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Essays on Macroeconomics and Oil

A dissertation submitted in partial satisfaction
of the requirements for the degree
Doctor of Philosophy in Economics

by

Nida Çakır

2013

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Abstract of the Dissertation

Essays on Macroeconomics and Oil

by

Nida Çakır

Doctor of Philosophy in Economics

University of California, Los Angeles, 2013

Professor Lee E. Ohanian, Chair

In these essays, I examine (i) the empirical methods that are widely used in the literature to measure total factor productivity growth and (ii) the impact of nationalization on productivity in the oil industry. The first chapter, which is an ongoing work with SHI, Wei, investigates two empirical measures, quantity-based (primal) measure and price-based (dual) measure, of total factor productivity growth. My co-author and I analyze how these two measures are affected by output market imperfection or variable capacity utilization. We find that under constant-returns-to-scale production function assumption, existence of the imperfect competition in the output market creates a gap between the measured TFP growth and the true TFP growth, no matter which method is used. However, theoretically, it does not affect the equivalence between the two measures. Under variable capacity utilization, we show that constant-returns-to-scale assumption is almost enough to guarantee the validity of the two methods in correctly capturing the true TFP growth. In the second and third chapters, I analyze the link between nationalization and productivity. The second chapter documents the trends in expropriation acts, and evaluates the impact of expropriations on labor productivity of resource-rich developing countries in the oil industry. In the first part of this chapter, I investigate the trends in the expropriation acts that took place in 102 developing countries during the period 1922-2006. I find that more than half of the acts occurred between 1970 and 1976, there has been an increase in the number of expropriations in recent years, and the extractive sector including petroleum is more likely to be expropriated. Motivated by these facts, in the second part, I examine the oil industry in a period of widespread expropriations, the 1970s. In a sample of major oil-producing countries including OPEC and non-OPEC members, I show that losses in relative labor productivity after nationalization range from 25 percent to 55 percent. In the third chapter, I attempt to provide an answer for why nationalization is associated with lower productivity by examining the case of the 1975 Venezuelan oil industry nationalization. The first part of the chapter documents the facts. I find that prior to nationalization there was a significant contraction in manpower (particularly in the foreign work force) and exploration, and an increase in production and productivity. Production and productivity declined sharply, however, by the beginning of the nationalization process. This decline continued even after the process was finalized and a substantial expansion took place in the industry. In the second part, I explain these facts by using a dynamic partial equilibrium framework for nonrenewable resources featured by imperfect substitutability between domestic and foreign workers. The anticipation of nationalization preceding 1970 can explain the drop in the total work force at the expense of lower exploration which accompanies increasing productivity. The lost foreign expertise can explain the path of productivity during and after nationalization. A comparison of the simulated and actual time series shows that around 56 percent of the increase in productivity prior to 1970, and about 39 percent of the decline in productivity during and after the nationalization process can be attributed to the proposed mechanism.

The dissertation of Nida Çakır is approved.

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2013

To my husband, Murat, whose immense love and endless support kept me afloat during turbulent times. With his patience and support, it is easier to accomplish anything.

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Vita

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CHAPTER 1

A Discussion on the Measurement of TFP Growth

1.1 Introduction

In the macroeconomic literature, the total factor productivity (TFP) is usually viewed as representing the technological progress experienced by the whole economy. When an empirical assessment of the TFP growth is to be performed, two measures may be explored: the quantity-based measure and the price-based measure. Solow (1957) [10] first proposes the quantity-based method which emphasizes the effect of the technological shock on the total amount of output that could be produced given certain amounts of inputs. This method computes the rate of the TFP growth as the residual of the per capita output growth rate less the appropriately weighted average of the per capita input growth rates, where the weights are taken as the corresponding income shares of the inputs. The price-based dual method rests on the cost reduction aspect of the technological development, i.e., it calculates the TFP growth rate as the difference between the output price changes and the weighted average price changes for the relevant inputs. It has already been established that under the joint assumption of constant-return-to-scale production function, perfect competition and full capacity utilization, both methods correctly capture the TFP growth. Our paper provides a tentative discussion about what would happen if one or more conditions are violated. To be more specific, throughout the paper, we maintain the assumption of constant-return-to-scale production function while analyzing the properties of these two measures when 1) there are monopolistic profits, and/or when 2) the use of some factors is different from their long-run equilibrium level.

One interesting application of this discussion would be the case study of the newly industrialized countries in Asia, especially the growth experience of Singapore. In a series of papers, Alwyn Young adopts the primal method, and concludes that the growth of

Singapore is mainly due to factor accumulation with only a small contribution of the TFP improvement. Chang-Tai Hsieh, on the contrary, applies the dual method to the same country and finds that there is rapid TFP growth. Some discrepancy between these two measures is to be expected because data on quantities and prices used may be from different sources. However, as suggested by other studies, such discrepancy may reveal more economically interesting problems of the underlying economy, rather than simply statistical measurement errors.

For instance, Hall (1988) [4] and Roeger (1995) [9] study the impact of imperfect competition on the primal measure and the dual measure, respective, and argue that it is possible to estimate the markups of the output price over its marginal cost by means of these two measures. Fernald and Neiman (2003) [3] suggest that the capital market imperfection and the existence of large economic profits could reconcile Young and Hsieh's TFP growth estimates in Singapore. Our findings in this paper confirm the claim that the market imperfection causes the estimated TFP growth, no matter which method is used, to deviate from the true TFP growth. However, if these profits are fully reflected by the factor prices, the primal measure and the dual measure remain the same, so the observed difference between them is merely a statistical issue, rather than being economically meaningful.

The discrepancy between the true TFP growth and its measured counterpart may also arise when some inputs are treated as being fixed in the short run but variable in the long run. Towards this direction, the study by Ernst R. Berndt and Melvyn A. Fuss (1982) [1] represents the first step. They argue that for the quasi-fixed factors, the market prices do not necessarily reflect the corresponding marginal products. As a result, estimates based on these distorted prices may be biased. Our paper shows that, however, under the constant-return-to-scale assumption, such bias completely undoes itself, so both the primal method and the dual method produce reliable estimates for the true TFP growth.

To concentrate on the TFP related issue in the aggregate economy, we treat the production side as if all production is done by a representative firm using capital and labor. Our analysis is a partial equilibrium analysis, mainly focusing on the firm-side problem. The rest of the paper is organized as follows. Section 1.2 considers the situation with imperfect competition in the output market under full capacity utilization, while

Section 1.3 allows variable utilization rate of the quasi-fixed factor in the short run with competitive output market. We supply several concluding remarks in Section 1.4, and suppress all proofs into the attached appendix.

1.2 Model with imperfect competition

This section starts with the presentation of the benchmark case. Then, we continue with introducing imperfect competition.

1.2.1 Benchmark case

This subsection lays out the general environment we will work with throughout the paper, and develops the validity of both the primal measure and the dual measure under the joint assumption of constant-return-to-scale aggregate production function, perfect competition in the output market and full capacity utilization. The results obtained in this subsection will serve as a benchmark in the following analysis.

We consider a one-good economy which is produced by combining capital K and labor L according to

$$Y_t = z_t F(K_t, L_t) \tag{1.1}$$

The function $F(\cdot, \cdot)$ is homogeneous of degree 1. z_t is the total factor productivity at time t which is not directly observed but can be estimated from (1.1) if the quantities of the output Y_t and those of the inputs K_t and L_t are available. Henceforth, to simplify notation, the time-subscript will be ignored if there is no risk of causing ambiguity.

The representative firm faces competitive input markets for its capital and labor. Let w and r be the wage rate and the rental rate of capital denominated in money, respectively.[1] Since both inputs can be adjusted instantly with respect to the input price changes, the profit-maximization or the cost-minimization consideration requires

[1]Including money in our model helps us explain the setup more clearly, especially when it comes to the case where the output market is not competitive. However, aside from this simplicity, money plays no important role in our model.

the inputs be priced by their marginal products:[2]

$$w_t = z_t F_L(K_t, L_t), \quad r_t = z_t F_K(K_t, L_t) \tag{1.2}$$

With competitive output market, the output good Y will be priced by its marginal cost of production, which we normalize to one. In other words, the benchmark model treats the output good Y as the numeraire. Under this specification, w and r become the real prices of labor and capital.

The primal measure and the dual measure of TFP growth rate g are defined as

$$g_t^P = \frac{\dot{Y}_t}{Y_t} - s_{Kt}\frac{\dot{K}_t}{K_t} - s_{Lt}\frac{\dot{L}_t}{L_t}, \tag{1.3}$$

$$g_t^D = s_{Kt}\frac{\dot{r}_t}{r_t} + s_{Lt}\frac{\dot{w}_t}{w_t} \tag{1.4}$$

where $\dot{X}$ is the time derivative of variable X.

$$s_K = \frac{rK}{Y} = \frac{F_K(K,L)K}{F(K,L)}, \quad \text{and} \quad s_L = \frac{wL}{Y} = \frac{F_L(K,L)L}{F(K,L)}$$

are the income shares, as well as elasticities with respect to output, for capital and labor.

It is easy to obtain the following result

$$g_t^P = g_t^D = \frac{\dot{z}_t}{z_t} \tag{1.5}$$

which establishes the equivalence of the primal and the dual methods, as well as their validity. Appendix A contains a short proof.

1.2.2 Imperfect competition case

This subsection deviates from the competitive market assumption for the output market and assumes that the measured output contains moderate economic profits due to market

[2]

$$F_K(K,L) = \frac{\partial}{\partial K}F(K,L), \quad \text{and} \quad F_L(K,L) = \frac{\partial}{\partial L}F(K,L)$$

imperfection. Since our focus is how the mis-measured profits affect the observed TFP growth according to both the primal and the dual estimates, we do not bother ourselves to provide a complete description of such market imperfection and how it influences other parts of the economy. Instead, we model the output market imperfection as a markup of the output good price over its marginal cost, and distribute the resulted non-trivial profits to the labor income and the capital income. Therefore, in our setup, market imperfection may impact the estimated TFP growth by affecting the measured factor prices, as well as the measured income shares. Now let us turn to a more formal analysis.

We find it easy for us to define the value of one unit of money in our economy to be the competitive price of the output good, or in other words, to be the marginal cost of producing one unit of the output good. Under this definition, the shadow prices of labor and capital have the same expressions as in the benchmark case:

$$w_t = z_t F_L(K_t, L_t), \quad r_t = z_t F_K(K_t, L_t)$$

The output good will be sold at price

$$P_t = 1 + B_t, \tag{1.6}$$

where B_t is the time t markup which is taken as exogenous in our paper. The representative firm rents capital and labor at their competitive prices and enjoys a profit equal to $B_t Y_t$ at time t. However, from the perspective of an outside researcher who adopts a competitive view for the representative firm, such profit is not directly observable and may be mistakenly included as either part of the capital income or part of the labor income. For instance, the researcher may first collect the total payment to labor and derives the payment to capital as a residual. If there exist non-trivial economic profits, the unit cost of labor implied by this treatment could be above its shadow price w if labor has a positive share of these profits. Moreover, all the remaining profits are taken as capital income, which drives a gap between the capital income share and the elasticity of output with respect to capital input, as well as distorting the rental price of capital r if it is inferred from the capital income.

We model these concerns by first paying capital and labor according to their shadow prices, and then after the production, distributing the resulted profits between capital and labor with the share parameter of labor equal to $\beta_t \in [0, 1]$.

The following chart illustrates how the total income is split among different parties of the economy.

Total income: $(1 + B)Y$,

Capital rental payment: $rK = zF_K(K, L)K = s_K Y$,

Labor rental payment: $wL = zF_L(K, L)L = s_L Y$,

Profits: $\pi = BY = \begin{cases} \beta\pi = \beta BY \rightarrow \text{labor}, \\ (1-\beta)\pi = (1-\beta)BY \rightarrow \text{capital}. \end{cases}$

Again, assume that the usage of capital K and labor L in production is measured without error. Output Y is measured at price P and factor prices include their profit shares. We will use letters with hat to denote the measured variables:

$$\text{Measured output: } \hat{Y} = (1 + B)Y, \tag{1.7}$$

$$\text{Measured capital rental rate: } \hat{r} = \frac{rK + (1-\beta)BY}{K} = r(1 + D^r), \tag{1.8}$$

$$\text{Measured wage rate: } \hat{w} = \frac{wL + \beta BY}{L} = w(1 + D^w), \tag{1.9}$$

$$\text{Measured capital share: } \hat{s}_K = \frac{\hat{r}K}{\hat{Y}} = s_K \frac{1 + D^r}{1 + B}, \tag{1.10}$$

$$\text{Measured labor share: } \hat{s}_L = \frac{\hat{w}L}{\hat{Y}} = s_L \frac{1 + D^w}{1 + B}, \tag{1.11}$$

where

$$D^r \triangleq (1-\beta)B\frac{Y}{rK} = B\frac{1-\beta}{s_K}, \tag{1.12}$$

$$D^w \triangleq \beta B\frac{Y}{wL} = B\frac{\beta}{s_L} \tag{1.13}$$

are the resulted markups of the factor prices over their competitive counterparts. Variable B in expressions (1.12) and (1.13) indicates the scale of the profits that can be divided by capital income and labor income. The size of these markups also depends on the magnitude of the bargaining power of the two factors relative to their elasticities with respect to output.

The measured TFP growth is now computed using the measured variables as follows:

$$g_t^P = \frac{\dot{\hat{Y}}_t}{\hat{Y}_t} - \hat{s}_{Kt}\frac{\dot{K}_t}{K_t} - \hat{s}_{Lt}\frac{\dot{L}_t}{L_t},$$
$$g_t^D = \hat{s}_{Kt}\frac{\dot{\hat{r}}_t}{\hat{r}_t} + \hat{s}_{Lt}\frac{\dot{\hat{w}}_t}{\hat{w}_t}$$

We show that[3]

$$g_t^P = \frac{\dot{z}_t}{z_t} + \frac{\dot{B}_t}{1+B_t} + \frac{B_t(s_{Lt}-\beta_t)}{1+B_t}(\frac{\dot{L}_t}{L_t} - \frac{\dot{K}_t}{K_t}), \tag{1.14}$$

and

$$g_t^D = \frac{\dot{z}_t}{z_t} + \frac{\dot{B}_t}{1+B_t} + \frac{B_t}{1+B_t}[(s_{Lt}-\beta_t)(\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t})] - \frac{B_t}{1+B_t}[(1-\beta_t)\frac{\dot{s}_{Kt}}{s_{Kt}} + \beta_t\frac{\dot{s}_{Lt}}{s_{Lt}}]. \tag{1.15}$$

Expression (1.14) illustrates how market imperfection affects the primal measure of TFP growth. On the one hand, changing markup adds additional noise. On the other hand, the way of bargaining over profits between capital income and labor income alters the relative importance of the two factors in accounting for the output growth. As a result, it may create measurement distortions unless the bargaining power is set correctly, equal to the competitive labor share s_{Lt}.

The following are a few sufficient conditions under which the primal measure correctly characterizes the true TFP growth $\dot{z}_t/z_t$. When $B_t \equiv 0$, the second and the third terms disappear and expression (1.14) reduces to $\dot{z}_t/z_t$. This is the benchmark case analyzed in the last subsection.

A maybe more interesting case is that, with the presence of imperfect competition in the output market, if the markup is constant over time $B_t \equiv \bar{B}$ and the profits are divided according to the right share $\beta_t = s_{Lt}$, the primal measure correctly captures the growth of TFP z_t. Moreover, even if $\beta_t \neq s_{Lt}$, the primal measure would be valid provided that $B_t \equiv \bar{B}$ and capital and labor grow at the same rate.

[3]See Appendix A.

We may use (1.14) to evaluate some of the empirical estimates for the TFP changes. For instance, Table 5 and Table 6 in Young (1992) [11] show that in Singapore, capital accumulation grew much faster than labor in most of the periods considered. As a result, if there does exist large economic profits, as argued by Fernald and Neiman (2003) [3], and the capital income share is taken as one minus the labor income share ($\beta = 0$ in our model), the primal measure g_t^P is likely to underestimate the true TFP growth.

Expression (1.15) can be interpreted in a similar way. What is worth emphasizing is that now bargaining over profits also affects the implied markups of the factor prices D_t^r and D_t^w over their shadow costs r and w. As a result, except distorting the relative growth rate of the factor prices, there is an additional term with respect to the relative changing income shares which comes from the variations of D_t^r and D_t^w over time.

It is more difficult to assess the performance of the dual measure with imperfect competition since w_t and r_t in (1.15) are the shadow prices of labor and capital, and are not observed directly. However, we may still get some intuition from (1.15). Assume constant markup $B_t \equiv \bar{B}$ so that the term with respect to $\dot{B}_t$ disappears. The higher growth rate of the capital stock K implies a lower growth rate for its shadow price r, so the third term tends to bias the measured TFP growth downwards if $\beta_t < s_{Lt}$. The behavior of the last term concerning the variations in factor income shares is not straightforward. However, income shares usually remain roughly constant and thus their effect on g_t^D can be expected to be small.

The equivalence between the two measures

$$g_t^D = g_t^P \tag{1.16}$$

is an established result in the benchmark model. Appendix A shows formally that it holds under the set of assumptions mentioned at the beginning of subsection II.2. A loose argument may go as the following. Under the constant-return-to-scale assumption, the quantities of labor and capital and their shadow prices are not independent, but rather linked by the income shares. This implicitly restricts the behaviors of the growth rates for these variables. In fact, the difference between the relative variation in quantities and in prices will be exactly offset by the relative variation in the factor income shares:

$$(1-\beta_t)\frac{\dot{s}_{Kt}}{s_{Kt}}+\beta_t\frac{\dot{s}_{Lt}}{s_{Lt}}=(s_{Lt}-\beta_t)[(\frac{\dot{r}_t}{r_t}-\frac{\dot{w}_t}{w_t})-(\frac{\dot{L}_t}{L_t}-\frac{\dot{K}_t}{K_t})].$$

Therefore, the existence of imperfect competition does not create any discrepancy between the two measures.

1.2.3 Comparison with Hall and Roeger

Many studies try to identify the markups of the output prices over the marginal costs resulted from imperfect competition by looking at their effects on the measured TFP, among which Hall (1988) [4] and Roeger (1995) [9] may serve as representatives.

Hall (1988) [4] focuses on the Solow residual (the primal measure) and concludes that when there is non-trivial markup

$$P_t=(1+B_t)MC_t,$$

the primal measure is[4]

$$(\frac{\dot{Y}_t}{Y_t}-\frac{\dot{K}_t}{K_t})-\alpha_t(\frac{\dot{L}_t}{L_t}-\frac{\dot{K}_t}{K_t})=B_t\alpha_t(\frac{\dot{L}_t}{L_t}-\frac{\dot{K}_t}{K_t})+\frac{\dot{z}_t}{z_t} \tag{1.17}$$

where α_t is the measured income share of labor, $1-\alpha_t$ is the income share of capital which includes all the profits ($\beta=0$).

Above expression is not exactly the same as (1.14), which is obtained by assuming that when computing the Solow residual, the value of output $\hat{Y}_t=P_tY_t$, instead of the real output Y_t, is used. If we adjust for this difference, the term $\dot{B}_t/(1+B_t)$ will be dropped. Moreover, since the measured income share of labor is

$$\alpha_t=\frac{w_tL_t}{\hat{Y}_t}=\frac{s_{Lt}}{1+B_t},$$

hence, (1.14) reduces to Hall's expression.

[4] We adjust the notation according to our definition. The original version is expression (11) in Hall (1988) [4] where the markup parameter $\mu=1+B$.

The distortion inflicted on the measured TFP considered by Hall is mainly through distorting the relative income shares of labor and capital. As illustrated by (1.14), changing markups may add additional volatility to the primal measure.

The equivalence between the two measures seems to contradict with Roeger (1995) [9], in which the corresponding discrepancy is used to estimate the degree of the market imperfection in U.S. manufacturing. His expression for the dual measure is[5]

$$\alpha_t \frac{\dot{w}_t}{w_t} + (1-\alpha_t)\frac{\dot{r}_t}{r_t} - \frac{\dot{B}_t}{1+B_t} = \frac{B_t s_{Lt}}{1+B_t}(\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t}) + \frac{\dot{z}_t}{z_t} \tag{1.18}$$

where α_t is the measured labor income share as in Hall (1988). The comparable counterpart in our formulation would be $g_t^D - \dot{B}_t/(1+B_t)$ which yields the same expression when we replace β by 0 and assume constant income shares.

In deriving the dual measure and the relationship between the two measures, Roeger seems to assume that the shadow costs for labor and capital can be recovered correctly and the distortion occurs only in the measurement of the corresponding income shares. Expression (7) in Roeger (1995) [9] gives the relationship between the two measures which serves as the foundation of his estimation and can be rewritten in the following form:

$$SR_t - SRP_t = \frac{B_t s_{Lt}}{1+B_t}[(\frac{\dot{L}_t}{L_t} - \frac{\dot{K}_t}{K_t}) - (\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t})] + u_t, \tag{1.19}$$

where u_t is treated as the classical measurement error and in the ideal case, all u_t will be zero and the markup B_t could be estimated from the difference $SR_t - SRP_t$.

The important issue Roeger fails to take into account is that under the assumption of constant-return-to-scale production function, the variation of the factor quantities and the variation of the factor prices are linked implicitly by the share parameters. It can be

[5]Roeger (1995) uses the output price P_t in the expression for the dual measure instead of w_t, see expression (6) in Roeger (1995) [9]. We do the transformation of variables according to $P_t = 1 + B_t$ and

$$s_{Lt}\frac{\dot{w}_t}{w_t} + (1-s_{Lt})\frac{\dot{r}_t}{r_t} - \frac{\dot{P}_t}{P_t} = \frac{\dot{z}_t}{z_t}$$

where the latter is a more general dual measure under perfect competition. The markup variable B in Roeger's paper is $B/(1+B)$ in our paper.

shown that when s_{Lt} is constant,

$$\frac{\dot{r}_t}{r_t} + \frac{\dot{K}_t}{K_t} = \frac{\dot{Y}_t}{Y_t} = \frac{\dot{w}_t}{w_t} + \frac{\dot{L}_t}{L_t}.$$

So the term inside the brackets in (1.19) should be equal to zero if the consistently measured quantities and shadow prices are used. Therefore, the existence of the markups alone can not account for the difference between the primal measure and the dual measure under constant income share assumption, and also under a more general set of assumptions, as shown in Appendix A.

1.3 Model with variable capacity utilization

Another big issue discussed in the literature that may cause the measurement problem of the TFP growth is the under-utilization or over-utilization of certain inputs in the production process. In this section, we will further the discussion in Berndt and Fuss (1986) [1] and show what is brought about by the assumption of the constant-return-to-scale production function.

1.3.1 The definition of the utilization rate

The issue of capacity utilization arises because the stock of a certain input, which is what we usually observe, does not necessarily equal the service it provides in the production process. The most straight-forward definition of the utilization rate is

$$u_{Xt} = \frac{S_{Xt}}{X_t},$$

which says that the utilization rate u_X of input X at time t is the ratio of the service flow S_X supplied by input X and its quantity in stock, which is also denoted by X. However, in the data, the observation and the quantification of the service flow S_X may not be available. To deal with this problem, Berndt and Fuss (1986) [1] suggests the definition of the production function based on the stock variables, rather than the flow variables. The theoretical background of their method rests on the fact that some inputs, like the physical capital, etc., are quasi-fixed, meaning that their quantities can not be altered in the short run as responses to input price changes. As a result, the market prices for these inputs can not be used as reasonable measurements for their marginal products, so the income shares estimated from the market prices could be different from their elasticities in the production function.

More formally, suppose in our production function (1.1), the capital K is the quasi-fixed factor while the labor L can be adjusted freely with respect to changes in wage rates. In other words, the time t total stock of physical capital K_t is predetermined. Profit maximizing incentive of the representative firm implies that

$$w_t = z_t F_L(K_t, L_t),$$

i.e., given the capital stock K_t, labor L_t is chosen so that its marginal product is equal to the market wage w_t. Accordingly, the output produced by the representative firm is

$$Y_t = z_t F(K_t, L_t).$$

Both L_t and Y_t characterize the short run equilibrium.

In the long run equilibrium, the quasi-fixed capital stock can be adjusted freely. Hence, given factor prices w_t and r_t, the representative firm will optimally allocate its capital and labor such that

$$r_r = z_t F_K(K_t^*, L_t^*), \tag{1.20}$$

$$w_t = z_t F_L(K_t^*, L_t^*), \tag{1.21}$$

and the potential output is defined as

$$Y_t^* = z_t F(K_t^*, L_t^*). \tag{1.22}$$

As in Berndt and Fuss (1986) [1], as well as in Hulten (1986) [6], we define the utilization rate of capital to be

$$u_{Kt} = \frac{Y_t}{Y_t^*}, , \tag{1.23}$$

so full utilization of capital means that the cost of production is minimized given factor prices w_t and r_t.

Now let us first introduce the primal measure and the dual measure of the TFP growth in this context.

The income shares will be calculated at the market prices,

$$
\begin{aligned}
s_{Lt} &= \frac{w_t L_t}{Y_t} \\
s_{Kt} &= \frac{r_t K_t}{Y_t}
\end{aligned}
$$

It is shown in Appendix B that the optimal profit is zero, so the only distortion of the income shares comes from mistaking the market price for capital r_t for the marginal product of the installed capital K_t. The two measures are defined in the same way as in section II, which we repeat here

$$
\begin{aligned}
g_t^P &= \frac{\dot{Y}_t}{Y_t} - s_{Kt}\frac{\dot{K}_t}{K_t} - s_{Lt}\frac{\dot{L}_t}{L_t} \\
g_t^D &= s_{Kt}\frac{\dot{r}_t}{r_t} + s_{Lt}\frac{\dot{w}_t}{w_t}
\end{aligned}
$$

To facilitate analysis done in the next subsection, we also provide the two measures if the long run equilibrium outcomes are used in the estimation:

$$
\begin{aligned}
g_t^{P*} &= \frac{\dot{Y}_t^*}{Y_t^*} - s_{Kt}^*\frac{\dot{K}_t^*}{K_t^*} - s_{Lt}^*\frac{\dot{L}_t^*}{L_t^*} = \frac{\dot{z}_t}{z_t} \\
g_t^{D*} &= s_{Kt}^*\frac{\dot{r}_t}{r_t} + s_{Lt}^*\frac{\dot{w}_t}{w_t} = \frac{\dot{z}_t}{z_t}
\end{aligned}
$$

where

$$
s_{Lt}^* = \frac{w_t L_t^*}{Y_t^*}, \quad \text{and} \quad s_{Kt}^* = \frac{r_t K_t^*}{Y_t^*}
$$

The result that both measures equal the true TFP growth if the long run equilibrium quantities and income shares are used follows from the benchmark case.

In general, the mis-measured income shares and the mis-used price for capital in g_t^P and g_t^D would drive the two measures away from the true TFP growth $\dot{z}_t/z_t$. However, the next subsection will illustrate that under the assumption of the constant-return-to-scale production function and another minor assumption, both methods overcome this bias and thus can be viewed as the valid measures of the true TFP growth rate.

1.3.2 Variable utilization rate and the measured TFP growth

We maintain two assumptions in this subsection. The first is that the production function of the representative firm has constant return to scale, i.e., $F(K, L)$ is homogeneous of degree one. The second is that the production function F has strictly diminishing marginal products, i.e.,

$$\frac{\partial}{\partial K} F_K(K, \bar{L}) < 0, \text{ for all } \bar{L},$$
$$\frac{\partial}{\partial L} F_L(\bar{K}, L) < 0, \text{ for all } \bar{K}.$$

Appendix B shows that under these two assumptions, the representative firm's cost minimizing incentive requires

$$\frac{L_t}{L_t^*} = \frac{K_t}{K_t^*} = \frac{Y_t}{Y_t^*} = u_{Kt}. \tag{1.24}$$

The relationship revealed by expression (1.24) is the key that enables us to link the short run variables in the TFP calculation to their long run counterparts. For instance, it is easy to see that the short run and the long run income shares satisfy

$$s_{Kt} = \frac{r_t K_t}{Y_t} = \frac{r_t u_{Kt} K_t^*}{u_{Kt} Y_t^*} = s_{Kt}^*,$$
$$s_{Kt} = \frac{w_t L_t}{Y_t} = \frac{w_t u_{Kt} L_t^*}{u_{Kt} Y_t^*} = s_{Lt}^*.$$

Also, for variable X_t, the law of derivatives indicates that

$$X_t = u_{Kt} X_t^* \quad \Rightarrow \quad \frac{\dot{X}_t}{X_t} = \frac{\dot{X}_t^*}{X_t^*} + \frac{\dot{u}_{Kt}}{u_{Kt}}.$$

Given the constant-return-to-scale assumption, the two results follow directly from the fact that the income shares sum up to one:[6]

$$g_t^P = g_t^{P*}, \quad g_t^D = g_t^{D*}. \tag{1.25}$$

This equivalence result has a seemingly surprising implication. Since g_t^{P*} and g_t^{D*} are defined in the long run equilibrium where all factors are adjustable, the discussion about the benchmark model in Section II.1 suggests that both of them correctly capture the TFP growth. Therefore, under constant-return-to-scale production function, the primal measure g_t^P and the dual measure g_t^D also correctly capture the TFP growth:

$$g_t^P = g_t^D = \frac{\dot{z}_t}{z_t} \tag{1.26}$$

In general, we agree with Berndt and Fuss (1985) [1] and Hulten (1985) [6] that the fact that the firms may be in short run equilibrium and thus can not fully adjust their stock of inputs according to price changes usually creates deviations of the measured TFP growth, no matter which method is used, from the true TFP growth. However, after imposing two more restrictive but reasonable assumptions on the aggregate production function $F(\cdot, \cdot)$, we are able to reestablish the validity of the two measures, under the help of the proportionality of the representative firm's optimal choices.

1.4 Conclusion

In this paper, as a first step in studying the issue of productivity, we focus on the so-called total factor productivity (TFP) and analyze its two empirical measures, the quantity-based primal measure, and the price-based dual measure.

Their validity and equivalence under the joint assumption of the constant-return-to-scale production function, perfectly competitive output market and full capacity utilization has already been well established. Therefore, in the paper, we pay more attention to the cases where one or more aforementioned conditions are violated. To be more precise, throughout the paper, we maintain the constant-return-to-scale assumption. With

[6] Refer to Appendix B for their formal proofs.

imperfect competition in the output market, we show that both the primal measure and the dual measure fail to capture the true TFP growth. However, the equivalence between them survives the market imperfection as modeled in the paper.

Our result with respect to variable capacity utilization may seem to be surprising at the first glance. We agree with the literature that the existence of the quasi-fixed factors could cause estimation errors in the measured TFP because the market prices of the quasi-fixed factors are not necessarily equal to their marginal products. However, we show that under the constant-return-to-scale production function assumption, along with a minor modification that requires the production function to have strictly diminishing marginal products with respect to the inputs, both the primal method and the dual method produce correct TFP growth rate due to the proportionality property exhibited by the firm's optimal production policy.

Most of the work is theoretical and familiarizes us with the methods widely used for measuring TFP growth. In the future, we would like to apply our findings to some real world economies, among which Singapore may be an interesting starting point.

1.5 Appendix

1.5.1 Appendix A: Proofs for Section 1.2

Proof of (1.5), $g_t^D = g_t^P$: This result holds for a more general class of economies which satisfies:

$$Y_t = r_t K_t + w_t L_t$$

where Y is the output, K and L are the inputs in production with factor prices r and w, respectively. Taking time derivative, we have

$$\frac{\dot{Y}_t}{Y_t} = \frac{\dot{r}_t K_t + r_t \dot{K}_t}{Y_t} + \frac{\dot{w}_t L_t + w_t \dot{L}_t}{Y_t} = s_{Kt}(\frac{\dot{r}_t}{r_t} + \frac{\dot{K}_t}{K_t}) + s_{Lt}(\frac{\dot{w}_t}{w_t} + \frac{\dot{L}_t}{L_t})$$

Therefore

$$g_t^P = \frac{\dot{Y}_t}{Y_t} - s_{Kt}\frac{\dot{K}_t}{K_t} - s_{Lt}\frac{\dot{L}_t}{L_t} = s_{Kt}\frac{\dot{r}_t}{r_t} + s_{Lt}\frac{\dot{w}_t}{w_t} = g_t^D$$

With constant-return-to-scale production function,

$$Y = zF(K, L) = zF_K(K, L)K + zF_L(K, L)L$$

If factors are paid their marginal products, the identity $Y = rK + wL$ holds and thus the equivalence between these two measures follows.

Proof of (1.5), $g_t^P = \dot{z}_t/z_t$: Take logarithm of the production function in (1)

$$\log Y_t = \log z_t + \log F(K_t, L_t)$$

Take derivative with respect to time,

$$\begin{aligned}\frac{\dot{Y}_t}{Y_t} &= \frac{\dot{z}_t}{z_t} + \frac{z_t F_K(K_t, L_t)\dot{K}_t + z_t F_L(K_t, L_t)\dot{L}_t}{z_t F(K_t, L_t)} \\ &= \frac{\dot{z}_t}{z_t} + \frac{r_t K_t}{Y_t} \cdot \frac{\dot{K}_t}{K_t} + \frac{w_t L_t}{Y_t} \cdot \frac{\dot{L}_t}{L_t} \\ &= \frac{\dot{z}_t}{z_t} + s_{Kt}\frac{\dot{K}_t}{K_t} + s_{Lt}\frac{\dot{L}_t}{L_t}\end{aligned}$$

Thus,

$$g_t^P = \frac{\dot{Y}_t}{Y_t} - s_{Kt}\frac{\dot{K}_t}{K_t} - s_{Lt}\frac{\dot{L}_t}{L_t} = \frac{\dot{z}_t}{z_t}$$

Proof of (1.14): For any variable X, the percentage change of $\hat{X} \triangleq (1 + D)X$ is

$$\frac{\dot{\hat{X}}_t}{\hat{X}_t} = \frac{(1 + D_t)\dot{X}_t + \dot{D}_t X_t}{(1 + D_t)X_t} = \frac{\dot{X}_t}{X_t} + \frac{\dot{D}_t}{1 + D_t}$$

The primal measure is

$$
\begin{aligned}
g_t^P &= \frac{\dot{\hat{Y}}_t}{\hat{Y}_t} - \hat{s}_{Kt}\frac{\dot{K}_t}{K_t} - \hat{s}_{Lt}\frac{\dot{L}_t}{L_t} \\
&= \frac{\dot{Y}_t}{Y_t} + \frac{\dot{B}_t}{1+B_t} - [1 + \frac{D_t^r - B_t}{1+B_t}]s_{Kt}\frac{\dot{K}_t}{K_t} - [1 + \frac{D_t^w - B_t}{1+B_t}]s_{Lt}\frac{\dot{L}_t}{L_t} \\
&= \frac{\dot{z}_t}{z_t} + \frac{\dot{B}_t}{1+B_t} + \frac{B_t}{1+B_t}[s_{Kt}\frac{\dot{K}_t}{K_t} + s_{Lt}\frac{\dot{L}_t}{L_t}] - \frac{D_t^r s_{Kt}}{1+B_t}\frac{\dot{K}_t}{K_t} - \frac{D_t^w s_{Lt}}{1+B_t}\frac{\dot{L}_t}{L_t} \\
&= \frac{\dot{z}_t}{z_t} + \frac{\dot{B}_t}{1+B_t} + \frac{B_t}{1+B_t}[(1-s_{Lt})\frac{\dot{K}_t}{K_t} + s_{Lt}\frac{\dot{L}_t}{L_t}] - \frac{(1-\beta_t)B_t}{1+B_t}\frac{\dot{K}_t}{K_t} - \frac{\beta_t B_t}{1+B_t}\frac{\dot{L}_t}{L_t} \\
&= \frac{\dot{z}_t}{z_t} + \frac{\dot{B}_t}{1+B_t} + \frac{B_t}{1+B_t}(s_{Lt} - \beta_t)[\frac{\dot{L}_t}{L_t} - \frac{\dot{K}_t}{K_t}]
\end{aligned}
$$

Proof of (1.15): For the dual measure g_t^D, first consider the derivative with respect to D_t^r and D_t^w. By definition,

$$
\begin{aligned}
&D_t^r s_{Kt} = (1-\beta_t)B_t \quad \rightarrow \quad \dot{D}_t^r s_{Kt} + D_t^r \dot{s}_{Kt} = -\dot{\beta}_t B_t + (1-\beta_t)\dot{B}_t \\
&D_t^w s_{Lt} = \beta_t B_t \quad \rightarrow \quad \dot{D}_t^w s_{Lt} + D_t^w \dot{s}_{Lt} = \dot{\beta}_t B_t + \beta_t \dot{B}_t
\end{aligned}
$$

Thus

$$
\dot{D}_t^r s_{Kt} + \dot{D}_t^w s_{Lt} = \dot{B}_t - D_t^r \dot{s}_{Kt} - D_t^w \dot{s}_{Lt}
$$

Then, the dual measure is

$$
\begin{aligned}
g_t^D &= \hat{s}_{Kt}\frac{\dot{\hat{r}}_t}{\hat{r}_t} + \hat{s}_{Lt}\frac{\dot{\hat{w}}_t}{\hat{w}_t} \\
&= \frac{1+D_t^r}{1+B_t}s_{Kt}(\frac{\dot{r}_t}{r_t} + \frac{\dot{D}_t^r}{1+D_t^r}) + \frac{1+D_t^w}{1+B_t}s_{Lt}(\frac{\dot{w}_t}{w_t} + \frac{\dot{D}_t^w}{1+D_t^w}) \\
&= \frac{\dot{z}_t}{z_t} + \frac{B_t}{1+B_t}(s_{Lt} - \beta_t)[\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t}] + \frac{\dot{D}_t^r s_{Kt} + \dot{D}_t^w s_{Lt}}{1+B_t} \\
&= \frac{\dot{z}_t}{z_t} + \frac{B_t}{1+B_t}(s_{Lt} - \beta_t)[\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t}] + \frac{\dot{B}_t}{1+B_t} - \frac{1}{1+B_t}[D_t^r s_{Kt}\frac{\dot{s}_{Kt}}{s_{Kt}} + D_t^w s_{Lt}\frac{\dot{s}_{Lt}}{s_{Lt}}] \\
&= \frac{\dot{z}_t}{z_t} + \frac{B_t}{1+B_t}(s_{Lt} - \beta_t)[\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t}] + \frac{\dot{B}_t}{1+B_t} - \frac{B_t}{1+B_t}[(1-\beta_t)\frac{\dot{s}_{Kt}}{s_{Kt}} + \beta_t\frac{\dot{s}_{Lt}}{s_{Lt}}]
\end{aligned}
$$

Proof of $g_t^P = g_t^D$: The difference between the dual measure and the primal measure is

$$g_t^D - g_t^P = \frac{B_t}{1+B_t}(s_{Lt} - \beta_t)[(\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t}) - (\frac{\dot{L}_t}{L_t} - \frac{\dot{K}_t}{K_t})] - \frac{B_t}{1+B_t}[(1-\beta_t)\frac{\dot{s}_{Kt}}{s_{Kt}} + \beta_t\frac{\dot{s}_{Lt}}{s_{Lt}}]$$

By the definition of the income share parameters,

$$\begin{aligned} s_{Kt}Y_t = r_t K_t \quad &\rightarrow \quad \frac{\dot{s}_{Kt}}{s_{Kt}} = \frac{\dot{r}_t}{r_t} + \frac{\dot{K}_t}{K_t} - \frac{\dot{Y}_t}{Y_t} \\ s_{Lt}Y_t = w_t L_t \quad &\rightarrow \quad \frac{\dot{s}_{Lt}}{s_{Lt}} = \frac{\dot{w}_t}{w_t} + \frac{\dot{L}_t}{L_t} - \frac{\dot{Y}_t}{Y_t} \end{aligned}$$

Also, CRS production function implies that

$$\frac{\dot{Y}_t}{Y_t} = s_{Kt}[\frac{\dot{r}_t}{r_t} + \frac{\dot{K}_t}{K_t}] + s_{Lt}[\frac{\dot{w}_t}{w_t} + \frac{\dot{L}_t}{L_t}]$$

Substituting out $\dot{Y}_t/Y_t$, we have

$$\begin{aligned} &(1-\beta_t)\frac{\dot{s}_{Kt}}{s_{Kt}} + \beta_t\frac{\dot{s}_{Lt}}{s_{Lt}} \\ =&(1-\beta_t)[\frac{\dot{r}_t}{r_t} + \frac{\dot{K}_t}{K_t}] + \beta_t[\frac{\dot{w}_t}{w_t} + \frac{\dot{L}_t}{L_t}] - (1-s_{Lt})[\frac{\dot{r}_t}{r_t} + \frac{\dot{K}_t}{K_t}] - s_{Lt}[\frac{\dot{w}_t}{w_t} + \frac{\dot{L}_t}{L_t}] \\ =&(s_{Lt} - \beta_t)[(\frac{\dot{r}_t}{r_t} - \frac{\dot{w}_t}{w_t}) - (\frac{\dot{L}_t}{L_t} - \frac{\dot{K}_t}{K_t})] \end{aligned}$$

Therefore,

$$g_t^D - g_t^P = 0$$

1.5.2 Appendix B: Proofs for Section 1.3

Proof of (1.24): Consider the two optimality conditions with respect to labor inputs, we have

$$z_t F_L(K_t, L_t) = w_t = z_t F_L(K_t^*, L_t^*).$$

Since the production function $F(\cdot,\cdot)$ is homogeneous of degree one, its partial derivative $F_L(\cdot,\cdot)$ is homogeneous of degree zero. Thus, above equality implies that

$$F_L(1, \frac{L_t}{K_t}) = F_L(1, \frac{L_t^*}{K_t^*}).$$

Then from the assumption that $F_L(\cdot, L)$ is strictly decreasing in L, we obtain

$$\frac{L_t}{K_t} = \frac{L_t^*}{K_t^*}$$

As a result, the potential output

$$\begin{aligned}
Y_t^* &= z_t F(K_t^*, L_t^*) \\
&= z_t K_t^* F(1, \frac{L_t^*}{K_t^*}) \\
&= z_t K_t^* F(1, \frac{L_t}{K_t}) \\
&= \frac{K_t^*}{K_t} Y_t
\end{aligned}$$

To sum up,

$$\frac{L_t}{L_t^*} = \frac{K_t}{K_t^*} = \frac{Y_t}{Y_t^*} = u_{Kt}$$

Proof that total profits are zero: The proportionality just proved above indicates that

$$\pi_t = Y_t - w_t L_t - r_t K_t = u_{Kt} \left[Y_t^* - w_t L_t^* - r_t K_t^* \right] = 0,$$

where the last equality follows from the zero-profit property of the constant-return-to-scale production function with fully flexible inputs.

Proof of (1.25): Consider the equivalence between the two primal measures first.

$$\begin{aligned}
g_t^P &= \frac{\dot{Y}_t}{Y_t} - s_{Lt} \frac{\dot{L}_t}{L_t} - s_{Kt} \frac{\dot{K}_t}{K_t} \\
&= \left[\frac{\dot{Y}_t^*}{Y_t^*} + \frac{\dot{u}_{Kt}}{u_{Kt}} \right] - s_{Lt}^* \left[\frac{\dot{L}_t^*}{L_t^*} + \frac{\dot{u}_{Kt}}{u_{Kt}} \right] - s_{Kt}^* \left[\frac{\dot{K}_t^*}{K_t^*} + \frac{\dot{u}_{Kt}}{u_{Kt}} \right] \\
&= \left[\frac{\dot{Y}_t^*}{Y_t^*} - s_{Lt}^* \frac{\dot{L}_t^*}{L_t^*} - s_{Kt}^* \frac{\dot{K}_t^*}{K_t^*} \right] + (1 - s_{Lt}^* - s_{Kt}^*) \frac{\dot{u}_{Kt}}{u_{Kt}} \\
&= g_t^{P*}
\end{aligned}$$

The equivalence between the two dual measures is even easier to establish because both measures use the same prices:

$$
\begin{aligned}
g_t^D &= s_{Lt}\frac{\dot{w}_t}{w_t} + s_{Kt}\frac{\dot{r}_t}{r_t} \\
&= s_{Lt}^*\frac{\dot{w}_t}{w_t} + s_{Kt}^*\frac{\dot{r}_t}{r_t} \\
&= g_t^{D*}
\end{aligned}
$$

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CHAPTER 2

Expropriations and Productivity: Evidence from the Oil Industry

2.1 Introduction

Economic policies have an important impact on development problem, which can be described as the inability of catching up with the wealth of the developed economies. The recent increase in the number of expropriations since the wave of forced divestment in the 1970s brings costs of expropriation into question. Although several studies focus on the determinants of expropriations and expropriation phenomenon itself, few studies analyze the consequences.[1] In this paper, my theme is to examine the impact of expropriation on labor productivity of developing countries.

The impact of forced divestment on economies can be devastating. Williams (1975) [16] highlights the importance of the value of the expropriations by means of providing an empirical outline for the period 1956-1972. He shows that the value of assets affected by nationalizations accounts for 25% of total foreign-owned capital stock in developing countries by the end of 1972. Duncan (1999) [4] considers eight largest developing country exporters of seven minerals over 1960-1996. He finds that countries with past expropriations experienced reduction in output by about 9 percent each year. Generally speaking, forced-divestment is expected to cause output losses due to inefficient production, and thereby low economic performance; but further documentation and deeper analysis are essential. In this context, this study provides an analysis over a historically significant period to shed more light into the consequences of the policy by considering expropriation

[1] Kobrin (1980) [7] classifies expropriation (forced divestment) into four types: nationalization, intervention, forced sale, and contract renegotiation, which will be described in the next section. Here, I use expropriation, forced divestment, and takeover interchangeably in return for forced divestment of foreign-owned property by the host government.

as an exogenous change in an historically important sector, which can further help us understand why some countries lag behind others.

Restuccia (2008) [11] examines the failure of Latin American countries in catching up with the wealth of the U.S. He finds that low total factor productivity accounts for the difference in GDP per capita, and shows that removing policy barriers to productivity can increase long-run GDP per worker in Latin America. Cole et al. (2005) [7], similarly, investigate Latin America's inability to catch-up the success of other Western economies. They show that labor productivity failure is the main reason. Then, they analyze the key factors that can account for that failure, and find barriers to competition encouraging. In this context, they argue that limiting government policies can lead to productivity losses. In one of their case studies, they present the case of nationalization of Venezuelan oil industry, and show that following nationalization productivity declines significantly. In this regard, my question is: are there any other examples of such productivity losses following expropriation?

In order to provide an answer, it is necessary to determine the period, region, and sector that expropriations are widespread. First, I document the trends in expropriation acts across the world over 1922-2006. After examining 703 acts occurred in 102 developing countries, I find that over half of all acts occurred from 1970 to 1976, extractive sector including oil is more vulnerable to forced divestment, and expropriation is more common in Africa and Latin America. Motivated by these facts, I continue my analysis with focusing on the oil industry expropriations, which account for 18% of all expropriation acts over 1922-2006, in the 1970s in Latin America and Africa. Investigating both OPEC and non-OPEC members that are major oil-producing countries, I show that expropriation brings losses in production and productivity. The losses in relative labor productivity range from 25% to 55% following expropriation.[2]

James A. Schmitz Jr., in a series of papers, examines the link between productivity and competition in a similar fashion. For instance, Schmitz and Teixeira (2008) [33] study the effect of privatization on productivity in Brazilian iron ore industry. Their analysis not only considers SOEs but also private producers. They show that after privatization labor productivity increases dramatically in both private and public firms. In another

[2]Labor productivity for each country is calculated relative to the U.S.

paper, Schmitz (2005) [32] argues that increased foreign competition in the U.S. and Canadian iron ore industries in the early 1980s was accompanied by productivity gains. Easiness for a government of delivering benefits to workers, less competition when SOEs are present in the industry, and changes in work practices are main explanations for changing productivity in these studies. Likewise, Galdon-Sanchez and Schmitz (2002) [12] examine to what extent competitive pressure impacts productivity in world iron ore industry in early 1980s. They show that the mines facing a striking increase in competitive pressure had around 100% productivity gains in the 1980s. In this regard, this paper contributes to the literature by documenting several expropriation cases and their relations to productivity patterns in a historically important sector during a historically important period, which has not been explored thorough enough.

In the next section 2.2, I present data description, and trends in expropriation acts. In Section 2.3, I present oil industry expropriations. This section explores productivity records of the selected countries.

2.2 Trends in Expropriations

Stephen J. Kobrin provides pioneering studies examining expropriations. He defines expropriation as the involuntary forced divestment of foreign direct investment.

Expropriation Kobrin (1980) [7] presents four types of forced divestment: nationalization, forced sale, intervention, and renegotiation; and describes them as follows: Nationalization is direct takeover of foreign property by the government. When by means of the use of coercive powers, the government induces sale of foreign property to either public or private parties, it is called forced sale. Intervention is taking control of foreign property by other actors, public or private. Finally, if the government forces contractual arrangements to be renegotiated causing ownership transfer, it is renegotiation. The data base I am using take into consideration this broad description of forced divestment.

The unit of analysis is an act, which is defined by Kobrin (1980) [7], Kobrin (1984) [8] as the involuntary divestment of any number of firms in an industry in a country in a given year.

Data Base The data on expropriation acts are primarily from Tomz and Wright (2008) [15].[3] Tomz and Wright (2008) [15] construct a new data set on the occurrence of expropriation since the late 1920s. They consider a broad definition of expropriation following Kobrin, and gather data for the period 1929-1960. Then, they combine their newly collected data set with the existing inventories by Kobrin (1984) [8] for the period 1960-1979, Minor (1994) [10] for the period 1980-1991, and finally Hajzler (2007) [5] for the period 1993-2004. Hence, they provide a unique extensive database for the occurrence of expropriation.

Hajzler (2010) [6] documents recent expropriations covering the period 1989-2006. I combine Tomz and Wright (2008) [15] data set with Hajzler (2010) [6]. Moreover, while examining nationalizations in oil production, I combine the data provided by Kobrin (1984b) [9] with the data by Guriev et al (2009) [2], and use this combined data set for my oil industry analysis. My data set includes 703 acts occurred in 102 developing countries over the years 1922-2006. This data set includes expropriations involving divestment of foreign direct investment. Although Kobrin (1984) [8], Minor (1994) [10], and Hajzler (2010) [6] present analyses of trends in expropriations, Tomz and Wright (2008) did not provide such an analysis. Therefore, I start with examining the trends in expropriation acts over a longer time period, 1929-2006, in order to see if the trends presented in the literature have changed with a longer time horizon, and also to determine the period of my analysis.

2.2.1 Patterns of Expropriation Acts

Figure 2.1 presents the trend in expropriation acts over time. I consider a three year moving average for smoothing purposes. Over half of the acts occurred during 1970-1976, and the acts made a peak during 1974-1975. The pattern I obtain is similar to the one presented by Kobrin, although earlier and more recent expropriations have been included. In the literature, this time-pattern has been attributed to several issues such as national security concerns, changing commodity prices, or becoming independent.[4] Kobrin (1980) [7] argues that this pattern is consistent with a secular bargaining power shift from

[3] I am deeply grateful to Mark L. J. Wright for sharing their data.
[4] Kobrin (1980) [7], Hajzler (2010) [6], Tomz and Wright (2008) [15].

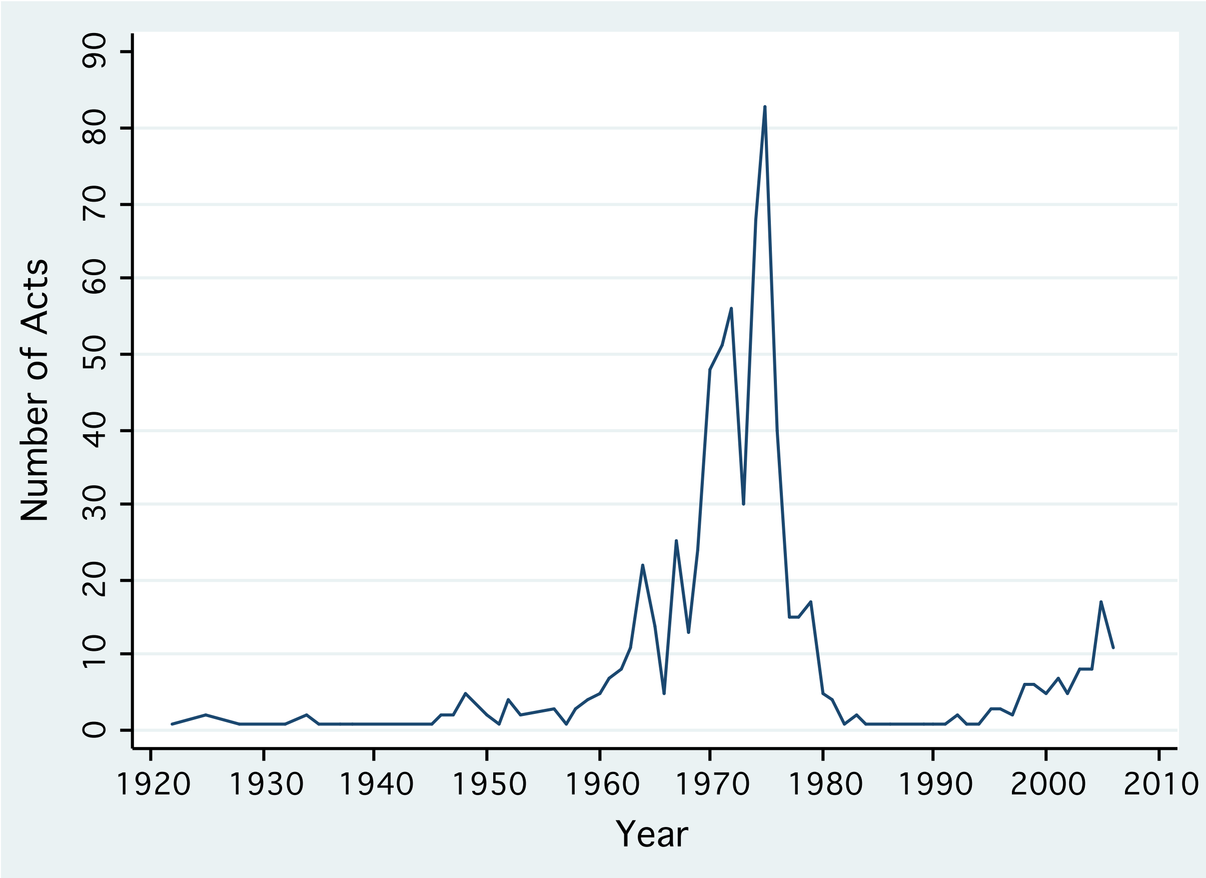

Figure 2.1: Time Pattern of Expropriations

investors to the host countries. In the 1970s, maintaining local-national ownership was important in terms of national security. Also, it was a period of relatively high commodity prices. In addition, widespread expropriations took place after many colonial states became independent.[5] Almost no expropriations took place during the 1980s and early 1990s. In recent years, however, there has been an acceleration of expropriations again.

Vulnerability to forced divestment varies by sector. Table 2.1 presents sectoral distribution of acts as percentages in total acts over the years 1929-2006. Not surprisingly, investments in natural resources, infrastructure, and banking and insurance are more vulnerable to expropriation. In total, these sensitive sectors represent around 64% of all acts. Extractive sector represents around 41% by itself. Hajzler (2010) [6] argues possible reasons for extractive sector being more vulnerable to forced divestment as widespread

[5]The reader could think about host country motivations for expropriation. There are several explanations in the literature. For instance, Kobrin (1980) [7] argues that benefits may not justify its costs due to change in investment or enterprise characteristics, hence expropriation may be an effective policy. Or, political pressures may develop whenever poor economic environment coincides with wealthy industries dominated by foreign-owned firms (scapegoat hypothesis).

sunk costs, volatile prices, relatively easy technologies to operate, and national security concerns. In general, they are desired to be controlled by the government possibly due to dominating the economy and thereby making foreign ownership intolerable.

Table 2.1: Sectoral Distribution of Acts

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

Moreover, I also present how sectoral distribution changes over time. Table 2.2 presents sectors and their distribution in all acts across different time periods. Extractive sector is consistently an important sector, in particular petroleum. Until the 1980s, petroleum is the most important sector among extractive, and its share has increased in recent years. The importance of services decreases significantly during 1960-1990, but increases in the 1990s, with a rise in infrastructure. In the 1990s and 2000s, the highest share among services is infrastructure. Among services, banking and insurance is particularly important in the 1960s and 1970s. The increasing trend in the importance of manufacturing until the late 1970s is reversed afterwards but it still constitutes an important sector.

Table 2.2: Sectoral Distribution of Acts Over Different Periods

		1940-49	**1950-59**	**1960-69**	**1970-79**	**1980-89**	**1990-99**	**2000-06**[a]
Extractive		**40**	**35**	**36.76**	**40.95**	**52.94**	**31.82**	**50**
	Agriculture	0	5	8.82	9.05	35.29	0	11.54
	Mining	0	15	11.76	12.38	0	22.73	19.23
	Petroleum	40	15	16.18	19.52	17.65	9.09	19.23
Manufacturing		**0**	**5**	**25.74**	**27.38**	**23.53**	**13.64**	**15.28**
Services		**60**	**60**	**37.50**	**31.67**	**23.53**	**54.55**	**34.62**
	Infrastructure	0	20	17.65	10.24	5.88	22.73	19.23
	Banking & Insurance	0	0	12.50	11.67	0	0	0
	Trade	0	0	7.35	4.05	5.88	4.55	3.85
	Construction	10	0	0	1.9	0	9.09	0
	Other	50	40	0	3.81	11.76	18.18	11.54
	Total	100	100	100	100	100	100	100

[a] % in total acts over each period interval

Kobrin (1980) [7] argues that in the analysis of expropriation acts grouping countries by class of 'taker' is important. Table 2.3 presents the number of acts and the number of countries by class of 'taker'. First, let's briefly describe these classes. *Light* takers experience $1-5$ acts, *relatively light* takers experience $6-10$ acts, *relatively heavy* takers experience $11-20$ acts, and finally *heavy* takers with 21+ acts, over 1922-2006. More than 75% of the countries belong to either light or relatively light takers group, but accounting only 37% of total acts. 25% of the takers, on the other hand accounts for 63% of all acts over 1922-2006, where relatively high takers accounts for the highest share in total acts, which is 35.3%.

Table 2.3: Countries and Acts by Class of Taker

	Light	**Rel.Light**	**Rel.Heavy**	**Heavy**
Number of Countries	64	13	18	7
(%)	(62.8)	(12.7)	(17.6)	(6.9)
Number of Acts	159	101	248	195
(%)	(22.6)	(14.4)	(35.3)	(27.7)

Table 2.4 indicates types of forced divestment over 1922-2006. Nationalization is the most prevalent form of taking, 53% of all acts, which is followed by forced sale, 27% of all acts. Contract renegotiation accounts for 12% of all acts, and finally intervention's share is only 8%. There is a significant shift, however, in the form of taking across different periods. Except nationalization, we observe a shift. Contract renegotiation becomes much more prevalent, on the other hand, forced sale becomes much less prevalent. Intervention also becomes less common. However, nationalization is consistently the most prevalent form of taking over this long period.

Table 2.4: Type of Taking

	% of Acts		
		1960-1979	1989-2006
Nationalization	53	53	54.6
Contract Ren.	12	8.04	34.09
Intervention	8	8.45	3.41
Forced Sale	27	30.52	7.95

Finally, Table 2.5 shows the regional distribution of all acts. Africa accounts for 39%, and Latin America 30% of all acts. Middle East and Asia have lower shares, 16.4% and 15.3%, respectively.

Table 2.5: Regional Distribution of Acts

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

To summarize, the 1970s is a period of widespread expropriations. Extractive sector, in particular petroleum, is more prone to forced divestment. Nationalization is consistently the most prevalent form of expropriation, which is more common in Africa and Latin America than the other regions. So, motivated by these facts, I will continue examining the impact of nationalization on productivity in a sample of countries in Africa and Latin America in the oil industry during 1960-1995.

2.3 Expropriations in the Oil Industry

The 1970s is a critical period in the oil industry. In particular, 1970-1976 is described as a period of structural transformation of oil industry. Kobrin (1984b) [9] summarizes this transformation very well: over 35 countries, including all major oil-exporting developing countries, expropriated between 1970 and 1976. They accounted for over 70% of 1970 world production. Although by 1970 almost all existing petroleum industries in developing countries were operated by foreign firms, by 1976 virtually every major oil-exporting developing country nationalized its industry. In other words, through effective participation of producer countries, industry structure was transformed.

Prior to the 1970s, the exploration and development risks required financial resources that exceeded the capacity of host countries. Moreover, reserves were located in less-developed countries (LDCs), but the major markets were in industrialized countries. As a result, the combination of large fixed costs and risk, the location of reserves and geographical separation of consumption and production resulted in vertical integration. However, conflict between the producers and global firms was inherent in the nature of the system. As the oil generated income of the countries grew, pressures of industrialization and modernization became more intense. This was accompanied by a shift in bargaining power to the host countries as a result of the nature of production, exploration and development, the maturation of technology and transfer of skills through FDI. Several other factors are also critical: barriers to entry fell, by means of new entrants, and also the postwar switch in petroleum as an energy source increased the demand. Tightening of the market around 1970 tipped the balance and allowed the producers to resolve the conflict through forced participation. So far, the operations had been on the concessions, under which in a territory sovereign gave the right to explore and produce contractually to an oil company. But, countries were not willing to be mere tax collectors. Given the dominance of the industry in the developing host countries, strategic control could only be attained through the transformation of equity concessions to contractual arrangements. It wasn't only about obtaining more rents, the more important question was sovereignty over their own resources; and the foreign ownership was inconsistent with national control.[6]

But, nationalization is risky in the sense that it could disrupt international oil company relationships, and it would put producing countries directly into selling business.[7] Moreover, it can be costly due to possible losses in production and productivity. In order to examine the impact of expropriation on production and productivity in the oil industry, I compile my own data set, which is described below.

2.3.1 Data

Crude oil production data is from British Petroleum Statistical Review of World Energy and OPEC historical data series. Employment data in petroleum refineries is taken from United Nations Industrial Development Organization (UNIDO) Statistics, and International Labour Office Report on Employment and Industrial Relations Issues in Oil Refining.[8] I select the countries in my sample according to the following criteria: major oil producing countries that expropriated foreign-owned assets in the oil industry over the period 1960 - 1990. Data availability in employment during this period is a critical concern, because my productivity measure is crude oil production per worker, and obtaining employment data in the oil industry over 1960 - 1990 in major-oil producing developing countries is a challenging task, which limits the size of my sample significantly.

[6] Kobrin (1984b) [9], Yergin (1991) [17].

[7] Yergin (1991) [17]

[8] I consider employment data in petroleum refineries as a proxy for employment in the oil industry.

I put expropriators into two categories: OPEC and non-OPEC members. Sample countries include Algeria and Venezuela as the OPEC members, and Colombia and Peru as the non-OPEC members. I also include USA as a benchmark for comparison.

2.3.2 Impact on Production and Productivity

Algeria's first commercial oil discovery was in 1956. Production began in 1958. The country achieved political independence in 1962 after more than a century of colonial rule by France. Sonatrach is the largest Algerian and African company and the 11th largest oil consortium in the world, which was founded on December 31, 1963. At the time, however, the Algerian state held only 4.5% of the exploration perimeters, while French interests were as high as 67.5%. After the Arab-Israeli War in June 1967, Algeria decided to nationalize the refining and distribution activities of Mobil and Esso, and Sonatrach signed an agreement with Getty Oil on October 19, 1968 receiving 51% of Getty Oil's interests. I consider the year 1967 as the year of nationalization in Algeria in the oil industry.

Brogini (1973) [1] documents evolution of the oil industry manpower during 1962-1971 in Algeria. I observe a significant contraction in the oil industry manpower prior to nationalization, which is reversed after nationalization by a striking expansion. Increasing oil production accompanies the declining trend in employment prior to nationalization. After nationalization, production continues to increase, however, the increase in production is not as fast as it was in pre-nationalization period. Hence, labor productivity, which is measured as crude oil production per worker, is increasing prior to nationalization, but it declines significantly after nationalization due to fast-expanded manpower which exceeds the rate of increase in oil production, as shown in Figure 2.2. In Figure 2.2, I present labor productivity in the oil industry measured as crude oil production per worker which is normalized to 100 in the year of nationalization.

Another interesting OPEC member case to be examined is the 1975 oil industry nationalization in Venezuela. The country experienced 100% nationalization of its oil sector in 1975. The process is started by the Reversion Law in 1971 mandating gradual transfer to government ownership of all unexploited concession areas by 1974. The nationalization process is finalized by the end of 1975. Figure 2.3 shows both production and productiv-

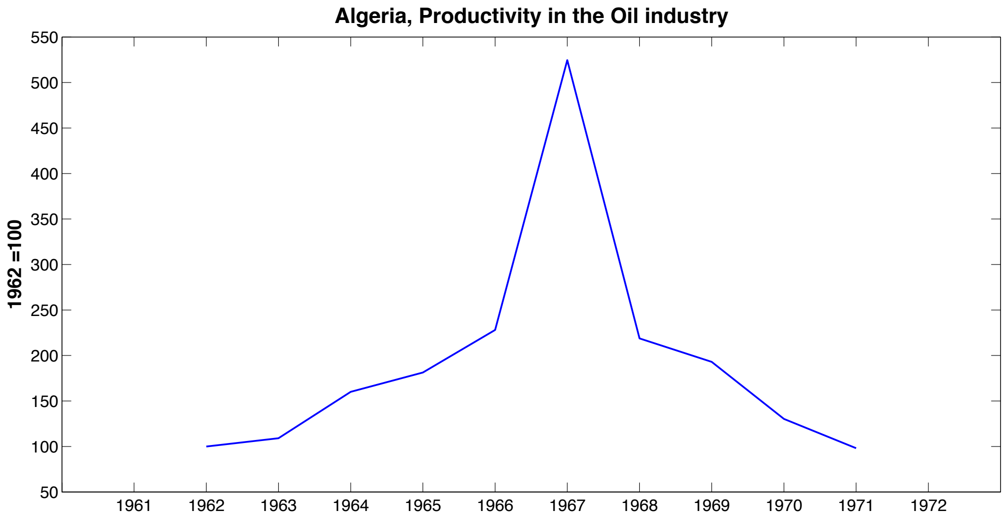

Figure 2.2: Labor Productivity in the Algerian Oil Industry

ity patterns during this period where I normalize the value in the year 1970 to 100. Prior to nationalization, increasing production is accompanied by a significant contraction in oil industry manpower, hence productivity increases. However, by the beginning of the nationalization process, I observe a striking decline in both production and productivity. After nationalization, declining production and productivity persist even though oil industry manpower expanded at a significant and fast rate.

Figure 2.4 presents OPEC crude oil production. It shows total OPEC production, Venezuelan production, and non-Arab OPEC production, where I normalize the production in 1970 to 100. Venezuelan production decline after 1970 is not due to an OPEC production cut, which on the other hand took place in some of the Arab OPEC members during early 1970s. As we can see, Venezuela deviates from the rest of the OPEC members significantly during 1970-1979.

A striking deviation from the rest of the world in employment trends is also observed as we can see in Figure 2.5. Venezuela shows significant contraction in employment during 1964-1976 contrary to the increasing trend in employment in the rest of the world since the late 1960s.

Figure 2.6 and Figure 2.7 compare Venezuela with Mexico, another major oil producing country in Latin America showing similar sectoral characteristics. The values in 1975 are normalized to 100. As we can see, both oil production and productivity indicate

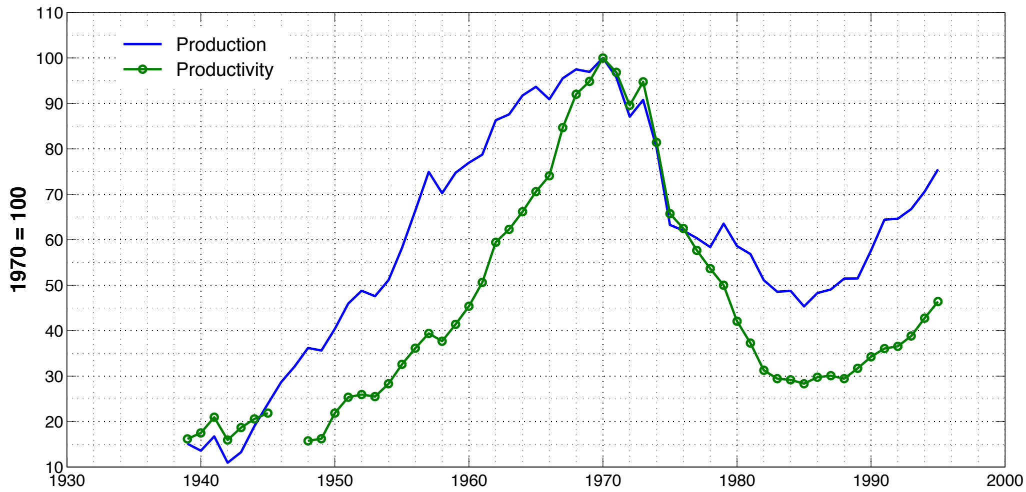

Figure 2.3: Production and Labor Productivity in the Venezuelan Oil Industry

opposite trends starting from the year 1970. These figures imply that the deviation is likely to be related to the nationalization policy.

After presenting two cases of oil industry nationalizations in modest detail, in the next subsection, I will present relative productivity differences.

2.3.3 The Impact of Nationalization on Relative Productivity

As I explained earlier, labor productivity is measured as crude oil production per worker, i.e. barrel per worker. For each country, using available data from same data sources for the sake of consistency, first I calculate labor productivities over the period 1962-1995. Second, labor productivity relative to the U.S. is computed by dividing each country's productivity by the productivity of the U.S. Then, the value at the time of nationalization is normalized to 100. Algeria nationalized in 1967, Venezuela in 1975, Colombia in 1972, and Peru in 1985. Finally, I compute five-year averages before and after nationalization excluding the value 100 at the time of nationalization. Table 2.6 presents the pre- and post-nationalization five-year average relative labor productivity values for each country.

As we can see, in each case there is a loss in relative productivity following nationalization. The losses range from 25% to 55%. In all cases, a significant increase in employment after nationalization occurred. On the contrary, during the same period, a stable followed

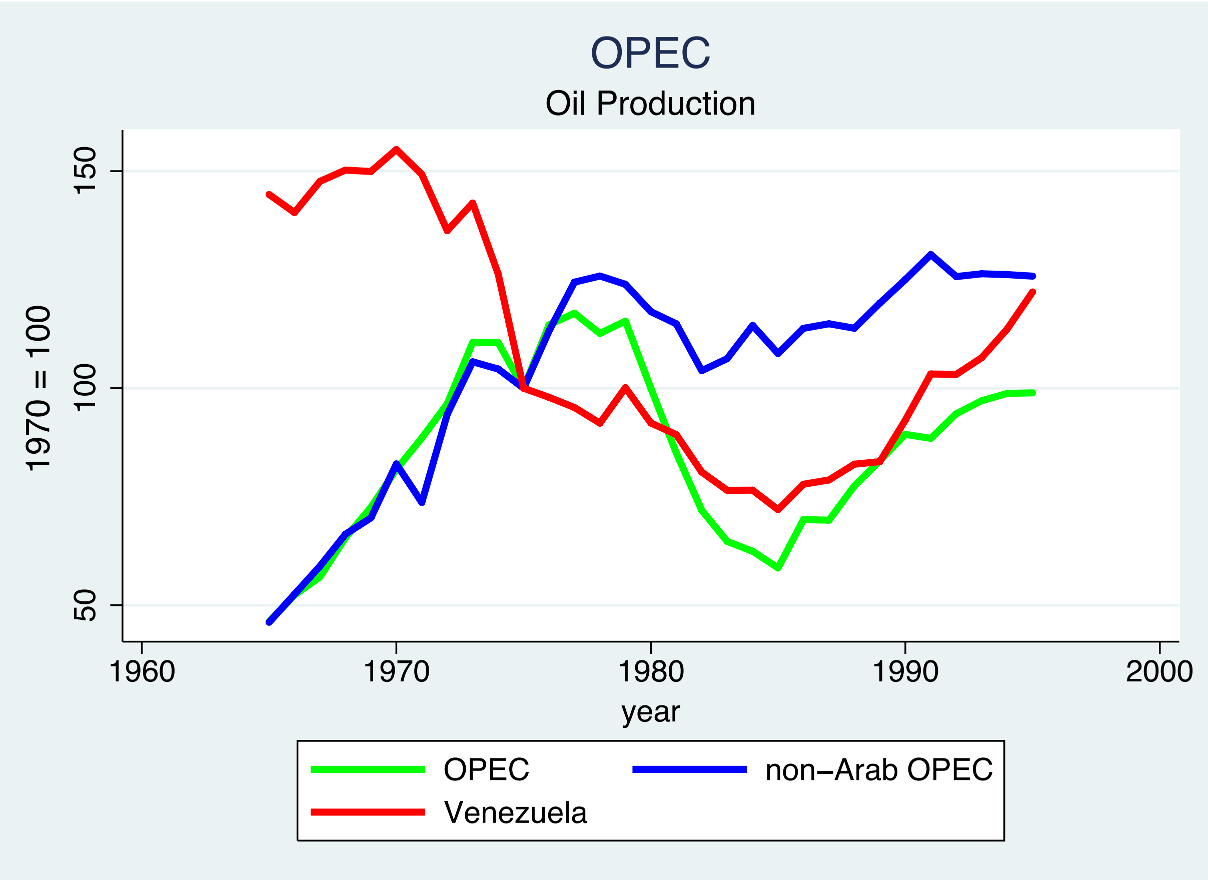

Figure 2.4: OPEC Oil Production

Table 2.6: Labor Productivity relative to the U.S.

	pre-nationalization	post-nationalization
Algeria	37.8	28.4
Colombia	128.2	57.4
Peru	158.5	74.5
Venezuela	130.9	86.4

by a declining employment trend in the U.S is observed. The influx of many workers at a fast rate causes productivity to fall in the expropriating countries. Lack of competition can be a factor in explaining falling productivity.

Lost foreign expertise can be another factor explaining the observed productivity pattern following nationalization. In both Venezuela and Algeria, elimination of foreign workers from the oil industry took place following nationalization whom are replaced with low-skilled domestic workers. Although this can be thought as a natural consequence of nationalization, elimination of foreigners is not common. For instance, Saudi Arabia did not eliminate foreigners from oil industry operations following nationalization. In the

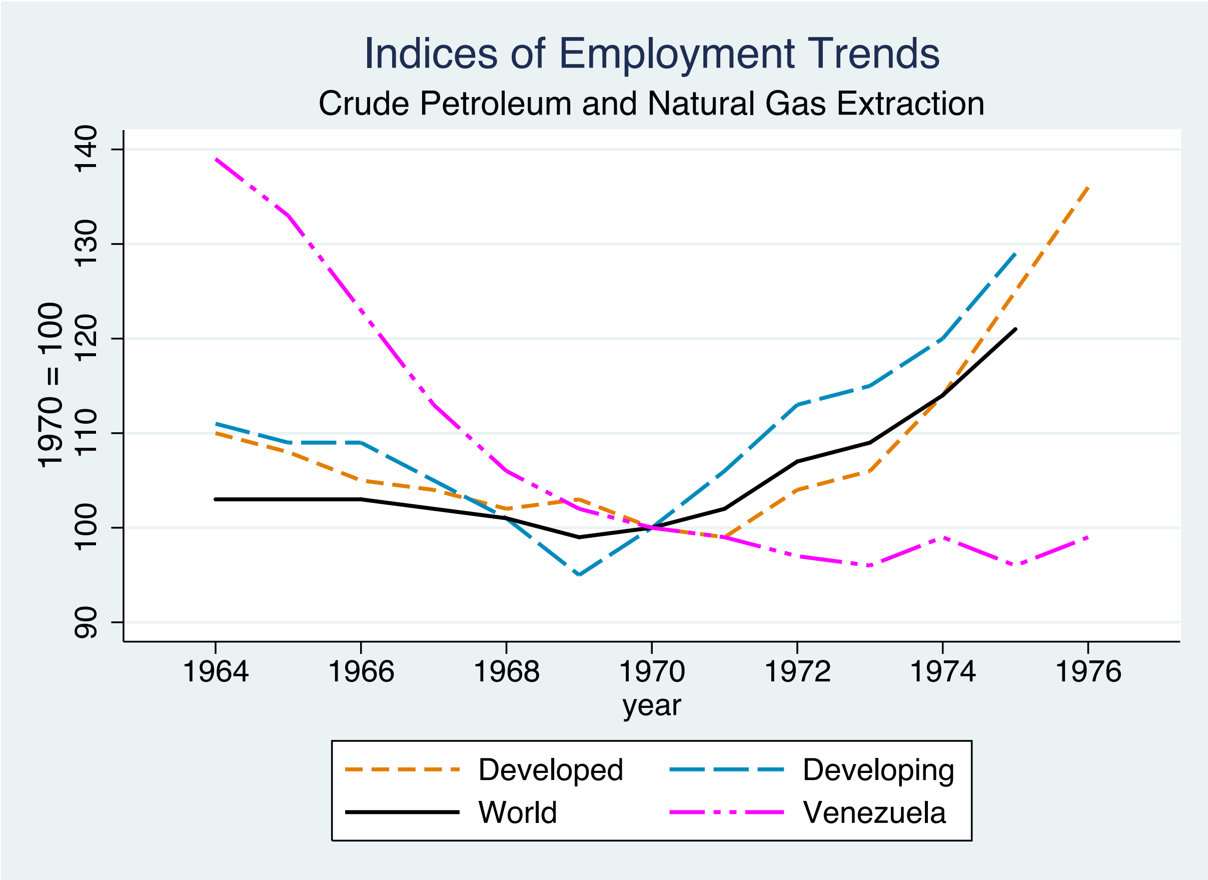

Figure 2.5: Employment Trends in the World

next chapter, I will explore why nationalization is associated with lower productivity by focusing on the case of Venezuela.

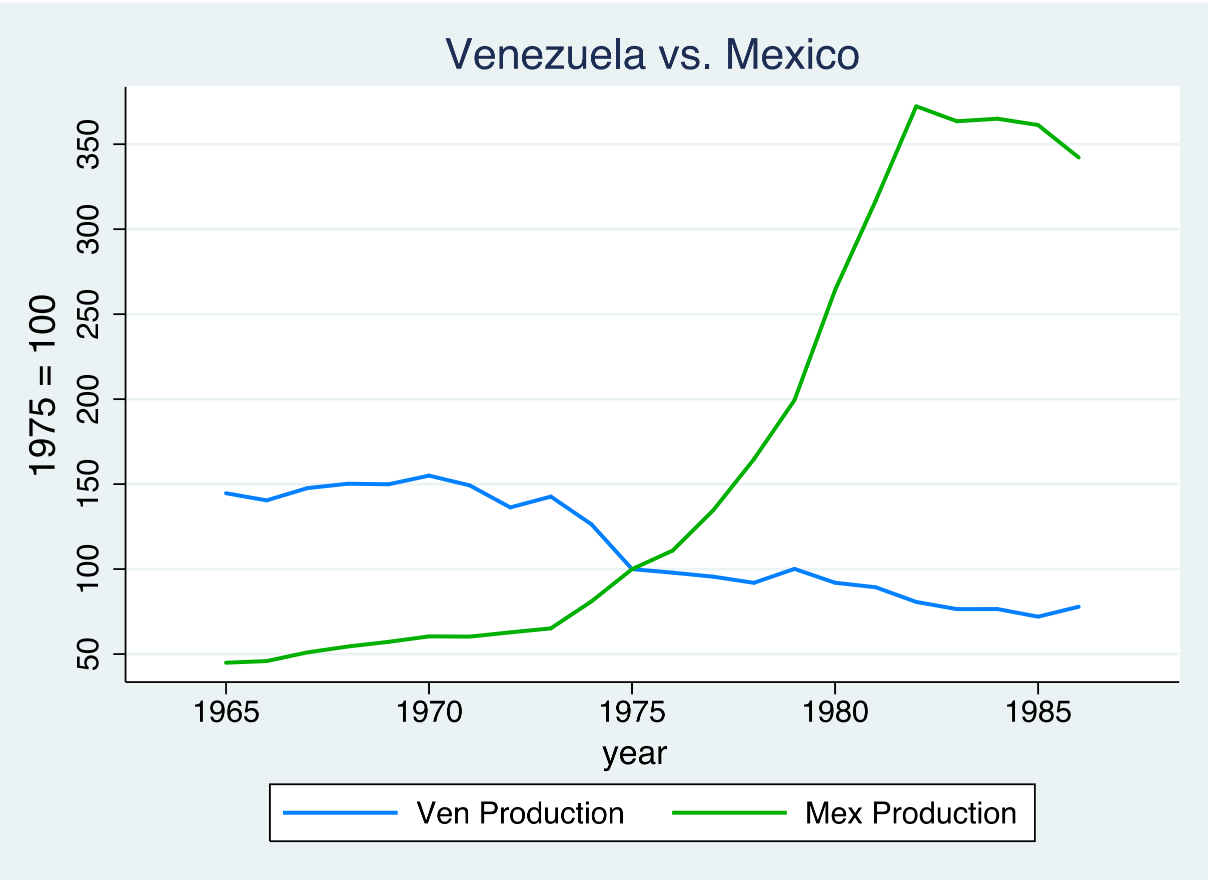

Figure 2.6: Oil Production in Venezuela and Mexico

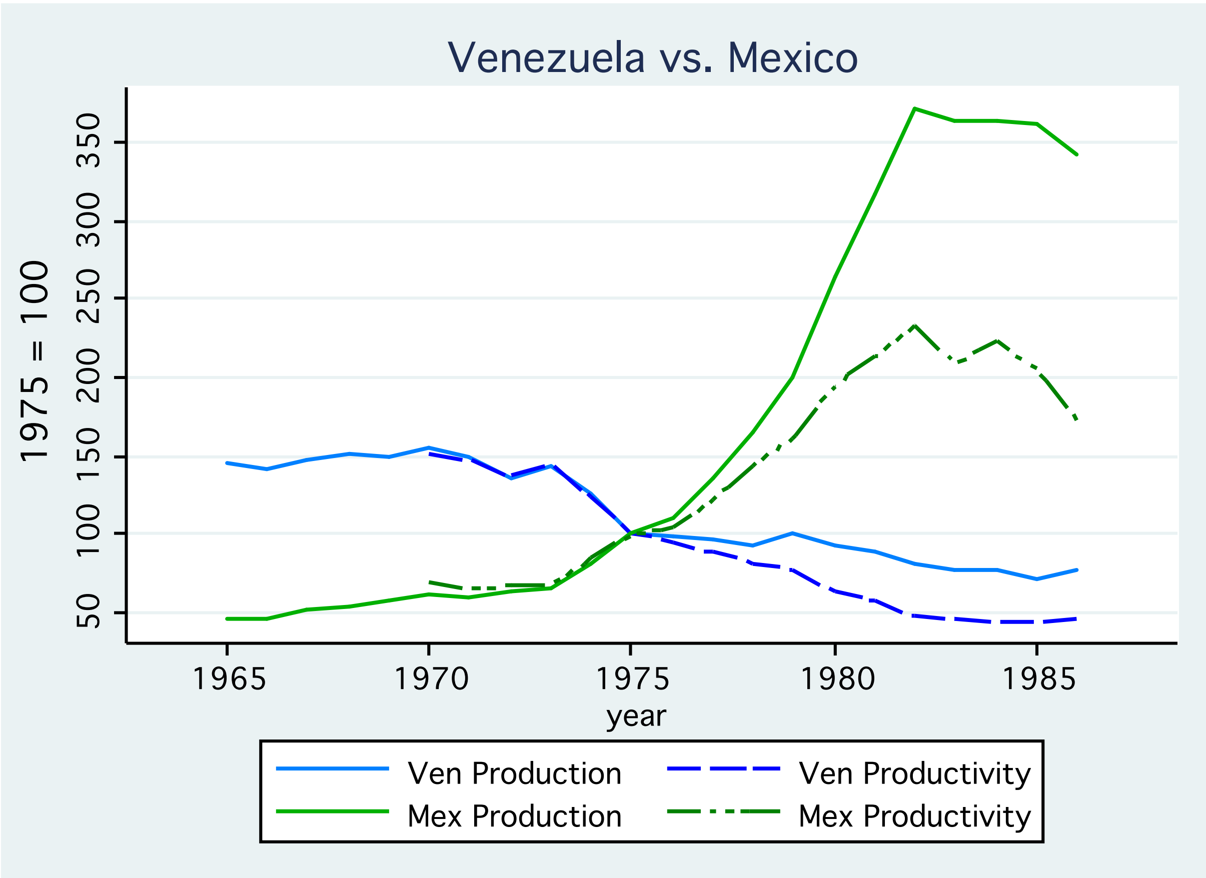

Figure 2.7: Oil Production and Productivity in Venezuela and Mexico

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CHAPTER 3

News of Nationalization? A Macroeconomic Analysis

3.1 Introduction

After their substantial rise in the 1970s, the importance of state-owned enterprises (SOEs) diminished following the large privatization programs of the 1980s and 1990s.[1] The SOE share of global GDP declined by more than 40 percent between 1979 and the early 2000s.[2] Following this process, a considerable amount of research was conducted supporting the proposition that privately-owned firms are more productive than otherwise-equivalent SOEs.[3] In recent years, however, the state ownership has been on the rise, again. The number of nationalizations has increased.[4] In 2010, *more than 75 percent* of the world's oil supplies were controlled by state-owned (national) oil companies.[5] The recent trend motivates a better understanding of the impact of nationalization: What are its effects? If it brings losses, what can account for them? This paper attempts to provide an analysis of these questions by considering the earlier era of widespread nationalization (the 1970s) and focusing on the 1975 Venezuelan nationalization experience in the oil industry.

I first examine the case of the Venezuelan oil industry by comparing annual time series data before and after nationalization. I show that production and productivity increased at a considerable rate until 1970. After that, a striking decline took place, and was particularly severe in the first five years after 1970; by 1985, the two had declined by around 55 percent and 72 percent, respectively, compared to their levels in 1970. The total number of workers in the industry was stable until 1957, but this stability was

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

[2] Megginson and Netter (2002) [23].

[3] Leading studies include La Porta and Lopez-de-Silanes (1999) [19]; Megginson, Nash, and Van-Randerborgh (1994) [22]; and Megginson and Netter (2002) [23].

[4] Examples include oil sector nationalizations in Azerbaijan, Bolivia, Ecuador, Kazakhstan, Venezuela, and very recently Argentina.

[5] The Economist, January 2012, Special report: State Capitalism.

replaced by a remarkable contraction between 1957 and 1975, where the total work force decreased by 49.4 percent (the number of domestic and foreign workers decreased by 43.7 percent and 90.9 percent, respectively). In line with the reduction in the labor force, exploration activity and investment in the industry also began declining in 1957, causing reserves to stagnate.

After nationalization, the percentage of foreigners in total employment did not exceed 0.85 percent until 1995. The Venezuelan work force, on the other hand, expanded rapidly after nationalization. Contraction during 1957-1975 was replaced by a fast expansion in domestic manpower, but mostly in white-collar workers. Similarly, exploration and hence reserves increased after nationalization. These comparisons motivate the following questions: First, what led to the contraction in manpower and exploration in the late 1950s, a process that started well before nationalization? Second, why could the industry not improve production and productivity despite the notable expansion in employment and increase in reserves during the post-nationalization period?

For better insight into these industry trends, I investigate the pre-1970 period in the Venezuelan oil industry. I claim that the regime change from dictatorship to democracy in 1957 induced increasing expenditures, resulting in a temptation to increase the government share of multinational companies' (MNCs) profits. This led to new tax laws, which progressively increased taxation rate significantly. Moreover, new oil concessions were frozen. These events induced an anticipated government takeover, and triggered the nationalization process, which began in 1970. I propose that the industry contraction during the late 1950s and 1960s was caused by the news about the future nationalization.

The elimination of foreign workers began in 1957, and continued thereafter. The retarded recovery in production and productivity despite the expansion in the post-nationalization period, together with losing foreigners, motivate us to relate the role of a missing factor in production in explaining the observed trends. In other words, I am led to a model where I distinguish between the two labor inputs, domestic and foreign workers. I provide novel evidence suggesting that foreigners are highly skilled workers, representing key technical, professional, and managerial positions. Then, I hypothesize that if the available know-how in the industry was mainly supplied by foreigners, and their skills were complementary with other factors of production, then nationalization would be costly, and would appear as a decline in the productivity of measured factors of production. I interpret this decline as “the missing input” of highly skilled workers in production.

The second part of the paper builds a dynamic partial equilibrium framework that incorporates the elements I have documented above. The production function in the model allows for imperfect substitutability across different labor inputs and feed in the observed path of tax rate on income. In this dynamic framework, extraction depletes the resource, which can be maintained or increased by exploration. The industry takes prices as given and decides on optimum exploration and production paths. The model allows us to assess the effects of anticipated tax changes under different timing assumptions. Our baseline simulations suggest that foresight of several years distorts the tax effects under no foresight assumption. I introduce nationalization as follows: assume that nationalization is simply exogenously given, and modeled as higher tax rate on income along with declining number of foreign workers. Our analysis attributes the increasing productivity prior to nationalization mostly to the declining efforts in exploration stemming from the anticipated changes. However, due to the dominating effect of lost foreign know-how over news about the future, extraction (production) declines. It is the declining number of foreign workers that offsets the rebound in the extractive effort due to expected policy changes prior to nationalization. By the realization of nationalization, productivity falls and continues to do so. A comparison of the simulated and actual time series over the period 1960-1980 shows that around 56 percent of the increase in productivity prior to 1970, and about 39 percent of the decline in productivity during and after nationalization can be attributed to the proposed mechanism.

Thus, this paper documents the impact of nationalization on industry performance, and how it proceeds in practice. It presents two theories, which have not been explored in the literature in the context of nationalization, as candidates for explaining the stylized facts, and provides evidence supporting the suggested mechanisms. Then, using macroeconomic tools, it tests the ability of the proposed channels in explaining the Venezuelan experience by developing a relatively simple but non-standard framework for non-renewable resources, and quantitatively studies a prominent policy question.

3.1.1 Related literature

This study contributes to several strands of the literature. First, James A. Schmitz Jr. presents industry-level analyses in which there is an exogenous change in competition, and where productivity can be measured before and after the competitive change. Schmitz (2005) [32] finds that exogenous changes in the world steel market led to increased foreign competition for Great Lakes iron ore producers. These changes resulted in a 100 percent increase in labor productivity, which can be explained by changes in work practices. Likewise, Schmitz and Teixeira (2004) [33] show that privatization of the Brazilian iron ore industry gave rise to productivity gains in newly privatized firms and existing private firms that had to compete with the new firms, and did so by eliminating restrictive work rules. In this paper, I follow a similar approach by presenting an industry case in which there is a large and exogenous policy change associated with significant losses in production and productivity.

Second, Pindyck (1978) [27] has extended the seminal work of Hotelling [17] on the optimal exploitation of a resource from a fixed reserve base to allow for exploration. I adopt his general framework. I use reserves as a form of capital in extraction, as in Devarajan and Fisher (1982) [11], Yucel (1986) [35], and Deacon (1993) [10], but different from the previous literature and motivated by the observed trends, I represent exploratory and extractive efforts with different labor inputs, measured in efficiency units and imperfect substitutes. This method allows us to test the proposed channels. In addition, I study the effects of different taxes on exploration and production under different beliefs about the future, implying that when tax changes are unanticipated I obtain results in line with the literature. However, when tax changes are anticipated, opposite effects are obtained. Although the effects of taxes on a resource industry have been explored, as far as I know, the effects of anticipated tax changes have not yet been studied. In this context, our paper not only contributes to the taxation of resources literature, but also to the news shocks literature, by documenting a case in which news shocks have important policy implications. Relevant papers that examine tax effects under policy foresight are Yang (2005) [34] and House and Shapiro (2006) [15]. Yang studies the effects of tax changes under policy foreknowledge by simulating a standard neoclassical growth model and shows that anticipated changes in capital and labor taxes have opposite effects on macroeconomic variables. House and Shapiro, under perfect foresight, investigate the macroeconomic implications of the timing of tax cuts in the US introduced by President Bush in 2001 and 2003.

I provide novel evidence about the composition of oil industry manpower in Venezuela, particularly of foreign workers, suggesting that they were in key positions and highly skilled. The specialized knowledge brought by foreign firms can be critical for industry operations, and removing them can be costly due to lost foreign know-how, as explored here. This finding is related to a growing literature studying the impact of multinational activity in developing countries, which suggests that the presence of foreign firms can bring welfare gains (Antras, Garicano and Rossi-Hansberg (2006) [1]; Burstein and Monge-Naranjo (2009) [5]; and Eeckhout and Jovanovic (2010) [12]).[6]

To provide a better understanding of the policy, I evaluate a nationalization experience quantitatively, where the parameters of the relevant functions represent the Venezuelan petroleum sector. To our knowledge, no research exists that explores a nationalization policy in a quantitative manner, nor that attempts to explain a developing country experience as I undertake to. Existing studies mostly focus on the productivity impact of denationalization or compare public ownership with private ownership. Examples include Megginson, Nash, and Van-Randerborgh (1994) [22]; La Porta and Lopez-de-Silanes (1999) [19]; Megginson and Netter (2002) [23]; and Chang et al. (2010) [6], citing the positive impacts of denationalization.

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

[6]This impact is not limited to static welfare gains. The presence of MNCs in a developing country can also affect the country's accumulation of know-how, yielding better exposure to it and improvements in welfare (Monge-Naranjo, 2012 [25]).

cent in recent years.[7] The authors find that capital accumulation and knowledge transfer account for the remarkable growth, and argue that openness of the oil sector to foreign investment contributes to expansion in the oil industry, resulting in overall expansion. The authors then show that a fall in total factor productivity and capital accumulation account for the subsequent collapse. They argue that government intervention can create misallocation, leading to a fall in TFP and capital accumulation, and find that policy distortions are able to account for most of the decline observed in Venezuela. Our analysis is in line with their arguments about the aggregate economy in that I claim that foreign know-how and increasing government participation resulting in an anticipated takeover can explain the collapse of the oil industry.[8] And, to understand Venezuelas development experience, which is critical in terms of the Latin American development problem, it is important to study the oil industry, particularly oil production.[9]

The remainder of the paper is organized as follows. In Section 3.2, I discuss features of the Venezuelan oil industry. After describing the data, I explore the main trends, discuss critical aspects of nationalization, and put forth our hypotheses in explaining the observed impact. In Section 3.3, I introduce our model. I present our quantitative analysis along with the calibration and simulation results in Section 3.4, and conclude in Section 3.5. Data construction and related details are presented in the Appendix.

3.2 Empirical Patterns in the Venezuelan Oil Industry

In this section, I will present stylized facts on the key patterns I observe in the Venezuelan oil industry. Additionally, I document main critical events in relation to the key stylized facts.

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

[8] 1958 was a turning point not only in the aggregate economy but also in the Venezuelan oil industry. I believe the collapse of the industry was implicitly triggered by the events of 1958 (discussed in more detail later in this section) which consequently made nationalization inevitable.

[9] Cole et al. (2005) [7] investigate the Latin American development problem, and find that barriers to competition, including limiting government policies, are a likely cause.

3.2.1 Data

In order to explore the impact of nationalization on the industry activity, I develop a data set which dates from the early 1940s to 1995. Oil industry statistics are from the Republic of Venezuela, Ministry of Mines and Hydrocarbons, Oil and Other Statistical Databooks (MMH Databooks). From these databooks, I have recorded annual industry-level time series data on various variables, such as crude oil production, proved reserves, new reserves, completed wells, work force, wages and salaries, gross investment in fixed assets, royalties, and income taxes. I obtain GDP price deflator and exchange rate data from the Penn World Tables, which I use to convert nominal domestic values into constant U.S. dollars.

For the Venezuelan aggregate economy, I have used the Conference Board, Total Economy Database, January 2011, and the Economic Commission for Latin America Database.

Data sources for the U.S. and Canada are BP Statistical Review of World Energy, June 2009, and EIA Petroleum and Other Liquids Database.[10]

3.2.2 Stylized Facts

Oil production began in Venezuela in the early 20th century, and the country became the largest oil exporter in the world by 1930s, and since then fiscal revenues from oil has been the largest component of the government's budget. First, I present trends in production and productivity, second, patterns in manpower, and finally, trends in exploration.

Figure 3.1 presents crude oil production, in bbl, and production per worker, in bbl per worker, both are normalized to 100 in the year 1970. Oil production figure in panel 1(a) indicates two nationalization periods, and a privatization period. The privatization, which began in the early 1990s, is also a partial privatization.[11] Although my goal is to investigate the earliest nationalization experience in Venezuela, this figure is important in showing that both incidents of nationalization show similar patterns of declining production. Privatization, on the other hand, coincides with an increasing trend in production.

[10] Appendix includes details on the constructed series.

[11] Chang et al (2010) [6] discuss the recent two events in Venezuela, 1991-1992 reopening of the oil sector to foreigners, and 2001-2002 beginning of a renegotiation process.

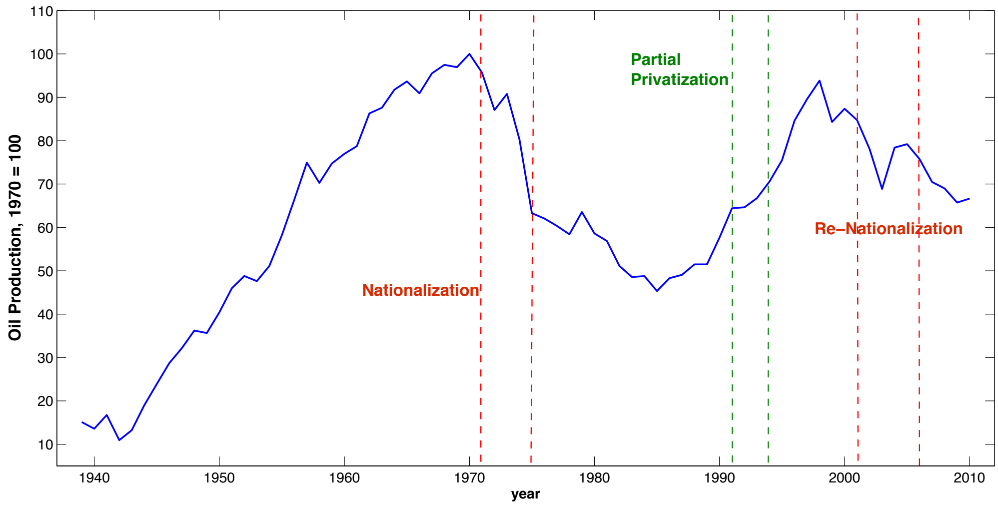

Figure 3.1: Oil Production in the Venezuelan Oil Industry

Venezuelan oil industry production and productivity records over 1939 - 1995 are given in Figure 3.2. The vertical lines present the main events describing the process of nationalization. Productivity is measured in barrels per worker, which captures the production path quite well.[12] Until 1970, there is an upward trend in both production and productivity. However, this was reversed in 1970 with a sharp decline with the beginning of the nationalization process, which is finalized in December, 1975. In 1985, ten years after nationalization, production and productivity are only 45% and 28% of their peak levels in 1970, respectively.[13] It is important to note that the fall in production is not due to OPEC quotas, which are agreed upon by each member during OPEC meetings.[14]

Figure 3.3, I plot the total number of workers along with proven reserves. The contraction in the manpower begins in the 1957 and continue until nationalization is finally implemented.

[12]In order to examine whether the loss in productivity is due to a TFP loss or a capital accumulation collapse, I perform a standard development accounting exercise. I decompose labor productivity into two components, TFP and physical capital per worker. By comparing pre- and post-nationalization averages for 10-years, I find that TFP can account more than $\frac{2}{3}$ of the decline in labor productivity. Even though this simple framework doesn't take into account all the factor contributing to production, it is helpful in providing some insights. Note that I perform the same exercise by using reserves as the form of capital, which gives us similar results.

[13]Production per operating well, which can also be considered as a measure of productivity, follows a similar pattern.

[14]OPEC production quota estimates have been reported only since 1982, hence in order to gain insight I can compare production of other OPEC members with that of Venezuela during this period. In contrast to Venezuela, during 1970-1980, Saudi Arabia, Iraq, Indonesia and Algeria increased their production. Note that, Indonesia became a member in 1962, and Algeria became a member in 1969.

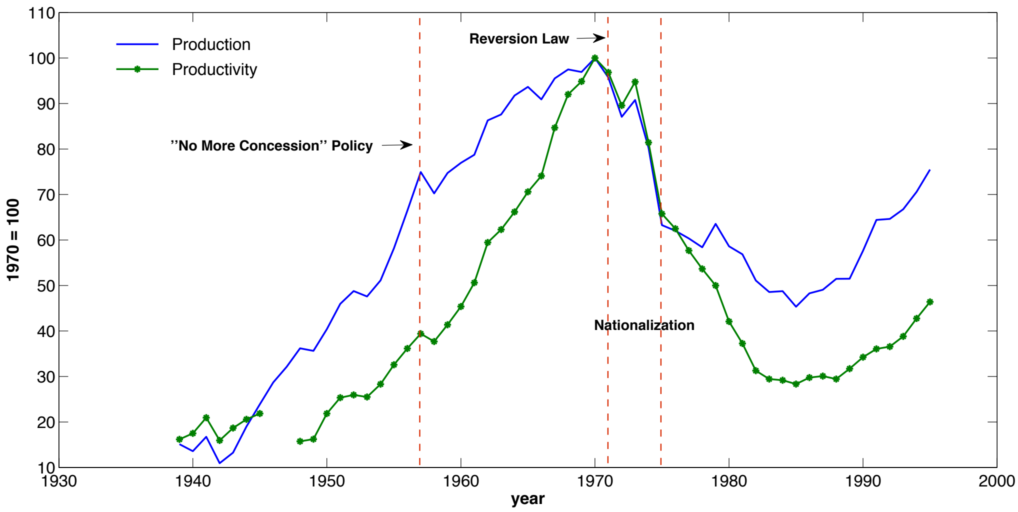

Figure 3.2: Oil Production and Productivity in the Venezuelan Oil Industry

Figure 3.4 allows us to take a profound look into the manpower by decomposing it according to nationality, and type of worker: blue-collar and white-collar. The total work force decreased by 49.4%, where the number of domestic workers and foreign workers decreased by about 43.7%, and 90.9%, respectively between the years 1957 and 1975. In 1948, around 11% of the total manpower was foreign, 78% of whom were white-collar constituting 29% of total white-collar workers. In 1957, 12% of the total work force was foreign, and 83% of foreign was white-collar making up 25% of the white-collars. By the time of nationalization, their percentage in total decreased to 2.2% of whom 95% was white-collar, but comprising only 4% of the total white-collar workers. After nationalization, until the year 1995, foreigners' percentage in total employment never exceeded 0.85%.

Venezuelan work force, on the other hand, expanded significantly after nationalization.[15] Contraction during the period 1957-1975 was replaced by a fast expansion, which mostly took place in white-collar workers.[16] In 1948, domestic white-collar workers comprised only 20.3% of the total employment in the oil industry. Although there was a

[15]During 1975-1979, the work force increased by about 10% each year, which is a fast rate. In addition, the participation of oil employment in economy-wide employment increased by about 32.4% during 1975-1984.

[16]Even though that increase was attributed largely to the new exploratory activity, Coronel (1983) [8] and Ellner (1993) [13] argue that the increase was also a sign of the failure of the state to maintain existing efficiency. In fact, by a simple accounting exercise, I show that there is a significant efficiency loss during nationalization process and afterwards.

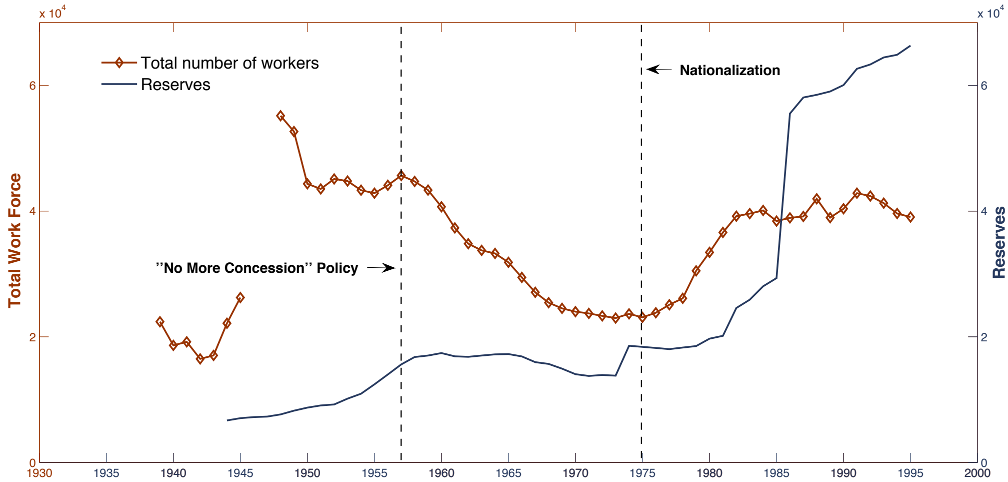

Figure 3.3: Total Work Force and Proven Reserves in the Venezuelan Oil Industry

decline in the number of workers during 1957-1975, the percentage of Venezuelan WC workers in total work force increased from 30.9% to 51.8% due to the fact that contraction in blue-collar workers was much stronger. After nationalization, expansion in BC workers was weaker, and hence WC domestic workers dominated the industry and comprised up to 71% of the oil industry manpower. In other words, composition of the work force changed after nationalization, which can imply a possible motive for replacing foreign workers.[17]

In Figure 3.5, I also plot reserves along with exploration, as well as investment. As can be seen, exploration is declining and investment is low. Hence, reserves are stagnant until the year 1965 and then decline till mid-1970s. Note that after nationalization, there is a substantial expansion in the industry.

3.2.3 Discussion

In this subsection, I relate my main observations with the events taking place in the industry. After discussing the main relevant events, I present my theories.

The oil industry was under the control of foreigners until the late 1930s in Venezuela, government control was minimal, and exports were dominated by oil. In 1943, through

[17]Ellner (1993) [13] points out that nationalization was committed to bring comprehensive worker gains in the Venezuelan oil industry from the high revenue generated by OPEC price hikes; however, gaining the support of the workers for the policy could be another objective.

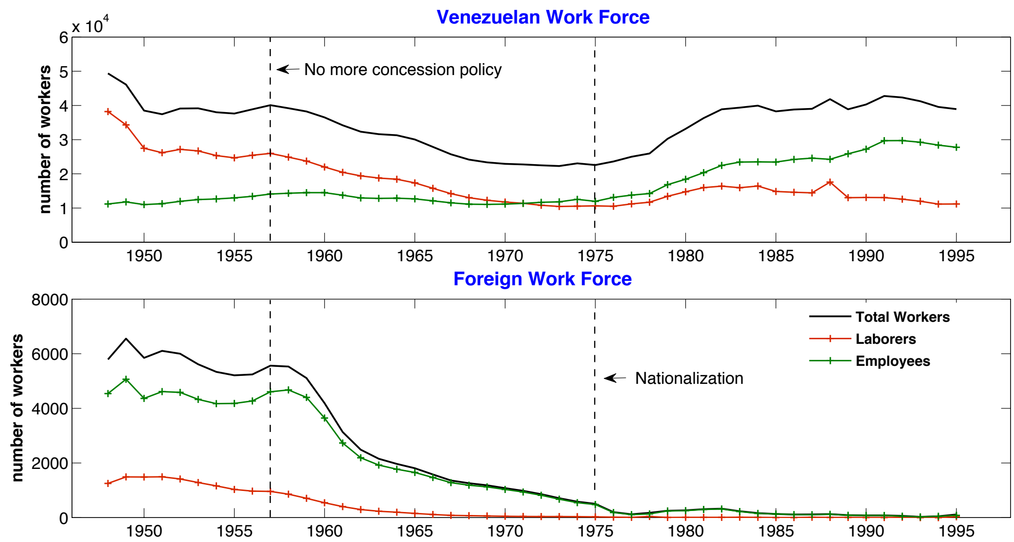

Figure 3.4: Decomposition of the Work Force in the Venezuelan Oil Industry

the new hydrocarbons law, greater participation of the government was introduced.[18] In 1944, new concessions were granted and manpower increased. Manzano and Monaldi (2010) [20] point out that companies by accepting the tax changes obtain a long-term planning horizon under a transparent tax regime. Substantial additional concessions were approved. Stability resulted in an expansion in the industry, investment and production increased. In brief, 1943 - 1958 is a period of stability and expansion, which can be seen clearly in the presented figures.

In 1957/58, the dictatorship ended, and the democratic period began with the adoption of a new constitution in 1961. A new regime with declining oil prices tempted the government to increase its take. The government increased its take from 50% to 65% unilaterally by increasing the income tax, which irritated the foreign oil companies according to Manzano and Monaldi (2010) [20]. Moreover, last oil concessions were granted in 1957, "no more concession" policy. Therefore, 1957/58 is the starting point of a major disaccord between the government and the MNCs, which coincides with the beginning of the contraction in the industry. Coronel (1983) [8] argues that the conditions of the policy, whose primary objective was to obtain national control over the industry and increase revenues, were severe, making profits almost impossible for the companies. His

[18]In earlier periods, main tax was royalty which was implemented at a low rate. By the law, income tax is introduced. The principle of a 50-50 split in profits between the government and the MNCs was adopted in 1948, Mikesell (1984) [24].

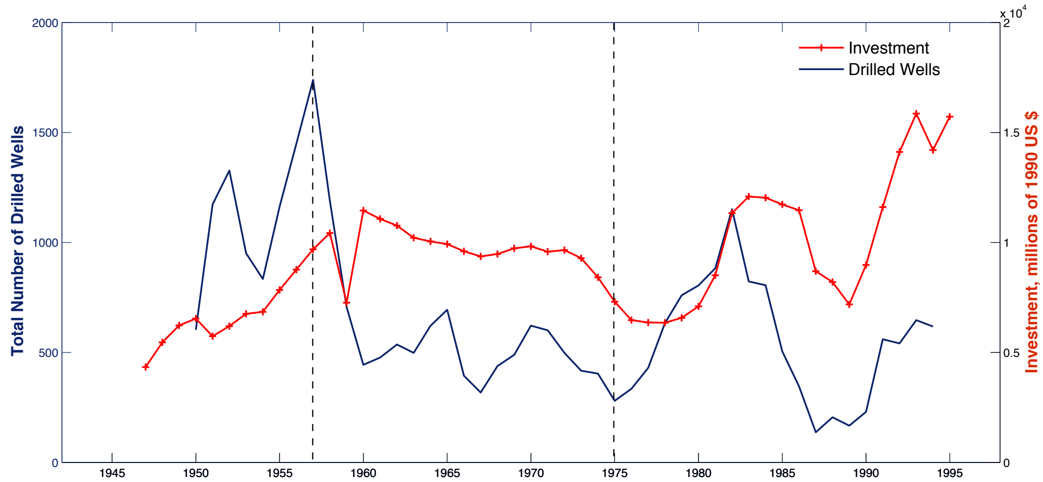

Figure 3.5: Total Wells Drilled and Investment in the Venezuelan Oil Industry

argument is in line with the Shell, the second largest producer in Venezuela following Creole, activities. Howarth and Jonker (2007) [16] point out that in the 1960s the Shell Group considered the conditions in Venezuela insufficiently attractive for further exploration activities. This implies that the policy announced during 1957-58 along with the unilateral tax increase distorted incentives significantly leading a considerable contraction in the industry. Accordingly, the government increased its participation through increasing income tax further, which can be seen in Table 3.1. In pre-1958 period, the royalty rate was in line with the rate applied in the U.S., 16.67%, and the income tax rate was not higher than the rate applied in the non-oil sector. However, in 1958, participation started to increase in a way that have made the Venezuelan oil industry unattractive and nationalization have become inevitable. It has been argued that during the 1960s, the intention was not nationalization but making arrangements in a way that allows the state to have more control. However, the process, which is precipitated by the "no more concession" policy and increased taxes, led to implementation of an anticipated nationalization. So, **news about the future** is a candidate for explaining the observed trends.

In 1971, the reversion law passed, which stated that all assets, plants, and equipment would revert to the nation. I assume that the nationalization process officially started with this law.[19] The law also substantially changed the nature of monitoring in the

[19]Petroleos de Venezuela, S.A. (PDVSA) is established to plan, coordinate, and control the activities of all the subsidiaries. In order to continue operations, technical and technological agreements are

Table 3.1: Total Government Take

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

[a] Martinez (1989) [21], Manzano and Monaldi (2010) [20]. The percentages are average total government take on oil companies' total profits. However, not a clear description of the take is provided. I assume that the total take includes mainly royalty and income taxes.

industry. The Ministry gained control, and the industry was co-managed with MNCs, Coronel (1983) [8]. New managerial power is likely to create inefficiency, because the ministry may not have enough experience regarding the organizational and managerial issues in the industry. Note that, during this period, i.e. 1971-1975, I observe a sharp decline in both production and productivity.

Prior to the nationalization, exploratory activity and investment were low. Therefore, after nationalization was implemented, the industry's goal was to expand. However, I see that in spite of all the effort the industry exerted, production and productivity are not responding.[20] The decree in 1957 brings losing foreign workers, which continues thereafter. This may imply a substantial loss in know-how if the available knowledge in the industry was dominated by international firms.[21] And, if foreigner know-how is complementary with the other factors of production, then nationalization would be costly. I believe that lack of a complementary factor in production can account for the impact of nationalization, and I consider **role of foreigners** as an important factor. In line with this theory, I provide evidence on the role of the foreign workers in the Venezuelan oil

planned to be made with foreign companies. Maintaining administrative structure of the companies after nationalization is an important issue, however different organizational structure may create problems in running companies effectively.

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

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

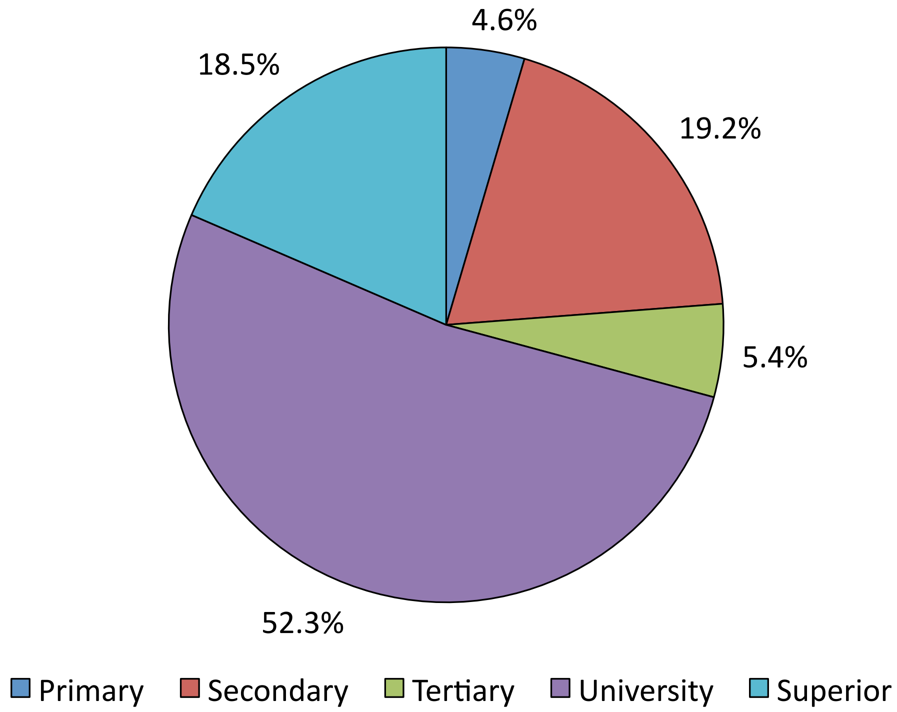

Figure 3.6: Education Level Distribution of the Foreign Personnel Employed in the Venezuelan Oil Industry, 1970

industry. Michelena and Soublette (1976) [31] argues that occupational groups composed of highly qualified personnel had high percentage of foreigners. They also provide data on foreign personnel employed in the oil industry for the year 1970. The data includes education level of the personnel, which I present in Figure 3.6 below. More than 70% of foreign manpower in 1970 are university graduates or higher. Given the fact that in the same year the average year of total schooling is 2.65 for the same age group in Venezuela,[22] I can conclude that foreigners were comprising key highly skilled workers in the industry and eliminating them is very likely to bring lost know-how.

Therefore, I consider two main factors presented and discussed above as critical. In the following section, I develop a model motivated by the observed trends in order to test to what extent anticipated policy and lost foreign know-how can explain the impact of nationalization.

[22]Barro and Lee (2010) [2]

3.3 Model

The model I present adopts the general framework developed by Pindyck (1978) [27] which is then applied by Yucel (1986) [35] and Deacon (1993) [10]. The model is a dynamic partial equilibrium framework for nonrenewable resources. I assume that the industry takes prices as given, and chooses exploration and production paths to maximize the present value of profits.[23] Assume that the industry is composed of identical firms and there are no externalities. Hence, I can consider a representative firm exploiting the resource. Reserves, which serve as a form of capital to support production, can be maintained or increased through exploration, even though returns to exploration decrease as discoveries increase. Production, on the other hand, depletes reserves. To simplify, our model abstracts from uncertainty.

I will consider two forms of taxation in natural resources: severance (royalty) taxes, i.e. taxes on production, and taxes on income. Both are common revenue sources for resource producing countries. Royalty taxes are levied on total sales, and income taxes are levied on total private profits. In reality, taxes are not usually contingent on prices, production, or reserves. Therefore, here I also assume that the tax rates are not contingent on them. Taxes will play an important role in our analysis, because I will describe a permanent change in policy through change in taxes.

First, I will describe our technologies, then introduce our model.

3.3.1 Technologies

I regard extraction as a process combining reserves as a form of capital with different extractive efforts in order to produce the resource, oil in our case. In some earlier papers, reserves are also assumed to serve as a capital input.[24] Despite this similarity, our technologies differ from them in several respects. First of all, in our model, the efforts participating in extraction as well as exploration are represented by different labor inputs that are measured in efficiency units. In extraction, reserve input is combined with labor inputs that are imperfect substitutes, and in exploration labor inputs that are imperfect

[23] By assuming the industry is a price taker, I am not departing completely from the Venezuelan reality.
[24] Devarajan and Fisher (1982) [11], Yucel (1986) [35], Deacon (1993) [10]

complements form additions to reserves. In order to measure the labor inputs, I collect novel data on the oil industry, in particular manpower, which enables us to construct our labor input series.[25] Secondly, I provide a quantitative analysis on the impact of nationalization on extraction and exploration through anticipated and unanticipated tax changes, which -to our knowledge- have not been addressed in the literature. Moreover, the parameters of the relevant functions represent the petroleum sector in Venezuela.

I continue with presenting our technologies in detail.

Extraction Technology I develop a production function that differs from the standard production function used in resource analysis. The alternative model is motivated by key facts of the Venezuelan oil industry. In section 2, I show that a considerable expansion in the workforce and significant increase in exploration took place in the industry after nationalization. However, this did not lead to a recovery in production and productivity, they continued to decline. The recovery started ten years after nationalization.[26] Given the fact that in this period domestic workforce and reserves increased but foreigners, who were high-skilled personnel, were eliminated, the main missing factor to be considered would be foreign workers. These motivate the following hypothesis: If foreigners have skills that are complementary with the other factors of production, then their elimination would bring losses. In order to implement this theory, I develop a production function with three inputs. This technology distinguishes between skilled and unskilled labor, and takes reserves as the form of capital.

I consider four categories of labor input in our analysis: extractive skilled & unskilled (or less skilled), and exploratory skilled & unskilled. I assume that the skill level is exogenous, that is, individual's skill level is not determined within the model. Therefore, I consider not only a skill-level criterion but also an operational criterion. I will present exploration technology in detail in the following part, and now continue with describing the extraction technology.

Let's denote the production function with $H(\cdot)$. Reserves must enter into this tech-

[25] Presented in the Appendix in detail.

[26] Although time-to-build nature of exploration is likely to result in a later recovery in production, ten years is a long period, because it is argued that generally exploration takes three to five years to be effective in extraction. Hence, I cannot attribute the late recovery to time-to-build nature of exploration.

nology in a certain way.[27] In this context, the main characteristics of the production technology are as follows:

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

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

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

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

where $0 < \upsilon < 1$, and $\Gamma(S, U)$ is homogenous of degree $\leq 1 - \upsilon$. In other words, I need a Cobb-Douglas technology. So, I assume that $H(R, S, U)$ is a non-increasing returns to scale Cobb-Douglas production function. To support our hypothesis, skilled and unskilled labor must interact in a certain way that help us account for the observed trends. For this purpose, I choose to represent $\Gamma(S, U)$ by a CES functional form. Hence, I consider a production technology with a general nested CES functional form, which has the main characteristics described above. It allows for different substitutability across factors and is formulated as follows:

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

where $0 < \mu, \upsilon, \gamma < 1$; $\sigma \leq 1$; and $\upsilon + \gamma \leq 1$. The extractive efforts, U and S, are measured in efficiency units. Each input type is a product of the number of workers and a productivity index, which is assumed to be constant. $h_U, h_S > 0$ are the corresponding productivity parameters. The technology is a non-increasing returns to scale Cobb-Douglas function

[27]Our discussion is in line with Dasgupta and Heal (1974) [9].

in two inputs: reserves, R_t, and a compound term $[\mu(h_U U_t)^\sigma + (1-\mu)(h_S S_t)^\sigma]^{\frac{1}{\sigma}}$. The second term is a CES aggregate over unskilled labor, U, with share parameter μ, and skilled labor, S, with share parameter $1-\mu$. The parameters υ and γ measure the shares of reserves and composite labor in income, respectively. The parameter σ governs the degree of substitutability between unskilled labor and skilled labor, and hence key to our theory.[28]

Next, I describe the exploration technology.

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

I choose the following Cobb-Douglas technology for exploration: [29]

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

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

Given our technologies, I can now present the model.

[28] σ being zero means Cobb-Douglas for the nested aggregate. The elasticity of substitution between unskilled labor and skilled labor is $\frac{1}{1-\sigma}$. Note that this definition holds only if all other input quantities are constant, Blackborby and Russell (1989) [4].

[29] Cobb-Douglas exploration function has been used in the literature, Pindyck (1978) [27], Yucel (1986) [35], etc. In general, the output of exploratory activity is assumed to depend not only on exploratory effort, which is usually represented by the number of drilled wells, but also on the stock of cumulative discoveries over time. Due to our objective and for the sake of simplicity, I suppress the additional argument.

3.3.2 Reserve Dynamics, and the Firm's Problem

Reserves dynamics are governed by the following state equation:

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

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

At each date t, the producer seeks to solve

$$v(R_t, P_t, w_{U_t}, w_{S_t}, w_{u_t}, w_{s_t}, \tau_{r_t}, \tau_{\pi_t}) =$$

$$\text{Max}\{\Pi(\cdot) + \beta\mathbb{E}[v(R_{t+1}, P_{t+1}, w_{U_{t+1}}, w_{S_{t+1}}, w_{u_{t+1}}, w_{s_{t+1}}, \tau_{rt+1}, \tau_{\pi t+1})]\}$$

subject to the constraints

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

$$R_{t+1} = R_t - H(U_t, S_t, R_t) + G(E_{u_t}, E_{s_t}) \tag{3.1}$$

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

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

Here, τ_π is the tax rate on income, τ_r is the royalty (severance) tax rate, and P is the real price of the commodity. w_i's are the real unit costs of different types of labor, where $i = U, S, u, s$. I allow for the producer to deduct c proportion of the exploration expenses from the tax bill.[30]

Denote the marginal product of reserves and the marginal product of unskilled and

[30] In our specification, I abstract from the fact that the quality of deposits decline as production increase, that is extraction becomes more costly as reserves decline and low-cost reserves are exploited first. For instance, Solow and Wan (1976) [30] develop a model with deposits differing in quality where the total reserves are fixed. One reason for our exclusion is insufficient data on costs.

skilled labor as H_R, H_U, H_S, respectively. Then, optimality conditions describing the solution of the model are:

$$(1-\tau_{\pi_t})[(1-\tau_{r_t})P_t H_{U_t} - w_{U_t}] = \eta_t H_{U_t} \tag{3.2}$$

$$(1-\tau_{\pi_t})[(1-\tau_{r_t})P_t H_{S_t} - w_{S_t}] = \eta_t H_{S_t} \tag{3.3}$$

$$(1-\tau_{\pi_t} c) w_{u_t} = \eta_t \theta_1 \frac{G_t}{E_{u_t}} \tag{3.4}$$

$$(1-\tau_{\pi_t} c) w_{s_t} = \eta_t \theta_2 \frac{G_t}{E_{s_t}} \tag{3.5}$$

$$\beta \mathbb{E}\left[(1-\tau_{\pi_{t+1}})(1-\tau_{r_{t+1}})P_{t+1} H_{R_{t+1}} + \eta_{t+1}(1-H_{R_{t+1}})\right] = \eta_t \tag{3.6}$$

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

The first order conditions for extractive efforts, equations (2) and (3), yield that the marginal current profit of producing a unit of the resource at time t is equal to the scarcity value of a unit of reserves in the ground. The scarcity value, η_t[31], is the expected present value of having one more unit of reserves in the next period. Equations (4) and (5) imply that the producer chooses optimal exploratory efforts so that after-tax marginal exploration cost is equal to the resource rent. Finally, equation (6) is the dynamic intertemporal optimization equation.[32] For a more straightforward economic interpretation, I use equation (2) and rearrange equation (6) which yields:

$$\eta_t = \beta \mathbb{E}\left[\eta_{t+1} + (1-\tau_{\pi_{t+1}})\frac{w_{U_{t+1}}}{H_{U_{t+1}}} H_{R_{t+1}}\right]$$

It implies that the rent at time t must be equal to the expected present value of the rent at time $t+1$ plus the after-tax marginal cost of extracting the additional output resulting from an additional unit of reserves at time $t+1$.

Equations (1) through (6) govern the evolution of the variables $R_t, U_t, S_t, E_{u_t}, E_{s_t}, \eta_t$ taking exogenous variables $\{P_t, w_{U_t}, w_{S_t}, w_{u_t}, w_{s_t}, \tau_{\pi_t}, \tau_{r_t}\}$ as given. Our quantitative results depend on the parameters of the functions.

[31] Also known as the resource rent at time t.
[32] The so-called Euler Equation.

3.4 Quantitative Analysis

In this section, I will present my calibration and quantitative assessment of the impact of nationalization.

3.4.1 Calibration

I will calibrate the model to the data for the Venezuelan oil industry. The data is annual time series. Relative to standard models of resources, our approach has novel elements. I represent exploratory and extractive efforts by unskilled and skilled labor in exploration and production, respectively, hence, the related parameters are new.

I follow a similar approach used in Krusell, Ohanian, Rios-Rull, and Violante (2000) [18] to construct labor input and corresponding wages data, which is explained in detail in the appendix. Reserve additions data is constructed by following Pindyck (1978) [27], which will represent annual time series for $G(\cdot)$. For reserves and production, I use proven reserves and crude oil production data, respectively.

One period in the model is assumed to be a year in the data. The discount factor is set at 0.90 to generate an 11% annual real interest rate. The parameter governing the elasticity of substitution between skilled and unskilled labor is set at a baseline value, $\sigma = -0.5$, due to observed trend in the data. I argue that the complementary skilled labor and unskilled labor can help us understand the observed trends, and in order to test this argument σ must be set at a value less than 0. I will consider a range of alternative values for this parameter in our experiments.

The rest of the parameters are calibrated from the steady state model, where tax rates are set at zero. Constructed pre-1960 data averages are used for the steady state U, S, E_u, E_s, and their corresponding wages. Reserve additions at the steady state is the pre-1960 average of the constructed $G(\cdot)$ series. R at the steady state is set similarly. I assume that skilled workers are more productive than unskilled workers, and these productivities are constant over time. I target wage differences across different occupational groups by nationality in order to calibrate h_i's, where $i = U, S, u, s$.

Setting the ratio of extraction costs between unskilled and skilled labor at 1.7 (the average $\frac{w_U U}{w_S S}$ ratio for the Venezuelan oil industry), I obtain $\mu = 0.585$. I choose υ and γ so that production is equal to the new reserves added, and production to reserves ratio is 0.39. The pre-1960 ratio of exploration costs between unskilled and skilled labor is 1.726. Using this target along with the average reserve additions over the period 1948-1959, I obtain θ_1 and θ_2. The parameter values are summarized in Table 3.2.

For our quantitative analysis I also need to obtain c, the tax credit on exploration expenses. I calculate it following Deacon (1993) [10]. c in our model is equivalent to the term $(e + (1 - e)f)$ in his formulation, where e is the "fraction of drilling costs expensed for tax purposes", and f is the "present value of cost depletion deductions per unit of depletable expense." Following him, I set e at 0.45. During the period 1953-1957, the production to reserve ratio, d, is almost constant in the Venezuelan oil industry. I calculate d as the average production to reserves ratio over 1953-1957. This allows $f = \frac{d}{r+d}$, where r is the interest rate, which was set at 11%. Hence, I obtain $c = 0.651$.

Table 3.2: Calibration to Venezuelan oil industry data

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

3.4.2 Results

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

As I have discussed in section 2, the conflict which took place in 1957/58 eventually gave rise to the realization of an anticipated nationalization. This is why I choose 1959 to be the starting point. I describe and introduce nationalization as follows: First, I assume that the agents in the economy anticipate in the year 1959 that the government will increase its participation through higher taxes permanently, which will be initially realized in the year 1970. I suppose that the formal nationalization process starts in 1970, because later that year the Income Tax Law was amended, and the ministry co-managed the industry with the MNCs until the nationalization process was finalized in the year 1975. So, at time $t = 1$, which corresponds to the year 1959, the industry foresees a once-and-for-all change in tax rates.

Second, I argued that the foreign workers have become a missing factor in the industry. That is, nationalization has also brought lost foreign know-how leading us to consider taking the number of foreign workers as exogenously given and examine the corresponding impact. I assume that the skilled labor input in both extraction and exploration in the model represent the foreign labor input. Then, I feed the actual number of extractive and exploratory foreign labor into the model. Hence, I attempt to provide a quantitative analysis by focusing on the tax rate increases and decline in the foreign labor input.

Before proceeding with the quantitative assessment of the impact of nationalization, I first present dynamic effects of an increase in income tax and a decline in the number of skilled workers on the industry decisions under no foresight and foresight.[33] This enables us to understand how the proposed mechanisms work.

Baseline Simulations *Increase in the income tax rate:*

Figure 3.7 presents the impulse responses of a permanent income tax shock. The number of foreign workers does not change. Solid lines are the responses to an unanticipated permanent 52% exogenous rise in the income tax rate. The dashed lines are, on the other hand, the responses under 10-periods foresight.

News about the income tax increase realized at the beginning of time 11 arrives at the beginning of time 1. Before policy realization, the response of extraction is opposite. In response to anticipation of an increase in the income tax rate, extractive effort increases. However, exploratory effort decreases. The effect of an anticipated future increase in income tax on exploration and extraction can be understood by looking at the optimality conditions. The inter temporal first order condition implies that the future increase in the

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

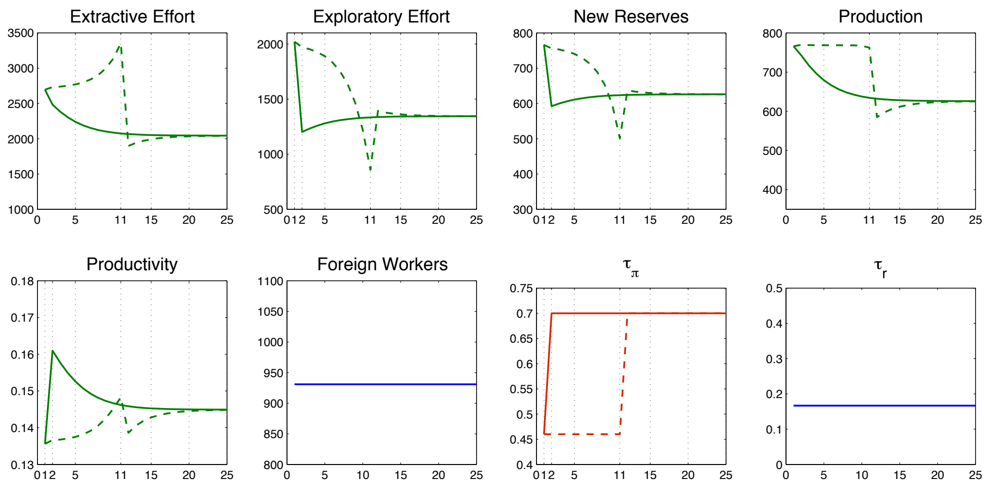

Figure 3.7: Impulse responses to income tax shock: Solid lines: responses to an unanticipated exogenous rise; dashed lines: responses to an anticipated exogenous rise, 10 periods foresight

income tax rates should cause the shadow value of additional reserves to decline as soon as the policy is announced. The decline in the shadow value would provide an incentive to increase the extractive efforts while induce disincentive for exploration.

Even though extractive efforts are increasing before the realization of the shock, lower reserves due to declining exploration prevent extraction from increasing. Hence, production is stable. Note that exploratory efforts decline more than the increase in extractive efforts resulting in declining total labor input. This implies increasing labor productivity, where labor productivity is measured as total production divided by total labor input. But, this may suggest a possible mis-measurement. Because, production takes into account exploratory effort only indirectly through its impact on reserves, but the productivity measure takes into account exploratory labor input directly through the total labor input component. In this sense, the increase in productivity seems puzzling, because I am expecting things to be more inefficient by an increase in income taxes.

Even though announcement of a higher tax on income seems to be harmless on extraction before it has been realized, both in terms of exploration and extraction it is costly, which is important from policy making perspective. The response after the policy realization is consistent with those to an unanticipated tax shock for extraction, however opposite for exploration. After realization of an unanticipated shock exploration falls immediately, but after the realization of an anticipated shock exploration increases first. The impact of the anticipated shock is driven by the change in the current shadow value which is determined by future expectation on taxes that is realized 10 periods in advance. On the other hand, for the case of unanticipated shock, the direct impact of higher income tax on current shadow value induces the impact on exploration.

The unanticipated rise in the income tax rate is realized at time $t = 1$. The rise in income tax rate lowers both exploration and extraction. Decline in exploratory effort is more severe and its trend dominates the path of the total labor input, hence productivity immediately rise due to the sudden drop in total number of workers, but then decrease due to declining extraction which outweighs the decline in total labor input. However, labor productivity converges to a higher level.

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

Losing foreign know-how:

Figure 3.8 presents the impulse responses of a permanent foreign know-how shock. Income tax is stable. Solid lines are the responses to an unanticipated permanent 70% exogenous decline in the number of foreign workers. The dashed lines are, on the other hand, the responses under 10 periods foresight. In our setting, this change corresponds to a 70% decline in both E_s and S, both are assumed to be exogenous.

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

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

In the long run, the overall impact of both anticipated and unanticipated lost foreign

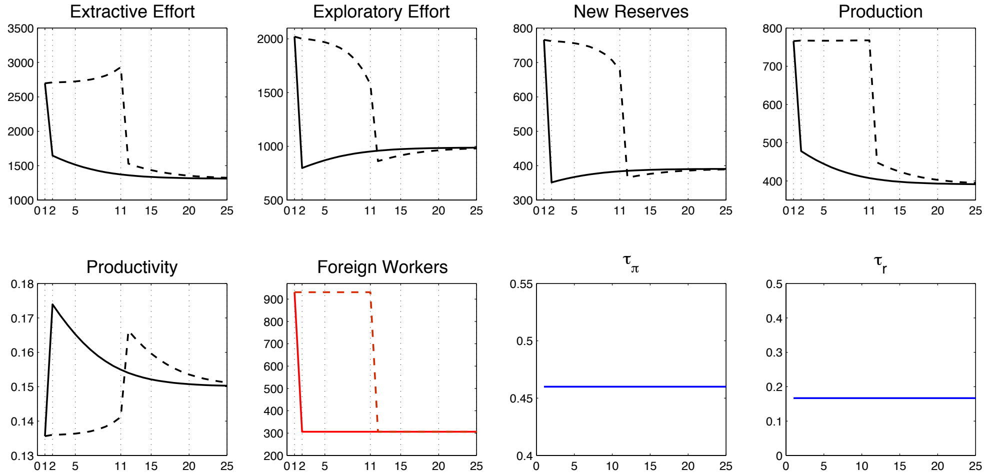

Figure 3.8: Impulse responses to know-how shock: Solid lines: responses to an unanticipated exogenous rise; dashed lines: responses to an anticipated exogenous rise, 10 periods foresight

know-how are similar. However, in the shorter term, ignoring foresight seems to only leads to small impact on exploration and extraction.

Nationalization Nationalization is simply exogenously given. In the early 1960s, the producer is anticipating a permanent increase in government take through higher income tax which has been realized in the year 1970. The income tax rate increased from 0.46 to 0.70, as I observe in the data. Moreover, expected nationalization brings elimination of foreign workers. In the data, from 1960 to 1970, number of foreign workers fell by around 74%. In our simulation, I feed declining number of foreign workers exogenously to the experiment. In our experiment the decline for the ten-year period is around 70%. Figure 3.9 shows actual data versus our simulated data.

Figure 3.9 suggests that simulated response to the tax increase and declining number of foreigners contribute significantly to explaining actual time series. In response to the anticipated increase in future income tax, extractive efforts increase, but this contributes only slightly to the production due to offsetting effect of declining extractive effort put by the foreigners and declining exploratory efforts and hence declining reserves. Exploratory effort fall due to both anticipated increase in the tax rate and less effort put by foreign exploration workers resulting in a severe decline in exploration. This implies declining

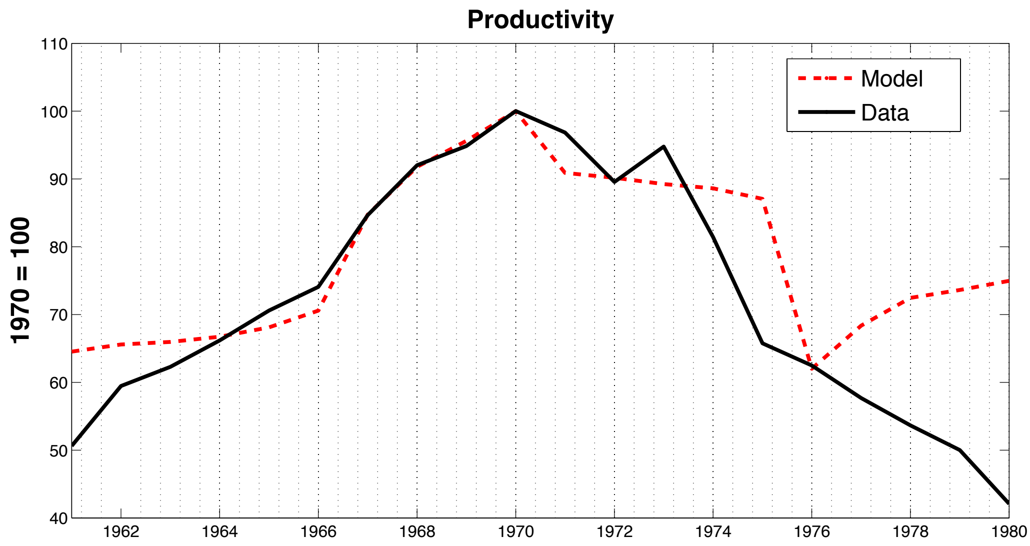

Figure 3.9: Actual versus Simulated Data

reserves, and hence falling production, but increasing productivity. After the increase in tax rate is realized there is a significant decline in extraction leading to declining productivity, which however increased after nationalization by expanded domestic manpower. The proposed mechanism can account for around 56 percent of the increase in productivity prior to 1970, and about 39 percent of the decline in productivity during and after nationalization.

3.5 Conclusion

Encouraged by revenue windfalls due to price hikes or the desire to gain control over a vitally important commodity, a number of developing countries have instituted nationalization several times. From the point of view of a resource-rich country, implementation of nationalization can bring higher income or better income redistribution through the government's exercising full control over the industry. However, these can come at the expense of losses in production and productivity.

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

Future research may consider improving the model in several aspects to capture the real world better. First, I abstract from any kind of uncertainty, which is not an ideal assumption due to highly uncertain nature of exploration. Second, our framework implicitly assumes that reserves are in the same quality. Declining quality of reserves can be a better representation, which can be captured via a latent variable representing productivity of reserves whose growth rate is negative, or via the assumption that extraction becomes more costly as cumulative amount already extracted increases, as in Solow and Wan (1976) [30], and Heal (1976) [14]. Third, I did not attempt to explain post-1975. For this analysis, the objective of the firm must be different. Developing two different problems for pre and post 1975 periods can help explain the paths after nationalization. Finally, developing a general equilibrium model with two sectors, resource and non-resource, can result in understanding how a government policy such as nationalization can contribute to the development problem of a resource rich country.

3.6 Appendix

3.6.1 Data Construction

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

We construct our annual data series for new reserves that will represent $G(\cdot)$ in the spirit of Pindyck (1978) [27]. He emphasizes that although new discoveries and extensions have a strong dependence on well drilling and cumulative reserve additions, revisions behave like a random process with a mean value several times the mean value of discoveries plus extensions. Hence, he obtains a constructed series by multiplying his data on discoveries plus extensions by the ratio of the mean value of reserve additions to the mean value of discoveries plus extensions. That is, he substitutes for annual revision its mean value in order to eliminate additional variance and possible negative discoveries. We follow the same procedure due to the fact that in our data revisions behave in a similar manner. Hence, we calculate new reserves as the multiplication of discoveries plus extensions with the ratio of the average reserve additions to the average value of discoveries plus extensions.

Labor Input Data Collecting oil industry manpower data 1950-1990 is a challenging task. Data is not digitally available, and even for the U.S. there is limited historical data. The earliest industry level data available for the U.S. is for the year 1997. However, we are able to collect anecdotal evidence and statistical data that will help us constructing the labor input and corresponding wages series. Our data sources are MMH Databooks, Michelena and Soublette (1976) [31], and Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census Databook [26] for the year 1987.

For the years 1948-1995, MMH databooks provide annual data on the number of workers and earnings in the petroleum industry in Venezuela. Earnings are annual total wages and salaries charged to operations in current million Bolivares, but we recorded them in millions of 1990 U.S.$. Michelena and Soublette (1976) [31] present the occupational profile in the oil industry in Venezuela in 1974, and data on foreign personnel employed in the oil industry in 1970. Foreign employment data includes entity, age, education level, office held, experience in profession, and basic remuneration.

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

Next, we describe how we construct the groups in more detail.

Construction of the Groups MMH Databooks report only the total number of employees and laborers in the oil industry by their nationality, i.e. Venezuelan versus foreign. They did not provide any further information on the demographic characteristics. So, we try to provide evidence from other sources that can help us construct our labor input series. Michelena and Soublette (1976) [31] presents the occupational profile of the oil industry for the year 1974, which we present in Table 3.3:

Table 3.3: Occupational Profile, Venezuelan Oil Industry, 1974

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

This table includes both oil and petrochemical industries. However, oil industry workers account for more than 76% of this profile, so we will use it as a proxy for the oil industry. Here, technologist is equivalent to a mid-level technical education graduate. “Others” in the last category includes secretaries, clerical and unskilled workers. We consider professionals as one broad group consisting managers, administrative workers, and technical workers where technical workers include technical, research, and others categories. Technologists and operators are regarded as mid-level workers, and finally, “others” in the last category are considered as unskilled workers. Assuming that this occupational distribution was true at any time t, using data on the total number of workers in the oil industry, we obtain three broad groups at time t.

We have the number of foreign workers in the oil industry by the office held, i.e. occupation, in 1970. First, we group them according to the above broad categories, and calculate the percentage distribution. Table 3.4 presents it:

Table 3.4: Foreign Workers in the Oil Industry, 1970

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

Under the assumption that this distribution holds at all times, we obtain the time series data for foreign workers in the industry by occupation. Then, given the total employment distribution, the rest of the workers are recorded as domestic professionals, domestic mid-level workers, and domestic unskilled workers.[34] Now, we have ten groups, foreign: professionals -management, technical, administration-, mid-level, and unskilled; and domestic: professionals -management, technical, administration-, mid-level, and unskilled.

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

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

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