Staged Privatization: An Efficient Approach[1]

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Abstract: This paper provides a theory on staged or step-by-step privatization. We show that such an approach can be efficient, in the sense that it can successfully transform a state-owned enterprise into an *efficient* market-based firm by the time when the reform is complete. It may explain the popularity of staged privatization around the world. We have also conducted empirical analysis, which yields supporting evidence for our theory.

Keywords: staged privatization, lockup policy, tradable shares, nontradable shares

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1. Introduction

Privatization is important for many countries. For some countries, it is nothing short of a revolution. Researchers have looked at various aspects of privatization. We here focus on one particularly issue: how to privatize? The experience of big-bang and gradual reforms have proven this issue to be important. All privatizations have the same purpose: transform a State-Owned Enterprise (SOE) into a market-based well-functioning firm. In this paper, we identify an incomplete-contract approach that can transform an SOE to a market-based *efficient* firm. Interestingly, this approach has been adopted by the Chinese government in recent privatizations and most of the privatized firms perform exceedingly well immediately after privatization.

Megginson-Nash-Netter-Poulsen (2004) indicated that privatizations are typically carried out through one of three ways: asset sale, voucher privatization, or share issue privatization. In an asset sale, the government sells ownership of an SOE directly to an existing private firm, an institution or a small group of individuals. Such deals are typically made through direct face-to-face negotiations. In a voucher privatization, the government distributes vouchers (paper claims of ownership) to citizens. These vouchers are usually free, or almost free, and are available to most citizens. In a Share Issue Privatization (SIP), the government sells equity shares to the pubic. The government may sell a fraction or all of an SOE through any one of these methods. Among these methods, SIP is the dominant form of privatization in terms of asset value.

The existing studies show that most privatizations in the real world are carried out by a multi-stage process and a temporary lockup of shares works as an instrument. Perotti (1995, Table 2) showed many cases of staged privatization in the U.K. Jones-Megginson-Nash-Netter (1999) observed that, among SIPs in 59 countries, only 11.5% of the firms sold all of their capital at once and less than 30% sold more than half of their capital in their initial public offerings. Megginson and Netter (2001) observed that reform programs typically consist of many small privatizations and there are few outright sales of SOEs. Biais and Perotti (2002) also indicated that privatization schemes often include features that make fast resales of recently privatized firms' shares costly or impossible. Most shares of privatized firms are initially nontradable, are distributed through a pension scheme or are under a reward scheme for long-term holdings. Countries that have such features include France, the U.K., Czech Republic, Turkey, Mongolian, Bolivia, Zambia, Morocco, Nigeria, Tunisia, Jamaica, Chile, Mexico, Argentina, and Columbia. The rewarding schemes tend to exist in Western countries (e.g., the U.K.) and the pension schemes tend to exist in South American countries. Bortolotti et al. (2003) also indicated that partial sales are a common feature of privatization processes. Finally, Gupta (2005) observed that most privatizations begin with a period of partial privatization in which only non-controlling portions of firms are sold on the stock market.

Why should privatization be staged? Why is an SOE not sold all at once? What is the role of a lockup? There are a few theoretical papers on the issue. Different authors present different arguments on the practice of staged privatization. Zou (1994) studied dynamic privatization in a growth model, with an endogenous time span of privatization as we do. In his paper, convergence to a market-based firm is determined by the adjustment cost of privatization and the efficiency difference between SOEs and privately owned firms. We focus on the incentive to the insiders in restructuring effort. The restructuring includes establishing an effective board of directors, introducing strategic partners, and ensuring a profit-oriented management. We indeed observe such activities being carried out by insiders during the Chinese privatization process. These activities have been widely viewed by the market and emphasized by the government as crucial to the success of privatization.

Perotti (1995) further observed that SOEs in both developed and developing countries are mostly privatized through a sequence of partial and staggering sales. In addition, Perotti found that governments often temporarily take a risk-bearing role even well after the transfer of control to the private sector. Perotti proposed two explanations for these behaviors. One is the existence of temporary market capacity constraints (downward sloping demand). The other is based on a confidence-building strategy on the part of the government in its willingness to retain a stake in the firm. The latter is explained as follows. The government may or may not tax earnings from private shares (those shares of an SOE sold to private individuals); if the government does not sell the firm all at once, its tax revenue from the firm will be lower, which may be a signal to indicate that this government has no intention of taxing earnings from the shares. Hence, partial privatization can serve as a signal of a no-tax government. In a separating equilibrium, a no-tax government uses staged privatization, while a taxing government uses one-time privatization. The tax reduces the firm's incentive to invest. Hence, this equilibrium may explain why in reality many governments privatize SOEs in stages. Notice that Perotti treats the length of lockup as exogenous, with a portion of the shares being sold at $t=1$ and the rest being sold at $t=2.$ In contrast, the lockup in our model is endogenous.

There are a few other studies on staged privatization, including Katz and Owen (1995), Boycko, Shleifer and Vishny (1996), Cornelli and Li (1997), Schmitz (2000), and Biais and Perotti (2002). Katz and Owen (1995) treated an SOE as an asset for sale, which the government needs to package before selling, including providing sufficient ownership for the buyer and enough subsidy for the firm. Boycko, Shleifer and Vishny (1996) studied privatization by a divided government. Cornelli and Li (1997) presented an auction model, in which the optimal privatization scheme uses the number of shares sold as an instrument to attract the most valuable investors. Schmitz (2000) identified conditions under which private ownership, government ownership or partial ownership can be optimal. Finally, Biais and Perotti (2002) analyzes a political process of privatization in a democracy. There are also some empirical studies that test these theories, including Perotti and Guney (1993), Dewenter and Malatesta (1997), Jones-Megginson-Nash-Netter (1999) and Megginson-Nash-Netter-Poulsen (2004). However, none of their models resembles the most recent Chinese privatization program that our theory is fit for.

The Chinese privatization is also a staged process with multiple steps. Started in 1990, every listed firm (including non-SOEs) except four was divided into two types of shares: tradable shares (T-shares) and nontradable shares (N-shares), where the T-shares are tradable on the stock market but the N-shares are not. We call this a Share-Issuing Privatization (SIP). With such divided shares, the Chinese capital market in 2005 was defined by a split-share structure, with about one third of domestically listed shares being T-shares and the rest being N-shares. This meant that two thirds of the Chinese market capitalization was in N-shares, most of which were held by the central government, local governments and state-owned institutions. Then in 2005, the government announced the second privatization step: the Split-Share reform (SS reform), in which all N-shares were allowed to become T-shares after an initial lockup. The unlocking of N-shares is implemented over time based on certain qualification guidelines. Up to 2008, a total of 65 groups of firms has been qualified for unlocking, which consists of about 90% of the listed firms. This privatization program is the most thorough reform and perhaps the final phase of China's three-decade economic reform endeavor.

Our study aims at developing a unique theory to explain staged privatization. Different from the existing literature, we focus on efficient privatization. In our theoretical analysis, we show that an incomplete-contract approach with an ex-post lockup option can imply efficient privatization (Proposition 1). This approach implies a multi-stage privatization that resembles many privatizations around the world. In contrast, a complete-contract approach with an ex-ante lockup decision implies inefficient privatization (Proposition 4). This latter approach implies a one-time upfront privatization that resembles the Russian privatization and some privatizations in Eastern Europe.

The staged privatization has shown to be a stunning success in the case of China. With rich data from the Chinese privatization, we have conducted an empirical study on our theory. In our empirical analysis, for firms that went through the SS reform before the end of 2006 (more than 90% of all listed firms), we show that the firms that went through the reform early have higher ROA (return on assets), ROE (return on equity), and MB (market to book value) than those that went through the reform later.

Interestingly, every initial price offering (IPO) of a company has an initial lockup.[3] In fact, an initial lockup of 180 days is standard in all IPOs. Brav and Gompers (2003) proposed three possible motivations for IPO lockups: a signal for firm quality, a commitment device to alleviate moral hazard, and a mechanism for underwriters to extract additional compensation from the issuing firm. Arguments for the existence of these three potential effects are as follows. First, with a cost of lockup on insiders, a lockup can truthfully signal firm quality in equilibrium. Second, by committing to hold onto a large portion of the firm for a period of time, the insiders can convince shareholders that they will act in the best interests of shareholders. Third, a lockup agreement does not prevent an insider to sell shares within the lockup period if the lead underwriter consents, which allows underwriters to earn additional fees. Brav and Gompers (2003) found (1) empirical support for the commitment hypothesis, (2) no support for insiders signalling their quality by locking themselves in for a longer period of time, and (3) little evidence in support of the view of underwriters extracting additional compensation. Our study may advance the understanding of lockups from a unique angle.

This paper is organized as follows. In Section 2, we setup the model. In Section 3, we present the theory. In Section 4, we present some extensions of the theory. In Section 5, we present empirical analysis using data on listed firms in the Chinese stock market. Finally, we conclude the paper in Section 6. The proofs are all in the Appendix.

2. The Model

The Reform Program

Consider a privatization program with two steps, with the objective of transforming an SOE to a market-based firm. In the first step, the firm is divided into equity shares, with a portion θ of the shares being sold to the public. These shares are tradable (called T-shares) on the stock market and the rest are nontradable (called N-shares). Holders of the T-shares are called T-holders and holders of the N-shares are called N-holders. After the first step, the SOE becomes a partially privatized SOE. In the second step, the government allows the N-shares in the partially privatized SOE to become tradable after a lockup period.

[3] The Chinese privatization is substantially different from an initial price offering. First, N-shares are all secondary shares, as opposed to primary shares. Second, lockups in the Chinese privatization are legally enforceable, non-renegotiable ex post, and last for much longer than 180 days (minimum three years).

The Objective of Privatization: Efficiency

Specifically, consider a privatization program in interval [0, 1], where the program starts at $t=0$ and output is produced at $t=1$. There is one T-holder (private shareholders) and one N-holder (the insiders or controlling shareholders). The production function is

$$y = f(a,k),$$

where a is the effort from the N-holder and k is the capital stock. We assume that a is non-verifiable ex ante but observable ex post. In practice, it means that the government cannot impose a ex ante; hence, the government has to provide incentives to induce certain a. Since a is observable ex post, an ex-post government policy can depend on it. We may call a the restructuring effort. The costs for these two inputs are $c(a)$ and k, respectively. Given the real interest rate (the rental rate of capital) r, efficiency is determined by

$$f_a(a^*,k^*) = c'(a^*), \qquad f_k(a^*,k^*) = r. \tag{1}$$

The first equation in (1) means that the owners/insiders of the firm invest efficiently in the firm; the second equation means that the firm uses capital efficiently.

The government's objective is to transform a firm into a market-based efficient firm, as defined by (1), by the end of the reform process. The key is the restructuring effort a. The reform program needs to induce sufficient incentives for the controlling shareholders to spend effort on restructuring.

The Reform Strategy: Staged Privatization

At $t=0$, the government has a reform policy as defined by the initial proportion θ of tradable shares. We assume that θ is verifiable ex ante, which means that the government can impose θ ex ante. Sometime later after the government has observed a, the government announces another reform policy as defined by a lockup length $\lambda(a)$. We assume that λ is ex-ante nonverifiable but ex-post verifiable, i.e., the government cannot commit to λ ex ante but it can impose λ ex post. Function $\lambda(a)$ means that the government will not allow a firm to unlock their N-shares ex post at $t=\lambda(a)$ if it has not completed restructurings up to the level a. Only when the firm is good enough, will it be allowed to join the scheme. The scheme allows all N-shares to unlock at time $t=\lambda$.

In summary, the ex-ante reform policy is θ and the ex-post reform policy is $\lambda(\cdot)$. At $t=1$, the firm is completely operating under market forces, as shown in Figure 1. This process can be rigorously defined by an incomplete contract at $t=0$ in which the government imposes θ ex ante and retains the right to decide when to unlock the N-shares ex post. One key feature in an incomplete contract is that it can contain rights to decide certain matters ex post.

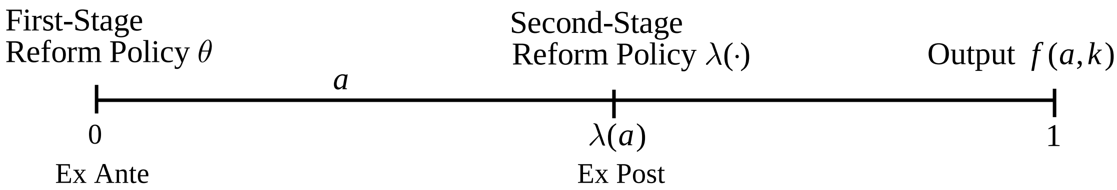

Figure 1. The Timeline of the Privatization Scheme

Demand for Shares

Before $t = 1$, the holders can trade tradable shares. Each share guarantees one share of output. However, different shareholders have different discount rate $\delta \in (0, 1)$ of time preference. All shareholders would like to have the opportunity to trade their shares; they would like to sell their shares to those who have a larger δ (less discount on future) than their own.

It is known in many studies that the demand for shares is downward sloping at any moment of time [see, for example, Perotti (1995), Field and Hanka (2001), and Brav and Gompers (2003)]. We now model this demand by heterogeneous time preferences among shareholders. Each holder has discount on the future. If her N-shares can be unlocked early, she can sell them early to a person whose discount factor is larger. In reality, the rates of time preference can be very different for different people. For example, an elderly may have much higher discount on future than a young person. If the income from a share paid at $t = 1$ is y for a holder with a rate of time preference ρ per unit of time, the share at t is worth $ye^{-\rho(1-t)} = y\delta^{1-t}$, where $\delta \equiv e^{-\rho}$. We call δ a measure of the person's time preference on future income. A larger δ means less discount on future income. Hence, anyone with time preference $\hat{\delta} \geq \delta$ will be willing to buy the share at price $p_t \equiv y\delta^{1-t}$ at time $t \in [0, 1)$. Suppose that the potential demand or the total market interest in the stock is n shares and the total supply of shares is one unit. Here, n is the total number of buyers in the market if each buyer buys at most one share. Let the density of potential demand be $F(\delta)$, for $\delta \in [0, 1]$. Then, the total demand at price p_t is $n[1 - F(\delta)]$. Hence, the demand function for shares at time t is

$$x_t(p_t) = n[1 - F(\delta)] = n\left\{1 - F\left[\left(\frac{p_t}{y}\right)^{\frac{1}{1-t}}\right]\right\}. \tag{2}$$

This demand is downward sloping in price.

3. Staged Privatization as an Efficient Solution

In this section, we identify an efficient solution based on an incomplete contract between the government and the firm. The solution is a multi-stage privatization program.

The First Stage of Privatization

In the first stage, the focus of the reform is to raise enough capital for the firm. Instead of relying on the government's central plan to provide funding, from now on, the firm will be financially on its own. At the same time, the firm is allowed to retain its revenue from now on.

Specifically, in the first stage, the government sells a portion θ of the firm's shares to the public. With the demand function in (2), the demand for shares at $t = 0$ is

$$x_0(p) = n\left[1 - F\left(\frac{p}{y}\right)\right].$$

Given the supply θ of shares in the market, the equilibrium condition in the stock market is

$$x_0(p_0) = \theta,$$

which determines the equilibrium share price at $t = 0$:

$$p_0 = yF^{-1}\left(1 - \frac{\theta}{n}\right).$$

Hence, the financial capital raised from the initial share issue is

$$k = p_0\theta = \theta y F^{-1}\left(1 - \frac{\theta}{n}\right).$$

Therefore, to achieve efficient privatization, the government chooses $\theta \in [0,\ 1]$ such that

$$k^* = \theta f(a^*, k^*)F^{-1}\left(1 - \frac{\theta}{n}\right), \tag{3}$$

where a^* and k^* are the first-best investments defined in (1). If $f(a^*, k^*) > k^*$, by Lemma 1 in the Appendix, when n is large enough, we can guarantee the existence and uniqueness of θ that satisfies (3).

The Second Stage of Privatization

In the second stage, the reform is based on a government's lockup policy $\lambda(a)$. Given the government's policies $\{\theta, \lambda(a)\}$, the N-holder considers her optimization problem. On the one hand, with her effort a, she is allowed to sell her shares in the amount $1 - \theta$ at time $t = \lambda(a)$. By (2), the demand at $t = \lambda(a)$ is

$$x_\lambda(p) = n\left\{1 - F\left[\left(\frac{p}{y}\right)^{\frac{1}{1-\lambda}}\right]\right\}.$$

Since the total supply of shares in the market is 1 at $t = \lambda(a)$, the equilibrium condition is

$$n\left\{1-F\left[\left(\frac{p_\lambda}{y}\right)^{\frac{1}{1-\lambda}}\right]\right\}=1,$$

which implies the share price at $t=\lambda(a)$:

$$p_\lambda = y\left[F^{-1}\left(1-\frac{1}{n}\right)\right]^{1-\lambda}.$$

On the other hand, at $t=\lambda(a)$, if the N-holder has discount factor δ, a share is worth $y\delta^{1-\lambda}$ to her if she does not sell the share. Hence, this person will sell her shares if and only if $y\delta^{1-\lambda}\le p_\lambda$ or $\delta\le\delta_n$, where

$$\delta_n \equiv F^{-1}\left(1-\frac{1}{n}\right). \tag{4}$$

This δ_n is the upper bound of the time preference of the shareholders who prefer to sell their shares. If $n\to\infty$, then $\delta_n\to 1$; that is, virtually any N-holder will sell her shares in a large economy. In other words, she can always find a buyer who would prefer to pay a higher price than her own valuation. Hence, for an N-holder with effort a and time preference $\delta\le\delta_n$, her payoff at $t=0$ is

$$\pi_N(a)=p_\lambda(1-\theta)\delta^\lambda - c(a) = f(a,k)\delta_n^{1-\lambda(a)}(1-\theta)\delta^{\lambda(a)}-c(a). \tag{5}$$

The key question is whether or not she is willing to spend enough effort to improve the firm before she is allowed to sell her shares in the firm.

The Solution

The following proposition states that the above privatization scheme can lead to an efficient solution. The proof is in the Appendix.

Proposition 1. *A staged privatization program $\{\theta,\lambda(\cdot)\}$ can transform a firm into an efficient firm with the first-best investments a^* and k^* if the N-holder of the firm (the original owners of the firm) has time preference δ satisfying*

$$\delta\le\delta_n-\frac{1}{1-\theta}\int_0^{a^*}\frac{dc(\tau)}{f(\tau,k^*)}, \tag{6}$$

where the amount θ of tradable shares in the first stage of privatization is determined by

$$k^*=\theta f(a^*,k^*)F^{-1}\left(1-\frac{\theta}{n}\right), \tag{7}$$

and the lockup policy in the second stage of privatization is defined by

$$\lambda(a)=\begin{cases}\dfrac{\ln\delta_n-\ln\left[\delta+\dfrac{1}{1-\theta}\displaystyle\int_0^a\frac{dc(\tau)}{f(\tau,k^*)}\right]}{\ln(\delta_n/\delta)}, & \text{if } a<a^*,\\[2ex] \dfrac{\ln\delta_n-\ln\left[\delta+\dfrac{1}{1-\theta}\displaystyle\int_0^{a^*}\frac{dc(\tau)}{f(\tau,k^*)}\right]}{\ln(\delta_n/\delta)}, & \text{if } a\ge a^*.\end{cases} \tag{8}$$

This lockup policy is decreasing and, if the marginal cost of effort is constant, it is also convex, as shown in Figure 2.

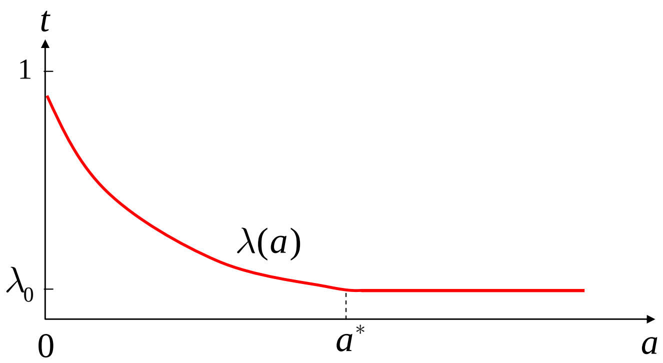

Figure 2. The Lockup Policy in Staged Privatization

In equilibrium, all the owners with preferences satisfying (6) are supposed to choose $a=a^*$ and hence are allowed to unlock their N-shares at $t=\lambda_0$. Hence, in practice, we expect many firms to be unlocked in a short span of time. Only the least efficient firms may have a much longer lockup period. In the implementation of the privatization scheme, λ_0 can be stated as the minimum lockup length.

A condition such as (6) is necessary for the government's incentive scheme to work. In the scheme, the government allows those firms that have done enough restructurings to unlock their N-shares. For those N-holders who view the current and future incomes as basically the same, this scheme obviously cannot work. As the later two propositions will show, in a risky and large economy, the scheme works for most firms.

Our first stage of privatization is just like the Chinese privatization policy which started in 1990. Our second stage of privatization is just like the Chinese privatization policy which started in 2005. Our theory indicates that this privatization scheme can be efficient. That is, a privatized firm can be an efficient market-based firm at the completion of the program. The performance of such firms seems to confirm this.

Remark 1. In the model, the N-holders receive N-shares for free. In reality, some receive N-shares for free while others get them for almost free. It is simple to modify the model to take the latter into account.

Remark 2. The government's lockup policy λ can also be based on a more general signal of the form $\phi(a)+\tilde{\varepsilon}$ with noise $\tilde{\varepsilon}$ as long as the signal is observable ex post.

Remark 3. We can allow an initial capital stock k_0 so that the production function becomes $f(a, k_0+k)$. Here, k is the additional capital raised by an initial share sale. The same result holds. This extension is trivial.

4. Extensions

4.1. Staged Privatization under Uncertainty

In this section, we introduce uncertainty into the model. We show that uncertainty will not change our conclusion.

Suppose that output is uncertain ex ante with

$$\tilde{y} = \tilde{A} f(a,k), \tag{9}$$

where $E(\tilde{A})=1$ and $\operatorname{var}(\tilde{A})=\sigma^2$. Suppose that the N-holder has mean-variance preferences of the form:

$$u(\tilde{y}) = E(\tilde{y}) - \beta \operatorname{var}(\tilde{y}) = f(a,k) - \beta\sigma^2 \left[f(a,k) \right]^2 .$$

Here, β is a measure of risk aversion and σ is a measure of risk. We assume that all the shareholders have the same risk preference (the same β).[4]

The government's objective is again to transform the firm into an ex-ante efficient firm. That is, given the real interest rate r, the government tries to transform the firm into a market-based firm defined by

$$f_a(a^*, k^*) = c'(a^*), \qquad f_k(a^*, k^*) = r.$$

Each share for a shareholder with time preference δ is worth $u(\tilde{y})\delta^{1-t}$ at t. Anyone with time preference $\hat{\delta} \geq \delta$ will be willing to buy the share at price $p_t \equiv u(\tilde{y})\delta^{1-t}$ at t. Suppose that the potential demand or the total market interest in the stock is n shares and the total supply of shares is one unit. Let the density of potential demand be $F(\delta)$, for $\delta \in [0, 1]$. Then, the total demand at the price p_t is $n\left[1-F(\delta)\right]$. Hence, the demand function for shares at t is

[4] Like time preferences, we can also consider a distribution of heterogeneous risk preferences among the shareholders. The main result still holds. In fact, heterogeneous time preferences have arguably included heterogeneous risk preferences as a special case.

$$x_t(p_t) = n\left[1 - F(\delta)\right] = n\left\{1 - F\left[\left(\frac{p_t}{u(\tilde{y})}\right)^{\frac{1}{1-t}}\right]\right\}.$$

We have a downward sloping demand.

In the first stage, the government sells a portion θ of the firm's shares to the market. With the total supply of shares in the market being θ at $t = 0$, the equilibrium share price is

$$p_0 = u(\tilde{y})F^{-1}\left(1 - \frac{\theta}{n}\right).$$

Hence, the financial capital raised from the initial share issue is

$$k = p_0\theta = u(\tilde{y})F^{-1}\left(1 - \frac{\theta}{n}\right)\theta.$$

Then, the government should choose θ such that

$$k^* = \theta\left[1 - \beta\sigma^2 f(a^*, k^*)\right] f(a^*, k^*)F^{-1}\left(1 - \frac{\theta}{n}\right). \tag{10}$$

If $f(a^*, k^*) > k^*$, when n is large enough, we can guarantee the existence and uniqueness of θ.

In the second stage, the reform is based on a government's lockup policy $\lambda(a)$. Given the government's policies $\{\theta, \lambda(a)\}$, the N-holder considers her optimization problem. With her effort a, she will be allowed to sell her shares in the amount $1-\theta$ at date $t = \lambda(a)$. With the total supply of shares in the market being 1 at $t = \lambda(a)$, the equilibrium price is

$$p_\lambda = u(\tilde{y})\left[F^{-1}\left(1 - \frac{1}{n}\right)\right]^{1-\lambda}.$$

If the N-holder has discount factor δ, each share is worth $u(\tilde{y})\delta^{1-\lambda}$ to her if she does not sell the share. This shareholder will sell her shares if $u(\tilde{y})\delta^{1-\lambda} \le p_\lambda$ or $\delta \le \delta_n$, where δ_n is defined in (4). Hence, for an N-holder with time preference $\delta \le \delta_n$, her payoff at $t = 0$ is

$$\pi_N(a) = p_\lambda(1-\theta)\delta^\lambda - c(a) = \left[1 - \beta\sigma^2 f(a,k)\right] f(a,k)\delta_n^{1-\lambda(a)}(1-\theta)\delta^{\lambda(a)} - c(a). \tag{11}$$

As shown in the following proposition, we again find an efficient solution. The proof is in the Appendix.

Proposition 2. *A staged privatization program $\{\theta, \lambda(\cdot)\}$ can transform a firm into an efficient firm with the first-best investments a^* and k^* if the N-holder of the firm has time preference δ satisfying*

$$\delta \le \delta_n - \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau, k^*)\left[1 - \beta\sigma^2 f(\tau, k^*)\right]}, \tag{12}$$

where the amount θ of tradable shares in the first stage of privatization is determined by

$$k^* = \theta\left[1-\beta\sigma^2 f(a^*,k^*)\right] f(a^*,k^*)F^{-1}\left(1-\frac{\theta}{n}\right),$$

and the lockup policy in the second stage of privatization is defined by

$$\lambda(a) = \begin{cases} \dfrac{\ln\delta_n - \ln\left\{\delta + \dfrac{1}{1-\theta}\displaystyle\int_0^a \frac{dc(\tau)}{f(\tau,k^*)\left[1-\beta\sigma^2 f(\tau,k^*)\right]}\right\}}{\ln(\delta_n/\delta)} & \text{if } \; a < a^*, \\ \dfrac{\ln\delta_n - \ln\left\{\delta + \dfrac{1}{1-\theta}\displaystyle\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*)\left[1-\beta\sigma^2 f(\tau,k^*)\right]}\right\}}{\ln(\delta_n/\delta)} & \text{if } \; a \geq a^*. \end{cases}$$

Similarly, instead of proportional uncertainty in (9), suppose that output has the following additive form:

$$\tilde{y} = f(a,k) + \tilde{\varepsilon}, \tag{13}$$

where $E(\tilde{\varepsilon}) = 0$ and $\mathrm{var}(\tilde{\varepsilon}) = \sigma^2$. Again, suppose that the N-holder has mean-variance preferences of the form:

$$u(\tilde{y}) = E(\tilde{y}) - \beta\,\mathrm{var}(\tilde{y}) = f(a,k) - \beta\sigma^2.$$

Then, in the first stage, the government should choose θ such that

$$k^* = \theta\left[f(a^*,k^*) - \beta\sigma^2\right]F^{-1}\left(1-\frac{\theta}{n}\right). \tag{14}$$

In the second stage, the reform is based on a government's lockup policy $\lambda(a)$, taking into account the payoff of the N-holder with time preference $\delta \leq \delta_n$:

$$\pi_N(a) = p_\lambda(1-\theta)\delta^\lambda - c(a) = \left[f(a,k) - \beta\sigma^2\right]\delta_n^{1-\lambda(a)}(1-\theta)\delta^{\lambda(a)} - c(a). \tag{15}$$

We again find an efficient solution, as stated in the following proposition. The proof is in the Appendix.

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$$\delta \leq \delta_n - \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*) - \beta\sigma^2}, \tag{16}$$

where the amount θ of tradable shares in the first stage of privatization is determined by

$$k^* = \theta f(a^*,k^*)F^{-1}\left(1-\frac{\theta}{n}\right),$$

and the lockup policy in the second stage of privatization is defined by

$$\lambda(a)=\begin{cases}\dfrac{\ln\delta_n-\ln\left\{\delta+\dfrac{1}{1-\theta}\displaystyle\int_0^{a}\frac{dc(\tau)}{f(\tau,k^*)-\beta\sigma^2}\right\}}{\ln(\delta_n/\delta)}, & \text{if } a<a^*,\\[2ex] \dfrac{\ln\delta_n-\ln\left\{\delta+\dfrac{1}{1-\theta}\displaystyle\int_0^{a^*}\frac{dc(\tau)}{f(\tau,k^*)-\beta\sigma^2}\right\}}{\ln(\delta_n/\delta)}, & \text{if } a\geq a^*.\end{cases}$$

The results in Propositions 2 and 3 indicate that, if risk and/or risk aversion is high enough and if the economy is large enough ($n\to\infty$), virtually all N-holders will be enticed by the privatization scheme to improve their firms adequately in time for unlocking their shares. The end result is that these firms will become efficient market-based firms.

4.2. One-Time Privatization under a Complete Contract

Suppose now that the government takes a complete-contract approach.

In this case, a lockup is announced and committed ex ante. The payoff of an N-holder with time preference $\delta\leq\delta_n$ is

$$\pi_N(a)=p_\lambda(1-\theta)\delta^\lambda-c(a)=f(a,k)\delta_n^{1-\lambda}(1-\theta)\delta^\lambda-c(a).$$

Since λ is independent of a, the first-order condition (FOC) $\pi_N'(a)=0$ implies

$$f_a(a,k)(1-\theta)\delta^\lambda\delta_n^{1-\lambda}=c'(a). \tag{17}$$

This indicates that the efficient condition $f_a(a,k)=c'(a)$ can never be satisfied. Hence, we know that staged privatization with a pre-determined lockup is inefficient.

Then, government policies $\{\theta,\lambda\}$ are determined by:

$$\begin{aligned}&\max_{a,k,\lambda,\theta}\ f(a,k)-rk-c(a)\\ &\text{s.t. } f_a(a,k)(1-\theta)\delta^\lambda\delta_n^{1-\lambda}=c'(a),\\ &\qquad k=\theta f(a,k)F^{-1}\left(1-\frac{\theta}{n}\right).\end{aligned} \tag{18}$$

The following proposition shows that the optimal lockup is $\lambda^*=0$ in this case. The proof is in the Appendix.

Proposition 4. *If the lockup is decided ex ante, the optimal lockup is to have no lockup. That is, a one-time privatization is optimal. This solution is inefficient.*

The difference between the two privatization strategies can be understood as the difference between complete and incomplete contracts. Our solutions indicate that, if a lockup is chosen ex ante, it cannot be dependent on effort and the optimal solution is inefficient; on the other hand, if a lockup is chosen ex post (after effort is invested), it can be dependent on effort and the optimal solution is efficient.

5. Empirical Analysis

5.1. The Empirical Model

In this section, we provide empirical analysis on staged privatization in China. Although staged privatization is typical in privatization programs around the world, for an empirical study, we can only find rich data from China. For China, economic growth hinges almost exclusively on privatization and its privatization program has been characterized by step-by-step privatizations. This privatization process involves a large number of firms, covering all industrial sectors. Among all publicly listed firms in China (over 1,400 firms), more than 60% of them are SOEs. This provides us with a rich set of data to test our theory.

The first stage of the most recent privatization program in China started in 1990, which led to the creation of China's stock exchanges in 1990 and 1991. After that, the publicly listed SOEs became partially privatized SOEs and the shares of all the listed firms except four, including private firms, were divided into tradable and nontradable shares. From then on, SOEs refer to partially privatized SOEs. An N-holder in China is either a legal-person shareholder, who receives dividends just like a T-holder, or the government. A legal person is an institution or a person, including a foreigner, who is entitled to the legal rights and responsibilities of a contract. While T-holders obtain their shares from the stock market, N-holders obtain their shares through various other means. For example, when a firm or the government wants to introduce a strategic partner (including another firm or a foreigner), it negotiates with the potential partner for a portion of the firm's equity at an agreed price. With the introduction of the second stage of the privatization program (the SS reform) in 2005, as a holder of non-tradable shares and typically with a large share holding, a legal-person holder has incentives to improve the firm. Even when a holder is the government, we have ample evidence that it makes an effort to improve SOEs. The central government actively puts pressure on local governments to improve the firms' situations. In fact, the central government sets specific targets for local governments to satisfy within certain time limit. These targets are aimed at meeting the requirements of the SS reform.

N-holders play an important role in the Chinese reform. A few factors determine their importance. First, they are typically large shareholders (very large by Western standard with each typically having 30-60% share holdings). N-holders in a Chinese firm are always among the biggest five shareholders. These shareholders control most of the important management positions. In contrast, managers' share holdings are negligible and T-holders are usually scattered and each holds a tiny portion of the firm. Second, N-shares receive the same dividends as T-shares. Third, N-holders are often local governments or institutions that are closely related or controlled by local governments. Some firms introduce foreign investors as legal-person holders. Although foreign involvement is small overall, in those firms that foreigners are involved, foreigners typically hold a large portion of shares in the firm, 28% on average. In this situation, commitments from N-holders can assure the market that they will continue to contribute to the firm rather than expropriate minority shareholders by cashing out their investment soon. Hence, lockups in the Chinese reform may be an effective way in controlling moral hazards. This is a key component in our theoretical model.

Our theory predicts that firms with higher restructuring effort and hence better performance will be selected earlier to go through the SS reform. We will test two implications of this prediction. Firstly, we will test whether or not firms with higher profitability are selected to go through the reform earlier. Secondly, since the CEO of an SOE actually manages the firm on behalf of the government, the government is likely to use promotions and demotions as an effective way to control incentives. Hence, we will test whether or not the sensitivity of CEO turnover to performance is higher for firms that went through the reform earlier.

Our dependent variable is an ordered multiple choice indicator. The Chinese capital market is considered to be immature because of weak investor protection, an inactive takeover market, ineffective external monitoring by large shareholders, high ownership concentration, low managerial ownership, and the dominance of state ownership. La Porta et al. (1998, 2000) and Volpin (2002) found evidence that corporate governance in such an environment is poor and that managers are highly entrenched. Further, SOEs both in developed and developing markets are known to have multiple tasks, which may lower their incentive to maximize profits and market value. One potential mechanism in dealing with this problem is the use of promotion and demotion. We indeed find that the government employs promotions and demotions as a measure to entice top managers of SOEs into working hard. We find that the top manager turnover rate is about 20% in our sample. Similar findings were presented by Chang and Wong (26%, 2009), Kato and Long (24%, 2006), and Firth et al. (40%, 2006). These rates are higher than those in the US as documented by Denis et al. (13%, 1995) and Huson et al. (9%, 2004) and those in Japan as documented by Kang et al. (13%, 1995) and Kaplan (15%, 1994). This measure may explain the higher sensitivity of turnover to performance in China. Hence, we will use an ordered multiple choice indicator rather than the traditional binary choice indicator as the dependent variable. This multi-choice indicator can indicate a manager's many career changes, including a demotion, a promotion or a lateral change of jobs, while the binary choice indicator can only indicate whether or not a turnover is voluntary.

5.2. Data

We trace the career paths of departing managers in SOEs, including former government officials appointed by governments and professional managers hired by governments. We define turnover as when a manager departs. There was a total of 1104 turnovers in the SOEs from 2001 to 2006. Some turnovers were voluntary such as a resignation due to health problems, but others were forced such as an early termination of the manger's contract; also, some turnovers were punishments such as demotions, some were rewards such as promotions, yet others were lateral changes of jobs with no implication of a demotion or promotion. In order to distinguish these different cases of departure, we trace the destinations of the departing managers. These information came from the firms' annual reports and internet publications which are available at www.baidu.com. We find that, among the departures of CEOs, 219 were promotions, 640 were demotions, 17 were lateral movements, and 49 were retirements. But, we cannot find related information for the other 179 cases.

Our empirical analysis focuses on CEO turnover among listed firms whose ultimate controllers are the central and local governments. We exclude banks, insurance companies and other financial firms because they use different accounting measures. If there are multiple turnovers in a certain year, we count the first observation only. We treat short-term turnovers as outliers, and we do not expect frequent turnovers to be correlated with the firm's performance. In the end, we have a total of 4818 firm-year observations and the average annual turnover rate of CEO is found to be about 20%.

5.3. Empirical Results

Our theoretical model predicts that well-performing firms will be allowed to unlock their N-shares early. We first test this prediction by univariate comparisons. The firms went through the SS reform in groups, one group a time. Excluding the initial experimental group, a total of 65 groups went through the SS reform over time. We gather ten groups in consecutive reforming time into one batch, so that we can compare firms that went through the reform during different time periods. We have a total of 17 batches. Table 1 contains the comparison statistics between the first batch and a later batch. Table 1 indicates that early reforming firms tend to have a high ROA, ROE and market value. Also, we find that firm sizes in different batches are not significantly different from each other, indicting that the difference in performance is not due to firm size. These preliminary evidence support our theory.

Table 1: Statistics for Firms in Different Reform Batches

	ROA	Sales Growth Rate	ROE	Market Value	No. of Observations
First Batch	5.798	0.284	8.905	3.42E+09	259
					20.64%
Second Batch	3.265***	0.179***	5.259***	2.59E+09***	263
	t=-6.737	t=-4.579	t=-3.735	t=-3.744	20.96%
Third Batch	1.885***	0.211***	1.76***	2.39E+09***	320
	t=-12.129	t=-2.350	t=-5.780	t=-3.170	25.50%

Fourth Batch	0.085***	0.275	-13.133**	1.34E+09***	227
	t=-14.049	t=0.161	t=-1.847 (2)	t=-18.492	18.09%
Fifth Batch	0.835***	0.837	4.172***	8.70E+09	63
	t=-4.284	t=1.558	t=-2.453	t=-0.801	5.02%
Sixth Batch	-1.202***	1.56***	-3.12***	2.00E+09***	64
	t=-2.824	t=2.625	t=-2.906	t=-4.327	5.10%
Last Batch	-3.412***	0.438***	-89.26**	1.65E+09***	59
	t=-3.060	t=0.707	t=-1.706 (2)	t=-8.459	4.70%

In this table and the rest, *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level.

Next, we test whether or not managers were rewarded for good performance. Based on our theoretical model and the privatization literature, we predict that state shareholders will use promotions and demotions to motivate CEOs. Groves et al. (1995) and Pinto et al. (1993) argued that since managers' incentive plays an important role in the long process of privatization, they should be monitored in the intermediate period. Groves et al. (1995) found that demotions and promotions motivated managers well in 769 SOEs during 1980 and 1989 in China. Also, Fredrickson et al. (1988) and Gibelman and Gelman (2000) found that social and political factors played a role in determining managerial turnover. Although the Chinese Corporate Law requires CEOs to be determined and monitored by the board of directors, the state shareholder can exercise control through its controlling share holdings and its authority in appointment and dismissal of CEOs. Also, among Chinese SOEs, ownership tends to be concentrated and the board tends to be controlled by members who are directly or indirectly affiliated with the ultimate controller (the government). Through its control, the government can use promotions and demotions as the incentive mechanism on CEOs. Our theoretical analysis also implies that managers in well-performing firms are more likely to be promoted and managers in badly performing firms are more likely to be demoted and that the sensitivity of turnover to performance will be larger for firms going through the SS reform early.

The regression results using an ordered-logit model are presented in Table 2. We use an ordered multiple choice indicator rather than the traditional binary choice indicator as the dependent variable. This multi-choice indicator is -1 if the CEO is demoted, 1 if the CEO is promoted, and 0 if it is a lateral movement, official retirement or no change. For robustness of our regressions, we use both accounting-based and market-based measures on a firm's performance.

Table 2: Ordered Logit Regressions[5]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Performance is defined as	ROA	ROA	ROE	ROE	Growth rate	Growth rate	Loss	Loss
Performance	0.035***	0.030***	0.021***	0.018***	0.134***	0.121***	-0.412***	-0.343**
	(4.39)	(3.49)	(5.19)	(4.17)	(3.70)	(3.18)	(-3.07)	(-2.47)
First mover × Performance		0.047*		0.032**		0.144		-1.182**
		(1.97)		(2.52)		(1.19)		(-2.33)
Firm size	0.115***	0.111***	0.100**	0.093**	0.135***	0.132***	0.125***	0.125***
	(2.81)	(2.72)	(2.36)	(2.19)	(3.05)	(2.98)	(3.07)	(3.08)
Largest share holding	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002
	(-1.15)	(-1.15)	(-1.23)	(-1.18)	(-0.92)	(-0.87)	(-0.97)	(-0.94)
Institutional share	-0.197**	-0.198**	-0.181**	-0.180**	-0.119	-0.119	-0.158**	-0.151*
	(-2.48)	(-2.49)	(-2.23)	(-2.21)	(-1.42)	(-1.43)	(-2.01)	(-1.92)
CEO age	0.004	0.011	0.192	0.204	0.968	0.967	-0.029	-0.045
	(0.01)	(0.02)	(0.33)	(0.36)	(1.57)	(1.57)	(-0.05)	(-0.08)
Political connection	-0.185**	-0.175*	-0.203**	-0.194**	-0.250**	-0.245**	-0.189**	-0.183**
	(-2.05)	(-1.93)	(-2.21)	(-2.11)	(-2.52)	(-2.47)	(-2.09)	(-2.03)
Hierarchy	-0.029	-0.029	-0.024	-0.023	-0.035	-0.034	-0.037	-0.038
	(-0.74)	(-0.73)	(-0.61)	(-0.57)	(-0.82)	(-0.81)	(-0.96)	(-0.98)
Cut1	-0.863	-0.894	-0.958	-1.017	-0.126	-0.150	-0.763	-0.758
Cut2	4.135	4.108	4.045	3.993	4.827	4.804	4.222	4.230
No. of observations	4818	4818	4624	4624	4062	4062	4816	4816
Log Likelihood	-2701.87	-2699.95	-2590.42	-2587.31	-2300.09	-2299.41	-2706.37	-2703.87

In Panels (1) and (2) of Table 2, we use the industry adjusted ROA, defined as the difference between a firm's ROA and its industry mean, which measures a firm's relative performance in the industry. Panel (1) shows that the probability that a CEO is demoted is significantly lower or the probability that a CEO is promoted is significantly higher for firms with a higher adjusted ROA. Further, if the adjusted ROA increases by one standard deviation from the mean, the probability that the CEO is demoted decreases by about 2% and the probability that the CEO is promoted increases also by about 2%. In Panel (2), to test whether or not the sensitivity of turnover is affected by policy burdens involving privatization, we add the interaction term between the first mover and the adjusted ROA to the regression model. The dummy First Mover is 1 if the firm is selected to go through the SS reform in 2005 and 0 otherwise. About 20% of the firms went through the reform in 2005. Panel (2) shows that the sensitivity of CEO turnover to performance increases significantly if a firm is selected to go through the reform early. Further, if a firm's adjusted ROA increases by one standard deviation from the mean and the firm is in an early reform batch, the probability that the CEO is demoted decreases by

[5] In all our regressions, we regard the person holding the title of general manager or chief executive as CEO. Also, to remove outliers, all the accounting measures are winsorized at the 1st and 99th percentiles.

about 2.5% and the probability that the CEO is promoted increases by about 1% more than for those CEOs who are in firms whose adjusted ROA also increases by one standard deviation but it is in a later reform batch.

Following the literature on CEO turnovers, we add further control variables. We use the logarithm of total assets to control for firm size. Big firms tend to have a large impact on the economy and they may be more challenging to operate. Hence, managers in big firms may accumulate more management experiences. Chang and Wong (2009), Kato and Long (2006) and Firth et al. (2006) found that managers in large firms are less likely to be forced to leave. We also found that managers in big firms are more likely to be promoted.

On monitoring, Brunello et al. (2003) did not find evidence that large minority shareholders will monitor managers effectively in Italy. However, Denis et al. (1997) found that large monitory shareholders play an important role in monitoring managers in the US. In Table 2, we found that the existence of large institutional shareholders will increase forced turnovers, indicating that large minority shareholders play an important role in monitoring CEOs in China.

We further control for other variables relating to ownership structure and political connections. When more shares are taken by the biggest shareholder, the holder has more incentive to monitor the manager, implying a higher turnover rate. Volpin (2002) found that the existence of a large stakeholder will enhance the negative link between CEO turnover and performance. However, when the controlling power is large enough, the largest shareholder may press the manager to expropriate minority shareholders, resulting in a low turnover rate. In Table 2, we show that the two effects cancel each other out and the percentage of shares held by the largest shareholder does not have a significant effect on the turnover rate.

We use the number of hierarchy levels to control for ownership structure. Volpin (2002) found that this number will not affect the relationship between turnover and performance regardless of whether a firm is a stand-alone firm or affiliated with a pyramidal group. Our findings confirm that the length of the largest shareholder's control chain will not significantly affect the turnover rate.

We use a political dummy to distinguish professional managers from managers who were former bureaucrats. This dummy is 1 if the manager has ever worked for the central or local governments and 0 if otherwise. Claessens and Djankov (1999) found that managers appointed by state owners perform worse than those appointed by private owners. However, political connections are regarded as an important resource in China. We include this variable to test whether or not a manager's political connection will influence his/her current career. Table 2 shows that a bureaucratic appointment increases the probability of demotion. Also, as a manager approaches the official retirement age, he/she is more likely to be replaced regardless of the firm's performance. Hence, we control for CEO age in our regressions. However, we find that CEO age has no significant effect on the turnover rate.

We also consider alternative measures of a firm's performance. In Panels (3) and (4) of Table 2, we use the industry adjusted ROE to measure a firm's performance. In Panels (5) and (6), we use the industry adjusted annual sales growth rate. We find that our main conclusions are robust to these alternative performance measures.

Also, Kaplan (1994) found that CEO turnover in Japanese firms are most sensitive to negative earnings. Chang and Wong (2009) found that the sensitivity of performance to turnover is more pronounced when a firm is making a loss. Hence, in Panels (7) and (8), we use a loss dummy as a performance measure. This dummy is 1 if a firm's earnings before interest and tax are less than zero and 0 if otherwise. Our main conclusions still hold with this loss measure.

Further, if we use the industry median rather than the mean to adjust the industry effect, if we use an absolute control dummy rather than the percentage of shares held by the largest shareholder, if we use an age dummy rather than the continuous age variable, if we use a dummy to separate central-government owned firms from local-government owned firms, or if we remove official retirements from our turnover sample, our main conclusions still hold.

Finally, to check the robustness of our main conclusions further, we now use the traditional binary choice indicator as the dependent variable. This binary choice indicator separates forced turnovers from voluntary ones only. Furthermore, to control for the time-invariant firm fixed effect, we use the fixed-effect logit regression model for panel data rather than the simple cross-section data analysis; the latter ignores the correlation of the fixed effects in the same firm across time. The regression results are presented in Table 3. Again, our main conclusions hold under this specification.

Table 3: Fixed-Effect Logit Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Performance is defined as	ROA	ROA	ROE	ROE	Growth rate	Growth rate	Loss	Loss
Performance	-0.039***	-0.034***	-0.021***	-0.018***	-0.107**	-0.100**	0.369**	0.286*
	(-3.40)	(-2.78)	(-3.87)	(-3.13)	(-2.42)	(-2.14)	(2.30)	(1.72)
First mover × Performance		-0.073*		-0.039*		0.066		-1.391**
		(-1.65)		(-1.86)		(-0.46)		(-2.00)
Firm size	-0.313**	-0.311**	-0.306*	-0.300*	-0.408**	-0.402**	-0.311**	-0.302**
	(-2.04)	(-2.02)	(-1.88)	(-1.84)	(-2.15)	(-2.11)	(-2.02)	(-1.96)
Institutional share	0.231**	0.221**	0.210*	0.195*	0.230**	0.231**	0.203*	0.192*
	(2.15)	(2.05)	(1.89)	(1.76)	(2.02)	(2.03)	(1.90)	(1.79)
Largest share holding	0.016*	0.017**	0.019**	0.020**	0.017*	0.017*	0.016**	-

								0.018**
	(1.94)	(2.02)	(2.23)	(2.34)	(1.82)	(1.84)	(1.96)	(-2.11)
CEO age	0.011	0.012	0.011	0.011	-0.004	-0.004	0.012	0.012
	(1.29)	(1.33)	(1.23)	(1.28)	(-0.39)	(-0.39)	(1.36)	(1.42)
Political connection	0.077	0.066	0.036	0.027	0.199	0.197	0.082	0.070
	(0.51)	(0.44)	(0.23)	(0.18)	(1.14)	(1.14)	(0.54)	(0.46)
Hierarchy	-0.141	-0.127	-0.120	-0.102	-0.187	-0.185	-0.111	-0.090
	(-0.89)	(-0.80)	(-0.74)	(-0.63)	(-1.04)	(-1.03)	(-0.70)	(-0.57)
No. of observations[6]	2820	2820	2656	2656	2126	2126	2819	2819
Log Likelihood	-956.51	-955.10	-900.35	-898.51	-736.83	-736.73	-959.48	-957.41

In summary, our empirical findings are consistent with our theory. First, we find that better performing firms, as measured by higher ROA, ROE, and market value, were selected to go through the SS-reform earlier. Second, the sensitivity of CEO turnover to performance is higher for firms that were selected to go through the reform in 2005 (the first year of the SS reform). Specifically, CEOs in firms that were selected to go through the reform early were more likely to be promoted if the firms performed well and were more likely to be demoted if the firms performed badly.

6. Concluding Summary

This study provides a theory on staged privatization. We identify an efficient approach to privatize based on an incomplete-contract approach. This theory can explain the popularity of staged privatization around the world. In particular, the recent privatization of Chinese SOEs adopted such an approach. We have also conducted an empirical investigation, which provides support for our theory.

[6] The number of observations drops significantly as compared with the earlier regressions since a fixed-effect regression excludes firms that have no turnover during the whole period.

Appendix

Lemma 1: Existence and Uniqueness of θ

Lemma 1. *If* $f(a^*,k^*) > k^*$ *and* n *is sufficiently large, then equation (7) has a unique solution of* $\theta \in (0,\ 1)$.

Proof. Denote $\phi(\theta) \equiv \theta f(a^*,k^*) F^{-1}\left(1-\frac{\theta}{n}\right)$. We have

$$\phi(0) = 0 \qquad \text{and} \qquad \phi(1) = f(a^*,k^*) F^{-1}\left(1-\frac{1}{n}\right).$$

Since $\lim_{n\to\infty} F^{-1}\left(1-\frac{1}{n}\right) = 1$ and $f(a^*,k^*) > k^*$, when n is sufficiently large, we have

$$\phi(0) < k^* < \phi(1).$$

Hence, by continuity of ϕ, there is at least one $\theta^* \in (0,\ 1)$ such that $\phi(\theta^*) = k^*$.

Further, we have

$$\phi'(\theta) \equiv y^* F^{-1}\left(1-\frac{\theta}{n}\right) - \frac{\theta y^*}{n} \frac{1}{f\left[F^{-1}\left(1-\frac{\theta}{n}\right)\right]},$$

where f is the density function of F. Hence, we have

$$\lim_{n\to\infty} \phi'(\theta) = y^* > 0.$$

That is, when n is sufficiently large, ϕ is strictly increasing. Therefore, θ^* is unique.

Proof of Proposition 1

Given the profit function in (5), with $k = k^*$, we have

$$\pi_N'(a) = f_a(a,k^*)(1-\theta)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)} + f(a,k^*)(1-\theta)\lambda'(a)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)} \ln\left(\frac{\delta}{\delta_n}\right) - c'(a).$$

Consider a general lockup policy $\lambda(a)$ of the following form:

$$\lambda(a) = \begin{cases} \lambda(a) & \text{if} \quad a < a^*, \\ \lambda_0 & \text{if} \quad a \geq a^*. \end{cases} \tag{19}$$

For $a \geq a^*$, $\lambda(a)$ can take any constant $\lambda_0 \in [0,1]$. Then, we have

$$\pi_N'(a) = f_a(a,k^*)(1-\theta)\delta^{\lambda_0}\delta_n^{1-\lambda_0} - c'(a).$$

Since $\pi_N'(a^*) < 0$ and $\pi_N(a)$ is concave in a, we have $\pi_N'(a) < 0$ for all $a \geq a^*$. This means that, in $[a^*, \infty)$, the N-holder will choose a^*.

On the other hand, for $a < a^*$, we need $\pi_N'(a) > 0$ or

$$f_a(a,k^*) + \lambda'(a) f(a,k^*) \ln\left(\frac{\delta}{\delta_n}\right) > \frac{c'(a)}{(1-\theta)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}},$$

or

$$\lambda'(a) < \frac{1}{f(a,k^*)\ln(\delta/\delta_n)}\left[\frac{c'(a)}{(1-\theta)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}} - f_a(a,k^*)\right]. \tag{20}$$

If we take $A(a) \equiv \left[\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}\right]^{-1}$, then $\lambda(a) = \dfrac{\ln[\delta_n A(a)]}{\ln(\delta_n/\delta)}$. Hence, inequality (20) becomes:

$$\frac{A'(a)}{A(a)} < \frac{1}{f(a,k^*)}\left[f_a(a,k^*) - c'(a)\frac{A(a)}{1-\theta}\right].$$

It is satisfied if

$$\frac{A'(a)}{A(a)} = -\frac{c'(a)}{f(a,k^*)}\frac{A(a)}{1-\theta},$$

which implies

$$dA^{-1}(a) = \frac{1}{1-\theta}\frac{dc(a)}{f(a,k^*)}.$$

Then, the above implies

$$A^{-1}(a) = C + \frac{1}{1-\theta}\int_0^a \frac{dc(\tau)}{f(\tau,k^*)},$$

where C is an arbitrary constant. Obviously, $A(a)$ is decreasing, implying that $\lambda(a)$ is decreasing. Also, since

$$\lambda(a) = \frac{\ln\delta_n - \ln A^{-1}(a)}{\ln(\delta_n/\delta)},$$

We have

$$\lambda'(a) = -\frac{1}{\ln(\delta_n/\delta)}\frac{\left[A^{-1}(a)\right]'}{A^{-1}(a)} = -\frac{1}{(1-\theta)\left[\ln(\delta_n/\delta)\right]}\frac{1}{A^{-1}(a)}\frac{c'(a)}{f(a,k^*)} < 0,$$

$$\lambda''(a) = \frac{1}{(1-\theta)\left[\ln(\delta_n/\delta)\right]}\left\{\frac{\left[A^{-1}(a)\right]'}{\left[A^{-1}(a)\right]^2}\frac{c'(a)}{f(a,k^*)} - \frac{1}{A^{-1}(a)}\frac{c''(a)f - c'(a)f_a}{\left[f(a,k^*)\right]^2}\right\}.$$

If $c(a)$ has a constant marginal cost: $c(a) = \gamma a$, then we have $\lambda''(a) > 0$, i.e., $\lambda(a)$ is convex. Hence, as shown in Figure 2, this reform policy is downward sloping and convex.

Although this C can be arbitrary, we do need to restrict it to ensure $0 \leq \lambda(a) \leq 1$. To have $\lambda(a) \geq 0$ for all $a \leq a^*$, since $\lambda(a)$ is decreasing, we need $\lambda(a^*) \geq 0$ only. That is, $A^{-1}(a^*) \leq \delta_n$, or

$$C \leq \delta_n - \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*)}.$$

To have $\lambda(a) \leq 1$ for all $a \leq a^*$, since $\lambda(a)$ is decreasing, we need $\lambda(0) \leq 1$ only. That is, $C \geq \delta$. Hence, we need the following condition to ensure $0 \leq \lambda(a) \leq 1$:

$$\delta \leq C \leq \delta_n - \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*)}.$$

Such a C exists if and only if condition (6) is satisfied. In other words, as long as the time preference δ of the N-holder satisfies (6), we can identify a proper $\lambda(a)$ to induce a^*. The end result is a market-based efficient firm.

If the marginal cost of effort is constant and is small relative to output, then any N-holder with $\delta < \delta_n$ will be enticed by the reform program to improve the firm. In a large economy with $n \to \infty$, we have $\delta_n \to 1$, implying that virtually any N-holder has enough incentive to improve the firm adequately. Finally, we can simply take $C = \delta$. If so, although unnecessary, we can choose the following λ_0 to ensure continuity of $\lambda(\cdot)$:

$$\lambda_0 = \lambda(a^*) = \frac{\ln \delta_n - \ln\left[\delta + \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*)}\right]}{\ln(\delta_n / \delta)}.$$

Proof of Proposition 2

Given the profit function in (11), with $k = k^*$, we have

$$\begin{aligned}\pi_N'(a) = &\left[1-\beta\sigma^2 f(a,k^*)\right] f_a(a,k^*)(1-\theta)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)} \\ &+\left[1-\beta\sigma^2 f(a,k^*)\right] f(a,k^*)(1-\theta)\lambda'(a)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)} \ln\left(\frac{\delta}{\delta_n}\right) - c'(a).\end{aligned}$$

Consider a general lockup policy $\lambda(a)$ of the following form:

$$\lambda(a) = \begin{cases} \lambda(a) & \text{if } \ a < a^*, \\ \lambda_0 & \text{if } \ a \geq a^*. \end{cases} \tag{21}$$

For $a \geq a^*$, $\lambda(a)$ can take any constant $\lambda_0 \in [0, 1]$. Then, we have

$$\pi_N'(a) = f_a(a,k^*)\left[1-\beta\sigma^2 f(a,k^*)\right](1-\theta)\delta^{\lambda_0}\delta_n^{1-\lambda_0} - c'(a).$$

Since $\pi_N'(a^*) < 0$ and $\pi_N(a)$ is concave in a, we have $\pi_N'(a) < 0$ for all $a \geq a^*$. This means that, in $[a^*, \infty)$, the N-holder will choose a^*.

On the other hand, for $a < a^*$, we need $\pi_N'(a) > 0$ or

$$f_a(a,k^*)+\lambda'(a)f(a,k^*)\ln\left(\frac{\delta}{\delta_n}\right)>\frac{c'(a)}{(1-\theta)\left[1-\beta\sigma^2 f(a,k^*)\right]\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}},$$

or

$$\lambda'(a)<\frac{1}{f(a,k^*)\ln(\delta/\delta_n)}\left[\frac{c'(a)}{(1-\theta)\left[1-\beta\sigma^2 f(a,k^*)\right]\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}}-f_a(a,k^*)\right]. \tag{22}$$

If we take $A(a)\equiv\left[\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}\right]^{-1}$, then $\lambda(a)=\dfrac{\ln[\delta_n A(a)]}{\ln(\delta_n/\delta)}$. Hence, inequality (22) becomes:

$$\frac{A'(a)}{A(a)}<\frac{1}{f(a,k^*)}\left[f_a(a,k^*)-c'(a)\frac{A(a)}{(1-\theta)\left[1-\beta\sigma^2 f(a,k^*)\right]}\right], \tag{23}$$

which is satisfied if

$$\frac{A'(a)}{A(a)}=-\frac{c'(a)}{f(a,k^*)}\frac{A(a)}{(1-\theta)\left[1-\beta\sigma^2 f(a,k^*)\right]},$$

which implies

$$(1-\theta)dA^{-1}=\frac{dc(a)}{f(a,k^*)\left[1-\beta\sigma^2 f(a,k^*)\right]},$$

implying

$$A^{-1}(a)=C+\frac{1}{1-\theta}\int_0^a\frac{dc(\tau)}{f(\tau,k^*)\left[1-\beta\sigma^2 f(\tau,k^*)\right]}.$$

where C is a free parameter. Since

$$\lambda(a)=\frac{\ln\delta_n-\ln A^{-1}(a)}{\ln(\delta_n/\delta)},$$

we have

$$\lambda'(a)=-\frac{1}{\ln(\delta_n/\delta)}\frac{\left[A^{-1}(a)\right]'}{A^{-1}(a)}=-\frac{1}{(1-\theta)\ln(\delta_n/\delta)}\frac{c'(a)}{f(a,k^*)\left[1-\beta\sigma^2 f(a,k^*)\right]}\frac{1}{A^{-1}(a)}<0.$$

Hence, this lockup policy is downward sloping.

Although this C can be arbitrary, we do need to restrict it to ensure $0\le\lambda(a)\le 1$. To have $\lambda(a)\ge 0$ for all $a\le a^*$, since $\lambda(a)$ is decreasing, we need $\lambda(a^*)\ge 0$ only. That is, $A^{-1}(a^*)\le\delta_n$, or

$$C\le\delta_n-\frac{1}{1-\theta}\int_0^{a^*}\frac{dc(\tau)}{f(\tau,k^*)\left[1-\beta\sigma^2 f(\tau,k^*)\right]}.$$

To have $\lambda(a)\le 1$ for all $a\le a^*$, since $\lambda(a)$ is decreasing, we need $\lambda(0)\le 1$ only. That is, $A^{-1}(0)\ge\delta$, i.e., $G\ge\delta$. Hence, we need the following condition to ensure $0\le\lambda(a)\le 1$:

$$\delta \le C \le \delta_n - \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*)\left[1-\beta\sigma^2 f(\tau,k^*)\right]}.$$

Such a C exists if and only if (12) is satisfied. In other words, as long as the time preference δ of the N-holder satisfies (12), we can identify a proper $\lambda(\cdot)$ to induce a^*. We can simply take $C=\delta.$ If so, we can choose the following λ_0 to ensure continuity of $\lambda(\cdot)$:

$$\lambda_0 = \lambda(a^*) = \frac{\ln \delta_n - \ln A^{-1}(a^*)}{\ln(\delta_n/\delta)} = \frac{\ln \delta_n - \ln\left\{\delta + \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*)\left[1-\beta\sigma^2 f(\tau,k^*)\right]}\right\}}{\ln(\delta_n/\delta)}.$$

Proof of Proposition 3

Given the profit function in (15), with $k=k^*$, we have

$$\begin{aligned}\pi_N'(a) = {} & f_a(a,k^*)(1-\theta)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)} \\ & + \left[f(a,k^*)-\beta\sigma^2\right](1-\theta)\lambda'(a)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}\ln\left(\frac{\delta}{\delta_n}\right) - c'(a).\end{aligned}$$

Consider a general lockup policy $\lambda(a)$ of the following form:

$$\lambda(a) = \begin{cases} \lambda(a) & \text{if } \ a < a^*, \\ \lambda_0 & \text{if } \ a \ge a^*. \end{cases} \tag{24}$$

For $a \ge a^*$, $\lambda(a)$ can take any constant $\lambda_0 \in [0,\,1].$ Then, we have

$$\pi_N'(a) = f_a(a,k^*)(1-\theta)\delta^{\lambda_0}\delta_n^{1-\lambda_0} - c'(a).$$

Since $\pi_N'(a^*) < 0$ and $\pi_N(a)$ is concave in a, we have $\pi_N'(a) < 0$ for all $a \ge a^*$. This means that, in $[a^*,\,\infty),$ the N-holder will choose a^*.

On the other hand, for $a < a^*$, we need $\pi_N'(a) > 0$ or

$$f_a(a,k^*) + \lambda'(a)\left[f(a,k^*)-\beta\sigma^2\right]\ln\left(\frac{\delta}{\delta_n}\right) > \frac{c'(a)}{(1-\theta)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}},$$

or

$$\lambda'(a) < \frac{1}{\left[f(a,k^*)-\beta\sigma^2\right]\ln(\delta/\delta_n)}\left[\frac{c'(a)}{(1-\theta)\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}} - f_a(a,k^*)\right]. \tag{25}$$

If we take $A(a) \equiv \left[\delta^{\lambda(a)}\delta_n^{1-\lambda(a)}\right]^{-1}$, then $\lambda(a) = \dfrac{\ln[\delta_n A(a)]}{\ln(\delta_n/\delta)}$. Hence, inequality (25) becomes:

$$\frac{A'(a)}{A(a)} < \frac{1}{f(a,k^*)-\beta\sigma^2}\left[f_a(a,k^*) - c'(a)\frac{A(a)}{1-\theta}\right]. \tag{26}$$

Assume $f(a,k^*) > \beta\sigma^2$ for all $a \in [0,\,a^*]$; if this is not satisfied, the output has no social value. (26) is satisfied if

$$\frac{A'(a)}{A(a)} = -\frac{c'(a)}{f(a,k^*) - \beta\sigma^2}\frac{A(a)}{1-\theta},$$

implying

$$(1-\theta)dA^{-1} = \frac{dc(a)}{f(a,k^*) - \beta\sigma^2},$$

implying

$$A^{-1}(a) = C + \frac{1}{1-\theta}\int_0^a \frac{dc(\tau)}{f(\tau,k^*) - \beta\sigma^2},$$

where C is a free parameter. Since

$$\lambda(a) = \frac{\ln\delta_n - \ln A^{-1}(a)}{\ln(\delta_n / \delta)},$$

we have

$$\lambda'(a) = -\frac{1}{\ln(\delta_n/\delta)}\frac{\left[A^{-1}(a)\right]'}{A^{-1}(a)} = -\frac{1}{(1-\theta)\ln(\delta_n/\delta)}\frac{1}{A^{-1}(a)}\frac{c'(a)}{f(a,k^*) - \beta\sigma^2} < 0,$$

$$\lambda''(a) = \frac{1}{(1-\theta)\ln(\delta_n/\delta)}\frac{1}{A^{-1}(a)} \cdot \left[\frac{c'(a)}{f(a,k^*) - \beta\sigma^2}\frac{\left[A^{-1}(a)\right]'}{A^{-1}(a)} - \frac{c''(a)\left[f(a,k^*) - \beta\sigma^2\right] - c'(a) f_a(a,k^*)}{\left[f(a,k^*) - \beta\sigma^2\right]^2}\right].$$

Hence, the lockup policy $\lambda(a)$ is decreasing. If the marginal cost is constant, $\lambda(a)$ is also convex.

Although this C can be arbitrary, we do need to restrict it to ensure $0 \le \lambda(a) \le 1$. To have $\lambda(a) \ge 0$ for all $a \le a^*$, since $\lambda(a)$ is decreasing, we need $\lambda(a^*) \ge 0$ only. That is, $A^{-1}(a^*) \le \delta_n$, or

$$C \le \delta_n - \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*) - \beta\sigma^2}.$$

To have $\lambda(a) \le 1$ for all $a \le a^*$, since $\lambda(a)$ is decreasing, we need $\lambda(0) \le 1$ only. That is, $A^{-1}(0) \ge \delta$, i.e., $C \ge \delta$. Hence, we need the following condition to ensure $0 \le \lambda(a) \le 1$:

$$\delta \le C \le \delta_n - \frac{1}{1-\theta}\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*) - \beta\sigma^2}.$$

Such a C exists if and only if (16) is satisfied. In other words, as long as the time preference δ of the N-holder satisfies (16), we can identify a proper $\lambda(\cdot)$ to induce a^*. We can simply take $C = \delta$. If so, we can choose the following λ_0 to ensure continuity of $\lambda(\cdot)$:

$$\lambda_0 = \lambda(a^*) = \frac{\ln \delta_n - \ln A^{-1}(a^*)}{\ln(\delta_n / \delta)} = \frac{\ln \delta_n - \ln\left\{\delta + \dfrac{1}{1-\theta}\displaystyle\int_0^{a^*} \frac{dc(\tau)}{f(\tau,k^*) - \beta\sigma^2}\right\}}{\ln(\delta_n / \delta)}.$$

Proof of Proposition 4

The Lagrange function for problem (18) is

$$L = f(a,k) - rk - c(a) + \mu_1\left[f_a(a,k)(1-\theta)\delta^\lambda \delta_n^{1-\lambda} - c'(a)\right] + \mu_2\left[\theta f(a,k) F^{-1}\left(1-\frac{\theta}{n}\right) - k\right].$$

The FOCs are

$$\begin{aligned}
0 &= f_a(a,k) - c'(a) + \mu_1\left[f_{aa}(a,k)(1-\theta)\delta^\lambda \delta_n^{1-\lambda} - c''(a)\right] + \mu_2 \theta f_a(a,k) F^{-1}\left(1-\frac{\theta}{n}\right), \\
0 &= f_k(a,k) - r + \mu_1 f_{ak}(a,k)(1-\theta)\delta^\lambda \delta_n^{1-\lambda} + \mu_2\left[\theta f_k(a,k) F^{-1}\left(1-\frac{\theta}{n}\right) - 1\right], \\
0 &= \mu_1 f_a(a,k)(1-\theta)\delta^\lambda \delta_n^{1-\lambda} \ln\left(\frac{\delta}{\delta_n}\right), \\
0 &= -\mu_1 f_a(a,k)\delta^\lambda \delta_n^{1-\lambda} + \mu_2\left[f(a,k) F^{-1}\left(1-\frac{\theta}{n}\right) - \frac{\theta}{n}\frac{f(a,k)}{f\left[F^{-1}\left(1-\frac{\theta}{n}\right)\right]}\right].
\end{aligned} \tag{27}$$

When n is large enough, we have

$$F^{-1}\left(1-\frac{\theta}{n}\right) < \frac{\theta}{n}.$$

Hence, we know $\mu_1\mu_2 < 0$. By the third FOC, we know that λ must take a corner value, either 0 or 1. By (17), we have $f_a(a,k) > c'(a)$. Then, by multiplying the first FOC by μ_2, we have

$$\mu_2\left[f_a(a,k) - c'(a)\right] + \mu_1\mu_2\left[f_{aa}(a,k)(1-\theta)\delta^\lambda \delta_n^{1-\lambda} - c''(a)\right] + \mu_2^2 \theta f_a(a,k) F^{-1}\left(1-\frac{\theta}{n}\right) = 0.$$

Hence, we have $\mu_2 < 0$, implying $\mu_1 > 0$. Therefore, we have $\lambda = 0$.

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