NBER WORKING PAPER SERIES

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Working Paper 16126
http://www.nber.org/papers/w16126

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2010

For excellent research assistance, we are grateful to Luis Fernando Castro,Teresa Fort, and Tomoko Wada. We also thank Yuki Ikeda for editorial assistance. We have benefitted from insightful conversations and comments from Ximena Del Carpio, Tito Cordella, Eduardo Engel, Aart Kraay, Justin Lin, Osmel Manzano, Juan Antonio Morales, Claudio Raddatz, Roberto Rigobón, Luis Servén and seminar participants at the World Bank, the Atlanta Fed, the Inter-American Development Bank, and the Conference on Development Economics, Bolivia 2009. We gratefully recognize the financial support from the World Bank's Knowledge for Change Program and the Latin America and Caribbean Flagship Report on "The Role of Commodities." The views expressed in this paper are those of the authors, and do not necessarily reflect those of the World Bank, their Boards of Directors, the countries they represent, or the National Bureau of Economic Research.

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NBER Working Paper No. 16126
June 2010
JEL No. F4,O1

ABSTRACT

This paper studies the cycles of nationalization and privatization in resource-rich economies. We discuss available evidence on the drivers and consequences of privatization and nationalization, review the existing literature, and present illustrative case studies. Our main contribution is then to develop a static and dynamic model of the choice between private and national regimes for the ownership of natural resources. In the model, this choice is driven by a basic equality-efficiency tradeoff: national ownership results in more redistribution of income and more equality, but undermines incentives for effort. The resolution of the tradeoff depends on external and domestic conditions that affect the value of social welfare under each regime. This allows us to characterize how external variables — such as the commodity price — and domestic ones — such as the tax system — affect the choice of private vs. national regimes. The analysis therefore identifies the determinants of the observed cycles of privatization and nationalization, and is consistent with a variety of observed phenomena.

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1 Introduction

Why is the process of *institutional* innovation so volatile and often subject to reversion, particularly in developing countries? While the process of technological innovation generally follows a pattern of continuous progress, the process of institutional reform takes a more complex, cyclical pattern. Institutional reform tends to occur in times of crises but often, as social or economic conditions change, these reforms are reversed (Sturzenegger and Tommasi, 1998).

One of the most salient institutional reforms in the post-communist era has been the privatization of commercial enterprises all around the world (Chong and Lopez de Silanes, 2005). Lately, however, the benefits of privatization have been called into question, and many countries have moved to re-nationalize some of these enterprises (Manzano and Monaldi, 2008). In no area has this been more prevalent than in the exploitation of commodities in resource-rich economies (Kobrin, 1984; Rigobon, 2009). Looking back at the historical experience, it becomes evident that many of these economies have moved back and forth between private and national regimes (Chua, 1995; Minor 1994). Their behavior is a prime example of the instability of institutions, defined as the set of rules and norms under which the economy functions. Compared to these regime shifts, other issues surrounding the exploitation and administration of natural resources seem to be of secondary importance.

This paper studies the cycles of nationalization and privatization in resource-rich economies as a prime instance of unstable institutional reform. It starts by presenting available evidence on the drivers and consequences of privatization and nationalization. We review the received literature and identify systematic patterns on regime choices and shifts. We then present an analytical narrative of an illustrative case study (Bolivia and hydrocarbons) of repeated nationalization and privatization of a natural-resource industry. (The Appendix examines two additional cases, Venezuela-oil and Zambia-copper, which show rather similar patterns.) We focus on the periods before and after privatization and nationalization of the natural resource, with the objective of relating regime shifts to the behavior of the price of the commodity, its level of production and capital investment, the taxes and other fiscal revenues derived from its

exploitation, and the level of average income and degree of inequality of society at large.

The literature review and the case studies motivate and provide a context for the main contribution of the paper: a dynamic model of the choice between private and national regimes. The model is built around a basic tradeoff between equality and efficiency. Greater equality is obtained under public ownership of a "national" resource, while more efficiency obtains when the ownership and administration of the resource are in private hands. The connection between ownership and the equality-efficiency tradeoff is given by the set of incentives for effort that each regime provides to economic agents. In the private regime, there is a differential compensation scheme that depends on observed productivity, thus encouraging agents to increase their efforts. Under the national regime, the government cannot credibly commit not to equalize income ex post [1] thus engendering equality but also minimal individual effort.[2]

The resolution of the tradeoff depends on external and domestic conditions that affect national welfare under each regime. Hence our framework allow us to study how external variables –such as the price of the commodity in question– and domestic ones –such as the tax regime and government quality– affect the choice of private or national regimes. As external and domestic conditions fluctuate, cycles of privatization and nationalization emerge.

We argue that the theory is consistent with the stylized facts highlighted in our empirical review. Realistically, the model implies that privatization results in an increase of efficiency at the expense of consumption inequality. It also implies that privatization occurs when resource prices fall, while increases in resource prices eventually lead to nationalization. In addition, the model identifies several factors and parameters that determine the choice of nationalization vis-a-vis privatization. Increased risk aversion, for example, makes inequality more costly, and hence favors nationalization. This is reflected in the model in a decrease in the threshold price at which the country is better off by switching from a privatized regime to state ownership and, in the dynamic version of the model, an increase in the average duration of state ownership regimes.

[1] This assumption is similar in spirit to that of Perotti (1995), but our model and analysis is quite different.

[2] In the model, work effort is a proxy for all activities that are affected by economic incentives and that may have an impact on productivity. From a long run perspective, therefore, it does not only represent labor but also investment in human and physical capital, as well as managerial and entrepreneurial endeavors.

Likewise, in the dynamic model, an increase in exogenous costs of nationalizing previously privatized industries reduces not only the likelihood of nationalization but also makes it more unlikely that a nationalized sector be privatized. This is because privatization is not forever, and hence its value depends on the option to re-nationalize the industry, which falls with the aforementioned exogenous costs.

Our model stresses that observed cycles of privatization and nationalization may ultimately reflect the inability of a government to commit to a given policy; in our case, restraining itself from redistributing income ex-post when the domestic resource is under state ownership. In this sense, our theory implies that institutional reform can break such cycles, but only if better institutions enhance the state's ability not to renege on previous promises. The model also illustrates how political tensions about increased inequality and the associated conflict can naturally emerge as a by product of the solution of the equity-efficiency problem. In contrast, we assign no direct role to other political characteristics, such as ideological preferences or historical colonization origins, which are sometimes stressed in the literature.

The rest of the paper proceeds as follows. Section 2 provides the main facts surrounding the occurrence of privatization and nationalization. It first reviews the existing literature and then presents the experience of Bolivia as a case study of regime shifts. Sections 3 and 4 develop a model on the choice between private and national regimes. Section 3 discusses the static model, taking the regime choice as given. Section 4 introduces a dynamic version, where the possibility of regime choice and shifts arises. By calibrating and simulating the model, we explore and discuss the characteristics under which each of the regimes is more likely to be prevalent and the conditions that lead to more frequent regime changes. Section 5 concludes.

2 Stylized Facts

The received literature documents five key facts that motivate and guide our theoretical examination:

Fact 1: Nationalizations and privatizations are repeated, cyclical phenomena, which often come in waves common to several countries. Kobrin (1984) analyzed expropriations in 79 developing countries over the period 1960-79. He found that expropriations grew in the 1960s, peaked in the early 1970s and declined afterwards. Minor (1994) and Safik (1996) extended Kobrin's study to include the period up to 1993. They found that in the late 1980s and early 1990s, as many as 95 countries around the world experienced extensive privatization processes. Most recently, however, Manzano and Monaldi (2008) report the opposite trend in the last few years, albeit in a smaller group of countries, mostly in Latin America. For them, the current wave of nationalization is only the latest chapter of a repeating cycle, as they had previously experienced the nationalizations of the 1970s and the privatizations of the 1990s.

Chua (1995) is arguably the most comprehensive historical study of the privatization - nationalization cycle, with focus on Latin America and Southeast Asia. She found that, in spite of the differences between these two regions, there is an observable tendency of cycling back and forth between nationalization and privatization in both regions. In Latin America (most prominently, Argentina, Brazil, Chile, Mexico, Peru, and Venezuela), a first wave of privatization extended from the 1870s to the 1920s. Partly as reaction to the Great Depression, nationalizations became quite frequent and extensive in the 1930s. After World War II, a second tide of privatization occurred, only to be reversed under the populist regimes of the 1960s and 1970s. Two decades later, in the early 1990s, the pendulum fluctuated back to privatization, which, as mentioned above, occurred in a massive scale. In Southeast Asia (particularly, Malaysia, Pakistan, and Thailand), the cycle started later given their more recent history of independence. Initially, most of the economy was privately run. This changed in the late 1960s and early 1970s, when extensive nationalizations occurred. Also coinciding with the Latin American cycle, in the late 1980s and early 1990s, many state-owned companies were privatized in Southeast Asia.

Fact 2: Privatization - nationalization cycles tend to occur more often in the natural resources and utilities sectors. Kobrin (1984) documents that in the last five decades expropri-

ations encompassing large portions of the economy do occur, but they are less frequent than selective expropriations and have been mostly concentrated in a dozen of countries. In her historical account, Chua (1995) also finds that in the majority of countries under analysis, utility and natural resource companies are significantly more prone to undergo the nationalization and privatization recurring cycle. Her account of the ownership swings of oil exploitation companies in Latin America is particularly revealing.

The next fact is related to the previous one and has to do with the underlying causes of ownership changes:

Fact 3: Nationalization of natural resource industries tends to occur when the price of the corresponding commodity is high. Duncan (2006) investigated the causes of expropriation in the minerals sectors of developing country exporters. In this study, expropriation is defined as any act by which a government gains a greater income share than it was entitled to under the original contract with the foreign investor. The sample analyzed consists of the eight largest developing country exporters for seven major minerals (bauxite, cooper, lead, nickel, silver, tin and zinc). Covering the period 1960-2002, Duncan used probit regressions to estimate the effects of price booms and political and economic crises on the probability of expropriation. The results indicated that price booms are significantly positively correlated with the instances of expropriation. The paper concluded that a high real price for minerals is a stronger predictor for state expropriation risk than political or economic crises are. In a related study, Guriev, Kolotilin, and Sonin (2009) examined the determinants of nationalization in the oil sector, using panel data for 161 countries for the period 1960-2002. They run logit pooled regressions of nationalization events on oil price shocks and the quality of government institutions, controlling for country fixed effects and per capita GDP, among other variables. The regression results showed that governments are more likely to practice expropriations when the oil price is high and when government institutions are weak (although the latter result is controversial, as we discuss below).

A fourth fact is also related to commodity price changes and their effect on fiscal revenues:

Fact 4: Contracts for the exploitation of natural resources between governments and private companies are such that commodity price windfalls are mostly appropriated by private firms. This may explain why nationalizations tend to occur during commodity price booms. Manzano and Monaldi (2008) analyzed the recent trend of nationalization in the Latin American oil sector, pointing out to issues in the taxation system and political economy of this sector. The oil industry is in general characterized by considerable rents and sunk costs. This makes the industry very attractive for government expropriation when oil prices rise and the tax system is inadequate, in the sense of being regressive and lacking consideration for price contingencies. Accordingly, the authors argue that the new wave of nationalizations is induced largely by the increase in the international oil price.[3] Likewise, in his study on expropriation in the mineral sector in major exporting countries, Duncan (2006) argues that a combination of high commodity prices and low profit sharing from private firms to host governments gave them large incentives to expropriate.

The last fact is also related to underlying causes of ownership changes:

Fact 5: Nationalization is more likely when inequality is endemic or worsens in the country, and especially when the rents from natural resource or utility companies are perceived as benefitting only a minority. Chua (1995) concluded that nationalization in Latin America and Southeast Asia was promoted against not only foreigners but also domestic residents who were perceived as unfairly privileged. The private ownership and management of utility and natural resource companies was deemed to have worsened the inequality already present in these societies. Accordingly, differences across ethnic lines were a key factor to induce the ownership shifts in Southeast Asia, while an anti-elitist movement played a significant role in Latin America.

[3]Rigobon (2008) studied oil production and profit-sharing contracts between governments and private companies. The simulation analysis of his model was directed at comparing two kinds of tax mechanisms – royalties and income taxes. His results showed that royalties can generate more stable tax revenues and lower agency costs. However, they may create more distortions in the production plan (because the quantity produced is more susceptible to price fluctuations when royalties increase). More controversially, Rigobon argued that under royalties, the probability that firms may earn large profits is higher, thereby stimulating government's incentive for expropriation. By contrast, with income taxes, the volatility of private profits is lower, thus possibly mitigating expropriation risk. However, the variance of the tax revenue stream is higher and the potential losses due to agency problems are larger under income taxes

The social pressure stemming from inequality is heightened and realized in times of government changes. This may explain why Duncan (2006) finds that mineral expropriations were more likely during the wave of independence of developing countries and also why Guriev, Kolotin, and Sonin (2009) find that oil nationalizations tended to occur when government leadership was replaced.

Finally, we should remark that the relationship between the likelihood of nationalization and government regime type is rather ambiguous. While Duncan (2006) finds that mineral expropriations are more likely during democratic governments, Guriev, Kolotin, and Sonin (2009) find that oil nationalizations tend to happen when democracy and constraints on the executive are weak. Moreover, as pointed out above, Duncan finds no connection between mineral nationalizations and political crises (except independence). It would seem that the underlying pressures of wealth and income inequality, observed high commodity prices, and perceived unfairness in the distribution of natural resource profits can lead to nationalizations in both democracies and dictatorships and under both political stability and political disruption.

Case Study: Bolivia and Hydrocarbons

Bolivia's first oil well was built by the Standard Oil Company in 1922 and its first oil field began production just two years later. Standard Oil's operations in Bolivia proved to be quite profitable. The Chaco War between Bolivia and Paraguay (1932-35) convinced the Bolivian government of the importance of natural resource ownership for both economic and geopolitical considerations. It became quite clear that Standard Oil was benefitting greatly from the oil concessions it had obtained. In 1936 Colonel David Toro founded the state-owned petroleum company, *Bolivian Fiscal Oil Fields* (YPFB, its Spanish abbreviation), and the next year the government confiscated all of the Standard Oil Company's holdings. Standard Oil's expulsion from Bolivia was the first-ever nationalization in Latin America, and effectively nationalized Bolivia's entire petroleum industry. The next decade was a dynamic political period in Bolivia. In 1952, the *Nationalist Revolutionary Movement* (MNR) overthrew a military regime and

conducted a revolutionary program that granted universal suffrage, implemented agrarian and educational reform, and nationalized the country's mines. Contrary to government expectations, however, agricultural output dropped, tin production halved, the country experienced inflation rates of 900%, and hydrocarbon production was well below potential.

In 1956, in the midst of the economic downturn, Hernán Siles Zuazo was elected president. He initiated a new economic program that invited North American petroleum companies back to Bolivia. He encouraged them to invest by passing a new hydrocarbon law, The Davenport Code. The law granted foreign companies property rights over the oil and gas they discovered. In 1961, the Gulf Oil Company discovered new natural gas and petroleum reserves, and in 1964 it renewed its contract with the Bolivian government and negotiated concessions to gas and pipeline rights in the country. In 1968 a mixed company of YPFB and Gulf Oil was founded and plans were made to export gas to Argentina. Clearly, the large investments in exploration, extraction, and distribution of hydrocarbons were paying off, as production improved sharply and profits increased several fold.

In 1969 Alfredo Obando seized government control through a coup d'état. Soon after, Obando nationalized the much coveted Gulf Oil at a cost of $78 million, a fraction of its true worth. YFPB was left as the sole supplier of natural gas to Argentina. During the 1970s Bolivian politics continued their dynamic and tumultuous course. Maybe reflecting this mixed environment, the exploitation of hydrocarbon resources was conducted by an uneasy partnership of public and private interests. In fact, in 1972 the government passed the *General Hydrocarbon Law* to promote foreign investment, even if government retained property rights. The YPFB signed contracts with private firms and began exporting natural gas to Argentina.

From 1978 to 1982 Bolivia experienced one of the most turbulent periods in its political history. Nine presidents came and went during the four year period, and the economy deteriorated severely. In 1985, when Victor Paz Estenssoro was inaugurated as president, he faced skyrocketing inflation rates and a dire economic situation. He responded by implementing *The New Economic Policy*. The program froze wages, raised the price of fuel, devalued

the Bolivian peso, eliminated price supports, and laid off four-fifths of the mining workforce. After the reforms, Gross national income per capita (GNI) began a noticeable upward trend, whereas inequality, as measured by the Gini coefficient, fell almost ten points (see Figure 1.c). In contrast, investment in the energy sector and total FDI experienced only a small increase in 1987 and then remained relatively flat (Figure 1.b). After a small increase in 1986, Bolivia's gas production stagnated and reserves were continually low (Figure 1.a). This lack of positive response was partly due to low hydrocarbon prices. In fact, while the new reforms were being implemented, natural gas prices continued to fall. They trended down steadily until 1992 when they experienced a small spike—offset almost entirely in 1994—before continuing their descent (see Figure 1.a). Nevertheless, as the events that followed suggest, the lack of activity in the hydrocarbon sector was also due to the weak incentives that nationalized ownership implied.

In 1993, Gonzalo Sanchez de Lozada won the presidency with a privatization and capitalization program. A year after his election, GNI was still trending upward and there was significantly lower income inequality. In this domestic environment and with still low hydrocarbon prices, Sanchez de Lozada privatized nearly the entire state-run economy by selling controlling interests in six large companies, including YPFB. Immediately thereafter, Bolivia's FDI began a dramatic and steady upward climb (see Figure 1.b). Investment in the energy sector increased as well, and production of natural gas began growing just a year later. Despite gas prices' continued fluctuation—an upward trend was not evident until at least 1999—gas reserves began a gradual upward trend in 1996. The effects of investment and production increases were evident and reserves jumped from 14.05 trillion cubic feet in 1999 to 49.82 tcf in 2000. Reserves peaked in 2003 at 7901 tcf, a 463% increase over a five year period. In 1997, Bolivia completed construction of a natural gas pipeline to Brazil, which represented the country's single largest investment—the Bolivian component alone had cost $550 million. It was also a testament to the sizeable sunk investments necessary to exploit the country's natural gas reserves.

After two other administrations, Gonzalo Sanchez de Lozada was elected for a second period

in 2002. Following the downward economic tide in Latin America, the Bolivian economy went into a recession. After peaking in 1998, gross national income per capita began a steady decline and income inequality rose. Discontent became widespread and protesters demanded nationalization of the country's natural gas resources. Tensions peaked in October 2003 when riots broke out in opposition to the potential construction of a pipeline to Chile for use in future gas exports to the U.S. Now referred to as *The Gas War*, the unrest resulted in approximately 60 deaths and one thousand injured civilians. Sanchez de Lozada was forced to resign and Vice-president Carlos Mesa took over. In 2004 Mesa held a referendum on hydrocarbon property rights, but even this did not quell the violent demonstrations, and he was ultimately forced to resign as well.

Figure 1.c illustrates the changing economic situation. In 1999 GNI began a steady downward trend and, perhaps even more importantly, the Gini coefficient rose dramatically (from 1991 to 2003 the Gini rose almost 43 percent). Rising inequality was concurrent with a steady decline in the share of government collection in the value of oil and gas production. The falling percentage was likely attributable to the fact that the Bolivian government generally collected revenues through fixed royalty payments (Manzano and Monaldi, 2008). When the price of gas rose, as happened from 1995 to 2005, the production value rose while the government's take remained fixed.

In December 2005 Evo Morales, founder of the party *Movement Toward Socialism*, was elected president. Amidst rising gas prices, declining fiscal contribution of the gas companies, and increasing inequality, he had gained popularity by campaigning on a platform of nationalization. FDI and investment in the energy sector had been trending down since 1999, and in the year of Morales' election they both plummeted. In fact, FDI in 2005 was actually negative. Natural gas prices, on the other hand, reached a historical peak in 2005. On May 1, 2006, in accordance with his campaign promises, Morales nationalized Bolivia's gas fields and oil industry.

3 A Single Period

This section and the next develop a model of an industry that can operate under either a private ownership regime or a state ownership regime. The economy is infinitely lived, but in this section we confine attention to one typical period given the ownership regime, and focus on the determination of the net benefits of each regime. This hinges on a crucial efficiency-equity tradeoff derived from a moral hazard problem, together with the inability of the government to commit not to redistribute income under state ownership.

More specifically, we assume that the productivity of workers depends on unobservable effort.[4] Efficient contracts would then prescribe that more productive workers be paid more than less productive ones, in order to elicit the right amount of effort. While this is possible under private ownership, the government cannot refrain from equalizing the incomes of workers ex post under state ownership. But this destroys incentives for effort. The result is that private ownership is associated with more efficiency but less equality than state ownership, which is consistent with the stylized facts stressed in the previous section. Importantly, the result of the equity-efficiency tradeoff depends on a number of parameters, such as the degree of risk aversion, as well as other exogenous data including the price of the country's resource.

3.1 Workers

We consider an economy that produces a commodity via an increasing and concave production function $F = F(L)$, where L is labor input. Because technology is strictly concave, there is an implicit fixed factor of production that can be interpreted as land or capital.

The commodity is sold in the world market in exchange for world currency, which is taken as numeraire. The commodity price, denoted by p, is exogenous to the economy under analysis.

The economy is populated by a continuum of ex-ante identical workers of measure $N > 0$.

[4] As mentioned in the introduction, work effort in the model represents, in general, economic activities that are influenced by remuneration incentives and that may, in turn, affect production and productivity. They include not only labor input but also human and physical capital investment, as well as managerial and entrepreneurial behavior. As in the case of work effort in the model, these activities are subject to moral hazard in the sense that their compensation is tied to observed productivity and not only exercised input.

The labor supply of worker $i \in [0, N]$, denoted by l_i, is a random variable whose distribution depends on worker i's effort, a_i. One can interpret l_i as the worker's productivity for the job, which may be uncertain but is enhanced, on average, by effort spent on education or training. Crucially, labor supply is observable by everyone but effort is private information of the worker. Because exerting effort is costly, the asymmetry of information introduces moral hazard problems into the model.

Naturally, exerting more effort is beneficial for productivity. For simplicity, assume that l_i can be either high ($l_i = l_H$) or low ($l_i = l_L < l_H$), and that the probability of high productivity is an increasing and concave function of effort: $\Pr(l_i = l_H|a) = \pi(a)$, where $\pi(a), \pi'(a) > 0$ and $\pi''(a) < 0$. Given effort, the realization of labor productivity is i.i.d. across workers. We follow the standard assumption of imposing a law of large numbers so that if all workers spend effort a, the actual proportion of workers with high productivity equals $\pi(a)$.

Consider the decision problem of an individual worker. Regardless of the industry regime, the worker faces a labor market characterized by a wage schedule $\{y_H^*, y_L^*\}$, where y_H^* and y_L^* are the payments to a worker with high labor productivity and low labor productivity, respectively. Total income of a worker with productivity l_i is $y_i^* + T$, where T is a lump-sum transfer.

Denote the utility of income by $u(c)$ and the cost of effort by $\phi(a)$. We assume $u' > 0 > u''$, $\phi(0) = \phi'(0) = 0$ and $\phi', \phi'' > 0$ for all $a > 0$.[5] Then, given the wage schedule $\{y_H^*, y_L^*\}$, the worker chooses a to maximize her expected utility

$$\max_{a \geq 0} \pi(a) u(y_H^* + T) + (1 - \pi(a)) u(y_L^* + T) - \phi(a) \tag{1}$$

The first order necessary condition is

$$\pi'(a) [u(y_H^* + T) - u(y_L^* + T)] - \phi'(a) = 0 \tag{2}$$

[5]The condition $\phi(0) = 0$ is an innocuous normalization and $\phi'(0) = 0$ is used to guarantee that positive effort is chosen whenever $y_H^* > y_L^*$.

This has an obvious interpretation. $\phi'(a)$ is the cost of increasing effort by an infinitesimal unit; the gain is that, with increased probability, $\pi'(a)$, the agent gets to consume $y_H^* + T$ instead of $y_L^* + T$. Then, under our assumptions, $a > 0$ if and only if $y_H^* > y_L^*$: the worker will exert effort only if a more productive worker is paid more. Moreover, condition (2) implies that effort increases in the wage differential.[6]

The wage structure, taxes, and industry ownership regime are taken as given to individual workers, but are endogenous from the viewpoint of the economy as a whole. We now turn to their determination.

3.2 State Ownership

Consider a period in which the industry is under state ownership. We make two assumptions about this regime:

- The government maximizes an equally weighted sum of the utilities of domestic workers.
- Under state ownership, the government chooses a wage schedule and taxes *after* effort has been spent and individual productivity is observed.

The last assumption is the crucial one. It can be justified on the basis of political pressures. Any wage contract offered in advance of the choice of effort is assumed to be non-credible, as the state would always be able to renegotiate the terms of the contract. Alternatively, one may assume that the state can impose taxes and transfers to effectively undo any prior contract.

Under these assumptions, risk sharing motives lead the government to choose a wage schedule that equalizes consumption across agents: $y_H = y_L$. This is because, at the time the government chooses the wage schedule, effort and individual productivity are already given. Hence the wage schedule no longer distorts effort choice, and the government chooses it to prevent consumption inequality.

[6] To see this, let $\Delta = y_H^* - y_L^*$, and rewrite (2) as $u(\Delta + y_L^* + T) - u(y_L^* + T) = \gamma(a)$, where $\gamma(a) = \phi'(a)/\pi'(a)$. Differentiating this expression with respect to Δ, and noting that $\gamma'(a) > 0$, gives $da/d\Delta > 0$.

But, of course, if agents predict that their compensation does not depend on productivity, they will exert the minimum amount of effort; namely, $a_S = 0$. Labor input then falls to its minimum value.

More formally, and assuming (without loss of generality) that $T = 0$, given any probability of high productivity, π, the planner chooses y_H and y_L to maximize the sum of workers' utilities:

$$N\left[\pi u(y_H) + (1-\pi)u(y_L)\right]$$

subject to the feasibility constraint

$$N\left[\pi y_H + (1-\pi)y_L\right] = pF(N\left(\pi l_H + (1-\pi)l_L\right))$$

The term on the left side is the total wage cost: a number πN of workers are productive and are paid y_H each, while $(1-\pi)N$ workers are less productive and receive y_L. The right side is the value of production, noting that total labor input is the sum of $N\pi l_H$ from productive workers and $N(1-\pi)l_L$ from the less productive ones. Note that, in this problem, the planner takes π as given, since π is determined by the prior effort choices of workers.

The first order conditions with respect to y_H and y_L are

$$\pi u'(y_H) = \lambda\pi; \qquad (1-\pi)\,u'(y_L) = \lambda\,(1-\pi)\,;$$

where λ denotes the Lagrange multiplier on the resource constraint. The optimal allocation implies $u'(y_H) = u'(y_L)$. Hence, given the strict concavity of the utility function, $y_H = y_L$.

Return now to the worker's problem. As discussed above, $y_H = y_L$ implies that effort is zero, $a = 0$. Hence, aggregate labor supply is $L_S = N\left[\pi(0)l_H + (1-\pi(0))l_L\right]$, which is the smallest possible labor supply.

We see, then, that state ownership results in perfect equity but inefficiently low effort choice. This is because the government cannot refrain from equalizing workers' consumption ex post,

which destroys any incentives for exerting effort.

For future reference, note that the welfare of the typical worker under state ownership is

$$U_S = U_S(p) = u(pF(L_S)/N).$$

which is a function of the commodity price p.

3.3 Private Ownership

In periods in which the industry operates under private ownership, the key difference is that private owners can commit to pay different amounts to workers according to their productivity. This implies that private ownership will result in more efficient effort choice. But this comes at the expense of equity.

We assume an industry structure in which private owners compete for workers. There is a continuum of firms of measure 1. Each firm produces domestic goods via the production function $F(L)$, sells the goods at the price p, and pays two taxes, a dividend tax $0 \leq \tau < 1$ and a sales tax $0 \leq \theta < 1$. The receipts from these taxes are rebated lump-sum to the workers.[7]

Each firm takes as given a wage schedule $\{y_H^*, y_L^*\}$ of what highly productive and less productive workers are paid in the market. Given those market prices, each firm offers its own wage schedule $\{y_H, y_L\}$ and chooses the number of workers n and a suggested effort level a to maximize expected profits

$$\{p(1-\theta)F(n[\pi(a)l_H + (1-\pi(a))l_L]) - n[\pi(a)y_H + (1-\pi(a))y_L]\}(1-\tau)$$

[7] An alternative approach is to assume a unique firm. A disadvantage of this approach, however, is that the firm will have monopsonistic power on the labor input it hires. This monopsonistic power together with the optimal contract under imperfect information delivers the extreme result that workers with low productivity are paid zero. With our industry structure, all workers have an outside option in the labor market and, therefore, wages will not be zero for low productivity workers. Although we consider more reasonable the multiple firms approach, all qualitative results hold if we assume an industry structure with a unique firm.

subject to

$$\begin{aligned} u(y_H + T) - u(y_L + T) - \gamma(a) &= 0 \\ \pi(a)u(y_H + T) + (1 - \pi(a))u(y_L + T) - \phi(a) &\geq U^*. \end{aligned} \tag{3}$$

where $\gamma(a) = \phi'(a)/\pi'(a)$.

The first constraint is the incentive compatibility (IC) constraint and requires the wage schedule $\{y_H, y_L\}$ and suggested effort a to be consistent with the worker's optimal effort choice.[8] The second constraint is the participation or individual rationality (IR) constraint and requires the proposed contract to provide a level of utility at least as large as U^*, the utility that a worker can get in the market, given by

$$U^* = \pi(a^*)u(y_H^* + T) + (1 - \pi(a^*))u(y_L^* + T) - \phi(a^*).$$

Let $\eta(1-\tau)$ and $\lambda(1-\tau)$ denote the Lagrange multipliers on the IC and IR constraints.

The first order condition with respect to n is

$$p(1-\theta)F'(n\ell(a))\ell(a) = \pi(a)y_H + (1 - \pi(a))y_L, \tag{4}$$

where $\ell(a) = \pi(a)l_H + (1 - \pi(a))l_L$ is the expected labor supply given effort a. The intuition is simple. Since each worker is expected to supply $\ell(a)$ units of labor, the left hand side is the expected increase in revenue to the firm of hiring one more worker. The wage cost of doing so will be y_H if the worker turns out to be productive, that is, with probability $\pi(a)$, and y_L if the worker has low productivity. Hence the right hand side is the expected wage payment to the additional worker.

[8] Using the worker's first order condition as a constraint on the principal's problem does not guarantee the optimality of the contract. This 'first order approach' is valid if the distribution function of labor endowment conditional on effort satisfies a monotone likelihood ratio condition and a convexity assumption (Rogerson, 1985). These two conditions are satisfied in our environment.

The first order condition with respect to y_H can be written as

$$\frac{n}{u'\left(y_H+T\right)}=\lambda+\frac{\eta}{\pi(a)} \tag{5}$$

and the first order condition with respect to y_L, as

$$\frac{n}{u'\left(y_L+T\right)}=\lambda-\frac{\eta}{1-\pi(a)}. \tag{6}$$

To interpret these two conditions, suppose (counterfactually) that η were zero, that is, that the incentive compatibility constraint did not bind. In that case, the two conditions would collapse to $u'(y_H+T)=u'(y_L+T)$, that is, $y_H=y_L$. This means that the firm would pay the same amount to workers regardless of their productivity. This would be the case not because the firm cares about equity, but because it would be the cheapest way to pay workers their outside option of U^*.

It is apparent, then, that the need to provide incentives for effort creates a wedge between y_H and y_L which is costly to the firm. In the first order conditions above, that wedge is induced by a positive multiplier η, which reduces $u'(y_H+T)$ relative to $u'(y_L+T)$, and hence increases y_H over y_L. (See Propositions 2 and its corollary below.)

Lastly, the first order condition with respect to effort, after using incentive compatibility, is

$$n\pi'(a)\left[p(1-\theta)F'(n\ell(a))\left(l_H-l_L\right)-\left(y_H-y_L\right)\right]=\eta\gamma'(a) \tag{7}$$

The left hand side is the increase in expected profit of a marginal increase in a. The right hand side is the marginal cost of the incentive compatibility constraint: a small increase in a implies that the difference between $u(y_H+T)$ and $u(y_L+T)$ must increase by $\gamma'(a)$. To obtain the associated cost, we multiply $\gamma'(a)$ by the shadow cost of the incentive constraint, η.

Some properties of the solution now emerge. First, the Karush-Kuhn-Tucker conditions imply that $\lambda\geq 0$. Intuitively, the marginal value on profits of increasing the reservation utility

U^*, given by $-\lambda$, cannot be positive. The next propositions characterize additional properties of the optimal contract.

Proposition 1: *The IR constraint is binding.*

Proposition 2: *The IC constraint multiplier* $\eta > 0$.

Proofs of both Propositions are given in the Appendix.

Corollary: *The optimal contract is monotone, that is,* $y_H > y_L$.

Proof: Rearranging (5) and (6), and using $\eta > 0$ gives $u'(y_H + T) < u'(y_L + T)$. The strict concavity of the utility function then implies $y_H > y_L$.

We now consider the industry equilibrium. Because all firms are equal, in equilibrium $n = N$ and $\{y_H, y_L\} = \{y_H^*, y_L^*\}$. In addition, the government collects taxes and rebates them lump-sum to the workers. Thus, the government budget constraint is

$$TN = \tau \left\{ p(1-\theta)F(N\ell(a)) - N\left[\pi(a)y_H^* + (1-\pi(a))y_L^*\right]\right\} + \theta pF(N\ell(a)) \tag{8}$$

Collecting results, the system of six equations (3 - 8), with $n = N$ and $\{y_H, y_L\} = \{y_H^*, y_L^*\}$, determine the six $\{y_H^*, y_L^*, a^*, T^*, \lambda, \eta\}$. The solution implies that the average worker has utility:

$$U_P(p) = \pi(a^*)\, u(y_H^* + T^*) + (1 - \pi(a^*))u(y_L^* + T^*) - \phi(a^*)$$

Note that, just like in the state ownership regime, U_P and the industry equilibrium under private ownership depend on the resource price p, which affects the set of equations (3 - 8).

For future reference, we define the before-dividend-tax indirect return function of the firm,

$$R(p) = p(1-\theta)F(N\ell(a^*)) - N[\pi(a^*)y_H^* + (1-\pi(a^*))y_L^*].$$

3.4 Efficiency and Welfare

Positive effort under private ownership (see proposition 2) implies that effective labor and production is greater than under state ownership. In this sense, the model is consistent with the stylized facts that privatized firms are generally more efficient than state ones. This also means that workers can have higher average consumption in a privatized regime. However, profits are partially appropriated by private owners and there is costly consumption inequality.

The constraint $\tau < 1$ is crucial to obtain a non-trivial tradeoff between the national and private regimes. In particular, if dividend taxes converge to 1 and sales taxes are set to zero, the government is able to attain the ex-ante constrained-efficient allocation under a private ownership regime. In effect, the private regime acts as a commitment device which, together with the right taxes, implements the second best allocation. This is summarized in the next proposition.

Proposition 3: *A private-ownership regime with* $\theta = 0$ *and* $\tau \to 1$ *attains the ex-ante constrained-efficient allocation.*

Proof: See Appendix

For the rest of the paper we maintain the realistic assumption that dividend taxes are strictly below one. This is also the only sensible option, if only because in the full dynamic model no privatization would ever be possible if potential buyer know that they will pay a one hundred percent tax on their profits.

Under this assumption, there are two opposing forces at any price p. On the one hand, a state ownership regime induces perfect risk sharing across workers, but at the cost of low aggregate productivity. On the other hand, by providing incentives to exert effort, private firms are able to achieve higher labor productivity. This higher output together with the lump-sum transfers obtained from the taxation of sales and profits benefit not only high ability workers but also the low ability ones. However, because private owners appropriate a fraction of total profits –and the possible existence of distortionary sales taxes– the allocation under private ownership

regime is not constrained efficient creating a non trivial tradeoff between the private and state ownership regimes.

3.5 Numerical Explorations

Further insight on the properties of the model can be obtained by resorting to numerical methods. We view our numerical experiments as providing further insights into the working of the model and not as a realistic parametrization of any privatization - nationalization episode; our model is too stylized for that purpose. In any case, however, we will calibrate the model to obtain durations of privatization and nationalization regimes that resemble those observed in Bolivia during the last decades. This issue is discussed in more detail when we describe the computation of the dynamic version of our model.

We make assumptions about functional forms and parameter values that generate predictions that are qualitatively consistent with the empirical regularities discussed in section 2. We then perturb these parameters and analyze how changes in the environment impact the equilibrium of the model.

We assume a utility of income of the constant absolute risk aversion form,

$$u(c) = \left(1 - e^{-\gamma c}\right)/\gamma,$$

where $\gamma > 0$ is the coefficient of absolute risk aversion; a cost of effort function given by

$$\phi(a) = \varphi a^2/2\,,$$

where $\varphi > 0$; a Cobb-Douglas production function,

$$F(L) = AL^{\alpha},$$

where A is the level of productivity and $0 < \alpha < 1$; and a function transforming effort into

probabilities of drawing high labor endowment given by

$$Pr(l_i = l_H|a) = \pi(a) = 1 - \delta e^{-\nu a},$$

where $0 < \delta < 1$ measures the probability of low endowment when effort is zero and $\nu > 0$ measures the sensitivity of the probability to changes in effort.

In our baseline parameterization, the labor endowment of a worker that draws high productivity is $l_H = 1$, and that of a worker with low productivity is $l_L = 0.1$. That is, high labor endowment workers are ten times more productive that low labor endowment workers. The coefficient of absolute risk aversion is set at $\gamma = 2.5$, and the cost of effort parameter is $\varphi = 1$. We assume that the probability of drawing low productivity if effort is zero is $\delta = 0.99$, and the sensitivity of this probability to changes in effort is $\nu = 2$. The level of technology is set at $A = 0.15$, total population is $N = 1$, and the exponent on labor in the production function is $\alpha = 0.66$. Finally, taxes are set at $\tau = 0.30$ and $\theta = 0.30$. Table 1 summarizes the baseline parametrization.

Given these assumptions, it is straightforward to solve for the outcome of the state ownership regime. The private ownership regime is a little more involved, as its solution is only given in implicit form by the system (3 - 8). The computation of equilibrium is described in the Appendix.

In all cases that we computed, we found two threshold prices $\underline{p} << p^*$ that partition the set of prices $[0, \infty)$ so that, for all prices below $\underline{p}$ and above p^*, welfare is larger under a state ownership regime, while for all prices between $\underline{p}$ and p^*, welfare is larger in a private ownership regime. The threshold $\underline{p}$, however, is always very close to zero (never greater than one) and disappears in the dynamic version of the model as soon as we introduce a cost of nationalizing the industry. For that reason, we focus only on the regions $(\underline{p}, p^*)$ and (p^*, ∞), which we refer to as the "low price" region and the "high price" region.[9]

[9] At very low prices, those below $\underline{p}$, private firms have few incentives to differentiate workers. In effect, as the price approaches zero, the optimal contract requires agents to exert zero effort. But if effort approaches zero, productivity under private ownership approaches productivity under state ownership. Therefore, state

If p is in the low price region, the private regime is worth more to the country than the national regime. The government would accept less risk sharing in exchange for the higher average labor productivity that prevails in a private ownership regime. On the other hand, if the commodity price is above p^*, the elimination of income inequality becomes more important, as more output is appropriated by private owners making concerns for efficiency less of an issue. In effect, higher commodity prices can be thought of as substituting for the low productivity in a state ownership regime. An implication is that pressures for national ownership are likely to grow at large values of p, which is consistent with the facts described in section 2.

Table 2 reports exercises on comparative statics to analyze how the threshold p^* changes as we change parameter values. The first row of the table reports the threshold price of the baseline parametrization. An inspection of the table reveals that all parameters have a monotonic relation with the privatization threshold p^*.[10]

Consider first the impact of changes in the preference parameters γ and φ. Table 2 shows that the threshold p^* is *decreasing* in the risk aversion parameter γ. As workers become more risk averse, the welfare costs associated with the lack of risk sharing in a private ownership regime increase and, therefore, the set of prices for which a state ownership regime is superior than the private regime increases as well; that is, p^* decreases. Likewise, p^* is *decreasing* in the cost of effort parameter φ . Intuitively, as the cost of effort increases, firms need to increase the 'punishment' to workers with low labor endowment to induce them to exert effort. Hence, the lack of risk-sharing becomes more costly which reduces the nationalization threshold p^*.

Consider next the impact of changes in the probability of success parameters δ and ν. The parameter δ measures the probability of drawing a low labor endowment when effort is zero. An increase in δ has two effects: first, it reduces the value of a state ownership regime because aggregate labor declines, and second, it increases the incentives to exert effort in a privatized regime because the probability of drawing high labor endowment when effort is low declines.

ownership becomes welfare superior for p close to zero, as all production is distributed to the workers, while under private ownership firms take part of the profits.

[10] Table 2 does not report changes in A. The reason is that in the nationalization-privatization choice, only the product Ap matters. Thus, an increase in A immediately implies that p^* declines.

Thus, firms are able to induce workers to exert the same amount of effort with a smaller dispersion in wages. Both effects imply that p^* is *increasing* in δ. Likewise, p^* is *increasing* in the sensitivity parameter ν. As ν increases, a marginal increase in effort induces a larger increase in the probability of success, which makes exerting effort more attractive to workers and, therefore, easier for firms to provide incentives. Thus, the benefits of a privatized regime increases with ν.

We now consider the sensitivity of the threshold price p^* to changes in the relative productivity of high and low productivity workers assuming that the average labor supply in a state-owned regime –that is, when effort is zero– remains constant. Note that these mean preserving changes do not affect welfare in a state-ownership regime but they do in a private ownership regime: an increase in the relative productivity of highly productive workers increases the efficiency gains of differentiating workers through a more unequal payment schedule. In other words, a mean preserving spread in labor endowment makes a private ownership regime more efficient but also more unequal. Suppose that instead of being ten times for productive, high ability workers are five times more productive than low ability workers –that is, l_H/l_L decreases from 10 to 5. The threshold price p^* decreases from 40.1 to 27. In effect, firms in a privately owned regime have less incentives to differentiate workers –and, therefore, increase productivity relative to a state ownership regime– because the relative gain of doing so is now lower. Thus, p^* declines.

The threshold price p^* is increasing in the technology parameter α. Intuitively, as α increases the technology becomes more 'linear' and, therefore, the degree of decreasing marginal product of labor decreases with α. In other words, the benefits of inducing workers to exert effort increases with α. Thus p^*increases as well.

Finally, consider a change in the tax code, as summarized by changes in dividend and sales taxes. An increase in the dividend tax τ increases the lump-sum transfers to the workers in a private ownership regime. This increase in T has two effects: first, more income is redistributed from the firms to the workers, and second, the differential in labor income between high and low ability workers becomes less important as their relative total income (including lump-sum

transfers) becomes more equal. Thus, the welfare losses associated with consumption inequality in a private ownership regime decline, making private ownership more desirable, as reflected by a higher p^*.[11] Likewise, p^* is increasing in the sales tax θ. A change in the sales tax has a similar impact as an increase in τ in terms of the change in incentives through the increase in lump-sum transfers T. The change in θ, however, has an additional impact on the firm's behavior, since from a firm's point of view, a higher θ is equivalent to a lower price p. Each firm must reduce wages (y_H and y_L), which implies again that transfers are a higher share of each workers' income, reducing consumption inequality under private ownership.

4 The Dynamics of Privatization and Nationalization

4.1 Multiperiod Version of the Model

In this section we study the full dynamic version of the model. Time is discrete and denoted by $t = 0, 1, ..., \infty$. Workers are infinitely lived and discount future utilities with the discount factor β. Firms are also infinitely lived and discount future profits with the discount factor $1/(1+r)$. To simplify the model, we assume that workers cannot borrow or save.

The price of the economy's resource is now assumed to follow an exogenous Markov process, which is the only source of aggregate uncertainty and dynamics. The timing of events is as follows. We say that the industry was *privatized* in period $t-1$ if, at the end of that period, firms were privately owned. Otherwise, we say that the industry was in a *state ownership* regime. At the beginning of period t, the price p_t is realized, and then the government decides whether to keep the regime the same or to switch to the other regime. After the privatization - nationalization decision is made, production and consumption take place.

As before, we assume that the government is benevolent in that it maximizes the welfare of the average worker. Here, though, the government's regime choice is an intertemporal decision

[11] In contrast with a competitive industry, a change in τ does affect the decisions of firms because it modifies the incentive compatibility constraint of workers through a change in the lump-sum transfer T

problem, in which the stochastic behavior of the price p_t needs to be taken into consideration in relation with various costs and benefits.

Our results in the preceding section can now be regarded as the one-period equilibrium industry outcomes under either private ownership or state ownership. In particular, we showed how to compute the average worker's payoffs under either regime, U_P and U_S respectively, and how those payoffs depend on the price p_t.

To complete the specification of the dynamic setting, we assume that changing regime entails a direct cost or benefit. To be precise, we assume that nationalizing the industry (switching from private ownership to state ownership) is associated with a one period loss of c_S goods. This cost is assumed to be exogenous and interpretable as the deadweight loss resulting from a political backlash or international sanctions following nationalization.

Likewise, privatizing the industry results in a temporary boost to government revenues due to the proceeds from selling state firms. We assume that the government makes a take-it or leave-it offer to a measure one of incumbent firms in exchange for the rights to operate in the industry. Competitive bidders drive the offer up to the firm's value and, therefore, the government extracts all the rents. We assume that a fraction $0 \leq \kappa \leq 1$ of these rents are transferred lump-sum to the current workers. The remaining fraction is a loss that can be interpreted as the cost of reorganizing the industry, selling the firms, corruption, and the like.

Under our assumptions, dynamic behavior is relatively easy to characterize in recursive form. Let $V_P(p)$ denote the value for the government at the *end* of a period in which the price is p and the regime ends up being private ownership, and has been in private ownership for at least one period. Likewise, let $V_P^0(p)$ denote the value for the government at the *end* of a period in which the industry is privatized (after having been state owned the previous period) and the price is p. Similar definitions hold for $V_S(p)$, the value in a state ownership regime, and $V_S^0(p)$, the value in a period in which the industry is nationalized.

Then, the function $V_P(p)$ satisfies the Bellman equation

$$V_P(p) = U_P(p) + \beta \int \max\{V_P(p'), V_S^0(p')\} Q(p, dp') \tag{9}$$

where $Q(p, A) = \Pr\{p_{t+1} \in A | p_t = p\}$ is the transition function governing the price process, and p' is next period's price. The interpretation is straightforward: the value of a privatized regime is today's payoff to the average worker, $U_P(p)$, plus the discounted value of tomorrow's option to continue in the privatized regime, $V_P(p')$, or to nationalize the industry, $V_S^0(p')$.

Similarly, the value in a state ownership regime $V_S(p)$ satisfies

$$V_S(p) = U_S(p) + \beta \int \max\{V_P^0(p'), V_S(p')\} Q(p, dp'). \tag{10}$$

In periods of regime change, that is, when the industry is just privatized or just nationalized, the value functions are respectively given by

$$V_P^0(p) = U_P^0(p) + \beta \int \max\{V_P(p'), V_S^0(p')\} Q(p, dp') \tag{11}$$

$$V_S^0(p) = U_S^0(p) + \beta \int \max\{V_P^0(p'), V_S(p')\} Q(p, dp'), \tag{12}$$

where $U_P^0(p)$ and $U_S^0(p)$ denote the static payoffs in the privatization period and nationalization period respectively.

Because nationalization entails a cost c_S, the payoff in a nationalization period is, simply,

$$U_S^0(p) = u\left[\frac{pF(L_S) - c_S}{N}\right],$$

We now describe the payoff in a privatization period, $U_P^0(p)$. To that end, let $W^0(p)$ denote the value of a private firm in the privatization period, and let $W(p)$ denote the value of the firm in subsequent periods. These functions are different because the additional lump-sum transfer at the privatization period modifies the incentives to exert effort.

The function $W(p)$ satisfies the recursive equation

$$W(p) = (1-\tau)R(p) + \frac{1}{1+r}\int_{\Omega} W(p')Q(dp', p),$$

where $\Omega = \{p' : V_P(p') \geq V_S^0(p')\}$ is the set of prices tomorrow for which the industry remains private, and $R(p)$ is the firm's before-dividend-tax profit function. In computing the present discounted value of the firm tomorrow, we are considering only those prices for which the firm will not be nationalized in the next period, Ω.

Likewise, the value of the firm in a privatization period is given by

$$W^0(p) = (1-\tau)R^0(p) + \frac{1}{1+r}\int_{\Omega} W(p')Q(dp', p),$$

where $R^0(p)$ is the firm's before-dividend-tax profit function at the privatization period.

We obtain the static payoff $U_P^0(p)$ and the profit function $R^0(p)$ by solving the static equilibrium with private ownership including the transfer from selling the firms. This static equilibrium is identical to the one described in section 3.3, except that here the government budget constraint (8) includes an additional source of funds, $\kappa W^0(p)$, raised from selling state firms:

$$pF(N\ell(a_0))\left[\tau(1-\theta)+\theta\right] - \tau N\left[\pi(a_0)y_{H0} + (1-\pi(a_0))y_{L0}\right] + \kappa W^0(p) = T_0 N$$

Once we have the equilibrium allocation, we compute the static payoffs

$$U_P^0(p) = \pi(a_0)u(y_{H0}+T_0) + (1-\pi(a_0))u(y_{L0}+T_0) - \phi(a_0)$$

and

$$R^0(p) = p(1-\theta)F(N\ell(a_0)) - N[\pi(a_0)y_{H0} + (1-\pi(a_0))y_{L0}].$$

Given U_P, U_S, U_P^0, U_S^0, and the law of motion for p, the dynamic equilibrium is given by solutions V_P, V_S, V_P^0, and V_S^0 of the four functional equations (9), (10), (11), and (12). For an

interesting range of parameters, the solution is illustrated in Figure 2. The functions V_P and V_S inherit the shapes of U_P and U_S respectively. The figure identifies a trigger price p^* such that:

$$V_P(p^*) = V_S^0(p^*)$$

From (9), p^* is the price at which the government is exactly indifferent between nationalizing a privately owned industry or leaving it in private hands. As long as the price is below p^*, the government refrains from nationalization, while nationalization occurs if the price jumps above p^*.

The figure also identifies another trigger price, p^{**}, such that

$$V_S(p^{**}) = V_P^0(p^{**})$$

From (10), p^{**} is the price at which the government is indifferent between privatizing a state owned sector or not. Hence, if the industry is under state ownership, it will remains in that regime as long as p_t is above p^{**}. Privatization occurs, however, if p_t falls under p^{**}.

In equilibriums of the form just described, there is a range of prices $p_t \in (p^{**}, p^*)$ for which the industry could be either in private ownership or state ownership regime depending on the previous history of prices. That is, this model features a form of hysteresis the sense that the ownership regime in period t depends not only on the current price p_t but also on the history of prices $p_0, p_1, ..., p_{t-1}$ leading to p_t . This is a consequence of the gap in the value functions due to the nationalization costs and privatization benefits represented by c_S and κ.

4.2 Dynamic Implications

In addition to the functional forms used in section 3.5, we assume the following stochastic process for the price,

$$p_t = \bar{p} \exp(z_t),$$

where z_t follows a stationary first order autoregressive process,

$$z_t = \rho z_{t-1} + \varepsilon_t, \quad |\rho| < 1 \text{ and } \varepsilon_t \sim N(0, \sigma^2).$$

Under this assumption, the price p_t is log-normal with a stationary distribution that has mean $E(p_t) = \bar{p} \exp\left(\tilde{\sigma}^2/2\right)$ and variance $VAR(p_t) = \bar{p}^2 \left(\exp \tilde{\sigma}^2 - 1\right) \exp \tilde{\sigma}^2$, where $\tilde{\sigma}^2 = \sigma^2/\left(1-\rho^2\right)$ is the variance of the stationary distribution of z_t.

We interpret a period in the model to be one year, and set the parameters that determine the evolution of the price p_t by running a first order autoregression on the logarithm of real yearly crude oil prices.[12] The point estimates of these regressions are $\rho = 0.89$, $\sigma = 0.24$, and $\bar{p} = 54.6$. Thus, the expected value and standard deviation of the invariant distribution of the price p_t are 62.8 and 35.5 respectively.

It remains to set the parameters β, r, κ, and c_S. We choose these parameters (and those common with the static model) to imply privatization and nationalization cycles of similar duration to those observed in Bolivia –historically, a state ownership regime in Bolivia lasts between 20 and 25 years while private ownership, between 12 and 15 years. We assume a subjective discount factor of $\beta = 0.95$ and an interest rate of $r = 0.1$. We assume that 50 percent of the resources raised at the privatization period are redistributed to the workers, so that $\kappa = 0.5$. A reasonable value for the nationalization cost c_S is more difficult to choose. Here we simply assume that the nationalization cost is such that if the commodity price is 30 percent of its long-run average value, namely $0.3E(p_t)$, consumption in a state ownership regime is zero. This implies $c_S = 0.3E(p_t)F(L_S)$. For our baseline calibration, the nationalization cost is $c_S = 0.64$, which represent about 31 percent of the value of production at the nationalization price p^*. These parameters are reported in Table 1.

Table 3 reports numerical experiments based on the dynamic model. The table displays the privatization and nationalization trigger prices p^{**} and p^*, and the average duration of each

[12] Oil prices are average annual prices per barrel of oil, in constant 2008 U.S. Dollars. Adjustment for inflation is obtained using the U.S. consumer price index. The spot oil price correspond to the West Texas Intermediate, as reported by Dow Jones & Company.

regime. To be precise, we define the duration of a state ownership regime as the average number of years for the first time a price starting at $p_t = p^*$ reaches p^{**}. We note, however, that the proposed statistic is a lower bound on the duration of the regime, for the initial price could start at a value above p^*. Likewise, we define the duration of a privately owned regime as the average number of periods for the price to move from p^{**} to p^*. These statistics are computed using Montecarlo simulations and depend on the model parameters only through the invariant distribution of prices and the thresholds p^* and p^{**}.

The first row of the table reports the thresholds prices and duration statistics of the baseline parametrization. In this economy, the industry is state-owned at all prices greater than $p^* = 60.4$ and privately-owned at all prices smaller than $p^{**} = 36.7$. The average duration of a state ownership regime is 22 years and that of a private ownership regime is 14 years.

Consider an increase in risk aversion from the baseline $\gamma = 2.5$ to $\gamma = 3$. Both threshold prices decline, the average duration of a state ownership regime increases substantially and that of a privately ownership regime decreases slightly. The intuition for the change in the threshold prices is similar to that in the static model: an increase in risk aversion makes a state owned regime more appealing due to the larger costs associated with the lack of risk sharing in a privately owned regime. To understand the changes in the duration statistics, note that the stationary distribution of prices do not change but the threshold prices are now $p^{**} = 29.4$ and $p^* = 54.1$. Because prices are mean reverting, clearly the time it takes for the price to move from 29.4 to 54.1 will be substantially smaller than the time it will take to go from 54.1 to 29.4 for the simple reason that the average price is above both threshold prices.

The intuition for the changes in threshold prices due to changes in the parameters φ, δ, ν, l_L/l_H, α, τ, θ, and A is similar to that discussed in the static model. These changes together with the observation that the invariant distribution of prices remains the same in all experiments provide intuition for the changes in the duration statistics. Consider, for example, a decrease in the ratio l_H/l_L from 10 to 5 keeping the same average labor supply when effort is zero. This change implies a decline in both threshold prices, with the privatization threshold being

just $p^{**} = 25.7$ and the nationalization threshold, $p^* = 51.7$. It is clear that it will take a long time for a mean reverting process with average value of 62.8 to move from 51.7 to 25.7. This observation explains that the average duration of a state-owned regime is about 53 years. On the other hand, the mean reverting property of the price process implies that the average duration of a private ownership regime is reduced to 13 years.

We now consider changes in the parameters that are specific to the dynamic model. Consider, first, an increase in the nationalization cost c_S to 0.86.[13] The nationalization threshold p^* increases from 60.4 to 67.8 and the privatization threshold p^{**} decreases from 36.7 to 36.2 It is clear why p^* increases: because the nationalization cost is higher, the welfare loss associated with the lack of risk sharing of a privately owned regime that justifies nationalizating the industry must be larger. This, in turn, implies that p^* increases. Note, however, that although the nationalization cost is paid only at the nationalization period and, therefore, it mainly affects the value function in a state-owned regime, the privatization threshold changes as well. The reason for this change is the indirect negative impact that an increase in c_S has on the value of a private ownership regime due to the possibility of future nationalizations of the industry. In any case, however, changes in c_S have a much larger impact on the nationalization threshold p^* than on the privatization threshold p^{**}. In terms of duration, the increase in p^* and the decrease in p^{**} imply that each regime lasts longer. Indeed, the average duration of a state owned regime increases from 22 years to 24 years, and that of a state privately owned regime 14 to 18 years. Clearly, the duration of the private ownership regime increases substantially more than that of a state-owned regime.

Consider next a change in the privatization benefit κ. Assume that κ declines from 0.5 to 0.25, so that 75 percent of the benefits of privatizing the industry are lost or are used for purposes other than transferences. On a qualitative level, this change has the same impact as an increase in the nationalization cost c_S –both imply a higher loss of resources. The difference being that a drop in κ operates through a change in the value of a private ownership regime

[13]The cost $c_S = 0.86$ implies that about 37 percent of the value of output is used to pay the costs associated with nationalizating the industry when the commodity price is $p_t = p^*$.

at the privatization period while an increase in c_S operates through a change in the value of a state ownership regime at the nationalization period. Thus, p^{**} decreases, p^* increases, and the average duration of each regime increases as well.

The last two experiments involve perturbing the persistence and the volatility of the stochastic process z_t. Because these changes affect the invariant distribution of p_t, the interpretation of the results must be taken with caution. In all cases, we adjust $\bar{p}$ so that the invariant distribution of p_t has always the same mean of $E(p_t) = 62.8$. However, there are no enough parameters to simultaneously adjust the mean and standard deviation of p_t. Thus, changes in the persistence parameter ρ necessarily involves changes in the volatility of p_t.

Consider a mean preserving change in the persistence parameter ρ. A decline in persistence from 0.89 to 0.5 increases the privatization threshold p^{**} from 36.7 to 40.5 and the nationalization threshold p^* from 60.4 to 63.4.[14] The mean preserving decline in persistence leads to the somewhat counterintuitive result that the duration of each regime decreases. Intuition suggest that the less persistent the price, the more likely the price will cross the trigger prices. However, the standard deviation of the invariant distribution of prices decreases substantially as the persistence parameter ρ decreases. This drop in the volatility in prices explains the increase in the duration of each regime.

The last experiment consists of a mean preserving spread in the distribution of prices. We increase the volatility σ from 0.24 to 0.48 adjusting $\bar{p}$ so that the expected long-run price remains constant. Both threshold prices decline, the duration of state ownership regime declines substantially and that of private ownership does not change. Intuition suggests that duration of a privately owned regime should decrease as well. In effect, if the model is calibrated on a monthly basis we do observe a decline of a few months in the duration of a privately owned regime. The yearly frequency of the model is too coarse to capture the shorter duration.

[14] Neither p^* nor p^{**}, however, move monotonically with (mean preserving) changes in ρ.

4.3 Discussion

It is worth stressing the ways in which the model is consistent with the five stylized facts identified in our empirical review in section 2:

As to *Fact 1*, the dynamic model clearly stresses the repeated, cyclical nature of privatization - nationalization episodes. In the model, the choice between state versus private ownership reflects an underlying equity-efficiency tradeoff, which is affected in a natural way by the price of the national resource. Also, while we have modeled a single country in isolation, note that because the resource price is presumably common to many producer countries, the model is clearly consistent with the observation that privatization episodes often involve multiple countries.

With respect to *Fact 2,* our analysis is not necessarily restricted to a specific sector, but it does focus on factors that are likely to be more prevalent in natural resource sectors than in alternative ones. The model, in particular, assigns a key role to the movements in the international price of the national resource. In the model, also, the exploitation of the resource is the main (indeed the only) productive activity of the domestic economy. These two features are typical of economies based on the exploitation and export of natural resources.

Fact 3 is reproduced by the model, as its calibrated versions easily imply that nationalizations happen when the price of the domestic resource is high. This occurs because, when prices are high, concerns about equity become relatively more pressing.

Privatizations occur in our model when prices fall below a threshold value. If prices subsequently increase, the resulting windfalls are appropriated, partly or wholly, by the private buyers, until the price increase triggers nationalization. In this sense, the model is consistent with *Fact 4*. But it also reveals more. The fact that private owners can benefit from price bonanzas in a privatized regime is necessary for the resource to have been previously sold by the state. By construction, in our model private owners do not appropriate supranormal profits, so that their profitability when prices are high is only compensating them for below market profits when prices are low.

In the model, nationalization occurs when inequality becomes relatively more important for social welfare. At the same time, nationalization happens as profits of the privately owned firm are at their highest. Hence, the model can explain *Fact 5.* But note, again, that in the model private owners do make normal profits even after accounting for the possibility of expropriation. Indeed, the price at which the owners acquire the resource in the first place does take into account the fact that nationalization will occur when the price increases sufficiently.

Also, note that in our model inequality lowers social welfare because of risk aversion. Increases in the risk aversion coefficient may therefore capture a stronger concern for inequality. If this interpretation is valid, the model does deliver the correct prediction in that increased risk aversion makes state ownership and nationalizations more likely.

5 Concluding Remarks

We have argued that privatization - nationalization cycles can be usefully regarded as the resolution of an equity-efficiency tradeoff. In our model, that tradeoff is generated by a conventional moral hazard problem. Our theory has intuitive implications, both static and dynamic, and can be extended in several directions.

An implicit assumption underlying our theory is that, in a privatized regime, workers cannot pool wage income risks among themselves. This is a natural assumption and is consistent with the view that countries that display privatization - nationalization cycles are likely to suffer from financial frictions as well. In this regard, one can reinterpret our analysis of changes in risk aversion parameters as attempts to capture what would happen if financial imperfections were less binding. The theory would then say that financial development would reduce the incentives for nationalization. Of course, future research would be desirable to flesh out this connection.

The theory highlights that cycles of nationalization and privatization are, ultimately, linked to the government's inability, under a nationalized regime, not to redistribute income among

domestic workers. In this sense, our theory implies that institutional improvements, here the ability of the government to commit in advance to a (non-) redistributive policy, may help eliminating privatization - nationalization cycles. Conversely, our theory de-emphasizes other explanations, such as political conflict, that have received attention in this context.

Admittedly, though, more research appears to be warranted to flesh out these and other policy implications of the theory. It is likely that some of the elements that we have taken as exogenous in our model, such as the structure of capital markets or the costs of nationalization, are related to policy instruments and institutions. If so, the analysis of this paper could be reinterpreted as tracing the impact of changes in those policies and institutions. Clearly, however, making such a reinterpretation would require a more detailed specification of the fundamentals of the economy.

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Table 1. Baseline Parameters

Symbol	*Description*	*Value*
A	Productivity	0.15
α	Labor exponent (technology)	0.66
γ	Coefficient of absolute risk aversion	2.5
φ	Cost of effort parameter	1
δ	Probability of success parameter	0.99
ν	Probability of success parameter	2
l_H	High labor endowment	1
l_L	Low labor endowment	0.1
τ	Dividend Tax	0.30
θ	Sales Tax	0.30
Additional parameters of the dynamic model		
ρ	Persistence of log-price	0.89
σ	Standard deviation of log-price	0.24
$\bar{p}$	Parameter in price evolution	54.6
β	Discount factor (annualized)	0.95
r	Interest rate (annualized)	0.10
c_S	Nationalization cost (level)	0.64
κ	Privatization benefit (fraction)	0.50

Table 2: Static Model

Symbol	*Description*	*Value*	p^*
–	Baseline Economy	–	40.1
γ	Risk Aversion	2	53.5
		3	31.6
φ	Effort parameter	0.5	48.6
		1.5	35.1
δ	Probability of success parameter	0.9	6.9
ν	Probability of success parameter	1.5	32.9
		2.5	45.4
l_H/l_L	Ratio of labor endowments	5	27.0
	(mean preserving)	20	49.4
α	Labor exponent in technology	0.5	17.8
		0.75	55.8
τ	Dividend tax	0.1	35.8
		0.5	45.3
θ	Sales tax	0.1	35.8
		0.5	44.9

Table 3: Dynamic Model

Symbol	*Description*	*Value*	*Thresholds*		*Average Duration of Regime*	
			p^{**}	p^{*}	*State-owned*	*Private*
–	Baseline Economy	–	36.7	60.4	22	14
γ	Risk Aversion	2	48.3	70.4	13	16
		3	29.4	54.1	38	13
φ	Effort parameter	0.5	44.1	66.9	15	15
		1.5	32.4	56.7	29	14
δ	Prob. of success parameter	0.9	18.5	45.6	164	13
	Prob. of success parameter	1.5	30.6	55.2	35	13
		2.5	41.5	64.6	17	14
l_H/l_L	Ratio of labor endowments	5	25.7	51.7	53	13
	(mean preserving)	20	45.2	67.8	14	15
α	Labor exponent (techn.)	0.5	17.6	42.3	196	12
		0.75	50.0	74.3	12	17
τ	Dividend tax	0.2	34.9	57.8	24	13
		0.4	38.7	63.4	21	14
θ	Sales tax	0.2	34.9	57.8	25	13
		0.4	38.7	63.4	21	14
A	Productivity	0.1	53.4	75.0	10	17
		0.2	28.1	53.0	43	13
c_S	Nationalization cost	0.43	37.4	52.6	18	10
		0.86	36.2	67.8	25	18
κ	Privatization benefit	0.25	36.4	62.4	23	15
		0.75	36.9	59.5	21	13
ρ	Persistence of shock	0.5	40.5	63.4	20	4
	(mean preserving)	0.95	35.7	59.6	24	24
σ	Volatility of shock	0.12	38.1	58.2	96	14
	(mean preserving)	0.24	31.2	58.0	10	14

Figure 1.a / Bolivia

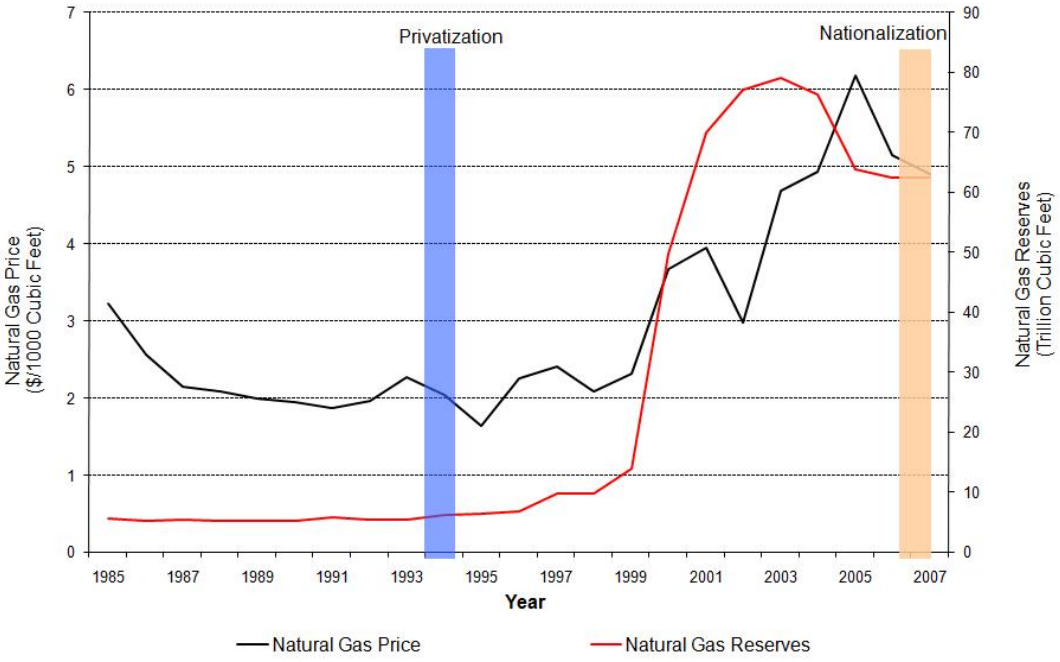
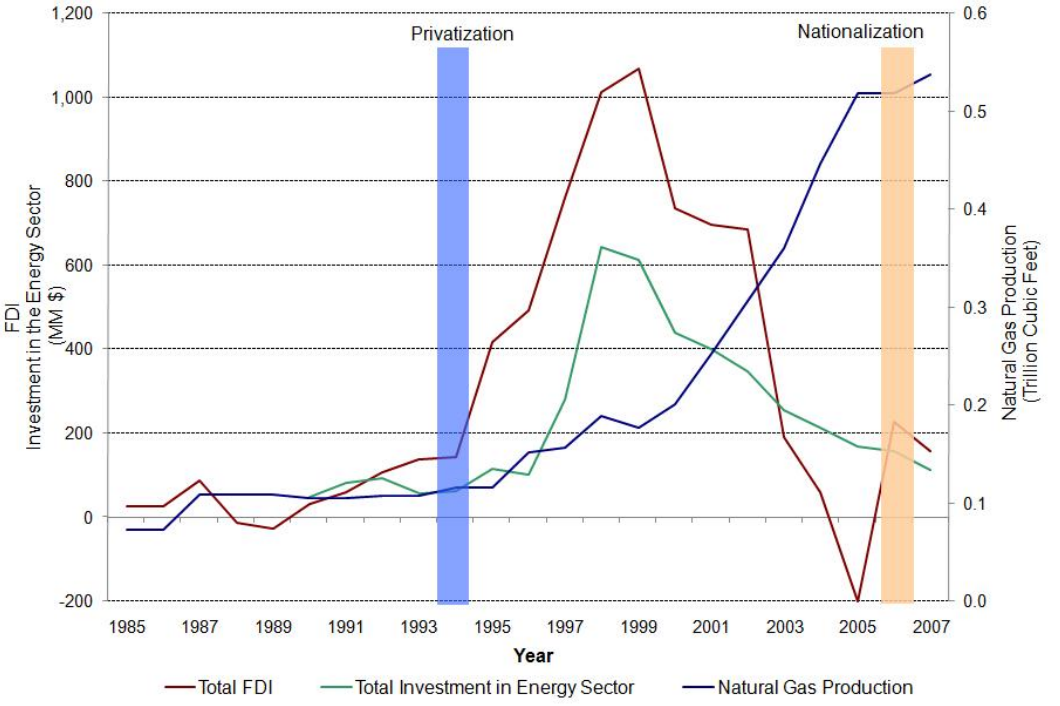


Figure 1.b / Bolivia



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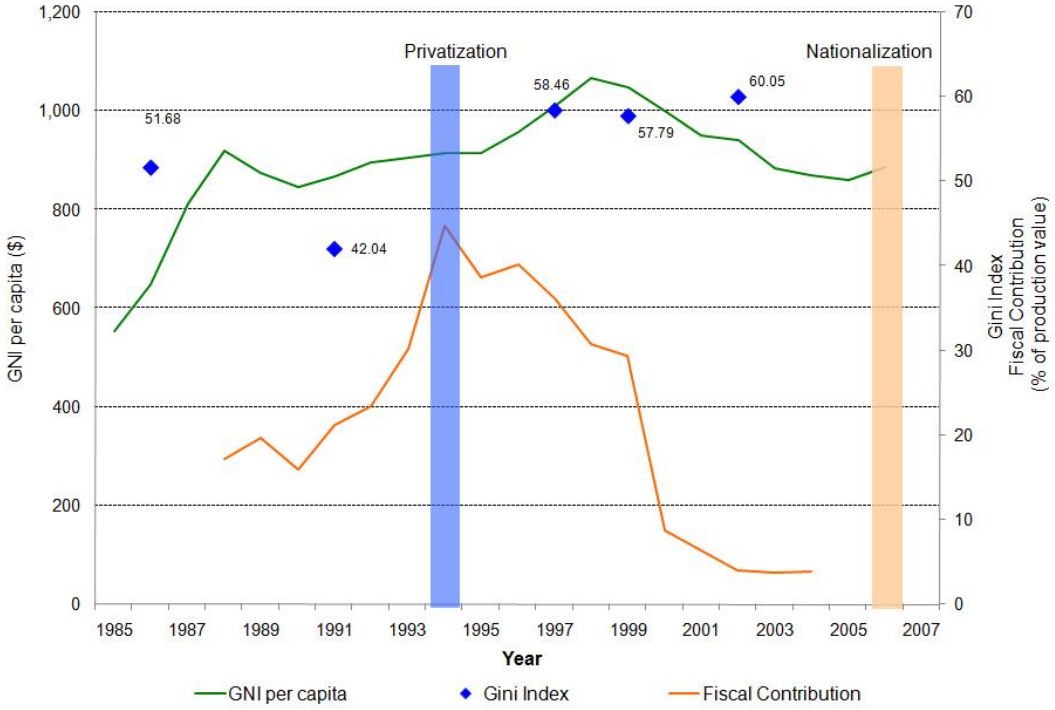
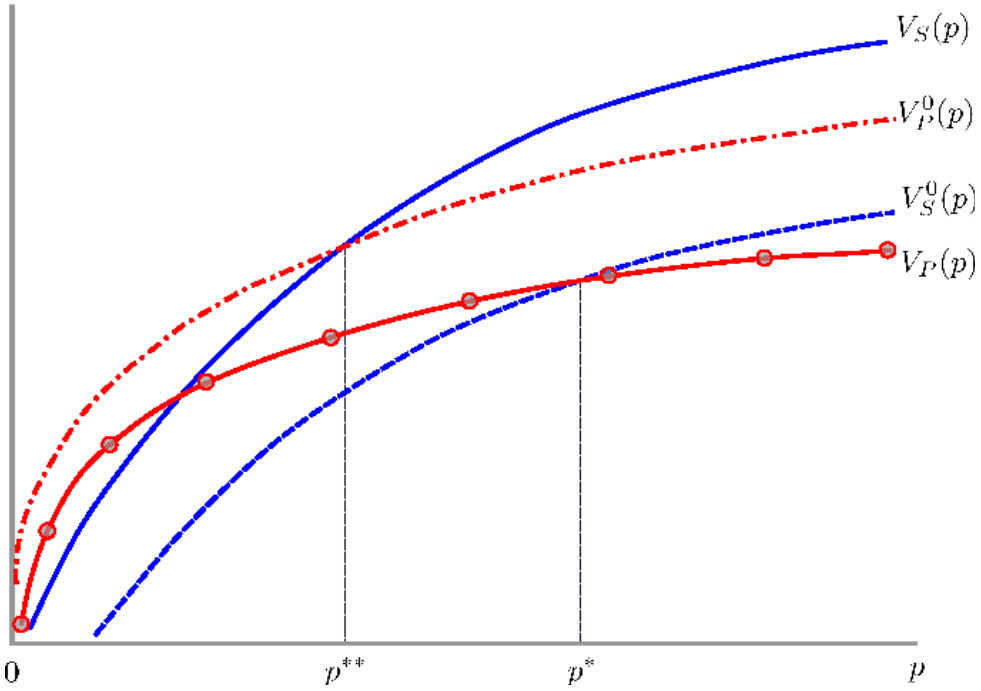


Figure 2. Value Functions and Threshold Prices



A Additional Case Studies

A.1 Venezuela

Venezuela is another Latin American country with vast hydrocarbon reserves, which has undergone alternating cycles of nationalization and privatization. Its cycles have generally been more protracted than Bolivia's, however; probably because Venezuela relied much more heavily on profit taxes—as opposed to fixed royalties—to raise revenue. The government raised the percentage of profits it would expropriate in incremental steps, resulting in relatively extended privatization and nationalization cycles. Despite Venezuela's more gradual transitions, the substantial fluctuations in international oil prices were frequently accompanied by a tumultuous and dynamic political environment.

Oil was first discovered in Venezuela in 1907. Its exploration and production dominated economic activity shortly thereafter; and by 1928, it had become the world's leading petroleum exporter. Under the dictatorial rule of General Juan Vicente Gómez, the Standard Oil Company and the Royal Dutch Oil Company operated uninterrupted in Venezuela for 23 years. After a brief interlude during which the government made no new petroleum concessions, Venezuela enacted the 1943 Petroleum Law. Although the law substantially increased government revenues from oil profits, it also encouraged future development efforts by extending existing concessions for almost 40 years.

In 1945 Rómulo Betancourt and the Democratic Action Party gained control of the government. They promulgated a new constitution that granted universal suffrage and legalized all political parties. In addition, the 1943 Petroleum law was overhauled to assure the government a 50 percent tax on the oil industry's profits. The reforms met with strong opposition and in 1948 the government was overthrown by a military coup. Marcos Pérez Jimenéz assumed dictatorial control and voided the 1947 constitution. Pérez was a strong supporter of foreign oil companies, but his repressive regime undertook numerous expensive and ostentatious construction projects. When he was finally ousted in 1958, he fled to the U.S. stealing $250 million

from his country's treasury and leaving over $500 million in foreign debt.

1958 marked an important turning point in Venezuela's history. Betancourt was elected to power and implemented a series of reforms designed to induce prolonged institutional and political stability. Although he increased the government's take of oil profits from 50 to 60 percent, the ruling parties all agreed to respect the principles of capital accumulation and the sanctity of private property rights. In 1960, the Corporación Venezolana de Petróleos (CVP) was founded in order to oversee the exploration, extraction, refinement, and delivery of the country's hydrocarbons. In that same year, Venezuela founded the Organization of Petroleum Exporting Countries (OPEC). An international cartel including Kuwait, Saudi Arabia, Iraq, and Iran, OPEC was designed as a means of ensuring its member countries' welfare by fixing the world price of oil.

In 1969 Rafael Caldera was elected president. Rising oil prices and continued political stability resulted in robust economic growth. In 1971 Caldera raised the oil profit tax rate to 70 percent and passed the Hydrocarbons Reversion Law. The new law stated that all oil company assets would revert to the state once their concessions expired. Caldera was peacefully succeeded by Carlos Andrés Pérez in 1973. In that same year, OPEC members agreed to a 12 percent increase in oil prices and three years later Petróleos de Venezuela (PDVSA) was founded.

On January 1, 1976, Venezuela nationalized its entire petroleum industry. Foreign oil companies mounted little resistance. The move had been fully anticipated, the companies had received no new concessions since 1960, their share of profits had already been cut to just 30 percent, and the government compensated them with $1 billion. All foreign oil companies present in Venezuela at the time were consolidated into four autonomous entities and placed under administrative supervision of PDVSA. Because PDVSA lacked the necessary resources to run the entities successfully, it signed a number of service contracts with the multinational firms' subsidiaries in order to continue operations. Unprecedented oil prices continued to fuel strong economic growth and large government revenues. These revenues were accompanied,

however, by rampant spending, corruption, and high inflation.

When world oil prices fell in the late 1970's, Venezuela's economy plunged into recession. Real GDP declined, unemployment rose, high inflation persisted, and the autonomous state-owned oil companies took on excessive debts to maintain their planned investment strategies. In 1981, oil prices continued to fall and OPEC members responded by halving production. Figure 2.a illustrates the steep price decline and 2.b shows a concurrent decrease in production. Jaime Lusinchi became president in 1983 and responded to the deteriorating economic situation by devaluing the currency and implementing price controls. Although the price controls helped curb inflation, uncertainty about the exchange system prompted capital flight. This exacerbated the government's foreign debt problems and it responded by appropriating PDVSA reserves. The PDVSA became increasingly politicized, a process that severely undermined its autonomy.

Figure 2.c depicts the dramatic fall in GNI that ensued as well as the substantial percentage increase in oil's fiscal contribution. For the next seven years, the government's percentage take of oil profits hovered between 70 and 90 percent. Despite such high percentage takes, world oil prices fell so significantly that government revenue continued to decline. In the meantime, FDI was practically non-existent and investment in the nationalized-industry, as measured by the number of land and offshore rigs, fell sharply (see Figure 2.b). Carlos Andrés Pérez returned to power in 1988 and launched an unpopular austerity program. Social unrest grew and after two unsuccessful coup attempts to remove him, Congress impeached Pérez on corruption charges.

Pérez was succeeded by Rafael Caldera in 1994. As evident in Figure 2.a, oil prices had fallen steadily and were almost 70 percent lower than they had been in 1980. FDI was still relatively low and the rig count was below its 1982 average (see Figure 2.b). Figure 2.c shows that GNI was still depressed but that inequality had also decreased significantly —the Gini coefficient was over 25 percent lower than it had been in 1981. In addition, the oil profits' percent of fiscal contribution to government revenue had fallen dramatically from its high in 1991. In this economic climate, Caldera implemented a new business plan for PDVSA that strove to foster multinational companies' participation in the oil industry. The plan included

pacts between foreign companies to initiate new oil field exploration as well as future profit-sharing agreements—it effectively began privatization of Venezuela's struggling oil industry.

After privatization, Figure 2.b shows a dramatic increase in both FDI and rig count, while oil production steadily increased. Although petroleum prices remained relatively flat, and in fact dropped in 1998, Figure 2.a shows reserves trending up. Figure 2.c depicts GNI beginning to grow, but its recovery is accompanied by a concurrent increase in inequality. Although the government's percentage take of profits rose significantly in 1997— three years after privatization—the increase was short-lived. In 1998 oil prices fell sharply. Annual inflation exceeded 30 percent, half the Venezuelan populace lived below the poverty line, and income inequality continued to grow. In this environment, Hugo Chavez, a revolutionary in the failed coups of 1992, was elected president. He had pledged to implement political and economic reforms that would give the poor a greater share of Venezuela's oil wealth. In 1999 he introduced a referendum to increase presidential powers, implement six-year terms, and halt the privatization of state assets. The referendum passed and a year later Chavez was reelected to a six-year term.

After Chavez's election, FDI and the rig count dropped precipitously (see Figure 2.b). Figure 2.a illustrates a sharp increase in world oil prices, while Figure 2.c depicts a concurrent increase in GNI and the government's percentage take of oil profits. Although Chavez garnered strong support among the working class, his reform policies met with stubborn resistance from the business community. In 2002 a coalition of military and business leaders successfully ousted Chavez, but strong international criticism and fervent outpouring of support from his followers helped him return to power within two days. Later that year, the government attempted to assume full control of PDVSA. Business and labor organizations were strongly opposed to the move and organized a massive retaliatory strike in January that included the petroleum industry. Figure 2.b illustrates the resulting decline in oil production. The strike lasted nine weeks after which the leaders conceded defeat. The government responded by firing half the workforce and assuming full political control of PDVSA, effectively nationalizing the petroleum

industry without providing market compensation (Manzano and Monaldi, 2008). Despite the skyrocketing oil prices evident in Figure 2.a, Figure 2.b shows a sharp decline in FDI and the rig count immediately after nationalization. Production also fell and reserves stagnated. In 2006 Chavez was reelected with 63 percent of the vote. The following year he tightened state control by nationalizing all of Venezuela's energy and telecommunication firms.

Figure A.1.1 / Venezuela

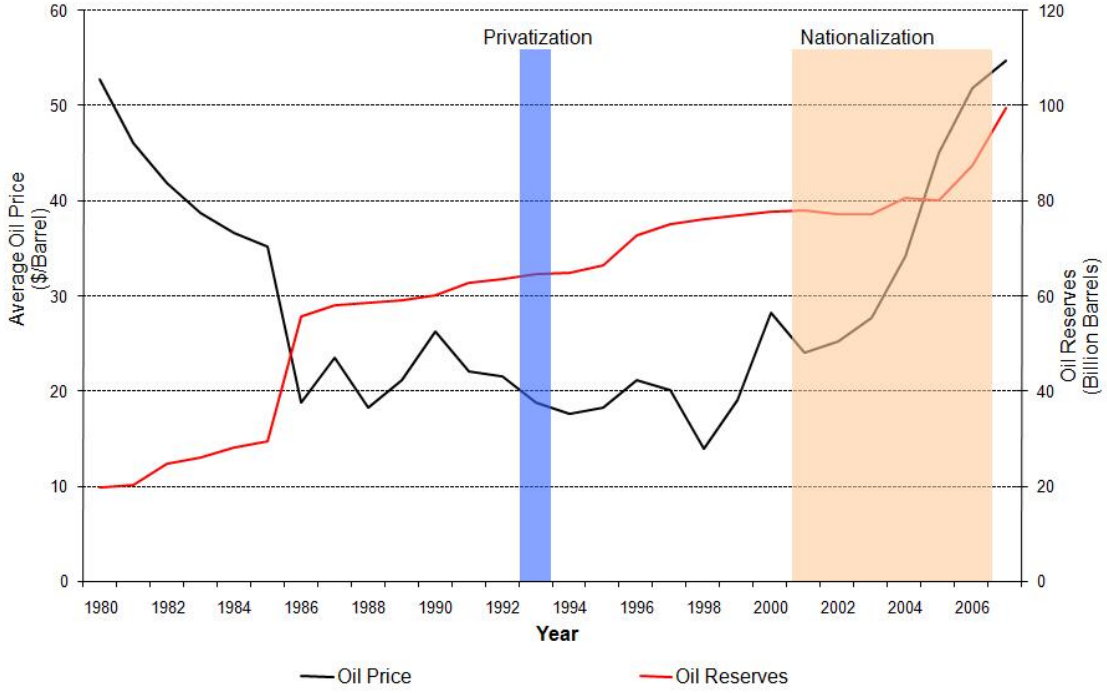


Figure A.1.2 / Venezuela

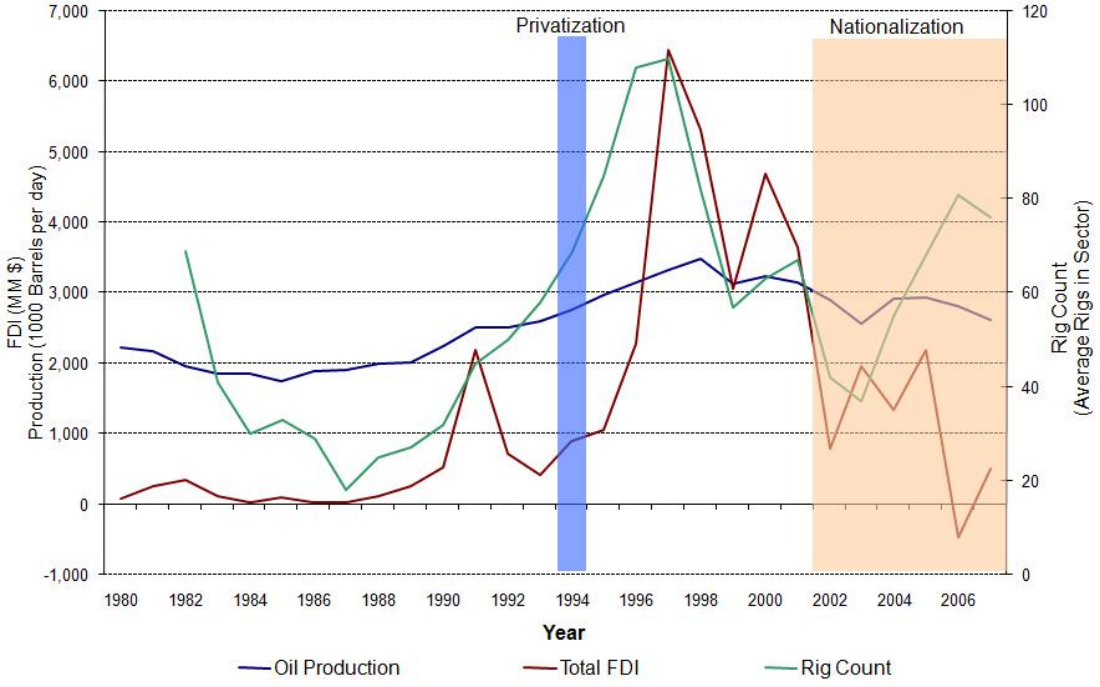
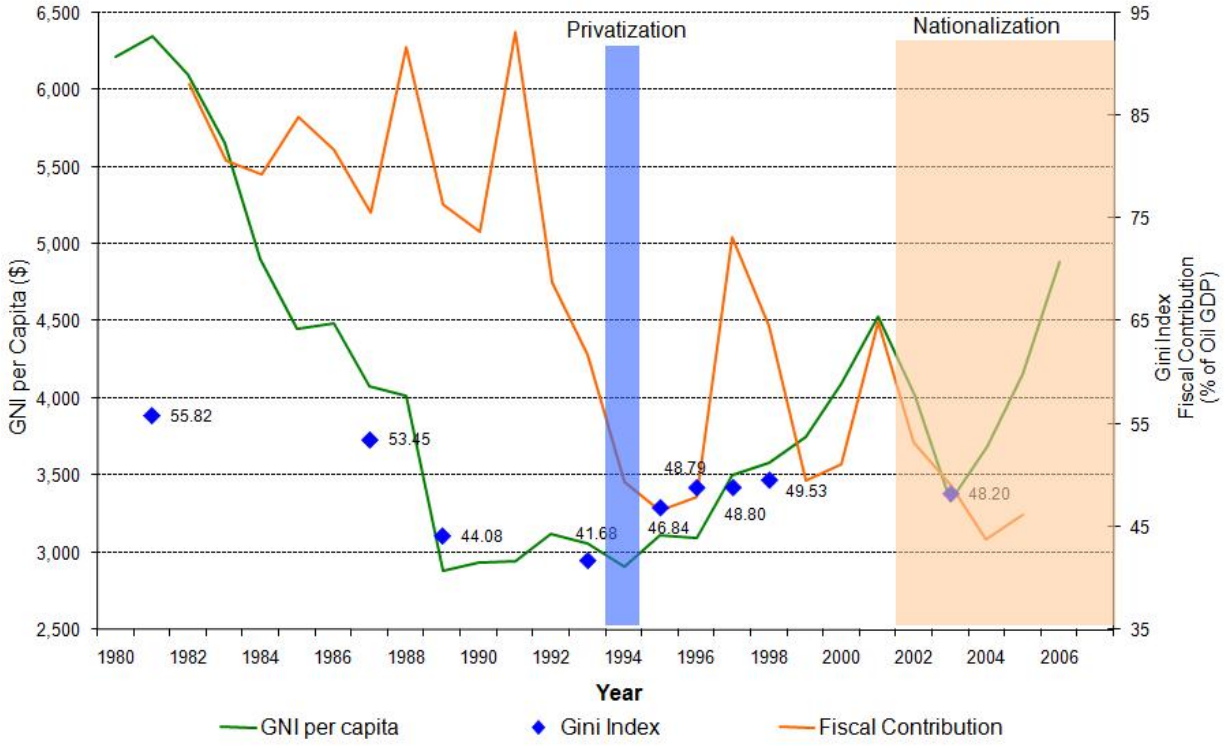


Figure A.1.3 / Venezuela



A.2 Zambia

While Venezuela's economy is dominated by the petroleum industry, the Zambian economy is highly reliant on copper. The mineral was first discovered in the landlocked African country while it was still under British colonial rule and known as Northern Rhodesia. Since then, copper production, and by extension international copper prices, have played a prominent role in Zambia's political and economic development. Zambia underwent a nationalization and privatization cycle similar to those experienced in Bolivia and Venezuela. In Zambia, however, the process was somewhat different. Whereas the cycle in both Latin American countries went from privatization in the 1990s to nationalization in this decade, Zambia's cycle was more protracted and went from nationalization to privatization.

Copper exploitation first began in Northern Rhodesia in 1889 when the British government granted a charter to the British South African Company (BSAC). The charter gave BSAC administrative power over the region and assigned it ownership rights to all of the country's minerals. With the onset of World War I, world copper demand grew significantly. Production in Northern Rhodesian expanded quickly and exporting began. In 1924 local white and African opposition to BSAC rule intensified and the company responded by ceding administrative control of the region to the British Colonial Office in London. The Colonial Office promptly set up a legislative council in the country to which the white population elected five members. Four years later, significant copper discoveries were made in the area now referred to as the Copperbelt. The discoveries prompted an influx of new investment, but it was financed entirely by the South African Anglo-American Corporation and the American Rhodesian Selection Trust companies.

In 1931 world copper prices collapsed. They rose again sharply in 1935, but the local inhabitants benefited little from the increase. BSAC still owned the areas' mineral rights and thus exacted substantial royalty fees from the mining companies. In addition, the British government expropriated half of the revenue the local government raised from the companies' remaining profits. By 1938 Northern Rhodesia supplied 13 percent of the world's copper, but

the Anglo-American Corporation and the Rhodesian Selection Trust monopolized the industry. World War II further increased demand for copper and as a result African miners in the area finally succeeded in ameliorating their working conditions. Over the next decade, copper prices continued to fluctuate drastically. In 1949 they were devalued, but by the early 1950's they had risen sharply. Mining companies in Northern Rhodesia began to pay regular dividends and the local government finally received a share of the royalties BSAC had been collecting. The mining boom also prompted another major strike and African workers were finally awarded higher wages and greater job stability.

The copper boom ended in 1956 and in 1964 the country became the Independent Republic of Zambia. The local government acquired all the mineral rights from BSAC and increased its taxation rates on mining companies' profits. As evident in Figure 3.a, copper prices rose after independence and then stayed at relatively high levels. Figure 3.c shows that GNI also grew steadily during this period as well. In 1968 President Kenneth Kaunda implemented the Mulungushi reforms which founded the Industrial Development Conglomerate—a government entity designed to expropriate and hold a controlling equity in a number of key foreign firms. Nationalization continued in 1970 when the government acquired majority holdings in the two major foreign mining companies. The Anglo-American Corporation became the Nchanga Consolidated Copper Mines (NCCM) and the Rhodesian Selection Trust was morphed into the Roan Consolidated Mines (RCM). These companies were held under the new parastatal body called Mining Development Corporation (MINDECO). In 1971 the government consolidated its holding companies under the Zambia Industrial and Mining Corporation (ZIMCO). As depicted in Figure 3.b, FDI stagnated a year after nationalization.

Copper prices fluctuated erratically during the early 1970's. Figure 3.a depicts a substantial plunge in 1975 followed by a downward trend until 1985. As a result, the economy contracted significantly and protests broke out across the country. The sizeable decline in GNI is illustrated in Figure 3.c. Rising world oil prices exacerbated Zambia's economic downturn and it was forced to look abroad for loans. Investment in the country plummeted, and as evident in Figure 3.b,

FDI in 1981 was actually negative. In 1982 the government consolidated NCCM and RCM into the giant Zambia Consolidated Copper Mines Ltd. (ZCCM). Despite the merger, exhausting reserves and increasing costs forced the government to cut back on mining operations, and it closed the Kansanshi and Chambishi mines shortly thereafter. Figure 3.a illustrates the severe depletion in reserves— they declined almost 50 percent between 1984 and 1988. Figure 2.b also shows that copper production was trending down.

In 1991 Zambia held multiparty elections and President Frederick Chiluba replaced Kaunda. With support from the IMF and World Bank, Chiluba privatized a number of government companies, including the country's copper firms. Political and economic strife persisted and mining costs continued to escalate. Despite the decline in GNI after privatization, Figure 3.c shows a reduction in inequality. From 1991 to 1993 the Gini coefficient fell over 12 percent, and it is likely that this decrease enabled Zambia's privatization process to continue. In 2000, Chiluba further privatized the mining industry by divulging 80 percent of ZCCM. FDI jumped, and Figure 3.b also shows a dramatic increase in production as well. A year later, copper prices began to grow steadily (see Figure 3.a). Figure 3.b shows that FDI maintained its upward trend and as a result production continued to grow as well. In addition, Figure 3.c reveals that GNI began to recover from its stagnant period with a steady upward trend. It can be argued that the high level of investments after privatization has allowed for output in Zambia to increase even in the context of the current international crisis.

Figure A.2.1 / Zambia

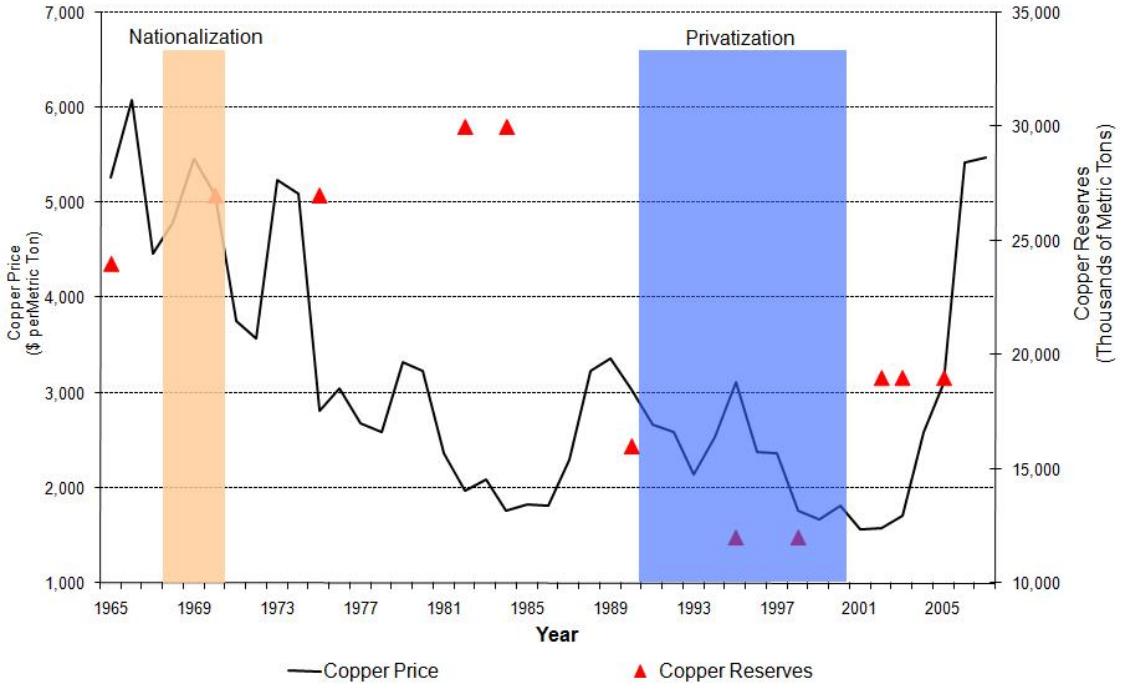


Figure A.2.2 / Zambia

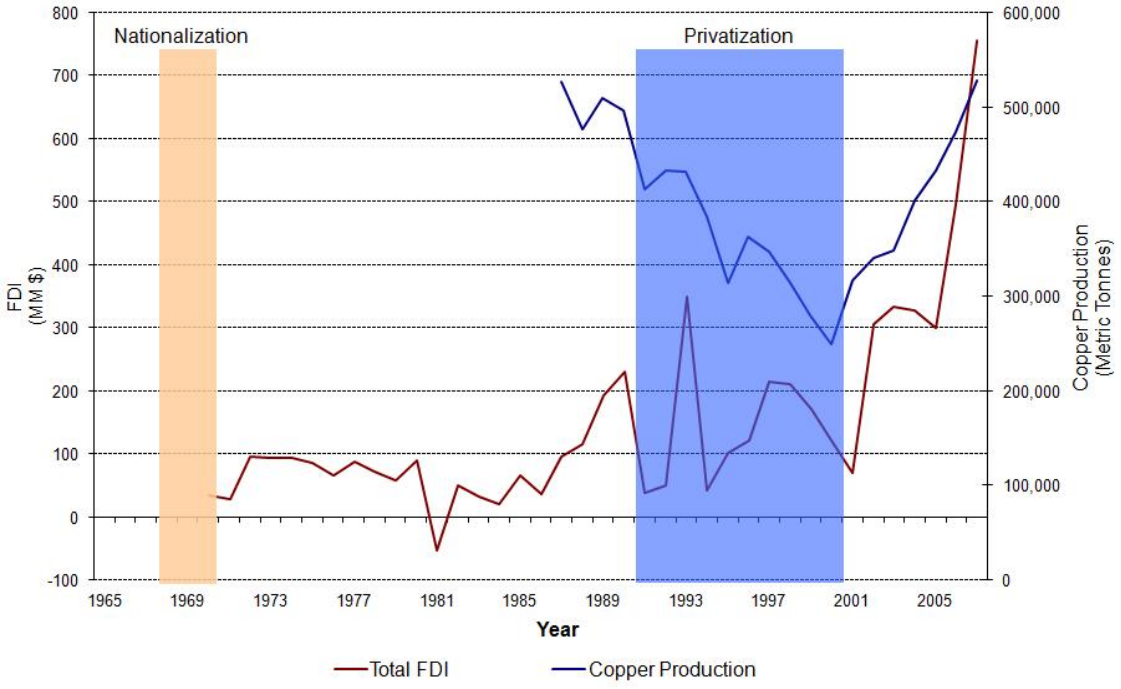
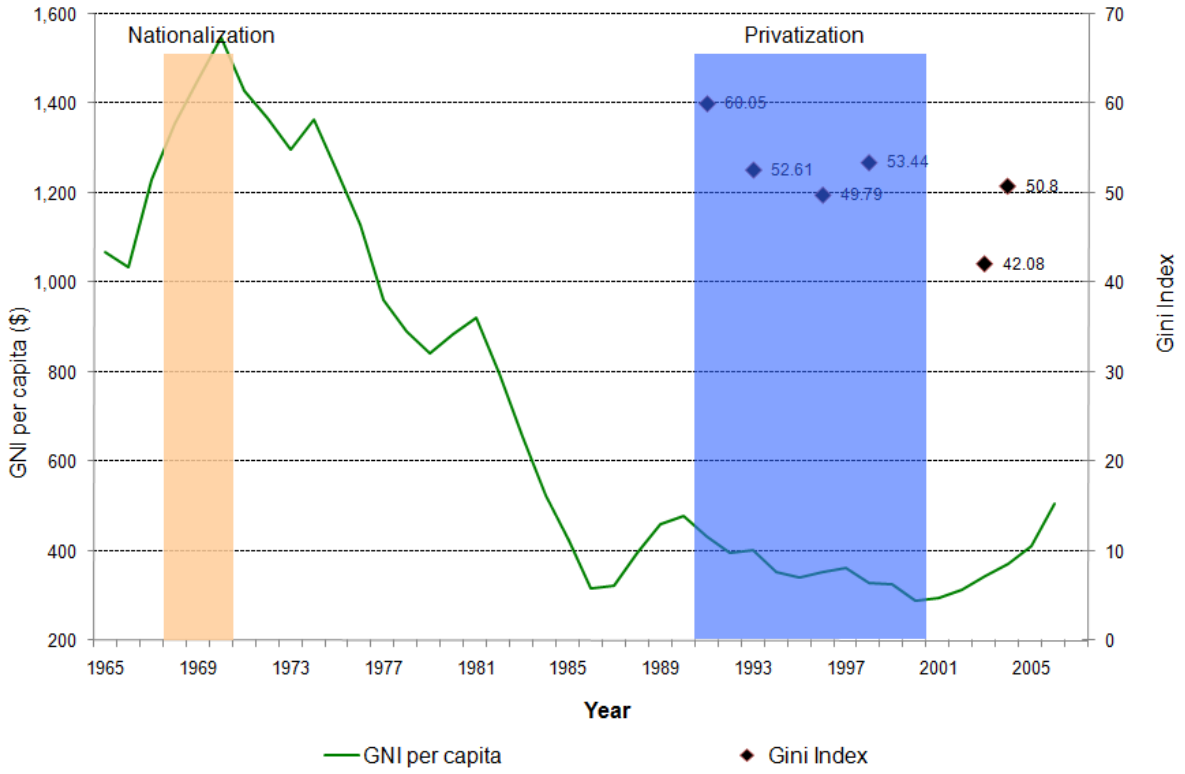


Figure A.2.3 / Zambia



B Technical Appendix

B.1 Proofs

Proposition 1: *The IR constraint is binding.*

Proof: We proceed by contradiction. Suppose $\{y_H^o, y_L^o, a^o, n^o\}$ is an optimal plan and

$$\pi(a^o)u(y_H^o + T) + (1 - \pi(a^o))u(y_L^o + T) - \phi(a^o) > U^*.$$

We propose a feasible plan that induces the worker to supply the same effort a^o but increases the firm's profits. Because the proposed plan is incentive compatible, we can write the above inequality as

$$\pi(a^o)\gamma\left(a^o\right) + u(y_L^o + T) - \phi(a^o) > U^*.$$

Therefore, there is an $\epsilon > 0$ such that $\pi(a^o)\gamma(a^o) + u(y_L^o - \hat{\epsilon} + T) - \phi(a^o) > U^*$. Consider now the plan $\{\hat{y}_H, \hat{y}_L, a^o, n^o\}$, where $\hat{y}_L = y_L^o - \hat{\epsilon}$ and $\hat{y}_H$ solves $u(\hat{y}_H + T) = u(\hat{y}_L + T) + \gamma(a^o)$. Clearly, $\hat{y}_L < y_L^o$ and $\hat{y}_H < y_H^o$. The plan $\{\hat{y}_H, \hat{y}_L, a^o, n^o\}$ is incentive compatible, satisfies the IR constraint, and increases the firm's profits. Thus, $\{y_H^o, y_L^o, a^o, n^o\}$ cannot be optimal; therefore, the IR must be binding.

Proposition 2: *The IC constraint multiplier* $\eta > 0$.

Proof: This proof is a modified version of that in Holmstrom (1979). We proceed by contradiction. Suppose $\eta \leq 0$. Using $\gamma'\left(a\right) > 0$ and $\eta\gamma'\left(a\right) \leq 0$, the effort first order condition (7) implies

$$n\pi'(a)\left[p(1-\theta)F'(n\ell(a))\left(l_H - l_L\right) + y_L - y_H\right] \leq 0. \tag{14}$$

The first order conditions (5) and (6), together with $\eta \leq 0$ give

$$\frac{n}{u'(y_H + T)} = \lambda + \frac{\eta}{\pi(a)} \leq \lambda - \frac{\eta}{1 - \pi(a)} = \frac{n}{u'(y_L + T)}.$$

The concavity of u implies $y_L \geq y_H$. Thus,

$$n\pi'(a)\left[p(1-\theta)F'(n\ell(a))\left(l_H - l_L\right) + y_L - y_H\right] \geq n\pi'(a)p(1-\theta)F'(n\ell(a))\left(l_H - l_L\right) > 0.$$

This result contradicts (14); therefore, $\eta > 0$.

Proposition 3: A private-ownership regime with $\theta = 0$ and $\tau \to 1$ attains the ex-ante constrained-efficient allocation.

Proof: The ex-ante constrained-efficient allocation solves

$$\max_{a,y_H,y_L} N\left[\pi\left(a\right)u\left(y_H\right)+\left(1-\pi\left(a\right)\right)u\left(y_L\right)-\phi\left(a\right)\right]$$

subject to the IR and IC constraints

$$\begin{aligned} pF\left[N\left(\pi\left(a\right)l_H+\left(1-\pi\left(a\right)\right)l_L\right)\right]-N\left[\pi\left(a\right)y_H+\left(1-\pi\left(a\right)\right)y_L\right] &= 0 \\ u\left(y_H\right)-u\left(y_L\right)-\gamma(a) &= 0 \end{aligned}$$

Let N/λ and $\eta N/\lambda$ denote the Lagrange multiplier on the IR and IC constraints respectively. Then, the first order conditions with respect to y_H, y_L, and a, can be written as

$$\frac{N}{u'\left(y_H\right)}=\lambda+\frac{\eta}{\pi\left(a\right)}$$

$$\frac{N}{u'\left(y_L\right)}=\lambda-\frac{\eta}{1-\pi\left(a\right)}$$

$$N\pi'\left(a\right)\left\{pF'\left[N\ell(a)\right]\left(l_H-l_L\right)-\left(y_H-y_L\right)\right\}-\eta\gamma'\left(a\right)=0,$$

where the last condition uses the IC constraint. These conditions and the two constraints determine the constrained-efficient allocation $\{y_H^e, y_L^e, a^e, \lambda^e, \eta^e\}$.

Consider now the private ownership regime. Let $\tilde{y}_H^*=y_H^*+T^*$ and $\tilde{y}_L^*=y_L^*+T^*$, set $\theta=0$ and $\tau\rightarrow 1$. Then, the equilibrium allocation of the private ownership regime solves

$$\begin{aligned} u\left(\tilde{y}_H^*\right)-u\left(\tilde{y}_L^*\right)-\gamma(a^*) &= 0 \\ N/u'(\tilde{y}_H^*)-\left[\lambda^*+\eta^*/\pi(a^*)\right] &= 0 \\ N/u'(\tilde{y}_L^*)-\left[\lambda^*-\eta^*/\left(1-\pi(a^*)\right)\right] &= 0 \\ N\pi'(a^*)\left[pF'(N\ell(a^*))(l_H-l_L)-(\tilde{y}_H^*-\tilde{y}_L^*)\right]-\eta^*\gamma'(a^*) &= 0 \\ pF(N\ell(a^*))-N\left[\pi(a^*)\tilde{y}_H^*+(1-\pi(a^*))\tilde{y}_L^*\right] &= 0 \\ pF'(N\ell(a^*))\ell(a^*)-\left[\pi(a^*)\tilde{y}_H^*+(1-\pi(a^*))\tilde{y}_L^*\right]+T^* &= 0 \end{aligned}$$

The first five equations coincide with those of the constrained-efficient allocation and the last condition pins down the equilibrium transfer T^*. Therefore, $\{\tilde{y}_H^*, \tilde{y}_L^*, a^*\}=\{y_H^e, y_L^e, a^e\}$.

B.2 Computation of the static equilibrium under private ownership

We simplify the system (3 - 8) as follows. We write the payments y_H and y_L as a function of T, λ, and η by rewriting equations (5) and (6) as

$$y_H(T,\lambda,\eta) = (u')^{-1}\left[\frac{N}{\lambda+\eta/\pi(a)}\right] - T$$

$$y_L(T,\lambda,\eta) = (u')^{-1}\left[\frac{N}{\lambda-\eta/\left(1-\pi(a)\right)}\right] - T$$

Replacing these expressions into the remaining equations gives the following system of 4 equations in 4 unknowns,

$$\begin{aligned}
u(y_H(T,\lambda,\eta)+T) - u(y_L(T,\lambda,\eta)+T) - \gamma(a) &= 0\\
pF'(N\ell(a))\ell(a) - \pi(a)y_H(T,\lambda,\eta) - (1-\pi(a))y_L(T,\lambda,\eta) &= 0\\
N\pi'(a)\left[pF'(N\ell(a))(l_H-l_L) + y_L(T,\lambda,\eta) - y_H(T,\lambda,\eta))\right] - \eta\gamma'(a) &= 0\\
pF(N\ell(a))\left[\tau(1-\theta)+\theta\right] - \tau N\left[\pi(a)y_H(T,\lambda,\eta) + (1-\pi(a))y_L(T,\lambda,\eta)\right] - TN &= 0
\end{aligned}$$

We solve this system of equations on a grid of prices $\{p_1, p_2, ..., p_M\}$ using the Matlab routine `fsolve.m`.[15]

B.3 Computation of the dynamic model

Because there is a one to one mapping between p_t and z_t, we use z_t as our state variable. We guess that the privatization region is an interval of the form $\Omega = (-\infty, z^*]$ and solve the model under this assumption. We then check that all our experiments satisfy this property.

We use the following algorithm to solve the model

1. Find the functions $U_P(z)$, $R(z)$, $U_S(z)$, and $U_S^0(z)$ on a grid of points and linearly interpolate their values at each z not on the grid;

2. Choose a grid of points $\mathcal{Z} = \{z_i\}_{i=1}^M$;

3. Choose initial guesses $V_P(z;0)$, $V_S(z;0)$, $V_0^p(z;0)$, and $V_S^0(z;0)$ for each $z \in \mathcal{Z}$. For values of z not in $\mathcal{Z}$, we use linear interpolation. Set `j=0`.

   (a) Find the nationalization threshold z^* that solves $V_P(z^*;j) = V_S^0(z^*;j)$.

[15] Because a, η, λ, and T are all positive, when solving the system of equations we define $a = e^{\tilde{a}}$,$\eta = e^{\tilde{\eta}}$, $\lambda = e^{\tilde{\lambda}}$, and $T = e^{\tilde{T}}$, and solve for the zero using the tilde variables.

(b) Given z^*, iterate on the following functional equation to obtain the firm value $W(z)$ at each grid point $z \in \mathcal{Z}$

$$W(z) = (1-\tau)R(z) + \frac{1}{1+r}\int_{-\infty}^{z^*} W(z')Q(dz', z) \text{ for all } z \in \mathcal{Z}.$$

We evaluate the integral using Gauss-Hermite quadrature.

(c) Given $W(z)$, find $U_P^0(z)$ and $R^0(z)$ by solving the static equilibrium at the privatization period at each $z \in \mathcal{Z}$.

(d) Given $U_P^0(z)$, $R^0(z)$, and the guesses $V_P(z;j)$, $V_S(z;j)$, $V_P^0(z;j)$, and $V_S^0(z;j)$, update the value functions at each grid point $z \in \mathcal{Z}$ using the Bellman equations:

$$\begin{aligned}
V_P(z;j+1) &= U_P(z) + \beta \int_{-\infty}^{+\infty} \max\left\{V_P(z';j); V_S^0(z';j)\right\} Q(dz', z) \\
V_S(z;j+1) &= U_S(z) + \beta \int_{-\infty}^{+\infty} \max\left\{V_P^0(z';j); V_S(z';j)\right\} Q(dz', z) \\
V_P^0(z;j+1) &= U_P^0(z) + \beta \int_{-\infty}^{+\infty} \max\left\{V_P(z';j); V_S^0(z';j)\right\} Q(dz', z) \\
V_S^0(z;j+1) &= U_S^0(z) + \beta \int_{-\infty}^{+\infty} \max\left\{V_P^0(z';j); V_S(z';j)\right\} Q(dz', z)
\end{aligned}$$

We evaluate the integrals using Gauss-Hermite quadrature.

(e) If value functions are converged, stop; if they are not, set `j=j+1` and return to (a) using the obtained functions as the new guess.