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PRIVATIZATION AND NATIONALIZATION CYCLES

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This paper studies cycles of nationalization and privatization in resource-rich economies. It starts with a synthesis of available evidence on the drivers and consequences of privatization and nationalization. Then it develops a dynamic model of the choice between private and national regimes for the ownership of natural resources. The choice is driven by a basic equality-efficiency trade-off: national ownership results in more redistribution of income and more equality but undermines incentives for effort. We discuss how the resolution of the trade-off depends on external variables—such as the commodity price—and domestic ones—such as the tax system. The model thus identifies the determinants of the observed cycles of privatization and nationalization and is consistent with key stylized facts.

Keywords: Privatization, Nationalization, Institutions, Natural Resources, Oil

1. INTRODUCTION

A salient institutional reform at the end of the 20th century was the privatization of commercial enterprises around the world (Chong and Lopez de Silanes, 2005). After the millennium, however, the benefits of privatization have been called into question, and many countries have moved to re-nationalize some of these enterprises (Manzano and Monaldi, 2008; and Stroebel and van Benthem, 2013). The swings are not new: the historical experience suggests that many of these economies have moved back and forth between private and national regimes

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(Minor, 1994; and Chua, 1995). Cycles of privatization and nationalization occur mainly in countries with incipient institutional development and poor governance. In turn, they generate further institutional instability.

This paper is a study of such cycles in developing economies. It starts by discussing evidence from cross-country econometric studies and in-depth regional and country case studies. Four observations emerge.[1] First, nationalizations and privatizations are recurrent phenomena, often coming in waves common to several countries. Second, privatization–nationalization cycles tend to occur more often in the natural resources and utilities sectors. Third, nationalization of natural resource industries tends to happen when the price of the corresponding commodity is high. Fourth, privatization leads to higher productivity but also larger inequality, which in turn makes nationalization more likely.

These observations motivate and provide a context for the main contribution of the paper: a model of the choice between private and national regimes for the exploitation of natural resources. The model emphasizes a basic trade-off between equality and efficiency. Greater equality is obtained under public ownership of a natural resource, while more efficiency obtains when the resource is in private hands. The connection between ownership and the equality-efficiency trade-off is given by the incentives for effort that each regime provides to economic agents. In the private regime, there is a differential compensation scheme that depends on observed productivity, thus encouraging agents to increase effort. Under the national regime, the government cannot credibly commit not to equalize incomes ex-post, thus generating equality but also minimal individual effort.[2] The resolution of the trade-off depends on external and domestic conditions that affect national welfare under each regime. Hence, our framework allows us to study how external variables—such as the price of the commodity in question—and domestic ones—such as the tax regime and financial constraints—affect the choice of private or national regimes. As external and domestic conditions fluctuate, cycles of privatization, and nationalization emerge.

For concreteness, the model focuses on labor effort. But it could be generalized so that effort act as a proxy for all activities that are affected by economic incentives and may have an impact on productivity. From a long run perspective, therefore, effort may not only relate to labor but also to investment in human and physical capital, as well as managerial and entrepreneurial activity. Moreover, given that broadly understood effort applies to all economic activities, the trade-off between nationalization and privatization underscored in the paper applies not only to the natural resource sector but also to the economy in general.

The government's inability to credibly commit not to redistribute after effort and production have been done (in the state ownership regime) and not to take over the sector (in the private ownership regime) is a distortion that generates realistic and complex strategic issues. Under state ownership, domestic agents understand that the government will ultimately wipe away any relative gains from individual effort, which is unobservable; as a result, effort is inefficiently low. Privatization can be seen as a partial solution in which the resource is sold to outsiders or

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foreign investors, who are profit oriented, do not care about redistribution, and hence are able to provide better incentives for effort. Thus, private ownership enhances efficiency and, in fact, serves as a commitment device for the government. However, such a device comes at a cost, as the private regime results in more unequal consumption for domestic agents. Moreover, this cost also includes the profits appropriated by the investors if, as we assume, their welfare is not part of the government's objectives.

The model illustrates how political tension about increased inequality and associated conflicts can emerge as a by-product of the solution of the equity-efficiency problem. Our discussion assigns no direct role to other political characteristics, such as ideological preferences or political regime, which are sometimes stressed in the literature.[3] We abstract from these political considerations not to suggest that they are unimportant but, rather, to emphasize the economic forces behind the drive for privatization and nationalization: ownership regime change can occur even under benevolent governments when the institutional framework of the country is weak (suffering from commitment shortcomings, moral hazard, and informational asymmetry).

Our theoretical contribution is related to some recent papers. Rigobon (2010) studies oil production and profit-sharing contracts between a government and a private company. In Rigobon's model, the government defaults on the contract when profits exceed some exogenous threshold intended to capture the expropriation of "excess" rents. Guriev et al. (2011) considers a contract between a risk-neutral government and a risk-neutral foreign firm whereby the government delegates oil production to the firm. Importantly, the firm can renege on the contract by retaining all the revenues without paying taxes or royalties to the government in a given period. This implies that taxes cannot be too high and, consequently, that expropriation occurs if oil prices are high enough. Finally, Stroebel and van Benthem (2013) consider a contract between a risk-averse government and a risk-neutral firm. The optimal contract provides a trade-off between insurance (provided by price-contingent taxes paid by the firm) and expropriation (which entails benefits and costs to the government). In this model, expropriation occurs in equilibrium due to an asymmetry of information whereby the costs of nationalization are private information (to the government). The government expropriates the private firm when the price of oil is high or when expropriation cost is low.

While related to our model, these papers focus on the interaction between a single domestic agent (the government) and a (foreign) private firm; moreover, they concentrate on the expropriation incentives and decision. Our model considers a diversity of domestic economic agents and deals not only with nationalizations but also with the cycle that includes privatizations. Our approach allows us to consider the trade-off between efficiency and equity generated by moral hazard (by workers) and commitment problems (by the government).[4]

The rest of the paper proceeds as follows: Section 2 reviews the relevant empirical evidence. Sections 3 and 4 develop a model on the choice between private and national regimes: Section 3 describes a one period version which takes the

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current regime as given, while Section 4 analyzes a dynamic version where the possibility of regime shifts arises. Section 5 concludes. Technical proofs and the computation of equilibria are presented in the Appendix.

2. OBSERVATIONS FROM THE EMPIRICAL LITERATURE

We now present four key observations that motivate our theoretical examination. These are derived from both cross-country econometric studies and in-depth regional and country case studies. They are primarily focused on developing countries, where the cycles of nationalization and privatization have been most prevalent.

Observation 1: Nationalizations and privatizations are recurrent phenomena, which often come in waves common to several countries. Kobrin (1984) analyzed expropriations in 79 developing countries over the period 1960–1979. It finds that expropriations grew in the 1960s, peaked in the early 1970s and declined afterwards. Minor (1994) and Shafik (1996) extend Kobrin's study to include the period up to 1993. They find 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) and Stroebel and van Benthem (2013) report the opposite trend in the last decade, albeit in a smaller group of countries (including, for instance, Algeria, Bolivia, China, Ecuador, Russia, and Venezuela). For some of these countries, the current wave of nationalization is only the latest chapter of a recurrent process, as they had previously experienced nationalizations in the 1970s and privatizations in the 1990s (see also Mahdavi, 2014).

Chua (1995) is arguably the most comprehensive historical study of privatization and nationalization cycles, with focus on Latin America and Southeast Asia. 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, as they attained their national independence. Initially, most of these economies were privately run. This changed in the late 1960s and early 1970s, when extensive nationalizations occurred, as they did in Latin America. Also coinciding with the Latin American wave, many state-owned companies in Southeast Asia were privatized in the late 1980s and early 1990s.

Observation 2: Privatization–nationalization cycles tend to occur more often in the natural resources and utilities sectors. Kobrin (1984) documents that in the last five decades expropriations encompassing large portions of the economy

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do occur, but they are less frequent than selective expropriations and have been mostly concentrated in a dozen of countries. In its historical account, Chua (1995) finds that in the majority of countries under analysis, utility and natural resource companies are significantly more prone to undergo nationalization and privatization regime shifts. Chua's account of the ownership swings of oil exploitation companies in Latin America is particularly revealing.

There is a large diversity within natural resources, and a specific type of these resources has been most subject to privatization and nationalization cycles. Kobrin (1984), Chua (1995), and Duncan (2006) single out the mineral and fuel sectors. Their geographic location and production technology make them different and more prone to nationalizations. Auty (2001a, 2001b) differentiates between "point" resources such as oil fields and mineral mines and "diffuse" resources such as land, water, and others related to agriculture. "Point" resources are geographicaly concentrated and involve large, fixed, and specialized capital investment. This makes them particularly vulnerable to political control and abuse, including expropriation.

Observation 3: Nationalization of natural resource industries tends to occur when the price of the corresponding commodity is high. Duncan (2006) investigates the causes of expropriation in the mineral sectors of exporting developing countries. In the study, expropriation is defined as any act by which a government gains a greater income share than it is 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. Covering the period 1960–2002, Duncan (2006) uses probit regressions to estimate the effects of price booms and political and economic crises on the probability of expropriation. The results indicate that price booms are significantly positively correlated with instances of expropriation.

Guriev et al. (2011) examines the determinants of nationalization in the oil sector, using panel data for 161 countries for the period 1960–2002. The paper presents logit pooled regressions of nationalization events on oil price shocks and the quality of government institutions, controlling for country fixed effects and per capita GDP, among other variables. The results show that governments are more likely to practice expropriations when the oil price is high and when government institutions are weak. Analyzing the recent trend in the Latin American oil sector, Manzano and Monaldi (2008) argues that the new wave of nationalizations is induced largely by the increase in international oil prices, especially when tax systems are regressive and do not account for price contingencies (see also Stroebel and van Benthem, 2013). Likewise, Duncan (2006) argues that a combination of high commodity prices and low profit sharing from private firms to host governments gave the latter large incentives to expropriate.

Observation 4: Privatization leads to higher productivity but also larger inequality, and nationalization is more likely when inequality rises excessively.

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Chua (1995) concludes that nationalization in Latin America and Southeast Asia was promoted against not only foreigners but also domestic residents who were perceived as unfairly privileged. Private ownership and management of utility and natural resource companies was seen as worsening the inequality already present in these societies. Likewise, Albornoz et al. (2012) stresses the distributional effects of foreign investment as an important driver of expropriation.

Beyond these aggregate considerations, there are systematic differences in wage and labor outcomes in firms under private versus state ownership regimes; these differences turn out to be relevant to understand the mechanisms explored in the model below. State-owned enterprises (SOEs) tend to employ more people than private firms do, and they compensate their workers in a more egalitarian way. Using a sample of the largest 500 corporations worldwide according to sales in 1975, 1985, and 1995, Dewenter and Malatesta (2001) finds that government firms on average employ more workers, other things constant. Brainerd (2002) confirms this result in the case of Russia. Zhao (2002) uses a survey of Chinese urban households in 1996 and finds evidence that on average, employees of SOEs earn less than those in private firms but this varies according to skill. Specifically, unskilled workers in foreign enterprises earn significantly less than those in the state sector but skilled workers earn more in foreign firms. Moreover, when state-owned enterprises are privatized, employment levels typically decrease and wages for remaining employees often increase and become more dispersed. Chong and Lopez de Silanes (2003) presents a survey of 308 privatized firms in 84 countries and finds that employment declines in over 78% of cases. Galal et al. (1994) studies the post-privatization performance of 12 firms in Britain, Chile, and Mexico and finds that wages for remaining workers are often higher.

The flip side of the higher egalitarianism among workers in SOEs is their lower productivity. For example, Vining and Boardman (1992) finds that large SOEs worldwide are significantly less profitable and less efficient (by employee-to-sales ratio) than privately owned firms. Wolf (2009) finds similar results on profitability for the 50 largest oil and gas companies worldwide over 20 years. Dewenter and Malatesta (2001) concludes that labor productivity (sales-to-employee ratio) significantly increases following privatization in a cross-country sample of 63 privatized firms. Similarly, La Porta and Lopez de Silanes (1999) finds that Mexican SOEs which are privatized increase profitability and decrease employment. Moreover, it argues that workers are paid higher wages in exchange for greater effort.

3. A SINGLE PERIOD MODEL

We now develop a model of an industry that can operate under either a private ownership regime or a state ownership regime. In this section, we confine attention to one typical period taking the ownership regime as given, and focus on the determination of the net benefits of each regime. This highlights a crucial efficiency-equity trade-off derived from a moral hazard problem, together with

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the inability of the government to commit not to redistribute income under state ownership.

We assume that the productivity of workers depends on unobservable effort.[5] 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. This is possible under private ownership; under state ownership, the government cannot refrain from equalizing the incomes of workers ex-post, which destroys incentives for effort. The result is that private ownership is associated with more efficiency but less equality than state ownership, consistently with the stylized facts of the preceding section. Importantly, the equity-efficiency trade-off depends on a number of parameters, such as the degree of risk aversion, as well as other exogenous data including the price of the country's resource.

3.1. Workers

We consider an economy that produces a commodity via an increasing and concave production function $F = F(L)$, where L is labor. The commodity is sold in the world market in exchange for world currency, which is taken as numeraire. The commodity price, denoted by p, is exogenous to the economy under analysis.

The economy is populated by a continuum of ex-ante identical workers of measure N. The labor supply of worker i, denoted by l_i, is a random variable whose distribution depends on the worker's effort, a_i. One can interpret l_i as the worker's productivity for the job, which may be uncertain but is enhanced, on average, by effort spent on education or training. Crucially, everyone observes labor but effort is private information of the worker.

Naturally, exerting more effort is beneficial for productivity. Assume that l_i can be either high (l_H) or low ($l_L < l_H$), and that the probability of high productivity is an increasing and concave function of effort; that function is denoted by $\pi(a)$. Given effort, the realization of labor productivity is i.i.d. across workers. By the law of large numbers, if all workers spend effort a, the actual proportion of workers with high productivity equals $\pi(a)$.

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

Denote the utility of income by $u(c)$ and the cost of effort by $\phi(a)$. We assume $u' > 0 > u''$, $\phi(0) = \phi'(0) = 0$ and $\phi', \phi'' > 0$ for all $a > 0$.[6] Then, the worker chooses a to maximize her expected utility, given by $\pi(a)u\left(y_H^* + T\right) + (1 - \pi(a))\, u\left(y_L^* + T\right) - \phi(a)$. The first order necessary condition is

$$\pi'(a)\left[u\left(y_H^* + T\right) - u\left(y_L^* + T\right)\right] - \phi'(a) = 0. \qquad (\mathbf{1})$$

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

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to consume $y_H^* + T$ instead of $y_L^* + T$. Under our assumptions, $a > 0$ if and only if $y_H^* > y_L^*$. Furthermore, a is increasing in the wage differential.[7]

3.2. State Ownership

Consider a period in which the industry is under state ownership. We make two assumptions about this regime: (i) the government maximizes an equally weighted sum of the utilities of domestic workers, and (ii) the government chooses a wage schedule and taxes *after* effort has been spent and individual productivity is observed.

The last assumption is crucial and 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.

Given the probability π (and assuming without loss of generality that $T = 0$), 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 $N[\pi y_H + (1-\pi)y_L] = pF(N(\pi l_H + (1-\pi)l_L))$. The first order conditions with respect to y_H and y_L imply $u'(y_H) = u'(y_L)$ or, equivalently, $y_H = y_L$. Intuitively, since the wage schedule no longer distorts effort choice, the government chooses it to prevent consumption inequality. But, as agents predict that their compensation does not depend on productivity, they exert the minimum amount of effort, $a_S = 0$. Hence, aggregate labor is $L_S = N[\pi(0)l_H + (1-\pi(0))l_L]$, which is the smallest possible labor supply.

Note that this solution is independent of the commodity price. But the welfare of the typical worker does depend on p, and will be denoted by $U_S(p) = u(pF(L_S)/N)$. Summarizing,

PROPOSITION 1. *Under state ownership, the government equalizes consumption across agents, and effort, labor, and output fall to their smallest possible values.*

3.3. Private Ownership

When the industry operates under private ownership, 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. Also, private owners appropriate part of the benefits from the resource, as we will see.

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 a dividend tax τ and a sales tax θ. The receipts from these taxes are rebated lump-sum to the workers.[8]

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

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

subject to an incentive compatibility (IC) and an individual rationality (IR) constraints,

$$u(y_H + T) - u(y_L + T) - \gamma(a) = 0, \tag{2}$$
$$\pi(a)u(y_H + T) + (1-\pi(a))u(y_L + T) - \phi(a) \geq U^*,$$

where $\gamma(a) = \phi'(a)/\pi'(a)$. The IC constraint requires the wage schedule and suggested effort to be consistent with the worker's optimal effort choice.[9] The IR constraint requires the proposed contract to deliver a level of utility at least as large as the utility that the worker can get in the market.

The first order condition with respect to n is

$$p(1-\theta)F'(n\ell(a))\ell(a) = \pi(a)y_H + (1-\pi(a))y_L, \tag{3}$$

where $\ell(a) = \pi(a)l_H + (1-\pi(a))l_L$ is expected labor given effort a. At the optimum, the expected increase in revenue to the firm of hiring one more worker equals the expected wage payment to the additional worker.

The first order conditions with respect to y_H and y_L can be written, respectively, as

$$\frac{n}{u'(y_H + T)} = \lambda + \frac{\eta}{\pi(a)}, \tag{4}$$

$$\frac{n}{u'(y_L + T)} = \lambda - \frac{\eta}{1-\pi(a)}, \tag{5}$$

where $\eta(1-\tau)$ and $\lambda(1-\tau)$ are the multipliers on the IC and IR constraints. To interpret, suppose (counterfactually) that the IC constraint does not bind ($\eta = 0$). In this case, the first order conditions imply $y_H = y_L$. The firm would pay the same amount to workers regardless of their productivity 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. This wedge is induced by the multiplier η.

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

$$n\pi'(a)\left[p(1-\theta)F'(n\ell(a))(l_H - l_L) - (y_H - y_L)\right] = \eta\gamma'(a). \tag{6}$$

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 IC constraint: a small increase in a implies that the difference between $u(y_H + T)$ and $u(y_L + T)$ must increase by $\gamma'(a)$. To obtain the associated cost, we multiply $\gamma'(a)$ by the shadow cost of the incentive constraint, η.

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The following lemma, proven in the Appendix, lists properties of the optimal contract:

LEMMA 1. *(i) The IR constraint is binding; (ii) The IC constraint multiplier is positive, $\eta > 0$; (iii) The optimal contract is monotone, that is, $y_H > y_L$.*

We now consider the industry equilibrium. Because all firms are equal, in equilibrium $n = N$, $\{a, y_H, y_L\} = \{a^*, y_H^*, y_L^*\}$, and $U^* = \pi(a^*)u(y_H^* + T) + (1 - \pi(a^*))u(y_L^* + T) - \phi(a^*)$. In addition, the government rebates the collected taxes to the workers. Thus, the government budget constraint is

$$TN = \tau \left[p(1-\theta)F(N\ell(a)) - N\left(\pi(a)y_H^* + (1-\pi(a))y_L^*\right)\right] + \theta p F(N\ell(a)). \tag{7}$$

Collecting results, the system of equations (2)–(7), with $n = N$ and $\{y_H, y_L\} = \{y_H^*, y_L^*\}$, determine the six variables $\left\{y_H^*, y_L^*, a^*, T^*, \lambda, \eta\right\}$. The solution implies that the average worker has utility $U_P(p) = \pi(a^*)u(y_H^* + T^*) + (1 - \pi(a^*))u(y_L^* + T^*) - \phi(a^*)$. As in the state ownership regime, the equilibrium under private ownership depends on the resource price p. The following proposition summarizes:

PROPOSITION 2. *Under private ownership, workers exert positive effort and the high productivity workers are paid more than the low productivity ones. The optimal contract induces consumption inequality and imperfect risk sharing.*

3.4. Efficiency and Welfare

Positive effort under private ownership implies that effective labor, production, and average consumption are all greater than under state ownership. This, however, comes at the cost of consumption inequality. Also, some of the profits are appropriated by private owners; this is a cost if the welfare of owners is not part of the national welfare function, as would be the case if owners are foreigners, for example.

The cost associated with the profit share accruing to owners can be reduced by raising the tax rates τ and θ. But some limits on those taxes are needed for a non-trivial trade-off between the national and private regimes. In particular, if dividend taxes converge to 1 and sales taxes are set to zero, the government is able to attain the ex-ante constrained-efficient allocation under a private ownership regime – the allocation that a benevolent planner that is subject to the same information constraints as private firms would choose. This is summarized in

LEMMA 2. *A private-ownership regime with $\theta = 0$ and $\tau \to 1$ attains the ex-ante constrained-efficient allocation.*

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For the rest of the paper, we maintain the realistic assumption that $\tau < 1$. This is also the only sensible option, because in the full dynamic model no privatization will ever be possible if potential buyers have to pay 100% in taxes on their profits.

Under our assumptions, therefore, there is a non-trivial trade-off between the private and state ownership regimes at any price p. On the one hand, a state ownership regime induces perfect risk sharing across workers, but at the cost of low aggregate productivity. On the other hand, by providing incentives to exert effort, private firms are able to achieve higher labor productivity. This higher output, together with the lump-sum transfers obtained from the taxation of sales and profits, benefit not only high ability workers but also the low ability ones. However, risk sharing is imperfect and private owners appropriate a fraction of profits, so the allocation under private ownership regime is not constrained efficient either.

Note the key role of the assumption that the government cannot refrain from redistributing income *ex-post* if able to. If the government could pre-commit not to do that, state ownership would be preferred to private ownership, as the government would be able to elicit an efficient amount of effort without having to forgo the profits extracted by owners in a privatized regime. In that case, our analysis indicates that only state ownership would be observed (and we would have to search for a different explanation for the cycles of privatization and nationalization).[10]

The counterpart to the last observation is that privatization may be valuable to the country because it may serve as a commitment device, albeit imperfect. This would be reflected, in particular, by the fact that productivity is higher under private ownership than under state ownership. This is worth noting, because increased productivity has been often mentioned as an advantage of privatization, but for reasons that are quite different from ours.

3.5. Numerical Explorations

For a deeper understanding of the model, we resort to numerical exercises. We view these exercises as providing further insights into the working of the model and not as a realistic depiction of any privatization–nationalization episode; our model is too stylized for that purpose. But we do make assumptions about functional forms and parameters that generate predictions that are qualitatively consistent with the empirical regularities of section 2.

We assume constant absolute risk aversion utility, $u(c) = \left(1 - e^{-\gamma c}\right)/\gamma$, where $\gamma > 0$ is the coefficient of absolute risk aversion; a cost of effort function given by $\phi(a) = \varphi a^2/2$, where $\varphi > 0$; a Cobb–Douglas production function, $F(L) = AL^{\alpha}$, where A is the level of productivity and $0 < \alpha < 1$; and a function transforming effort into probabilities of drawing high labor endowment given by $\pi(a) = 1 - \delta e^{-\nu a}$, where $0 < \delta < 1$ measures the probability of low endowment when effort is zero and $\nu > 0$ measures the sensitivity of $\pi(.)$ to a.

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TABLE 1. Baseline parameters

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

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

Given these assumptions, it is straightforward to solve for the outcome of the state ownership regime. The private ownership regime is more involved, as its solution is only given in implicit form by the system (2)–(7); the computation is described in the Appendix. In all cases, that we computed, we found two threshold prices $\underline{p} << p^*$ that partition the set of prices $[0, \infty)$ so that, for all prices below $\underline{p}$ and above p^*, welfare is larger under a state ownership regime, while for all prices between $\underline{p}$ and p^*, welfare is larger in a private ownership regime. The threshold $\underline{p}$, however, is always very close to zero (never greater than one) and disappears in the dynamic version of the model as soon as we introduce a cost of nationalizing the industry. For that reason, we focus only on the regions $(\underline{p}, p^*)$ and (p^*, ∞), which we refer to as the "low price" region and the "high price" region.[11] Figure 1 displays a typical solution of the static model.

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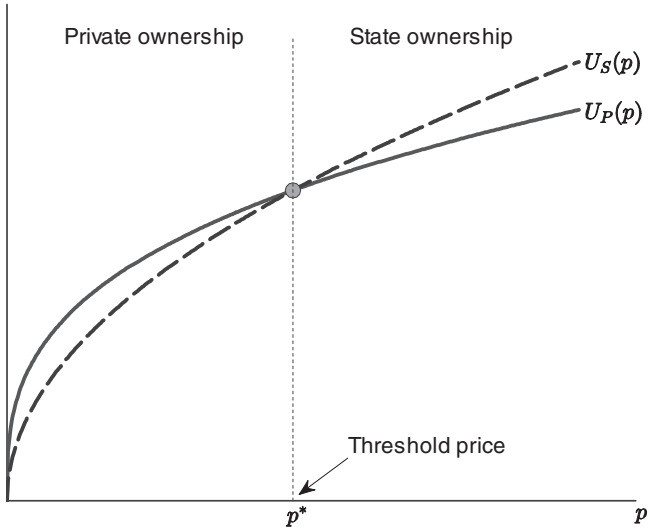


FIGURE 1. Optimal regime choice in static model.

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

Table 2 describes how the threshold p^* depends on parameter values. The first row of the table refers to the baseline parameterization. The table reveals that all parameters have a monotonic relation with the privatization threshold p^*. For example, p^* is decreasing in the risk aversion parameter γ. This is intuitive: 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 range of prices for which a state ownership regime is superior than the private regime increases as well; that is, p^* decreases. Likewise, p^* is decreasing in the cost of effort parameter φ : if 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, reducing p^*.

An increase in δ, the probability of drawing a low labor endowment when effort is zero, reduces the value of state ownership because aggregate labor declines;

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TABLE 2. Static model

Symbol	Description	Value	p^*
–	Baseline Economy	–	40.1
γ	Risk Aversion	2	53.6
		3	31.5
φ	Effort parameter	0.5	48.6
		1.5	35.1
δ	Probability of success parameter	0.9	6.9
ν	Probability of success parameter	1.5	32.9
		2.5	45.4
l_H/l_L	Ratio of labor endowments	5	27.0
		20	49.4
α	Labor exponent in technology	0.5	17.8
		0.75	55.8
τ	Dividend tax	0.2	37.9
		0.4	42.6
θ	Sales tax	0.2	37.9
		0.4	42.3

it also increases incentives to exert effort in a privatized regime, enabling firms to elicit the same amount of effort with a smaller dispersion in wages. On both counts, p^* increases. Likewise, p^* is increasing in the sensitivity parameter ν. A higher ν enhances the benefits of a privatized regime because a marginal increase in effort induces a larger increase in the probability of success, implying that effort is more rewarding to workers and, therefore, it is easier for firms to provide incentives.

Changes in the relative productivity of high versus low productivity workers, l_H/l_L, are analyzed under the assumption that that the average labor supply in a state-owned regime—that is, when effort is zero—remains constant. In a private ownership regime, an increase in l_H/l_L increases the efficiency gains of differentiating workers through a more unequal payment schedule. In other words, an increase in the spread of labor productivity makes a private ownership regime more efficient. Thus, p^* increases, as shown in the table. Likewise, p^* is increasing in the technology parameter α. As α increases the technology becomes more "linear"; accordingly, the benefits of inducing workers to exert effort increase, and p^* increases as well.

Finally, p^* increases with the tax rates τ and θ. Under private ownership, higher tax rates take profits from outside owners and allow for higher lump-sum transfers to the workers. This, in turn, means not only that the average worker's income increases, but also that the difference in labor income between high and low ability workers becomes less important, since their relative total income (including lump-sum transfers) becomes more equal. Thus, private ownership becomes more desirable, as reflected by a higher p^*.[12]

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4. THE DYNAMICS OF PRIVATIZATION AND NATIONALIZATION

4.1. Multiperiod Version of the Model

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

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

As before, we assume that the government is benevolent in that it maximizes the welfare of the average worker. Here, though, the government's regime choice is an intertemporal decision problem, in which the stochastic behavior of the price p_t needs to be taken into consideration in relation with various costs and benefits.

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

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

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

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

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is p. Similar definitions hold for $V_S(p)$, the value in a state ownership regime, and $V_S^0(p)$, the value in a period in which the industry is nationalized.

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

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

where $Q(p, B) = \Pr\{p_{t+1} \in B | p_t = p\}$ 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, $V_P\left(p'\right)$, or to nationalize the industry, $V_S^0(p')$.

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

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

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

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

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

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 cost c_S, the payoff in a nationalization period is, simply, $U_S^0(p) = u\left[(pF(L_S) - c_S)/N\right]$. To describe the payoff in a privatization period, $U_P^0(p)$, 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 $\Omega = \left\{p' : V_P(p') \geq V_S^0(p')\right\}$ is the set of prices tomorrow for which the industry remains private, and $R(p)$ is the firm's before-dividend-tax profit function.[13]

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

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

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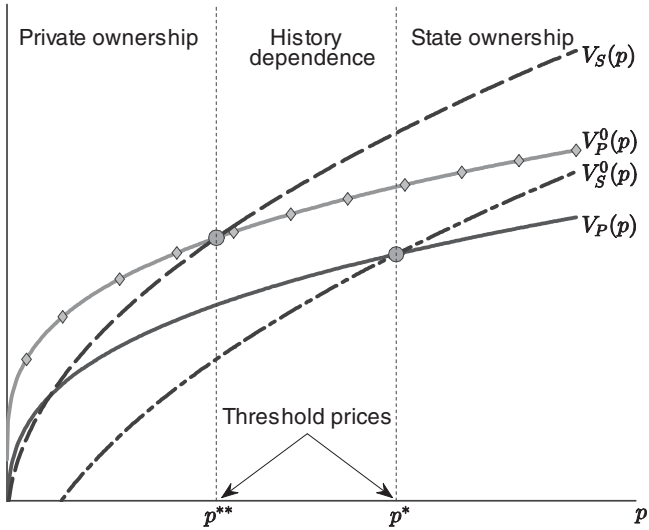


FIGURE 2. Optimal regime choice in dynamic model.

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

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

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

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

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

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 functional equations (8), (9), (10), and (11). For an interesting range of parameters, the solution is illustrated in Figure 2. The functions V_P and V_S inherit the shapes of U_P and U_S respectively. The figure identifies a trigger price p^* such that $V_P(p^*) = V_S^0(p^*)$. From (8), p^* is the price at which the government is indifferent between nationalizing a privately owned industry or not. As long as the price is below p^*, the government leaves the industry in private hands; nationalization occurs if the price jumps above p^*.

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The figure also identifies another 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 equilibria 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 preceding 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 $p_0, p_1, ..., p_{t-1}$ 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. Key Implications and Interpretation

We assume that the price follows $\log p_t = \log \bar{p} + z_t$, where z_t is an AR(1) process, $z_t = \rho z_{t-1} + \varepsilon_t$, $|\rho| < 1$ and $\varepsilon_t \sim N(0, \sigma^2)$.[14] We interpret a period in the model to be one year, and estimate the parameters of the price process by running a first order autoregression on the logarithm of real yearly crude oil prices.[15] The point estimates of these regressions are $\rho = 0.89$, $\sigma = 0.24$, and $\bar{p} = 54.6$. Thus, the expected value and standard deviation of the invariant distribution of the price p_t are 62.8 and 35.5 respectively.

To complete the model calibration, we choose the parameters β, r, κ, and c_S (and those common with the static model) to imply privatization and nationalization cycles of similar duration to those observed in the hydrocarbon sector in Bolivia—historically, a state ownership regime in Bolivia lasts between 20 and 25 years while private ownership, between 12 and 15 years.[16] We assume a subjective discount factor of $\beta = 0.95$ and an interest rate of $r = 0.1$. We assume that 50% of the resources raised at the privatization period are redistributed to the workers, so that $\kappa = 0.5$. A reasonable value for the nationalization cost c_S is more difficult to choose. Here, we simply assume that the nationalization cost is such that if the commodity price is 30% of its long-run average value, namely $0.3E(p_t)$, consumption in a state ownership regime is zero. This implies $c_S = 0.3E(p_t)F(L_S)$. For our baseline calibration, the nationalization cost is $c_S = 0.64$, which represent about 31% of the value of production at the nationalization price p^*. These parameters are reported in Table 1.

Given the baseline parameters, we compute numerically the trigger prices p^{**} and p^* as well as other interesting implications of the model, such as the average duration of each regime. We define the duration of a state ownership regime as the average number of years that it takes for the price to reach p^{**} for the first time, starting at p^*; the duration of a privately owned regime is defined analogously. These statistics depend on parameters only through the invariant distribution of prices and the thresholds p^* and p^{**}.[17]

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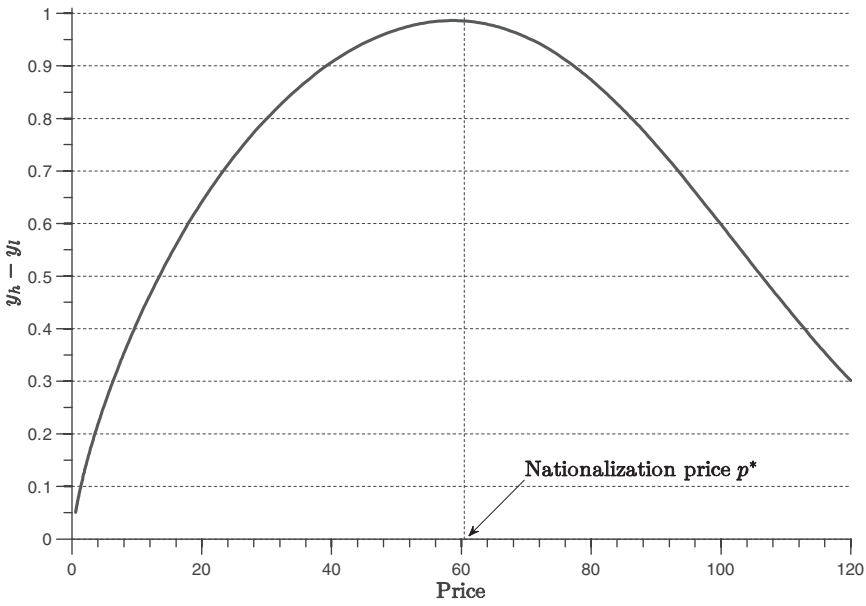


FIGURE 3. Labor income difference under private regime.

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

Further insight is obtained by delving deeper into the dynamics of income inequality. Figure 3 plots the difference of the incomes of the two types of workers, $y_H - y_L$, as a function of the resource price p, assuming private ownership. The difference widens for an initial range of values of p up to a maximum near $p = 58.7$. Nationalization occurs for values of p above $p^* = 60.4$; $y_H - y_L$ is still very close to its maximum at this price. Hence, the figure indicates that income differences increase with p while the resource is in private hands, and are close to maximal when nationalization occurs.

Figure 4, in turn, plots output, labor supply, and effort as functions of p, assuming again a private regime. Effort increases with p for low values, and then decreases; the graphs of labor and output mirror that of effort. This reflects that providing incentives for effort is increasingly costly as the resource price increases. A higher p means that the average income of workers goes up (because of competition and transfers); accordingly, inducing high effort requires firms to pay a larger wage differential, due to concave utility. Firms respond to this trade-off by indeed increasing the wage differential (as shown in Figure 3) but also allowing effort to fall when p increases (except for low values of p, as noted).

Notably, in a private regime, the fact that effort falls with p is consistent with a simultaneous increase in income inequality. In this respect, figures 3 and 4

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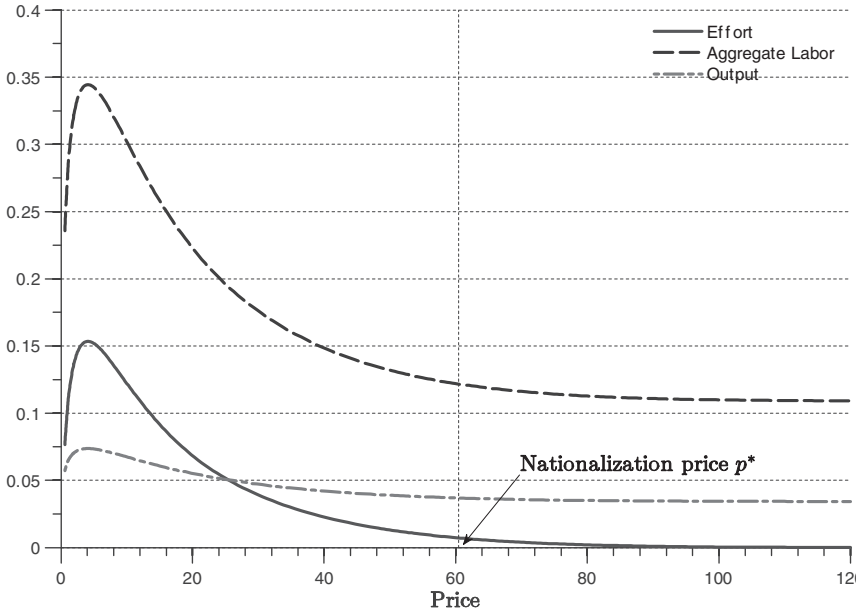


FIGURE 4. Effort, aggregate labor, and output under private regime.

reinforce each other. They show that inequality goes up with p for two reasons: the incomes of high productivity workers increase relative to the incomes of low productivity ones; and the numbers of the former (the highly paid ones) fall relative to the latter, since smaller effort implies a smaller $\pi(a)$.

As noted earlier, in a private regime, part of the revenue from the resource is appropriated by firm owners in the form of after tax profits. Hence, nationalization has an additional benefit in the expropriation of those profits and its redistribution towards the workers. To assess this force, Figure 5 shows how income is split between workers and firms in a private regime as the price p changes. The figure shows that the payoffs to firm owners indeed increases with p. But the figure also shows that workers benefit too. In fact, the respective shares are virtually independent of p in the baseline model: firm owners are paid about 16% of revenues, workers the rest.

These observations add up to the following: If the resource is in a private regime, increases in p imply that the main advantage of the regime, efficient effort provision leading to higher productivity, shrinks. At the same time, higher p means that wage inequality widens, and also that the amount paid to firm owners, as after tax profits, increases. Hence, if p rises sufficiently, that is, if it rises above p^*, it becomes optimal for the government to nationalize the resource, paying the cost c_S. State ownership implies that workers' incomes are equalized and that no revenue is lost to outsiders (potential firm owners). But it has a cost: suboptimal amounts of effort and labor supply. This cost is greater when the price p falls

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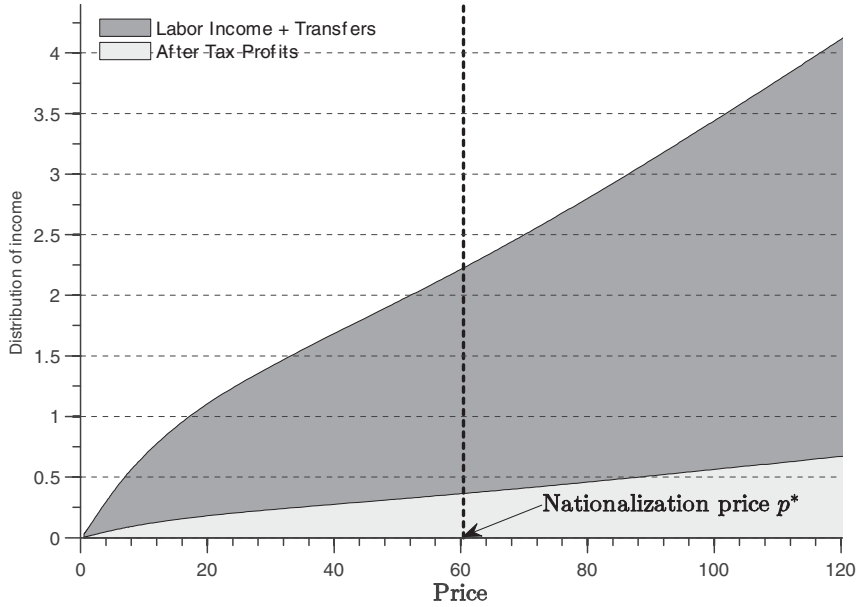


FIGURE 5. Distribution of aggregate income under private regime.

away from p^*, as Figure 3 implies. If p crosses p^{**}, the government privatizes the resource to restore efficiency, even at the cost of increased inequality.

It is worth stressing that, in a private regime, the shares of income going to workers and private owners is roughly independent of p, while income inequality clearly worsens as p increases. This indicates that it is the dynamics of inequality, rather than the loss of rents to outside owners, which drives the switches between private and state ownership over time.

4.3. Comparative Dynamics

Table 3 reports the threshold prices and duration statistics implied by different parameterizations. The first row refers to the baseline parameterization; in subsequent rows, the baseline parameters are changed one at a time.

The findings are intuitive. Consider, for instance, an increase in risk aversion from the baseline $\gamma = 2.5$ to $\gamma = 3$. Both threshold prices decline, the average duration of a state ownership regime increases substantially, and that of a privately ownership regime decreases slightly. The intuition for the change in the thresholds is the same as in the static model: higher risk aversion increases the social welfare cost of inequality, thus making nationalization more socially attractive relative to private ownership. To understand the duration statistics, note that the stationary distribution of prices does not change. Since prices are mean reverting and the

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TABLE 3. Dynamic model

Symbol	Description	Value	Thresholds p^{**}	Thresholds p^{*}	Average Duration of Regime: State-owned	Average Duration of Regime: Private
–	Baseline Economy	–	36.7	60.4	22	14
γ	Risk Aversion	2	48.3	70.4	13	16
		3	29.4	54.1	38	13
φ	Effort parameter	0.5	44.2	66.9	15	15
		1.5	32.4	56.7	30	13
δ	Prob. of success parameter	0.9	18.5	45.6	166	13
ν	Prob. of success parameter	1.5	30.6	55.2	35	13
		2.5	41.5	64.6	16	14
l_H/l_L	Ratio of labor endowments	5	25.7	51.7	54	13
		20	45.2	67.6	14	15
α	Labor exponent (techn.)	0.5	17.6	42.3	200	12
		0.75	50.0	74.3	13	17
τ	Dividend tax	0.2	34.8	57.7	25	13
		0.4	38.7	63.4	21	14
θ	Sales tax	0.2	34.9	57.8	26	13
		0.4	38.6	63.4	20	15
A	Productivity	0.1	53.4	75.0	10	16
		0.2	28.1	53.0	43	13
c_S	Nationalization cost	0.43	37.4	52.6	19	10
		0.86	36.2	67.8	25	18
κ	Privatization benefit	0.25	36.4	62.4	23	15
		0.75	37.0	59.5	22	13
ρ	Persistence of shock	0.5	40.5	63.4	19	5
	(mean preserving)	0.95	35.7	59.6	25	24
σ	Volatility of shock	0.12	38.1	58.2	98	14
	(mean preserving)	0.48	31.2	58.0	11	14

average price is above both threshold prices, the decline in the latter implies a longer average transition from p^* to p^{**} and a shorter transition from p^{**} to p^*.

The analysis of changes in the parameters φ, δ, ν, l_L/l_H, α, τ, θ, and A, is similar: the impact on p^* and p^{**} is as in the static model; since the stationary distribution of p is unchanged, duration statistics then change accordingly.

Consider now parameters specific to the dynamic model. An increase in the nationalization cost c_S to 0.86 raises the nationalization threshold p^* from 60.4 to 67.8 and lowers the privatization threshold p^{**} from 36.7 to 36.2.[18] It is obvious why p^* increases: given a higher nationalization cost, the welfare costs of a privately owned regime must become larger before nationalization is called for. That the privatization threshold p^{**} also changes may be more of a surprise, however, since c_S is paid only when there is nationalization. The explanation of

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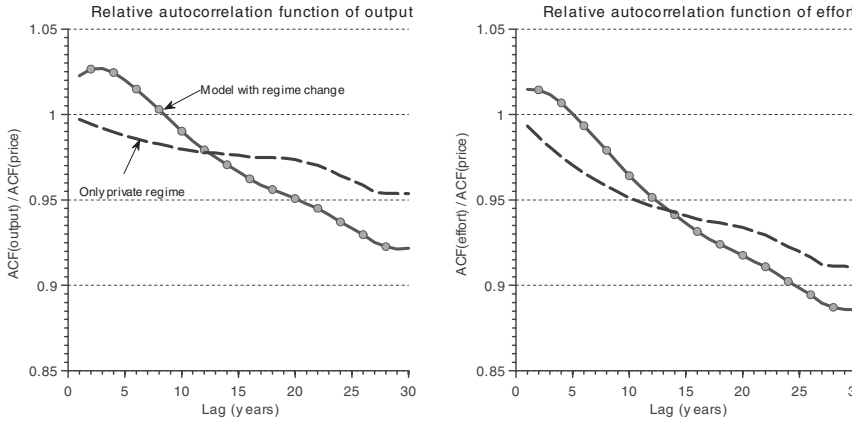


FIGURE 6. Persistence of output and effort.

the fall in p^{**} is the indirect negative impact of a higher c_S on the value of private ownership due to the expectation of future re-nationalization at a higher cost. Because of discounting, changes in c_S have a larger impact on p^* than on p^{**}, increasing the average duration of the private ownership regime substantially more than that of a state-owned regime. The analysis of a change in the privatization benefit κ is similar.

The bottom entries of Table 3 examine perturbations of the stochastic process z_t. A mean preserving[19] fall in the persistence parameter ρ from 0.89 to 0.5 increases the privatization threshold p^{**} from 36.7 to 40.5 and the nationalization threshold p^* from 60.4 to 63.4.[20] In addition, the duration of both regimes declines. Intuitively, lower persistence implies that p will cross the thresholds p^* and p^{**} more frequently, leading to shorter regime durations.[21] Similarly, a mean preserving increase in the price volatility σ from 0.24 to 0.48 leads to a fall in both threshold prices and shorter durations, which is intuitive.[22]

To clarify the propagation mechanism embedded in the model, Figure 6 summarizes stochastic properties of the endogenous variables vis-à-vis the price p_t. In the left panel, a solid-circled line displays the ratio of the autocorrelation function of output to that of the price – the relative autocorrelation function—for the baseline parameterization of the model. A second, dashed line displays the corresponding function for a model in which the industry is always private.[23] The right panel of the figure displays the relative autocorrelation functions for effort.

For any given lag, we say that the endogenous variable displays more (less) persistence than the price if the relative autocorrelation function at that lag is above (below) one. Output displays more persistence than the price at lags one through nine and less persistence at longer lags. The differences are significant: output is almost three percentage points more persistent than the price at the third lag, and almost eight percentage points less persistent than the price at the 30th lag. The results for labor effort are similar.

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The endogenous variables have different persistence than the price for two reasons. First, the model delivers policy functions that are nonlinear functions of the price. Second, and more importantly, the endogenous choice between private and national regimes induces more persistence at shorter lags and less persistence at longer lags. To assess the importance of each, compare the relative autocorrelation functions of the baseline model and of the model with only a private regime. The latter differs from unity only due to the nonlinearity of the policy functions. The difference between the two relative autocorrelation functions then reflects the additional propagation mechanism induced by the privatization–nationalization choice.

As shown by Figure 6, the endogenous variables in the model with only private firms are *less* persistent than the price at all lags, while those in the model with regime change are more persistent than the price at short lags. The higher persistence at short lags in the model with regime change is due to the high persistence in the national regime, as effort, labor, and output are all constant in that regime. On the other hand, the model with only private firms is more persistent than the model with regime change at longer lags because the shifts in regime, whose likelihood increases with lag length, induce large changes in the endogenous variables. Notably, the relative autocorrelation functions cross at the 14th lag, consistent with the observation that, on average, there are regime shifts every 14 years (from private to national) and every 22 years (from national to private).

4.4. Discussion

It is worth stressing the ways in which the model is consistent with the set of four observations identified in Section 2. As to *Observation 1*, the dynamic model stresses the repeated, cyclical nature of privatization–nationalization episodes. In the model, the choice between public versus private ownership reflects an underlying equity-efficiency trade-off, which is affected in a natural way by the cyclical fluctuations of the natural resource price. Moreover, while we have modeled a single country, our model is consistent with the observation that these episodes often involve multiple producer countries because the resource price is presumably common to them.

With respect to *Observation 2*, our analysis stresses factors that are likely to be more prevalent in natural resource sectors than in alternative ones. The model, in particular, assigns a key role to the movements in the international price of the national resource. Furthermore, in the model the exploitation of the resource is the main (indeed the only) productive activity of the domestic economy. These two features are typical of economies based on the exploitation and export of natural resources.

Observation 3 is reproduced by the model. Its calibrated versions imply that nationalizations happen when the price of the domestic resource is high, reflecting heightened concerns about equity. Privatizations occur in our model when prices

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fall below a threshold value. If prices subsequently increase, the resulting windfalls are partly appropriated by the private buyers, until the price increase triggers nationalization.

Finally, nationalization occurs in the model when inequality across workers becomes relatively more important. At the same time, when a nationalization is triggered profits of the privately owned firm are at their highest. In this sense, the model accounts for *Observation 4*.[24]

5. CONCLUDING REMARKS

Our model highlights that cycles of nationalization and privatization are, ultimately, linked to the government's inability, under a nationalized regime, not to redistribute income among domestic workers. In this sense, the model implies that institutional improvements may help eliminating privatization–nationalization cycles, but only to the extent that such reforms enhance the ability of the government to commit in advance to a (non-) redistributive policy. Institutional reforms to increase transparency and accountability, or to strengthen property rights, are examples in this regard.

A less obvious suggestion for policy relates to the possible impact of financial reform on privatization–nationalization cycles. An implicit assumption underlying our theory is that, in a privatized regime, workers cannot pool wage income risks with each other. This is a natural assumption and is consistent with the view that countries that display privatization–nationalization cycles are likely to suffer from financial frictions as well. In this regard, we 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 reforms would reduce the incentives for nationalization.

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

NOTES

1. In the working paper version of the paper (Chang et al. 2010), we present an analytical narrative of three illustrative case studies of repeated nationalization and privatization of a natural-resource industry: Bolivia and hydrocarbons, Venezuela and oil, and Zambia and copper. There, we focus on the periods before and after privatization and nationalization, with the objective of relating regime shifts to the behavior of the price of the commodity, its level of production and capital investment, the taxes and other fiscal revenues derived from its exploitation, and the average income and degree of inequality of society at large.

2. This assumption is similar to that of Perotti (1995), but our model and analysis are quite different.

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3. The conventional wisdom (Biglaiser and Danis, 2002; Jensen, 2008; Li, 2009; and Mahdavi, 2014) is that democratic regimes are more likely to privatize and autocratic regimes are more prone to nationalize. More nuanced conclusions stress the importance of political checks and balances in reducing the likelihood of expropriation even in autocracies (Li, 2009) and the relevance of populist tendencies in increasing the possibility of nationalization even in democracies (Albornoz et al. 2012).

4. Our paper is also linked to the literature on the "natural resource curse" that follows seminal work by Sachs and Warner (1995). See also Auty (2001a, 2001b); Atkinson and Hamilton (2003); Bulte et al. (2005); Manzano and Rigobon (2007); and Alexeev and Conrad (2009, 2011).

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

6. $\phi(0) = 0$ is a normalization. $\phi'(0) = 0$ guarantees that positive effort is chosen whenever $y_H^* > y_L^*$.

7. 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 $\gamma'(a) > 0$, gives $da/d\Delta > 0$.

8. Alternatively, we could assume a single firm. This approach, however, delivers the extreme result that low productivity workers are paid zero under the optimal contract. With our industry structure all workers have an outside option that imposes a lower bound on their labor incomes. In any case, results are qualitatively the same under both industry structures.

9. Using the worker's first order condition as a constraint on the principal problem is legitimate since our problem satisfies the conditions in Rogerson (1985) for the validity of the "first order approach."

10. Readers might notice that, in contrast with our assumptions about redistributing labor income, in a private regime the government can commit not to increase profit taxes or sales taxes after production. One justification is essentially the same as the one for assuming $\tau < 1$: if the government could tax profits ex post, then it would expropriate all profit. Then privatization would not be feasible, and we would have to look for a different theory. In practice, and presumably for these reasons, privatization contracts often stipulate tax rules with the purpose of preventing the government from taxing profits ex post. Our assumption is, effectively, that such rules cannot be reneged upon unilaterally unless there is nationalization.

11. At very low prices, those below $\underline{p}$, private firms have few incentives to differentiate workers. In effect, as the price approaches zero, the optimal contract requires agents to exert zero effort. But if effort approaches zero, productivity under private ownership approaches productivity under state ownership. Therefore, state ownership becomes welfare superior for p close to zero, as all production is distributed to the workers, while under private ownership firms take part of the profits.

12. The change in θ has an additional impact on the firm's behavior since, from the 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.

13. From Section 3, $R(p) = p(1-\theta)F(N\ell(a^*)) - N[\pi(a^*)y_H^* + (1-\pi(a^*))y_L^*]$.

14. The literature is inconclusive regarding the stationarity of oil and mineral prices. See Noguera (2013) for a review and new results. We assume that resource prices are stationary for tractability, as in Guriev et al. (2011) and Stroebel and van Benthem (2013). As noted in the latter paper, a unit root process for resource prices would reinforce the result that nationalization is more likely as prices increase.

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

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16. Bolivia is chosen because its regime changes were (1) rather regular and repeated over a long period of time, and (2) specifically related to a natural resource sector (hydrocarbons). The phenomena were less regular and more generalized (across sectors) in countries such as Russia and Venezuela, which admittedly are larger and more influential than Bolivia.

17. They are computed via Monte Carlo simulations: we run 3,000 simulations of length 50000, where the initial price is drawn randomly from the invariant distribution of prices. For each simulation we compute the average duration of each regime and next average the results across simulations.

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

19. We adjust $\bar{p}$ so that the invariant distribution of p_t has the same mean of $E(p_t) = 62.8$. However, there are not enough parameters to simultaneously maintain the mean and standard deviation of p_t constant while changing the persistence of the process. Thus, keeping the mean constant, changes in ρ or σ necessarily involves changes in the volatility of p_t. This should be kept in mind when interpreting of the results of this experiment.

20. Neither p^* nor p^{**}, however, move monotonically with changes in ρ.

21. When ρ declines, the long-run variance of the price declines as well, as noted in a preceding footnote. This, in turn, could lead to longer regime durations; in our parameterization, however, this effect is dominated by the one discussed in the main text.

22. Actually, the table says that the duration of private ownership does not change. But if the model is calibrated on a monthly basis we do observe a decline of a few months in the duration of a privately owned regime. The yearly frequency of the model is too coarse to capture the shorter duration.

23. We run 250 simulations of length 100,000, where the initial price is drawn randomly from the invariant distribution of prices. We compute the sample autocorrelation function for each simulation and average the results across simulations.

24. But note again that, in the model, private owners do make normal profits even after accounting for the possibility of expropriation. Indeed, the price at which the owners initially acquire the resource takes into account that nationalization will occur when the price increases sufficiently.

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APPENDIX

A.1. PROOFS

Proof of Lemma 1: (i) We proceed by contradiction. Suppose $\left\{y_H^o, y_L^o, a^o, n^o\right\}$ is optimal but

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

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

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

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

(ii) As in Holmstrom (1979), we proceed by contradiction. Suppose $\eta \leq 0$. Using $\gamma'(a) > 0$ and $\eta\gamma'(a) \leq 0$, the optimal effort choice (6) implies

$$n\pi'(a)\left[p(1-\theta)F'(n\ell(a))\,(l_H - l_L) + y_L - y_H\right] \leq 0. \tag{A1}$$

The first order conditions (4) and (5), together with $\eta \leq 0$ give

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

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

$$\begin{aligned} &n\pi'(a)\left[p(1-\theta)F'(n\ell(a))\,(l_H - l_L) + y_L - y_H\right] \\ &\quad \geq n\pi'(a)\,p(1-\theta)F'(n\ell(a))\,(l_H - l_L) > 0. \end{aligned}$$

This result contradicts (A1). Therefore, $\eta > 0$.

(iii) Rearranging (4) and (5), and using $\eta > 0$ gives $u'\,(y_H + T) < u'\,(y_L + T)$. The concavity of $u\,(c)$ implies $y_H > y_L$. ■

Proof of Lemma 2: The constrained-efficient allocation solves

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

subject to the IR and IC constraints

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

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to which we attach the multipliers N/λ and $\eta N/\lambda$, respectively. The first order conditions with respect to y_H, y_L, and a, can be written as

$$\frac{N}{u'(y_H)} = \lambda + \frac{\eta}{\pi(a)}$$
$$\frac{N}{u'(y_L)} = \lambda - \frac{\eta}{1-\pi(a)},$$

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

These conditions and the constraints determine the constrained-efficient allocation $\left\{y_H^e, y_L^e, a^e, \lambda^e, \eta^e\right\}$.

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

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

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

A.2. COMPUTATION OF THE STATIC EQUILIBRIUM UNDER PRIVATE OWNERSHIP

We simplify the system (2)-(7) as follows. We write the payments y_H and y_L as a function of T, λ, and η by rewriting equations (4) and (5) as

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

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

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

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

We solve this system of equations on a grid of prices $\{p_1, p_2, ..., p_M\}$.

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A.3. COMPUTATION OF THE DYNAMIC MODEL

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

We use the following algorithm to solve the model:

1. Find the functions $U_P(z)$, $R(z)$, $U_S(z)$, and $U_S^0(z)$ on a grid of points and linearly interpolate their values at each z not on the grid;
2. Choose a grid of points $\mathcal{Z} = \{z_i\}_{i=1}^M$;
3. Choose initial guesses $V_P(z;0)$, $V_S(z;0)$, $V_0^P(z;0)$, and $V_S^0(z;0)$ for each $z \in \mathcal{Z}$. For values of z not in $\mathcal{Z}$, we use linear interpolation. Set `j=0`.
   (a) Find the nationalization threshold z^* that solves $V_P(z^*; j) = V_S^0(z^*; j)$.
   (b) Given z^*, iterate on the following functional equation to obtain the firm value $W(z)$ at each grid point $z \in \mathcal{Z}$

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

   We evaluate the integral using Gauss–Hermite quadrature.
   (c) Given $W(z)$, find $U_P^0(z)$ and $R^0(z)$ by solving the static equilibrium at the privatization period at each $z \in \mathcal{Z}$.
   (d) Given $U_P^0(z)$, $R^0(z)$, and the guess $V_P(z; j)$, $V_S(z; j)$, $V_P^0(z; j)$, and $V_S^0(z; j)$, update the value functions at each grid point $z \in \mathcal{Z}$ using the Bellman equations

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

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

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

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

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

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