# Endogenous Exit and China's State-Sector Transformation[†]

Adam A. Oppenheimer[‡] Yutong Zhong[*§]

Job Market Paper

November 9, 2026

Click here for latest version

**Abstract**

Between 1998 and 2007, China's GDP grew by nearly 10 percent annually. Song, Storesletten and Zilibotti (2011) emphasize resource reallocation from state-owned enterprises (SOEs) toward more productive private firms as a central driver of this growth. Yet Hsieh and Song (2015) highlight substantial productivity growth within the shrinking state sector. We argue that exit should be evaluated against the productivity growth that would have occurred had exiting firms continued operating. Conventional productivity decompositions and the analysis of Hsieh and Song (2015), however, overlook the subsequent productivity deterioration these firms might have experienced, potentially understating the contribution of exit. We develop a framework that recovers this unobserved potential productivity distribution and find that selective exit explains 58 percent of SOE productivity growth. Our year-by-year analysis shows that selection dominates during early "grasp the large, let go of the small" reforms, while incumbent improvements become more important following later governance reforms. We then estimate a structural model showing that reducing government financial support for struggling SOEs promotes exit and reallocates resources toward more productive private firms, whereas governance reform improves incumbents but can impede reallocation. Our findings suggest that state-sector productivity growth reinforces, rather than challenges, the importance of reallocation.

---

[*]Yutong Zhong is the job market candidate.

[†]We are deeply indebted to Anmol Bhandari, Hannes Malmberg and Kjetil Storesletten for their invaluable guidance throughout the project. We also thank Laura Castillo-Martínez, Anton Cheremukhin, Tianyu Fan, Jason Hall, Kyle Herkenhoff, Loukas Karabarbounis, Robert Parham, Todd Schoellman, and Lieyuan Yang for insightful discussion.

[‡]University of Minnesota, Department of Economics. Email: oppen040@umn.edu.

[§]University of Minnesota, Department of Economics. Email: zhong462@umn.edu.

# 1 Introduction

A central explanation for China's remarkable economic growth emphasizes the reallocation of resources from inefficient state-owned enterprises toward more productive private firms (Brandt, Hsieh and Zhu, 2008; Hsieh and Klenow, 2009; Song, Storesletten and Zilibotti, 2011). Hsieh and Song (2015), however, argue that this explanation overlooks an important margin: even as the state sector contracted, it experienced substantial productivity growth of its own. Between 1998 and 2007, the productivity of state-owned enterprises (SOEs) approached private-sector levels. Hsieh and Song (2015) emphasize productivity improvements among surviving SOEs and the creation of new state firms as important sources of growth, suggesting that China's transformation involved not only the reallocation of resources away from state ownership, but also substantial improvements within the state sector itself.

This paper revisits that interpretation. We argue that conventional approaches to measuring productivity growth can substantially understate the contribution of selective exit, making improvements within the state sector appear more important than they actually were. The key insight is that the contribution of exit to productivity growth should be evaluated by asking how productivity would have evolved had exiting firms continued operating. Conventional productivity decompositions typically evaluate exit using firms' previously observed productivity. But firms may experience adverse productivity shocks before exiting, in which case their earlier productivity can substantially overstate how productive they would have been had they survived. Failing to account for this deterioration understates the relative importance of exit to productivity growth and overstates the relative importance of improvements among continuing firms.

The first contribution of the paper is to develop a novel decomposition framework. Our framework bridges conventional productivity accounting and structural models of firm dynamics by expressing aggregate productivity growth in terms of the underlying processes governing incumbent productivity, exit, and entry. It delivers an accounting decomposition as a special case: using a benchmark with unchanged incumbent productivity and no exit or entry, we decompose observed productivity growth into contributions from these three processes, while correcting for selection. More generally, the framework can evaluate how the productivity distribution would evolve under different firm-dynamic regimes. The framework thus provides a common tool for empirical productivity accounting and structural counter-

factual analysis without requiring a particular model of how policies affect firm behavior.

Accounting for selective exit requires confronting a fundamental empirical challenge: how productive would exiting firms have been had they continued operating? We observe their productivity before exit, but not the subsequent productivity realizations that may have led them to exit. We show that the distribution of these unobserved realizations can nevertheless be recovered from firm-level panel data. Identification relies on three key assumptions. First, all firm states are observed in the data (so there are no states with certain exit). Second, productivity follows a first-order Markov process. Third, firms draw their current productivity before deciding whether to exit, and conditional on this draw, exit is independent of past productivity. Under these assumptions, and a rank condition on observed transitions among survivors, we can separately identify the productivity transition process and exit rule.

We apply the framework to China's Annual Survey of Industrial Firms (ASIF) from 1998 to 2007. The data cover state-owned manufacturing enterprises and private firms above a revenue threshold and provide annual information on firm ownership, production, capital, and employment. We use the data to construct measures of firm-level productivity and track firm entry and exit. Applied to the data, our decomposition shows that changes in selection account for 57.6 percent of SOE productivity growth over the full period, compared with 23.2 percent from changes in incumbent productivity dynamics and 19.3 percent from entry. This contrasts with the findings of Hsieh and Song (2015), who emphasize productivity improvements among surviving SOEs and the creation of new state firms as the main drivers of SOE productivity convergence, and attribute little change in aggregate output growth to the closure of state firms. While their analysis concerns aggregate output rather than productivity growth within the state sector, our results reveal a much larger role for selection in SOE productivity convergence.

The relative importance of these mechanisms also changes over time: selection dominates during the early reform period (1998–2002), while improvements in incumbent productivity dynamics become the dominant source of growth during the later period (2003–2007). This pattern broadly coincides with the evolution of China's SOE reforms. In the late 1990s, the policy of "grasp the large, let go of the small" encouraged the closure, sale, merger, and privatization of smaller and poorly performing SOEs while consolidating larger state enterprises. The State-owned Assets Supervision and Administration Commission (SASAC) was established in 2003 to exercise ownership and supervisory functions over central SOEs, and subsequent reforms, including the split-share structure reform beginning in 2005 for listed

firms, increasingly emphasized changes to corporate governance and managerial incentives. The decomposition does not establish that these particular reforms caused the estimated changes in selection or productivity dynamics. But the timing of the empirical results is consistent with a transition from reforms operating heavily through exit and ownership change toward reforms increasingly focused on improving the productivity of surviving SOEs.

The decomposition provides a broad picture of China's state-sector transformation, quantifying the contributions of incumbent productivity dynamics, selection, and entry to SOE productivity growth and documenting how their relative importance changed over the reform period. To understand the economic mechanisms behind these patterns, the second contribution of the paper is to develop and estimate a structural firm-dynamics model of SOE reform. We use the model to quantify how different reforms contributed to SOE productivity growth and state-sector contraction, and how they affected aggregate productivity through the reallocation of resources between state and private firms.

The model captures three central features of China's SOE reforms. First, soft budget constraints protect poorly performing SOEs from exit; hardening these constraints exposes weaker firms to greater selection. Second, SOEs can invest to improve future productivity, and governance reform increases the effectiveness of these investments. Third, the state-directed entry environment determines the creation and composition of new state firms. The state and private sectors are linked in equilibrium, so changes in SOE productivity, survival, and entry also affect private-sector activity and aggregate productivity. We estimate the model along China's 1998–2007 reform transition. The model reproduces the sharp contraction of state ownership and generates substantial convergence of SOE productivity toward that of private firms. As an untargeted validation, we apply our statistical decomposition to model-generated firm data and find that, as in the data, selection accounts for the largest share of SOE productivity growth over the reform period.

We use the estimated model to quantify the effects of individual reforms by comparing the historical reform path with three counterfactuals. In the first, we maintain pre-reform government support for unprofitable SOEs, allowing firms that would otherwise exit to remain in operation. In the second, we hold the effectiveness of SOEs' investments in management and organizational improvements at its pre-reform level. In the third, we maintain the pre-reform environment governing the entry of new SOEs. In each counterfactual, the other reforms proceed as historically implemented. The counterfactuals show that while budget hardening and governance reform both raise SOE productivity, they have different

implications for the state sector's share of economic activity. Hardening budget constraints raises average SOE productivity by increasing the exit of less productive firms, while reducing state-sector employment and reallocating resources toward private firms. Governance reform also raises SOE productivity, but through improvements among incumbents. This reform increases SOE survival and employment, drawing labor away from private firms. New SOE entry further offsets the contraction of the state sector.

We next examine whether the source of SOE productivity growth matters for aggregate outcomes. We construct two counterfactual reforms that raise SOE productivity through different mechanisms. In the first, the government reduces bailout protection for unprofitable SOEs, thereby hardening their budget constraints. This makes less productive firms more likely to exit and raises average productivity among those that remain. In the second, the government strengthens corporate governance by improving oversight and managerial accountability, making SOEs' investments in management and organizational improvements more effective at raising productivity. Unlike the first reform, this reform improves incumbent productivity while maintaining pre-reform bailout protection. We calibrate both reforms to generate the same 10 percent increase in employment-weighted SOE productivity by 2007.

The two reforms produce sharply different outcomes despite generating the same improvement in SOE productivity. Under budget hardening, the SOE employment share falls to 21.8 percent, while aggregate productivity rises by 25.4 percent relative to the pre-reform equilibrium. Under governance reform, the SOE employment share is 40.8 percent, and aggregate productivity rises by only 12.4 percent. Thus, the source of SOE productivity growth has important implications for both the allocation of resources between state and private firms and aggregate productivity.

Reform timing also matters. China's SOE reforms unfolded over several years, with the late 1990s characterized by the closure, merger, and privatization of smaller SOEs under the "grasp the large, let go of the small" reforms, followed by corporate governance reforms in the 2000s. In the model, we consider a counterfactual in which the full reform package is implemented in 1999 rather than sequentially. Introducing governance reform earlier enables SOEs to start improving their productivity sooner, increasing their likelihood of survival. By 2007, the counterfactual produces more productive SOEs and leaves more employment under state ownership, but generates lower aggregate productivity by crowding out activity among more productive private firms. The comparison shows that the timing of reforms affects not only the path of SOE productivity growth but also the allocation of economic

activity between state and private firms.

Taken together, the empirical and structural results provide a unified interpretation of China's state-sector transformation. The decomposition shows that selection was the largest source of SOE productivity growth over 1998–2007, particularly early in the reform period, while improvements in incumbent productivity dynamics became more important later. These temporal patterns coincide with the sequence and purpose of the reforms implemented during this period. The structural model then shows that these mechanisms have different implications for resource allocation: hardening budget constraints raises SOE productivity through selective exit and reallocates resources toward more productive private firms, whereas governance reform improves incumbent productivity but preserves more activity under state ownership. Selective exit therefore helps reconcile productivity growth within the state sector with the reallocation of economic activity toward private firms.

## 1.1 Related Literature

This paper connects four strands of literature: productivity decompositions, firm dynamics, endogenous sample selection, and the transformation of China's state sector.

The paper first contributes to the productivity-decomposition literature. Classic decompositions allocate observed productivity growth across productivity changes within continuing firms, reallocation among incumbents, entry, and exit (Baily et al., 1992; Griliches and Regev, 1995; Foster et al., 2001). Melitz and Polanec (2015) refine the treatment of entry and exit by comparing entering and exiting firms with contemporaneous survivors. These decompositions are accounting identities built from realized firm flows. They show which observed groups and movements accompany aggregate productivity growth. Their components are not changes in the mechanisms that generate those movements. Asturias et al. (2023) provide an important bridge to firm dynamics. They introduce reforms into a Hopenhayn-style model and study how those reforms appear in the Foster et al. (2001) terms. We instead make the law-of-motion mechanisms themselves the objects of decomposition. We estimate the incumbent productivity transition process, the exit rule and the mass and composition of entry. We then measure each mechanism's contribution by replacing its path in mixed-regime counterfactuals. This mechanism-based decomposition complements conventional accounting. Stationary firm churning may generate nonzero accounting components even when no mechanism changes. A change in one mechanism may also appear in

several accounting terms.

The economic structure of these objects comes from the firm-dynamics literature. Jovanovic (1982) explains firm growth and exit through learning and market selection: firms gradually learn about their efficiency, so more efficient firms expand and survive while less efficient firms contract and exit. Hopenhayn (1992) embeds stochastic productivity, endogenous continuation, and entry in competitive industry equilibrium, showing how these margins jointly determine turnover and the cross-sectional firm distribution. Ericson and Pakes (1995) extends this tradition to environments in which firms invest in their future states and interact strategically. Subsequent quantitative work uses related heterogeneous-firm environments to study how particular forces operate through firm growth, selection, and entry, including job-destruction policies (Hopenhayn and Rogerson, 1993), exposure to trade (Melitz, 2003), financing constraints (Clementi and Hopenhayn, 2006), and aggregate shocks (Clementi and Palazzo, 2016). Across these applications, the evolution of the firm distribution is generated by three linked margins: the dynamics of incumbent states, state-dependent continuation, and the inflow of entrants.

Relative to this literature, our contribution is to make the induced law of motion an object of empirical recovery and decomposition. Structural firm-dynamics papers typically begin with technologies, costs, frictions, and policies and derive the transition, continuation, and entry processes implied by equilibrium. At the decomposition stage, we proceed in the complementary direction: under the identifying restrictions developed below, we recover the time-varying firm-dynamic objects from firm-panel data and use mixed-regime counterfactuals to quantify how changes in each mechanism reshape the firm distribution. This places the framework between a flow accounting identity and a complete structural model. It imposes the economic organization of a firm-dynamics law of motion without requiring that every deep parameter and equilibrium channel be specified at the decomposition stage. The approach contributes in two ways. First, it distinguishes changes in firms' underlying productivity trajectories from changes in selection conditional on destination productivity and from changes in entrant mass and composition. Second, it provides mechanism-level targets for structural interpretation: a proposed reform channel should reproduce not only aggregate productivity growth, but also the observed changes in incumbent dynamics, selection, and entry. The decomposition therefore identifies which dynamic margins changed and how much those changes mattered, while a structural model can map those reduced-form changes back to policy and deep primitives.

Recovering the transition and exit mechanisms separately, however, creates a problem of endogenous selection. Current productivity is observed only when the firm remains active. Classical sample-selection methods recover outcome relationships under nonrandom observation, beginning with Heckman (1979). Later work extends these methods to panel, dynamic, and nonparametric settings (Wooldridge, 1995; Kyriazidou, 1997, 2001; Das et al., 2003). Most closely related, d'Haultfoeuille (2010) studies settings in which selection depends on the missing outcome itself. He uses an instrument that changes the outcome but has no direct effect on selection once the outcome is held fixed. Under a completeness condition, this identifies both the selection probability and the full outcome distribution. We adapt this logic to a Markov productivity-transition and firm exit problem. In our setting, lagged productivity serves as the instrument. Lagged productivity shifts the distribution of current productivity but, under our baseline exclusion, has no direct effect on exit conditional on current productivity and predetermined controls. This variation allows us to recover the complete latent transition kernel and the destination-specific exit rule separately. We then use their separate recovery to construct the mixed-regime counterfactuals required by the decomposition, which combine the transition process from one regime with the exit rule from another.

The application contributes to the broader literature on China's reform-era growth and the transformation of its state sector. One strand emphasizes productivity differences, financial and policy distortions, and the reallocation of resources from state toward private firms (Brandt et al., 2008; Hsieh and Klenow, 2009; Song et al., 2011; Khandelwal et al., 2013). Another emphasizes the transformation of the state sector itself. Hsieh and Song (2015) provide the closest quantitative account of this transformation. They document the sharp contraction of the state sector together with rapid productivity growth among surviving SOEs and the creation of new state firms, and their quantitative accounting assigns much of the aggregate gain from SOE reform to the latter two forces rather than to firm closure. We reach a different conclusion about the source of productivity growth within the state sector: once selective survival is accounted for, changes in exit account for the largest share of SOE productivity growth over 1998–2007. The difference is not a contradiction. Hsieh and Song (2015) quantifies the aggregate consequences associated with realized groups of surviving, entering, and exiting firms, whereas we ask which underlying firm-dynamic forces generated the rise in SOE productivity itself.

This distinction also motivates the structural part of the paper. A large literature studies

the institutional forces that could have changed these firm-dynamic margins during China's transition. Work on soft budget constraints emphasizes how government support can keep poorly performing state firms in operation and how harder budget constraints can strengthen selection (Qian and Roland, 1998; Brandt and Zhu, 2001; Kornai et al., 2003). A related literature studies how corporatization, managerial incentives, and governance reform changed the performance of surviving SOEs (Groves et al., 1994; Li, 1997; Chen et al., 2021; Gu and Jia, 2022). Other work emphasizes ownership-dependent distortions and the conditions governing private and state entry (Hsieh and Klenow, 2009; Song et al., 2011; Brandt et al., 2013; McMillan and Naughton, 1992; Jiang et al., 2024). Our structural model brings these channels together: government bailout affects which otherwise would have exited SOEs survive, governance changes the productivity of the firms that remain, and state and private entry contribute to how activity is reallocated across ownership types. This allows us to move from identifying which margins drove SOE productivity convergence to quantifying which reforms generated those margins and how they affected aggregate productivity and the size of the state-sector.

The remainder of the paper proceeds as follows. Section 2 and Section 3 develop the decomposition framework and establish identification. Section 4 applies the framework to China's SOE reform. Section 5 and Section 6 develop and estimate the structural model. Section 7 studies the quantitative implications of SOE reforms. Section 8 concludes.

# 2 An Empirical Framework for Firm Dynamics

We consider an economy populated by heterogeneous firms. A firm $i$ has log productivity $z_{it}$ at time $t$. The observed data consist of an unbalanced panel. The data record firms' entry and exit, as well as their productivity while active. The productivity of an inactive firm is not observed. We call the productivity of an active firm the firm's *operating productivity*, and the productivity draw a firm receives before making the decision whether to continue operating or exit the firm's *next-period potential productivity*.

We are interested in recovering three potentially time-varying objects: the process governing productivity transitions, the exit probability conditional on next-period potential productivity, and the mass and productivity distribution of entrants. The transition process

can reveal the unobserved distribution of potential productivity draws among firms that subsequently exit. The exit rule can characterize the degree of selection into continued operation. The entry process describes the composition of new firms. Separately recovering all three makes it possible to distinguish productivity changes experienced by incumbents from selective survival and entry.

## 2.1 Firm Dynamics and Aggregate Productivity

Our framework makes two main assumptions. First, productivity follows a first-order Markov process: the distribution of next-period potential productivity may depend on current operating productivity but, conditional on current operating productivity, is independent of earlier productivity realizations. Second, conditional on next-period potential productivity, a firm's exit decision does not depend on current or earlier operating productivity.

We now describe the model's timing. Let $\mu_t(B)$ denote the unnormalized measure of firms operating in period $t$ with log productivity in a set $B$. Between periods $t-1$ and $t$, an incumbent with period-$(t-1)$ operating productivity $z^-$ draws period-$t$ potential productivity $z$ from $P_t(\mathrm{d}z \mid z^-)$. After observing this draw, the firm exits with probability $Q_t(z)$. Conditional on $z$, exit does not depend directly on the firm's previous productivity. The potential productivity draw of an exiting firm is not observed in the data. Finally, new firms enter with total mass $\lambda_t$ and productivity distribution $G_t$. We write the entry process as $E_t(\mathrm{d}z) = \lambda_t G_t(\mathrm{d}z)$. All three processes may vary over time.

The firms operating in period $t$ consist of surviving incumbents and new entrants. For any set $B$, their distribution satisfies

$$\mu_t(B) = \int \left[ \int_B [1 - Q_t(z)]\, P_t(\mathrm{d}z \mid z^-) \right] \mu_{t-1}(\mathrm{d}z^-) + E_t(B). \tag{2.1.1}$$

The first term is the mass of incumbents that draw productivity in $B$ and survive; the second is the mass of entrants in $B$.

For convenience, we write the law of motion more compactly as

$$\mu_t = (1 - Q_t) P_t \mu_{t-1} + E_t. \tag{2.1.2}$$

Here, $P_t\mu_{t-1}$ gives the period-$t$ distribution of potential productivity among incumbents, while multiplication by $1 - Q_t$ accounts for their survival and $E_t$ gives period-$t$ entry. We

use this notation to construct counterfactual transition laws below.

Given $\mu_t$, we measure aggregate productivity as a weighted mean of firm log productivity. Let $m(z) > 0$ denote the weight assigned to an active firm with log productivity $z$. Aggregate productivity in period $t$ is

$$\Phi(\mu_t; m) = \frac{\int z\, m(z)\, \mu_t(\mathrm{d}z)}{\int m(z)\, \mu_t(\mathrm{d}z)}. \tag{2.1.3}$$

While in principle the framework can accommodate changing weights, throughout the paper we hold $m(z)$ fixed over time and across counterfactuals. We leave changing weights, which could be interpreted as a reallocation margin, for future research.

## 2.2 Comparing Firm-Dynamics Regimes

For a transition between two periods, consider two regimes $A$ and $B$ with respective primitives

$$\mathcal{R}^A = (P^A, Q^A, E^A), \qquad \mathcal{R}^B = (P^B, Q^B, E^B). \tag{2.2.1}$$

Starting from the same inherited firm measure $\mu_0$ and using a common weighting rule $m$, define the aggregate-productivity map

$$F(P, Q, E; \mu_0, m) \equiv \Phi((1 - Q)P\mu_0 + E; m). \tag{2.2.2}$$

The outcome difference between regimes is

$$\Delta\Phi^{B,A} = F(P^B, Q^B, E^B; \mu_0, m) - F(P^A, Q^A, E^A; \mu_0, m). \tag{2.2.3}$$

The difference in (2.2.3) can be decomposed by replacing the three processes sequentially. We use $W$, $X$, and $N$ to denote the effects of productivity transitions (within), exit, and entry, respectively. Separately, the superscript records the order in which the underlying processes $P$, $Q$, and $E$ are replaced. Because the processes interact, this ordering affects the value of each effect. For example, the superscript $PQE$ indicates that we first replace the productivity transition, then the exit rule, and finally the entry process:

$$W^{\mathrm{PQE}} = F(P^B, Q^A, E^A) - F(P^A, Q^A, E^A), \tag{2.2.4}$$

$$X^{\mathrm{PQE}} = F(P^B, Q^B, E^A) - F(P^B, Q^A, E^A), \tag{2.2.5}$$

$$N^{\mathrm{PQE}} = F(P^B, Q^B, E^B) - F(P^B, Q^B, E^A), \tag{2.2.6}$$

where the common arguments $(\mu_0, m)$ are suppressed. Thus, the leading symbol identifies the effect, while the superscript identifies the process-replacement ordering. By construction, $\Delta\Phi^{B,A} = W^{\mathrm{PQE}} + X^{\mathrm{PQE}} + N^{\mathrm{PQE}}$.

The interpretation of each component depends on the order in which the processes are replaced. In this example, the within contribution evaluates the change in the productivity-transition process under the reference exit and entry processes; the exit contribution evaluates the change in the selection rule conditional on the new productivity dynamics; and the entry contribution evaluates the change in the entrant population conditional on the new productivity transition and exit processes.

In certain contexts, a particular decomposition order may be defensible. In others, a Shapley decomposition, which averages each component's contribution across all six possible replacement orders, may be appropriate (Shapley, 1953; Shorrocks et al., 2013). We discuss the choice of ordering for decomposing observed productivity growth in the next subsection.

## 2.3 Productivity Growth and Conventional Decompositions

A useful reference regime is the identity transition without exit or entry:

$$\mathcal{R}^0 = (I, 0, 0), \qquad I(\mathrm{d}z' \mid z) = \delta_z(\mathrm{d}z'), \tag{2.3.1}$$

where $\delta_z$ denotes the Dirac measure at $z$. This leaves the inherited firm population unchanged, so $F(I, 0, 0; \mu_0, m) = \Phi(\mu_0; m)$. We call this the *frozen benchmark*. Comparing observed firm dynamics with this benchmark thus enables decompositions of observed productivity growth.

Now consider decomposing growth under the observed processes $(P, Q, E)$, using $(I, 0, 0)$ as the reference. Let $S_0$ denote the measure of surviving firms at their initial operating productivity and $S_1$ denote the measure of surviving firms at their next-period operating productivity. Let $X_0$ denote the measure of eventual exiters at their initial operating productivity and $X_1^*$ denote the measure of exiting firms at their next-period potential productivity. Finally, let $E_1$ denote the measure of entrant firms at their next-period operating productivity.

Using this notation, we can write the observed distributions as

$$\mu_0 = S_0 + X_0, \qquad \mu_1 = S_1 + E_1. \tag{2.3.2}$$

The next-period potential productivity distribution of all incumbents, including those that eventually exit, can be written as

$$P\mu_0 = S_1 + X_1^*. \tag{2.3.3}$$

Applying the survival rule gives the next-period productivity distribution of surviving firms

$$(1 - Q)P\mu_0 = S_1. \tag{2.3.4}$$

Starting from the frozen benchmark, it first replaces the identity transition with the estimated transition process $P$, generating the within effect $W$; it then replaces the no-exit rule with the estimated exit rule $Q$, generating the exit effect $X$; and finally replaces zero entry with the estimated entry process $E$, generating the entry effect $N$. The resulting sequence of firm measures, with each arrow labeled by its associated effect, is

$$S_0 + X_0 \xrightarrow{W} S_1 + X_1^* \xrightarrow{X} S_1 \xrightarrow{N} S_1 + E_1. \tag{2.3.5}$$

Consequently, the change in weighted mean productivity has the exact decomposition

$$\begin{aligned} \Phi(\mu_1; m) - \Phi(\mu_0; m) = & \underbrace{[\Phi(S_1 + X_1^*; m) - \Phi(S_0 + X_0; m)]}_{W\text{: incumbent evolution}} \\ & + \underbrace{[\Phi(S_1; m) - \Phi(S_1 + X_1^*; m)]}_{X\text{: selective exit}} \\ & + \underbrace{[\Phi(S_1 + E_1; m) - \Phi(S_1; m)]}_{N\text{: entry}}. \end{aligned} \tag{2.3.6}$$

The within component ($W$) evaluates the effect of productivity transitions among *all* initial incumbents, rather than among only eventual survivors. The exit component ($X$) measures how selective exit changes aggregate incumbent productivity relative to a counterfactual in which exiters remain active at their next-period potential productivity. The entry component ($E$) adds new firms to the post-transition, post-selection incumbent population.

**Connection with conventional accounting decompositions.** We compare our approach to the dynamic Olley–Pakes decomposition of Melitz and Polanec (2015) (DOPD). DOPD is not a sequence of process replacements. Instead, it is an accounting path that evaluates the DOPD exit, within, and entry effects in the following sequence

$$S_0 + X_0 \xrightarrow{X^{DOPD}} S_0 \xrightarrow{W^{DOPD}} S_1 \xrightarrow{N^{DOPD}} S_1 + E_1. \tag{2.3.7}$$

Its exit effect $X^{DOPD}$ compares initial productivity with and without the firms that eventually exit:

$$X^{\text{DOPD}} = \Phi(S_0; m) - \Phi(S_0 + X_0; m). \tag{2.3.8}$$

By contrast, the selection contribution from our benchmark ordering is

$$X^{\text{PQE}} = \Phi(S_1; m) - \Phi(S_1 + X_1^*; m). \tag{2.3.9}$$

The two paths agree on the entry contribution and on the combined contributions of within and exit. The approaches differ in how they partition the within and exit effects. Conceptually, the difference concerns when exit is evaluated. DOPD measures the effect of exit as the change in initial-period productivity from exit. The decomposition under the $PQE$ ordering instead measures the effect of exit on next-period productivity by comparing surviving incumbents with the counterfactual population in which exiters remain active at their next-period potential productivity. If the purpose of the decomposition is to measure the contribution of selective exit to productivity growth, the second approach is more natural.

Appendix E presents the corresponding methods and results for three other conventional decompositions, following Baily et al. (1992), Foster et al. (2001), Griliches and Regev (1995). It also summarizes their benchmark and weighting conventions.

**Illustration: hardening budget constraints.** Consider a population of initially identical incumbents with productivity $z_0 = 1$ and equal weights. Each incumbent draws potential next-period productivity $z_1^* = 2$ or $z_1^* = 0$, each with probability 1/2. There is no entry. In a soft-budget regime all firms survive. In a hard-budget regime, a firm exits when its draw is below 1, so firms drawing 0 exit and those drawing 2 survive. The productivity process is

the same in both regimes. In expectation, the two regimes imply

$$\Phi_0 = 1, \qquad \Phi_1^{\text{soft}} = 1, \qquad \Phi_1^{\text{hard}} = 2. \tag{2.3.10}$$

First, consider a regime comparison. Comparing the hard-budget environment with the soft-budget environment attributes the entire difference to the exit rule, since the productivity transition and entry processes are shared by the two regimes. This is a consequence of the fact that a decomposition of growth comparing two regimes must assign zero contribution to any component shared by the regimes, as switching that component from one regime's process to the other's will have no effect.

Now decompose observed growth in the hard-budget economy relative to the frozen benchmark $(I, 0, 0)$. First consider the $PQ$ ordering, in which the decomposition replaces the productivity transition before the exit rule. Replacing the transition process while retaining the no-exit rule leaves aggregate productivity at 1, so the within effect is zero. Replacing the exit rule next removes firms with low productivity draws and raises aggregate productivity from 1 to 2, so the exit effect is one.

Now consider the reverse $QP$ ordering, in which the exit rule is replaced before the productivity transition. With the identity transition still in place, every firm retains its initial productivity of 1 and no firm exits. The exit effect is therefore zero. Replacing the productivity transition next generates the low productivity draws that activate the new exit rule and raises aggregate productivity to 2, so the entire gain is assigned to the within effect.

In contrast, all firms that eventually exit had initial productivity 1, equal to the initial mean, so Equation (2.3.8) attributes zero to exit and one to within under DOPD. While this is the same assignment as the $QP$ ordering, in general the approaches will not be equal.

## 2.4 Links with Structural Models of Firm Dynamics

In this subsection, we evaluate which economic environments are consistent with the assumptions underlying our framework.

**Models with Markov productivity and state-dependent survival.** In heterogeneous-firm models such as Hopenhayn (1992), incumbent productivity evolves stochastically, continuation decisions determine which firms remain active, and entry decisions determine the inflow of new producers. When current productivity is a sufficient state and exit deci-

sions occur after the relevant productivity draw, these dynamics can be summarized by our transition, exit, and entry processes. Melitz (2003) provides a related example of firm selection under monopolistic competition, although productivity remains fixed after entry in the canonical model. These models illustrate the economic mechanisms represented by our framework, though their precise exit timing may differ from our assumptions.

**Models with endogenous productivity transitions.** In models with investment, innovation, or organizational improvement, firms make decisions that influence their future productivity. For example, Ericson and Pakes (1995) allow firms to invest in improving their future states, while Olley and Pakes (1996) model investment and survival decisions alongside productivity dynamics. Such environments are consistent with our framework when the resulting productivity transition and exit processes satisfy our Markov assumptions. The recovered processes summarize the outcomes of firms' decisions without separately identifying the underlying investment incentives or technologies.

**Time-varying environments and transitory heterogeneity.** Our framework allows the productivity transition, exit, and entry processes to vary freely over calendar time, accommodating changes in technologies, market conditions, and policies. It also permits transitory shocks to profitability or continuation values that generate different exit decisions among firms with identical productivity. Provided the distribution of these shocks, conditional on next-period potential productivity, does not depend on earlier productivity realizations, they can be integrated out to obtain an exit probability $Q_t(z')$. Similarly, changes in the entry environment may affect both entrant mass and the productivity distribution of entrants.

**Environments outside the baseline.** Our assumptions may fail when firms have additional persistent states that affect productivity transitions or survival independently of current productivity. For example, learning models such as Jovanovic (1982) requires tracking beliefs about underlying efficiency; financial-friction models such as Cooley and Quadrini (2001) requires firms' financial positions; and innovation models such as Klette and Kortum (2004) requires information about firms' product portfolios. Strategic competition, as in Ericson and Pakes (1995), also requires tracking competitors' states. Such environments generally cannot be summarized by productivity alone, although some could be accommodated by expanding the state space.

# 3 Identification and Estimation

Current productivity is observed only for surviving firms. The data therefore identify the survivor flows $M_{jk}$ – the probability that a firm starting in state $j$ survives and is observed in state $k$ – but not the underlying transition process $P$ and exit rule $Q$ separately. We first illustrate how Markov exit and the row-sum restrictions on $P$ identify these processes in a two-state example, and then establish the general result under a rank condition. Our empirical benchmark uses a continuous-state AR(1) productivity process and a probit exit rule. The nonparametric estimator and additional selection-model derivations are reported in Appendix B.

## 3.1 Identification: A Two-State Example

Suppose productivity takes two values, $L$ and $H$. A firm first draws its period-$t$ productivity and then decides whether to exit. Let $D_{it}$ equal one if firm $i$ exits between $t-1$ and $t$, and zero if it survives. The period-$t$ productivity draw is observed only when $D_{it} = 0$.

Fix an interval from $t-1$ to $t$. To simplify notation, write $P_{jk}$ and $Q_k$ for the transition and exit probabilities in that interval. The latent productivity transition is

$$P_{jk} \equiv \Pr(z_{it} = k \mid z_{i,t-1} = j), \qquad j, k \in \{L, H\}.$$

We impose the Markov exit restriction that inherited productivity has no additional effect on exit after current productivity is held fixed:

$$\Pr(D_{it} = 1 \mid z_{it} = k, z_{i,t-1} = j) = \Pr(D_{it} = 1 \mid z_{it} = k) \equiv Q_k.$$

For each origin–destination pair, the data identify the probability that a firm survives and is observed in the destination state:

$$M_{jk} \equiv \Pr(z_{it} = k, D_{it} = 0 \mid z_{i,t-1} = j) = P_{jk}(1 - Q_k).$$

Thus, $M$ is the observed survivor-flow matrix. It is not a transition matrix conditional on

survival because its rows need not sum to one. Instead,

$$\sum_{k\in\{L,H\}} M_{jk} = \Pr(D_{it} = 0 \mid z_{i,t-1} = j),$$

so one minus the row sum is the observed exit probability from origin state $j$. The matrix $M$ therefore contains both the observed survival rates and the destination distribution of surviving firms. Nevertheless, each element combines the latent transition probability $P_{jk}$ with the destination-specific survival probability $1 - Q_k$.

The requirement that each row of $P$ sum to one provides the additional restrictions needed for identification. Define

$$r_k \equiv \frac{1}{1 - Q_k}.$$

Because $P_{jk} = M_{jk} r_k$, the two row-sum restrictions imply

$$M_{LL} r_L + M_{LH} r_H = 1, \qquad M_{HL} r_L + M_{HH} r_H = 1. \tag{3.1.1}$$

The two equations identify $r_k$ whenever the rows of $M$ are linearly independent. Economically, each origin productivity must have a linearly independent transition process, while each destination productivity has an exit process that is shared regardless of origin.

For illustration, consider

$$M = \begin{pmatrix} 3/8 & 3/16 \\ 1/8 & 9/16 \end{pmatrix}.$$

The row sums imply observed exit probabilities of $7/16$ from state $L$ and $5/16$ from state $H$.

The two equations in Equation 3.1.1 gives

$$r_L = 2, \qquad r_H = \frac{4}{3}.$$

It follows that

$$Q_L = \frac{1}{2}, \qquad Q_H = \frac{1}{4}, \qquad P = \begin{pmatrix} 3/4 & 1/4 \\ 1/4 & 3/4 \end{pmatrix}.$$

This example shows how the observed survivor flows and the row-sum restrictions on $P$ recover the latent transition and exit processes. The next subsection establishes the corresponding result for an arbitrary finite productivity grid.

## 3.2 General Finite-State Identification

Consider a finite productivity grid

$$\mathcal{Z} = \{z_1, \ldots, z_J\}.$$

Let $P_{jk}$ denote the probability that an incumbent moves from origin state $z_j$ to destination state $z_k$, and let $Q_k$ denote the probability of exit after drawing $z_k$. As in the two-state example, the data identify the survivor flows

$$M_{jk} \equiv \Pr(z_{it} = z_k, D_{it} = 0 \mid z_{i,t-1} = z_j).$$

where $D_{it}$ equal zero if firm $i$ survives between $t-1$ and $t$.

Identification relies on two restrictions. First, exit satisfies the Markov restriction

$$D_{it} \perp z_{i,t-1} \mid z_{it},$$

or, equivalently,

$$\Pr(D_{it} = 1 \mid z_{it} = z_k, z_{i,t-1} = z_j) = Q_k.$$

Thus, lagged productivity can affect exit through its effect on current productivity, but it has no additional effect after current productivity is held fixed. Under this restriction,

$$M_{jk} = P_{jk}(1 - Q_k),$$

which can be written as

$$M = P \,\mathrm{diag}(1 - Q).$$

Second, the observed survivor-flow matrix $M$ must have full rank. This condition requires the origin states to generate sufficiently different patterns of survivor flows across destination states.

Define

$$r_k \equiv \frac{1}{1 - Q_k}.$$

Since every row of $P$ sums to one,

$$\sum_{k=1}^{J} M_{jk} r_k = 1$$

for every origin state $j$. Stacking these restrictions gives

$$Mr = \mathbf{1}.$$

**Proposition 1** (Finite-state identification)**.** . *Suppose the Markov exit restriction holds and $M$ has full rank. Then the productivity transition process and exit rule are uniquely identified by*

$$r = M^{-1}\mathbf{1}, \qquad Q_k = 1 - \frac{1}{r_k}, \qquad P = M \operatorname{diag}(r).$$

Appendix A.1 provides the proof.

The Markov exit and rank restrictions play distinct roles. Markov exit requires that, conditional on current productivity, exit does not depend on a firm's past productivity or any additional unobserved state. For example, we rule out a hidden distress state that independently determines whether a firm exits.[1] The rank condition requires sufficiently different survivor flows across origin states to recover the destination-specific exit probabilities. It also rules out destination states with certain exit: if $Q_k = 1$, column $k$ of $M$ is zero and $M$ cannot have full rank.[2] If either restriction fails, the observed survivor flows do not generally identify $P$ and $Q$ separately.

## 3.3 Benchmark Estimation

For the empirical benchmark, we impose a parsimonious continuous specification. For each interval from $t-1$ to $t$, productivity follows

$$z_{it} = \mu_t + \rho_t z_{i,t-1} + \varepsilon_{it}, \qquad \varepsilon_{it} \sim \mathcal{N}(0, \sigma_t^2), \tag{3.3.1}$$

[1] Measurement error in productivity may violate the Markov exit restriction. Even if exit depends only on true current productivity, past measured productivity may provide additional information about exit when current productivity is measured with error. In this case, our identification argument no longer applies directly.

[2] The full-rank condition is the finite-state analogue of the completeness condition used to identify nonparametric selection models in d'Haultfoeuille (2010).

and, after drawing $z_{it}$, exit follows a probit specification:

$$Q_t(z_{it}) = \Phi(\gamma_{0t} + \gamma_{1t} z_{it}). \tag{3.3.2}$$

Here $\Phi$ denotes the standard normal cumulative distribution function. The probit specification provides a smooth generalization of the deterministic productivity cutoff common in firm-dynamics models. For $\gamma_{1t} < 0$, define the cutoff $z_t^* = -\frac{\gamma_{0t}}{\gamma_{1t}}$. As $\gamma_{1t} \to -\infty$ while holding $z_t^*$ fixed, the exit rule converges to $Q_t(z) = \mathbf{1}\{z < z_t^*\}$. Thus, the conventional cutoff rule is a limiting case. The probit specification allows for heterogeneity in exit decisions among firms with identical productivity while preserving the Markov exit restriction.

The benchmark estimation specification uses firm productivity as its only state variable. As a robustness check, we allow predetermined firm characteristics to affect both productivity transitions and exit probabilities, accounting for differences among firms with similar productivity. See Appendix B.3 for details.

For a survivor, current productivity is observed. Its joint density contribution is

$$\frac{1}{\sigma_t}\phi\left(\frac{z_{it} - \mu_t - \rho_t z_{i,t-1}}{\sigma_t}\right) \Phi(-\gamma_{0t} - \gamma_{1t} z_{it}). \tag{3.3.3}$$

Let $D_{it}$ be an indicator equal to one if firm $i$ exits between $t-1$ and $t$, after its period-$t$ productivity draw, and zero if it survives and is observed at $t$.

For an exiter, current productivity $z_{it}$ is unobserved. Its likelihood contribution is therefore the probability of exit conditional on inherited productivity, obtained by integrating the destination-specific exit probability over the latent productivity transition:

$$\Pr(D_{it} = 1 \mid z_{i,t-1}) = \int Q_t(z)\, P_t(dz \mid z_{i,t-1}) = \Phi\left(\frac{\gamma_{0t} + \gamma_{1t}(\mu_t + \rho_t z_{i,t-1})}{\sqrt{1 + \gamma_{1t}^2 \sigma_t^2}}\right). \tag{3.3.4}$$

We estimate the transition and exit parameters jointly.

The parametric benchmark has a close connection to the classical Heckman (1979) selection model: realized productivity both enters the outcome equation and survival equation, so the productivity innovation is correlated with the implied selection disturbance. Appendix B.2 gives the complete mapping, inverse-Mills-ratio representation, and comparison with Olley and Pakes (1996).

## 3.4 Entry and Alternative Estimators

Unlike the productivity of exiting firms, the productivity of entrants is observed. We therefore measure the entry process directly from the mass and productivity distribution of firms entering the population. Together with the estimated productivity transition and exit processes, this provides the three components required for the decomposition.

We consider two alternatives to the benchmark estimation specification. First, we estimate productivity transitions and exit probabilities flexibly on a finite productivity grid, without imposing the Gaussian–probit functional form. Appendix B.1 describes the estimator and regularization procedure. Second, we allow predetermined firm characteristics to affect both processes, examining whether observable differences among firms with similar productivity change their estimated contributions to productivity growth. Appendix B.3 provides the details.

Finally, the framework can distinguish changes in firm ownership from firm disappearance. In our application, state-owned enterprises may become privately owned while continuing to operate, leaving their productivity observable. Appendix D extends the identification and decomposition to distinguish privatization from firm exit.

# 4 Decomposing Productivity Growth in China's State Sector

We first describe the institutional background and data, then document the empirical patterns motivating the decomposition. We next use the decomposition to measure the contribution of selection, incumbent productivity improvement, and entry to SOE productivity growth and how these contributions evolved over the reform period, before assessing the robustness of the results.

## 4.1 Institutional Background

The reform of state-owned enterprises (SOEs) in China began in 1978. Prior to reform, the urban industrial economy operated under a centrally planned system in which production, input allocation, prices, and employment were heavily controlled by the state. SOEs

faced weak competitive pressure, managers had limited autonomy, and incentives were often poorly aligned with profitability or productivity. Because firms were expected to fulfill administrative objectives and losses were routinely accommodated through fiscal support or directed bank lending, budget constraints were soft and inefficient firms could continue operating without meaningful risk of exit (Lau et al. (2000); Brandt and Zhu (2001); Naughton (2007)).

Early reforms targeted efficiency gains and a gradual movement toward more market-oriented behavior for firms. At the same time, they also reflected a broader strategy of "reform without losers," motivated by concerns about social stability. From 1978 to 1993, reforms were introduced that expanded enterprise autonomy, decentralized administrative control to local governments, and implemented managerial responsibility systems that partially linked compensation for both managers and workers to firm performance, all while constraining deviations from the planned-economy framework. Concurrently, the introduction of a dual-track pricing system – under which firms operated partly at market prices and partly under planned allocations – exposed SOEs to market incentives while deliberately limiting the speed and scope of adjustment. Under this gradualist approach, loss-making SOEs were typically supported through directed credit from state-owned banks and implicit government guarantees rather than being allowed to fail or shed labor (Lau et al. (2000); Brandt and Zhu (2001)). As a result, while early reforms encouraged efficiency gains and nudged firms toward market-oriented behavior, budget constraints remained soft and exit was largely absent: Hsieh and Song (2015) report that the annual exit rate among state-owned firms was only around 0.9% between 1991 and 1995. This prevented market selection from playing a central role in reallocating resources within the state sector (Groves et al. (1994); Jefferson et al. (1996); Li (1997)). At the same time, this incremental transition moved the economy away from a fully planned system toward a hybrid regime combining administrative control with market mechanisms, shaping the institutional environment in which subsequent, more far-reaching reforms would take place.

By the mid-1990s, this gradual reform strategy had become increasingly difficult to sustain. Many SOEs remained chronically unprofitable and imposed growing fiscal burdens on local governments and the banking system (Berkowitz et al. (2017)). Continued protection of underperforming firms became increasingly costly, setting the stage for a more radical restructuring of the state sector in the late 1990s (Lardy (2014)).

**Selection and restructuring.** The centerpiece of the late-1990s restructuring was the policy known as "grasp the large, let go of the small" (*zhuā dà fàng xiǎo*), formally introduced at the 1999 Fourth Plenum of the Communist Party's Central Committee. The policy differentiated SOEs by size and strategic importance. Large SOEs in key sectors were consolidated into enterprise groups and reorganized through corporatization, while small and medium-sized SOEs were privatized, merged, or closed (Naughton (2007); Hsieh and Song (2015)). This "grasp the large" approach involved not only restructuring existing firms into limited liability or joint-stock companies but also establishing new large state-owned enterprises in strategic sectors (Hsieh and Song (2015), Rubens (2023)). Meanwhile, local governments were granted expanded authority to restructure smaller firms, and many loss-making enterprises were liquidated or transferred to private ownership.[3]

These restructuring efforts were accompanied by broader institutional changes that that made firm exit more feasible. Beginning in the late 1990s, the central government implemented enterprise restructuring programs that expanded the use of bankruptcy procedures and supported large-scale layoffs through reemployment programs and an emerging social safety net. Millions of workers were displaced from the state sector, and the number of state-owned firms declined sharply during this period (Hsieh and Song (2015); Brandt and Rawski (2008)). Together, these reforms hardened budget constraints and introduced a meaningful exit margin for poorly performing firms, allowing market selection to play a substantially larger role in reallocating resources within the state sector.

**Governance and ownership reforms.** Following the initial wave of restructuring, a second phase of reforms in the early 2000s focused on improving the governance and performance of the remaining state enterprises. A major institutional development was the establishment of the State-Owned Assets Supervision and Administration Commission (SASAC) in 2003. SASAC consolidated previously fragmented state ownership, which had been dispersed across multiple government ministries and local bureaucracies, and assumed responsibility for managing and supervising central SOEs as the formal representative of the state as owner (Naughton (2006); Lardy (2019)). SASAC enhanced oversight of state assets and implemented corporate governance reforms, including restructuring boards and introducing

[3] Gu and Jia (2022) provide a structural analysis of the corporatization and privatization margins, showing that large SOEs could rationally prefer corporatization to preserve borrowing capacity, helping explain how the "grasp the large, let go of the small" strategy could be seen as consistent with endogenous profit maximizing behavior.

new performance evaluation systems for SOE managers.

During this period, many SOEs were reorganized as limited liability or joint-stock companies under the framework of China's Company Law, and corporate governance structures were gradually formalized through the introduction of boards of directors and clearer separation between ownership and management (Naughton (2007)). Complementary capital market reforms further strengthened governance. In particular, regulations introduced requirements for independent directors on the boards of listed companies, bringing greater external oversight and professional management practices to SOEs (Bhabra and Li (2011)).

This was followed in 2005 by the split-share structure reform, which addressed a fundamental distortion in the governance of publicly listed SOEs. Prior to the reform, listed SOEs operated under a dual-share structure in which roughly two-thirds of shares were held by the state as non-tradable blocks, while only the remaining one-third were freely traded by private investors. Because managerial evaluation and promotion were formally linked to overall firm value, and non-tradable state shares were effectively valued on the basis of book asset values rather than market prices, the link between market valuation and managerial incentives was weak. This dual structure created an incentive misalignment, systematically rewarding asset accumulation over productive efficiency.[4] The split-share structure reform dismantled this dual system by converting non-tradable state shares into tradable shares. By exposing state-held shares to market pricing, the reform strengthened the link between managerial incentives and market-based performance. In doing so, it shifted incentives away from asset expansion and toward productivity and profitability.

Taken together, these reforms fundamentally reshaped China's state sector during the late 1990s and early 2000s, leading to a substantial reduction in the number of state-owned firms and significant changes in the governance and organization of those that remained.

## 4.2 Data

Our analysis uses the Annual Survey of Industrial Firms (ASIF) from China for the years 1998–2007. The ASIF is an annual survey of manufacturing enterprises conducted by the National Bureau of Statistics of China and is one of the most important sources of information

[4]The structure also generated broader market distortions including ineffective boards, profit tunneling through related-party transactions, rampant stock market speculation, blocked merger activities, and stunted development of corporate bond and derivative markets (Liao et al. (2014)).

on the performance of China's manufacturing sector.[5] The data provide annual firm-level observations for all state-owned enterprises and for private firms exceeding 5 million RMB in annual revenue, allowing systematic comparison of state and private firm performance. This includes a large and expanding set of manufacturing firms, with coverage increasing from roughly 100,000 to over 300,000 firms over the sample period. In addition to substantial firm entry, a key feature of the data is the prevalence of exit: among state-owned firms observed in 1998, approximately 80% exit by 2007.

The unit of observation is a registered firm in a given year. Within state-owned industrial groups, each firm owned by the group is a separate observation in our data. Our baseline variables include the firm's industry at the four-digit level,[6] location, age, ownership status, total assets, total liabilities, industrial production, value added, revenue, employment, wage payments, capital stock, intermediate input purchases, export revenues, and subsidies.[7] After removing observations with missing or implausible values for key production variables, our final sample contains more than 1.7 million firm-year observations.

For the construction of capital and other production variables, we largely follow Hsieh and Klenow (2009). Our baseline measure of capital is the book value of fixed capital net of depreciation. As a robustness check, we construct capital using the perpetual inventory method with an annual depreciation rate of 9% and province-sector-specific investment rates, following the online appendix of Brandt et al. (2012).

To maintain a common productivity concept across the empirical and structural analyses, our baseline measure of firm productivity is based on the production technology

$$y_{it} = z_{it} \left( K_{it}^{\alpha} L_{it}^{1-\alpha} \right)^{\eta}, \tag{4.2.1}$$

where $z_{it}$ is firm productivity, $K_{it}$ is capital, and $L_{it}$ is employment. We set $\alpha = 0.4$ and $\eta = 0.7$, the same parameterization used in the structural model developed in Section 5.[8]

Our analysis requires precise identification of firm ownership. We adopt the ownership

[5] We construct the panel using a method that closely follows the approach outlined in Brandt et al. (2012).

[6] To preserve greater sectoral granularity in our analysis, we follow Liu (2019) and map the original 4-digit industry codes to an expanded set of 80 2-digit codes, rather than using the standard classification of 30 2-digit sectors in manufacturing.

[7] Data on value added and industrial production in 2004 are imputed since they are missing in the original data.

[8] Using the same productivity measure in the statistical decomposition and the structural analysis allows the model-generated decomposition to be compared directly with its empirical counterpart.

classification from Hsieh and Song (2015), which provides a consistent framework for distinguishing state-owned and privately-owned firms. To isolate ownership effects from transition effects, we restrict attention to firms that maintain consistent ownership throughout the sample period – either "forever state-owned" or "forever private-owned" – and exclude firms that change ownership status during the transition.[9]

As robustness checks, we consider alternative approaches to measuring productivity. First, we construct the Hsieh–Klenow measure using an elasticity of substitution of $\sigma = 3$ across firms within an industry. Second, following Brandt et al. (2017), we estimate production functions that allow for heterogeneous factor shares and returns to scale and construct firm-level revenue productivity from the estimated residuals.

## 4.3 Empirical Patterns

This subsection documents the empirical patterns that motivate our analysis. We first show that between 1998 and 2007, the productivity distribution of state-owned enterprises (SOEs) converged substantially toward that of privately owned enterprises (POEs), and that this convergence occurred broadly across industries.[10] We then present descriptive evidence on the margins through which this catch-up may have occurred, focusing on within-firm productivity growth, selective exit, and entry. These patterns motivate the application of the decomposition framework developed earlier in the paper.

### Convergence Between SOEs and POEs

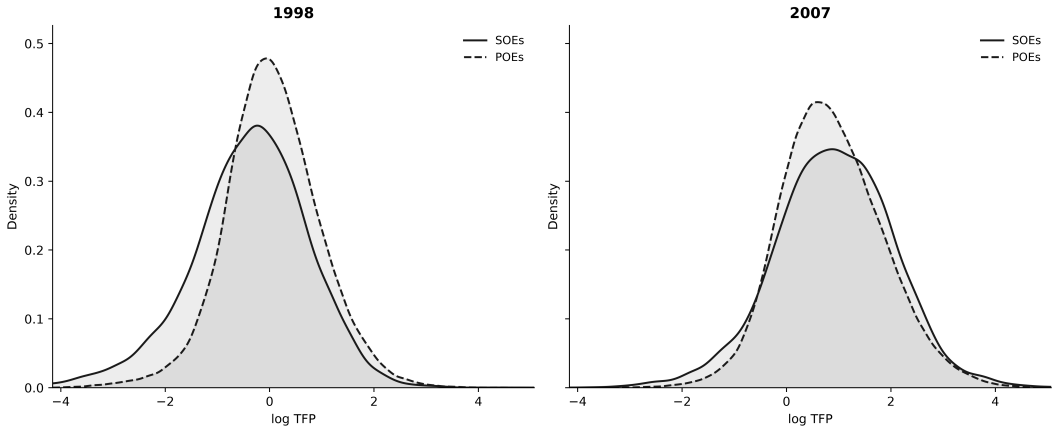
We begin by documenting convergence in productivity between SOEs and POEs between 1998 and 2007.

Figure 1 compares the distributions of log TFP for SOEs and POEs in 1998 and 2007. In 1998, SOEs lag substantially behind POEs: the mean log TFP of SOEs is -0.383, compared

[9]While privatization played an important role in China's aggregate productivity growth during this period (see Chen et al., 2021; Wang et al., 2024), our focus is instead on comparing productivity dynamics among firms with persistent ownership status, in order to assess how state-owned enterprises evolved relative to a private-sector benchmark in the presence of state-sector-specific reforms.

[10]Related studies also document that state-owned and privatized firms began with substantially lower TFP but caught up with always-private firms by 2007 (Hsieh and Song, 2015; Chen et al., 2021; Brandt et al., 2022; Gu and Jia, 2022). Brandt et al. (2022) find that the TFP gap between state-owned and private manufacturing firms continued to narrow and became slightly positive after 2007. Both Chen et al. (2021) and Brandt et al. (2022) caution against interpreting convergence in TFP across ownership types too strongly.

Figure 1: TFP convergence between state-owned and private firms, economy-wide




with 0.053 for POEs. Over the subsequent decade, both groups experience productivity growth, but SOEs improve at a faster rate. By 2007, the two distributions nearly coincide. The mean log TFP of SOEs rises to 0.909, while the mean for POEs rises to 0.873. Thus, the SOE–POE mean gap falls from 0.436 log points in 1998 to just 0.036 log points in 2007. Although the overlap is not exact – the SOE distribution remains somewhat more dispersed – the two groups are nearly identical in mean productivity by the end of the sample.

To assess whether convergence occurred broadly across industries, Figure 2 plots sector-level convergence patterns. For each sector, we compute the initial gap in productivity between SOEs and POEs in 1998 and the subsequent annualized change in that gap between 1998 and 2007. The figure shows a strong negative relationship: sectors in which SOEs initially lagged further behind experienced faster subsequent catch-up. This pattern holds whether productivity is measured using sector-level median TFP or an aggregate industry-level Solow residual.

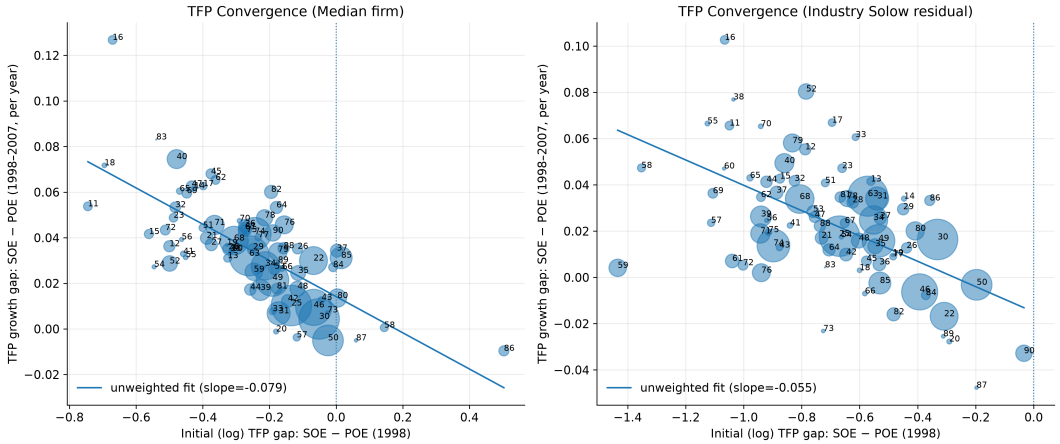
Taken together, these facts show that SOEs began the reform period substantially less productive than POEs but largely closed the gap by 2007, and that this convergence occurred across most industries rather than being driven by a small subset of sectors.

## Stylized Facts on the Sources of Convergence

We next present descriptive evidence on the margins through which this convergence may have occurred. Figure 3 summarizes three key patterns.

First, surviving SOEs – those operating in both 1998 and 2007 – experienced substantial productivity growth. The top-left panel compares the distribution of log TFP among SOEs

Figure 2: TFP convergence between state-owned and private firms across sectors




*Notes:* Marker size represents the sector's market share in 1998. Median is the median firm productivity within the sector. We exclude tobacco manufacturing (24) because it is state controlled. The unweighted line is an unweighted OLS fit; the weighted line weights sectors by their 1998 market shares.

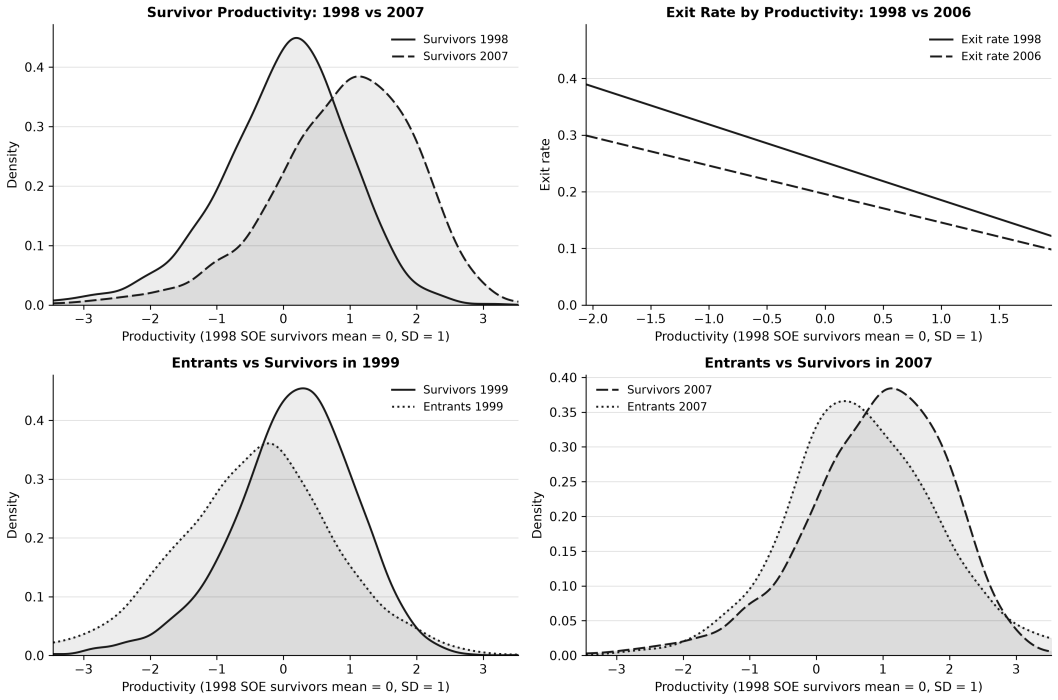
that are present in both years. This distribution shifts markedly to the right over time. The mean log TFP of surviving SOEs rises from 0.000 in 1998 to 0.900 in 2007, an increase of 0.900 log points. This suggests that at least part of the observed convergence reflects productivity gains among continuing firms rather than purely compositional change.

Second, exit patterns suggest an important role for selection. The top-right panel plots a linear approximation to the exit rule as a function of TFP for 1998 and 2006. Exit rates are high and strongly declining in productivity in both periods, indicating substantial selection on performance. In 1998, the fitted exit rule has an intercept of 0.252 and a slope of $-0.067$, while in 2006 the intercept falls to 0.196 and the slope becomes flatter at $-0.050$. Thus, exit is both more prevalent and more strongly tilted toward low-productivity firms early in the reform period. This pattern is consistent with a stronger role for selective exit in the earlier years of reform.

Third, entry appears less likely to account for the catch-up of SOEs to POEs. The bottom panels compare entrants with surviving incumbents for 1999 and 2007. In 1999, the mean log TFP of entrants is -0.438, well below the 1998 mean of 0.000 for surviving SOEs. By 2007, entrants are closer to survivors but remain somewhat less productive: mean log TFP is 0.715 for entrants, compared with 0.900 for survivors. These patterns suggest that entry did not drive convergence and may, if anything, have worked against it.

Taken together, these facts indicate that both within-firm productivity growth and selective exit plausibly contributed to the convergence between SOEs and POEs, while entry

Figure 3: Drivers of productivity growth among state-owned firms




may have worked against convergence.

These stylized facts do not reveal the relative quantitative importance of the three margins. In particular, productivity growth among observed continuers combines changes in latent incumbent productivity dynamics with selection into continued operation. The next subsection therefore applies the selection-corrected decomposition developed in Sections 2 and 3 to separate the contributions of the productivity transition process, exit, and entry.

## 4.4 Decomposition Results

We now apply the framework developed in Sections 2 and 3 to quantify the contributions of incumbent productivity transitions, exit, and entry to Chinese state-owned enterprise (SOE) observed productivity growth between 1998 and 2007. We conduct two complementary exercises. The first treats the entire period as a single observation interval, allowing a direct comparison with conventional productivity decompositions. The second chains annual transitions to examine how the contributions of these processes evolved throughout the reform period.

## Benchmark Specification

We use the firm-level productivity measure defined in Section 4.2. The benchmark sample consists of firms that are classified as state owned whenever observed, excluding firms with observed ownership transitions.[11]

For each observation interval, we jointly estimate the incumbent productivity transition $P$ and exit rule $Q$ using the AR(1)–probit specification from Section 3.3. We measure the entry process $E$ directly from newly observed SOEs. Robustness to alternative productivity measures and estimation specifications is reported in Appendix G.

Both exercises use the frozen benchmark introduced in Section 2,

$$P^0 = I, \qquad Q^0 = 0, \qquad E^0 = 0. \tag{4.4.1}$$

Starting from the observed 1998 productivity distribution, this benchmark allows no productivity transitions, exit, or entry, so aggregate productivity remains at its initial level. Comparing the estimated historical processes against this benchmark allows us to decompose observed productivity growth into contributions from incumbent productivity transitions, exit, and entry. Because the three processes interact, their contributions depend on the order in which they are introduced. We therefore average across all six possible orders using Shapley values.

We report both firm-count- and employment-weighted decompositions, holding the conditional size mapping fixed across counterfactuals as described in Section 2.3. Appendix C provides implementation details.

## The Full Reform Period

We first treat 1998–2007 as a single observation interval, as if firms were observed only at these two endpoints. Firms present in 1998 but absent in 2007 are classified as exiters, regardless of when they actually disappeared, while firms absent in 1998 but present in 2007 are classified as entrants. This endpoint treatment abstracts from turnover within the nine-year interval. In particular, firms that enter after 1998 and disappear before 2007 are absent from both endpoint cross-sections and therefore do not enter the direct decomposition. We

[11] In constructing the firm panel, we use information on firm names, addresses, industry, and other characteristics to link firms whose identifiers change following mergers, acquisitions, restructuring, or corporatization. This procedure reduces the extent to which measured exit reflects only administrative changes in firm identifiers.

Table 1: Direct decomposition of SOE productivity growth, 1998–2007

| Weighting | Observed change | Transition $P$ | | Exit $Q$ | | Entry $E$ | |
|---|---|---|---|---|---|---|---|
| Firm count | 1.165 | 0.270 | (23.2%) | 0.671 | (57.6%) | 0.224 | (19.3%) |
| Employment | 1.258 | 0.281 | (22.3%) | 0.731 | (58.1%) | 0.246 | (19.6%) |

*Notes:* Entries are contributions to the change in aggregate SOE productivity, measured as the relevant weighted mean of log productivity. Percentages are shares of the observed 1998–2007 change and sum to 100 within each row.

jointly estimate the long-horizon productivity transition and exit rule to infer the unobserved 2007 productivity distribution for firms classified as exiters. This allows us to quantify the contribution of their exit to the rise in average SOE productivity.

Table 1 shows that selection accounts for the largest share of SOE productivity growth. Under firm-count weighting, exit contributes 57.6% of the total increase, compared with 23.2% from incumbent productivity transitions and 19.3% from entry. The results are similar under employment weighting, with exit accounting for 58.1% of productivity growth.

The role of selection is substantially larger in our decomposition than in standard accounting decompositions applied to the same data. Foster et al. (2008) attributes 7.6% of observed SOE productivity growth from 1998 to 2007 to exit, while the dynamic Olley-Pakes decomposition (Melitz and Polanec, 2015) attributes 18.6%. Both estimates are substantially below the exit contribution in our decomposition. A key reason for this gap is how the methods treat exiting firms. Standard accounting decompositions measure exit using exiters' observed productivity in 1998. However, some firms disappear by 2007 after experiencing adverse productivity shocks. Their 1998 productivity may therefore be higher than the productivity they would have had in 2007, causing standard methods to understate the productivity gain from their exit. By jointly estimating productivity changes and exit, our framework estimates the missing 2007 productivity distribution of exiters and incorporates this deterioration when measuring selection. Appendix E reports the full comparison across standard accounting methods.

The direct decomposition establishes the importance of selection over the full period but, by treating 1998–2007 as a single transition, does not reveal when each contribution arose. The chained annual decomposition shows that selection was most important early in the reform period, while incumbent productivity improvements became increasingly important later.

## Selection First, Incumbent Improvement Later

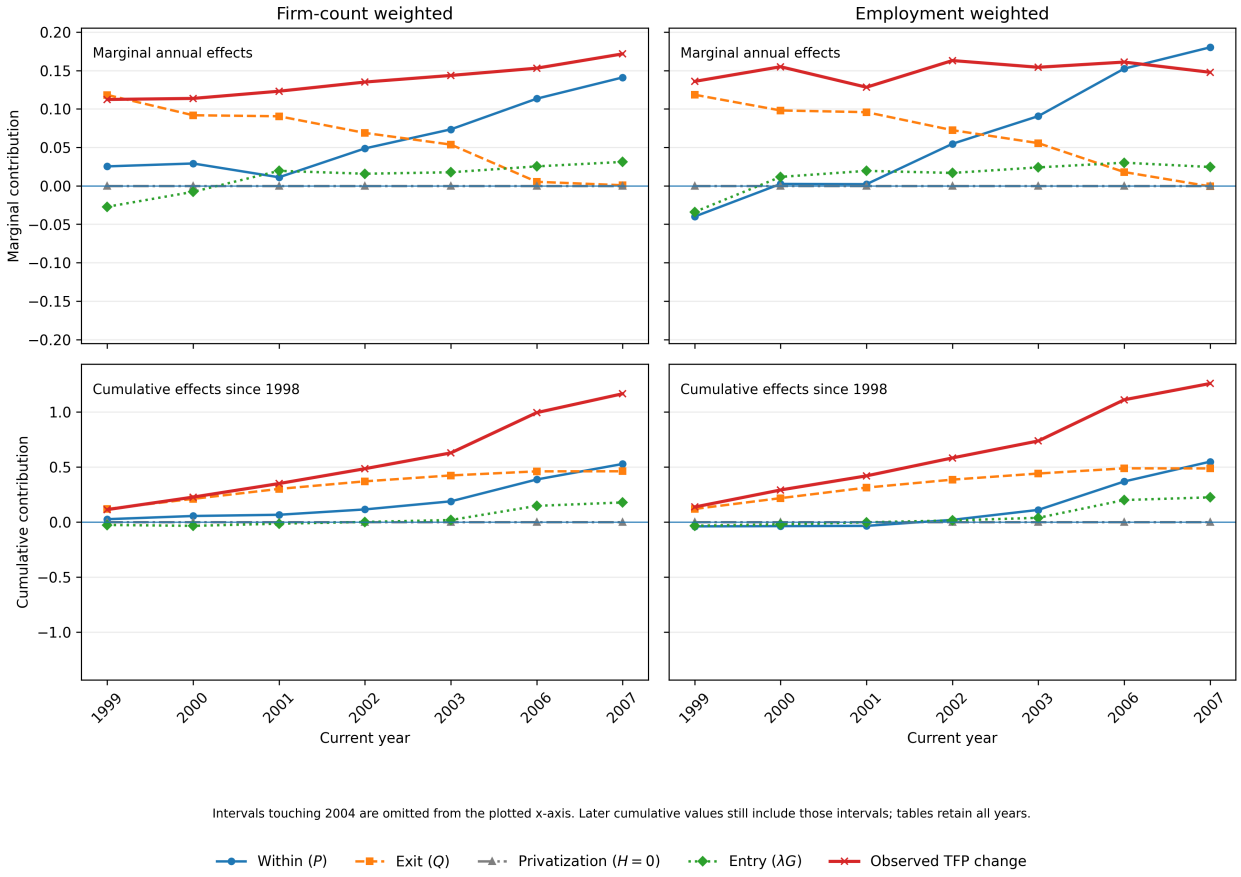
For the chained annual decomposition, we estimate productivity transitions, exit, and entry separately for each annual interval. This captures more of the intermediate turnover omitted by the direct decomposition: firms that enter in one observed year become incumbents that can experience productivity changes or exit in subsequent years. Starting from the observed 1998 distribution, each counterfactual path carries forward its own productivity distribution rather than resetting to the observed distribution each year. We compute cumulative Shapley contributions at each horizon and obtain annual contributions from their year-to-year changes. Appendix C provides implementation details.

Figure 4 reveals a clear shift in the source of productivity growth over time. During the early reform years, productivity growth comes primarily from stronger selection. In 1998–1999, for example, changes in the exit environment contribute about 0.12 log points under both weighting schemes, compared with only 0.03 log points from changes in incumbent productivity dynamics under firm-count weighting and a negative contribution of about $-0.04$ under employment weighting. As the reform progresses, the contribution from selection diminishes while incumbent productivity improvements become increasingly important. By 2006–2007, productivity transitions contribute approximately 0.14 log points under firm-count weighting and 0.18 under employment weighting, while the incremental contribution from exit is nearly zero. The contribution of entry is small throughout but becomes more positive in the later reform years.

This changing selection effect follows directly from the estimated exit schedules. Early in the reform, low-productivity SOEs face substantially higher disappearance probabilities than more productive firms, generating large productivity gains through selection. Over time, both the average exit rate and the productivity differential in exit probabilities decline. With fewer firms disappearing and exit becoming less selective, the contribution of the exit to productivity growth progressively diminishes.

The shift from selection-driven growth toward improvements in incumbent productivity dynamics also broadly coincides with the institutional transition described in Section 4.1: from large-scale SOE restructuring in the late 1990s and early 2000s to governance reforms beginning in 2003. Although this temporal alignment does not identify the causal effects of particular reforms, it motivates the structural analysis developed later in the paper.

Figure 4: Chained annual decomposition of SOE productivity growth




*Notes:* The upper panels report the marginal annual contributions of incumbent productivity transition ($P$), exit rate ($Q$), entry process ($E$) and privatization ($H$). The lower panels report their cumulative contributions since 1998. The contribution of privatization is zero by construction because the benchmark sample excludes firms with observed ownership transitions. The left panels use firm-count weighting and the right panels use employment weighting. Intervals touching 2004 are omitted from the plotted horizontal axis because key production variables in 2004 are imputed; results from these intervals enter the cumulative contributions.

## Why the Direct and Chained Decompositions Differ

The two decompositions differ in how they account for firm dynamics over the observation horizon. The direct decomposition treats 1998–2007 as a single transition, regardless of when firms actually entered or exited. The chained decomposition instead follows the evolution of the SOE productivity distribution throguh a sequence of annual transitions. Firms that exit early are removed from subsequent productivity transitions, while firms that enter during the period are exposed to later productivity changes and selection. These dynamics affect how the three processes interact and therefore how their contributions are allocated. The chained decomposition thus provides a different attribution of productivity growth, rather

than simply breaking down the direct decomposition into annual contributions.

## 4.5 Robustness and Alternative Estimands

The benchmark uses a productivity measure consistent with the production technology in our structural model and estimates productivity transition and exit process using an AR(1)–probit specification, without additional firm controls or ownership conversion. We assess each restriction separately. Appendix G reports the full decomposition results for each alternative specification.

First, controlling for firm characteristics leaves the main results largely unchanged. Adding lagged leverage, profitability, firm size, age, and industry to the transition and exit equations reduces the contribution of exit from 57.6 to 50.3 percent under firm-count weighting and from 58.1 to 51.6 percent under employment weighting. Exit remains the largest contributor in both cases, while the contribution of entry is essentially unchanged.

Second, relaxing the AR(1)–probit specification through more flexible estimators produces greater variation in the exact contributions of productivity improvements and exit, but the annual pattern remains robust: exit dominates early in the reform period, while incumbent productivity improvements become more important later.

Third, we also consider an alternative productivity measure following Hsieh and Klenow (2009). Relative to our benchmark measure, this specification assigns an even larger role to exit, accounting for 79.6 percent of cumulative productivity growth under firm-count weighting and 84.3 percent under employment weighting. The shift from early selection toward later incumbent improvement remains evident.

Finally, we distinguish privatization from firm disappearance by extending the decomposition to include SOEs that change ownership. We find that privatization makes only a small direct contribution to state-sector productivity growth, while the qualitative conclusions remain similar. Because this exercise also expands the sample and re-estimates the productivity and exit processes, differences from the benchmark cannot be attributed solely to privatization.

Taken together, these exercises reinforce the central finding that selection was particularly important early in China's SOE reforms, whereas improvements in incumbent productivity dynamics became more important in later reform periods.

# 5 Structural Model

The empirical analysis provides a diagnostic account of China's state-owned enterprise (SOE) productivity growth. It separates changes in incumbent productivity dynamics, selection, and entry, and shows how their relative importance evolved over the reform period. The decomposition, however, does not explain the economic forces behind these patterns or their consequences for state-sector contraction and aggregate productivity.

To address these questions, we develop a structural firm-dynamics model incorporating three reform channels: the hardening of soft budget constraints, which exposes unprofitable SOEs to exit; improvements in corporate governance, which increase the returns to productivity-enhancing investment; and state-directed SOE entry. By modeling how these reforms shape firms' decisions and the allocation of resources in equilibrium, we quantify their effects on SOE productivity growth, state-sector contraction, and aggregate productivity.

## 5.1 Environment

**Firms and markets.** Time is discrete, with $t = 0, 1, \ldots$. There is a continuum of firms. The firms operate in a competitive output market, with output as the numeraire. Firms are categorized by ownership type. A firm's ownership is permanent and is indexed by $j \in \{S, P\}$, where $S$ denotes an SOE and $P$ a POE. The economy has an inelastic aggregate labor supply $\bar{L}$ that is fixed over time, and we normalize $\bar{L} = 1$.[12] Firms rent capital at the fixed user cost $R$ and hire labor at wage $w_t$. When production decisions are made, a firm knows its productivity $z$ and its current wedge pair $\tau = (\tau_Y, \tau_K)$, where $\tau_Y$ is an output wedge and $\tau_K$ is a capital wedge. Throughout this section, a time subscript indicates that a variable may vary over time.

**Production and static operating decisions.** A firm produces according to

$$y = z(k^{\alpha}\ell^{1-\alpha})^{\eta}, \tag{5.1.1}$$

[12] Treating manufacturing labor supply as fixed abstracts from a modest employment trend over the reform period. BLS estimates constructed from Chinese official sources show that manufacturing employment declined in the late 1990s and began to recover after 2000; in the consistently defined 2002–2007 series, it rose from 85.9 million to 96.9 million workers, an increase of about 13 percent (Banister, 2005, 2013).

where $y$ is output, $k$ is capital, $\ell$ is labor, $\alpha$ is the fraction of inputs go to capital and $\eta < 1$ is the span-of-control parameter.

Given $(z, \tau)$ and prices, the firm chooses capital and labor to maximize current profit:

$$\pi_{j,t}(z, \tau; w_t) = \max_{k,\ell \geq 0} \left\{ (1 - \tau_Y) z (k^\alpha \ell^{1-\alpha})^\eta - w_t \ell - (1 + \tau_K) R k - f_{j,t} \right\}, \tag{5.1.2}$$

where $f_{j,t}$ is the ownership-specific fixed operating cost. Optimal input choices satisfy

$$w_t = \eta(1 - \alpha)(1 - \tau_Y)\frac{y}{\ell}, \qquad (1 + \tau_K)R = \eta\alpha(1 - \tau_Y)\frac{y}{k}. \tag{5.1.3}$$

The evolution of productivity and wedges, together with governance, exit, and entry decisions, is specified next.

## 5.2 Firm Dynamics and Decisions

**Timing.** An incumbent enters period $t$ with known productivity and wedge pair. The firm then decides whether to operate. A firm that operates chooses capital and labor; SOEs also choose governance effort, which affects future productivity transitions but not current production. Production then takes place, after which the firm exits exogenously with ownership-specific probability $\omega_j$. Conditional on not facing exogenous exit, a firm's productivity evolves into the next period as a function of their current productivity, and for SOEs, also as a function of their governance investment. Finally, the firm's next-period wedge pair is drawn, at which point the firm decides whether to continue operating for another period or exit. The timing of the productivity realization and the exit decision matches that of the statistical framework.

Entry follows a similar timing structure but differs by ownership. A potential POE entrant pays its entry cost before observing its initial productivity and current wedges. Conditional on its draws it may decide to exit before operating, although the fixed entry cost cannot be recovered. A potential SOE project first observes its initial draw and is activated only if its value is sufficiently high to cover the SOE entry cost. We formalize these entry rules below.

**Productivity and wedge dynamics.** Productivity is the only persistent firm characteristic. At the beginning of each period, the current wedge pair is drawn according to

$$\tau = (\tau_Y, \tau_K) \sim G_{j,t}, \tag{5.2.1}$$

with draws independent across firms and over time. Wedges therefore capture temporary variation in firms' operating conditions rather than becoming an adiditional persistent state. This assumption keeps the dynamic problem tractable and aligns the model with the benchmark framework in Section 2.

POE productivity follows

$$\log z' = \rho_P \log z + \mu_P + \varepsilon'_P, \qquad \varepsilon'_P \sim \mathcal{N}(0, \sigma_P^2). \tag{5.2.2}$$

SOE productivity follows

$$\log z' = \rho_S \log z + \mu_S(a; \xi_t) + \varepsilon'_S, \qquad \varepsilon'_S \sim \mathcal{N}(0, \sigma_S^2), \tag{5.2.3}$$

where $a \geq 0$ represents governance investment and $\xi_t \geq 0$ describes institutional effectiveness of corporate governance. In practice, $a$ represents costly actions such as recruiting and incentivizing professional managers, strengthening internal monitoring and performance evaluation, and reorganizing production and decision-making. These investments improve the firm's future productivity rather than its current output. We specify

$$\mu_S(a; \xi_t) = \mu_{S,b} + (1 - \eta) \log(1 + \xi_t a), \tag{5.2.4}$$

with governance cost, measured in units of final output,

$$c(a) = a^{1+\nu}, \qquad \nu > 0. \tag{5.2.5}$$

Governance investment and institutional effectiveness are complementary: if either $a$ or $\xi_t$ equals zero, productivity drift remains at the baseline $\mu_{S,b}$, while a higher $\xi_t$ raises the marginal productivity return to governance investment. The logarithmic specification captures diminishing effectiveness of additional governance effort. The scaling by $1 - \eta$ is convenient because, given the span-of-control production technology, it implies that governance raises optimal firm scale in proportion to $1 + \xi_t a$.

**Dynamic firm values and governance.** Let $J_{j,t}(z,\tau)$ denote the optimized value of operating after current productivity and wedges are observed but before the endogenous exit or bailout decision, and let $V_{j,t}(z,\tau)$ denote the firm's private value after that decision.

A POE's operating value is

$$J_{P,t}(z,\tau) = \pi_{P,t}(z,\tau;w_t) + \beta(1-\omega_P)\int\int V_{P,t+1}(z',\tau')P_P(dz' \mid z)G_{P,t+1}(d\tau'). \tag{5.2.6}$$

An SOE chooses governance effort as part of its dynamic problem:

$$\begin{aligned} J_{S,t}(z,\tau) = \max_{a\geq 0}\Big\{ & \pi_{S,t}(z,\tau;w_t) - c(a) \\ & + \beta(1-\omega_S)\int\int V_{S,t+1}(z',\tau')P_S(dz' \mid z,a;\xi_t)G_{S,t+1}(d\tau')\Big\}. \end{aligned} \tag{5.2.7}$$

Because current wedges enter only current profit and are redrawn before the next period, they do not affect the marginal return to governance effort. Optimal governance therefore depends on productivity but not on the current wedge realization; write it as $a^*_{S,t}(z)$.

**Exit and government bailouts.** Under a hard budget constraint, a firm operates only if its operating value is nonnegative. POEs face such a constraint, so their private value is

$$V_{P,t}(z,\tau) = \max\{J_{P,t}(z,\tau), 0\}. \tag{5.2.8}$$

Thus a POE with a negative operating value exits.

SOEs, by contrast, may receive government support that allows them to continue operating even when their operating value is negative. We represent these soft budget constraints through $\delta_{S,t}(z,\tau) \in [0,1]$, the probability that an SOE that would otherwise exit receives a bailout.[13] A reduction in this probability hardens the budget constraint by exposing a larger share of negative-value SOEs to exit.

Conditional on a bailout, let $T_{S,t}(z,\tau)$ denote the transfer received by the firm. To induce

[13] A budget constraint is soft when losses do not necessarily lead to closure because an external sponsor is expected to provide support (KORNAI*, 1986; Kornai et al., 2003). Such support can take the form of a fiscal transfer, directed or rolled-over credit, tax relief, a guarantee, or another intervention that prevents financial failure. We represent these instruments by their transfer-equivalent value and focus on their common extensive-margin consequence: whether a privately unviable firm remains in operation.

continued operation, the transfer must satisfy

$$J_{S,t}(z,\tau) + T_{S,t}(z,\tau) \geq 0. \tag{5.2.9}$$

**Proposition 2** (Minimum no-rent bailout)**.** *Suppose that, after observing current productivity and wedges $(z,\tau)$, the government commits to a bailout transfer that cannot be increased by the firm's subsequent choices of capital, labor, or governance effort. If an SOE would otherwise prefer to exit, the smallest transfer that induces continued operation without giving the manager a positive rent is*

$$T^*_{S,t}(z,\tau) = \max\{-J_{S,t}(z,\tau), 0\}. \tag{5.2.10}$$

*Under this transfer rule, the firm's optimal capital, labor, and governance choices are unchanged, and its private value is*

$$V_{S,t}(z,\tau) = \max\{J_{S,t}(z,\tau), 0\}. \tag{5.2.11}$$

Appendix A.2 provides the proof.

If $J_{S,t}(z,\tau) < 0$, the participation constraint implies that the minimum feasible transfer is $T^*_{S,t}(z,\tau) = -J_{S,t}(z,\tau)$. The manager is therefore exactly indifferent between operating and exiting. Because the transfer is fixed once $(z,\tau)$ is observed and does not rise with subsequent input or governance choices, it enters the firm's objective as a constant and leaves those choices unchanged.[14]

The bailout policy therefore drops out of the manager's private value but not from the physical law of motion: a bailed-out negative-value SOE remains active, employs inputs, and draws future productivity. The ownership-specific endogenous exit probabilities are

$$q_{P,t}(z,\tau) = \mathbf{1}\{J_{P,t}(z,\tau) < 0\}, \qquad q_{S,t}(z,\tau) = [1 - \delta_{S,t}(z,\tau)]\mathbf{1}\{J_{S,t}(z,\tau) < 0\}. \tag{5.2.12}$$

Combining endogenous exit with the ownership-specific exogenous exit probability $\omega_j$, the

[14] This construction parallels the "not-too-tight" solvency constraints of Alvarez and Jermann (2000): their debt limits are the loosest that prevent default, whereas $T^*_{S,t}(z,\tau)$ is the smallest transfer that prevents exit. In both cases, the relevant participation constraint binds.

total exit rate conditional on current productivity and wedges is

$$\mathcal{Q}_{j,t}(z,\tau) = \omega_j + (1-\omega_j) q_{j,t}(z,\tau), \qquad j \in \{S,P\}. \tag{5.2.13}$$

**Entry decisions.** Potential POE entrants pay $c_{e,t}^P$ before drawing initial productivity $z_0 \sim F_{P,t}^{E,z}$ and wedges $\tau_0 \sim G_{P,t}$. After observing the draw, the entrant operates whenever $J_{P,t}(z_0,\tau_0) \geq 0$. Letting $M_{P,t}$ denote the mass of potential POE entrants, the measure of accepted entrants is

$$e_{P,t}(dz,d\tau) = M_{P,t}\mathbf{1}\{J_{P,t}(z,\tau) \geq 0\} F_{P,t}^{E,z}(dz) G_{P,t}(d\tau). \tag{5.2.14}$$

The equilibrium condition determining whether $M_{P,t}$ is positive is imposed in Section 5.3.

SOE entry is state directed. A potential mass $M_{S,t}^0$ draws initial productivity from $F_{S,t}^{E,z}$ and wedges from $G_{S,t}$, and a potential entrant enters only if its operating value covers the entry cost:

$$e_{S,t}(dz,d\tau) = M_{S,t}^0 \mathbf{1}\{J_{S,t}(z,\tau) \geq c_{e,t}^S\} F_{S,t}^{E,z}(dz) G_{S,t}(d\tau). \tag{5.2.15}$$

The potential mass controls the scale of SOE entry, while $F_{S,t}^{E,z}$, $G_{S,t}$, and the activation threshold determine the composition of SOE entrants.

## 5.3 Aggregation and Equilibrium

**Firm distributions.** Let $\mu_{j,t}$ denote the measure of active firms over current productivity and wedge realizations. Given the entrant measures, productivity transitions, and survival rules defined above, for any set $B$ of current firm configurations, the distribution evolves according to

$$\begin{aligned}\mu_{j,t+1}(B) = e_{j,t+1}(B) &\\ + (1-\omega_j) \int\int \mathbf{1}\{(z',\tau') \in B\}[1 - q_{j,t+1}(z',\tau')] &\\ \times P_{j,t}(dz' \mid z, a_{j,t}(z)) G_{j,t+1}(d\tau')\, \mu_{j,t}(dz,d\tau), &\end{aligned} \tag{5.3.1}$$

where $a_{P,t} \equiv 0$.

**Labor-market clearing, private entry, and wage determination.** With positive POE entry, the equilibrium wage $w_t$ is pinned down by the free entry condition

$$\int\int V_{P,t}(z_0, \tau_0; w_t) G_{P,t}(d\tau_0) F_{P,t}^{E,z}(dz_0) = c_{e,t}^P. \tag{5.3.2}$$

Under the normalization $\bar{L} = 1$, let

$$\bar{\ell}_{P,t}^E(w_t) = \int\int \ell_{P,t}(z, \tau; w_t) \mathbf{1}\{J_{P,t}(z, \tau) \geq 0\} F_{P,t}^{E,z}(dz) G_{P,t}(d\tau) \tag{5.3.3}$$

denote labor demand generated by one unit of potential POE entrant mass, and let $L_t^{-PE}(w_t)$ denote aggregate labor demand from all firms other than current POE entrants. Labor-market clearing requires

$$1 = L_t^{-PE}(w_t) + M_{P,t} \bar{\ell}_{P,t}^E(w_t), \tag{5.3.4}$$

where $M_{P,t}$ denotes the mass of potential private entrants. Given the wage, labor-market clearing therefore determines the mass of potential POE entrants:[15]

$$M_{P,t} = \frac{1 - L_t^{-PE}(w_t)}{\bar{\ell}_{P,t}^E(w_t)}. \tag{5.3.5}$$

**Equilibrium.** Given initial firm distributions and an anticipated policy path, an equilibrium consists of value and policy functions, entrant flows, ownership-specific firm distributions, and a wage path such that firms optimize, the entry rules and POE free-entry condition are satisfied, firm distributions obey Equation 5.3.1, and the labor market clears at every date.[16]

[15] This describes the interior case with positive POE entry. If the free-entry wage implies a negative $M_{P,t}$ from (5.3.5), the nonnegativity constraint on entry binds, so $M_{P,t} = 0$ and the wage instead adjusts to satisfy $L_t^{-PE}(w_t) = 1$ and the POE free-entry condition becomes an inequality.

[16] We abstract from the government's financing problem. Bailout transfers affect the equilibrium allocation by allowing SOEs that would otherwise exit to remain in operation, but we assume that these transfers are financed through nondistortionary lump-sum taxes. The output and capital wedges may reflect taxes, subsidies, preferential financing, or other distortions; we treat these wedges as reduced-form objects and do not separately model their sources or fiscal implications.

## 5.4 Reform Mapping and Connection to the Decomposition

The model maps the reform chronology described in Section 4.1 into three structural channels: budget hardening, improvements in corporate governance, and state-directed SOE entry. Table 2 identifies the structural margins governing each channel and summarizes its main economic mechanism.

Table 2: Mapping China's state-sector reforms into the structural model

| Reform channel | Structural margins | Economic mechanism |
|---|---|---|
| Budget hardening under "Grasp the Large, Let Go of the Small" | Bailout probability $\delta_{S,t}(z,\tau)$; exogenous exit rate $\omega_S$; fixed operating cost $f_{S,t}$ | Reduces protection from losses and makes SOE survival more selective |
| Post-2003 governance reforms | Institutional effectiveness $\xi_t$ | Raises the effectiveness of governance investment and improves future productivity |
| State-directed SOE entry | Potential entrant mass $M^0_{S,t}$; entry cost $c^S_{e,t}$; entrant productivity distribution $F^{E,z}_{S,t}$; entrant wedge distribution $G_{S,t}$ | Determines the scale and composition of SOE entry |

*Notes:* The table lists the structural margins directly affected by each reform channel. Changes in these margins also propagate through firm values, governance choices, wages, entry, selection, and firm distributions in equilibrium.

The mapping is intentionally parsimonious. In particular, the post-2003 governance channel summarizes a broad set of organizational reforms through the single reduced-form parameter $\xi_t$.[17]

The structural model is designed to speak directly to the empirical decomposition. The decomposition summarizes firm dynamics through the productivity transition $P$, exit $Q$, and entry processes $E$, while the structural model additionally includes transitory wedges that

[17]Following the creation of SASAC, SOEs, especially central SOEs, were subject to a broad set of organizational reforms, including more formal boards, the introduction of outside directors (and independent directors for listed firms), clearer separation between ownership and management, and stronger managerial performance evaluation (Naughton, 2006; Lardy, 2019; Naughton, 2007; Bhabra and Li, 2011). Thus, the post-2003 institutional changes are summarized in reduced form by the changes in $\xi_t$.

affect firms' current decisions. To make the two objects comparable, we integrate over these transitory wedges and recover the model-implied counterparts of the empirical $P$, $Q$, and $E$ processes.[18] This allows us to apply the same decomposition to model-generated data and ask whether the estimated model reproduces not only the aggregate evolution of the state sector, but also the relative roles of incumbent productivity dynamics, selection, and entry in SOE productivity growth.

# 6 Estimation and Validation

We estimate the model in two steps. First, we solve a pre-reform stationary equilibrium, interpreted as the economic environment prevailing before the reform transition and disciplined by moments observed in 1998. This stationary equilibrium determines the initial ownership-specific firm distributions and the structural parameters governing the pre-reform environment. These parameters are then held fixed throughout the transition estimation. Second, taking the resulting 1998 distribution as the initial state, we estimate the reform transition using moments from 1998 through 2007. For each candidate transition parameter vector, we solve the equilibrium transition path and construct the same moments in the model and the data. Details of the parameter estimates, moments, and estimation procedure are reported in Appendix H.

**Initial condition and expectations.** We take the observed 1998 cross section to represent the initial state inherited from the pre-reform stationary equilibrium. For POEs, the pre-reform equilibrium features the standard private-firm entry and exit environment. The POE entry cost is normalized to $c_{e,P} = 1$ and remains constant throughout the baseline reform transition. For SOEs, the pre-reform regime features no governance investment, no SOE entry, no exogenous exit, and full bailout of firms with negative continuation value. The pre-reform stationary equilibrium is therefore solved without anticipation of the subsequent reforms.

We distinguish this inherited 1998 state from decisions governing the subsequent transition. Once the 1998 state is realized, the future reform path is revealed and perfectly

[18] Formally, the model-implied exit process conditional only on productivity is $Q_{j,t}(z) = \int \mathcal{Q}_{j,t}(z, \tau_Y, \tau_K)\, G_{j,t}(d\tau_Y, d\tau_K)$. Because current wedges do not affect optimal governance effort, the SOE productivity transition is $P_{S,t}(dz' \mid z) = P_S(dz' \mid z, a^*_{S,t}(z); \xi_t)$, and the entrant process is the productivity marginal of the accepted entrant measure, $E_{j,t}(dz) = \int e_{j,t}(dz, d\tau)$.

anticipated. Firms' decisions governing the 1998–1999 transition therefore use continuation values from the reform transition rather than the pre-reform value functions. In particular, SOEs can choose governance effort in 1998 that affects productivity in 1999, and the post-reform bailout rule determines which SOEs continue into 1999. The model therefore treats reform as an unanticipated departure from a pre-reform stationary equilibrium, followed by perfect foresight over the subsequent reform sequence.

**Identification.** The exit parameters are disciplined by different parts of the exit distribution. We calibrate exogenous exit rates from exit among highly profitable firms, for which endogenous exit incentives are weak. Conditional on these rates, the POE fixed operating cost is identified from the overall POE exit rate, while the pre-reform SOE fixed operating cost is identified from the fraction of nonviable SOEs in 1998. During the reform transition, the overall SOE exit rate identifies the level of the bailout probability, $\gamma_0$, while the relationship between exit and productivity identifies bailout selectivity, $\gamma_z$. The post-2003 SOE fixed operating cost is then disciplined by exit among low-profitability SOEs in late reform periods.

The entry parameters are identified jointly from the number, size, productivity, and input choices of observed entrants. Entrant firm shares discipline the mass of potential entrants, while entrant employment relative to incumbent employment disciplines entry costs. Mean entrant productivity identifies the location of the potential-entrant productivity distribution after accounting for endogenous selection into entry. Finally, entrant–incumbent differences in labor–output and capital–labor ratios discipline the means of the common SOE wedge distributions: although entrants and incumbents draw from the same distributions within each period, their realized wedges differ because entry and continuation are selective. We estimate separate entry and wedge parameters for the early and post-2003 reform periods, with the 2007 SOE employment share providing an additional joint restriction on the transition.

Governance parameters are identified from productivity transitions among continuing SOEs. We first remove the productivity evolution implied by the no-governance process and estimate how the remaining productivity improvement varies with initial productivity. We evaluate this relationship at common points of the productivity distribution across years, so changes in the composition of surviving firms are not mistaken for changes in governance effectiveness. Differences in productivity improvement across these fixed productivity values in the early and late reform periods primarily identify $\xi_{\text{early}}$ and $\xi_{\text{late}}$, respectively, while

the curvature of the relationship identifies the governance-cost curvature, $\nu$. Appendix H provides the detailed construction of these moments.

**Parameter estimates.** The parameters most important for the mechanisms studied below are those governing bailout selectivity and governance. For estimation, we assume that the same bailout rule applies throughout the reform transition and parameterize the bailout probability for an otherwise nonviable SOE as

$$\delta_{S,t}(z,\tau) = \Phi(\gamma_0 + \gamma_z \log z)\,, \tag{6.0.1}$$

where $\Phi$ denotes the standard normal cumulative distribution function.[19] The estimated cofficients are

$$\gamma_0 = 1.647, \qquad \gamma_z = 2.051. \tag{6.0.2}$$

Because bailout probability is increasing in $\gamma_0 + \gamma_z z$, the positive estimate of $\gamma_z$ implies that, among SOEs that would otherwise exit, more productive firms are more likely to receive government support.

While the bailout parameters govern selection through the exit margin, governance investment provides a separate channel through which surviving SOEs can improve their productivity. In the model, the productivity effect of governance effort is governed by the parameter $\xi$. We allow this parameter to change with the 2003 governance reform. Specifically, $\xi_{\text{early}}$ governs the effectiveness of governance investment during the early reform period before 2003, while $\xi_{\text{late}}$ governs its effectiveness from 2003 onward. The estimated values are

$$\xi_{\text{early}} = 0.0116, \qquad \xi_{\text{late}} = 0.0631, \tag{6.0.3}$$

while the estimated curvature of governance costs is

$$\nu = 0.707. \tag{6.0.4}$$

[19] A more general bailout rule would take the form

$$\delta_{S,t}(z,\tau) = \Phi(\gamma_0 + \gamma_z \log z + \gamma_{\tau_Y}\tau_Y + \gamma_{\tau_K}\tau_K)\,,$$

where $\gamma_{\tau_Y}$ and $\gamma_{\tau_K}$ measure the extent of bailout on current output and capital wedges, respectively. Identifying these coefficients would require matching coefficients on lagged wedges in exit regressions estimated in the data and the model. Because the wedge shocks are iid, the model-implied coefficients on lagged wedges are zero for every value of $\gamma_{\tau_Y}$ and $\gamma_{\tau_K}$. These parameters are therefore not identified in the current specification, so we set them to zero and restrict bailout to depend only on productivity.

Thus, holding governance effort fixed, the post-2003 regime makes governance investment substantially more effective at raising productivity. The complete calibration and estimation results are reported in Appendix Tables 4–6, and the corresponding model–data moment fit is reported in Appendix Tables 7–10.

## 6.1 Model Validation

We validate the model against three features of the reform transition: the contraction of the state sector, state and private firm productivity convergence, and the decomposition of productivity growth within the state sector. Most of these outcomes are not directly targeted in estimation.[20]

The model closely reproduces the contraction of the state sector. Starting from the 1998 initial condition, the model-simulated SOE shares of firms, employment, capital, and output track the observed declines well over the reform period (1999-2007). The fit is especially strong for the overall magnitude of ownership reallocation. Appendix Figure 3 reports the full model–data paths.

The model also generates substantial state and private firm productivity convergence. The employment-weighted log productivity gap falls from approximately 0.38 in 1998 to 0.15 in 2007, closing about 60% of the initial gap. SOE productivity therefore grows less relative to POE productivity in the model than in the data.

This remaining gap reflects an important quantitative tension in simultaneously matching productivity catch-up and the contraction of the state sector. Increasing productivity growth among continuing SOEs raises their continuation values and size and therefore tends to slow the reallocation of activity toward POEs. Stronger selection of low-productivity SOEs, by contrast, would accelerate the contraction of the state sector, while a larger contribution from SOE entry would require more or more productive entrants and would also affect the ownership transition. Because the model already closely matches the magnitude of state-sector contraction, these margins cannot be adjusted freely to generate additional SOE productivity growth without worsening the fit along other dimensions. Appendix Figure 4 reports the productivity paths.

Our main validation exercise asks whether the model reproduces the *sources* of SOE

[20]The 1998 ownership shares discipline the initial condition and the 2007 SOE employment share enters the late-reform estimation block, but the intervening ownership paths, the productivity gap, and the decomposition results provide largely independent tests of the model.

productivity growth identified by the statistical decomposition in Section 4.4. We first map simulated productivity back to the original productivity measure used in the empirical analysis and then apply the same direct 1998–2007 decomposition to the data and the model.[21]

Table 3: Validation: decomposition of SOE productivity growth, 1998–2007

| Weighting | Sample | Total change | $P$ | | $Q$ | | $\lambda G$ | |
|---|---|---|---|---|---|---|---|---|
| Firm-count | Data | 1.165 | 0.270 | (23.2%) | 0.671 | (57.6%) | 0.224 | (19.3%) |
| | Model | 0.964 | 0.259 | (26.8%) | 0.615 | (63.8%) | 0.091 | (9.4%) |
| Employment | Data | 1.258 | 0.281 | (22.3%) | 0.731 | (58.1%) | 0.246 | (19.6%) |
| | Model | 0.901 | 0.243 | (27.0%) | 0.517 | (57.3%) | 0.142 | (15.7%) |

*Notes:* Entries under $P$, $Q$, and $\lambda G$ report their contributions to the direct 1998–2007 change in SOE productivity. Shares of the total change are reported in parentheses. The count-weighted specification corresponds to the baseline statistical decomposition; the employment-weighted specification provides an additional validation exercise.

The decomposition delivers two main results. First, consistent with the incomplete SOE–POE convergence above, the model understates total SOE productivity growth by about 20%. Second, despite this shortfall in magnitude, the model closely reproduces the composition of productivity growth: selection, $Q$, is the dominant force, while productivity growth among continuing firms, $P$, makes a smaller but substantial contribution. The main compositional discrepancy is entry, whose contribution is weaker in the model. Thus, the model captures the relative importance of selection and within-firm productivity growth while understating the overall magnitude of SOE productivity improvement.

Taken together, these validation exercises show that the model captures the simultaneous contraction and productivity convergence of the state sector and, more importantly, reproduces the central empirical result that selection is the dominant source of SOE productivity growth. The remaining quantitative gap reflects both weaker entry contributions and the broader tension between generating faster productivity catch-up among incumbent SOEs and preserving the rapid ownership reallocation observed in the data.

[21] The structural model is solved in detrended productivity units, which are used in the preceding SOE–POE convergence exercise. For the decomposition, we restore the common productivity trend. Because this trend cancels from the SOE–POE productivity gap but contributes to productivity growth over time, the 2007 model-implied SOE–POE gap of approximately 0.15 and the cumulative increase in SOE productivity reported in the decomposition are different objects and are not directly comparable.

# 7 Counterfactual Reform Analysis

The preceding sections document the evolution of China's SOE reforms, show that the sources of SOE productivity growth changed over the transition, and estimate a model that reproduces the main features of that transition. We now use the model to quantify the effects of the major reforms. We first ask how hardening soft budget constraints, governance reform, and changes in the SOE entry regime contributed to the rise in SOE productivity and contraction of state ownership. Because hardening budget constraints and improving governance can both raise SOE productivity while having different effects on firm survival and state-sector employment, we next compare reforms that generate the same SOE productivity gain through these two mechanisms. Finally, because China introduced these reforms sequentially, their effects may depend on timing and order: reforms implemented earlier change the population of firms exposed to those that follow. We therefore ask how alternative reform sequences would have changed the transition, even though they ultimately lead to the same post-reform steady state.

## 7.1 Reform Channels in China's State-Sector Transformation

We begin by quantifying how the reforms introduced in Section 4.1 contributed to the joint rise in SOE productivity and contraction of state ownership. We consider three components of the reform process: the selective-survival changes associated with the late-1990s exit reform, the post-2003 governance reform, and the change in the SOE entry regime. For each, we compare the historical reform path with a counterfactual that removes that component while leaving the other reforms unchanged.

Table 4 shows that the reforms played sharply different roles. Reforms that increased pressure on poorly performing SOEs to exit substantially reduced state-sector employment and raised SOE productivity. Relative to the counterfactual without these reforms, they lowered the SOE employment share from 42.4 to 30.5 percent and raised SOE TFP in 2007 by about 11 percent. They also generated a substantially larger increase in aggregate TFP. Stronger selection therefore contributed to both productivity catch-up and state-sector contraction: weaker SOEs were more likely to exit, raising average productivity among the firms that remained while shifting activity away from state ownership. Appendix I.2 further

Table 4: Reform Channels and China's State-Sector Transformation

| | Δ Output (%) | Δ Aggregate TFP (%) | Δ SOE TFP (%) | SOE employment share (%) |
|---|---|---|---|---|
| Historical reform package | 17.2 | 19.4 | 22.8 | 30.5 |
| Without selective-exit reform | 10.2 | 11.4 | 10.7 | 42.4 |
| Without governance reform | 21.9 | 24.8 | 9.3 | 22.6 |
| Without new SOE entry | 21.7 | 24.6 | 28.8 | 23.0 |

*Notes:* All outcomes refer to 2007. Output, aggregate TFP, and employment-weighted SOE TFP are percent changes relative to continuation of the pre-reform regime through 2007; under that benchmark, the SOE employment share is 59.4 percent. Each counterfactual removes one reform from the historical package while leaving the remaining reform paths unchanged, so differences across rows are not additive. The productivity-independent component of SOE exit is held at its historical path in all displayed regimes. "Without selective-exit reform" restores pre-reform bailout protection and SOE fixed operating costs. "Without governance reform" restores the pre-reform governance technology. "Without new SOE entry" removes post-reform SOE entry while leaving the incumbent reform paths unchanged.

examines the role of soft budget constraints by comparing alternative degrees of bailout protection while holding the other reform margins fixed.

Governance reform also contributed substantially to SOE productivity growth, but had the opposite effect on state-sector size. Without governance reform, SOE productivity would have risen by only 9.3 percent, compared with 22.8 percent under the historical path. At the same time, the SOE employment share would have fallen further, to 22.6 percent. By improving incumbent productivity, governance reform increased the number of SOEs able to remain active and retain employment. In the model, this preservation of state-sector activity also reduced aggregate TFP relative to the counterfactual without governance reform.

Changes in the SOE entry regime further replenished the state sector. Without post-reform SOE entry, the SOE employment share would have fallen to 23.0 percent. Average SOE productivity would have been higher as well, because new entrants are less productive on average than the highly selected and improved incumbent population.

The historical contraction of the state sector therefore reflects the interaction of forces operating in different directions. A more selective exit environment made the state sector both smaller and more productive. Governance reform also raised productivity but preserved more incumbent SOEs, while new entry rebuilt part of the sector. In particular, the first two reforms can both generate substantial SOE productivity growth while having very different implications for state-sector contraction. This motivates the next exercise, which holds the amount of SOE productivity improvement fixed and isolates the consequences of the mechanism generating it.

## 7.2 Why the Source of SOE Productivity Growth Matters

We construct two counterfactual reforms that generate the same improvement in SOE productivity through different mechanisms. Both raise employment-weighted SOE TFP by 10 percent by 2007. In the first, the gain is generated by hardening soft budget constraints and strengthening selection among incumbent SOEs. In the second, incumbent productivity improves while the pre-reform level of bailout protection is maintained. Holding the SOE productivity gain fixed allows us to compare the consequences of the two mechanisms directly.

Table 5: Same SOE Productivity Growth, Different Sources

| Regime | Δ Output (%) | Δ Aggregate TFP (%) | Δ SOE TFP (%) | SOE employment (%) | Bailout incidence (%) | Fiscal exposure (% of output) |
|---|---|---|---|---|---|---|
| Budget hardening | 22.4 | 25.4 | 10.0 | 21.8 | 21.4 | 1.22 |
| Incumbent productivity improvement | 11.1 | 12.4 | 10.0 | 40.8 | 50.5 | 10.32 |

*Notes:* Both regimes are calibrated to raise employment-weighted SOE TFP by 10 percent relative to the pre-reform equilibrium in 2007. The budget-hardening regime generates the gain through stronger selection while shutting off governance improvement. The incumbent-productivity regime maintains pre-reform bailout protection and adjusts governance effectiveness to reach the same SOE TFP target. The SOE entry process, private-sector environment, productivity-independent SOE exit component, and all other structural parameters are held fixed across the two experiments. Output and productivity columns report percent changes relative to the pre-reform equilibrium.

Table 5 shows that the resulting economies look very different despite having the same SOE productivity gain. By 2007, the SOE employment share is 21.8 percent under budget hardening, compared with 40.8 percent under incumbent productivity improvement. The aggregate TFP gain relative to the pre-reform benchmark is also 13 percentage points larger under budget hardening. Continued bailout protection makes the fiscal consequences different as well: both bailout incidence and fiscal exposure remain substantially higher under the incumbent-productivity reform.

The differences between the two mechanisms are not confined to the 1998–2007 transition. Appendix I.1 follows both regimes to their long-run equilibria. The incumbent-productivity reform eventually produces a more productive state sector, but it also sustains a larger SOE presence and greater reliance on bailout support than budget hardening. The contrast between the two reforms therefore persists even after the transition dynamics have dissipated.

These persistent differences reflect how the two reforms generate productivity growth. Budget hardening raises average SOE productivity partly by allowing weaker firms to exit,

releasing resources from state ownership. Incumbent productivity improvement instead raises the productivity and continuation value of firms that would otherwise be more likely to exit. Consequently, similar improvements in measured SOE productivity can imply very different patterns of firm survival, state-sector employment, aggregate productivity, and fiscal exposure.

## 7.3 Reform Sequencing and the Transition

China introduced its SOE reforms sequentially rather than all at once. Reforms implemented earlier can change the population of firms exposed to those that follow, so alternative sequences can generate different transition paths even when they ultimately lead to the same post-reform steady state. We examine this possibility by comparing the historical sequence with a counterfactual in which the final reform package is introduced in 1999.

Under the historical sequence, changes in the SOE exit environment begin in 1999, while the governance and post-reform entry regimes are introduced later. In the counterfactual, we bring these later reforms forward to 1999, so that the full reform package is implemented at the start of the transition. Both paths converge to the same post-reform steady state. Differences between them therefore reflect the consequences of reform timing for the transition rather than differences in long-run policy.

Table 6: Reform Timing: Same Long-Run Regime, Different Transitions

| Policy path | Δ Output (%) | Δ Aggregate TFP (%) | Δ SOE TFP (%) | SOE employment (%) | Bailout incidence (%) | Fiscal exposure (% of output) |
|---|---|---|---|---|---|---|
| Historical sequencing | 17.2 | 19.4 | 22.8 | 30.5 | 20.4 | 1.46 |
| Final reform package from 1999 | 14.3 | 16.0 | 43.0 | 35.5 | 19.0 | 1.27 |

*Notes:* All outcomes refer to 2007. Under the historical path, the reform components are introduced at their estimated dates. In the counterfactual, the final bailout rule, governance regime, and SOE entry regime are all introduced in 1999. The eventual policy regime is identical across the two paths. Output and productivity columns report percent changes relative to the pre-reform equilibrium.

Table 6 shows that front-loading the reforms produces much faster productivity improvement within the state sector. By 2007, SOE TFP is 43.0 percent above the pre-reform benchmark, compared with 22.8 percent under the historical sequence. But the state sector is also larger: its employment share is 35.5 percent rather than 30.5 percent. Aggregate TFP growth is lower, at 16.0 percent rather than 19.4 percent.

Two forces account for this difference. Introducing governance reform earlier gives incum-

bent SOEs more time to improve their productivity, so the productivity distribution facing exit decisions in subsequent years is stronger and more firms remain active. Introducing the later SOE entry regime earlier also adds state firms sooner. Front-loading the reform package therefore accelerates productivity growth within the state sector while reducing the contraction of state ownership during the transition.

The sequencing experiment highlights a distinction between improving SOEs more quickly and reallocating activity away from state ownership more quickly. Earlier reform can produce a more productive state sector at a given date while leaving that sector larger and generating lower aggregate productivity. Even when reform paths converge to the same post-reform steady state, the order in which reforms are introduced can therefore have important consequences for the transition.

# 8 Conclusion

China's state-sector transformation illustrates that rising productivity within a sector can accompany a decline in that sector's economic footprint. When less productive state-owned enterprises (SOEs) exit, average productivity among the remaining SOEs rises and resources shift toward private firms. By contrast, productivity improvements among incumbent SOEs and the entry of productive state firms raise state-sector productivity while sustaining a larger role for state ownership. Understanding China's experience therefore requires distinguishing productivity gains generated within continuing firms from those generated by exit and entry.

Our decomposition provides a way to do this empirically. Rather than interpreting productivity growth through the realized performance of surviving, entering, and exiting firms, the framework separately recovers changes in incumbent productivity dynamics, endogenous exit, and entry. China provides a particularly useful laboratory because all three margins changed substantially during a major reform episode, but the framework is not specific to state ownership or to China. It applies more broadly to settings in which changes in firm performance are intertwined with changes in which firms survive and enter. Separating these processes also creates a natural bridge from measurement to mechanism: once we know which margins changed, we can ask what economic forces generated those changes and what their broader consequences were.

The structural analysis adds a distinct lesson about reform transitions. Once reforms

affect different firm-dynamic processes, their consequences depend not only on which policies are ultimately adopted but also on when they are introduced. Earlier reforms change which firms are still operating when later reforms arrive. In our counterfactuals, alternative reform sequences therefore lead to different productivity and ownership outcomes during the transition, even though they ultimately lead to the same long-run outcome. The transition itself is thus an important economic consequence of reform.

A natural next step is to study what happens to workers as firms contract or exit. In the benchmark model, workers leaving SOEs are immediately absorbed by other firms. In practice, they may experience unemployment, move across sectors or locations, or suffer earnings losses along the way. Incorporating these adjustment costs would allow us to ask how the productivity gains from selection are shared against the costs borne by displaced workers. Linking firm exit to workers' subsequent employment and earnings would therefore extend the analysis from how reform reallocates activity across firms to how that reallocation affects workers.

# References


**Alvarez, Fernando and Urban J Jermann**, "Efficiency, equilibrium, and asset pricing with risk of default," *Econometrica*, 2000, *68* (4), 775–797.

**Asturias, Jose, Sewon Hur, Timothy J Kehoe, and Kim J Ruhl**, "Firm entry and exit and aggregate growth," *American Economic Journal: Macroeconomics*, 2023, *15* (1), 48–105.

**Baily, Martin Neil, Charles Hulten, and David Campbell**, "Productivity Dynamics in Manufacturing Plants," *Brookings Papers on Economic Activity: Microeconomics*, 1992.

**Banister, Judith**, "Manufacturing Employment in China," *Monthly Labor Review*, 2005, *128* (7), 11–29.

_ , "China's Manufacturing Employment and Hourly Labor Compensation, 2002–2009," Technical Report, U.S. Bureau of Labor Statistics 2013.

**Berkowitz, Daniel, Hong Ma, and Shuichiro Nishioka**, "Recasting the Iron Rice Bowl: The Reform of China's State-owned Enterprises," *Review of Economics and Statistics*, 2017, *99* (4), 735–747.

**Bhabra, Harjeet S and Tiemei Li**, "Independent Directors and Corporate Performance: Evidence from Listed Firms in China," *Corporate Ownership and Control*, 2011, *8* (3), 46.

**Brandt, Loren and Thomas G Rawski**, *China's great economic transformation*, Cambridge university press, 2008.

_ **and Xiaodong Zhu**, "Soft Budget Constraint and Inflation Cycles: A Positive Model of the Macro-Dynamics in China during Transition," *Journal of Development Economics*, 2001, *64* (2), 437–457.

_ **, Chang-Tai Hsieh, and Xiaodong Zhu**, "Growth and structural transformation in China," *China's great economic transformation*, 2008, pp. 683–728.

_ **, Johannes Van Biesebroeck, and Yifan Zhang**, "Creative Accounting or Creative Destruction? Firm-level Productivity Growth in Chinese Manufacturing," *Journal of Development Economics*, 2012, *97* (2), 339–351.

_ , _ , **Luhang Wang, and Yifan Zhang**, "WTO Accession and Performance of Chinese Manufacturing Firms," *American Economic Review*, 2017, *107* (9), 2784–2820.

_ , **John Litwack, Elitza Mileva, Luhang Wang, Yifan Zhang, and Luan Zhao**, "Recent Productivity Trends in China: Evidence from Macro- and Firm-Level Data," *China: An International Journal*, 2022, *20* (1), 93–113.

_ , **Trevor Tombe, and Xiaodong Zhu**, "Factor Market Distortions across Time, Space and Sectors in China," *Review of economic dynamics*, 2013, *16* (1), 39–58.

**Chen, Yuyu, Mitsuru Igami, Masayuki Sawada, and Mo Xiao**, "Privatization and Productivity in China," *The RAND Journal of Economics*, 2021, *52* (4), 884–916.

**Clementi, Gian Luca and Berardino Palazzo**, "Entry, exit, firm dynamics, and aggregate fluctuations," *American Economic Journal: Macroeconomics*, 2016, *8* (3), 1–41.

_ **and Hugo A. Hopenhayn**, "A Theory of Financing Constraints and Firm Dynamics," *Quarterly Journal of Economics*, 2006, *121* (1), 229–265.

**Cooley, Thomas F. and Vincenzo Quadrini**, "Financial Markets and Firm Dynamics," *American Economic Review*, 2001, *91* (5), 1286–1310.

**Das, Mitali, Whitney K Newey, and Francis Vella**, "Nonparametric estimation of sample selection models," *The Review of Economic Studies*, 2003, *70* (1), 33–58.

**d'Haultfoeuille, Xavier**, "A new instrumental method for dealing with endogenous selection," *Journal of Econometrics*, 2010, *154* (1), 1–15.

**Ericson, Richard and Ariel Pakes**, "Markov-Perfect Industry Dynamics: A Framework for Empirical Work," *The Review of Economic Studies*, 1995, *62* (1), 53–82.

**Foster, Lucia, John C Haltiwanger, and Cornell John Krizan**, "Aggregate Productivity Growth: Lessons from Microeconomic Evidence," in "New Developments in Productivity Analysis," University of Chicago Press, 2001, pp. 303–372.

_ , **John Haltiwanger, and Chad Syverson**, "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?," *American Economic Review*, 2008, *98* (1), 394–425.

**Griliches, Zvi and Haim Regev**, "Firm Productivity in Israeli Industry 1979–1988," *Journal of Econometrics*, 1995, *65* (1), 175–203.

**Groves, Theodore, Yongmiao Hong, John McMillan, and Barry Naughton**, "Autonomy and Incentives in Chinese State Enterprises," *The Quarterly Journal of Economics*, 1994, *109* (1), 183–209.

**Gu, Shijun and Chengcheng Jia**, "Firm dynamics and SOE transformation during China's economic reform," *Journal of International Money and Finance*, 2022, *127*, 102672.

**Heckman, James J**, "Sample selection bias as a specification error," *Econometrica: Journal of the econometric society*, 1979, pp. 153–161.

**Hopenhayn, Hugo A**, "Entry, Exit, and Firm Dynamics in Long Run Equilibrium," *Econometrica: Journal of the Econometric Society*, 1992, pp. 1127–1150.

**Hopenhayn, Hugo and Richard Rogerson**, "Job Turnover and Policy Evaluation: A General Equilibrium Analysis," *Journal of Political Economy*, 1993, *101* (5), 915–938.

**Hsieh, Chang-Tai and Peter J Klenow**, "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 2009, *124* (4), 1403–1448.

_ **and Zheng Michael Song**, "Grasp the Large, Let Go of the Small: The Transformation of the State Sector in China," Technical Report, National Bureau of Economic Research 2015.

**Jefferson, Gary H, Thomas G Rawski, and Yuxin Zheng**, "Chinese Industrial Productivity: Trends, Measurement Issues, and Recent Developments," *Journal of Comparative Economics*, 1996, *23* (2), 146–180.

**Jiang, Helu, Yu Zheng, and Lijun Zhu**, "Entry barriers and growth: The role of endogenous market structure," *International Economic Review*, 2024, *65* (3), 1221–1248.

**Jovanovic, Boyan**, "Selection and the Evolution of Industry," *Econometrica: Journal of the Econometric Society*, 1982, pp. 649–670.

**Khandelwal, Amit K, Peter K Schott, and Shang-Jin Wei**, "Trade Liberalization and Embedded Institutional Reform: Evidence from Chinese exporters," *American Economic Review*, 2013, *103* (6), 2169–2195.

**Klette, Tor Jakob and Samuel Kortum**, "Innovating Firms and Aggregate Innovation," *Journal of Political Economy*, 2004, *112* (5), 986–1018.

**KORNAI*, JÁNOS**, "The soft budget constraint," *Kyklos*, 1986, *39* (1), 3–30.

**Kornai, János, Eric Maskin, and Gérard Roland**, "Understanding the Soft Budget Constraint," *Journal of Economic Literature*, 2003, *41* (4), 1095–1136.

**Kyriazidou, Ekaterini**, "Estimation of a panel data sample selection model," *Econometrica: Journal of the Econometric Society*, 1997, pp. 1335–1364.

_ , "Estimation of dynamic panel data sample selection models," *The Review of Economic Studies*, 2001, *68* (3), 543–572.

**Lardy, Nicholas R**, *Markets over Mao: The Rise of Private Business in China*, Columbia University Press, 2014.

_ , *The State Strikes Back: The End of Economic Reform in China?*, Peterson Institute for International Economics, 2019.

**Lau, Lawrence J., Yingyi Qian, and Gérard Roland**, "Reform without Losers: An Interpretation of China's Dual-Track Approach to Transition," *Journal of Political Economy*, 2000, *108* (1), 120–143.

**Li, Wei**, "The Impact of Economic Reform on the Performance of Chinese State Enterprises, 1980–1989," *Journal of Political Economy*, 1997, *105* (5), 1080–1106.

**Liao, Li, Bibo Liu, and Hao Wang**, "China's Secondary Privatization: Perspectives from the Split-Share Structure Reform," *Journal of Financial Economics*, 2014, *113* (3), 500–518.

**Liu, Ernest**, "Industrial Policies in Production Networks," *The Quarterly Journal of Economics*, 2019, *134* (4), 1883–1948.

**McMillan, John and Barry Naughton**, "How to reform a planned economy: lessons from China," *Oxford review of economic policy*, 1992, *8* (1), 130–143.

**Melitz, Marc J**, "The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 2003, *71* (6), 1695–1725.

_ **and Sašo Polanec**, "Dynamic Olley-Pakes Productivity Decomposition with Entry and Exit," *The RAND Journal of Economics*, 2015, *46* (2), 362–375.

**Naughton, Barry**, "Claiming Profit for the State: SASAC and the Capital Management Budget," *China Leadership Monitor*, 2006, *18*, 1–9.

_ , *The Chinese Economy: Transitions and Growth*, MIT press, 2007.

**Olley, G. Steven and Ariel Pakes**, "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 1996, *64* (6), 1263–1297.

**Qian, Yingyi and Gerard Roland**, "Federalism and the soft budget constraint," *American economic review*, 1998, pp. 1143–1162.

**Rubens, Michael**, "Market Structure, Oligopsony Power, and Productivity," *American Economic Review*, 2023, *113* (9), 2382–2410.

**Shapley, Lloyd S.**, "A Value for $n$-Person Games," in Harold W. Kuhn and Albert W. Tucker, eds., *Contributions to the Theory of Games II*, Vol. 28 of *Annals of Mathematics Studies*, Princeton, NJ: Princeton University Press, 1953, pp. 307–317.

**Shorrocks, Anthony F et al.**, "Decomposition procedures for distributional analysis: a unified framework based on the Shapley value," *Journal of Economic Inequality*, 2013, *11* (1), 99–126.

**Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti**, "Growing Like China," *American Economic Review*, 2011, *101* (1), 196–233.

**Wang, Ruiting, Xue Wang, Gang Xu, and Tao Zha**, "Privatization's Impacts on State-Owned Enterprises: A Tale of Zombie versus Healthy Firms," Technical Report, National Bureau of Economic Research 2024.

**Wooldridge, Jeffrey M**, "Selection corrections for panel data models under conditional mean independence assumptions," *Journal of econometrics*, 1995, *68* (1), 115–132.