

Privatization and Nationalization Cycles

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August 2009



Abstract

This paper studies the cycles of nationalization and privatization in resource-rich economies as a prime instance of unstable institutional reform. The authors discuss the available evidence on the drivers and consequences of privatization and nationalization, review the existing literature, and present illustrative case studies. This leads to the main contribution of the paper: a static and dynamic model of the choice between private and national regimes for the ownership of natural resources. In the model, the basic tradeoff is given by equality (national ownership) versus efficiency (private

ownership). The connection between resource ownership and the equality-efficiency tradeoff is given by the incentives for effort that each regime elicits from workers. The resolution of the tradeoff depends on external and domestic conditions that affect the value of social welfare under each regime. This leads to a discussion of how external conditions—such as the commodity price—and domestic conditions—such as the tax system-- affect the choice of private vs. national regimes. In particular, the analysis identifies the determinants of the observed cycles of privatization and nationalization.

This paper—a product of the Growth and the Macroeconomics Team, Development Research Group—is part of a larger effort in the department to understand technological and institutional change and innovation. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The authors may be contacted at chevia@worldbank.org and nloayza@worldbank.org.

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⁰For 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 and Luis Servén. 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, or the countries they represent.

1 Introduction

Why is the process of *institutional* innovation so volatile and even 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 when social or economic conditions change, these reforms are reverted (Sturzenegger and Tommasi, 1998).

One of the most important 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 put into question, and in many countries governments 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 is 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 the available evidence on the drivers and consequences of privatization and nationalization. We first review the received literature in order to find systematic patterns on regime choices and shifts. We then present the analytical narrative of an illustrative case study of repeated nationalization and privatization of a natural-resource industry. This is the case of Bolivia regarding the exploitation of hydrocarbons. In the appendix we present two additional case studies, Venezuela (oil) and Zambia (copper), which show rather similar patterns. Through these case studies, we investigate how countries' comparative advantage in a given natural resource has rendered cycles of government participation. We focus on the periods before and after privatization and

nationalization of the natural resource, with the objective of relating the regime shifts with 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 serve to motivate and provide a context for the main contribution of the paper. This is a static and dynamic model of the choice between private and national regimes. In the model, the basic tradeoff is given by equality versus efficiency. Greater equality is obtained under public ownership of a “national” resource, while larger efficiency occurs when ownership and administration of the resource is private. The connection between ownership and the equality-efficiency tradeoff is given by the set of incentives for work effort that each regime elicits from households. In the private regime, there is a differential compensation scheme that depends on observed productivity, thus encouraging workers to increase their efforts. In the national regime, governments cannot credibly commit to relate compensation to productivity, thus engendering equality but also minimal individual effort.

The resolution of the tradeoff depends on external and domestic conditions that affect the value of social welfare under each regime. Through this context, we study how external conditions –such as the price of the commodity in question– and domestic conditions –such as the tax regime and government quality– affect the choice of private or national regimes. As these conditions fluctuate, they may engender the possibility of cycles of privatization and nationalization.

We argue that the theory is consistent with several of the stylized facts highlighted in section 2. 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. Likewise, an increase in exogenous costs of nationalizing previously privatized industries reduces the circumstances under which nationalization takes place but also makes it more unlikely that a nationalized sector is 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.

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 presents a static model, where the regime choice is permanent; and Section 4 introduces a dynamic version, where the possibility of regime 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 regimes changes. Section 5 concludes.

2 Stylized Facts and Motivation

The received literature suggests some key facts that should motivate and guide any theoretical examination. The first is that *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, focused 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.

The second key fact is that *nationalization-privatization cycles tend to occur more often in the natural resources and utilities sectors*. Kobrin (1984) documents that in the last five decades expropriations 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 third fact is related to the previous one and has to do with the underlying causes of

ownership changes: *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 share in the output of an investment 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 including bauxite, cooper, lead, nickel, silver, tin and zinc. Covering the period 1960-2002, Duncan used probit regressions to estimate the effects of price booms, political crisis and economic conditions 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 closely related study, Guriev, Kolotilin, and Sonin (2008) examined the determinants of nationalization in the oil sector, using panel data for the period 1960-2002. They run logit pooled regressions of nationalization events on oil price shocks, quality of government institutions, and a vector of controls comprising human capital, oil wealth, region dummies, GDP, and population. The regression results showed that governments are more likely to practice expropriations when the oil price is high.

A fourth fact is also related to commodity price changes and their effect on fiscal revenues: *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.¹

The fifth fact is also related to underlying causes of ownership changes: *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.* More directly, 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.

The sixth fact is similar to the previous one in that it emphasizes causes related to underdevelopment: *nationalization is more likely in countries with low human capital, undiversified productive structure, and faulty public institutions.* In the same study where they established the importance of oil price booms, Guriev et. al. (2008) found that governments are more likely to practice nationalization when the quality of institutions (measured by indicators of institutionalized democracy and constraints on the executive) and human capital (measured by adult literacy) are deficient. Kobrin (1984) and Minor (1994) remarked that countries that had experienced mass expropriations were those whose economies were heavily dependent on a few commodities. Several mechanisms may be at play. When public institutions are faulty, governments are more likely to violate contracts and break the rule of law, as reputational costs, domestic disapproval, and external sanctions are minimal in those circumstances. Moreover, when human capital is generally low and the economy is poorly diversified, income and con-

¹Rigobon (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.

sumption tend to be more volatile under a privatized system. In addition, if the production structure is heavily concentrated in a few industries, such as those related to natural resources, the outside options for workers who are not well remunerated in those industries are quite limited. All this may engender the political pressure to nationalize key industries in an effort, albeit misguided, to remedy the instability and disparity of the privatized regime.

The seventh fact focuses on the sometimes misused advantages of privatization: *Privatized firms are more productive than nationalized firms due to their incentive-driven investment and labor policies; yet, when they are nationalized, the practices that lead to higher productivity are not kept.* Schmitz and Teixeira (2008) analyzed privatization's impact on private productivity taking as an example the Brazilian iron ore industry. They provided evidence that, while under nationalization productivity gains in the industry were minimal, privatization in the late 1980s led to significant productivity gains not only in previously state-owned enterprises (SOEs) but also in existing private firms. Schmitz and Teixeira conjectured that the existence of SOEs affects private productivity through two channels. First, governments can distribute benefits more easily to constituents working at SOEs in the industry, a practice which distorts the incentives to exercise effort at work. Secondly, the existence of SOEs leads to less competition and less pressure to decrease costs to all participants in the industry. Further evidence on the higher productivity of privatized firms abounds. La Porta and Lopez de Silanes (1999) examined the performance of Mexican SOEs in various industries (including natural resources) after they were privatized. They found that the output of privatized firms rose by more than 50%. Moreover, they found that firms' operating profits increased by 24% and that incentive-related productivity gains accounted for 64% of this improvement. Using data on 230 firms in 32 developing countries, Boubakri, Cosset, and Guedhami (2005) examined when and how privatization works. The study found that privatization led to a significant increase in profitability, efficiency, investment, and output. Their analysis also showed that the macroeconomic environment, structural reforms, and corporate governance played a key role in determining the performance of newly privatized firms. Finally, the edited volume by Chong and Lopez de Sil-

anes (2005) presents several studies that evaluate the 1990s experience of privatization in Latin American countries. All in all, they found that privatization brought about substantial gains in productivity but its results on employment and income distribution were not as desirable.

Case Study: Bolivia and Hydrocarbons

Replete with natural resources, including minerals and hydrocarbons, Bolivia has experienced waves of privatization and nationalization that date back to the 1900s. While under Spanish colonial rule, Bolivian silver mines were widely exploited. In the 20th century, these mines were superseded by tin mines which played a significant role in the country's economy for almost an entire century. Bolivia's first oil well was drilled in 1922 and today the hydrocarbon industry dominates the economy. Bolivia's abundant natural resources have resulted in an economy whose health is subject to world price fluctuations in the commodities it produces. These fluctuations have been accompanied by political instability and repeated nationalization and privatization cycles.

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) showed the Bolivian government and its military 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, *Yacimientos Petrolíferos Fiscales Bolivianos* (YPFB), 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 *Movimiento Nacionalista Revolucionario* (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 clearly below potential.

In 1956, in the midst of the economic downturn, Hernando 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 YFPB 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 realized and potential 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 (*Ley General de Hidrocarburos*) to promote foreign investment, even if government retained property rights. The YFPB 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 Paz Estenssoro was inaugurated as president, he faced skyrocketing inflation rates and a dire economic situation. He responded by implementing *La Nueva Política Económica*. The program froze wages, raised the price of fuel, devalued the Bolivian peso, elim-

inated price supports, and laid off four-fifths of the mining workforce. As Figure 1.c shows, gross national income per capita (GNI) began a noticeable upward trend after the reforms, whereas inequality, as measured by the Gini coefficient, fell almost ten points. In contrast, as Figure 1.b indicates, investment in the energy sector and total FDI experienced only a small increase in 1987 and then remained relatively flat. As shown in Figure 1.a, after a small increase in 1986, Bolivia's gas production stagnated and reserves were continually low. 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 the 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. Figure 1.a illustrates the confluent growth in prices and reserves. After three years, 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.

In 2002, Gonzalo Sanchez de Lozada was elected. Following the downward 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 "*La Guerra del Gas*," 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). Figure 1.c also shows how 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 Manaldi, 2008). When the price of gas rose, as happened from 1995 to 2005 (see Figure 1.a), 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 the 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, but in the year of his 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 Static Model

This section describes a model of an industry that can operate under either a private ownership regime or a state ownership regime. We focus on what occurs in a period, given the ownership regime. The net benefits of each regime hinge on a crucial efficiency-equity trade-off 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. 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, of course, 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 with a continuum of ex-ante identical workers. The economy is infinitely lived, but in this section we confine attention to one typical period, as already mentioned.

The economy can produce a commodity that has price p in the world market, and can be produced with only labor via a production function $F = F(L)$, where L is labor input.

The continuum of workers has measure N . The effective labor supply of any worker $i \in [0, N]$, denoted by l_i , is a random variable whose distribution depends on agent i 's effort, a_i . One can interpret l_i as worker i 's realized productivity for the job, which may be uncertain but is enhanced, on average, by effort spent on education or training.

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 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.

Crucially, effective labor supply is observable, but effort is not. Because exerting effort is costly, there are moral hazard problems in the model.

Consider the decision problem of an individual worker. Regardless of the industry regime, the worker faces a labor market characterized by a payment schedule $\{y_H^*, y_L^*\}$, where y_H^* is the payment to a worker with high labor endowment and y_L^* is the payment to a worker with low labor endowment. The total income of a worker with labor endowment l_i is $y_i + T$, where T is a lump-sum transfer. We assume that workers cannot save (or that they only live for one period), so that each worker choose efforts to maximize the expected utility of income minus the cost of effort.

Denote the utility of consumption (income) by $u(c)$ and the cost of effort by $\phi(a)$. Then, given the wage schedule $\{y_H^*, y_L^*\}$, the worker chooses a to maximize expected utility

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

We assume that $\phi(0) = \phi'(0) = 0$ and $\phi'(a), \phi''(a) > 0$ for $a > 0$. The first order condition is

$$\pi'(a)[u(y_H^* + T) - u(y_L^* + T)] = \phi'(a) \tag{1}$$

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 expend effort only if a more productive worker is paid more. Moreover, condition (1) implies that effort increases with the wage differential.²

The wage structure, taxes, and industry ownership regime are taken as given to individual

²To see this, let $\Delta = y_H^* - y_L^*$, and rewrite (1) 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 $\gamma'(a) > 0$, we find $da/d\Delta > 0$.

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 payment schedule and taxes *after* effort has already 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 our assumptions, there is no loss of generality in assuming that $T = 0$ and that the government chooses a payment schedule so as to equalize consumption across agents: $y_H^* = y_L^*$. This is because, at the time the government chooses the payment schedule, effort and individual productivity are already given. Hence the payment schedule no longer distorts effort choice, and the government chooses it to prevent consumption inequality.

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

More formally, given any probability of high productivity, π , the planner chooses y_H and y_L to maximize the sum of workers' utilities:

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

subject to the feasibility condition

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

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

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

which implies $u'(y_H) = u'(y_L)$ and, therefore, $y_H = y_L$.

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

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

which is a function of the 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.

Each firm takes as given the schedule $\{y_H^*, y_L^*\}$ of what highly productive and less productive workers are paid in the market. The problem of each firm is to choose the number of workers, n , a level of effort a , and its own wage schedule $\{y_H, y_L\}$ to maximize expected profit:

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

subject to the following Incentive Compatibility and Participation Constraints,

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

where U^* is the expected utility that a worker can get in the market, given by

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

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

Letting $\eta(1 - \tau)$ and $\lambda(1 - \tau)$ denote the Lagrange multipliers on the constraints, and

cancelling the $1 - \tau$ term, the first order condition with respect to n is

$$p(1 - \theta)F'(n\ell(a))\ell(a) = \pi(a)y_H + (1 - \pi(a))y_L, \quad (2)$$

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.

The first order condition with respect to y_H is

$$-n\pi(a) + \eta u'(y_H + T) + \lambda\pi(a)u'(y_H + T) = 0$$

or

$$u'(y_H + T) \left[\lambda + \frac{\eta}{\pi(a)} \right] = n. \quad (3)$$

The first order condition with respect to y_L is

$$u'(y_L + T) \left[\lambda - \frac{\eta}{1 - \pi(a)} \right] \leq n, \quad (= 0 \text{ if } y_L > 0). \quad (4)$$

To interpret the previous 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 given

by the terms in η , which reduce $u'(y_H + T)$ relative to $u'(y_L + T)$, and hence increase y_H over y_L .

Lastly, from the first order condition with respect to a , and using the incentive compatibility condition,

$$n\pi'(a) [p(1 - \theta)F'(n\ell(a)) (l_H - l_L) - (y_H - y_L)] = \eta\gamma'(a) \quad (5)$$

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 must then multiply $\gamma'(a)$ by the shadow cost of the incentive constraint, η .

Some properties of the solution now emerge. First, it should be clear that $\lambda \geq 0$, because the marginal value on profits of increasing the reservation utility, U^* , that workers can get in the market is $-\lambda$, which cannot be positive. The next two propositions, proved in the appendix, characterize additional properties of the optimal contract,

Proposition 1: *The participation constraint holds at equality.*

Proposition 2: *The multiplier η is non-negative.*

The case $\eta = 0$ cannot be ruled out, because it could be too costly for the firm to provide incentives. If $\eta = 0$, then $a = 0$ and $y_H = y_L$.

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

$$TN = \tau \{p(1 - \theta)F(N\ell(a)) - N [\pi(a)y_H^* + (1 - \pi(a))y_L^*]\} + \theta pF(N\ell(a)) \quad (6)$$

Collecting the results, an equilibrium allocation solves the following conditions:

$$u(y_H + T) - u(y_L + T) = \gamma(a) \quad (7a)$$

$$p(1 - \theta)F'(N\ell(a))\ell(a) - [\pi(a)y_H + (1 - \pi(a))y_L] = 0 \quad (7b)$$

$$u'(y_H + T) [\lambda + \eta/\pi(a)] = N \quad (7c)$$

$$u'(y_L + T) [\lambda - \eta/(1 - \pi(a))] \leq N \quad (= N \text{ if } y_L > 0) \quad (7d)$$

$$N\pi'(a) [p(1 - \theta)F'(N\ell(a))(l_H - l_L) - (y_H - y_L)] = \eta\gamma'(a) \quad (7e)$$

$$pF(N\ell(a)) [\tau(1 - \theta) + \theta] - \tau N [\pi(a)y_H + (1 - \pi(a))y_L] = TN \quad (7f)$$

This system of 6 equations determines 6 unknowns: $\{y_H, y_L, a, T, \lambda, \eta\}$. The solution implies that the average worker has utility:

$$u(y_H + T) + (1 - \pi(a))u(y_L + T) - \phi(a)$$

Note that, just like in the state ownership regime, U_P and the industry equilibrium under private ownership depend on the resource price p .

U_P can be greater or less than U_S , the payoff associated with state ownership. If effort is positive, effective labor and therefore production will be greater than under state ownership. In this sense, the model is consistent with one of the stylized facts, namely, 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, there is costly consumption inequality, and in addition profits can be appropriated by private owners.

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 Numerical Explorations

Further insights on the properties of the model can be obtained by resorting to numerical methods. We do not aim to provide a realistic parametrization of any privatization-nationalization episode. Our model is too simple for that purpose. We view our numerical experiments as providing further insights into the working of the model. For that purpose, we make assumptions about functional forms and parameter values that generate predictions that are qualitatively consistent with the empirical regularities discussed in section 2. Next, we 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,

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

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 pro-

ductivity is $l_H = 1$, and that of a worker with low productivity is $l_L = 0.1$. That is, there is a large productivity differential between the two types of workers. The coefficient of absolute risk aversion is set at $\gamma = 2$, and the parameter that enters the cost of effort function 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 $\nu = 2.5$. The level of technology is set at $A = 0.25$, and the exponent on labor in the production function, at $\alpha = 2/3$ —if labor markets were competitive, this implies a labor share of $2/3$. Finally, the baseline taxes are set at $\tau = 0.20$ and $\theta = 0$. Table 1 summarizes these numbers.

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 (7). In the appendix we discuss how to compute the equilibrium.

In all cases that we computed, the proposed parametrization of the model implies the existence of a threshold price p^* (which could be 0 or ∞) that partitions the set of feasible prices p . For all prices below p^* , aggregate welfare is larger in a private ownership regime, while for all prices above p^* , welfare is larger in a state ownership regime. We interpret this finding as reflecting an equity-efficiency trade-off or, more formally, a trade-off between efficiency and risk sharing across workers that happen to draw different labor endowments but are otherwise identical. When prices are low, concerns for efficiency outweigh those for risk sharing. The planner is willing to accept less risk sharing in exchange for the higher average labor productivity that prevails in a private ownership regime. On the other hand, when prices are high (above p^*) total income conditional on a level of labor productivity is large and, therefore, the level of labor productivity becomes less of an issue relative to the lack of risk sharing.

Note that the implication that nationalization occurs at large values of p is consistent with the observed facts, as described in section 2. In addition, and already mentioned, the model implies that privatized firms are more efficient than state owned ones.

To build intuition on the working of our model, Table 2 reports exercises on comparative statics to analyze how the privatization-nationalization threshold \hat{p} changes as we move

the different parameters. The first row of the table reports the threshold p^* for the baseline parametrization of the model. An inspection of the table reveals that all parameters have a monotonic relation with the privatization threshold p^* .

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 optimal 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 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 expend effort in a privatized regime because the probability of drawing high labor endowment when effort is low declines. Thus, firms are able to induce workers to expend 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 highly and less productive workers assuming that the average labor supply in a state-owned regime—that is, when effort is zero—remains constant. Note that, in terms of welfare, these mean preserving experiments are equivalent in a state-owned regime, but they are not in a privately-owned 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. In the baseline economy, the worker with high labor endowment is ten times more productive than a worker with low labor endowment. Suppose that the worker with high labor endowment is now four times more productive than a worker with low labor endowment, but the average labor supply in a state-owned regime does not change—that is, the ratio l_L/l_H increases from 0.1 to 0.25. The labor productivities are now $l_L \cong 0.11$ and $l_H \cong 0.42$, and the threshold price p^* decreases from 29.5 to 11.5. 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.

Consider, finally, a change in the tax code as summarized by changes in dividend and sales taxes. A higher 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^* .³ 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.

Before moving to the dynamic model, we mention that, in the static model, what matters in the nationalization-privatization choice is the product Ap . Thus, an increase in A immediately

³In contrast with a competitive industry, changes in τ do affect the decisions of firms because it modifies the incentive compatibility constraint of workers through change in the lump-sum transfer T

implies that the threshold price p^* declines.

4 The Dynamics of Privatization and Nationalization

4.1 Multiperiod Version of the Model

In this section we study a dynamic version of the model. Time is discrete and denoted by $t = 0, 1, \dots, \infty$. Workers are infinitely lived and discount the future with the discount factor β . Firms, also infinitely lived, discount future profits with the discount factor $1/(1+r)$. In principle, we allow for the case $\beta \neq 1/(1+r)$. 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 then 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. Assume that the government is benevolent in that it maximizes the welfare of the average worker.

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 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

$$V_P(p) = U_P(p) + \beta \int \max\{V_P(p'), V_S^0(p')\} Q(p, dp') \quad (8)$$

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

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

In periods of regime change, that is, when the industry is just privatized or just nationalized,

the value functions are respectively given by

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

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

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 direct 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 (6) includes an additional source of funds, $\kappa W^0(p)$, raised from selling state firms.

Thus, the static equilibrium at the privatization period solves the system of equations

$$\begin{aligned}
u(y_{H0} + T_0) - u(y_{L0} + T_0) &= \gamma(a_0) \\
p(1 - \theta)F'(N\ell(a_0))\ell(a_0) - [\pi(a_0)y_{H0} + (1 - \pi(a_0))y_{L0}] &= 0 \\
u'(y_{H0} + T_0) [\lambda_0 + \eta_0/\pi(a_0)] &= N \\
u'(y_{L0} + T_0) [\lambda_0 - \eta_0/(1 - \pi(a_0))] &\leq N \quad (= N \text{ if } y_{L0} > 0) \\
N\pi'(a_0) [p(1 - \theta)F'(N\ell(a_0))(l_H - l_L) - (y_{H0} - y_{L0})] &= \eta_0\gamma'(a_0) \\
pF(N\ell(a_0)) [\tau(1 - \theta) + \theta] - \tau N [\pi(a_0)y_{H0} + (1 - \pi(a_0))y_{L0}] + \kappa W^0(p) &= T_0N
\end{aligned}$$

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 (8), (9), (10), and (11). For an interesting range of parameters, the solution is illustrated by Figure xx. 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 (8), 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 (9), 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 remain 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 in 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, \dots, 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 3.4, 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 with mean $E(p_t) = \bar{p} \exp(\tilde{\sigma}^2/2)$ and variance $VAR(p_t) = \bar{p}^2 (\exp \tilde{\sigma}^2 - 1) \exp \tilde{\sigma}^2$, where $\tilde{\sigma}^2 = \sigma^2 / (1 - \rho^2)$

is the variance of the stationary distribution of z_t .

We interpret a period in the model to be one month, and we set the parameters that determines the evolution of the price p_t by running a first order autoregression on the logarithm of monthly crude oil prices (see Hamilton, 2009). The point estimates of these regressions are $\rho = 0.984$, $\sigma = 0.077$, and $\bar{p} = 32.7$.

It remains to set the parameters β , r , κ , and c_S . We assume a subjective discount factor of $\beta = 0.95$ and an interest rate of $r = 0.1$, both measured on an yearly basis. We assume that 25 percent of the resources raised at the privatization period are redistributed to the workers, so that $\kappa = 0.25$. 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 price of the product is $E(p_t)/2$, consumption in a state ownership regime is zero. That is, $c_S = 0.5E(p_t)F(L_S)$. For our baseline parametrization, this condition implies $c_S = 1.02$. These parameters are reported in Table 1.

Table 3 reports the numerical experiments based on the dynamic model. The table displays the two threshold prices p^* and p^{**} as well as the average duration of each regime. To be precise, the column labeled ' $p^* \rightarrow p^{**}$ ' reports the average number of periods for the first time a process starting at $p_t = p^*$ reaches p^{**} . We interpret this statistic as a measure of the average duration of a private ownership regime. Of course, if the initial price is below p^* , the average number of periods that it takes to cross the threshold p^{**} increases. Thus, the proposed statistic is a lower bound on the average duration of a private ownership regime. Similarly, the column labeled ' $p^{**} \rightarrow p^*$ ' provides a measure of the expected duration of a state-owned regime. These duration statistics, computed using Montecarlo, depend only on the two threshold values p^* and p^{**} , and on the statistics of the invariant distribution of prices. For all rows of Table 3 except for the last two, these statistics are $E(p_t) = 35.9$ and $\sqrt{VAR(p_t)} = 16.3$.

The first row of the table reports the thresholds prices and duration statistics for the baseline economy. In this economy, the industry is state-owned at all prices greater than $p^{**} = 38.8$ and it is privately-owned at all prices smaller than $p^* = 26$. Note that the threshold price of

the static model computed in section 3.4 is between the two threshold prices of the dynamic economy. This is a property that holds across all experiments. In addition, the average duration of a state owned regime is almost 8 years (93 months) , and that of a private ownership regime, almost 7 years (82 months).

Consider an increase in risk aversion to from $\gamma = 2$ to $\gamma = 3$. Both threshold prices decline, the average duration of a state-owned regime increases substantially, and that of a privately-owned regime decreases. 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 of the regimes, note that the stationary distribution of prices do not change but the threshold prices are now $p^{**} = 13.4$ and $p^* = 27.6$. Because prices are mean reverting, clearly the time it takes for the price to move from 13.4 to 27.6 will be substantially smaller than the time it will take to go from 27.6 to 13.4 for the simple reason that p^{**} is substantially below the average price.

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 these experiments provide intuition for the changes in the duration statistics. Consider, for example, an increase in the ratio l_L/l_H from 0.1 to 0.25 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 $p^{**} = 9.0$ and the nationalization threshold, $p^* = 31.8$. It is clear that it will take a long time for a mean reverting process with average value of 35.9 to move from 31.8 to 9.0. This observation explains that the average duration of a state-owned regime is over 5000 months or, equivalently, over 416 years. On the other hand, the mean reverting property of the price process implies that the average duration of a private ownership regime is just 10 month.

We now consider changes in the parameters that are specific to the dynamic model. Con-

sider, first, an increase in the nationalization cost c_S from 1.02 to 1.54.⁴ The nationalization threshold p^* increases from 38.8 to 45 and the privatization threshold p^{**} decreases from 26 to 25. It is clear why p^* increases: because the nationalization cost is higher, the welfare loss associated with the lack of risk sharing of a private ownership regime that justifies nationalizing 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 duration, the increase in p^* and the decrease in p^{**} imply that each regime lasts longer. Indeed, the average duration of a privately owned regime increases from 82 to 138 months and that of a state-owned regime, from 93 to 125 months. 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 . To compare the results with those of an increase in c_S , assume that κ declines from 0.25 to 0, so that all the benefits of nationalizing the industry are lost or are used for purposes other than transfers. On a qualitative level, these two changes have exactly the same impact on the equilibrium of the model. The difference being that a drop in κ operates through a change in the value of a private ownership regime 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^* increases, p^{**} decreases, and the average duration of both regimes increase.

The last two experiments of Table 3 involve perturbing the stochastic process for the prices p_t . These include changing the persistence and volatility of the z_t process. Because these changes affect the invariant distribution of p_t , the interpretation of the results must be taken

⁴The costs $c_S = 0.51$ and $c_S = 1.54$ are associated with break even prices of 25 percent and 75 percent of the average price under the invariant distribution. (See the discussion about the calibration of c_S .)

with caution. In all cases we adjust the parameter \bar{p} so that the invariant distribution of p_t has always the same mean of $E(p_t) = 35.9$. However, there are not enough parameters to adjust the standard deviation of that process as well. Thus, changes in the persistence ρ necessarily involves changes in the volatility of p_t as well.

Consider a mean preserving change in the persistence ρ . Table 3 shows that, while the privatization price p^{**} is monotonic in ρ —the lower is ρ , the lower the privatization price p^{**} —the nationalization price p^* does not show a clear pattern. In any case, however, the duration statistics show a clear pattern. The lower is ρ , the longer lasts each cycle. The reason is that as ρ decreases, the volatility of the invariant distribution of prices decreases as well. Indeed, the standard deviation of p_t when $\rho = 0$ is just 2.8. The lower persistence implies that p_t returns fast to its average value of 35.9. This explains the short duration of a privatization ownership regime. The low persistence and low standard deviation also explains the extremely long lasting state ownership regime. Indeed, with such a low standard deviation and persistence it is highly unlikely that the price will fall below 18.1, the privatization threshold when $\rho = 0$.

The last experiment consists of a mean preserving spread in the distribution of prices. Consider increasing σ from 0.077 to 0.15 adjusting \bar{p} so that the expected price remains constant. Because the threshold prices do not change substantially when we increase σ , it is clear that the duration of each regime declines. Indeed, the average duration of a private ownership regime drops from 82 to 78 months, and that of a state ownership regime, from 93 to 47 months. The decline in duration is asymmetric across regimes because the threshold price p^* is more sensitive to the change in volatility.

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 expended 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 nationalization/privatization 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.

Relatedly, more research appears to be warranted to identify the 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.

What should be clear, nevertheless, is that our model of privatization and nationalization cycles has the potential of rationalizing a variety of available evidence starting with natural assumptions about efficiency, equity, financial markets, and government commitment. Conversely, our theory de-emphasizes other explanations, such as political conflict, that have received attention in this context.

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Table 1. Baseline Parameters

<i>Symbol</i>	<i>Description</i>	<i>Value</i>
A	Productivity	0.25
α	Labor exponent (technology)	2/3
γ	Coefficient of absolute risk aversion	2
φ	Cost of effort parameter	1
δ	Probability of success parameter	0.99
ν	Probability of success parameter	2.5
l_H	High labor endowment	1
l_L	Low labor endowment	0.1
τ	Dividend Tax	0.20
θ	Sales Tax	0
<i>Additional parameters of the dynamic model</i>		
ρ	Persistence of log-price	0.984
σ	Standard deviation of log-price	0.077
\bar{p}	Parameter in price evolution	32.71
β	Discount factor (annualized)	0.95
r	Interest rate (annualized)	0.10
c_S	Nationalization cost (level)	1.02
κ	Privatization benefit (fraction)	0.25

Table 2: Static Model

<i>Symbol</i>	<i>Description</i>	<i>Value</i>	<i>p*</i>
–	Baseline Economy	–	29.5
γ	Risk Aversion	1	71.9
		3	17.1
φ	Effort parameter	0.5	35.9
		2	22.9
δ	Probability of success parameter	0.9	13.2
ν	Probability of success parameter	2	25.3
		3	32.9
l_L/l_H	Ratio of labor endowments (mean preserving)	0.05	36.8
		0.25	11.5
α	Labor exponent in technology	0.5	7.6
		0.75	42.3
τ	Dividend tax	0.01	25.7
		0.5	36.0
θ	Sales tax	0.25	33.7
		0.75	45.0

Table 3: Dynamic Model

<i>Symbol</i>	<i>Description</i>	<i>Value</i>	<i>Thresholds</i>		<i>Average Duration of Regime</i>	
			p^{**}	p^*	$p^* \rightarrow p^{**}$	$p^{**} \rightarrow p^*$
–	Baseline Economy	–	26.0	38.8	93	82
γ	Risk Aversion	1	68.1	78.5	13	425
		3	13.4	27.6	827	71
φ	Effort parameter	0.5	32.5	45.7	57	109
		2	19.2	31.7	219	69
δ	Prob. of success parameter	0.9	9.0	23.8	3525	73
ν	Prob. of success parameter	2	21.6	34.2	155	72
		3	29.5	42.4	71	94
l_L/l_H	Ratio of labor endowments (mean preserving)	0.05	34.0	46.7	12	168
		0.25	9.0	31.8	>5000	10
α	Labor exponent (techn.)	0.5	0.1	19.7	>5000	145
		0.75	38.8	52.1	39	138
τ	Dividend tax	0.01	22.1	34.3	141	71
		0.5	32.4	46.9	60	117
θ	Sales tax	0.25	30.2	43.9	68	106
		0.75	40.6	59.0	44	223
A	Productivity	0.1	70.5	77.6	10	327
		0.5	11.3	27.3	1710	80
c_S	Nationalization cost	0.51	27.8	33.1	48	38
		1.54	25.0	45.0	125	138
κ	Privatization benefit	0	25.7	39.8	99	90
		0.5	26.0	38.8	93	82
ρ	Persistence of shock (mean preserving)	0	18.1	37.4	>5000	4
		0.75	21.9	37.3	4869	14
σ	Volatility of shock (mean preserving)	0.01	25.8	31.6	>5000	60
		0.15	25.4	43.6	47	78

Figure 1.a / Bolivia

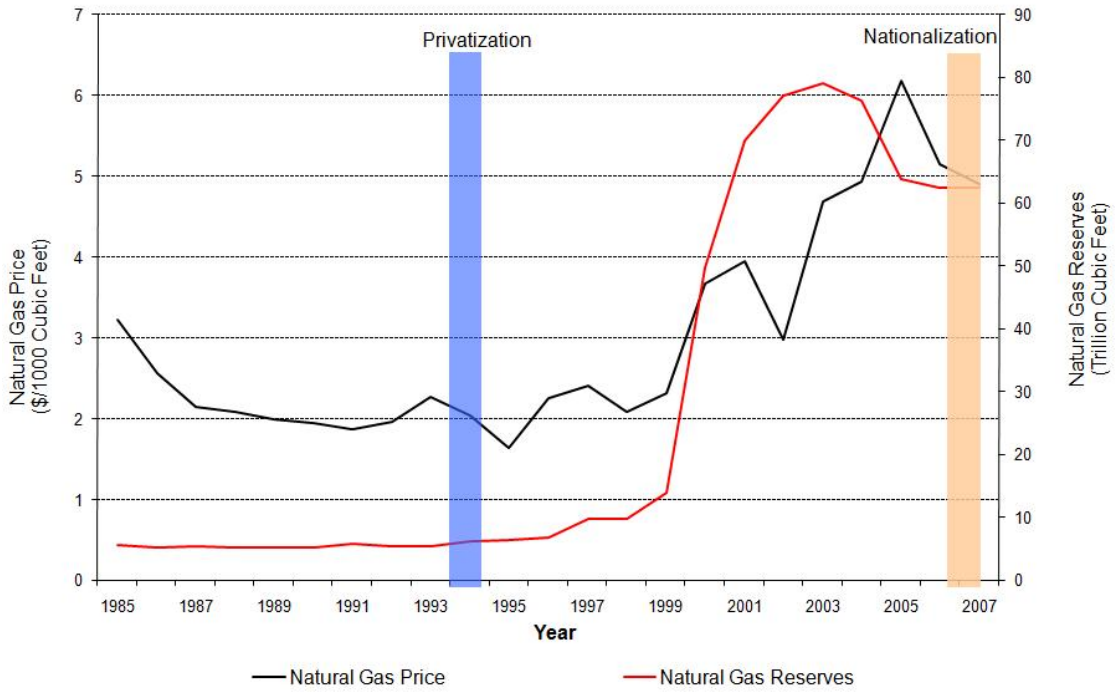


Figure 1.b / Bolivia

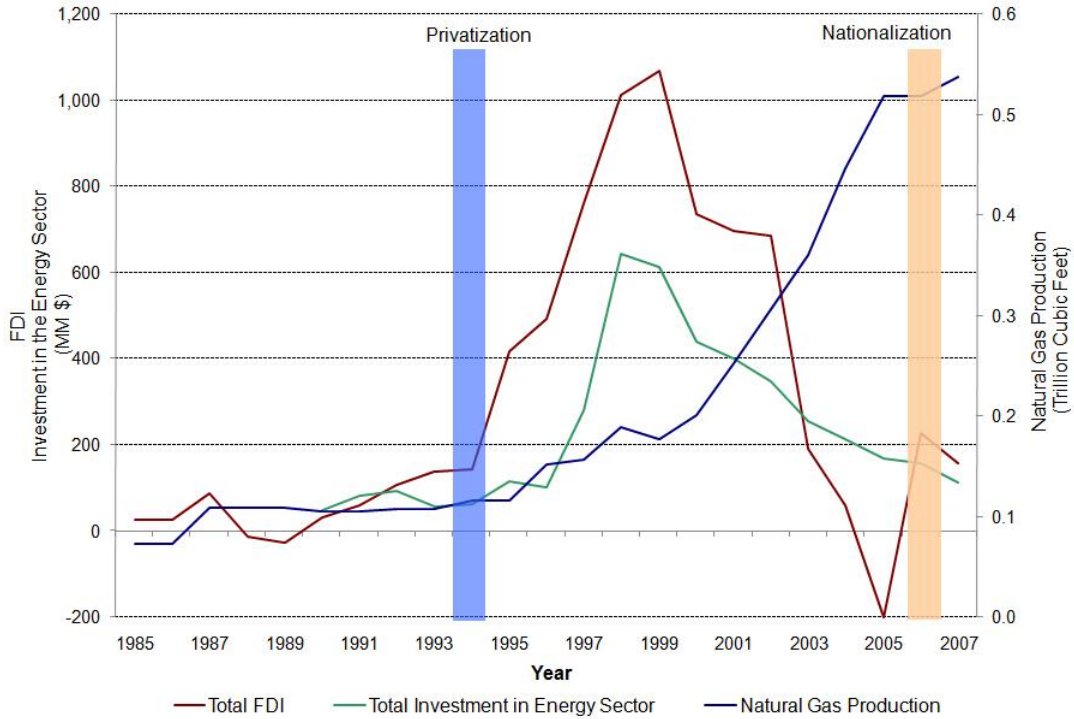


Figure 1.c / Bolivia

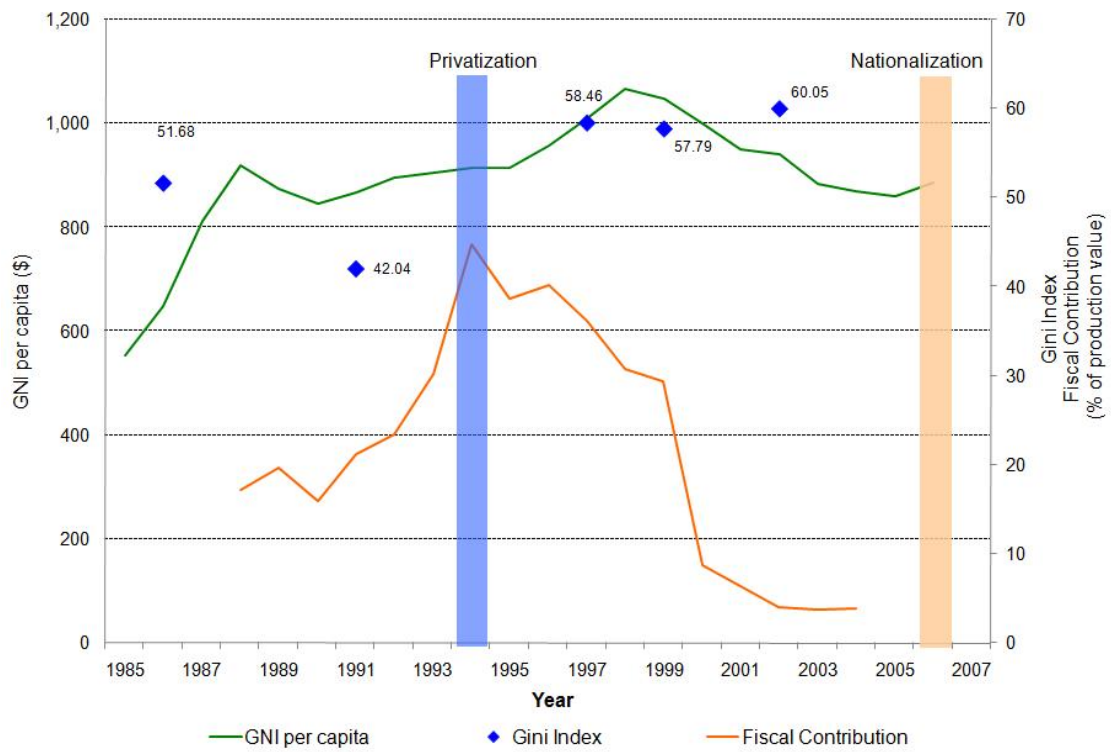
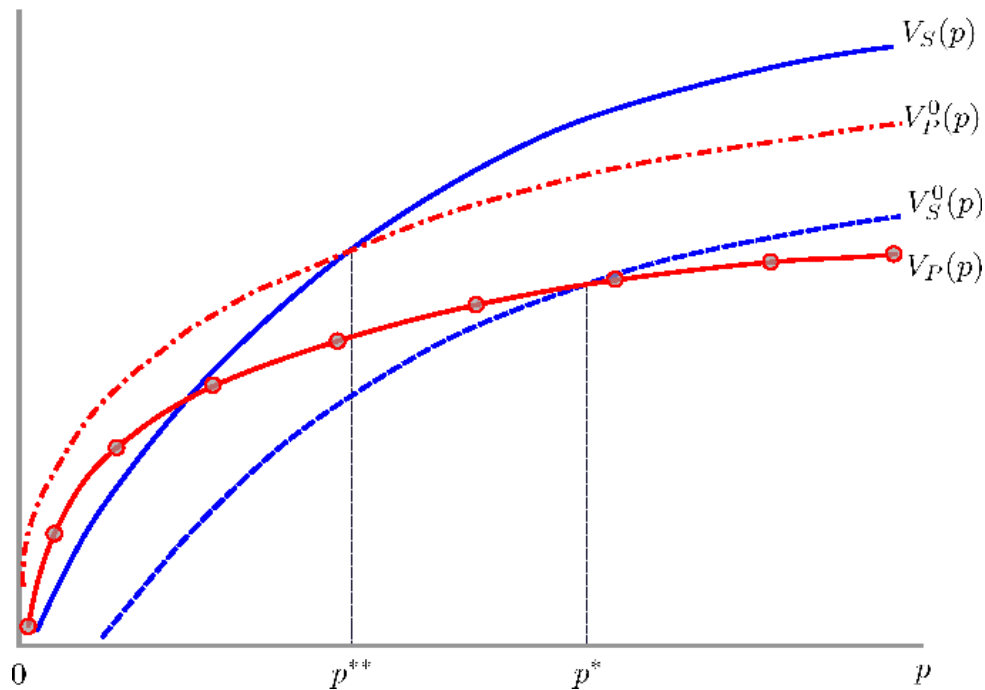


Figure 2. Value Functions and Threshold Prices



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

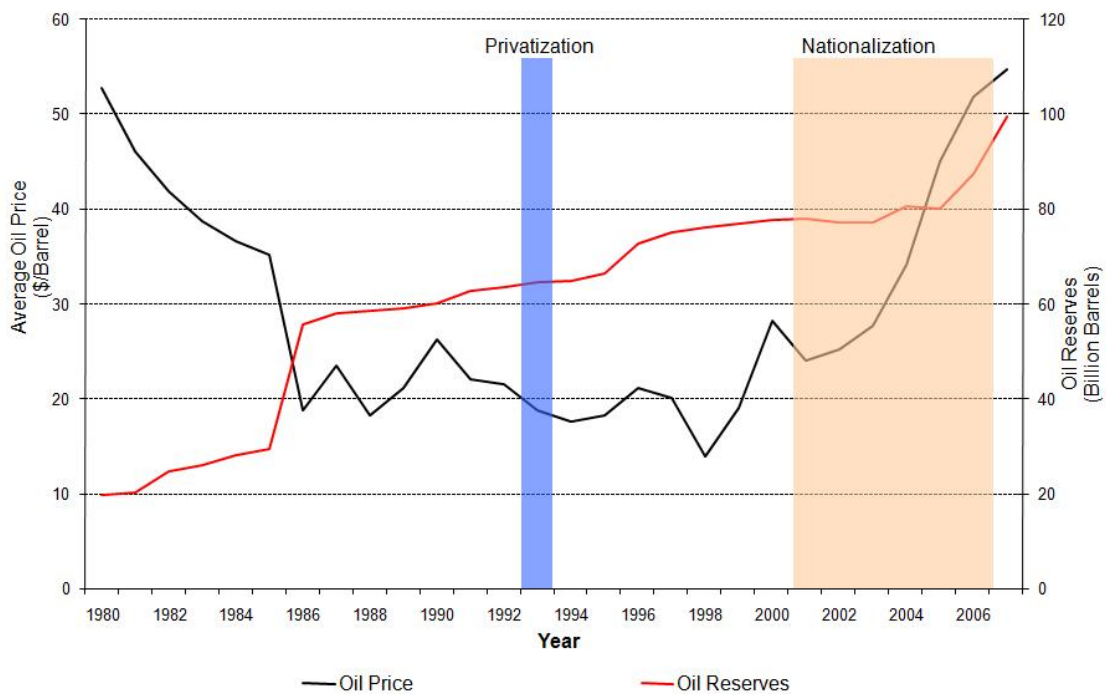


Figure A.1.2 / Venezuela

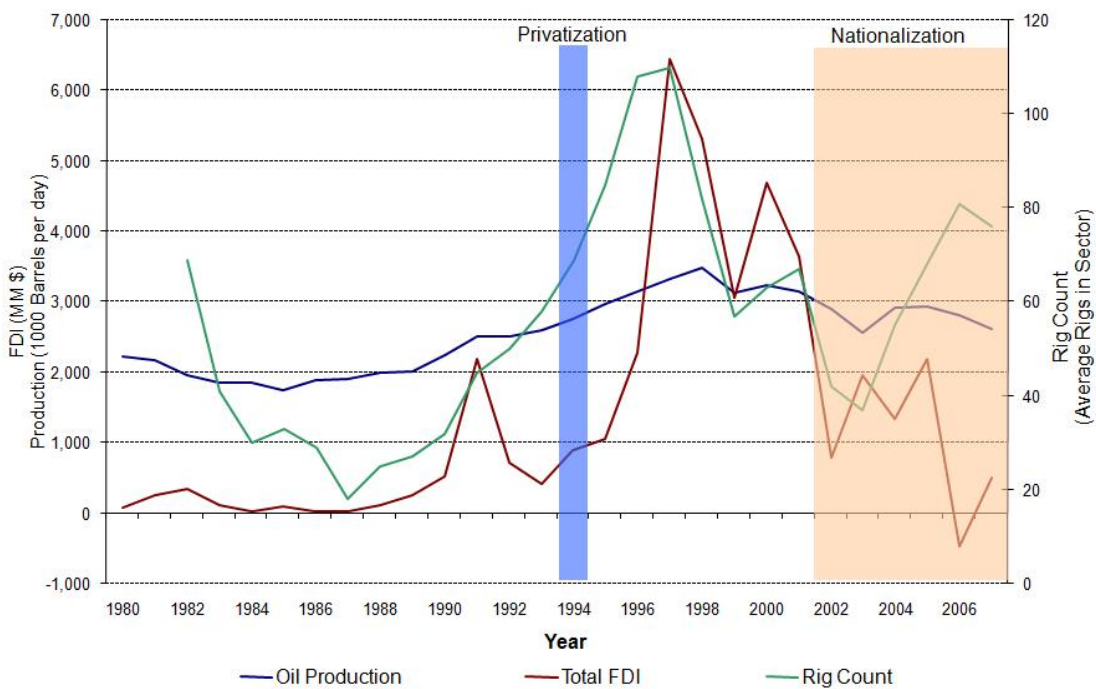
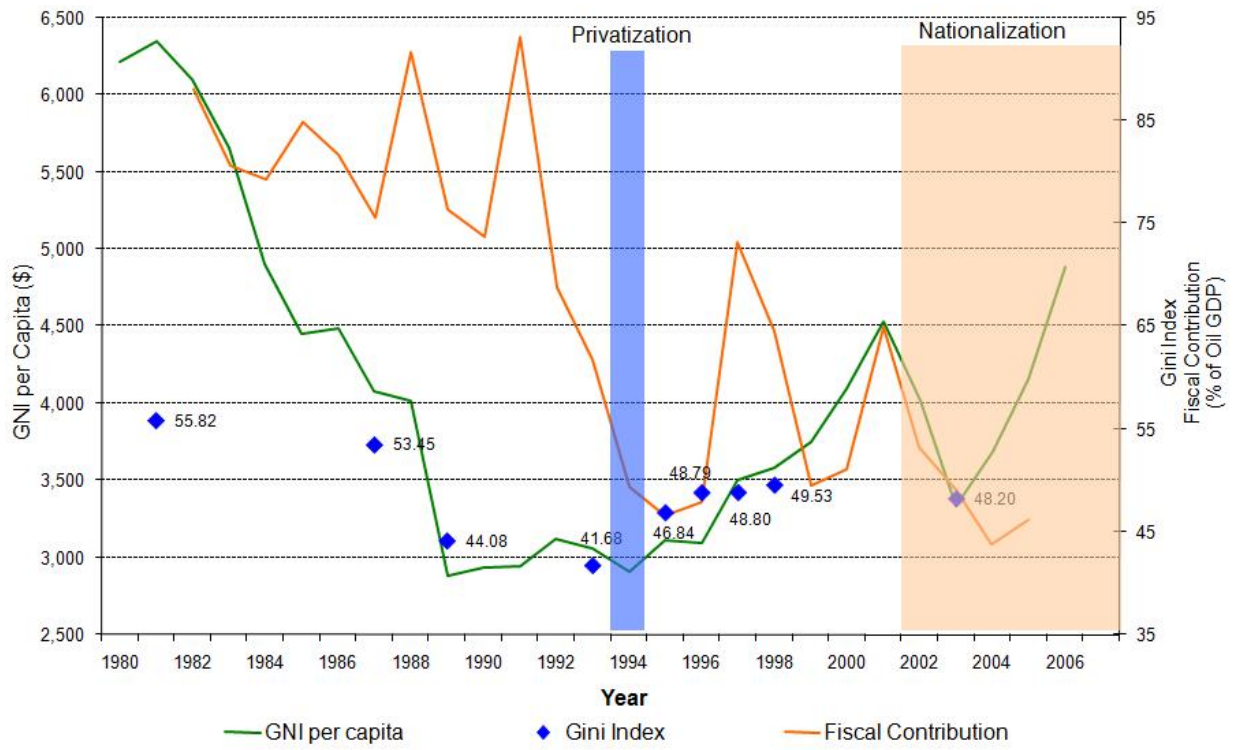


Figure A.1.3 / Venezuela



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 Rhodesia 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

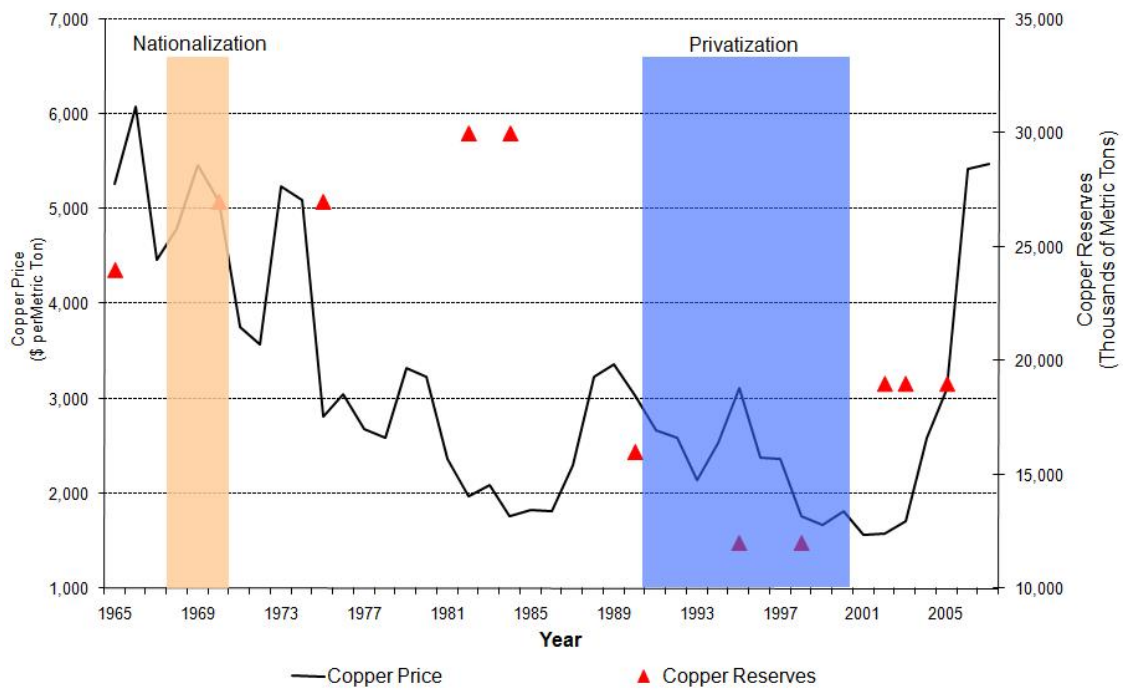


Figure A.2.2 / Zambia

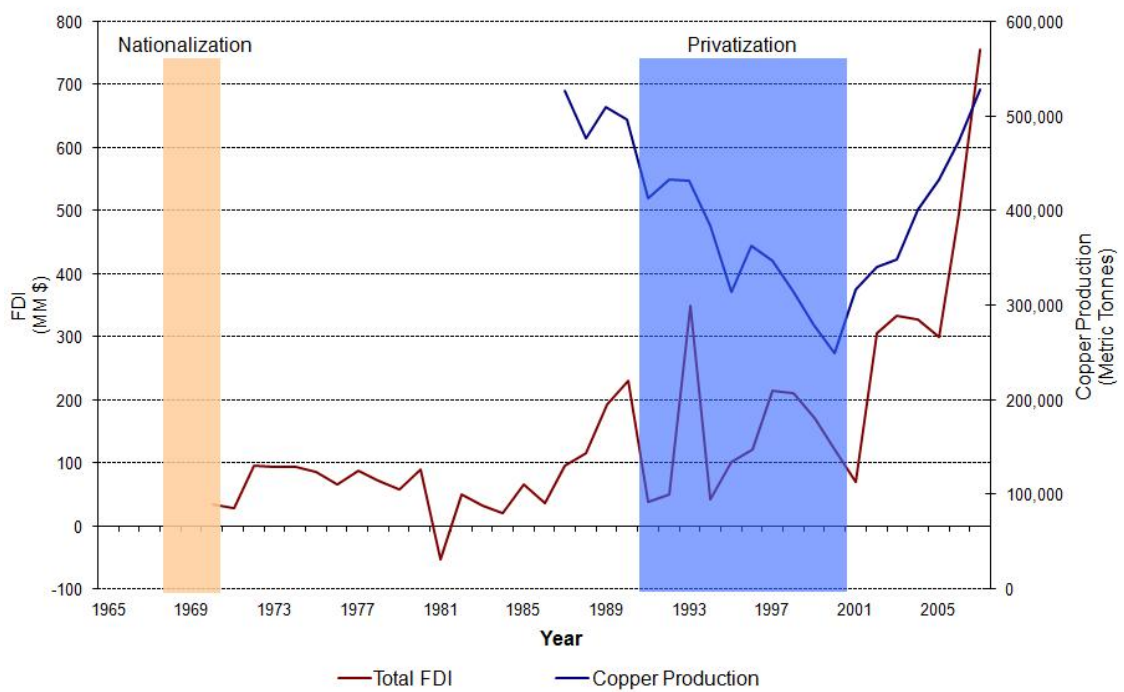
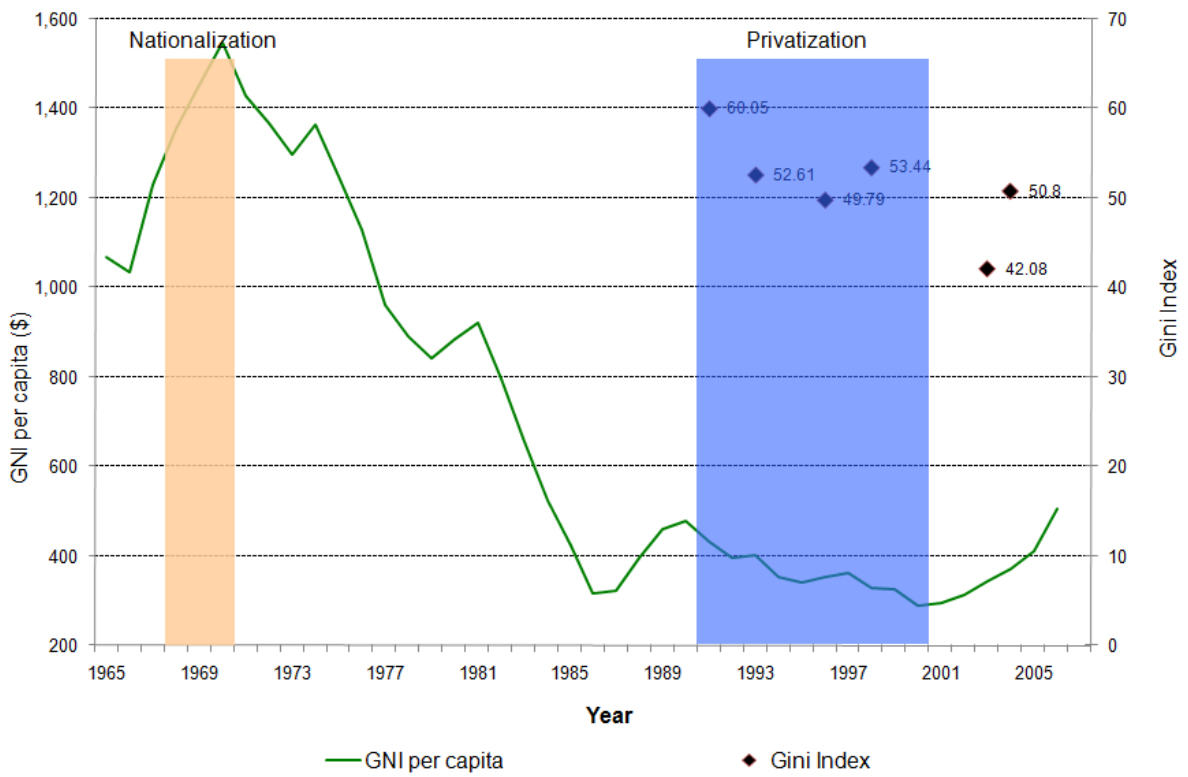


Figure A.2.3 / Zambia



Technical Appendix

Proofs of Proposition 1 and 2

Proposition 1: *The participation constraint holds at equality.*

Proof: By way of 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^0 but increases the firm's profits. Because the proposed plan is incentive compatible, we can write the last inequality as

$$\pi(a^o)\gamma(a^0) + u(y_L^o + T) - \phi(a^o) > U^*$$

Therefore, there is an $\epsilon > 0$ such that

$$U^* < \pi(a^o)\gamma(a^o) + u(y_L^o - \hat{\epsilon} + T) - \phi(a^o)$$

Consider 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 satisfies $u(\hat{y}_H + T) = u(\hat{y}_L - \hat{\epsilon} + T) + \gamma(a^o)$. Clearly, $\hat{y}_H < y_H$ and $\hat{y}_L < y_L$. Then, by construction, the plan $\{\hat{y}_H, \hat{y}_L, a^o, n^o\}$ is incentive compatible, satisfies the participation constraint, and increases the firm's profits, which contradicts the optimality of the original plan. Therefore, the participation constraint holds at equality. QED.

Proposition 2: *The multiplier η is non-negative.*

Proof: By way of contradiction, assume $\eta < 0$. Then, the incentive constraint binds and $a > 0$. Also, equation (3) and $u' > 0$ implies $\lambda + \eta/\pi(a) > 0$. Now, conditions (3) and (4) imply

$$u'(y_H + T) = \frac{n}{\lambda + \eta/\pi(a)} > \frac{n}{\lambda - \eta/(1 - \pi(a))} \geq u'(y_L + T),$$

where the strict inequality follows from $\lambda + \eta/\pi(a) > 0$ and $\eta < 0$. Then, the strict concavity of $u(\cdot)$ implies $y_H < y_L$, which contradicts the hypothesis. Therefore, $\eta \geq 0$. QED.

Computation of the Static Equilibrium with Private Ownership

Solving a system of 6 equations in 6 unknowns could be a challenging numerical task. For that reason we simplify the system of equations (7) as follows. We start by rewriting equations (7c) and (7d) as

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

$$y_L(T, \lambda, \eta) = \max \left\{ 0; (u')^{-1} \left[\frac{N}{\lambda - \eta/(1 - \pi(a))} \right] - T \right\}$$

That is, we write the payments y_H and y_L as a function of T , λ , and η . We then replace these expressions into the remaining conditions and reduce the problem to solving the following system of 4 equations in 4 unknowns,⁵

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

We solve this system of equations for a grid of prices p using the Matlab routine `fsolve.m`.

Algorithm for the Dynamic Model

Because there is a one to one mapping between p_t and z_t , in the computation of the model we work with z_t as our state variable. Using the insights from the static model, we guess that the privatization region is an interval of the form $\Omega = (-\infty, z^*]$. We solve the model under this assumption and 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 $U_S^0(z)$. Choose a grid of points $\{z_i\}_{i=1}^M$
2. Choose initial guesses $V_P(z; 0)$, $V_S(z; 0)$, $V_P^0(z; 0)$, and $V_S^0(z; 0)$. Set $j=0$,
 - (a) Find z^* (the nationalization threshold) that solves $V_P(z^*; j) = V_S^0(z^*; j)$
 - (b) Given z^* , iterate on the following functional equation to obtain the firm value $w(z_i)$

$$W(z_i) = (1 - \tau)R(z_i) + \frac{1}{1 + r} \int_{-\infty}^{z^*} W(z')Q(dz', z_i) \text{ for all } i = 1, 2, \dots, M$$

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_i for $i = 1, 2, \dots, M$.
- (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

⁵Because a , η , λ , and T are all positive, when solving the system of equations we define $a = e^{\bar{a}}$, $\eta = e^{\bar{\eta}}$, $\lambda = e^{\bar{\lambda}}$, and $T = e^{\bar{T}}$, and solve for the zero using the tilde variables.

the value functions at each grid point z_i using the Bellman operators:

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

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).