Does External Monitoring from Government Improve the Performance of State-Owned Enterprises?*

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Abstract

This paper investigates how external monitoring from government influences the performance of state-owned enterprises (SOEs), by affecting managerial expropriation in procurement (proxied by input prices) and shirking in production management (proxied by productivity). Because firm-level input prices are usually not observed, we apply a structural approach of production function estimation to estimate them together with firm-level productivity, providing a methodologically practical approach to overcome the common data limitation. Using a nationwide policy shock in China that strengthened government monitoring on SOEs exclusively, we find enhancing monitoring can substantially improve SOEs' input prices and productivity. Moreover, as spatial-dimension evidence, higher monitoring costs increase input prices paid by SOEs and reduce productivity. Such negative effect is largely alleviated by the monitoring-strengthening policy. The results suggest that government monitoring can be an effective policy instrument to improve SOE performance.

Keywords: *productivity, input prices, external monitoring, SOE performance, production function estimation*

JEL classification: *D2, L11, O38*

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1 Introduction

Effective external monitoring on firm management — from investors, debtors, or supervising government — is an indispensable component in corporate governance to reduce managerial expropriation and shirking (e.g., Becker, 1968; Allingham and Sandmo, 1972). Chinese state-owned enterprises (SOEs) in manufacturing industries, as in many other countries, have been renowned for ineffective external monitoring on their management. This is largely due to unclear property rights ("owned by all people in the country") and weak legal enforcement arising from strong political connections. While previous work in analyzing the performance of Chinese SOEs has emphasized *internal* incentivization (e.g., Groves et al., 1994; Li, 1997; Estrin et al., 2009; Chen et al., 2017), the impact of *external* monitoring has been largely ignored. In this paper, we empirically examine the role played by external monitoring from government on SOE performance.

Another innovation of our analysis is to distinguish the impact of external monitoring on firm performance in terms of material prices and productivity. Facing weaker external monitoring, SOE managers are more likely to be corrupt in material procurement compared with their private counterparts by, for example, taking kickbacks, self-dealing, and secret transactions with relational firms. This directly increases the input prices paid by SOEs and consequently reduces profit. Beyond that, ineffective external monitoring may result in lower productivity, because it can increase managerial shirking directly, or indirectly if (higher) productivity and (lower) input prices are complementary in promoting profit. As a result, it is important to separate input prices from productivity in order to understand the mechanism through which external monitoring takes effect.

One challenge is that our dataset, like many other production survey datasets, does not include firm-level material prices or productivity. To address this common issue, we estimate firm-level measures of input prices and productivity using the structural approach of production function estimation initially developed in Grieco et al. (2016) and extended in Grieco et al. (2017). This provides a methodologically feasible approach to overcome the common data limitation in the literature of firm performance studies. The central idea is to use firms' optimality conditions on input choices together with information on wages and input expenditures to infer and control for materials input prices in the estimation of the production function. It contrasts to the traditional practice in broad studies of firm performance (e.g., Brandt et al., 2012; Chen et al., 2017; Berkowitz et al., forthcoming), which estimate total factor productivity (TFP) without accounting for firm heterogeneity in material prices in the production function estimation frameworks of Olley and

Pakes (1996), Levinsohn and Petrin (2003), De Loecker and Warzynski (2012), Ackerberg et al. (2015), and Gandhi et al. (2016). These papers assume homogeneous material prices in order to use deflated material expenditure as a proxy for input quantity when estimating productivity, although recent studies have shown large heterogeneity in input prices across firms (Ornaghi, 2006; Atalay, 2014). In addition, productivity estimation may be biased if the heterogeneity of input prices is correlated with inputs choice and is ignored (Grieco et al., 2016; De Loecker et al., 2016; Brandt et al., 2017). Our approach separates firm heterogeneity in input prices from productivity, while allowing for capital markets distortions/mis-allocations, difference in firm productivity management, and corruptions in input procurement. Such a feature is crucial in the performance comparison across firms (especially between SOEs and non-SOEs).

Using the Annual Survey of Industrial Firms in China during 1998-2007, we document the weak performance of SOEs in productivity and the ability to secure better input prices. The productivity of SOEs is about 20 percent lower and they face 6.4 percent higher input prices compared with their private counterparts on average, after controlling for observable characteristics such as size, industry, and location. This is despite SOEs' privileges in input and output markets, market power, and bargaining power to access to discounted input prices arising from their connections to governments. The higher input prices, as a result, is consistent with the existence of serious corruption and/or shirking in the material procurement process. Because material expenditure accounts for over 80 percent of total variable costs in Chinese manufacturing industries, the impact of such overpayment on materials is substantial: it leads to about a 5.1 percent profit loss for SOEs. However, this association does not imply causality, because other confounding factors aside from external monitoring (e.g. differences in labor hiring/firing frictions between SOEs and non-SOEs) might also contribute to the price difference.

To explore the causality and circumvent the confounding factors, we use variations of monitoring strength from both time and spatial dimensions to form difference-in-difference analysis and investigate how strengthened external monitoring can have an impact on SOE performance. In the time dimension, we examine the effect of *The State-owned Assets Supervision and Administration Commission* (SASAC) on SOE performance in China. SASAC was established in 2003 under the leadership of the State Council. It directly enhanced the external monitoring on the management of SOEs nationwide, by a combination of measures such as designating a board of supervisors and imposing more accurate performance evaluation for top executives. In addition, SASAC reinforced legal procedures for punishing corrupt executives of SOEs.[1] Because SASAC only

[1] Gong and Wu (2012) summarize the court cases of corruption that involved government officials and top

affects SOEs but not private firms, it naturally serves as a quasi experiment to identify the impact of improved external monitoring by comparing the performance change of these two types of firms. Consistently, our data shows that (in Figure 1) the profitability of SOEs started to catch up with that of non-SOEs' quickly after the establishment of SASAC, with a substantial jump in 2004. Notably, this shrinking gap was mainly driven by the improved performance of SOEs. In our analysis, we find that SASAC reduced the input prices paid by SOEs by 3.9 percent, closing the gap between SOEs and non-SOEs by about one-half. It also increased the productivity of SOEs by 12.6 percent relative to their private counterparts, closing the gap by about 53 percent. This result not only corroborates the catch-up of SOEs during the data period (Hsieh and Song, 2015), but also further provides channels through which SASAC has an impact—by reducing managerial expropriations and shirking.

To strengthen the causality result further, we explore the spatial variation in monitoring costs and evaluate how it influences SOE performance. Higher costs of external monitoring lead to more managerial expropriation and shirking, which consequently increase input prices and reduce productivity. We proxy monitoring costs by SOEs' physical distance to their oversight government following Huang et al. (forthcoming). Greater distance means higher monitoring costs, and implies weaker monitoring by the oversight government on the firm management. A potential concern is that such proxy may also confound other firm performance drivers, such as agglomeration and localization. Fortunately, non-SOEs are also registered to be affiliated with the government in the same way. The difference is that for non-SOEs, their affiliated government bears no responsibility to monitor their performance. This helps us to identify the effect of distance as a proxy for monitoring costs from its effect as a factor of agglomeration and localization. In our empirical analysis, we find that SOEs at greater distances to their oversight government pay higher input prices and have lower productivity. Because variation of oversight distances implies different monitoring strength, this result provides further evidence on the impact of external monitoring on SOE performance from the spatial dimension.

Interestingly, as a reinforcement for monitoring SOEs, SASAC largely alleviates such negative influence of oversight distance on SOE performance. It reduces the performance gaps in terms of both input prices and productivity between SOEs that are far from their oversight government and those close by. This could arise from the larger potential gains for SOEs farther from their oversight

executives in SOEs from a mainstream media in China, Procuratorial Daily. They found that annual average court cases increased from 235 before (and during) 2003 to 333 after 2003. Given that these types of cases usually involved misconduct years before the trials, the increase reflects an enhanced external monitoring and legal punishment strength after 2003.

government (i.e., weaker monitoring before SASAC), or that SASAC might have implemented higher order of monitoring on SOEs that were farther away. Both reasons contribute to SASAC's heterogeneous impact of external monitoring on the performance of SOEs. When using the TFP measure, estimated using the traditional proxy approach without separating input price heterogeneity from productivity, we find a qualitatively similar result.

Overall, external monitoring, by affecting input prices and productivity, has substantial implications for the aggregate performance of SOE firms as well as the entire manufacturing sector. In our accounting analysis, the monitoring costs due to geographic distance raise aggregate input price by 1.09 percent and reduce the aggregate productivity by 2.61 percent within the group of SOEs. This translates into an increase of 0.16 percent for input prices and a loss of 0.42 percent in productivity for the manufacturing sector. SASAC, as an SOE-exclusive policy, has significantly reduced the aggregate input price by 4.03 percent and increased aggregate productivity by 10.97 percent for SOEs. As a result, the overall aggregate input price for the entire manufacturing sector was reduced by 0.56 percent and aggregate productivity was increased by 1.46 percent.

To secure our results from other potential driving forces, we conduct a wide range of analysis, although the establishment of SASAC was the biggest policy initiative regarding SOEs during the data period. First, privatization and improvement of market competition in the Chinese economy, started earlier and reinforced in the first half of our data period, may drive our results. We rule out the competition hypothesis by explicitly controlling for individual firms' market size in all regressions, and show that the privatization story is unlikely using a subsample excluding privatized firms. Moreover, privatization and the change of market structure were relatively smooth, in contrast to the striking improvement of SOE performance concurrent with the establishment of SASAC. Second, it is still possible that the enhancement of privilege and internal incentive of SOEs that came along with SASAC, if any, improved SOEs' performance. Nonetheless, they alone cannot explain the finding in the spatial dimension that SOEs at greater distances to their oversight government underperform their counterparts close by. Also, the subsidies to SOEs relative to non-SOEs in fact decreased after SASAC, suggesting that government may even have reduced the privileges of SOEs. In addition, the results are robust after controlling for the potential differential trends between SOEs and non-SOEs, using a balanced panel, adopting an alternative definition of SOEs following Hsieh and Song (2015), and controlling for firm fixed effects. Finally, the results are also consistent after controlling for China's access to World Trade Organization (WTO) and firms' trade participation.

Our focus on input prices, through which external monitoring can have an impact in addition to productivity, is motivated by the well-known fact of heavy use of materials in Chinese manufacturing firms. On average, the material expenditure of SOEs is more than five times the wage bill. This implies that a one percent saving in material prices increases profitability more than five times the equivalent saving in labor costs can do, even without considering the substitution between labor and material inputs. While the roles of labor and capital inputs have been widely used to explain the weak performance of SOEs based on value-added production functions (i.e., Tsai, 2004; Firth et al., 2009; Song et al., 2011; Berkowitz et al., forthcoming), the literature has paid much less attention to the role played by material prices, mainly due to the lack of firm-level material input prices. Using a gross production function, this paper complements this literature by showing that ineffective external monitoring is substantially responsible for SOE's inferior performance, by increasing their input prices and reducing productivity. This result has a meaningful implication: the efficiency of SOEs can be improved by strengthening external monitoring, without large-scale worker layoffs or further overhauling the incentive scheme.

This paper contributes to the literature on the performance of SOEs (especially in China), by empirically quantifying the impact of external monitoring from government, which has been largely ignored. The findings echo the literature documenting significant gaps between Chinese state-owned and private manufacturing firms in profitability, TFP, and capital productivity (e.g., Jefferson and Rawski, 1994; Zhang et al., 2001; Xu, 2011; Brandt et al., 2012). Meanwhile, a large literature, emphasizing changes inside firms, attributes the catch-up of Chinese SOEs to privatization and incentivization reforms (i.e., Groves et al., 1994; Li, 1997; Megginson and Netter, 2001; D'Souza et al., 2005; Dong et al., 2006; Estrin et al., 2009; Xu, 2011; Chen et al., 2017). Complementing this literature, our results suggest that strengthening monitoring, from the external of firms, to improve SOE performance can be an effective alternative policy to privatization and incentive schemes. This finding has practical policy implications for SOE reforms, especially in developing countries and industries where state ownership must be maintained due to economic or political reasons.

This study also relates to the literature on the impact of government auditing and enforcement of legal punishment on corruption. Consistent with our results, Di Tella and Schargrodsky (2003) find that an anti-corruption crackdown reduced the prices of public hospitals in Buenos Aires by 15 percent. Olken (2007) finds that increased audit probabilities can substantially reduce corruption in a nationwide infrastructure project in Indonesia. Avis et al. (forthcoming) use Brazil's anti-corruption program to examine the extent to which government audits of federal funds can reduce politician corruption, by enhancing political and judiciary accountability. See Olken and Pande (2012) for a comprehensive review. Different from these studies, our paper shows that strengthened government monitoring and auditing can improve the performance of manufacturing SOEs as well as the aggregate economy, by reducing procurement corruption and shirking.

Finally, this paper also relates to the literature on the impact of monitoring/sanction in corporate governance. Although the corporate governance theory has long recognized the importance of effective monitoring of firm performance,[2] its effect on agent behavior is mixed in the literature. The agency theory in traditional economics suggests that a self-interested agent will work harder and perform less expropriation to reduce the probability of a sanction (Alchian and Demsetz, 1972; Calvo and Wellisz, 1978; Fama and Jensen, 1983; Laffont and Martimort, 2002). In contrast, the "crowding-out" theory in behavior economics predicts that increased monitoring may reduce effort, because the induced distrust violates the norm of reciprocity (Frey, 1993). Overall, the empirical literature, mainly based on experiments, shows mixed evidence (e.g., Nagin et al., 2002; Dickinson and Villeval, 2008). Our paper instead uses a nationwide quasi-natural experiment in Chinese manufacturing industries and finds a strong positive impact of monitoring on firm performance via the channels of input prices and productivity.

The rest of the paper is organized as follows. Section 2 provides the economic background of Chinese SOE reform and external monitoring. Section 3 introduces a stylized model to highlight the impact mechanism of external monitoring on firm material prices and productivity. Section 4 describes the data and estimate the key measures of material prices and productivity via a structural approach, which will be used in the empirical study of firm performance. Section 5 conducts the main empirical study by investigating the role of external monitoring from both time and spatial dimensions. Section 6 discusses alternative explanations of the results with a series of robustness checks. We conclude in Section 7.

[2]This literature emphasizes that opportunistic behavior is intrinsic in human nature. Whenever the expected benefits outweigh the costs, rational managers would use their effective control rights to chase projects that give them private benefits rather than pursuing investors' interests. Some examples include Baumol (1959), Williamson (1964), Marris (1964), Becker (1968), Allingham and Sandmo (1972), Jensen (1986), and Grossman and Hart (1988). Also refer to Shleifer and Vishny (1997) for a review of this literature.

2 Economic Background

2.1 SOE Reform and External Monitoring before SASAC

Chinese SOEs have undergone three phases of reform since 1978. The first phase (1978-1984) focused on management reform, with an attempt to increase economic incentives for SOEs by giving them greater autonomy and allowing them to keep a proportion of their profits. The second phase (1984-1992) was market-orientated, introducing market competition in the economy. The traditional administrative relationship between SOEs and government was replaced by a contractual relationship during this period. The third phase (1993-present) focused on ownership reform via privatization and the introduction of the modern enterprise system. Many SOEs were partially or fully privatized by introducing private investors. Even after years of privatization, however, SOEs still played an important role in the Chinese economy. For example, in 2003 SOEs accounted for 56.0 percent of total assets in manufacturing industries and provided 37.6 percent of manufacturing employment. Overall, after these reforms, the responsibility for output decisions had been shifted from the state to firms (Xu, 2011), and the profit objective of the SOEs and non-SOEs was more aligned than ever. Of course, SOEs and non-SOEs might still face different labor market frictions. We discuss its potential impact and the robustness of our results to it in Section 5.1.

Despite the waves of reform, the problem of external monitoring on SOEs remained. This was fundamentally because SOEs did not have clearly assigned property rights: by constitution they are "owned by all the people" in the country. Each person in the economy only has a tiny share of ownership and this ownership is nominal because individuals cannot claim dividends from SOEs directly. Thus, no one has an incentive to monitor SOEs. Government, as the nominal investor representing all the people, was supposed to supervise and monitor SOEs. But before 2003, the external monitoring by the government was very weak. First, not being the final owners and residual keepers, the government officers in charge did not have a strong incentive to monitor SOEs. Even worse, multiple government departments collectively supervised the same SOEs. They usually shirked responsibility among each other and eventually no one took real responsibility for the losses of SOEs. In addition, China had a relatively low requirement for information disclosure even for listed firms during the data period. As a result, there was serious information asymmetry between firms and the government, which exacerbated the problem due to the large costs of monitoring SOEs, especially in remote areas.

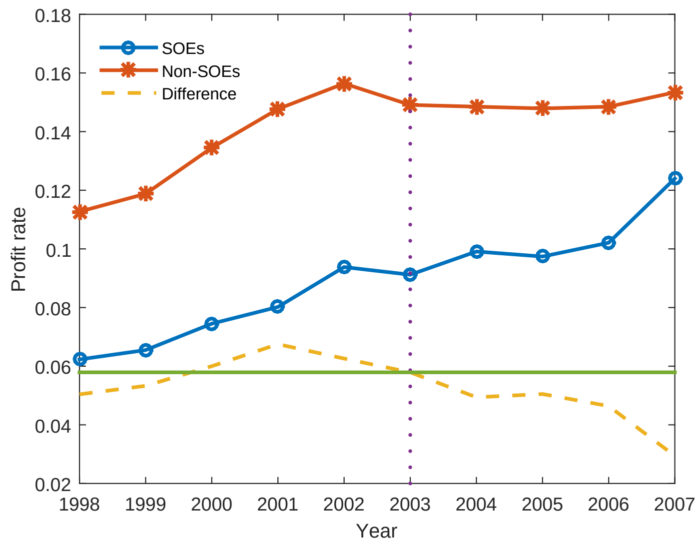
Without effective monitoring, SOE managers almost had the ultimate control over the firm's production and transactions. Such a de facto serious insider control problem in corporate governance facilitates managerial expropriation and shirking. First, corruption or kickbacks were common when SOEs purchased products and services (Cheng, 2004). It was almost a norm that SOE managers took a certain percentage of the transaction price as a kickback from procurement bidders or intermediate material suppliers. Second, it was also common for SOE managers to conduct self-dealing and relational transactions. For example, SOEs managers may purchase intermediate materials from private firms owned by their family members or close business partners/friends who charge prices higher than market prices. In such way, SOE managers can "expropriate" state-owned assets and transfer them to their own pockets. Moreover, facing weak monitoring, SOE mangers might shirk in bargaining for better material prices in the input market. Instead, they had a strong incentive to pursue perquisite consumption, such as daily necessities, cigarettes, luxury wines, liquors, and personal electronics, which were usually recorded illegally as intermediate inputs expenditure.[3] These problems drove up the material input prices paid by SOEs. Similarly, weak external monitoring on SOEs may cause managerial shirking in production directly, or indirectly due to the complementarity between (higher) productivity and (lower) input prices in increasing profits, which drives down productivity. These problems echo the SOEs' underperformance in profitability: the average profit rate of SOEs in the manufacturing industries was consistently about 6 percentage points lower than that of non-SOEs during 1998 to 2003, as shown in Figure 1.

2.2 External Monitoring after SASAC

To strengthen monitoring and management of SOEs, the State Council of China announced the establishment of SASAC in March 2003. Its hierarchy consists of central, provincial, and prefecture-level SASAC offices. The central SASAC was established in March 2003; the provincial and prefecture level SASAC offices were established later. In particular, provincial SASAC offices were completed in all 31 provinces (including autonomous regions and municipalities directly controlled by the central government) by early 2004. Since then, SASAC has become the single powerful government department that takes full responsibility for the performance of SOEs, solving the problem of government shirking of monitoring responsibility before SASAC, when multiple

[3] As a side evidence, take Moutai as an example, which is the number one luxury liquor brand in China and a popular corruption consumption good. After President Xi Jinping launched his Anti-corruption Campaign at the end of 2012, which affected the government and SOEs, the stock price of Moutai dropped over 50 percent in 14 months, from November 2012 to January 2014. During the same period, in contrast, the Shanghai Stock Exchange Composite Index remained almost unchanged.

Figure 1: Average profit rate of SOEs and non-SOEs in Chinese manufacturering industries



Note: The average profit rate is calculated as the revenue-weighted average for a balanced panel of Chinese manufacturing firms during 1998-2007. The pattern is similar for the median profit rate.

government departments together monitored the same SOE. Specifically, each SOE is supervised by one of the SASAC offices, depending on the level of its oversight government: the central SASAC mainly supervises the central SOEs and local SASACs supervise local SOEs.

Upon the establishment of SASAC, the State Council announced a series of policies and regulations on the practice of SASAC nationally, which clarified the roles of SASAC and its measures used to manage SOEs (i.e., *Policies, Laws & Regulations: Decree of the State Council of the People's Republic of China. No. 378* effective in 2003). Table A1 summarizes the main responsibilities and measures that SASAC took to strengthen the supervision and monitoring on SOEs. The main functions of SASAC is to perform investors' responsibilities, supervise SOEs, and monitor state-owned assets. It took several specific and complementary measures to achieve these goals. First, SASAC improved the assessment criteria and index system to ensure the preservation and growth of state-owned assets. Based on this system, SASAC uses statistics and auditing to implement effective monitoring on SOEs. Second, it helps SOEs to establish a modern enterprise system to improve corporate governance. Third, it is responsible for appointing, evaluating, and removing top executives of SOEs based on their performance. Fourth, it dispatches supervisory panels, which report to SASAC directly, to the supervised SOEs to monitor their daily management. Finally, SASAC participates in formulating the operational budgets and final accounts of SOEs. It is also responsible for ensuring that SOEs turn over their capital gains to the state. Overall, these specific measures have together directly strengthened the external monitoring on SOEs.

Noticeably, Figure 1 shows that the gap of average profit rate between SOEs and non-SOEs was significantly narrowed after SASAC. From 2003 to 2004, the gap reduced by about 1 percentage point (from 6 percent to 5 percent), and it continued to shrink to 3 percent in 2007. The narrowing gap was mainly driven by the improved performance of SOEs after 2003.

Several important features of SASAC stand out. First, SASAC only directly affects SOEs. Second, as the single government agency responsible for the management and supervision of SOEs, it took full responsibility for the performance of SOEs. This is in sharp contrast to the situation before 2003, when multiple government departments were responsible for supervising the same SOEs and none actually took the responsibility for the losses of SOEs. Third, SASAC itself is directly led and supervised by the State Council and Central Discipline Inspection Commission. The latter is a special agency supervised by the central government and is responsible for auditing and detecting misbehavior and corruption of government officials and SOE managers. It has a special team residing in SASAC to reduce the possibility of corruption of SASAC itself. These features, together with detailed measures undertaken by SASAC, increased the economic and legal costs of opportunism of SOE managers, and consequently reduced incentives for managerial expropriation and shirking. In sum, SASAC provides a sharp, nationwide quasi-experiment policy change to identify the impact of strengthened monitoring on SOE performance.

2.3 Besides SASAC: A Map of SOE Reforms During the Data Period

Although the establishment of SASAC was the biggest policy initiative regarding SOEs during the data period, it never came alone. First, privatization of SOEs, which started since 1992, was still in effect and it was reinforced in 1996 following the guideline of "grasp large, let go small". Many SOEs were privatized during the data period. Second, in the Fourth Plenary Sessions of 15th Central Committee of the Communist Party in September 1999, the central government formed ten guidelines for SOE reform and development. The guidelines emphasize the integration of privatization, monitoring, market competition, and establishment of modern enterprise system to improve SOE performance. These policies may improve the internal monitoring and incentive due to improved corporate governance, besides external monitoring. Moreover, Chinese government also gradually reduced the barriers for private firms to enter many industries, including those ones in which SOEs have monopoly power, to meet the WTO requirement and increase the viability of Chinese firms after WTO. Overall, these policies were initiated earlier and they progressed relatively smoothly during the data period, in contrast to the striking improvement of SOE performance concurrent with the establishment of SASAC. In Section 6, we discuss the impact of these policies in detail and show that they are unlikely to drive our main results.

3 A Stylized Model of External Monitoring and Firm Performance

We develop a stylized theoretical model to demonstrate the mechanism through which the strength of external monitoring can create a specific type of distortion, by influencing a firm's input prices and productivity. We discuss broader possibilities of distortions and frictions faced by manufacturing firms and their implications to our econometric model in the end of this section.

In the theoretical model, a firm makes two layers of decisions sequentially: first by a top manager and then by a production unit. The top manager chooses her effort levels, which determine input prices and productivity. Then, observing the input prices and productivity, the production unit chooses quantities of labor and material to maximize firm profit. The top manager is self-interested and her choices are made to maximize her own payoff: her share of the firm profit (performance payment)[4] plus the kickback in material procurement, net of the costs of exerting the effort and the expected punishment for taking kickbacks, which depend on the strength of external monitoring. This implies that the manager may not maximize firm profit: when external monitoring is weak, she may find that taking kickback (thus higher input prices) is more profitable for her than exerting a greater level of effort to bargain for better material prices and/or promote productivity. That is, distortions in input prices and productivity may arise from the decisions of the self-interested top managers balancing the trade-off between the performance payment and procurement kickback net of costs, on which the strength of external monitoring can have an impact.

Specifically, the top manager can choose two types of effort: procurement effort (e_M) and productivity effort (e_ω). The procurement effort is the top managers' effort in bargaining for a better (lower) price in the procurement of material inputs, which increases firm profit and thus increases her performance payment. Meanwhile, the top manager may take a kickback in the procurement, as a percentage (x) of the procurement value. If the manager bargains hard (exerting a high level of e_M) for lower input prices, she would get a lower kickback rate. That is, x is a function of e_M and $\partial x/\partial e_M < 0$). The manager may be caught and subject to punishment due to taking a kickback. It is natural to assume that the expected punishment for taking a

[4]This includes the immediate payoff to the manager if the firm performs well, or future payoff in the broader forms of, for example, better career path etc. For easy reference, we simply call it performance payoff.

kickback, $c(x(e_M), \theta)$, increases strictly in external monitoring strength θ and endogenous kickback rate x. At the same time, the productivity effort, e_ω, represents the effort the top manager exerts to improve production efficiency, by way of promoting firm culture or workers' morale. It directly affects the firm productivity. We assume that productivity (ω) increases in e_ω: that is, $\partial\omega/\partial e_\omega > 0$. Both of these efforts incur the usual effort costs: $C_M(e_M)$ for procurement effort and $C_\omega(e_\omega)$ for productivity effort.[5]

Given the effort levels exerted by the top manager (thus p_M and ω), firm profit maximized by the production unit is denoted as $\pi(p_M(e_M), \omega(e_\omega))$, as will be discussed in Eq. (8) in Section 4.2, and the associated expenditure on material input as $E_M(p_M(e_M), \omega(e_\omega))$.[6] The top manager's maximization problem is thus as follows:

$$\max_{\{e_M, e_\omega\}} \Pi(e_M, e_\omega) - C_M(e_M) - C_\omega(e_\omega) - C(e_M, \theta), \tag{1}$$

where the total payoff to the top manager from the performance payment and kickback is written as $\Pi(e_M, e_\omega) \equiv \pi(p_M(e_M), \omega(e_\omega)) + x(e_M)E_M(p_M(e_M), \omega(e_\omega))$,[7] and $C(e_M, \theta) \equiv c(x(e_M), \theta)$ is the expected punishment to the top manager for taking a kickback. We assume $\Pi''_{e_M e_M} < 0$, $\Pi''_{e_\omega e_\omega} < 0$ and $\Pi''_{e_M e_\omega} > 0$. That is, the total payoff function for the top manager has decreasing marginal returns to efforts and the two types of effort are complementary to promote the total payoff. We assume the effort cost functions as well as the corruption punishment function are convex with respective to the exerted effort: $C''_M > 0$, $C''_\omega > 0$, and $C''_{e_M e_M} > 0$. Importantly, we further assume $C''_{\theta e_M} < 0$. This is reasonable, because when external monitoring is stronger (i.e., larger θ), the marginal expected punishment is larger for lower e_M (thus higher corruption level x). Under these assumptions, we have the following proposition:

Proposition 1 (Impact of External Monitoring) *Stronger external monitoring increases both material procurement and productivity efforts, resulting in lower material input prices and higher productivity.*

The proof is detailed in Appendix A,[8] and the intuition is straightforward. Stronger external

[5] To illustrate the idea, we assume that external monitoring incurs punishment only on procurement corruption, but not on shirking in productivity effort. This assumption is reasonable for two reasons. First, in practice it is much more difficult to detect and punish productivity shirking than procurement corruption. Second, the simplified model yields the same qualitative prediction on the impact of external monitoring on input prices and productivity, compared with the augmented model, by also allowing for punishment for productivity shirking.

[6] To highlight the impact of external monitoring, we ignore other determinants of profit for now.

[7] To simplify the notation, we normalize the profit and cost functions by the profit share parameter in the performance payment to the top manager, so that firm profit share to the top manager now is 1 after normalization.

[8] To fix this idea, we focus on interior solution under regularity conditions, and assume all functions are differentiable up to second order whenever necessary.

monitoring increases the expected punishment to corruption, which incentivizes the top manager to reduce procurement corruption (i.e., by increasing procurement effort). Although the external monitoring does not have a *direct* impact on productivity effort, it has an *indirect* impact: the complementarity between procurement and productivity efforts incentivizes the manager to increase productivity effort, as a response to the increased procurement effort induced by stronger external monitoring. As a result, both efforts are higher when external monitoring is stronger, and consequently, the firm pays lower material prices and has higher productivity.

Three predictions directly follow from Proposition 1. First, because SOEs faces lower external monitoring than non-SOEs, Proposition 1 implies that SOEs pay higher input prices and have lower productivity:

Conjecture 1 (SOE vs. non-SOE) *SOEs pay higher input price and have lower productivity compared with non-SOEs, other things being equal.*

Second, the establishment of SASAC directly improved the external monitoring on SOEs (but not on private firms), so we expect that SASAC has a positive impact on SOE performance in terms of productivity and input prices, relative to non-SOEs:

Conjecture 2 (SASAC Effect) *The establishment of SASAC reduced material input prices and increased productivity of SOEs, other things being equal.*

Moreover, if external monitoring does have an impact on SOE performance, then higher monitoring costs, which increase the difficulty of monitoring and thus reduce monitoring strength, serve as a barrier for SOE performance:

Conjecture 3 (Monitoring Costs and SOE Performance) *Higher monitoring costs reduce SOE performance, through the input prices and productivity channels, other things being equal.*

Discussion. This stylized theoretical model is one of possible ways to characterize the mechanism through which the strength of external monitoring can create distortions in individual firm's input prices and productivity. We emphasize that, conditional on input prices and productivity, the *production unit* of the firm makes optimal production decisions. However, *at the firm level*, such conditional-optimal decisions may not be optimal generally, due to the distortions in input prices and productivity within the firm and frictions in the market.

Bearing this spirit, our econometric model in Section 4.2 allows for potential distortions in capital, productivity, input prices, and wage rates across firms. This feature is important for the purpose of this study, because SOEs and non-SOEs (or even firms within each group generally) may differ substantially in their capital stock, productivity, and ability/incentive to secure better input prices. For example, SOEs may have better access to the financial market, leading to lower capital costs of SOEs relative to non-SOEs; some firms (SOEs or non-SOEs) may pay higher wage rates than other firms due to different reasons; firms facing different external monitoring strength, as the main focus discussed in this section, may differ substantially in their input prices and productivity. We further discuss the detailed advantages of our econometric approach in the beginning of Section 4.2 and show that its limitations are unlikely to affect our analysis in the end of Section 5.1.

In the rest of the paper, we test the above three conjectures in the context of Chinese manufacturing industries. The empirical results show that stronger external monitoring can improve firm performance in terms of productivity and material prices, lending support to the effectiveness of external monitoring on reducing managerial expropriations and shirking.

4 Data and Estimation

4.1 Data and Summary Statistics

The data used in the analysis is drawn from the Chinese Annual Surveys of Industrial Production, which are collected annually by the National Bureau of Statistics in China. The data cover non-state-owned firms with annual sales above five million RMB (or equivalently about US$600,000) and *all* state-owned firms during 1998-2007. The surveys record detailed firm-level information on total sales, number of workers, wage expenditure, material expenditure, book value of capital stock, and so forth. But the data do not provide information on material prices or quantities. In total, the dataset contains 326,294 firms across 19 major two-digit Standard Industrial Classification (SIC) manufacturing industries.

Following Huang et al. (forthcoming) and many others, we define a firm as an SOE if it has a share of state ownership over 30 percent.[9] This definition yields 35,551 SOEs. We call the other firms non-SOEs, as they essentially consist of firms whose main ownership is individual, corporate, foreign, or collective. As several papers have noted (.e.g, Hsieh and Song, 2015; Chen et al., 2017; Berkowitz et al., forthcoming), many SOEs were privatized in the data period. Although privatization may improve monitoring in general, it also involves radical changes of the firm in many other aspects (such as internal restructuring and incentivization), which cannot be identified

[9] Alternatively, one could define SOEs using a different cutoff point, or using the firm's registration ownership type. We show in Section 7 that the results are robust to alternative definitions of SOEs.

from the change in monitoring from the available data. Thus, in this paper, we do not explore the impact of privatization; instead we show in Section 6 that our results on the causality between external monitoring and firm performance are robust to a subsample that excludes these privatized firms.

Table 1: Summary statistics of Chinese manufacturing industries

Statistics	SOEs	Non-SOEs
Total Sales (Median)	1.642	2.143
Material Expenditure (Median)	1.217	1.664
Capital Stock (Median)	1.315	0.439
Wage Expenditure (Median)	0.211	0.145
Material Share over Total Variable Cost (Median)	0.795	0.903
Number of Firms	35,551	290,743

[1] All monetary values in this table are in millions of 2000 U.S. dollars.

[2] Total Variable Cost uses a 5% interest rate as cost for capital.

Several important facts emerge in summary statistics Table 1. First, compared with non-SOEs, SOEs are significantly larger in capital stock and number of workers. SOEs possess three times the capital stock and almost twice the work force as non-SOEs do on average. Given that larger firms usually have greater market power in the input and output markets, these findings suggest that controlling firm size is necessary for comparing the two groups. Second, materials expenditure accounts for a substantial share of total variable cost. This feature is shared by both types of firms. In particular, the material expenditure of SOEs is more than five times their costs for labor. As a result, our focus on the impact of external monitoring through the material price channel is of particular importance: saving of one percentage point in the material price increases profitability more than saving of five percentage points in labor does, even without considering substitution between labor and material. Previous literature focuses on the role of labor input in explaining the weak performance of SOEs (e.g., Bai et al., 2006; Berkowitz et al., forthcoming). In contrast, we study how the inferior performance of SOEs can be attributed to the lack of effective external monitoring, which results in higher material input prices, presumably due to managerial expropriation and shirking.

4.2 An Empirical Structural Model

Our dataset, like many other production survey datasets, does not include firm-level material prices. This places a challenge in the estimation of productivity as a well-recognized measure of firm performance: production function estimation (thus the measure of productivity) is biased if the heterogeneity of unobserved input prices is correlated with inputs choice and is ignored (Grieco et al., 2016; De Loecker et al., 2016; Brandt et al., 2017). To address this issue, we estimate firm-level measures of input prices and productivity using the production function estimation approach initially developed in Grieco et al. (2016) and extended in Grieco et al. (2017). Grieco et al. (2016) provide a method to estimate production functions consistently in the absence of material price data. Grieco et al. (2017) recognize quality as an important component of material prices and control for quality when estimating material input prices and productivity measures. Obtaining such a quality-adjusted measure is important to our analysis: to identify the effects of external monitoring, a fair comparison of firm input prices should consider firms' fundamental ability to access lower prices conditional on their choices of input quality. Overall, the feature of this approach is that it separates firm heterogeneity in input prices from productivity, while allowing for capital markets distortions/mis-allocations, difference in firm productivity management, and corruptions in input procurement. This is crucial in the performance comparison across firms (especially between SOEs and non-SOEs). In this section, we describe the approach to estimate these key measures.

4.2.1 Setup

In an industry, each firm j at period t produces output (Q_{jt}), which is of some output quality Φ_{jt}. The output quality can depend on the firms' intrinsic ability and their choice of input quality. We assume that goods of higher quality boost demand and so quality-inclusive output is $\tilde{Q}_{jt} = \Phi_{jt}Q_{jt}$.[10] Firms are monopolistically competitive and face a constant elasticity of substitution (CES) demand function:

$$P_{jt} = (\Phi_{jt}Q_{jt})^{1/\eta} = \left(\tilde{Q}_{jt}\right)^{1/\eta}, \tag{2}$$

where P_{jt} is the output price and η is the demand elasticity. The quality-inclusive output is produced using a gross CES production function using labor (L_{jt}), intermediate material inputs (M_{jt}), and capital (K_{jt}) as inputs:

$$\tilde{Q}_{jt} = \tilde{\Omega}_{jt}F(L_{jt}, M_{jt}, K_{jt}) = \tilde{\Omega}_{jt}\left[\alpha_L L_{jt}^{\gamma} + \alpha_M M_{jt}^{\gamma} + \alpha_K K_{jt}^{\gamma}\right]^{\frac{1}{\gamma}}, \tag{3}$$

[10] We use a ˜ to denote variables that are quality-inclusive throughout this paper.

where $\alpha_L, \alpha_M, \alpha_K$ are the distribution parameters, which sum up to one by normalization.[11] The elasticity of substitution among inputs (σ) is determined by γ, where $\gamma = \frac{\sigma-1}{\sigma}$. Since we observe output revenue but not the output quantity or prices in our data, we emphasize that we can only recover revenue-based productivity. Specifically, the Hicks-neutral $\tilde{\Omega}$ captures the combination of output-productivity and output-quality heterogeneity at the firm level.

Our goal is to estimate measures of input prices and productivity that are comparable across firms. This amounts to separating the impact of input price and quality dispersion from other potential sources of productivity differences across firms. This approach acknowledges the findings of Kugler and Verhoogen (2009, 2012) and others, which show that higher productivity firms tend to use higher quality inputs. De Loecker et al. (2016) posit the same relationship between productivity, input quality, and output quality to motivate the use of output prices as proxies for input prices. In light of this, we assume that $\tilde{\Omega}_{jt}$ is a function of the firms' underlying productivity, Ω_{jt} and its endogenous choice of input quality, H_{jt}. We follow Grieco et al. (2017) to adopt a functional form that allows productivity and input quality to be either substitutes or complements:

$$\tilde{\Omega}_{jt} = \left[\Omega_{jt}^{\theta} + H_{jt}^{\theta}\right]^{\frac{1}{\theta}}, \theta \neq 0. \tag{4}$$

The elasticity of substitution between productivity and input quality is measured as $\frac{1}{1-\theta}$: if $\theta < 0$, then productivity and input quality are gross complements of each other. Over time, productivity $\omega_{jt} \equiv \ln \Omega_{jt}$ evolves according to an AR(1) process:

$$\omega_{jt+1} = f_0 + f_{soe} SOE_{jt} + f_{SASAC} SASAC_t + f_1 \omega_{jt} + \epsilon_{jt+1}^{\omega}, \tag{5}$$

where ϵ_{jt+1}^{ω} is an i.i.d. shock to firm productivity. SOE_{jt} is a dummy indicating whether the firm is an SOE or not, and similarly $SASAC_t$ is a dummy indicating the SASAC is established or not. By including these two dummies in the evolution processes, in the spirit of Chen et al. (2017), we allow for different steady states for SOEs and non-SOEs as well as before and after SASAC.[12]

The variation in the unit price of physical material inputs across firms reflects two sources of

[11] We normalize the CES production function according to the geometric mean. Specifically, the inputs (labor, material, and capital) are normalized by their corresponding geometric mean, $\sqrt[n]{\Pi X_{jt}}$. The implication is that the geometric means of input variables (L_{jt}, M_{jt}, K_{jt}) in (3) are $\overline{L} = \overline{M} = \overline{K} = 1$. A branch of the literature has analyzed the importance and the method of normalization (de La Grandville, 1989; Klump and de La Grandville, 2000; Klump and Preissler, 2000; de La Grandville and Solow, 2006; León-Ledesma et al., 2010). Refer to Grieco et al. (2016) for more details.

[12] We also tested an unreported specification where all firms have a common evolution process for productivity and input prices, before and after SASAC. The main results on the impact of external monitoring are quantitatively and qualitatively similar to the main results.

heterogeneity: vertically differentiated input quality due to the firm's choice of H_{jt}, and a quality-adjusted materials price faced by the firm (denoted P_{Mjt}). As a result, even if firms were using the same quality of materials, the unit prices they would face may still differ. We follow Grieco et al. (2017) to capture this feature in a simple form:[13]

$$\tilde{P}_{Mjt} = P_{Mjt} H_{jt}. \tag{6}$$

We call $\tilde{P}_{Mjt}$ the quality-inclusive unit prices.[14] We denote $p_{Mjt} = \ln P_{Mjt}$ and assume that it evolves according to an AR(1) process:

$$p_{Mjt+1} = g_0 + g_{soe} SOE_{jt} + g_{SASAC} SASAC_t + g_1 p_{Mjt} + \epsilon^p_{jt+1}, \tag{7}$$

where ϵ^p_{jt+1} is an i.i.d. shock to input prices. This specification allows for different steady states of input prices for SOEs and non-SOEs, which also differ before and after SASAC.

We allow P_{Mjt} to differ across firms for a wide range of possibilities, such as firm characteristics (i.e., size, location, and ownership), non-optimality, frictions, and distortions. In particular, as the focus on the paper, SOEs, on the one hand, may have privileges over non-SOEs (and thus, face lower input prices) because of their larger bargaining power, connections to the local/central government, and/or access to other SOEs in upstream industries. On the other hand, ineffective external monitoring on SOE management may increases shirking or even corruption in input procurement, which may increase the input prices SOEs pay, as illustrated in Section 3. Our methodology of recovering P_{Mjt} does not impose a priori assumptions on whether SOEs face lower or higher quality-adjusted input prices (P_{Mjt}) compared with non-SOEs. In addition, even if SOEs' quality-adjusted prices are higher than those faced by non-SOEs, it is not necessarily true that SOEs' quality-inclusive prices ($\tilde{P}_{Mjt}$) are higher. For example, if SOEs tend to have lower productivity, they may find it optimal to choose lower quality inputs and hence, $\tilde{P}_{Mjt}$, the quality-inclusive unit input prices may be lower for SOEs compared with non-SOEs. For this reason, it is the quality-adjusted price P_{Mjt} that serves as a key measure of firms' ability to secure better material prices in the comparison between SOEs and non-SOEs.

[13] Grieco et al. (2017) consider a more general form, $\tilde{P}_{Mjt} = P_{Mjt} H^{\phi}_{jt}$, where the parameter ϕ captures the price effect of input quality and is flexibly estimated. The estimation results shows that ϕ is very close to one using the same data. So in this paper, we fix the price menu to be linear in H_{jt} for simplicity.

[14] $\tilde{P}_{Mjt}$ does not rely on the quantity purchased, M_{jt}. This implies that the material expenditure, E_{Mjt}, is the product of the unit price ($\tilde{P}_{Mjt}$) and the quantity purchased (M_{jt}). However, this does not exclude the possibility that larger firms face lower unit prices ($\tilde{P}_{Mjt}$). For example, a larger firm with bargaining power (say, bulk purchase) may face lower quality-adjusted prices (P_{Mjt}) than of a smaller firm, so if they chose the same quality of input, then the unit price of the larger firm would be lower.

After observing its capital stock, productivity, quality-adjusted input prices, and wage rate (P_{Ljt}), each firm maximizes its profit by choosing labor quantity, quantity and quality of material inputs, and output:

$$\pi(P_{Mjt}, \omega_{jt}, K_{jt}, P_{Ljt}) = \max_{L_{jt}, M_{jt}, \tilde{Q}_{jt}, H_{jt}} \quad P_{jt}\tilde{Q}_{jt} - \tilde{P}_{Mjt}M_{jt} - P_{L_{jt}}L_{jt}, \qquad \text{subject to:} \quad (2),\ (3) \text{ and } (6). \tag{8}$$

4.2.2 Estimation Method

We estimate the model to recover the quality-adjusted material prices (p_{Mjt}) and productivity (ω_{jt}) following the methodology developed by Grieco et al. (2016, 2017) with a two-step procedure. In the first step, we use firms' optimization conditions on labor and material quantity choices together with data on wages and material expenditures to infer quality-inclusive input prices and productivity, following Grieco et al. (2016). In the second step, we further use the condition associated with firms' optimal material quality choice to purge the quality from the recovered quality-inclusive input prices and productivity, following Grieco et al. (2017). To save space, we present the detailed implementation in Appendix B, while we stress the required assumptions as well as the advantages of this approach as follows.

The methodology requires that the *production unit* of each firm chooses labor and material quantity to maximize profit, given firm productivity, input prices, and capital, as discussed in Section 3. Similar assumptions are commonly employed in a broad set of applications in related literature (e.g., Katayama et al., 2009; Epple et al., 2010; Gandhi et al., 2016; De Loecker, 2011; De Loecker and Warzynski, 2012; Santos, 2012; Zhang, 2016; Doraszelski and Jaumandreu, 2013).[15] While flexible material choice is well accepted, the assumption of flexible labor choice is more controversial, especially in the United States and European countries with strong labor unions and high hiring/firing costs. In China, however, this is not an unrealistic assumption for several reasons. First, generally there is a lack of effectively-enforced laws and regulations to protect workers in China. This was especially true during the period (1998-2007) under consideration. An initial labor law, effective January 1995 (ended by the end of 2007) contained vague provisions

[15] Specifically, Gandhi et al. (2016) use the transformed first-order conditions of the firm's profit maximization problem to estimate the elasticity of substitution; Doraszelski and Jaumandreu (2013) use the first-order conditions of labor and material choices to recover unobserved productivity; Katayama et al. (2009) use the first-order conditions for profit maximization to construct a welfare-based firm performance measure; Epple et al. (2010) develop a procedure using the first-order condition of the indirect profit function to estimate the housing supply function; and De Loecker (2011) and De Loecker and Warzynski (2012) also use the first-order condition of labor choice and/or material choice of profit maximization to estimate firm-level markup.

for the protection of workers, but released enterprises from the original restrictions and served to promote business freedom. As a result, the labor market in China is significantly less restrictive than the United States and European economies.[16] Second, the labor market in China is very competitive due to the high volume of labor supply, which favors firms. Third, labor unions in China are very weak, and in most cases they are controlled by firms rather than workers. These factors together result in much lower hiring and firing costs and labor is much more flexible in China than in United States and European countries where labor protection laws, regulations, and unions are much stronger. Even for SOEs, after waves of incremental reforms and restructuring from the late 1970s to the mid-1990s, the responsibility for output decisions was shifted from the state to firms, and firms were allowed to retain more of their profits (e.g., Groves et al., 1994; Li, 1997; Xu, 2011). As a result, the profit objectives of SOEs and non-SOEs have been more aligned than ever. So we assume that the production units of both SOEs and non-SOEs optimally choose labor and material inputs, given their possibly distorted productivity, capital, and input prices. In Section 5.1, we discuss the potential impact of different labor market frictions between SOEs and non-SOEs, if any, and the robustness of our results to it.

Moreover, it is critical to note that this methodology does allow for many other types of non-optimal decisions as well as various types of distortion and resource misallocation across firms. First, it allows for distorted input prices faced by individual firms caused by managers' corruption and self-dealing in the procurement process, as shown in the theoretical analysis, as well as other forms of market friction or market power (e.g., geographic location, transportation costs, and firm size). For example, firms in remote areas may pay higher input prices due to transportation costs or localized input markets; larger firms may be more capable of negotiating for lower input prices. Second, the methodology also allows for productivity heterogeneity driven by many factors, including difference in external monitoring strength. For example, weak external monitoring may result in lower productivity, because it may increase shirking directly, or indirectly due to the complementarity between (higher) productivity and (lower) input prices in increasing profits, as discussed in the model in Section 3. Finally, this methodology accommodates many types of distortion and misallocation among firms. For example, supported by government, SOEs usually have priority to access more advanced equipment and technology, which potentially increase their productivity. Meanwhile, they might also over-invest in capital compared with non-SOEs, because SOEs have better access to financial resources, which results capital misallocation among firms.

[16] Using scores of different countries on the Employment Protection legislation indicator developed by the OECD to gauge the strictness of labor laws, Allard and Garot (2010) show that during 1994 to 2007 the labor market in China was fairly deregulated: it was significantly less restrictive than the United State and protective European economies.

Allowing for these features is especially important for this study, to ensure our key result is not driven by different distortions and misallocation between SOEs and non-SOEs.

4.3 Estimation Results

We estimate the model industry by industry. The results are reported in Tables A2 and A3. In each table, the top panel reports the parameters in the production and demand functions. The estimates suggest consistent results across all industries. In particular, the output elasticity of material inputs, $\hat{\alpha}_M$, is significantly larger than $\hat{\alpha}_L$ and $\hat{\alpha}_K$. This is consistent with the common observation of large material expenditure shares in production in Chinese industries. We find that the elasticity of substitution among capital, labor, and material is significantly greater than one, ranging from 1.2 to 2.7 among all industries. This finding is somewhat surprising, because the elasticity estimate is usually below one when using data from developed countries without controlling for the heterogeneity of input prices. However, this result corroborates Berkowitz et al. (forthcoming), who estimate an average elasticity of substitution among industries at 1.4 using the same data but a different estimation method. It is also consistent with Grieco et al. (2016), who use the same method but different data from a Colombian plant-level survey of a variety of industries.

The bottom panels in Tables A2 and A3 contain the estimates of the parameters in (4) and Markov processes of productivity and input prices. Overall, the results suggest the elasticities of substitution (i.e., $\frac{1}{1-\theta}$) between productivity and input quality are well below one: they range from 0.167 in the agricultural products industry, to 0.567 in the rubber industry. The results imply that productivity and input quality are complements. Therefore, firms with higher productivity will endogenously choose to use inputs of higher quality. Given that the unit input price is increasing in quality, the complementarity suggests that firms with higher productivity are associated with higher unit input prices. This corroborates the finding of positive correlation between firm productivity and input prices in Kugler and Verhoogen (2012), and it is also consistent with the estimate in Grieco et al. (2017) using a four-digit SIC Chinese industry.

The estimation results show that firms of different ownership have different evolution processes of productivity and input prices, and the evolution differs before and after SASAC. This finding is captured by the significant coefficients on the SOE and SASAC dummies in both regressions. We also find strong persistency in productivity and input prices, as reported in Tables A2 and A3. The persistence parameters for productivity range from 0.555 to 0.961 across industries. This is within the order of persistence documented in the literature, including Foster et al. (2008) and Ábrahám and White (2006), which document that the one-year-lag productivity persistence coefficient is between 0.6 to 0.8. Across industries, the persistence parameters of input prices are well above 0.9. They are close to the estimate of Grieco et al. (2017) using the same methodology, but higher than that found in Atalay (2014) where firm-level input prices and quantities are observed. This difference may be due to the input price measures in Atalay (2014) containing input quality, which is likely to be more volatile because it is an endogenous firm choice. In contrast, our price measure p_{Mjt} is quality-adjusted and its variation captures firm characteristics (other than input quality) such as geographic location, firm size, and ownership status, which are usually very persistent.

The distributions of productivity and quality-adjusted prices also present reasonable properties. The inter-quantile range of productivity ω is between 0.716 and 1.134 across industries. It is close to the results in Hsieh and Klenow (2009) using data from China and India, as well as Syverson (2004) using four-digit SIC industries in U.S. manufacturing sectors. The dispersion of the quality-adjusted input prices, p_{Mjt}, is much smaller. The inter-quantile range is between 0.159 and 0.374. However, the dispersion is still large economically. For example, an inter-quantile range of 0.159 implies that the input price (given the level of input quality) paid by the 75th percentile firm in the distribution is about 17.2 percent ($e^{0.159} - 1 \approx 0.172$) higher than that paid by the 25th percentile firm.

5 The Effect of External Monitoring

The central question of this paper is: how does external monitoring from government on firm management affect the performance of SOEs in China? We use three measures of firm performance to answer this question: conventional TFP, and our preferred measures of input prices and productivity. The conventional revenue-based TFP is estimated following Levinsohn and Petrin (2003), and it generically measures the profitability of firms echoing Figure 1. The separate accounts of input prices and productivity from our preferred method provide evidence on the channels through which external monitoring can have an impact. To proceed, we first compare the performance of SOEs to non-SOEs in terms of productivity and input prices. Then, we test the causal relationship between external monitoring and SOEs' performance, using the variation in monitoring strength in both the time and spatial dimensions. Specifically, in the time dimension, we use the establishment of SASAC in 2003 as a quasi-experimental change in the strength of external monitoring on SOEs. In the spatial dimension, we examine the role of monitoring costs, as proxied by the distance of SOEs to their oversight government, in determining firm performance.

5.1 SOEs vs. Non-SOEs

As discussed in Section 2, Chinese SOEs faced ineffective external monitoring on their management compared with non-SOEs, mainly due to SOEs' unclear property rights and weak legal enforcement. As a result, we predict that SOEs face higher material input prices and have lower productivity compared with their non-SOE counterparts, other things being equal, as summarized in Conjecture 1. To test this conjecture, we estimate the following equation:

$$Y_{jt} = \beta_0 + \beta_{soe} SOE_{jt} + \beta_z Z_{jt} + \lambda_{ind} + \lambda_{prov} + \lambda_t + \varepsilon_{jt}, \quad (9)$$

where Y_{jt} is the outcome variable for firm j in year t. We consider three outcome variables. The first two are input prices (p_{Mjt}) and productivity (ω_{jt}) recovered from our preferred approach, which explicitly separates input price heterogeneity from productivity. The third outcome variable, as a safeguard for comparison, is the traditional TFP measure estimated following the method of Levinsohn and Petrin (2003) using deflated material expenditure as a proxy for material quantity (thus, ignoring the potential firm heterogeneity in input prices). The parameter of interest is β_{soe}, which is the coefficient on the dummy variable SOE_{jt}. SOE_{jt} equals 1 if and only if the firm has state ownership greater than 30 percent. So β_{soe} measures the difference in the outcome variables between SOEs and non-SOEs. Z_{jt} contains a series of firm characteristics, such as firm age and size (capital stock). It also contains measures of firm technology characteristics, including a lagged research and development (R&D) investment dummy and capital intensity. In addition, we control for industry fixed effects (λ_{ind}), province fixed effects (λ_{prov}), and time fixed effects (λ_t) to capture cross-section differences and common time trends. The error term ε_{jt} is an i.i.d. shock.

Table 2: Performance Comparison of SOEs and Private Firms

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.067***	0.064***	-0.226***	-0.199***	-0.170***	-0.161***
	(0.001)	(0.001)	(0.004)	(0.003)	(0.002)	(0.002)
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity		YES		YES		YES
Observations	1196053	873414	1196053	873414	1196053	873414
Adjusted R^2	0.943	0.967	0.928	0.966	0.685	0.725

Standard errors (clustered at the firm level) are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

The estimation results confirm the conjecture. SOEs pay input prices that are 6.4 percent higher on average compared with their non-SOE counterparts after controlling for observable differences such as size, industry, and location, as reported in the full-fledged specification of column (2) in Table 2. Because material inputs account for over 80 percent of the total variable cost, the impact of such input price difference is quite significant—it translates to a difference of about 5.1 percent in profit rate. At the same time, SOEs' productivity is substantially lower than that of non-SOEs on average: as reflected in column (4), the productivity gap between the two groups is 19.9 percent.

Two opposite forces drive the results. On the one hand, SOEs' stronger bargaining power, access to discounted material prices due to their large size, and connections to the government/upsteam SOEs may enable them to access lower input prices. Advanced technologies and newer capital vintage may also improve the productivity of SOEs. However, on the other hand, with weak external monitoring, SOE managers may shirk in negotiating better prices, take kickbacks, and be involved in relational transactions and self-dealing, all of which may drive up the input prices SOEs pay. And shirking in production management may impair production efficiency and lead to low productivity. The results show that the latter force dominates.

Using the traditional TFP as the measure of firm performance, as a comparison, we find qualitatively similar results: SOEs on average underperform non-SOEs. In column (6), SOEs' TFP is about 16.1 percent lower than that of non-SOEs, which corroborates the literature that documents the productivity gap between the two groups (e.g., Jefferson and Rawski, 1994; Xu, 2011; Brandt et al., 2012; Hsieh and Song, 2015). This finding is also consistent with the results based on our preferred measure of productivity. The difference in TFP implies that our preferred productivity measure ω_{jt} indeed captures the key efficiency concept that has been studied in the literature. More importantly, the results using ω_{jt} as the performance measure reflect that the productivity gap still exists even after the input price heterogeneity is controlled.

Discussion. The results show the weak performance of SOEs in terms of both input prices and productivity. However, this association does not imply causality, because other factors aside from external monitoring (e.g. differences in labor hiring/firing frictions between SOEs and non-SOEs) might also contribute to the price difference.

To explore the causality, in the remainder of this section, we examine how the changing intensity of external monitoring due to the establishment of SASAC and differential monitoring costs can affect SOE performance. Specifically, in the time dimension, we examine the effect of *The State-*

owned Assets Supervision and Administration Commission (SASAC) on SOE performance relative to non-SOEs. In the spatial dimension, we explore the cross-sectional variation in monitoring costs and evaluate how it influences SOE performance. Such strategy is based on the idea of difference-in-difference approach.

Note that the difference-in-difference analysis is unlikely to be influenced by the aforementioned factors that may confound the comparison between SOEs and non-SOEs. This is due to three reasons. First, if there are differential hiring and firing frictions between SOEs and non-SOEs, our difference-in-difference estimator for the effect of SASAC is still valid, as long as such frictions do not change over time. Indeed, it is usually very difficult to change the hiring and firing frictions in a short term, given the stickiness of institutions and labor unions in an economy. Second, even there were a relative change of labor frictions over time, it would be relatively smooth and could not explain the sudden improvement of SOEs relative to non-SOEs after 2003, as shown later in Figure 5. In fact, as pointed out by Cooper et al. (2017), there was no obvious change of the law regarding labor protection in China during the data period.[17] Third, if external monitoring does not matter and the results were purely driven by other confounding factors, then monitoring-strengthening policy (SASAC) should not have differential effect on SOEs of different monitoring costs. But we find substantial differential effect, as will be reported in Section 5.3, suggesting that external monitoring does play a role in determining firm performance. We now turn to the investigation of the causality in the time dimension and the spatial dimension.

5.2 SASAC and SOE Performance: Time Dimension Evidence

This subsection investigates the impact of the establishment of SASAC as a nationwide quasi-experimental policy shock on SOE performance. Because SASAC strengthened the external monitoring on SOEs but not non-SOEs, the differential responses of these two types of firms after SASAC help us identify the impact of monitoring from the time dimension.

5.2.1 SASAC and Patterns of Key Measures

We present the distribution of input prices, productivity, and TFP to visualize the potential impact of SASAC on firm performance, without controlling for other firm characteristics. Because our

[17] An initial labor law, applicable to both SOEs and non-SOEs, was effective January 1995 and ended by the end of 2007 in China. It contained vague provisions for the protection of workers, but released enterprises from the original restrictions and served to promote business freedom.

estimation approach implicitly assumes different normalization points for productivity and input price measures for each industry,[18] *direct* cross-sectional comparison among industries is invalid without controlling for industry fixed effects.[19] Thus, we focus on contrasting the *changes* in the distributions before and after the establishment of SASAC, separately for SOEs and non-SOEs.

In Figure 2, we contrast the distribution of input prices (p_{Mjt}) before and after SASAC, separately for SOEs and non-SOEs.While the input price distribution remains almost unchanged for non-SOEs before and after SASAC, we observe a large drop for SOEs after SASAC. This is consistent with the conjecture that the strengthened external monitoring on SOEs from SASAC (but not on non-SOEs) may have reduced shirking in bargaining for better input prices and/or managerial expropriation in material procurement for SOEs only. Figure 3 shows that productivity improved substantially for both SOEs and non-SOEs after SASAC. The improvement may have been caused by multiple reasons, such as a growing trend of technology and implementation of policies (e.g., SASAC). However, the growth for SOEs is larger than that of non-SOEs. When using TFP as a performance measure, as shown in Figure 4, we observe a similar pattern: the distribution of TFP shifted to the right substantially after SASAC for SOEs, but only slightly for non-SOEs. Overall, the evidence suggests that SASAC may have an impact on SOEs performance.

Of course, entry/exit, privatization of SOEs, and different growth trends of SOEs and non-SOEs may also contribute to these patterns. To show that the patterns are robust to these alternative potential drivers, we zoom in our comparison into a balanced sample after dropping entrants, exiters and privatized SOEs during the data period. The results are reported in Figure 5. We present the evolution of average input prices, productivity, and TFP over the data period for SOEs and non-SOEs separately, as well as their differences.[20] Although the performance of SOEs was relatively weaker before 2003 in all three measures, the gaps relative to non-SOEs narrowed immediately after the establishment of SASAC and afterwards remained at a similar level. From 2003 to 2004, the gap reduced by 2.9, 9.6, and 10.1 percentage points, respectively, for input prices, productivity, and TFP.[21] More interestingly, the closing of the gaps was almost entirely

[18]As shown in footnote 11, we normalize the inputs (labor, material, and capital) of the CES production function using their industry-level geometric means. The consequence is that the different normalization points enter the recovered productivity and input prices additively (in logarithm), by changing their location (but not dispersion). For this reason (and to take away the industry difference), we normalize the input prices, productivity and TFP measures of individual firms by their corresponding industry means in Figure 2, 3 and 4.

[19]For example, consider an extreme case where industry 1 consists of SOEs only and industry 2 consists of non-SOEs only. Suppose the actual productivity distributions of the two groups are identical, but the mean productivity in industry 1 is normalized to be zero while the mean productivity in industry 2 is normalized to be one. This directly implies the productivity of non-SOEs is higher than that of SOEs, although the truth is that they are identical. However, the comparison over time is feasible because the normalization is the same over time.

[20]The documented patterns are robust when we use medians or levels (rather than logarithm) of the key measures.

[21]Although the balanced panel shows that SOEs outperformed non-SOEs after 2004 in all three key measures on

Figure 2: Distributions of p_M before and after SASAC, by group

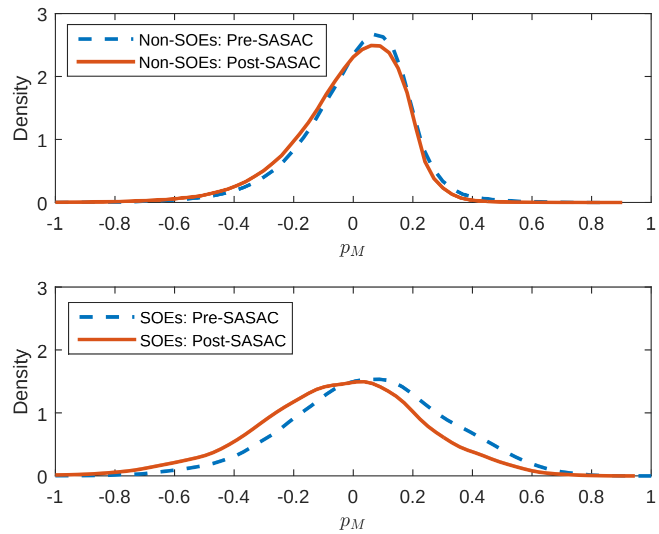


Figure 3: Distributions of ω before and after SASAC, by group

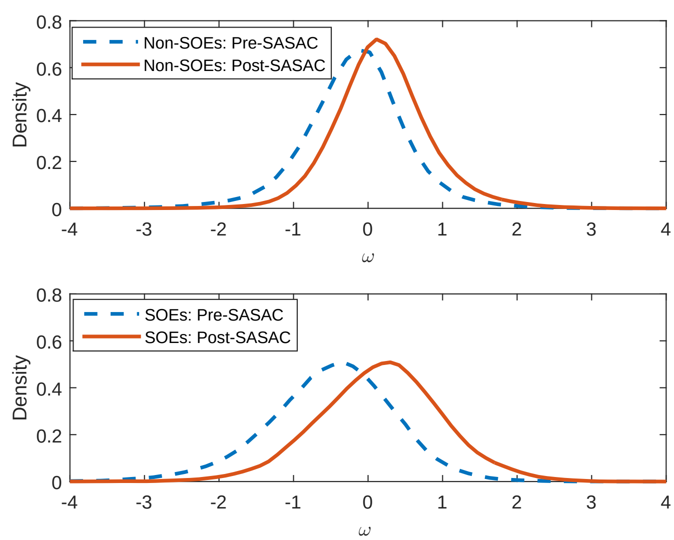
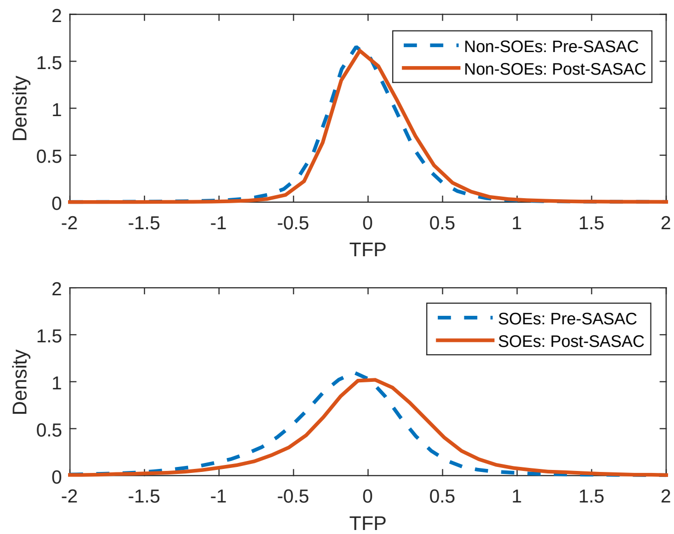


Figure 4: Distributions of TFP before and after SASAC, by group



due to the catch-up of SOEs, rather than the down-performing of non-SOEs. Indeed, non-SOEs grew steadily over the data period. This finding is consistent with the observation of closing profit gap between SOEs and non-SOEs in *The China Statistical Yearbook 2007*. In addition, the two types of firms share almost the same trend for all three key measures before SASAC, especially for input prices and TFP. This finding validates our use of difference-in-difference analysis in the empirical results.[22]

In general, these patterns are consistent with the conjecture that the establishment of SASAC, as a mechanism to strengthen external monitoring on SOEs exclusively, may have contributed substantially to the performance of SOEs. In particular, SASAC may have an important impact on SOE firms by reducing shirking and managerial theft, thus leading to lower input prices and higher productivity. In the next subsection, we conduct more rigorous statistical analysis to explore these impacts further.

5.2.2 Baseline Estimation Results

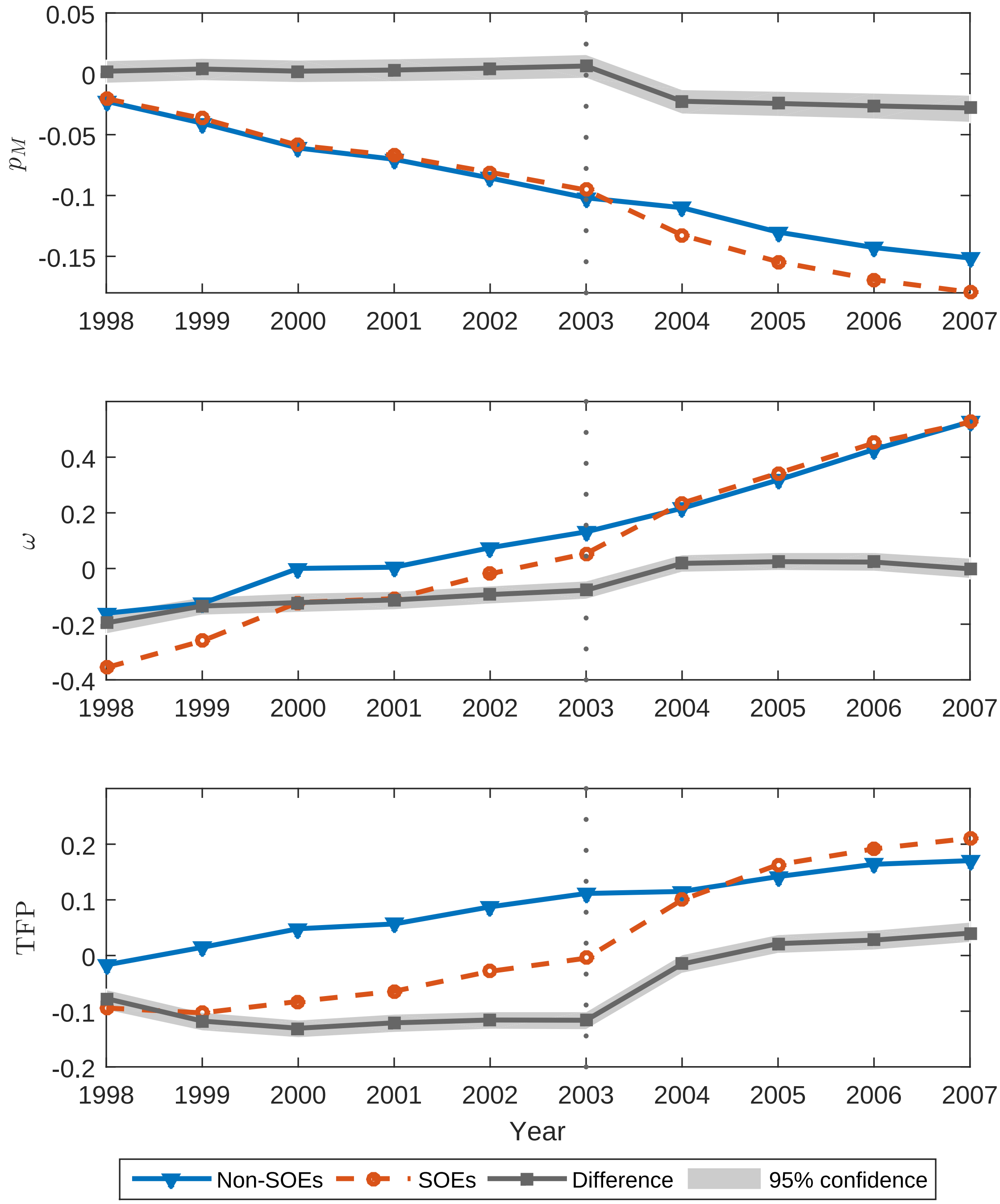
To formally investigate the impact of the strengthened monitoring after SASAC, as summarized in Conjecture 2, we estimate the following equation:

$$Y_{jt} = \beta_0 + \beta_{soe} SOE_{jt} + \beta_{soe*SASAC} \left(SOE_{jt} * SASAC_t \right) + \beta_z Z_{jt} + \lambda_{ind} + \lambda_{prov} + \lambda_t + \varepsilon_{jt}. \quad (10)$$

average, this is not the case for the unbalanced panel in general.

[22]Section 6.2 shows that the results are robust even after explicitly dealing with potential pre-trends.

Figure 5: Evolution of the means of the key measures, by group



Because the central government-level SASAC was established in March 2003, and the province-level SASACs for all 31 provinces were established during the period afterwards until early 2004, we define the cutoff year for dummy $SASAC_t$ as 2004. That is, $SASAC_t$ equals 1 from 2004 and onward.[23] All other variables in this equation are similarly defined as in (9). Since time dummies are included, the key parameter of interest, $\beta_{soe*SASAC}$, measures the impact of SASAC on SOEs, relative to non-SOEs. In Section 6, we examine a broad set of specifications as robustness checks, by considering privatization, market competition, SOE privilege enhancement, entry/exit, alternative SOEs definitions, firm fixed effects, and international trade participation.

As the baseline specification, we first examine the impact of SASAC on SOEs via the input price and productivity channels using our preferred measures. As reported in Table 3, SASAC reduces the input prices paid by SOEs substantially, relative to non-SOEs. In our preferred regression in column (2), we find that SASAC lowers the input prices of SOEs by 3.9 percent on average relative to non-SOEs. As SOEs paid 7.6 percent higher input prices than non-SOEs before SASAC, as captured by the coefficient on SOE_{jt} in column (2) in this table, such a reduction in SOEs' input prices indeed closes the gap between the two groups by half. This reduction reflects the impact arising from the strengthened external monitoring on SOEs after SASAC, which put more pressure on SOE managers to bargain harder for better input prices and reduced corruption in input procurement. This result corroborates the findings in Becker and Stigler (1974), which suggests that the right combination of monitoring and punishment can reduce corruption. Considering the heavy expenditure on material inputs, SASAC's impact on input prices is very meaningful for the rate of profit. The 3.9 percent reduction in input prices roughly contribute to an increase in the profit rate by about 3.1 percentage points.

We also find that SASAC has a significant and positive impact on our measure of productivity, as reported in columns (3) and (4) after controlling for various firm characteristics. In the full-fledged regression reported in column (4), SASAC increases the productivity of SOEs by 12.6 percent relative to non-SOEs. Compared with the pre-SASAC productivity difference (23.9 percent) between SOEs and non-SOEs, this impact is large—it reduces the productivity gap by over one-half. This result provides evidence that SASAC may have reduced shirking in production management substantially with its strengthened monitoring, which drives up the productivity of SOEs.

When using the traditional TFP, we find similar results—SASAC improves the TFP of SOEs

[23] We also conduct robustness check in section 6 to show that our results are robust using a subsample after dropping all observations in the transition year 2003.

Table 3: SASAC and SOE Performance

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.082***	0.076***	-0.283***	-0.239***	-0.200***	-0.191***
	(0.001)	(0.001)	(0.005)	(0.003)	(0.002)	(0.003)
SASAC*SOE	-0.056***	-0.039***	0.213***	0.126***	0.113***	0.095***
	(0.001)	(0.001)	(0.006)	(0.004)	(0.004)	(0.004)
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity		YES		YES		YES
Observations	1196053	873414	1196053	873414	1196053	873414
Adjusted R^2	0.943	0.967	0.929	0.966	0.686	0.726

Standard errors (clustered at the firm level) are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

relative to non-SOEs. In the full-fledged specification reported in column (6), SASAC increases SOEs' TFP by 9.5 percent on average, relative to non-SOEs. Meanwhile, the gap between SOEs and non-SOEs before SASAC, as captured by the coefficient on the dummy variable SOE_{jt}, is 19.1 percent. This suggests that SASAC reduces the TFP gap between SOEs and non-SOEs by about half.

These results are robust in the specifications after controlling for various firm characteristics, as well as in the robustness checks in Section 6. In sum, the results show that the strengthened external monitoring on management due to the establishment of SASAC in 2003, as a quasi-experiment in the time dimension that only affects SOEs, substantially reduced the gaps in input prices and productivity between the two groups of firms.

5.2.3 Dynamic Effects and Pre-Trend

This subsection serves two purposes. First, we test the dynamic effect of SASAC. Second, we test the common-trend assumption between SOEs and non-SOEs before SASAC, which is the basis for our difference-in-difference style analysis. To achieve these goals, we extend (10) in two directions. First, we incorporate a full set of interactions between the SOE dummy and time dummies after 2004 to capture the dynamic effect of SASAC. Second, we added the interaction between the SOE dummy and year dummies for one year, two years, and three years before SASAC to test for any potential differential pre-trend between these two groups of firms before SASAC. Specifically, we estimate the following equation:

$$Y_{jt} = \beta_0 + \beta_{soe} SOE_{jt} + \sum_{t=2001}^{2007} \beta_{soe*t} \left(SOE_{jt} * D_t \right) + \beta_z Z_{jt} + \lambda_{ind} + \lambda_{prov} + \lambda_t + \varepsilon_{jt}, \tag{11}$$

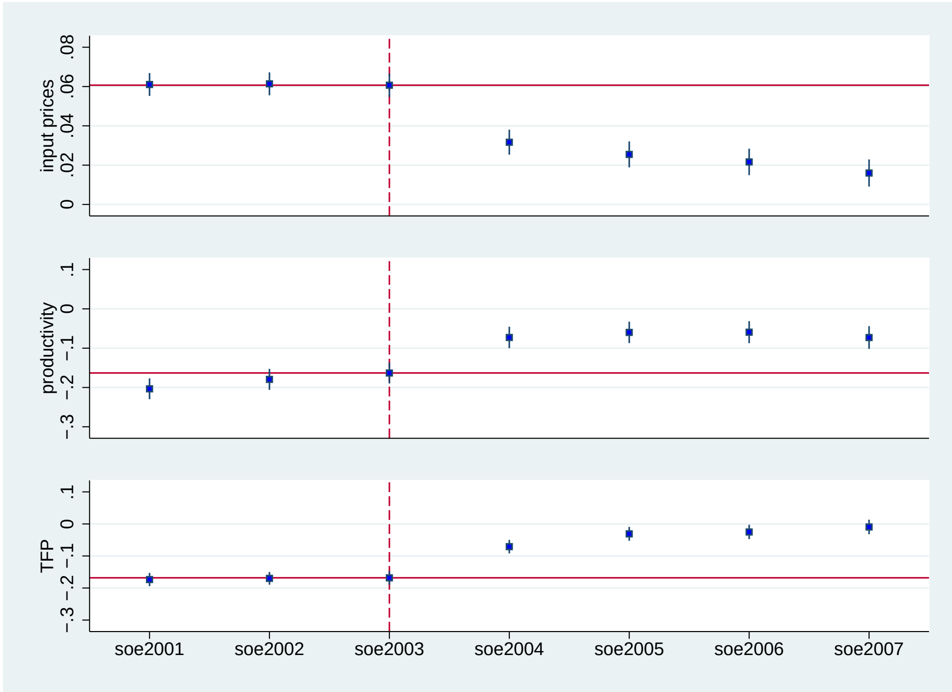
where D_t is the time dummy, and β_{soe*t} measures the differential performance of SOEs relative to non-SOEs in year t. All other variables and parameters are as previously defined. To make sure the results are not driven by entry and exit, we estimate (11) based on the aforementioned balanced panel. The estimation results for β_{soe*t} are visualized in Figure 6, with point estimates and 95 percent confidence intervals.

Three interesting observations stand out. First, there is a sharp change in β_{soe*t} from 2003 to 2004 even in this flexible specification, lending further evidence to the differential impact of SASAC on SOEs compared with non-SOEs. In particular, SOE input prices dropped down and productivity jumped significantly after 2003, relative to non-SOEs. TFP estimates show a similar pattern. These results are consistent with the conjecture that SASAC enhanced external monitoring strength, which effectively reduced material procurement corruption and shirking in production management.

Second, there is an obvious dynamic effect of SASAC on input prices, but not on productivity. After the large drop in 2004, the estimates of β_{soe*t} in the input price regression continue to drop further (at a rate that is faster than that, if any, before SASAC). For productivity, β_{soe*t} almost remains mostly stable after the large jump in 2004. The impact of SASAC on TFP, which in principle contains the impacts on input prices and productivity, shows a similar pattern to input prices.

The final observation is that there is no obvious pre-trend for input prices and TFP. As shown in the figure, from 2001 to 2003, the estimates of β_{soe*t} are not significantly different from each other in the regressions of input prices and TFP. This suggests that SOEs and non-SOEs had a common trend in input prices and TFP before the treatment (SASAC). As a result, the critical common pre-trend assumption for the difference-in-difference approach is satisfied, at least for the regressions using input prices and TFP. The estimates of β_{soe*t} for productivity, however, do show a slight growing trend before SASAC. From 2001 to 2003, the productivity gap was reduced by about 4 percent in total, with an average annual change of around 2 percent. Nonetheless, this is much smaller than the significant jump in productivity in 2004 (about 9 percent in a single year) when SASAC took effect. This sharp comparison suggests a strong differential impact of SASAC

Figure 6: Dynamic effect of SASAC and test for pre-trend: β_{soe*t}



Note: the range represents 95% confidence interval of the parameter estimates.

on SOEs and non-SOEs, which lends us the power to identify the impact of external monitoring on productivity even when there is a slight pre-trend in productivity before the treatment. To ensure further that the results are not driven by the differential pre-trend (especially for productivity), we remove the potential pre-trend and re-estimate the regression specifications in the robustness check in section 6.2. We find that the impact of the slight pre-trend is very limited. After detrending, all the major results are very similar to the baseline results, qualitatively and quantitatively.

5.3 The Role of Monitoring Costs: Spatial-dimension Evidence

To further strengthen the causality result between monitoring and SOE performance, this subsection tests the impact of monitoring costs on firm performance in the spatial dimension, and examines how the strengthened monitoring from SASAC heterogeneously influences the input prices and productivity of SOEs.

5.3.1 Monitoring Costs and SOE Performance

If external monitoring from the oversight government matters for SOE performance, then larger monitoring costs, which imply lower strength of monitoring, would lead to higher level of managerial expropriation and shirking and, as a result, weaker performance. This relationship is summarized in Conjecture 3.

Chinese SOEs, by registration, are affiliated to and overseen by one of the following government levels: central, province, or municipality (or prefecture).[24] We proxy the monitoring costs by the physical distance (in logarithm) of an SOE to its oversight government (*oversight distance* henceforth, for short). In the literature, distance has been documented to have significant consequences for firms. To analyze the determinants of the government's decision to decentralize SOEs, Huang et al. (forthcoming) document that information asymmetry and monitoring difficulties between SOEs and the oversight government increase in the physical distance between them. Consistent with their insight, in our context, greater oversight distance implies weaker monitoring on SOE's managerial effort from their oversight government, leading to a higher level of managerial expropriation and shirking. Bloom et al. (2012) also show that distance helps to explain the decentralization decision between multinational headquarters and overseas subsidiaries.

One potential concern is that the distance measure may contain more information than just monitoring costs. For example, because oversight governments are usually located in large cities, the distance to the oversight government may reflect agglomeration and localized material prices. Fortunately, non-SOEs are also registered to be affiliated to one level of government exactly in the same way as the system for SOEs. The difference is that the affiliated government is responsible for supervising and monitoring the SOEs' performance, but it bears no responsibility for monitoring the performance of affiliated non-SOEs. Such difference helps us to identify the effect of distance as a proxy for monitoring costs from its effect as agglomeration and localization. In light of this, we calculate the distance of non-SOEs to their affiliated government in the same way as that of SOEs, and add the distance measure and its interaction with the SOE dummy in the regression. While other factors (i.e., agglomeration and localization) affecting both SOEs and non-SOEs similarly are controlled by the distance variable, the monitoring effect is identified by the interaction between SOEs and oversight distance.[25]

[24] In general, a detailed classification of government levels is: central, province, municipality (or prefecture), county, and township. Nonetheless, the de facto supervision and monitoring on SOEs mainly come from the municipality-level governments or higher. That is, for SOEs registered to be overseen by the county-level government or lower, they are usually overseen by the municipality government indirectly, so we treat them as being supervised by the municipality government.

[25] In the data, many of firms are recorded as "others" in the affiliated government column. They include three types of firms: (1) subsidiary firms founded and owned by other legal bodies, (2) firms without an affiliated government, and (3) subsidiary firms founded and owned by non-centrally-affiliated firms or legal bodies from other provinces. We do not observe the affiliation of these firms to their founding firms/organizations. It is also unclear how cross-province operations would affect firm performance. As a result, we drop these observations in the regressions associated with oversight distances. After this treatment, we have a sample of 392,900 observations.

Table 4: Performance Comparison of SOEs and Private Firms: The Role of Monitoring Costs

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.062***	0.060***	-0.189***	-0.169***	-0.165***	-0.157***
	(0.002)	(0.001)	(0.008)	(0.006)	(0.005)	(0.005)
SOE*Dist	0.002***	0.001***	-0.011***	-0.006***	0.001	0.002
	(0.001)	(0.000)	(0.002)	(0.002)	(0.001)	(0.001)
Dist	YES	YES	YES	YES	YES	YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity		YES		YES		YES
Observations	541117	392900	541117	392900	541117	392900
Adjusted R^2	0.946	0.970	0.928	0.966	0.669	0.707

Standard errors (clustered at the firm level) are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Specifically, we estimate the following equation to test the impact of monitoring costs as specified in Conjecture 3:

$$Y_{jt} = \beta_0 + \beta_{soe} SOE_{jt} + \beta_{soe*dist} (SOE_{jt} * Dist_{jt}) + \beta_{dist} Dist_{jt} + \beta_z Z_{jt} + \lambda_{ind} + \lambda_{prov} + \lambda_t + \varepsilon_{jt}, \quad (12)$$

where $Dist_{jt}$ represents the oversight distance.[26] We are particularly interested in the parameter $\beta_{soe*dist}$, which captures the impact of monitoring costs on SOEs' performance.

The results are reported in Table 4. Again, SOEs on average pay higher input prices and have lower productivity. But more importantly, we find that monitoring costs (as proxied by oversight distance) matter for SOEs' performance in the preferred input prices and productivity measures, consistent with Conjecture 3. As characterized by the coefficients of $SOE * Dist$, oversight distance increases SOEs' input prices and reduces their productivity. Doubling the oversight distance (in logarithm) increases input prices paid by SOEs by 0.2 percent and reduces SOEs' productivity by 0.6 percent, relative to non-SOEs on average. These findings support the conjecture that higher monitoring costs for distant SOE firms reduces external monitoring on firm management and leads to expropriation and shirking in the production and input procurement processes.

However, column (6) shows that the coefficient of $SOE * Dist$ in the TFP regression is weak and insignificant. This suggests that monitoring costs may have ambiguous impact on TFP. A possible cause is that the TFP estimate is biased because of the ignored input price heterogeneity. Another

[26] The distance measure, $Dist_{jt}$, is indexed by firm j and year t. This is because in the data we observe around 1 percent of non-SOEs and 8 percent of SOEs changed distance due to decentralization (as analyzed in Huang et al., forthcoming) or relocation. We have tested our regressions with a sub-sample that excludes these firms, and the results are quantitatively and qualitatively similar. Results are available upon request.

possiblity is that SASAC changed how SOEs of different oversight distance were monitored—thus monitoring costs may affect SOE performance differently before and after SASAC. In addition, although we have used the distance of non-SOEs to their affiliated governments to control for the possible effects of agglomeration and localized markets, our result could still be biased if better SOEs are endogenously located nearer (relative to non-SOEs) to the oversight government. That is, the possibility of endogenous oversight distance may confound our estimate of $\beta_{soe*dist}$ as the effect of monitoring costs. Nonetheless, if $\beta_{soe*dist}$ is purely driven by the endogenous oversight distance (rather than monitoring costs), then SASAC, as a monitoring-strengthening policy shock, is unlikely to have an impact on coefficient $\beta_{soe*dist}$, because for the majority of SOEs the oversight distance did not change over time.[27] These considerations motivate us to investigate if the difference in monitoring costs lead to heterogeneous impact of SASAC in the following subsection.

5.3.2 Monitoring Costs and Heterogeneous Impact of SASAC

The above findings show that higher monitoring costs (as proxied by the greater distance of SOEs to their oversight government) reduce the performance of SASAC. Consistent with Huang et al. (forthcoming), which find that government tends to decentralizes SOEs that are far away, we conjecture that SASAC had the incentive to exert greater level of monitoring strength on SOEs that performed weaker. As a result, the nationwide policy can generate heterogeneous impact: SOEs that were far away from their oversight government improve more in input prices and productivity after SASAC. To examine such a possibility (i.e., impact of SASAC on the monitoring costs), we estimate the following extended equation,

$$\begin{aligned} Y_{jt} \;=\; & \beta_0 + \beta_{soe} SOE_{jt} + \beta_{soe*dist} \left(SOE_{jt} * Dist_{jt} \right) + \beta_{soe*sasac} \left(SOE_{jt} * SASAC_t \right) \\ & + \beta_{soe*dist*sasac} \left(SOE_{jt} * Dist_{jt} * SASAC_t \right) + \beta_{dist*sasac} \left(Dist_{jt} * SASAC_t \right) \\ & + \beta_{dist} Dist_{jt} + \beta_z Z_{jt} + \lambda_{ind} + \lambda_{prov} + \lambda_t + \varepsilon_{jt}. \end{aligned} \quad (13)$$

Compared with (12), there are three new terms in this equation. As usual, $SOE_{jt} * SASAC_t$ captures the impact of SASAC on SOE performance relative to non-SOEs. We added the term $Dist_{jt} * SASAC_t$ to control for the possibility that factors (such as agglomeration and localized input markets) contained in the distance measure may affect firms differently after SASAC. Importantly, $SOE_{jt} * DIST_{jt} * SASAC_t$ is the key term of interest in this regression: it captures

[27] See Footnote 26 for detailed percentages.

the impact of SASAC on SOEs of different oversight distances. In Section 6, we show the results are robust after considering privatization, market competition, SOE privilege enhancement, entry/exit, alternative SOEs definitions, firm fixed effects, and international trade participation.

The results of the baseline specification are reported in Table 5. The parameter $\beta_{soe*dist}$ has the same sign as that in Table 4, showing that before SASAC the oversight distance is positively associated to the input prices of SOEs and negatively associated to their productivity, relative to non-SOEs. Quantitatively, before SASAC, doubling the oversight distance increases SOEs' input prices by 0.3 percent and reduces their productivity by 0.7 percent relative to non-SOEs on average.

More importantly, the estimates of the $\beta_{soe*dist*sasac}$ shows a heterogeneous impact of SASAC on SOEs with different distance to their oversight government. The negative sign of $\beta_{soe*dist*sasac}$ in the input price regression and the positive sign in the productivity regression reflect that the gaps in input prices and productivity between SOEs of different oversight distances are narrower after the establishment of SASAC. When using the traditional TFP as a measure of firm performance, we find even stronger results. This shows that SASAC had heterogeneous impact on SOEs and it significantly alleviated the negative role of monitoring costs in firm performance. This finding is intuitive. First, SOEs that were far from their oversight government have weaker performance than these that were closer before SASAC. As a result, they have larger potential gains when monitoring is strengthened. Second, knowing that distinct SOEs had more serious monitoring problems, SASAC might have implemented higher order of monitoring on SOEs that were far away. Both of these two reasons may contribute to the reduction of the gap between distant SOEs and closer SOEs after SASAC. Importantly, it also implies that our estimate of $\beta_{soe*dist}$ in Table 4 is not simply driven by the potential endogenous oversight distance, in which case SASAC would have no impact (i.e., $\beta_{soe*dist*sasac} = 0$) as discussed in the end of Section 5.3.1.

To sum up, we find the strengthened external monitoring of SASAC on SOEs is responsible for the catch-up of SOEs relative to non-SOEs. The variation in monitoring strength in the spatial dimension due to monitoring costs further confirms the causal relationship between external monitoring and SOEs' performance.

Table 5: SASAC and SOE Performance: The Role of Monitoring Costs

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.067***	0.064***	-0.222***	-0.196***	-0.175***	-0.165***
	(0.002)	(0.001)	(0.009)	(0.007)	(0.005)	(0.005)
SASAC*SOE	-0.026***	-0.019***	0.141***	0.096***	0.051***	0.035***
	(0.003)	(0.002)	(0.013)	(0.010)	(0.008)	(0.008)
SOE*Dist	0.005***	0.003***	-0.014***	-0.007***	-0.004**	-0.004**
	(0.001)	(0.000)	(0.002)	(0.002)	(0.001)	(0.002)
SASAC*SOE*Dist	-0.007***	-0.005***	0.008**	0.003	0.015***	0.015***
	(0.001)	(0.001)	(0.004)	(0.003)	(0.002)	(0.002)
SASAC*Dist	YES	YES	YES	YES	YES	YES
Dist	YES	YES	YES	YES	YES	YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity		YES		YES		YES
Observations	541117	392900	541117	392900	541117	392900
Adjusted R^2	0.946	0.970	0.928	0.966	0.669	0.708

Standard errors (clustered at the firm level) are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 6: Impact of Monitoring Costs on Aggregate Input Prices and Productivity (%)

	Input Price	Productivity	TFP
All	0.16	-0.42	-0.22
SOEs	1.09	-2.61	-1.46

5.4 Aggregate Impact

The above analysis suggests that, at the firm level, ineffective external monitoring is responsible for weak SOE performance, and strengthened monitoring can promote firm performance via the input prices and productivity channels. A natural question is: how important is the impact at the aggregate level for manufacturing industries? To shed light on this question, we separately evaluate the impact of monitoring costs caused by geographic distance and the establishment of SASAC on the aggregate productivity and input prices for SOE firms as well as for all firms in the manufacturing sector, based on the estimates in section 5.

First, in the spatial dimension, we have shown that higher monitoring costs due to geographic distance, by increasing managerial expropriation/shirking, leads to weaker SOE performance at the firm level. To see the impact at the aggregate level, we consider a counterfactual scenario where the oversight distance (as the proxy for monitoring costs) is zero. That is, we subtract $\hat{\beta}_{soe*dist} Dist_{jt} * SOE_{jt}$ (estimated from (13)) from the input prices, productivity, and TFP of all

SOEs, respectively. Then we compare the revenue-weighted aggregate values in the data with the counterparts computed from the counterfactual scenario. The differences as a result capture the aggregate impact of the monitoring costs arising from geographic distance. The results are presented in Table 6. The finding reflects that, within the group of SOEs, the monitoring costs increase aggregate input price by 1.09 percent, and reduce aggregate productivity and TFP by 2.61 and 1.46 percent, respectively. As a result, the overall aggregate input price for the entire sector (all firms included) is increased by 0.16 percent, and aggregate productivity and TFP are reduced by 0.42 and 0.22 percent, respectively. A caveat is that these changes do not include possible production reallocation across firms, in particular between the groups of SOEs and non-SOEs, because we keep the same revenue weight in the aggregation. However, the reallocation between the two groups of the firms is fairly weak (only accounting for 6 percent of the overall growth) for productivity and negative for input prices and TFP. This suggests that these documented changes are likely to be lower bounds of the actual impact of weak external monitoring induced by monitoring costs.

Second, in the time dimension, to understand the aggregate impact of SASAC on the group of SOEs as well as all firms in the manufacturing industries, we consider a counterfactual scenario where the SASAC effect is removed. SASAC not only has homogeneous impact on all SOEs, but also alleviates the negative effect of monitoring costs. Thus, in the counterfactual scenario, we remove $\hat{\beta}_{soe*sasac} SASAC_t * SOE_{jt}$ and $\hat{\beta}_{soe*dist*sasac} SASAC_t * SOE_{jt} * Dist_{jt}$ (both estimated from (13)) from the input prices, productivity, and TFP of all SOEs, respectively. Then we compare the aggregate values with the counterparts from the data. Table 7 shows that, as an SOE-exclusive policy, SASAC has significantly reduced the aggregate input price of SOEs by 4.03 percent, and increased aggregate productivity and TFP by 10.97 and 9.79 percent, respectively. Accordingly, the overall aggregate input price of the entire manufacturing sector is reduced by 0.56 percent, and aggregate productivity and TFP are increased by 1.46 and 1.29 percent, respectively.

Overall, this exercise implies that external monitoring indeed plays an important role in affecting aggregate economic performance. The SOE-exclusive policy of strengthening monitoring not only directly promoted the performance of the targeted group of firms, but also positively influenced the aggregate performance of the entire manufacturing sector.

Table 7: Impact of SASAC on Aggregate Input Prices and Productivity (%)

	Input Price	Productivity	TFP
All	-0.56	1.46	1.29
SOEs	-4.03	10.97	9.79

6 Alternative Explanations and Robustness

6.1 Alternative Explanations

Although the establishment of SASAC was the main and largest policy shocks regarding SOE during the data period, it was accompanied by several other contemporaneous policy measures which may confound our estimation results. This subsection provides evidence that our results are not driven by these policy measures, and the detailed estimation results are reported in the Online Appendix.

Privatization and Internal Monitoring/Incentive. Privatization comes with not only improved monitoring and corporate governance, but also radical changes in many other aspects that potentially have an impact on both productivity and input prices. Given that many firms were privatized during the data period, it is a valid concern that the estimated impact of SASAC might be contaminated or even driven by privatization. In addition, as discussed in Section 2, the central government formed ten guidelines for SOE reform and development in the Fourth Plenary Sessions of 15th Central Committee of the Communist Party in September 1999. These guidelines emphasized the integration of privatization, monitoring, market competition, and establishment of modern enterprise system to improve SOE performance. These policies might have improved the internal monitoring and incentive due to improved corporate governance, contributing to reduced input prices and increased productivity over time. To rule out this possibility, we drop all observations that involve a change in ownership status during the data period. The remaining sample, as a result, contains firms that are always SOEs or always non-SOEs from their first to the last years in the sample. The estimation results are similar to the baseline results.

Market Power/Competition. The reduction of entry barrier in many industries before 2002 may changed the market power of SOEs, which might well contribute to the change of input prices and (revenue) productivity. To address this issue, we have already included firm size in all the main regressions and our results are robust. More importantly, we observe no obvious change of market structure around the SASAC treatment period, in contrast to the striking improvement of

SOE performance. In the online appendix, we also show the results are robust after controlling for domestic market structure, as captured by the industry-year specific Herfindahl-Hirschman Index (HHI). These evidences suggest that the changing market power is unlikely to drive our results.

Change of Privileges. Another possible factor that may drive our result is the privilege of SOEs endowed by the government of China. If the strength of political connections between SOEs and government is increasing over time, then such connections may fortify the privilege of SOEs in input and output markets and enable them to have lower input prices and higher (revenue-based) productivity. If this is true, the result might be contaminated. However, this is unlikely to be the case for several reasons. First, such an increase in privilege, if any, must have happened exactly the same time as the establishment of SASAC (2004 as the cutoff year) to explain the striking jumps presented in Figure 5. This would be a strong coincidence, considering SASAC was designated to enhance the monitoring and supervision of SOEs, which might have decreased (rather than increased) SOEs' privilege. Second, even if there was indeed a sharp increase in SOEs' privilege exactly at the time when SASAC was established, it is more likely the privilege would be given to SOEs closer to the government, which would enlarge the difference between close-by SOEs and remote SOEs after SASAC. Consequently, $\beta_{SASAC*SOE*Dist}$ would be positive for input price and negative for productivity if this is true, which contradicts the findings. Finally, SOEs' privilege may actually have decreased on average over time. For instance, the average of subsidy-to-output ratio decreased from 1.24 percent (pre-SASAC) to 1.15 percent (post-SASAC) for SOEs; in contrast, the ratio for non-SOEs increased from 0.28 percent (pre-SASAC) to 0.31 percent (post-SASAC). Overall, increased privilege of SOEs, if any, alone cannot explain the patterns we have documented.

6.2 Other Robustness Checks

We further conduct a wide range of robustness checks to ensure that the main results are not contaminated by other driving forces in the data period. We discuss the motivation of each robustness check in this section, and leave the detailed discussion and estimation results in the Online Appendix. Overall, our main results are very robust to these checks.

Potential Differential Pre-trend. The identification of difference-in-difference approach relies on the common trend assumption of control and treatment groups. If there is differential pre-trend of SOEs and non-SOEs in the absence of SASAC, then our estimates may be contaminated. As shown in Section 5.2, the differential pre-trend between SOEs and non-SOEs, if any, is weak, especially for input prices and TFP. To ensure further that the results are not driven by the differential pre-trend (especially for productivity), we design a two-step approach to remove the potential pre-trend and re-estimate the regressions.

Balanced Panel. A potential concern is that the results might be driven by change in the composition of firms due to entry and exit in the data period. Indeed, entrants and exiters may be different from incumbents in input prices and productivity, and there were substantial entries and exits during the data period.[28] To address this concern, we estimate the regressions using a balanced panel, by dropping all firms that entered or exited during the data period.

World Trade Organization. China joined WTO at the end of 2001. In principle, this might have had an impact on all firms in China—for example, firms were able to access a larger variety of material inputs by importing directly or purchasing from middlemen, and thus input prices could be lowered. In all of the regressions, we have included year dummies, so the WTO effect (if common to all firms) is controlled in the analysis. Still, it is possible that the WTO membership might have had different impacts on SOEs and non-SOEs. If WTO has a larger impact on SOEs than non-SOEs, then the estimated impact of SASAC on SOE performance might be contaminated by the differential WTO effect. To examine this possibility, we estimate extended specifications by adding $WTO_t * SOE_{jt}$ to (10) and (13). If WTO has any heterogeneous impact on SOEs and non-SOEs, this additional term would pick it up.

Alternative Definition of SOE. In the main results, following Huang et al. (forthcoming) and many others, we define a firm as an SOE if its share of state ownership exceeds 30 percent. Alternatively, an SOE can be defined based on the firm's registered ownership type. In our main analysis, we choose not to use this way to define SOEs because it is very noisy—some former SOEs do not change their registered ownership type after ownership restructuring. An alternative is to combine the information on state share and registered ownership type. Following Hsieh and Song (2015), we define a firm as an SOE if its state share is over 50 percent or it is registered as controlled by the state. Hsieh and Song (2015) show that the revenue share and number of SOEs calculated using this definition are very close to those reported in the *China Statistical Yearbook*. We estimate regression specifications using this definition and find that the results are very robust.

Transition Period of SASAC. In our analysis, we use 2004 as the cutoff year to define the impact of SASAC: all observations in and after 2004 are considered as being treated by SASAC.

[28] The data set we use surveys private firms with annual sales above five million RMB (about six hundred thousand USD) and all SOEs. We define entrant and exiting as a firm enters or exits the dataset. This definition does not necessarily imply actual entry/exit of firms.

However, the establishment of SASAC took some time. Although the central government-level SASAC was established in March 2003, many of its policies and regulations were formed and announced latter in the same year. Meanwhile, province-level SASACs were established during the period between March 2003 and early 2004. Two questions emerge: (1) were firms affected by SASAC in 2003? and (2) were there other factors, such as transition costs that affected firm performance during the transition year (2003)? We check the robustness of our results to these two questions by estimating the regression specifications using a subsample after dropping the observations in the transition year (2003).

Importing and Exporting. As is well-documented in the literature, importing and exporting may have positive impacts on productivity. Grieco et al. (2017) document that importers may have advantages in input prices. If Chinese firms were expanding imports and exports over time, then the estimate of the effect of SASAC would pick up the impact of the increased importing and exporting. To address this potential problem, we further control for lagged import and export dummies in the estimation of (10) and (13). We find all the main parameters of interest are very similar to the baseline results.

Firm Fixed Effects. In the main results, we have controlled for a series of dummies (including province, industry, and year) and firm registration affiliation type in all the regressions. We think that is enough to control for cross-section fixed effects, because conditional on the same industry, province, year, and registration affiliation type, the unobserved/uncontrolled heterogeneity across individual firms should be small. Given that we further controlled for a set of firm-level characteristics such as firm age, size, and capital intensity, we believe the baseline results are soundly based. Nonetheless, to ensure further the results are robustness to other unobserved fixed effects at the firm level, we estimate extended specifications of (10) and (13) by adding firm dummies (and dropping time invariant factors), using data containing all the observations without privatized firms. We find that the results are consistent with the main results.

7 Conclusion

Effective external monitoring is an indispensable part of corporate governance to enhance firm performance by reducing shirking and managerial expropriations. This paper empirically investigates how the strengthened external monitoring from government can affect SOE performance, through the channels of intermediate input prices and productivity in the context of Chinese SOEs. We first document that overall SOEs pay 6.4 percent higher input prices and their productivity is about 20 percent lower, compared with their non-SOE counterparts. We provide evidence on the impact of external monitoring on SOE performance, using variations from both time and spatial dimensions. In the time dimension, the establishment of SASAC, by strengthening monitoring on SOEs exclusively, substantially narrowed the gaps between SOEs and non-SOEs in both input prices and productivity by around half. In the spatial dimension, SOEs with higher monitoring costs, as proxied by the distance of SOEs to their own oversight government, pay relatively higher input prices and have lower productivity. Such negative impact was largely mitigated by the strengthened government monitoring after SASAC. These firm-level effects have significant impacts on aggregate productivity and input price levels, for SOE firms and all firms as a whole.

The results corroborate the findings of studies that document significant gaps between SOEs and non-SOEs, and contribute to the long-standing debate on how to improve SOE performance in public policy. The results suggest that enhancement of government monitoring and credible punishment can serve as effective policy instrument to improve SOE performance, even without ownership change (privatization), massive capital investment, or layoff of workers. This is important for police makers especially in industries that can not be privatized due to economic or political reasons.

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Appendices

A Proof of Proposition 1

Proof.

The first-order conditions associated with the top manager's optimization problem (1) are:

$$e_M: \quad \Pi'_{e_M} - C'_M(e_M) - C'_{e_M}(e_M, \theta) = 0, \tag{A.1}$$
$$e_\omega: \quad \Pi'_{e_\omega} - C'_\omega(e_\omega) = 0. \tag{A.2}$$

Taking total differentiation of the first-order condition associated with e_ω with respect to θ yields

$$\Pi''_{e_M e_\omega} \frac{\partial e_M}{\partial \theta} + \left[\Pi''_{e_\omega e_\omega} - C''_\omega(e_\omega)\right] \frac{\partial e_\omega}{\partial \theta} = 0 \tag{A.3}$$

Given the assumptions on the total payoff function and the effort cost functions, we have $\Pi''_{e_M e_\omega} > 0$ and $\Pi''_{e_\omega e_\omega} - C''_\omega(e_\omega) < 0$ in Equation (A.3). As a result, we have

$$\text{sign}(\frac{\partial e_M}{\partial \theta}) = \text{sign}(\frac{\partial e_\omega}{\partial \theta}) \tag{A.4}$$

Similarly, taking total differentiation of the first-order condition associated with e_M with respect to θ, we have

$$\Pi''_{e_M e_\omega} \frac{\partial e_\omega}{\partial \theta} + \left[\Pi''_{e_M e_M} - C''_M(e_M) - C''_{e_M e_M}(e_M, \theta)\right] \frac{\partial e_M}{\partial \theta} \quad = \quad C''_{\theta e_M}(e_M, \theta). \tag{A.5}$$

Solving out $\frac{\partial e_\omega}{\partial \theta}$ from Equation (A.3) and replacing it in the above equation lead to

$$\left\{ \frac{\Pi''_{e_M e_\omega} \Pi''_{e_M e_\omega}}{\left[\Pi''_{e_\omega e_\omega} - C''_\omega(e_\omega)\right]} + \left[\Pi''_{e_M e_M} - C''_M(e_M) - C''_{e_M e_M}(e_M, \theta)\right] \right\} \frac{\partial e_M}{\partial \theta} \quad = \quad C''_{\theta e_M}(e_M, \theta). \tag{A.6}$$

Since we have assumed $C''_{\theta e_M}(e_M, \theta) < 0$ and the term in the bracket on the left hand side is also negative. As a result, we have

$$\frac{\partial e_M}{\partial \theta} > 0.$$

Because $\text{sign}(\frac{\partial e_M}{\partial \theta}) = \text{sign}(\frac{\partial e_\omega}{\partial \theta})$ as shown above in Equation (A.4), we also have $\frac{\partial e_\omega}{\partial \theta} > 0$.

Because material prices decrease in procurement effort and productivity increases in productivity effort, firms facing stronger external monitoring on their management naturally have lower material prices and higher productivity. ■

B Estimation Procedure

The key measures involved in this study are productivity Ω and input prices P_{Mjt}, both of which are quality-adjusted and heterogenous across firms. However, neither of them is observed in the data. Grieco et al. (2017) discuss the challenge of identification and propose a method to recover them from observables. The method takes advantage of the structural model of production decisions and estimates the production function using commonly observed variables including labor employment, wage expenditure, material expenditure, capital stock, revenues, and so forth. This appendix summarizes the approach developed by Grieco et al. (2017) to estimate the firm-level quality-adjusted productivity and material prices, which are the two key dependent measures we use in this paper.

The firm's profit maximization problem defined in (8) implies three first-order conditions for labor quantity, material quantity, and output quantity. The firm's profit maximization problem defined in (8) implies the following three first-order conditions for labor quantity, material quantity, and output quantity. We substitute P_{jt} by the demand functions, and use μ_{jt} to denote the Lagrange multiplier of the production constraint:

$$\frac{\partial \mathcal{L}}{\partial \tilde{Q}_{jt}} = \frac{1+\eta}{\eta}(\tilde{Q}_{jt})^{1/\eta} - \mu_{jt} = 0, \tag{B.1}$$

$$\frac{\partial \mathcal{L}}{\partial L_{jt}} = -P_{L_{jt}} + \mu_{jt}\tilde{\Omega}_{jt}\frac{\partial F}{\partial L_{jt}} = 0, \tag{B.2}$$

$$\frac{\partial \mathcal{L}}{\partial M_{jt}} = -\tilde{P}_{M_{jt}} + \mu_{jt}\tilde{\Omega}_{jt}\frac{\partial F}{\partial M_{jt}} = 0. \tag{B.3}$$

As a result, multiplying Equations (B.2) and (B.3) by L_{jt} and M_{jt} respectively, we have

$$\mu_{jt}\tilde{\Omega}_{jt}\frac{\partial F}{\partial L_{jt}}L_{jt} = E_{Ljt}, \tag{B.4}$$

$$\mu_{jt}\tilde{\Omega}_{jt}\frac{\partial F}{\partial M_{jt}}M_{jt} = E_{Mjt}, \tag{B.5}$$

where $E_{Ljt} = P_{Ljt}L_{jt}$ and $E_{Mjt} = \tilde{P}_{Mjt}M_{jt}$ represent the expenditure on labor and material, respectively. Dividing these two equations yields

$$\frac{\frac{\partial F}{\partial L_{jt}}L_{jt}}{\frac{\partial F}{\partial M_{jt}}M_{jt}} = \frac{E_{Ljt}}{E_{Mjt}}. \tag{B.6}$$

We can recover the unobserved material quantity M_{jt} as a function of observed variables from equation (B.6) upto a set of parameters to be estimated, as in Grieco et al. (2016). In the case of a CES production function, it is straightforward to show that the recovered material quantity and unit input price admit a simple closed-form solution:

$$M_{jt} = \left[\frac{\alpha_L E_{Mjt}}{\alpha_M E_{Ljt}}\right]^{\frac{1}{\gamma}} L_{jt}, \tag{B.7}$$

$$\tilde{P}_{Mjt} = \left[\frac{\alpha_M}{\alpha_L}\right]^{\frac{1}{\gamma}} \left[\frac{E_{Mjt}}{E_{Ljt}}\right]^{1-\frac{1}{\gamma}} P_{Ljt}.. \tag{B.8}$$

That is, they can be written as functions of observed variables in the data up to the unknown parameters to be estimated.

Next, we show that $\tilde{\Omega}_{jt}$ can also be written as a function of observed variables. To see this, substituting (B.1) into the first-order condition for labor (B.2), replacing $\tilde{Q}_{jt}$ by the production function and then M_{jt} by Eq. (B.7), we get

$$\tilde{\Omega}_{jt} = \frac{1}{\alpha_L}\frac{\eta}{1+\eta}L_{jt}^{-\gamma}E_{L_{jt}}\left[\alpha_L L_{jt}^{\gamma}\left(1+\frac{E_{M_{jt}}}{E_{L_{jt}}}\right)+\alpha_K K_{jt}^{\gamma}\right]^{1-\frac{1}{\gamma}(1+\frac{1}{\eta})}, \tag{B.9}$$

which is analogous to (7) in Grieco et al. (2016). In addition, $\tilde{Q}_{jt}$ can be recovered by substituting (B.7) and (B.9) back into the production function.

Therefore, we have shown that we are able to recover $(M_{jt}, P_{M_{jt}}, \tilde{Q}_{jt}, \tilde{\Omega}_{jt})$ uniquely from the observable data $(E_{Ljt}, E_{Mjt}, L_{jt}, K_{jt}, R_{jt})$ up to the parameters to be estimated. The estimation equation is constructed by plugging all these recovered variables into the revenue function $R_{jt} = P_{jt}\tilde{Q}_{jt}$. After the same algebra in Grieco et al. (2016), we obtain the following equation:

$$R_{jt} = \frac{\eta}{1+\eta}\left[E_{M_{jt}} + E_{L_{jt}}\left(1+\frac{\alpha_K}{\alpha_L}\left(\frac{K_{jt}}{L_{jt}}\right)^{\gamma}\right)\right]. \tag{B.10}$$

As shown in Grieco et al. (2016), the model parameters are identified with two additional constraints naturally implied by the model. The first additional constraint is the normalization assumption:

$$\alpha_L + \alpha_M + \alpha_K = 1. \tag{B.11}$$

The second is the ratio of input expenditure aggregation equation resulted directly from taking the geometric mean of first-order conditions for labor and material quantities of all firms:

$$\frac{\overline{E}_L}{\overline{E}_M} = \frac{\alpha_L}{\alpha_M}, \tag{B.12}$$

where $\overline{E}_L$ and $\overline{E}_M$ are the geometric means of labor expenditure and material expenditure for all firms, respectively. They can be computed directly from the data.

The estimation procedure for the associated model parameters, $\beta \equiv (\alpha_L, \alpha_M, \alpha_K, \eta, \gamma)$, follows exactly as in Grieco et al. (2016) using non-linear least squares (NLLS) with constraints (B.11) and (B.12),

$$\begin{aligned} \hat{\beta} \quad = \quad & \text{argmin}_{\beta}\sum_{jt}\left\{\log(R_{jt}) - \log(\frac{\eta}{1+\eta}) - \log\left[E_{M_{jt}} + E_{L_{jt}}\left(1+\frac{\alpha_K}{\alpha_L}\left(\frac{K_{jt}}{L_{jt}}\right)^{\gamma}\right)\right]\right\}^2 \\ & \text{subject to (B.11) and (B.12).} \end{aligned} \tag{B.13}$$

With β estimated, we can recover $\tilde{\Omega}_{jt}$ and $\tilde{P}_{Mjt}$ from (B.8) and (B.9) respectively. However, they both contain input quality h_{jt}: $\tilde{\Omega}_{jt}$ contains input quality as it echoes the linkage between input quality and output quality as suggested by Kugler and Verhoogen (2009, 2012); $\tilde{P}_{Mjt}$, by definition, is $P_{Mjt}H_{jt}$, thus it also contains input quality. In order to recover the quality-adjusted productivity ω_{jt} and quality-adjusted price p_{Mjt} from $\tilde{\Omega}_{jt}$ and $\tilde{P}_{Mjt}$, we follow Grieco et al. (2017) to make use of the optimization of firms' endogenous input quality choice. Specifically, the first order condition of endogenous input quality choice is

$$\frac{\partial \tilde{P}_{Mjt}(P_{Mjt}, H_{jt})}{\partial H_{jt}}M_{jt} = \mu_{jt}F(L_{jt}, M_{jt}, K_{jt})\frac{\partial \tilde{\Omega}_{jt}}{\partial H_{jt}} \tag{B.14}$$

Solve μ_{jt} from (B.5) and plug it into (B.14), and after some algebra we can derive a closed-form relation between endogenous input quality choice and productivity:

$$h_{jt} = \frac{1}{\theta} \ln \frac{\sigma_{Mjt}}{1-\sigma_{Mjt}} + \omega_{jt}, \tag{B.15}$$

where $h_{jt} = ln(H_{jt})$ is the input quality in logarithm and $\sigma_{Mjt} = \frac{\partial F}{\partial M_{jt}} \frac{M_{jt}}{F(\cdot)}$ is the output elasticity of material. σ_{Mjt} can be directly computed according to the estimated production function and material input quantity.

Substitute (B.15) into (4) to solve for productivity, and utilize the price menu function (6) directly for quality-adjusted prices, we obtain:

$$\omega_{jt} = \ln \tilde{\Omega}_{jt} - \frac{1}{\theta} \ln \left[\frac{1}{1-\sigma_{Mjt}} \right], \tag{B.16}$$

$$p_{Mjt} = \ln \tilde{P}_{Mjt} - \ln \tilde{\Omega}_{jt} - \frac{1}{\theta} \ln(\sigma_{Mjt}), \tag{B.17}$$

We estimate θ together with (f_0, f_1, g_0, g_1) associated with (5) and (7) via Generalized Method of Moments with a set of moment conditions:

$$E[Z_{jt} \otimes (\epsilon^{\omega}_{jt+1}, \epsilon^{p}_{jt+1})] = 0, \tag{B.18}$$

where $\epsilon^{\omega}_{jt+1} = \omega_{jt+1} - f_0 - f_1\omega_{jt}$ and $\epsilon^{p}_{jt+1} = \ln(p_{jt+1}) - g_0 - g_1 \ln(p_{jt})$. The instrumental set used in the estimation of this paper is

$$Z_{jt} = (\log(K_{jt})), \log(E_{Mjt}), \log(E_{Ljt}), \log(L_{jt}), \log(K_{jt}) \log(E_{Mjt}), \sigma_{M_{jt}}).$$

Formally,

$$\hat{\vartheta} = \text{argmin}_{\vartheta} \left[\sum_{jt} Z_{jt} \otimes (\epsilon^{\omega}_{jt+1}, \epsilon^{p}_{jt+1}) \right]' W \left[\sum_{jt} Z_{jt} \otimes (\epsilon^{\omega}_{jt+1}, \epsilon^{p}_{jt+1}) \right], \tag{B.19}$$

where $\vartheta = (\theta, f_0, f_1, g_0, g_1)$ and W is a weighting matrix. With ϑ estimated, it is straightforward to compute the productivity and input price measures from (B.16) and (B.17) respectively.

In addition to the two key measures, we estimate a total factor productivity measure (TFP) following Levinsohn and Petrin (2003) in order to contrast our study to the traditional analysis on SOEs' productivity. In particular, we follow the common practice of this approach to use deflated expenditure as proxy of material quantity in the estimation of production functions. As discussed in Grieco et al. (2016), this measure may be biased in the presence of input price heterogeneity, and it is silent on the heterogeneity of input prices across firms and over time. In this paper, we use it as a safeguard to show that our preferred productivity measure indeed captures the key efficiency concept that has been studied in the literature.

Table A1: Main Functions of SASAC

Summary	**Detailed Functions of SASAC**
1. Performs investor's responsibilities	Performs investor's responsibilities, supervises and manages the state-owned assets of the enterprises under the supervision of the central government (excluding financial enterprises), and enhances the management of state-owned assets.
2. Implementable measures to ensure preservation and increment of the value of the state-owned assets	Establishes and improves the index system of the preservation and growth of the value of state-owned assets, and works out assessment criteria; supervises and administers the preservation and growth of the value of the state-owned assets of the supervised enterprises through statistics and auditing; and is responsible for the management work of wages and remuneration of the supervised enterprises and formulates policies regulating the income distribution of the top executives of the supervised enterprises and organizes implementation of the policies.
3. SOE reform and establishment of modern enterprise system	Guides and pushes forward the reform and restructuring of state-owned enterprises, advances the establishment of modern enterprise system in SOEs, improves corporate governance, and propels the strategic adjustment of the layout and structure of the state economy.
4. On top executives of SOE	Appoints and removes the top executives of the supervised enterprises, and evaluates their performances through legal procedures and either grants rewards or inflicts punishments based on their performances; establishes corporate executives selection system in accordance with the requirements of the socialist market economy system and modern enterprise system, and improves incentives and restraints system for corporate management.
5. Dispatches supervisory panels to monitor SOE	In accordance with related regulations, SASAC dispatches supervisory panels to the supervised enterprises on behalf of the state council and takes charge of daily management of the supervisory panels.
6. SOE operational budget, final account, and capital gains	Organizes the supervised enterprises to turn the state-owned capital gains over to the state, participates in formulating management system and methods of the state-owned capital operational budget, and is responsible for working out the state-owned capital operational budget and final account and their implementation in accordance with related regulations.
7. Ensures SOEs to obey laws and safety production	Urges the supervised enterprises to carry out the guiding principles, policies, related laws and regulations and standards for safety production and inspects the results in accordance with the responsibilities as investor.
8. Draft laws, regulations, and rules	Responsible for the fundamental management of the state-owned assets of enterprises, works out draft laws and regulations on the management of the state-owned assets, establishes related rules and regulations and directs and supervises the management work of local state-owned assets according to law.
9. Other tasks	Undertakes other tasks assigned by the State Council.

Source: Official website of the State Asset Supervision and Administration Commission of the State Council, the People's Republic of China.

Table A2: Production Function and Evolution Processes Estimates

Parameter	Agri. Prod.	Food	Textile	Apparel	Leather	Timber	Paper	Printing	Cultural	Chemical
η	-5.894	-6.156	-8.132	-8.888	-8.560	-6.430	-7.922	-7.560	-9.373	-6.684
	(0.034)	(0.064)	(0.050)	(0.089)	(0.112)	(0.065)	(0.089)	(0.106)	(0.176)	(0.039)
σ	1.210	1.440	1.555	1.815	2.382	1.669	1.445	2.643	2.059	1.555
	(0.015)	(0.039)	(0.022)	(0.046)	(0.102)	(0.060)	(0.028)	(0.135)	(0.108)	(0.019)
α_L	0.042	0.076	0.077	0.126	0.100	0.074	0.067	0.122	0.117	0.058
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α_M	0.920	0.886	0.892	0.843	0.873	0.900	0.891	0.836	0.853	0.905
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
α_K	0.038	0.038	0.032	0.031	0.027	0.026	0.042	0.042	0.030	0.037
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
$\frac{1}{1-\theta}$	0.167	0.290	0.351	0.430	0.558	0.423	0.294	0.571	0.504	0.342
	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)
f_0	3.353	1.238	1.434	1.042	0.765	1.676	1.418	0.295	0.823	1.370
	(0.048)	(0.032)	(0.018)	(0.017)	(0.020)	(0.036)	(0.035)	(0.015)	(0.024)	(0.020)
f_{soe}	-0.199	-0.160	-0.069	-0.114	-0.208	-0.090	-0.092	-0.044	-0.102	-0.062
	(0.008)	(0.010)	(0.008)	(0.015)	(0.024)	(0.021)	(0.011)	(0.007)	(0.027)	(0.006)
f_{SASAC}	0.230	0.184	0.177	0.165	0.194	0.332	0.196	0.090	0.152	0.197
	(0.006)	(0.007)	(0.004)	(0.005)	(0.008)	(0.011)	(0.006)	(0.006)	(0.008)	(0.004)
f_1	0.702	0.782	0.656	0.616	0.672	0.555	0.716	0.886	0.647	0.722
	(0.004)	(0.006)	(0.004)	(0.006)	(0.008)	(0.009)	(0.007)	(0.006)	(0.011)	(0.004)
g_0	0.049	-0.038	-0.025	-0.042	-0.059	-0.103	-0.012	-0.038	-0.037	-0.034
	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)	(0.005)	(0.001)	(0.003)	(0.003)	(0.001)
g_{soe}	0.033	0.027	0.012	0.011	0.021	0.037	0.013	0.014	0.023	0.016
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.003)	(0.001)	(0.001)	(0.002)	(0.001)
g_{SASAC}	-0.027	-0.019	-0.007	-0.005	-0.012	-0.022	-0.009	-0.009	-0.006	-0.014
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
g_1	0.934	0.955	0.953	0.935	0.940	0.909	0.967	0.973	0.954	0.968
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.005)	(0.002)	(0.002)	(0.004)	(0.001)
#Obs	105955	42308	156914	87878	44174	35809	53812	36528	24505	133420

Table A3: Production Function Evolution Processes Estimates (continued)

Parameter	Medical	Rubber	Plastic	Machinery	Transp.	Telecom.	Measuring	Waste	Energy
η	-6.020	-7.253	-8.387	-7.449	-8.147	-8.844	-7.966	-7.102	-6.842
	(0.079)	(0.111)	(0.080)	(0.048)	(0.084)	(0.112)	(0.151)	(0.136)	(0.121)
σ	1.280	2.704	1.606	1.990	1.671	1.463	1.405	1.998	2.555
	(0.027)	(0.193)	(0.025)	(0.046)	(0.032)	(0.018)	(0.032)	(0.131)	(0.041)
α_L	0.081	0.088	0.071	0.089	0.093	0.090	0.110	0.086	0.154
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α_M	0.860	0.883	0.886	0.880	0.863	0.852	0.832	0.891	0.722
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
α_K	0.058	0.029	0.044	0.031	0.044	0.058	0.058	0.023	0.124
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$\frac{1}{1-\theta}$	0.208	0.567	0.363	0.484	0.386	0.304	0.280	0.537	0.563
	(0.002)	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.006)	(0.001)
f_0	1.478	0.640	1.222	0.781	0.605	0.747	0.895	1.158	0.192
	(0.041)	(0.025)	(0.022)	(0.013)	(0.015)	(0.019)	(0.030)	(0.047)	(0.009)
f_{soe}	-0.056	-0.064	-0.099	-0.034	-0.027	-0.038	-0.055	-0.122	-0.005
	(0.009)	(0.016)	(0.011)	(0.007)	(0.006)	(0.008)	(0.010)	(0.032)	(0.005)
f_{SASAC}	0.108	0.167	0.186	0.158	0.113	0.158	0.105	0.366	0.030
	(0.007)	(0.008)	(0.005)	(0.004)	(0.005)	(0.005)	(0.007)	(0.021)	(0.005)
f_1	0.792	0.762	0.680	0.743	0.833	0.818	0.793	0.584	0.961
	(0.006)	(0.010)	(0.006)	(0.004)	(0.005)	(0.005)	(0.007)	(0.015)	(0.004)
g_0	-0.021	-0.041	-0.024	-0.044	-0.025	-0.010	-0.014	-0.090	-0.027
	(0.001)	(0.004)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.009)	(0.003)
g_{soe}	0.016	0.011	0.017	0.019	0.013	0.012	0.011	0.037	-0.005
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)	(0.001)
g_{SASAC}	-0.012	-0.018	-0.010	-0.010	-0.007	-0.007	-0.009	-0.029	-0.006
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
g_1	0.951	0.973	0.952	0.970	0.980	0.991	0.958	0.912	0.992
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.008)	(0.002)
#Obs	36614	21574	85589	136895	81922	71614	32750	13051	41107

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Supplementary Materials for "Does External Monitoring from Government Improve the Performance of State-Owned Enterprises?"

by Shengyu Li and Hongsong Zhang

This appendix conducts a wide range of robustness checks to ensure that the main results are not contaminated by other driving forces in the data period. Overall, our main results are very robust to these checks.

1 Privatization

Privatization comes with not only improved monitoring and corporate governance, but also radical changes in many other aspects that potentially have an impact on both productivity and input prices. Given that many firms were privatized during the data period, it is a valid concern that the estimated impact of SASAC might be contaminated or even driven by privatization.

To rule out this possibility, we drop all observations that involve a change in ownership status during the data period. The remaining sample, as a result, contains all observations that are always SOEs or always non-SOEs from its first to the last year in the sample. Estimation results using this subsample would be free from the privatization concern. We report the results in Table OA1. All the main results are robust. In particular, SOEs still underperform in terms of both input prices and productivity compared with non-SOEs, consistent with the baseline results. SASAC reduces the input prices of SOEs by 4.6 percent and improves their productivity by 13.9 percent, relative to non-SOEs. Both estimates are very close to the baseline results in Table 3. The monitoring costs also play a similar role as in the baseline results. These findings confirm that the estimated impact of SASAC on SOEs is unlikely to be driven by privatization.

2 Market Power/Competition

As documented in section 4.1, SOEs in general are larger than non-SOEs and therefore may have greater market power. This market power may affect the markup of firms, which is picked up by the estimated productivity. The market power may also affect material prices in the input market. To check the robustness of the results to this possibility, we estimate an extended version of the main specifications (10) and (13), by controlling for the Herfindahl-Hirschman Index (HHI) at the industrial level. The results are reported in Table OA2. All the main results remain after controlling for HHI. In particular, before SASAC, SOEs paid higher input prices (by 7.6 percent) and had lower productivity (by 23.9 percent) compared with non-SOEs. The establishment of SASAC, after controlling for competition, reduces the input prices paid by SOEs by 3.9 percent and increases SOE productivity by 12.5 percent on average compared with non-SOEs. These numbers are, again, very close to the baseline results. The role of monitoring costs, as estimated and reported in column (2), (4), and (6), is very close to the baseline results in Table 5 too, qualitatively and quantitatively.

3 Potential Differential Pre-trend

To ensure further that the results are not driven by the differential pre-trend (especially for productivity), we design a two-step approach to remove the potential pre-trend and re-estimate the regression specifications. In the first step, we estimate the pre-trend of the dependent variables (input prices, productivity, and TFP) for SOEs and non-SOEs, separately using data in and before 2002, by including a time trend together with firm characteristics and a series of industry and time dummies in each regression. Then we construct the detrended dependent variables by subtracting from the original measures (input prices, productivity, and TFP) their pre-trend estimates *for all years*. Under the assumption that the pre-trend does not change after SASAC, this treatment removes the differential pre-trend between SOEs and non-SOEs. In the second step, we estimate regression specifications using the detrended dependent variables. The estimation results are reported in Table OA3. Again, all the main results are very similar to the baseline results in Tables 3 and 5. In particular, SOEs on average pay 6.9 percent more for input prices and have 23.1 percent lower productivity compared with non-SOEs before SASAC. SOEs with higher monitoring costs, as proxied by the distance to their oversight governments, have higher input prices with elasticity 0.003, and lower productivity with elasticity -0.007. The coefficient on the interaction term, $SASAC * SOE * DIST$, is almost the same as that reported in the baseline results as well. The coefficients on $SASAC * SOE$, although quantitatively smaller, are of the same sign and order of magnitude as the baseline results. In total, this suggests that the main results are not driven by the pre-trends of the two firm groups.

4 Balanced Panel

A potential concern is that the results might be driven by change in the composition of firms due to entry and exit in the data period. Indeed, entrants and exiters may be different from incumbents in input prices and productivity, and there were substantial entries and exits during the data period.[29] To address this concern, we run the regression specifications using a balanced panel, by dropping all firms that entered or exited during the data period. The estimation results are reported in Table OA4. In general, the results are consistent with the main results. SOEs pay higher input prices and have lower productivity relative to non-SOEs. Before SASAC, on average SOEs' input prices are 5.4 percent higher and productivity is 16 percent lower, both of which are at similar orders of magnitude as that estimated in the main results (i.e., 7.6 and 23.9 percent respectively) in Table 3. We also find that SASAC reduces the input price and productivity gaps between SOEs and non-SOEs substantially, by 3.0 and 10.8 percentage points, respectively. The results are again very close to the main results (3.9 and 12.6 percentage points, respectively) in Table 3. The impact of monitoring costs on firm performance is similar to the main results as well. Firms with larger external monitoring costs have higher input prices and lower productivity. The establishment of SASAC in general had a larger impact on SOEs with larger oversight distance, consistent with the main results. The results based on the traditional TFP measure are also quantitatively similar to the main results. In sum, these findings suggest that our main results are not driven by the firm entry and exit during the data period.

[29] The data set we use surveys private firms with annual sales above five million RMB (about six hundred thousand USD) and all SOEs. We define entrant and exiting as a firm enters or exits the dataset. This definition does not necessarily imply actual entry/exit of firms.

5 World Trade Organization

China joined WTO at the end of 2001. In principle, this might have had an impact on all firms in China—for example, firms were able to access a larger variety of material inputs by importing directly or purchasing from middlemen, and thus input prices could be lowered. In all of the regressions we controlled for year dummies, so the WTO effect (if common to all firms) is controlled in the analysis. Still, it is possible that the WTO membership might have had different impacts on SOEs and non-SOEs. If WTO has a larger impact on SOEs than non-SOEs in productivity and input prices, then the estimated impact of SASAC on SOE performance might be contaminated by the differential WTO effect. To examine this possibility, we estimate an extended specification by adding $WTO_t * SOE_{jt}$ to (10) and (13). If WTO has any heterogeneous impact on SOEs and non-SOEs, this additional term would pick it up. We report the estimation results in Table OA5. All the main results are robust to this additional control. The large gap in input prices and productivity between SOEs and non-SOEs remains, and the magnitude is very close to the baseline results in Tables 3 and 5. The establishment of SASAC improves SOEs' productivity and input prices, relative to non-SOEs. The magnitude of the improvement is also close to the baseline results. In addition, the monitoring costs play a similar role as in the baseline analysis.

As for the WTO effect, we do find that WTO improves the productivity of SOEs more than non-SOEs. An explanation for this effect is the increased competition after WTO, forcing SOEs, which performed worse before WTO, to improve efficiency more. But the impact of WTO on SOEs is much smaller than that of SASAC, by about one-third. Meanwhile, we find a significant but small impact of WTO on SOEs' input prices relative to non-SOEs. Compared with non-SOEs, WTO reduces SOEs' input prices by 1.0 percent on average, which is less than one-third of the impact of SASAC (3.3 percent). This small WTO impact again might be driven by the intensified competition following WTO, which forces SOEs to secure lower prices in material procurement but at a very limited magnitude. This finding confirms the result that strengthened external monitoring following SASAC had major impacts on input prices and productivity after 2004.

6 Alternative Definition of SOE

In the main results, following Huang et al. (forthcoming) and many others, we define a firm as an SOE if its share of state ownership exceeds 30 percent. Alternatively, an SOE can be defined based on the firm's registered ownership type. In our main analysis, we choose not to use this way to define SOEs because it is very noisy—some former SOEs do not change their registered ownership type after ownership restructuring. An alternative is to combine the information on state share and registered ownership type. Following Hsieh and Song (2015), we define a firm as an SOE if its state share is over 50 percent or it is registered as controlled by the state. Hsieh and Song (2015) show that the revenue share and number of SOEs calculated using this definition are very close to those reported in the *China Statistical Yearbook*. We estimate regression specifications using this definition and find that the results are very robust, as reported in Table OA6.

7 Transition Period of SASAC

In our analysis, we use 2004 as the cutoff year to define the impact of SASAC: all observations in and after 2004 are considered as being treated by SASAC. However, the establishment of SASAC took some time. Although the central government-level SASAC was established in March 2003, many of its policies and regulations were formed and announced latter in the same year. Meanwhile, province-level SASACs were established during the period between March 2003 and early 2004. Two questions emerge: (1) were firms affected by SASAC in 2003? and (2) were there other factors, such as transition costs that affected firm performance during the transition year (2003)? We check the robustness of our results to these two questions by estimating the regression specifications using a subsample after dropping the observations in the transition year (2003). The results are reported in Table OA7. All the main results of our interest are very close to those in the baseline specification. Quantitatively, the estimates of the impact of SASAC re slightly larger than those in the baseline. For example, after dropping the transition year, SASAC reduces SOEs' input prices by 4.2 percent and increase productivity by 13.8 percent. These values are slightly larger than those in the baseline (3.9 and 12.6 percent). These findings are reasonable, because if SASAC already had some impact during the transition year 2003, then dropping the observations in that year would naturally increase the estimated effects of SASAC.

8 Importing and Exporting

As is well-documented in the literature, importing and exporting may have positive impacts on productivity. Grieco et al. (2017) document that importers may have advantages in input prices. If Chinese firms were expanding imports and exports over time, then the estimate of the effect of SASAC would pick up the impact of the increased importing and exporting. To address this potential problem, we further control for lagged import and export dummies in the estimation of (10) and (13), and report the results in Table OA8.[30] We find that all the main parameters of interest are very similar to the baseline results, qualitatively and quantitatively, showing that the results are robust to controlling for importing and exporting.

9 Firm Fixed Effects

In the main results, we have controlled for a series of dummies (including province, industry, and year) and firms' registration affiliation type in all the regressions. We think that is enough to control for cross-section fixed effects, because conditional on the same industry, province, year, and registration affiliation type, the unobserved/uncontrolled heterogeneity across individual firms should be small. Given that we further controlled for a set of firm-level characteristics such as firm age, size, and capital intensity, we believe the baseline results are soundly based.

Nonetheless, to ensure further the results are robustness to firm fixed effects, we estimate two fixed effects specifications using data containing all the observations without privatized firms:

$$
\begin{aligned}
Y_{jt} &= \beta_{soe*SASAC}\left(SOE_{jt} * SASAC_t\right) + \beta_z Z_{jt} + \lambda_f + \lambda_t + \varepsilon_{jt}. && (9.1)\\
Y_{jt} &= \beta_{soe*SASAC}\left(SOE_{jt} * SASAC_t\right) + \beta_{SASAC*Dist}\left(SASAC_t * *Dist_{jt}\right) \\
&\quad + \beta_{soe*SASAC*Dist}\left(SOE_{jt} * SASAC_t * Dist_{jt}\right) + \beta_z Z_{jt} + \lambda_f + \lambda_t + \varepsilon_{jt}, && (9.2)
\end{aligned}
$$

where λ_f captures the firm-level fixed effect. Compared with the main regression in (10), we have dropped the SOE_{jt} term, province fixed effects, industry fixed effects, oversight distance, and the interaction $Dist_{jt} * SOE_{jt}$, because by definition there is no variation in these terms after controlling for firm fixed effects. Moreover, because the full panel dataset is unbalanced, with an average firm tenure of 3.63 years only, the estimates of the fixed-effects model naturally would have a high standard deviation. To avoid this issue, in the regressions we only keep firms that were included in the data for at least five years. This yields a smaller sample of 467,274 observations.

[30] The firm-level trade participation information is from the records of imports and exports from Chinese Customs. We have access to the data from 2000 to 2006 (rather than from 1998 to 2007). As a result, the number of observations is smaller than the previous ones.

We report the results in Table OA9. In general, the results are consistent with the main results. In all the regressions, we find a negative and significant effect of SASAC on input prices paid by SOEs and a positive and significant effect on productivity, relative to non-SOEs. The quantitative impacts are of similar orders of magnitude compared with the baseline results in Table 3. The role of monitoring costs is also qualitatively similar to our main results in Table 5. Overall, the main results are robust when firm fixed effects are included.

Table OA1: Robustness Check: Firms with no Privatization

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.102***	0.082***	-0.327***	-0.267***	-0.261***	-0.230***
	(0.001)	(0.002)	(0.005)	(0.009)	(0.004)	(0.007)
SASAC*SOE	-0.046***	-0.022***	0.139***	0.119***	0.115***	0.049***
	(0.001)	(0.003)	(0.006)	(0.012)	(0.005)	(0.010)
SOE*Dist		0.005***		-0.010***		-0.004*
		(0.001)		(0.002)		(0.002)
SASAC*SOE*Dist		-0.006***		0.002		0.019***
		(0.001)		(0.003)		(0.003)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Observations	776413	314870	776413	314870	776413	314870
Adjusted R^2	0.966	0.969	0.966	0.966	0.729	0.707

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA2: Robustness Check: Control for Competition in Domestic Market

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.076***	0.064***	-0.239***	-0.196***	-0.191***	-0.165***
	(0.001)	(0.001)	(0.003)	(0.007)	(0.003)	(0.005)
SASAC*SOE	-0.039***	-0.019***	0.125***	0.095***	0.094***	0.035***
	(0.001)	(0.002)	(0.004)	(0.010)	(0.004)	(0.008)
SOE*Dist		0.003***		-0.007***		-0.004**
		(0.000)		(0.002)		(0.002)
SASAC*SOE*Dist		-0.005***		0.003		0.015***
		(0.001)		(0.003)		(0.002)
HHI	-0.002***	-0.002***	0.029***	0.020***	0.009***	0.009***
	(0.000)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Observations	873367	392854	873367	392854	873367	392854
Adjusted R^2	0.967	0.970	0.966	0.966	0.726	0.708

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA3: Robustness Check: Control for Potential Pre-trend

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.082***	0.069***	-0.275***	-0.231***	-0.205***	-0.179***
	(0.001)	(0.001)	(0.003)	(0.007)	(0.003)	(0.005)
SASAC*SOE	-0.031***	-0.011***	0.072***	0.040***	0.073***	0.013
	(0.001)	(0.002)	(0.004)	(0.010)	(0.004)	(0.008)
SOE*Dist		0.003***		-0.007***		-0.004**
		(0.000)		(0.002)		(0.002)
SASAC*SOE*Dist		-0.005***		0.003		0.015***
		(0.001)		(0.003)		(0.002)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Observations	873414	392900	873414	392900	873414	392900
Adjusted R^2	0.717	0.759	0.629	0.659	0.203	0.223

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA4: Robustness Check: Balanced Panel

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.054***	0.040***	-0.160***	-0.104***	-0.132***	-0.099***
	(0.002)	(0.003)	(0.008)	(0.014)	(0.006)	(0.010)
SASAC*SOE	-0.030***	-0.015***	0.108***	0.053***	0.090***	0.038***
	(0.002)	(0.004)	(0.008)	(0.017)	(0.007)	(0.013)
SOE*Dist		0.004***		-0.017***		-0.008***
		(0.001)		(0.004)		(0.003)
SASAC*SOE*Dist		-0.004***		0.016***		0.017***
		(0.001)		(0.005)		(0.004)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Observations	133902	84825	133902	84825	133902	84825
Adjusted R^2	0.972	0.974	0.967	0.967	0.810	0.810

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA5: Robustness Check: Control for WTO Effect

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.080***	0.068***	-0.262***	-0.217***	-0.198***	-0.173***
	(0.001)	(0.002)	(0.004)	(0.007)	(0.003)	(0.005)
SASAC*SOE	-0.033***	-0.012***	0.090***	0.059***	0.084***	0.021**
	(0.001)	(0.002)	(0.005)	(0.010)	(0.004)	(0.008)
SOE*Dist		0.003***		-0.007***		-0.004**
		(0.000)		(0.002)		(0.002)
SASAC*SOE*Dist		-0.005***		0.004		0.016***
		(0.001)		(0.003)		(0.002)
WTO*SOE	-0.010***	-0.011***	0.060***	0.058***	0.018***	0.022***
	(0.001)	(0.001)	(0.004)	(0.004)	(0.003)	(0.004)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Observations	873414	392900	873414	392900	873414	392900
Adjusted R^2	0.967	0.970	0.966	0.966	0.726	0.708

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA6: Robustness Check: Alternative SOE Defintion by Hsieh and Song (2015)

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.083***	0.068***	-0.270***	-0.216***	-0.212***	-0.179***
	(0.001)	(0.002)	(0.004)	(0.007)	(0.003)	(0.005)
SASAC*SOE	-0.038***	-0.019***	0.123***	0.102***	0.094***	0.035***
	(0.001)	(0.002)	(0.004)	(0.009)	(0.004)	(0.008)
SOE*Dist		0.004***		-0.011***		-0.006***
		(0.000)		(0.002)		(0.002)
SASAC*SOE*Dist		-0.005***		0.002		0.016***
		(0.001)		(0.003)		(0.002)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Observations	873414	392900	873414	392900	873414	392900
Adjusted R^2	0.967	0.970	0.966	0.967	0.727	0.710

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA7: Robustness Check: Drop Transition Year 2003

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.079***	0.066***	-0.251***	-0.206***	-0.197***	-0.167***
	(0.001)	(0.002)	(0.004)	(0.007)	(0.003)	(0.006)
SASAC*SOE	-0.042***	-0.020***	0.138***	0.106***	0.097***	0.036***
	(0.001)	(0.002)	(0.005)	(0.010)	(0.004)	(0.008)
SOE*Dist		0.004***		-0.007***		-0.005***
		(0.000)		(0.002)		(0.002)
SASAC*SOE*Dist		-0.005***		0.003		0.016***
		(0.001)		(0.003)		(0.002)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Observations	787430	343274	787430	343274	787430	343274
Adjusted R^2	0.967	0.970	0.966	0.966	0.725	0.707

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA8: Robustness Check: Control for Import and Export

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SOE	0.073***	0.063***	-0.231***	-0.188***	-0.183***	-0.161***
	(0.001)	(0.002)	(0.004)	(0.007)	(0.003)	(0.006)
SASAC*SOE	-0.031***	-0.013***	0.109***	0.082***	0.073***	0.021**
	(0.001)	(0.002)	(0.004)	(0.010)	(0.004)	(0.009)
SOE*Dist		0.003***		-0.007***		-0.002
		(0.000)		(0.002)		(0.002)
SASAC*SOE*Dist		-0.004***		0.002		0.013***
		(0.001)		(0.003)		(0.002)
SASAC*Dist		YES		YES		YES
Dist		YES		YES		YES
Age, Size	YES	YES	YES	YES	YES	YES
R&D, K-intensity	YES	YES	YES	YES	YES	YES
Lag IMP & EXP	YES	YES	YES	YES	YES	YES
Observations	649795	301626	649795	301626	649795	301626
Adjusted R^2	0.967	0.970	0.966	0.966	0.725	0.709

Standard errors are in parentheses.

Added constant and fixed effects of province, year, industry and registration affiliation in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table OA9: Robustness Check: Firm Fixed Effects

	(1) input price	(2) input price	(3) productivity	(4) productivity	(5) TFP	(6) TFP
SASAC*SOE	-0.020***	-0.007***	0.146***	0.115***	0.055***	-0.006
	(0.001)	(0.002)	(0.005)	(0.011)	(0.006)	(0.011)
SASAC*SOE*Dist		-0.004***		0.001		0.022***
		(0.001)		(0.003)		(0.003)
SASAC*Dist		-0.002***		0.004**		0.004***
		(0.000)		(0.002)		(0.001)
Size	YES	YES	YES	YES	YES	YES
R&D,K-intensity	YES	YES	YES	YES	YES	YES
Observations	467274	216457	467274	216457	467274	216457
Adjusted R^2	0.483	0.451	0.688	0.671	0.042	0.033

Standard errors are in parentheses.

Controled for constant and year fixed effects in all regressions.

* $p < .10$, ** $p < .05$, *** $p < .01$