal to the expected present value of the flow of income that the additional unit of reserves generates next period plus the depreciated scarcity value in the next period.[43] In an untaxed environment, equations (3) and (6)–(8) govern the evolution of the variables $R_t, F_t, D_t, d_t, f_t, \eta_t$ taking exogenous variables $\{P_t, w_{D_t}, w_{F_t}, w_{d_t}, w_{f_t}\}$ as given.

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

$$\Pi(\cdot) = (1-\tau_{\pi_t})\{(1-\tau_{r_t})P_t O(R_t, F_t, D_t) - w_{D_t}D_t - w_{F_t}F_t\} - (1-\tau_{\pi_t}c)(w_{d_t}d_t + w_{f_t}f_t), \quad (9)$$

where τ_π is the tax rate on income and τ_r is the severance (royalty) tax rate. I allow for the producer to deduct c proportion of the exploration expenses from the tax bill. The tax-adjusted optimality conditions are

$$(1-\tau_{\pi_t})(1-\tau_{r_t})P_t = (1-\tau_{\pi_t})\frac{w_{i_t}}{O_{i_t}} + \eta_{t,} \quad (10)$$

$$\eta_t = (1-\tau_{\pi_t}c)\frac{w_{j_t}}{G_{j_t}}, \quad (11)$$

$$\eta_t = \beta\mathbb{E}\left[(1-\tau_{\pi_{t+1}})(1-\tau_{r_{t+1}})P_{t+1}O_{R_{t+1}} + \eta_{t+1}(1-O_{R_{t+1}})\right]. \quad (12)$$

The changes in tax rates affect both exploration and production. An increase in severance taxes reduces extractive and exploratory efforts, and the size of the reduction depends on the shares of the labor inputs and the elasticity of substitution. Lower exploratory efforts result in lower reserve additions and hence lower reserves. Lower reserves and lower extractive efforts result in lower output. The effect on output per worker, however, is ambiguous and depends on whether the decline in output dominates the decline in total effective labor. An income tax also decreases extraction and exploration efforts but to a lesser degree, as the expensing assumption implies that a certain proportion of the costs are deductible from taxable income. Therefore, as the effective tax rate on return to marginal exploration is low, so is the distortionary impact. Equation (12) shows how expected future changes in taxes affect exploration and extractive efforts. An increase in expected future taxes causes the opportunity cost of extraction today to decline, which makes extraction more attractive today but exploration less attractive.

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

5. QUANTITATIVE ANALYSIS

Prior to conducting experiments of interest, I calibrate the model using the Venezuelan data. First, I describe what aspects of the data identify key parameters in the model. Then, I present baseline quantitative results. Finally, counterfactual experiments and sensitivity analysis are presented.

5.1. Calibration and Impulse Responses

To calibrate the model parameters, I match the steady state of the model to the features of the Venezuelan oil industry for the pre-1960 period. One period in the

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model is assumed to be a year in the data. The discount factor, β, is set to 0.90, which delivers a steady-state annualized real interest of about 11%.[44] The elasticity of substitution parameter, σ, is set to -0.5, so that domestic and foreign labor in extraction are complements.[45]

I follow a similar approach used in Krusell et al. (2000) to construct my labor input series and the corresponding wages series, which are explained in detail in Appendix II.b in the Supplementary Material. Reserve additions data are constructed by following Pindyck (1978) and also explained in Appendix II.b in the Supplementary Material. For reserves and production, I use Venezuelan proven reserves and crude oil production data, respectively.

The parameters that I need to choose are μ, the domestic extractive labor income share; υ, the share of reserves; γ, the share of composite labor in extraction; the shares of domestic and foreign exploratory labor in income, θ_1 and θ_2; and productivities of different labor inputs, s_D, s_F, s_d, s_f. These parameters are calibrated from the steady state model, where tax rates are set at their pre-1960 values. Constructed pre-1960 data averages are used for the steady-state values of D, F, d, f, and their corresponding wages. $G(\cdot)$ at the steady state is the pre-1960 average of the constructed reserve additions series. The steady-state value of R is set similarly. Productivities are constant over time. I target wage differences across different occupational groups by nationality in order to calibrate s_D, s_F, s_d, s_f.

I target the ratio of the domestic labor share and foreign labor share in extraction expenditures to calibrate μ and obtain 0.68 (the average $\frac{w_D}{w_F}$ ratio for the Venezuelan oil industry is 0.405). I jointly calibrate θ_1 and θ_2. I target average pre-1960 ratio of domestic and foreign shares in exploration expenditures as well as average reserve additions over the period 1948–1959 to choose these parameters, resulting in setting the exploration costs ratio to 1.56. The other two parameters, υ and γ, are also jointly calibrated. I choose them so that the oil production to reserves ratio is 0.39, and production is equal to the new reserve additions.

I also need a value for c, the tax credit on exploration expenses. I calculate it following Deacon (1993). In my model, c is equivalent to the term $(e + (1 - e)f)$ in his formulation, where e is the "fraction of drilling costs expensed for tax purposes," and f is the "present value of cost depletion deductions per unit of depletable expense." Following Deacon (1993), I set e to 0.45. During the period 1953–1957, the production to reserves ratio, d, is almost constant in the Venezuelan oil industry. Thus, I calculate d as the average production to reserves ratio over 1953–1957. This allows $f = \frac{d}{r+d}$, where r is the real interest rate. Hence, I obtain $c = 0.651$. The parameter values are summarized in Table 2.

To gain insight into the role of anticipated tax increases, I first examine the effects of a higher income tax under foresight and no foresight assumptions.[46] Figure 7 presents impulse responses of a permanent income tax shock. Solid lines are the responses to an unanticipated (sudden) permanent 50% rise in the income tax rate. The dashed and dotted lines are the responses to the same tax increase with 10 periods of foresight and 3 periods of foresight, respectively.

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TABLE 2. Calibration

Parameter	Symbol	Value
Discount factor	β	0.90
Elasticity of substitution between extractive labor inputs	$\frac{1}{1-\sigma}$	0.667
Tax credit	c	0.651
Composite labor share in extraction	γ	0.7
Domestic extractive labor income share	μ	0.68
Share of reserves in extraction	υ	0.13
Domestic exploratory labor income share	θ_1	0.51
Foreign exploratory labor income share	θ_2	0.32
Productivity of extractive domestic labor	s_D	3.6
Productivity of extractive foreign labor	s_F	7.66
Productivity of exploratory domestic labor	s_d	3
Productivity of exploratory foreign labor	s_f	6.39

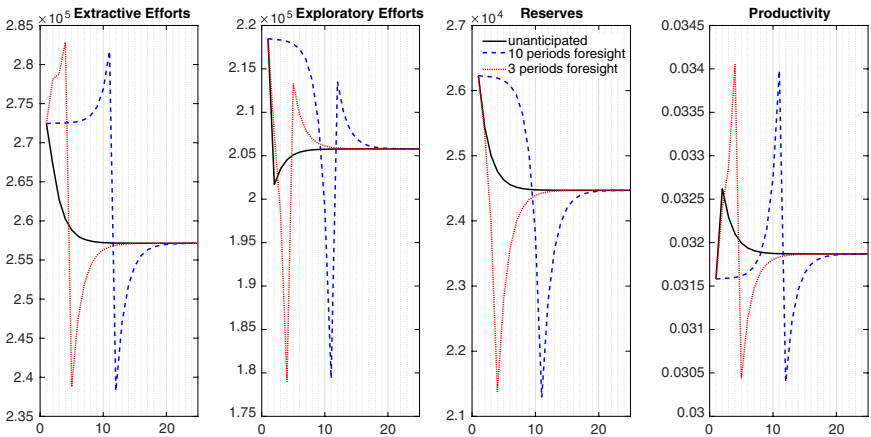

FIGURE 7. Impulse responses to an income tax shock: responses to anticipated versus unanticipated exogenous rises.

In the 10 periods of foresight case, news about the income tax increase, which would materialize at the beginning of time $t = 11$, arrives at the beginning of time $t = 1$. In response to the anticipated income tax increase, extractive efforts increase; however, exploratory efforts decrease. This is because the expected future increase in the income tax rate causes the shadow value of an additional unit of reserves to decline, increasing extractive efforts while disincentivizing exploration.

Lower reserves due to decreasing exploration put downward pressure on production. As a result, despite increasing extractive efforts, production only slightly increases and then stays relatively stable until the shock is realized. Exploratory efforts decline more than the increase in extractive efforts, resulting in declining

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total employment. So, production per effective worker (productivity) increases prior to the realization of the shock. Once the shock is realized, the sharp decline in extraction yields a sharp drop in productivity.

The dotted lines are the responses to the same tax increase with only three periods of foresight, that is, news about the income tax increase would materialize at the beginning of time $t = 4$. When the anticipated income tax shock has a shorter foresight, the responses are more abrupt with the path of initial responses looking somewhat different than the initial responses to an anticipated shock with longer foresight presented by the dashed lines. The extractive efforts increase more suddenly and more sharply in response to the shock expected to be realized sooner. Similarly, exploratory efforts fall more suddenly resulting in a sharp drop in reserves. These in turn yield a more sudden and sharp increase in productivity followed by a sudden drop upon realization of the shock. This illustrates the importance of the foresight horizon in accounting for the path of the variables when the policy change is anticipated.

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

In the long run, anticipated and sudden (tax) policy changes result in similar distortions. But in the short run, an anticipated change appears to benefit oil producers by allowing them to exert more extractive efforts to increase or maintain production, but appears to hurt a host country by lowering exploration compared to a sudden tax policy change. The horizon of foresight is important too. An anticipated tax policy change with a shorter foresight seems to be more detrimental for a host country than an anticipated tax change with a longer foresight, as the former causes producers to exert more extractive efforts more sharply and more suddenly along with a more sudden drop in exploratory efforts.

5.2. Nationalization

This subsection derives quantitative implications of nationalization in the Venezuelan oil industry. The initial period in the model refers to the year 1961, and I cover a 20-year period. Nationalization is simply exogenously given and introduced via permanent foreseen shocks. The agents in the economy anticipate that in the year 1961, the government will introduce nationalization permanently, which will be realized at the beginning of 1968. This is because the average government take in the Venezuelan oil industry started accelerating in 1968 [Manzano and Monaldi (2010)]. Later, in 1970–1971, the Income Tax Law was amended and the ministry co-managed the oil industry with the MNCs until the nationalization process was finalized in 1975.

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Nationalization has two components. First, the government increases its participation through higher income taxes. PDVSA Databooks present Petroleum Industry Effective Rates of Income Tax and Manzano and Monaldi (2010) present royalty tax rates. From the early 1940s to 1975, royalty rates stayed the same. From the early 1960s to the late 1960s, income tax rates were also relatively stable. They began increasing in 1967–1968 and peaked in 1975.[47] The income tax rate increased from 0.46 in 1961 to 0.70 in 1975. I assume the royalty tax rate stays the same and feed the actual annual income tax rate increases into the model.

The second component of nationalization is labor market distortions. This component has two dimensions. First, foreign labor becomes a missing factor—foreign labor distortion. This can be modeled as a tax on foreign worker wages making it more costly to hire foreign labor in extraction and exploration. The ideal way of calibrating these taxes would be to use foreign labor costs data. But, there are not time series wage data by nationality for the Venezuelan oil industry.[48] As the only direct empirical evidence I have in time series is foreign employment data, I use this information. My approach is as follows: foreign labor distortion is modeled as an exogenous shock that increases the marginal cost of extracting oil and exploring for oil. In order to generate a path for these shocks, I conduct the following exercise. I have data on changes in the number of foreign workers in the Venezuelan oil industry. I obtain the values of the shocks that would generate similar percentage changes in the model. Then, I feed these values into the model and examine how variables respond to these shocks. In the data, from 1961 to 1975, the number of foreign workers fell by 84%. I generate data-equivalent declines from 1961 to 1968 and from 1968 to 1975.[49]

The second dimension is domestic labor distortion—political favoritism. I model the post-nationalization expansion of domestic employment as a subsidy on domestic wages (t_s). Total real wages in the Venezuelan oil industry were relatively stable from 1967 to 1972.[50] Then, they increased, and from 1976 to 1983, they were again relatively stable. Between these two episodes, real wages increased by about 30% and, oil employment reversed its declining trend in 1973. From 1974 to 1980, the annual growth rate of real wages averaged at 4%. So, in the model, I assume $t_s = 0$ from 1961 to 1973, set it to 4% in 1974, and assume it will continue increasing by 4% every year until it reaches 30%.[51]

Figure 8 displays the behavior of productivity, total employment, and reserves in the baseline model during the 1961–1980 period relative to the actual Venezuelan time series. The values in the year 1970 are normalized to 100. Total employment is in effective units, and productivity is oil production per effective worker. The simple, carefully calibrated model economy is consistent with some key features of the data. The model generates qualitatively similar paths for employment, reserves, and particularly for productivity. Specifically, the model generates a decline in total labor and reserves until the early 1970s and then an increase. It can account for about 90% and 80% of the productivity path during 1961–1970 and 1961–1980, respectively. One difference is that, in the model, post-nationalization productivity does not fall as much as one would expect.

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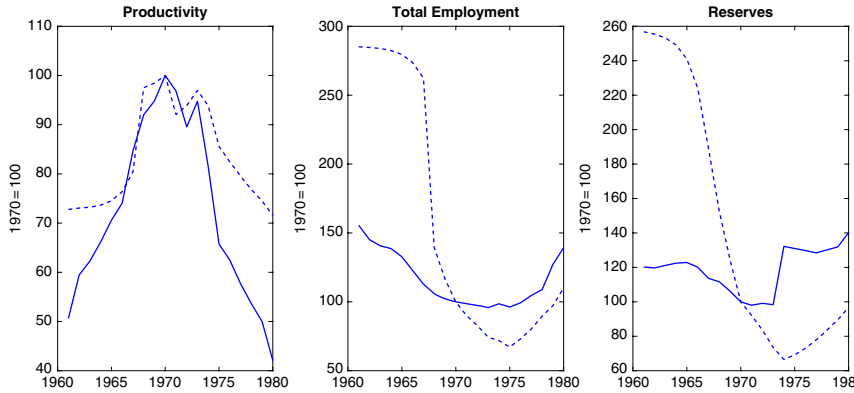

FIGURE 8. Data (solid) and baseline model (dash).

This deviation between data and model largely reflects the interaction between labor market distortions and the complementarity assumption between domestic and foreign labor in extraction. Foreign labor distortion, along with increasing income taxes, results in declining exploratory efforts, lowering total employment until 1973. Exploratory labor starts rising in 1973 due to domestic labor subsidy, but stronger foreign labor distortion prevents domestic extractive labor from rising due to the complementarity assumption until the end of 1975. Foreign labor distortion weakens in the post-nationalization period, and expansionary domestic labor distortion (subsidy) causes extractive efforts to rise. Increasing extractive efforts prevent productivity from deteriorating further, and labor productivity converges to a level only slightly below its 1961 level.

There is a very large increase in reserves data from 1973 to 1974 not being captured by the model. Upon closer inspection of the data, it turns out that there is a large increase in the revisions component of reserve additions data from 1973 to 1974 that can explain the majority of this change.[52] As revisions are not modeled in the paper, the model cannot account for changes in reserves driven by this component. As a result, the model would not be able to fully capture the large increase in (proven) reserves data.

To evaluate the cost of the policy, I also calculate profits of the industry at the old (initial) and new (end) steady states, and normalize the old steady-state profits to 100. Panel A of Table 3 presents measured profits for the baseline model.[53] Nationalization reduces the industry's profits significantly by 72%. For a moment, let's assume that in the pre-nationalization period, profits are shared 50−50 between the Venezuelan government and the MNCs, which is the sharing policy introduced by the 1943 Hydrocarbons Law. In this case, the government would get 50% of profits, but instead it gets only 28% in the new steady state, 44% less than in the pre-nationalization period. This suggests that the industry is worse off after nationalization: even though the whole profits are captured, they are much smaller.

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TABLE 3. Profits

	Pre-nationalization	Post-nationalization
A. Baseline model	100	28
B. Model with domestic and foreign labor distortions only	100	35
C. Model with foreign labor distortion only	100	22
D. Unanticipated (sudden) nationalization	100	37

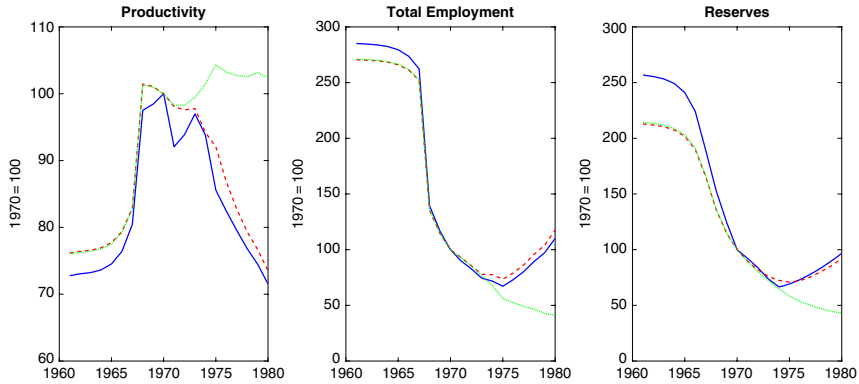

FIGURE 9. Baseline model (solid), model with labor distortions (dash), and model with only foreign labor distortion (dotted).

5.3. Assessing Nationalization

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

Political favoritism is common following a government takeover of a resource-rich developing country.[54] As a second experiment to examine the role of political favoritism, I simulate the model with only foreign labor distortion. The income tax rate is still fixed at its 1961 level and there is no political favoritism, that is, the domestic labor subsidy is zero. Now, the model fails to replicate the decline

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in labor productivity and the increases in labor and reserves post-nationalization (Figure 9, dotted lines). Production continues to decline due to low reserves and low extractive efforts post-1975, and so does total effective labor. As a result, labor productivity is relatively stable after 1975 and converges to a significantly higher level than the initial steady state. Without political favoritism, however, the industry's profits decline further, Panel C of Table 3. This implies that favoring domestic workers is very costly for productivity but not as bad for profits in the industry, Panel B versus Panel C of Table 3.

5.3.2. Sudden nationalization. How would output per worker and profits upon nationalization change if the policy change had been sudden? I simulate the model with permanent unforeseen shocks. Upon a sudden policy change, total labor falls sharply and stays low. Reserves also decline, but more gradually, and stay low. As a result, there is a sudden loss in production and a sudden increase in labor productivity which then drops and converges to a level slightly higher than the initial steady state, at odds with the data. Still, industry profits decline less than the baseline case, by 63%, Panel D of Table 3.

To provide additional insights into the potential costs of the policy, I also consider calculating relative estimates for the predicted, discounted sum of profits over the full period examined. Three scenarios—baseline, unanticipated (sudden) nationalization, and no nationalization—are considered. The "no nationalization" scenario assumes constant income and severance taxes at the pre-1960 levels without labor market distortions. Stable tax rates absent labor distortions benefit the industry by increasing the present discounted sum of profits by about 20% over 1961–1980 compared to the baseline. However, the industry's returns over a shorter time horizon, namely for pre-1970 period, are slightly higher (about 5%) under the baseline than without nationalization. This might suggest a short-run benefit to the host country from nationalization, providing a rationale for the policy. A sudden nationalization, on the other hand, lowers the discounted income streams of the industry by 29% and 33% compared to the baseline for 1961–1980 and pre-1970 periods, respectively. In other words, without nationalization the industry's present discounted sum of profits would have been higher over 1961–1980 particularly compared to a case where nationalization had been sudden. Anticipated nationalization seems to benefit the industry's returns on a shorter horizon, but only slightly.

These counterfactuals imply that not taking into account labor market distortions or the anticipatory nature of nationalization would understate the performance of the model in accounting for the productivity pattern over 1961–1980. An anticipated nationalization that only brings higher income taxes has limited distortionary effects. However, nationalization that causes a shift in the composition of the workforce results in significant losses. The cost is detrimental particularly in the short run, when nationalization is sudden due to a sudden drop in activity; in the long run sudden nationalization appears to be less costly to the host country

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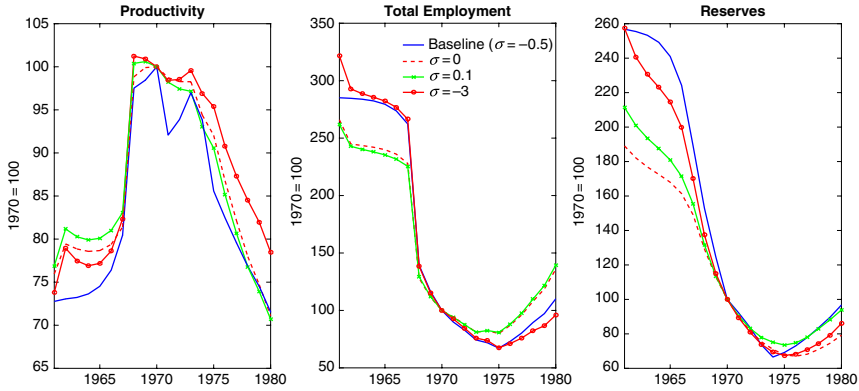

FIGURE 10. Model with different elasticities of substitution (σ).

than an anticipated nationalization. Finally, without nationalization the industry's discounted income streams would have been higher over 1961–1980, particularly compared to a case where nationalization had been sudden. Anticipated nationalization barely benefits the industry by bringing slightly higher income streams in the short run.

5.4. Sensitivity Analysis

First, I perform sensitivity analysis for the elasticity of substitution between foreign and domestic labor inputs in production, (σ), the parameter I was not able to pin down solely on the basis of simple steady-state moments. In the baseline calibration, σ is set at -0.5 so that foreign and domestic labor are complements. I pick a much smaller elasticity of substitution, $\sigma = -3$, Cobb–Douglas technology, that is, $\sigma = 0$, and a higher, positive elasticity of substitution, $\sigma = 0.1$, than the baseline value, and recalibrate the model for each of these cases. The results are presented in Figure 10.

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

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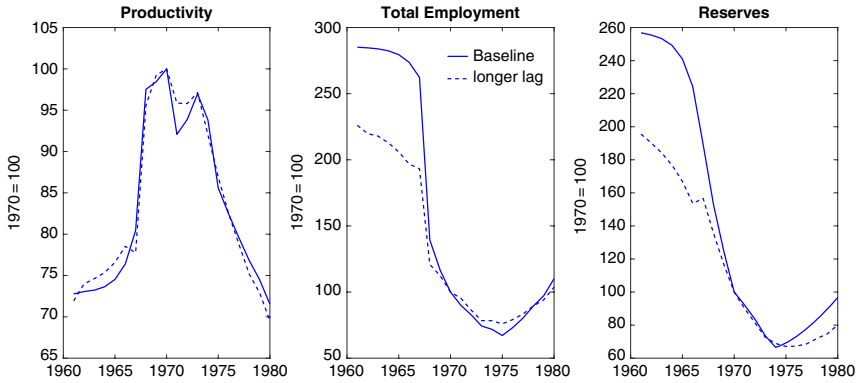

FIGURE 11. Model with a longer lag between exploration and reserves.

Second, in the baseline model, in line with the standard non-renewable resources literature, the lag between exploration and reserve accumulation is assumed to be one period. However, the lag between exploration and accumulation of reserves for extraction could be longer [Antill and Arnott (2000) and Arezki et al. (2017)]. In order to explore the implications of an alternative assumption regarding the lag between exploration and reserves, I consider a case where the lag is two periods and re-solve the model. Simply, I assume that one unit of exploration in period t produces one unit of productive reserves in period $t+2$ as follows:

$$R_{t+2} = R_{t+1} - O_{t+1} + G_t.$$

Reserves take more time to become productive, and overall, this brings a lower path of reserves resulting in a lower employment path and a similar productivity path compared to the baseline model as shown by Figure 11. To be more specific, in response to the anticipated nationalization, with a longer lag, the shadow value of an additional unit of reserves (η_t) declines more notable in the earlier periods of the sample resulting in a sharper decline in exploratory efforts than the baseline model. But, the larger decline in the opportunity cost of extraction today does not cause today's extractive efforts to increase, as the shadow value at time t does not affect the optimal extractive efforts directly.[55] They rather decline slightly in response to the slower accumulation of reserves. This causes production to decline slightly in the earlier periods, at odds with the Venezuelan experience. Therefore, as the declines in reserves and employment are more noticeable due to a notable decline in exploration efforts and slightly lower extractive efforts, productivity moves slightly up in the earlier periods compared to the baseline. In the post-nationalization period, despite increasing exploration efforts, slower accumulation of reserves causes a delayed response in extractive efforts and extraction. Hence, post-nationalization employment is overall similar to the baseline but reserves move down with only slightly lower productivity.

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6. CONCLUSION

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

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

I also perform counterfactual experiments to illustrate key factors accounting for the path of productivity and draw policy implications. I show that the shift in the composition of the workforce from foreign workers to domestic workers is a key factor in productivity's path. I find that political favoritism is very costly for productivity but not as costly for profitability. Finally, I find that if nationalization had been sudden rather than anticipated, short-run costs would have been higher due to a sudden drop in activity along with lower discounted income streams.

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

SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit https://doi.org/10.1017/S1365100518000846.

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NOTES

1. Leading studies include La Porta and Lopez-de-Silanes (1999), Megginson et al. (1994), and Megginson and Netter (2001).

2. Stroebel and Van Benthem (2013). In 2010, more than 75% 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.

3. It is important to note that sectoral data availability is an issue for developing resource-rich countries during the period examined.

4. This effect is not limited to static welfare gains. The presence of MNCs in a developing country can also affect the country's accumulation of know-how, yielding better exposure to it and improvements in Monge-Naranjo (2011). In a related context, Lim (in press) develops an endogenous growth model with heterogeneous labor to understand the knowledge conduit role of foreign MNCs in a developing host economy.

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

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

7. Real GDP per capita and oil production per capita mostly move in the same direction.

8. 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.

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

10. The Middle East and Asia have lower shares, 16.4% and 15.3%, respectively.

11. The time pattern of expropriations confirms this opportunistic motive [Duncan (2006) and Guriev et al. (2011)].

12. From 1970 to 1975, productivity declines slightly, about 5%, but from 1976 to 1985, it increases by around 30%.

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

14. Sonatrach signed an agreement with Getty Oil in 1968 receiving 51% of Getty Oil's interests.

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

16. See Appendix I.b in the Supplementary Material for details.

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

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

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19. In PDVSA databooks, total employment is disaggregated into employees and laborers by nationality. I assume that employees represent white-collar (WC) workers and laborers represent BC workers.

20. The former Aramco ownership distribution of equity capital was Exxon, Texaco, Chevron 30% each, and Mobil 10% [Luciani (1984)].

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

22. Chang et al. (2018) explore reopening of the oil sector to foreigners in the early 1990s and re-nationalization of the industry in the early 2000s.

23. Production per operating well, which can also be considered a measure of productivity in the oil industry, follows a similar path.

24. Cuddington and Moss (2001) 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 applications of microcomputers, take place in the early 1980s. Thus, increasing productivity in the post-1985 period can partly be due to the advances in technology in the early 1980s.

25. Venezuela is one of the founding members of OPEC in 1960. OPEC production quotas have been agreed upon by members during OPEC meetings but estimates have been reported since 1982. During the 1970s and 1980s, OPEC production restrictions took place. In 1973–1974, mostly Arab oil producers restricted output. From 1979 to 1985, Saudi Arabia, Libya, and Kuwait implemented the greatest percentage cutbacks, and countries like Indonesia, Nigeria, and Venezuela were among those least willing to cut production [Gately et al. (1986)].

26. British Petroleum Statistical Review of World Energy.

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

28. Source is a series of detailed studies of the financial performance of a large number of petroleum companies by the Energy Division of the Chase Manhattan Bank over 1968–1982. In these studies, the combined operations of these companies make up a major proportion of the worldwide activities of the petroleum industry. Therefore, the financial performance presented shows the experience of the overall industry.

29. From 1975 to 1982, capital investments increased by almost three-fold in the USA and Canada, by almost four-fold in Africa, and by more than five-fold in the Middle East.

30. Chase Manhattan Bank, Energy Division (1968−1982). From 1958 to 1982, the share of exploration expenditures in total capital expenditures ranged between 2% and 23% across the world.

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

32. Nationalization of the Venezuelan oil industry is argued to be established after intense negotiations with MNCs. To some extent, the control of the industry had already been in the hands of the state since 1971/1972. So, negotiations focused on establishing the amount and type of compensation rather than trying to stay in the country. Article 15 of the law provided the mechanisms of compensation in detail: "the amount of compensation of the expropriated assets cannot be higher than the net value covering properties, plants, and equipment . . .," and the actual compensation was about $1,012,571,901.67 [Coronel (1983)]. According to Martinez (1989), compensation payments to former concessionaires and equity holders on 31st of December in 1975 was in total $1342.28 million.

33. The expectation of a future nationalization would induce a shift towards increasing extraction more than would otherwise be optimal by increasing the opportunity cost of postponing extraction.

34. Hence, fear of nationalization could eventually make nationalization inevitable. So, there is a possibility of a self-fulfilling nationalization.

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

36. By assuming competitive producers, I am not departing from the Venezuelan reality.

37. The sequences of tax rates are viewed parametrically. To simplify the analysis, I assume perfect foresight.

38. This is how most of the contracts in oil-producing developing countries were specified during the period examined.

39. In some earlier papers, reserves are also assumed to serve as a capital input. Among others, Devarajan and Fisher (1982), Yucel (1986), and Deacon (1993).

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

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

42. Also known as the resource rent at time t, η_t summarizes what is sacrificed to obtain a unit of the resource, that is, the opportunity cost of extracting the resource.

43. Each unit of reserves has value, and it can be extracted or left in the ground to the next period with a scarcity value η. $(1 - O_{R_{t+1}})$ term on the right-hand side of the equation (8) is similar to $(1 - \delta)$ in the Euler equation of the neoclassical growth model. That is, $O_{R_{t+1}}$ here behaves like an endogenous depreciation rate. Once extracted at $t + 1$, tomorrow's shadow value will be reduced by $O_{R_{t+1}}$.

44. Asiedu and Villamil (2000) examine the determinants of a country's discount factor β in a model of investment when enforcement is imperfect.

45. Estimating a value for the elasticity of substitution parameter is not possible due to data limitations on skill premium. I hypothesize that complementary domestic and foreign labor inputs can help explain the observed path of productivity. Thus, σ must be set at a value ≤ 0. As a baseline value, I consider -0.5 and then perform sensitivity analysis.

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

47. I have data on effective income tax rates beginning in 1964. The average government take presented by Manzano and Monaldi (2010) (in their Figure 12.3) was stable in the early 1960s. So, I assume that the income tax rates from 1961 to 1963 are the same as the 1964 income tax rate.

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48. I use the very limited micro data on labor costs by nationality and occupation in the calibration, which are presented and discussed in detail in Appendix II.b in the Supplementary Material. For the nationalization experiment, though, I need more than a few years of data on foreign labor characteristics.

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

50. I have data only on total wages. As domestic workers constitute 92–99% of the total workforce during 1961–1980, I consider changes in the total real wages data as a proxy for changes in domestic worker wages.

51. In my view, changes in oil prices are not a major factor in explaining the trends in the Venezuelan oil industry as I discussed in Section 3. Thus, I assume that p stays at its initial steady-state value.

52. The connection of revisions to (proven) reserves data can be explained by the following definition. Adjustments to proven reserves are equal to net reserve additions to reserves minus reported year production (Energy Information Administration). Net additions to reserves are the sum of discoveries, extensions, and revisions [Barrett (1986)]. Revisions include adjustments to reserves estimates due to a discrepancy between the estimated and actual production in the previous year and have historically shown highly erratic movements over time making an economic explanation hard [Farzin (2001)]. In the Venezuelan data, discoveries, extensions, and revisions, changed by 34%, −44%, and 629%, respectively from 1973 to 1974, imply that the increase in net reserve additions in 1974 was mainly due to revisions. This empirical evidence is consistent with other anecdotal evidence. Coronel (1983) notes that in 1973–1974, there was a change in the parameters for the calculation of reserves, resulting in a large increase in revisions that were not a result of the booming oil prices. These suggest that the large increase in reserves over 1973–1974 is mainly driven by revisions.

53. Post-nationalization profits take into consideration the associated labor taxes and subsidies.

54. Brixiova and Egert (2012) analyze the optimal path of state sector employment by focusing on business environment and productivity of firms. They argue that when prospects for emergence of productive private firms are limited, keeping workers in public jobs for longer, rather than pursuing radical downsizing of the public sector, is rational.

55. The optimality condition for extractive efforts changes due to the change in the constraint, yielding an equality between price and the marginal extraction cost.

REFERENCES

Aitken, Brian J. and Ann E. Harrison (1999) Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *American Economic Review* 89(3), 605–618.

American Petroleum Institute (1975) *Basic Petroleum Data Book: Petroleum Industry Statistics*. Washington, D.C.

Antill, Nick and Robert Arnott (2000) *Valuing Oil and Gas Companies: A Guide to the Assessment and Evaluation of Assets, Performance and Prospects*. Cambridge, England: Woodhead Publishing Limited.

Antras, Pol, Luis Garicano and Esteban Rossi-Hansberg (2006) Offshoring in a knowledge economy. *Quarterly Journal of Economics* 121(1), 31–77.

Arezki, Rabah, Valerie A. Ramey and Liugang Sheng (2017) News shocks in open economies: Evidence from giant oil discoveries. *The Quarterly Journal of Economics* 132(1), 103–155.

Asiedu, Elizabeth and Anne P. Villamil (2000) Discount factors and thresholds: Foreign investment when enforcement is imperfect. *Macroeconomic Dynamics* 4(1), 1–21.

Barrett, Scott A. (1986) The economics of oil supply dynamics: Theory and practice. *Energy Economics* 8(4), 237–250.

Barro, Robert J. and Jong Wha Lee (2013) A new data set of educational attainment in the world, 1950–2010. *Journal of Development Economics* 104, 184–198.

https://doi.org/10.1017/S1365100518000846 Published online by Cambridge University Press

Bello, Omar D., Juan S. Blyde and Diego Restuccia (2011) Venezuela's growth experience. *Latin American Journal of Economics* 48(2), 199–226.
Blackorby, Charles and R. Robert Russell (1989) Will the real elasticity of substitution please stand up? (A comparison of the Allen/Uzawa and Morishima Elasticities). *American Economic Review* 79(4), 882–888.
Brixiova, Zuzana and Balazs Egert (2012) Business environment, start-ups, and productivity during transition. *Macroeconomic Dynamics* 16(S2), 213–231.
Brogini, Maurice (1973) *L'exploitation des Hydrocarbures en Algerie de 1956 a 1971: etude de geographie economique*. Nice, France: Universite de Nice.
Burstein, Ariel T. and Alexander Monge-Naranjo (2009) Foreign know-how, firm control, and the income of developing countries. *Quarterly Journal of Economics* 124(1), 149–195.
Bye, Vegard (1979) Nationalization of oil in Venezuela: Re-defined dependence and legitimization of imperialism. *Journal of Peace Research* 16(1), 57–78.
Chang, Roberto, Constantino Hevia and Norman Loayza (2018) Privatization and nationalization cycles. *Macroeconomic Dynamics* 22(2), 331–361.
Chase Manhattan Bank, Energy Division (1968–1982) *Capital Investments of the World Petroleum Industry*. New York: Chase Manhattan Bank.
Cole, Harold L., Lee E. Ohanian, Alvaro Riascos and James A. Schmitz (2005) Latin America in the rearview mirror. *Journal of Monetary Economics* 52(1), 69–107.
Coronel, Gustavo (1983) *The Nationalization of the Venezuelan Oil Industry*. Lanham, MD: Lexington Books.
Cuddington, John T. and Diana L. Moss (2001) Technological change, depletion, and the U.S. Petroleum Industry. *American Economic Review* 91(4), 1135–1148.
Dasgupta, Partha and Geoffrey Heal (1974) The optimal depletion of exhaustible resources. *The Review of Economic Studies* 41, 3–28.
Deacon, Robert T. (1993) Taxation, depletion, and welfare: A simulation study of the U.S. Petroleum Resource. *Journal of Environmental Economics and Management* 24(2), 159–187.
Devarajan, Shantayanan and Anthony C. Fisher (1982) Exploration and scarcity. *Journal of Political Economy* 90(6), 1279–1290.
Duncan, Roderick (2006) Price or politics? An investigation of the causes of expropriation. *Australian Journal of Agricultural and Resource Economics* 50(1), 85–101.
Eeckhout, Jan and Boyan Jovanovic (2012) Occupational Choice and Development. *Journal of Economic Theory* 147(2), 657–683.
Ellner, Steve (1993) *Organized Labor in Venezuela 1958–1991: Behavior and Concerns in a Democratic Setting*. Wilmington, DE: Scholarly Resources Books.
Energy Information Administration. *Definitions, Sources, and Explanatory Notes.* Washington, DC: U.S. Department of Energy.
Farzin, Y. Hossein (2001) The impact of oil price on additions to US proven reserves. *Resource and Energy Economics* 23(3), 271–292.
Gall, Norman (1975) The challenge of Venezuelan oil. *Foreign Policy* 18(Spring), 44–67.
Gately, Dermot, M. A. Adelman and James M. Griffin (1986) Lessons from the 1986 oil price collapse. *Brookings Papers on Economic Activity* 1986(2), 237–284.
Guriev, Sergei, Anton Kolotilin and Konstantin Sonin (2011) Determinants of nationalization in the oil sector: A theory and evidence from panel data. *The Journal of Law, Economics, and Organization* 27(2), 301–323.
Hajzler, Christopher (2007) Expropriation of Foreign Direct Investments, 1990–2006. University of Western Ontario, Working Paper.
Hajzler, Christopher (2012) Expropriation of foreign direct investments: Sectoral patterns from 1993 to 2006. *Review of World Economics* 148(1), 119–149.
Hajzler, Christopher (2014) Resource-based FDI and expropriation in developing economies. *Journal of International Economics* 92(1), 124–146.
Hausmann, Ricardo and Francisco Rodriguez (2006) *Venezuela: Anatomy of a Collapse*.

https://doi.org/10.1017/S1365100518000846 Published online by Cambridge University Press

Hotelling, Harold (1931) The economics of exhaustible resources. *Journal of Political Economy* 39(2), 137–175.

Howarth, Stephen and Joost Jonker (2007) *Powering the Hydro-Carbon Revolution, 1939-1973, A History of Royal Dutch Shell*, Volume 2. New York: Oxford University Press.

International Labour Organization, Sectoral Activities (1998) *Employment and Industrial Relations Issues in Oil Refining*. Geneva: International Labour Office.

Kobrin, Stephen J. (1980) Foreign enterprise and forced divestment in LDCs. *International Organization* 34(1), 65–88.

Kobrin, Stephen J. (1984) Expropriation as an attempt to control foreign firms in LDCs: Trends from 1960 to 1979. *International Studies Quarterly* 28(3), 329–348.

Kobrin, Stephen J. (1984) The nationalization of oil production, 1918–80. In: David W. Pearce, Horst Siebert and Ingo Walter (eds.), *Risk and the Political Economy of Resource Development*, pp. 137–164. London: Palgrave Macmillan.

Krusell, Per, Lee E. Ohanian, Jose-Victor Rios-Rull, and Giovanni L. Violante (2000) Capital-skill complementarity and inequality: Macroeconomic analysis. *Econometrica* 68(5), 1029–1053.

La Porta, Rafael and Florencio Lopez-de-Silanes (1999) The benefits of privatization: Evidence from Mexico. *The Quarterly Journal of Economics* 114(4), 1193–1242.

Lim, King Yoong (in press) Industrial transformation with heterogeneous labor and foreign experts. *Macroeconomic Dynamics*.

Luciani, Giacomo (1984) *The Oil Companies and the Arab World*. New York: St. Martin's Press.

Mackay, K. H. (1984) Estimates of manpower requirements and manpower availability in the world petroleum industry 1980–2000 and their implications. In: *Proceedings of the 11th World Petroleum Congress*, pp. 3–11. John Wiley and Sons, Chichester.

Manzano, Osmel and Francisco Monaldi (2010) *The Political Economy of Oil Contract Renegotiation in Venezuela, in The Natural Resource Trap: Private Investment without Public Commitment*. Cambridge, MA: MIT Press.

Martinez, Anibal R. (1989) *Venezuelan Oil Development and Chronology*. New York: Springer.

Megginson, William L., Robert C. Nash and Matthias Van-Randenborgh (1994) The financial and operating performance of newly privatized firms: An international empirical analysis. *The Journal of Finance* 49(2), 403–452.

Megginson, William L. and Jeffry M. Netter (2002) From state to market: A survey of empirical studies on privatization. *Journal of Economic Literature* 39(2), 321–389.

Michelena, Silva, Jose Agustin and Felix Soublette (1976) *Nacionalizacion Petrolera: Recursos Humanos*. Caracas, Venezuela: Universidad Central de Venezuela.

Mikesell, Raymond F. (1984) *Petroleum Company Operations and Agreements in the Developing Countries*. Washington, D.C.: Resources for the Future.

Minor, Michael S. (1994) The demise of expropriation as an instrument of LDC policy, 1980–1992. *Journal of International Business Studies* 25(1), 177–188.

Monge-Naranjo, Alexander (2010) Foreign firms and the diffusion of entrepreneurial skills. State College, PA: Penn State University.

Olmedillo, N. E. (1984) Human resources procurement and development in a growing industry, Caracas, Venezuela. In: *Proceedings of the 11th World Petroleum Congress*, pp. 21–29. John Wiley and Sons, Chichester.

Pindyck, Robert S. (1978) The optimal exploration and production of nonrenewable resources. *Journal of Political Economy* 86(5), 841–861.

Randall, Laura (1989) Mexico's Oil Workers: Union Gains and Labor Conditions. The Graduate School and University Center of the City University of New York, Bildner Center for Western Hemisphere Studies, Working Paper Series: U.S.-Mexico Studies. No: 6.

Rigobon, Roberto (2010) Dealing with expropriations: General guidelines for oil production contracts. In: William Hogan and Federico Sturzenegger (eds.), *The Natural Resources Trap: Private Investment without Public Commitment*, pp. 227–254. Cambridge, MA: MIT Press.

Sachs, Jeffrey D. and Andrew M. Warner (1999) Natural resource intensity and economic growth. In: Jorg Mayer, Brian Chambers and Ayisha Farooq (eds.), *Development Policies in Natural*

https://doi.org/10.1017/S1365100518000846 Published online by Cambridge University Press

Resource Economies, pp. 13–37. Cheltenham, U.K. and Northampton, MA: Elgar in association with UNCTAD.

Schmitz Jr., James A. (2005) What determines productivity? Lessons from the dramatic recovery of the U.S. and Canadian Iron Ore Industries following their early 1980s crisis. *Journal of Political Economy* 113(3), 582–625.

Schmitz Jr., James A. and Arilton Teixeira (2008) Privatization's impact on private productivity: The case of Brazilian Iron Ore. *Review of Economic Dynamics* 11(4), 745–760.

Stroebel, Johannes and Arthur Van Benthem (2013) Resource extraction contracts under threat of expropriation: Theory and evidence. *Review of Economics and Statistics* 95(5), 1622–1639.

Tennassee, Paul Nehru (1979) *Venezuela, Los Obreros Petroleros y la lucha por la democracia*. Fremont, CA: E.F.I. Publicaciones.

Tomz, Michael and Mark L. J. Wright (2010) Sovereign theft: Theory and evidence about sovereign default and expropriation. In: William Hogan and Federico Sturzenegger (eds.), *The Natural Resources Trap: Private Investment without Public Commitment*. Cambridge, MA: MIT Press.

U.S. Bureau of the Census, U.S. Census of Mineral Industries (1958) *Summary and Industry Statistics*, Volume 1. Washington, DC: U.S. Bureau of the Census.

U.S. Bureau of the Census, U.S. Census of Mineral Industries (1987) *Industry Series, Oil and Gas Field Services*. Issued August 1989.

Williams, M. L. (1975) The extent and significance of the nationalization of foreign-owned assets in developing countries, 1956–1972. *Oxford Economic Papers* 27(2), 260–273.

Woodward, Peter N. (1988) *Oil and Labor in the Middle East: Saudi Arabia and the Oil Boom*. Santa Barbara, CA: Praeger Publishers.

Yergin, Daniel (1991) *The Prize: The Epic Quest for Oil, Money & Power*. New York: Simon & Schuster.

Yucel, Mine Kuban (1986) Dynamic Analysis of Severance Taxation in a Competitive Exhaustible Resource Industry. *Resources and Energy* 8(3), 201–218.

https://doi.org/10.1017/S1365100518000846 Published online by Cambridge University Press