A Model of China's Vertical Economic Structure*

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Abstract

We model China's economy featuring a vertical structure: state-owned enterprises (SOEs) monopolize key upstream industries, whereas downstream industries are largely open to private competition. We show how the upstream SOEs extract rents from the liberalized downstream industries in the process of industrialization and globalization. The reversal of fortunes for SOEs — the profitability of SOEs exceeded that of non-SOEs around 2000 — is shown to be a symptom of the incompleteness of market-oriented reforms, which distorts factor prices, impedes structural change, depresses GDP, and reduces public welfare.

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1 Introduction

As a hallmark feature of the Chinese economy, SOEs have continuously received enormous attentions in academia and policies (e.g., Naughton (2005, 2018), Xu (2011), Szamosszegi and Kyle (2011), World Bank (2012), Lardy (2014), Huang et al. (2017)). In recent years, SOEs have become even more controversial in both domestic reform debates and international policy disagreement on the role of state in economic development (Naughton and Tsai (2015), Bardhan (2016), Dollar et al. (2020)). For example, in 2020, Chinese President Xi Jinping called for plans to make SOEs "stronger, better, and bigger" despite the open and constant complaints of the U.S. and European Union.[1]

Our paper aims to develop a theory to explain a historical puzzle about SOEs in China: why the profitability of SOEs surpassed that of non-SOEs between 2000 and 2007, right before the global financial crisis, and why the opposite was true in the 1990s (see Figure 1).[2] Our theory provides a new way to think about the whole model of China's economic development, with SOEs playing crucial roles and exerting profound and enduring impact.

[INSERT FIGURE 1 HERE]

The relative prosperity of SOEs between 2000 and 2007 is puzzling, because it seems to contradict the common notion that enhanced competition due to market-oriented reforms, including trade liberalization, hurts less efficient firms.[3] Moreover, given that the same period is one of the fastest-growing episodes after China started its reforms in the late 1970s, the phenomenon also seems at odds with the general conclusion of the resource misallocation literature that fast aggregate growth is unlikely when a large number of less productive firms (SOEs) persistently outperformed more productive ones (non-SOEs).[4]

To explain the phenomenon, we develop a simple theory of vertical structure observed in China's economy after 2000: SOEs monopolized key upstream industries (such as energy, telecommunications and finance) and also continually consolidated this power through government-arranged mergers, whereas downstream industries (such as most manufacturing of consumption goods and

[1] https://www.scmp.com/economy/china-economy/article/3108288/xi-jinping-calls-chinas-state-owned-enterprises-be-stronger .

[2] Similar patterns hold when using alternative measures such as profit per firm or profit per employment; see Li, Liu and Wang (2016). This paper focuses on the pre-2008 period, because after 2008 SOEs were obliged to implement various macroeconomic policies to fight against the global financial crisis and so on, making the analysis much more complicated. We leave it for future research.

[3] Abundant empirical evidence shows that SOEs are less productive and have lower investment efficiency than non-SOEs; see, e.g., Sun and Tong (2003), Dollar and Wei (2007), Liu and Siu (2011), Zhu (2012), Hsieh and Song (2015).

[4] See Lin et al. (1998), Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Song et al. (2011), Xu (2011).

consumption services) were mostly liberalized and became open to private competition. This under-appreciated fact of "vertical structure" will be documented in detail in Section 2.

Our core argument is as follows. Under this vertical structure, when downstream competitive non-SOEs expanded due to productivity growth and capital accumulation, demand increased for intermediate goods and services, which were monopolized by the upstream SOEs. Consequently, the upstream SOEs, even without productivity increases, would flourish more than the downstream non-SOEs. In addition, China's accession to the WTO in December 2001 created more external demand for the downstream tradeable, which ultimately enabled upstream SOEs to extract even more rents in the process of globalization. This linkage between trade and vertical structure helps explain why SOEs' profitability co-moved closely with the export-to-GDP ratio after 2001 in Figure 1, even though SOEs' share in total (direct) export was small (the share decreased from 70.20% in 1994 to 18.00% in 2008, as shown in Table A5 in Li, Liu and Wang (2016)). SOEs profitability was lower than that of non-SOEs in the 1990s because the vertical structure had not yet come into full shape. In that period, downstream industries were being liberalized, with SOEs gradually losing government protection and more productive non-SOEs entering, leading to massive bankruptcy, privatization, and exit of SOEs from these industries.

To formalize the above rent extraction mechanism within the vertical structure (i.e., upstream SOE monopoly and downstream liberalization), our general equilibrium model studies two cases: autarky and free trade. The autarky case highlights the mechanism through which SOEs in the upstream industries extract monopoly rents from the non-SOEs in the competitive downstream industries during the industrialization process (Proposition 1). We show how an increase in productivity of downstream non-SOEs and aggregate capital stock would benefit upstream SOEs through the vertical structure (Proposition 2). We also explain why the high profitability of SOEs is a worrying symptom (Proposition 3). The trade case highlights the new mechanism through which international trade facilitates industrialization and enables the upstream SOEs to extract even more rents from the downstream non-SOEs (Proposition 4). Moreover, we rationalize the vertical structure as an endogenous outcome of profit maximization of economy-wide aggregate SOE profits (Proposition 5), which captures the episode before 2000 in Figure 1.

Our paper is the first to document and theoretically model the under-appreciated vertical economic structure of China, which remains relevant today and has profound implications for China and developing/transitional economies at large. It is related to four strands of literature.

First, our paper sheds new light on structural change and economic growth by introducing the vertical structure into the non-agriculture sector (see Herrendorf et al. (2014), Monge and Lin (2019), Ngai et al. (2019)). We show how upstream monopolist firms benefit from industrialization and trade openness, but they impede industrialization and lower GDP simultaneously, whereas the existing literature typically assumes a horizontal structure (i.e., reallocation across horizontally substitutable sectors with symmetric market structures).[5] Second, our model contributes to the literature on economic transition and institutions, especially the role of state in development, by analyzing the vertical structure as a new aspect of partialness in market-oriented reforms (see Roland (2000), Xu (2011), Naughton (2018)). Specifically, we show how the vertical structure endogenously emerged, how it caused the subsequent prosperity of SOEs, and why it was an undesirable symptom of partial reforms instead of evidence against further SOE reforms. Therefore, our paper echoes the view that partial reforms have pitfalls.[6] Our model also illustrates a new type of development paradigm, in which the state runs the economy by controlling the commanding height (i.e., key upstream sectors) in the process of (downstream) liberalization, industrialization and globalization (see Wen (2015), Bardhan (2016), Xiong (2020)).[7] Third, our paper is related to the literature studying SOEs in China. While the existing literature has intensively discussed various sources and symptoms of SOE inefficiency such as misalignment of managerial incentives, state property rights, extra social and policy objectives, factor market distortions (especially financial market) and information asymmetry,[8] we highlight the SOE monopoly of upstream intermediate inputs as a new and independent source of inefficiency. Our general equilibrium model also explains why this inefficiency can be sustained and what the implications are. Fourth, our paper complements the existing literature on resource misallocation, which largely assumes a horizontal structure,[9] by showing how the vertical structure could generate opposite results. Namely, when the productivities of private firms increase in a sector, it would enhance profits of SOEs in the upstream sector but hurt profits of SOEs in a horizontally substitutable sector (with substitution elasticity larger than unity, as required by well-defined monopoly or monopolistic competition).[10]

2 Background and Facts

This section first briefly reviews the history of China's SOE reforms and then documents quantitative facts about the vertical structure. More detailed evidence on vertical structure is provided

[5] Exceptions include Sposi (2019), but his focus is not on SOEs or China. Other Recent literature on China's structural change includes Cao and Birchenall (2013), Yao and Zhu (2020) and Fang and Herrendorff (2021), but none of them examines the role of vertical structure.

[6] For analyses emphasizing the negative side of gradualism and/or partial reforms, see Bruno (1972), Murphy et al. (1992), Young (2000), Xu (2011), etc. For more positive views, see Lau et al. (2000), Roland (2000), Che (2009), Lin (2009), Wang (2015), etc.

[7] See also Wang (2013), Naughton and Tsai (2015).

[8] See, e.g., Groves et al. (1994), Li (1997), Lin et al. (1998), Naughton (2005, 2018), Hsieh and Klenow (2009), Song et al. (2011), Hsieh and Song (2015), Huang et al. (2017).

[9] See, e.g., Hsieh and Klenow (2009), Moll (2014), Itskhoki and Moll (2019), David and Venkateswaran (2019).

[10] Liu (2019) builds a model of production networks to show that subsidizing upstream sectors may improve welfare when market imperfections exist, but his model does not focus on explaining the profitability differences between SOEs and non-SOEs, nor does it analyze the role of structural change and trade globalization as in our paper. Jones (2013) discusses misallocation with vertical linkages, but not specifically about SOEs or China.

in Li, Liu and Wang (2016).

2.1 Brief History of China's SOE Reforms

Until the start of "reform and open up" in 1978, virtually all firms in China were SOEs or collectively-owned in both upstream and downstream industries. During the 1980s, the first stage of SOE reforms started, focusing on increasing enterprise autonomy through a system that required managers to meet performance targets in return for retained profit. This system initially improved SOEs' performance (Groves et al. (1994), Li (1997)). However, it quickly ran into trouble because managers were rewarded for success but not punished for failure and they were able to exploit their effective control over SOE assets. The second stage of SOE reforms began after the historical Southern tour of Deng Xiaoping in 1992. The state eventually launched a so-called "three-year battle" to restructure SOEs between 1998 and 2000.

Massive privatization of SOEs and layoffs of tens of millions began in 1995, when the central government formally set the policy of "nurturing the large and letting the small go". The central government explicitly pursued the strategy of retaining state control of 500 to 1,000 large SOEs in strategic sectors, where competition was severely restricted through administrative regulation.[11] Meanwhile, the government shut down or privatized most of the small and medium-sized SOEs, which were typically located in downstream industries such as footwear and apparel (Lin et al. (1998), Hsieh and Song (2015) and Naughton (2005, 2018)).

Throughout and after this round of SOE reform, central SOEs consolidated their monopoly position in upstream industries and reinforced their advantageous position even further through reorganizations such as mergers and groupings within the same industry. Since the upstream industries are generally in nontradable or regulated sectors, central SOEs were still shielded from competition after the WTO entry. By contrast, non-SOEs faced fierce competition in the largely liberalized downstream industries, which are typically tradeable and open to foreign direct investment. Overall, the monopoly position of SOEs in upstream industries was protected and strengthened while the downstream industries became more competitive.

2.2 Stylized Facts of Vertical Structure

This subsection first documents the quantitative facts about profitability of SOEs versus non-SOEs since 1993. It then provides evidence on the development of the vertical structure of China's economy.

[11] The State-Owned Assets Supervision and Administration Commission (SASAC hereafter) designated defense, electric power and grid, petroleum and petrochemical, telecommunications, coal, civil aviation, and shipping to be strategic industries. These turned out to be mostly upstream sectors.

Figure 2 divides the industrial sector into two groups based on profit margin (i.e., profit-to-revenue ratio) and compares the SOE shares in these two groups from 1995 to 2009. The left panel shows that SOEs always have a significantly higher presence in the high-profit-margin group than the other group, although both numbers decline over time. The right panel shows that, relative to 1995, SOEs' presence declined more dramatically in the low-profit-margin group. This unbalanced compositional shift indicates that sectorial asymmetry is an important aspect of the relative performance of SOEs versus non-SOEs illustrated in Figure 1.[12]

[INSERT FIGURE 2 HERE]

The next few tables and figures document the under-appreciated feature of vertical structure.[13] Figure 3 compares the value-added shares of SOEs in upstream and downstream industries within the industrial sector from 1995 to 2007. It shows that SOEs consistently dominated in the upstream industries, whereas their presence in downstream industries was not only low but also decreased more dramatically in percentage terms. Further, Table 1(a) reports the robust regression results showing that, even after controlling for industry-level capital intensities, SOEs are still disproportionately concentrated in upstream industries. Table 1(b) presents two other important facts about vertical structure. First, both the Lerner Index and the average revenue-based Herfindahl-Hirschman Indices (HHI) of the upstream industries were more than twice as large as those of downstream industries during the 2000s, suggesting a less competitive market structure in the upstream industries than downstream ones. Second, upstream output almost exclusively served the domestic market, whereas the downstream industries were much more export-oriented. For the industrial sector, the export-to-output ratio (export exposure) is 21.9% in the downstream industries versus 5.5% in the upstream industries. The upstream-downstream difference in export exposure is presumably even more striking for the whole economy after nontradable service sectors are also included. Even though some upstream inputs or services are technically tradable, but downstream private firms must purchase from domestic upstream SOEs rather than importing directly due to government regulations.[14] Table 1(c) shows that the vertical structure is a salient feature of China when considering the largest firms.

[INSERT FIGURE 3 and TABLE 1 HERE]

[12] We also decompose Figure 1 into upstream and downstream industries, showing that, conditional on the same ownership type, upstream firms enjoyed a greater profitability than downstream firms. Moreover, upstream SOEs experienced a faster growth in profitability than downstream non-SOEs (see Figure A1 in the appendix).

[13] Table A1 in the appendix provides the upstreamness indexes for each industry and describes how upstream and downstream industries are classified accordingly.

[14] Petroleum is a case in point. China is a net importer of raw petroleum. However, virtually no downstream private firms are allowed to directly import oils from abroad; instead, they must purchase oil or related products from domestic upstream SOEs such as Sinopec Group and China National Petroleum.

The facts documented above apply to the industrial sector. The same features remain true at the national level, although data availability is severely limited, especially time series data for various performance measures (see Figure A2).

3 Model

In this section, we first develop a general equilibrium model of vertical structure with structural change based on the facts documented in Section 2. We study autarky and open economy sequentially. Then we rationalize the emergence of vertical structure as an equilibrium outcome.

3.1 Autarky

3.1.1 Model Environment

Consider a closed economy populated by a continuum of agents with measure equal to unity. Agents are divided into two groups: an elite class with measure equal to $\theta \in (0,1)$ and the grassroots with measure $1-\theta$. Agents are identical within each group. The economy has two sectors: an agricultural sector producing the numeraire good n and an industrial sector. Within the industrial sector, there is a vertical structure with the upstream industry producing intermediate good m and the downstream industry producing a composite consumption good d. All the agents share the following utility function

$$u(c_n, c_d) = c_n + \frac{\epsilon}{\epsilon-1} c_d^{\frac{\epsilon-1}{\epsilon}}, \ \epsilon > 1, \tag{1}$$

where c_n and c_d denote consumption of good n and good d, respectively. ϵ is the price elasticity of demand for good d. Both c_n and c_d must be nonnegative. All technologies are constant returns to scale. One unit of labor produces A_n units of good n. To produce good d requires capital k, labor l, and intermediate good m. The production function is

$$F_d(k, l, m) = Ak^{\alpha} l^{\beta} m^{1-\alpha-\beta}, \tag{2}$$

where $\alpha \geq 0, \beta > 0, \alpha+\beta < 1$. The intermediate good m is produced with the following technology:

$$F_m(k, l) = A_m k^{\gamma} l^{1-\gamma}, \tag{3}$$

where $\gamma \in [0,1)$. Each agent, elite or grassroots, is endowed with L units of time (labor) and K units of capital. Good m is produced by a monopolist firm, which is owned by the "state" but fully controlled by the elite class as if the elite class owns it. Good n and good d are produced by competitive privately owned enterprises (POEs hereafter), which are owned by the grassroots. Only the upstream market is a monopoly, whereas all other goods and factor markets are perfectly competitive with free entry. The sectorial asymmetry in both state ownership and market structure (upstream SOE monopoly plus downstream POEs perfect competition) is referred to as the "vertical structure", as documented in Section 2.

3.1.2 Characterizing Equilibrium

Let W, R, p_n, p_d, and p_m denote the wage, rental price of capital, prices of good n, downstream good d, and intermediate good m, respectively. Without loss of generality, normalize p_n to one. Perfect competition with free entry in the downstream sector implies that the price equals the marginal cost:

$$p_d = \frac{R^{\alpha} W^{\beta} {p_m}^{1-\alpha-\beta}}{A\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}. \tag{4}$$

Applying Shephard's Lemma on (4), together with the aggregate demand for m derived from household utility maximization, we obtain:

$$D_m = (1-\alpha-\beta)\cdot p_n^{\epsilon}\cdot [\frac{R^{\alpha}W^{\beta}}{A\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}]^{1-\epsilon}\cdot {p_m}^{-[(1-\alpha-\beta)(\epsilon-1)+1]}. \tag{5}$$

The upstream monopolist SOE maximizes its profit, which implies

$$p_m = \mu \frac{R^{\gamma}W^{1-\gamma}}{A_m\gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}}, \tag{6}$$

where μ is the endogenous markup given by

$$\mu \equiv \frac{(1-\alpha-\beta)(\epsilon-1)+1}{(1-\alpha-\beta)(\epsilon-1)} > 1, \tag{7}$$

because the price demand elasticity for m from downstream good d is $(1-\alpha-\beta)(\epsilon-1)+1$, as shown in (5).[15]

The labor market clearing condition is given by

$$L = \underbrace{D_m \frac{\partial \frac{R^{\gamma}W^{1-\gamma}}{A_m\gamma^{\gamma}(1-\gamma)^{1-\gamma}}}{\partial W}}_{\text{by producer of intermediate good } m} + \underbrace{D_d\frac{\partial p_d}{\partial W}}_{\text{by producers of downstream good } d} + \underbrace{D_n\frac{1}{A_n}}_{\text{by producers of good } n}, \tag{8}$$

where D_d and D_n denote aggregate demand for goods d and n, respectively. To ensure $D_n > 0$, we require that $L > \overline{L}$, where $\overline{L}$ denotes the total industrial employment, or the sum of the first two terms on the right-hand side of (8). As long as good n is produced (i.e., $L > \overline{L}$), wages are equal

[15] For simplicity, this baseline model aims to capture the rent extraction mechanism of upstream SOEs via the vertical structure. Discussions on how to obtain endogenously variable markups (profit margins) that can match Figure 1 more closely are provided in Li, Liu and Wang (2016).

to the marginal product of labor in the agriculture sector:

$$W = A_n, \tag{9}$$

which implies that wage increases with agricultural productivity A_n but does not change with K, A_m, A, or L.[16] The capital market also clears:

$$K = \underbrace{D_m \frac{\partial \frac{R^\gamma W^{1-\gamma}}{A_m \gamma^\gamma (1-\gamma)^{1-\gamma}}}{\partial R}}_{\text{by producer of intermediate good } m} + \underbrace{D_d \frac{\partial p_d}{\partial R}}_{\text{by producers of downstream good } d}. \tag{10}$$

By combining (10), (4), (6) and (9), we obtain the equilibrium prices as summarized in the following lemma.

Lemma 1 *Suppose L is sufficiently large (or, more precisely, inequality (17)). There exists a unique equilibrium, in which wage W is given by (9) and the other prices are given by*

$$R = \varkappa^\xi \left[\left(A_n^{\alpha+\gamma(1-\alpha-\beta)-1} A_m^{1-\alpha-\beta} A \right)^{\epsilon-1} K^{-1} \right]^\xi, \tag{11}$$

$$p_m = \frac{\mu \varkappa^{\xi\gamma} A_n^{1-\gamma} A_m^{-1}}{\gamma^\gamma (1-\gamma)^{1-\gamma}} \left[\left(A_n^{\alpha+\gamma(1-\alpha-\beta)-1} A_m^{1-\alpha-\beta} A \right)^{\epsilon-1} K^{-1} \right]^{\xi\gamma}, \tag{12}$$

$$p_d = \left(\frac{\gamma(1-\alpha-\beta)+\alpha\mu}{\varkappa^\xi \mu} \right)^{\frac{1}{\epsilon-1}} \left[A_n^{\alpha+\gamma(1-\alpha-\beta)-1} A_m^{1-\alpha-\beta} A K^{\alpha+\gamma(1-\alpha-\beta)} \right]^{-\xi}, \tag{13}$$

where $\varkappa$ and ξ are exogenous parameters defined as

$$\varkappa \equiv \frac{\gamma(1-\alpha-\beta)+\alpha\mu}{\mu} \left\{ \frac{\left[\frac{\mu}{\gamma^\gamma (1-\gamma)^{1-\gamma}} \right]^{1-\alpha-\beta}}{\alpha^\alpha \beta^\beta (1-\alpha-\beta)^{1-\alpha-\beta}} \right\}^{1-\epsilon}, \tag{14}$$

$$\xi \equiv \frac{1}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}. \tag{15}$$

Observe that (12) implies $\frac{\partial p_m}{\partial A} > 0$, that is, an increase in the TFP of downstream private firms yields a higher price of good m monopolized by the upstream SOE. This is due to the general equilibrium effect that R is driven up as the marginal productivity of capital increases ($\frac{\partial R}{\partial A} > 0$ implied by (11)), so p_m increases with the upstream production cost as the markup stays unchanged. On the other hand, (13) implies $\frac{\partial p_d}{\partial A_m} < 0$, that is, a more productive upstream SOE helps lower the price of the downstream good produced by private firms. This is because an increase in the

[16] When all the labor has been absorbed into the industrial sector (that is, the economy has passed the so-called "Lewis turning point"), the equilibrium wage shall depend on K, A_m, A, and L. See the details in Section 5 of Li, Liu and Wang (2016).

upstream TFP lowers p_m (as implied by (12)), which dominates the resulting increase in R.

We can easily obtain the total industrial employment:

$$\overline{L}(A_n, A, A_m, K) \equiv \varkappa^{\xi} \frac{(1-\gamma)(1-\alpha-\beta)+\beta\mu}{\gamma(1-\alpha-\beta)+\alpha\mu} \left[\frac{\left(A_m^{1-\alpha-\beta}A\right)^{\epsilon-1}}{A_n^{\epsilon}} \right]^{\xi} K^{1-\xi}. \tag{16}$$

An increase in industrial productivity, A or A_m, will attract more labor from the agricultural sector into the industrial sector, whereas an increase in agricultural productivity A_n has the opposite effect on industrialization. Industrialization is also facilitated by capital accumulation ($\frac{\partial \overline{L}(A_n,A,A_m,K)}{\partial K} > 0$), as it tends to increase the marginal product of labor in the industrial sector. To ensure that the grassroot agents also consume good n, we must require:

$$L > \frac{\mu-\gamma(1-\alpha-\beta)-\alpha\mu}{(1-\gamma)(1-\alpha-\beta)+\beta\mu} \overline{L}(A_n, A, A_m, K), \tag{17}$$

which we impose throughout the paper. Observe that $\frac{\mu-\gamma(1-\alpha-\beta)-\alpha\mu}{(1-\gamma)(1-\alpha-\beta)+\beta\mu} > 1$.

Proposition 1 *Suppose (17) is true. In the autarky equilibrium, the upstream SOE's profit* Π_m *and the total GDP (per capita)* Y *are given by*

$$\Pi_m = \frac{(1-\alpha-\beta)(\mu-1)}{(1-\gamma)(1-\alpha-\beta)+\beta\mu} \overline{L}(A_n, A, A_m, K) A_n, \tag{18}$$

$$Y = \left[L + \frac{\alpha\mu+(1-\alpha-\beta)(\gamma+\mu-1)}{(1-\gamma)(1-\alpha-\beta)+\beta\mu} \overline{L}(A_n, A, A_m, K) \right] A_n, \tag{19}$$

where $\overline{L}(A_n, A, A_m, K)$ *is given by (16).*

Proposition 1 is a novel result of our paper. It underscores, before the economy passes the "Lewis turning point" (i.e., $\overline{L} < L$), how the key macroeconomic variables in our model are related to structural change (industrialization) characterized by $\overline{L}$. (18) implies that the upstream SOE profit is proportional to the total industrial employment $\overline{L}(A_n, A, A_m, K)$, reflecting the fact that the upstream extracts more rent as industrialization deepens. (19) indicates that GDP strictly increases with total industrial employment $\overline{L}$, revealing that structural change drives up total output. Also, (19) and (16) together imply that aggregate output exhibits decreasing returns to scale with respect to the factor inputs, even though all the technologies are constant returns to scale. This "efficiency loss" is due to the upstream SOE extracting monopoly rent.

To highlight the determinants of the upstream SOE's profit, we summarize the comparative static results of (18) as follows.

Proposition 2 *Suppose (17) is true. In the autarky equilibrium, an increase in the productivity of* *downstream POEs will increase the monopoly profit of the upstream SOE ($\frac{\partial \Pi_m}{\partial A} > 0$). The upstream SOE's profit will also increase with its own TFP and total capital stock ($\frac{\partial \Pi_m}{\partial A_m} > 0$ and $\frac{\partial \Pi_m}{\partial K} > 0$).*

Proposition 2 states that, under the vertical structure, an increase in the productivity of private firms in the downstream industry actually benefits the upstream SOE ($\frac{\partial \Pi_m}{\partial A} > 0$).[17] This is a key result of the paper. The intuition is as follows. First, an increase in the downstream productivity A lowers the price for the downstream final good ($\frac{\partial p_d}{\partial A} < 0$) and hence increases its demand ($\frac{\partial D_d}{\partial A} > 0$), which in turn raises the demand for the upstream intermediate good ($\frac{\partial D_m}{\partial A} > 0$). Second, an increase in the downstream productivity A increases the equilibrium price for the upstream intermediate good ($\frac{\partial p_m}{\partial A} > 0$ as explained earlier) and hence also increases the profit margin ($\frac{\mu - 1}{\mu} p_m$). These two forces jointly generate a higher profit for the upstream SOE ($\frac{\partial \Pi_m}{\partial A} > 0$). Note that the prediction is exactly opposite in the horizontal structure when SOEs and non-SOEs are located in horizontally substitutable sectors, as usually assumed in the resource misallocation structure (see the formal mathematical proof in the appendix; Li, Liu and Wang (2016) also provide robust confirming regression results using China's firm-level data (Section 7)).

The following proposition characterizes the equilibrium when the upstream monopoly is completely eliminated (i.e., free entry) so that the upstream market is perfectly competitive.

Proposition 3 *Suppose (17) is true. Under certain mild regularity conditions, when the upstream industry is fully liberalized and hence becomes perfectly competitive, the rental price of capital will rise, both the intermediate good and the downstream good will become cheaper, total industrial employment and total GDP will both become larger, and the welfare of the grassroots will be strictly higher whereas the elite group will become strictly worse off.*

The intuition for Proposition 3 is the following. Eliminating the upstream monopoly lowers p_m, which in turn lowers p_d. Therefore, the output of good d increases, absorbing more labor from the agricultural sector. It, in turn, drives up R. GDP expands primarily because the elimination of the upstream monopoly facilitates structural change, moving more labor from the relatively low value-added agricultural sector to the relatively high value-added industrial sector. The total capital income rises because the increase in the total rental income of capital (RK) more than compensates for the dissipation of the monopoly profit (Π_m). Meanwhile, W stays unchanged, as ensured by $L > \overline{L}$. So the total GDP increases from the factor income point of view.

From 2001 to 2007 China witnessed a more rapid increase in the profits of SOEs than private firms, while the aggregate GDP continued to rise steadily. As such, SOE defenders claimed that SOEs contributed significantly to China's economic exuberance and there was no need for major

[17] Not surprisingly, the upstream SOE's profit also increases with its own TFP ($\frac{\partial \Pi_m}{\partial A_m} > 0$) and the capital stock K ($\frac{\partial \Pi_m}{\partial K} > 0$).

reforms as SOEs performed better than non-SOEs. Our analysis stresses an opposite view: the unusual prosperity of SOEs was an undesirable symptom of the incompleteness of the SOE reforms. In particular, Proposition 1 and Proposition 2 show that both total GDP and the upstream SOE's profits would increase when the TFP of downstream private firms increases, even if the TFP of the upstream SOE remains unchanged. In other words, high profits of the upstream SOE can be merely a consequence rather than a cause of economic growth; it was the downstream private firms that were the key engine for the GDP expansion. In fact, Proposition 3 makes it clear that SOE monopoly undermines GDP and welfare.[18]

If the financial market is plagued by contracting frictions with collateral constraints akin to Kiyotaki and Moore (1997), then the more profitable upstream SOEs would enjoy advantages over downstream private firms in obtaining more favorable loans, *ceteris paribus*. Alternatively speaking, factor market discriminations can be the consequence, rather than the cause, of the high profitability of SOEs.[19] Another logical implication of our model is that upstream SOEs would benefit disproportionately more than downstream POEs if rural-urban migration costs are reduced (recall the *Hukou* system in China).

3.2 Open Economy

Now we extend our analysis to study how international trade affects the profit of the upstream SOE through the vertical structure. Trade globalization is particularly relevant for China's reforms and development, especially after its accession to the WTO in 2001.[20]

Consider a world with two countries, home (H) and foreign (F). The home economy is China, identical to the one specified in Section 3.1. Country F is a developed economy populated with a continuum of identical households with measure equal to unity. Each household is endowed with L^* units of labor and has the same preferences as households in country H, given by (1). For simplicity, we assume that all firms in country F are private and no capital or intermediate good is needed in production. Each foreign firm has free access to the following constant-returns-to-scale technologies: One unit of foreign labor, interpreted as a composite of raw labor and associated human capital, can produce either A^* units of good n or one unit of good d. All markets are perfectly competitive in country F. Trade is free between the two countries. This is a hybrid of Ricardian and Heckscher-Ohlin trade models. Without loss of generality, A_n is normalized to unity.

[18] Our model also implies that privatizing upstream SOEs without eliminating their administrative monopoly does not help (imagine what would happen in a model if the upstream SOE, keeping the monopoly position, is now privately owned by a brother of a politician). The effective way is to dismantle entry barriers to upstream sectors and create a level playing field.

[19] In an extended quantitative model (available upon request) with both upstream monopoly and financial frictions, we quantitatively evaluate the magnitude of welfare loss caused by these two distortions. Counterfactual results show that both caused significant welfare loss, but upstream monopoly was more harmful.

[20] See, e.g., Khandelwal et al. (2014) and Brandt et al. (2017).

To make our analysis relevant for China, we focus mainly on the case in which country H has comparative advantage in good d, which may be interpreted as a composite of manufacturing goods. Specifically, country H exports d and imports good n, interpreted as agricultural products (and tradable services). Moreover, the labor endowment in country H is sufficiently large so that in equilibrium country H produces and consumes both good d and good n and Country F also consumes both but only produces good n. The necessary and sufficient conditions for this equilibrium pattern are given in the appendix.

Lemma 2 *Under certain conditions (given in the appendix), in the free trade equilibrium, the upstream SOE's profit and total GDP in country H are given by*

$$\Pi_m = \frac{(1-\alpha-\beta)(\mu-1)}{(1-\gamma)(1-\alpha-\beta)+\beta\mu}\overline{\overline{L}}(A, A_m, K), \tag{20}$$

$$Y = \left[L + \frac{\alpha\mu + (1-\alpha-\beta)(\gamma+\mu-1)}{(1-\gamma)(1-\alpha-\beta)+\beta\mu}\overline{\overline{L}}(A, A_m, K)\right], \tag{21}$$

where $\overline{\overline{L}}(A, A_m, K)$ *is the total industrial employment in country H and is given by* $\overline{\overline{L}}(A, A_m, K) \equiv 2^{\xi}\overline{L}(1, A, A_m, K)$*, with* ξ *given by (15) and* $\overline{L}$ *given by (16).*

Compared with the autarky equilibrium (Proposition 1), the only difference is that now $\overline{L}(A_n, A, A_m, K)$ is replaced by $\overline{\overline{L}}(A, A_m, K)$ in the formulas, reflecting the fact that international trade scales up the total demand for (and hence the output of) the downstream good d. The comparative static results are also similar to those in Proposition 2. The comparison between autarky and open economy is stated in Proposition 4.

Proposition 4 *The monopoly profit of the upstream SOE and the GDP in country H are larger in the free trade equilibrium than in autarky.*

The result of Proposition 4 is due to $\overline{\overline{L}}(A, A_m, K) > \overline{L}(1, A, A_m, K)$, which precisely reflects the fact that trade openness boosts industrialization by absorbing more labor into the industrial sector, producing higher upstream profit and higher GDP.

This simple model formalizes an important and novel mechanism for how the high profitability of SOEs in China depends on international trade. Entering WTO in 2001 facilitated China's downstream exports and hence increased the induced aggregate demand for the upstream goods and services monopolized by SOEs. Consequently, upstream SOE profits rose with trade liberalization and, in fact, also with all export-facilitating policies such as export subsidies or currency devaluation.

Moreover, the analysis also suggests that a small change in external demand may cause a large change in the upstream SOE's profits due to the markup price effect. This is consistent with

Figure 1, which shows that SOE profitability increased disproportionately more than the non-SOEs' profitability when exports expanded until 2007. SOE profitability dropped more dramatically than non-SOEs' profitability when confronted by negative external demand shocks in 2008 during the global financial crisis. This may explain why SOE profitability co-moves closely with the export-to-GDP ratio even though upstream SOEs do not directly participate in trade. If the economic structure is horizontal, then we would not be able to simultaneously explain all of the features observed in Figure 1.

3.3 Emergence of Vertical Structure

The previous two subsections capture what happened after the vertical structure came into full shape after the massive privatization of downstream SOEs in the late 1990s. This subsection serves two purposes. One is to rationalize how the vertical structure endogenously emerged before 2000. The other is to explain why private firms outperformed SOEs in terms of profitability during the 1990s, before the vertical structure fully emerged, as shown in Figure 1.

Consider the same setting of autarky in Subsection 3.1 except that now the downstream good d is an aggregate of a continuum of differentiated goods:

$$c_d = \left(\int_0^1 c(i)^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}}, \text{ for } \eta > 1 \tag{22}$$

where $c(i)$ is consumption of differentiated good i, $i \in [0,1]$, and η is the elasticity of substitution. A downstream sector i is called liberalized if entry to that sector is free, and SOEs and non-SOEs are engaged in perfect competition. The production function for a firm in industry i is still given by (2) for each $i \in [0,1]$, where $A = A_p$ if it is a private firm, and $A = A_s$ if it is a state firm. We assume $A_s < A_p$. Let ϕ denote the fraction of downstream industries that are liberalized. The remaining $1 - \phi$ fraction of the industries are regulated such that each of them is monopolized by one state firm. From Section 2, we know that $\phi = 0$ holds before the downstream liberalization. $\phi = 1$ refers to the fully-blown vertical structure. Obviously, without subsidies, downstream SOEs are replaced by competitive private firms in the liberalized industries. In those regulated downstream industries, SOEs are delegated to different managers so they are engaged in monopolistic competition. Suppose the elite group (SASAC in reality) maximizes the economy-wide total profits of all SOEs by choosing ϕ.

Proposition 5 *(Endogenous Vertical Structure) In equilibrium, the profit-maximizing elite group chooses to only monopolize the upstream sector and fully liberalizes the downstream sectors ($\phi = 1$)*

when private firms are sufficiently more productive than state firms:

$$\frac{A_p}{A_s} > \left(\frac{\eta-1}{\eta}\right)\left[\frac{\eta-1}{\eta} + \frac{\mu}{\eta(\mu-1)(1-\alpha-\beta)}\right]^{\frac{1}{\eta-1}}.$$

The intuition is as follows. When a downstream industry is liberalized, the SOE in that industry will lose profit. On the other hand, this liberalized downstream industry will have a larger demand for upstream input than before, which increases the upstream SOE's profit. In addition, the profit of the remaining monopolist SOEs in the downstream industries will be reduced due to the cross-industry substitution effect. It turns out that when $\frac{A_p}{A_s}$ is sufficiently large, the indirect profit gain in the upstream industry from downstream liberalization dominates the direct SOE profit loss in all the downstream industries. Thus it pays to liberalize all downstream industries. This explains the endogenous emergence of the vertical structure (upstream SOE monopoly plus downstream private competition with free entry).

As Figure 1 shows, SOEs were less profitable than non-SOEs in the early 1990s and the gap widened substantially between 1994 and 1998. SOEs experienced a sharp increase in profitability between 1998 and 2000, a period featuring massive privatization of downstream SOEs and consolidation of upstream SOEs (the "three-year battle" mentioned in Section 2), and finally SOEs surpassed non-SOEs in profitability around 2000 when vertical structure emerged. We argue that this phenomenon is due to the gradual liberalization of downstream industries in the 1990s, a process through which the vertical structure gradually emerged. As documented in Section 2, the market-oriented economic reform accelerated after 1992 and the openness to foreign direct investment (FDI) and trade also deepened. With the entry and expansion of high-productivity non-SOEs, domestic or foreign, in liberalized downstream sectors, SOEs and non-SOEs competed in a horizontal structure, many SOEs had to rely on subsidies from the government or other SOEs to survive. This drove down the average profitability of SOEs. During the period of massive SOE privatization in the downstream industries in 1998-2000, most of the money-losing SOEs exited from the competitive downstream industries and, therefore, the average profitability of SOEs started to rise. The vertical structure came into full shape around 2001, and the fortune of SOEs as a whole was reversed.

4 Conclusion

We develop a simple model of vertical structure, in which upstream industries are controlled by the state via SOE monopoly, whereas downstream industries are largely liberalized and operate under private competition. Our model could not only resolve the specific historical puzzle in China as seen in Figure 1, but also provide a novel and potentially useful framework for economic development in general, which hopefully helps generate new insights on varieties of issues in the past, present and future, both for China and beyond.[21]

[21] Li, Liu and Wang (2016) also discuss sustainability of the vertical-structure model in China (especially the plunging SOE profitability after 2008), draw general implications from the variants of this model for India, Russia and Vietnam, differentiate natural versus administrative monopoly, and so on.

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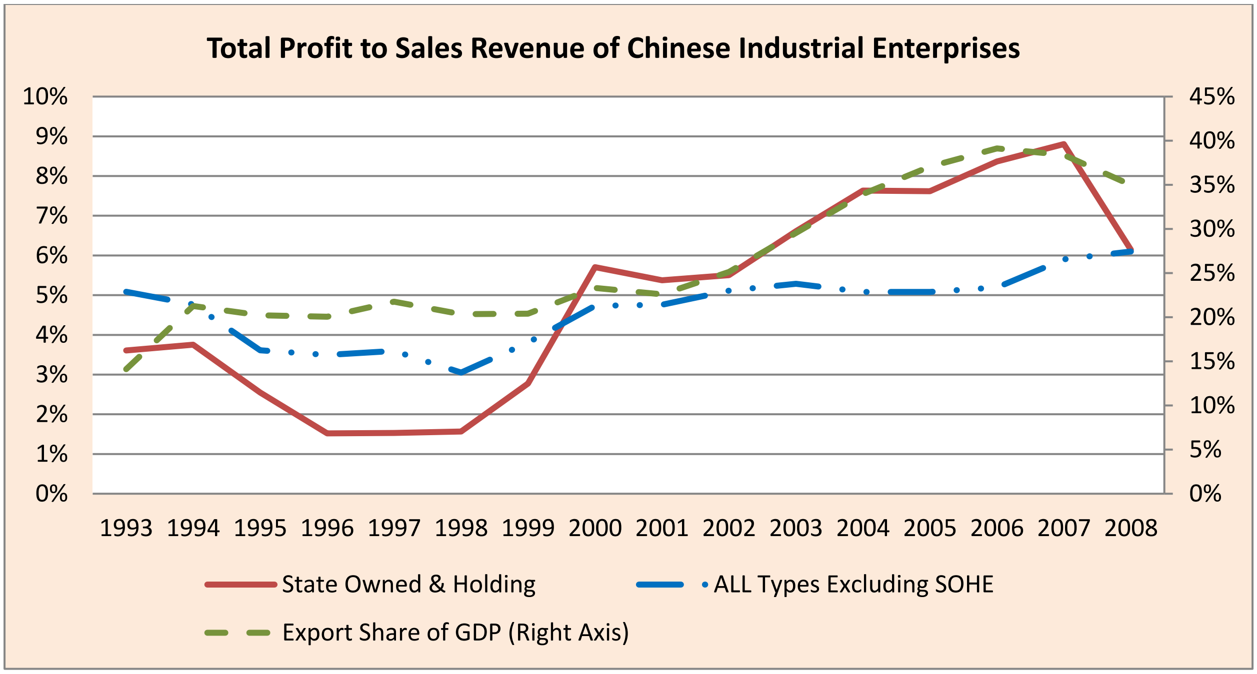


Figure 1: Total profit to sales revenues of Chinese enterprises in the industrial sector. We use CEIC (Table CN.BF: Industrial Financial Data: By Enterprise Type) to obtain total profit to sales revenue. In this table, CEIC categorizes industrial enterprises into state owned & holding, private, HMT & foreign, collective owned, shareholding corporations, foreign funded, and Hong Kong, Macau & Taiwan funded. We divide all the industrial enterprises into state owned & holding and the rest.

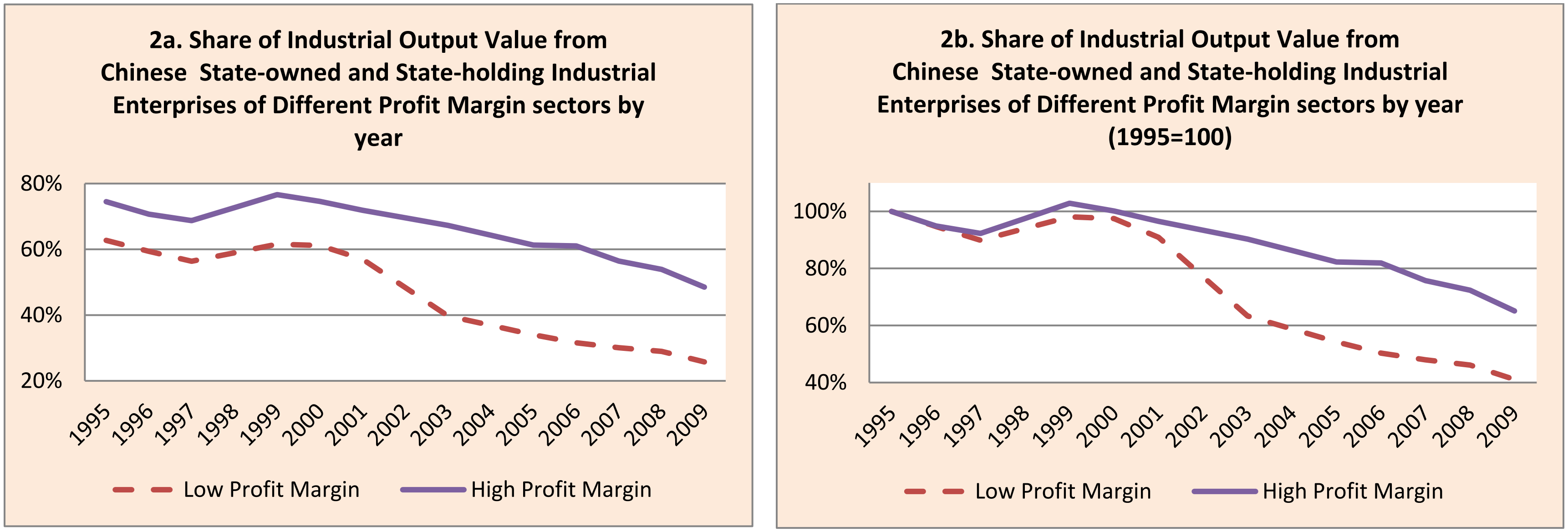
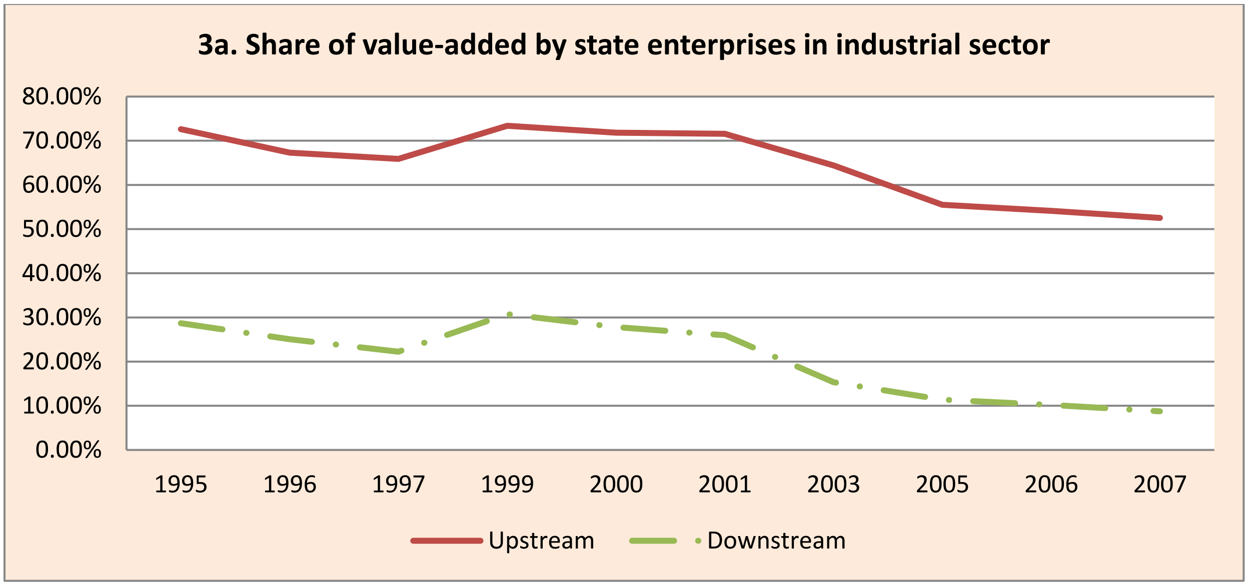


Figure 2: Share of output value from state enterprises in the industrial sector. The criterion that we use to break down the share of the state enterprises' gross industrial output value (GIOV) is profit margin from 1995-2009. Related data are from CEIC (Table CN.OE03 and 04). The low profit margin subsectors are those with less than or equal to 5% profit margin, which include subsectors such as textiles and agriculture. The high profit subsectors are those with greater than 10% profit margin, which include subsectors such as petrochemical, tobacco, and pharmaceuticals. In Figure 2a, the vertical axis is GIOV of the state enterprises as a percentage of total GIOV. GIOV of all enterprises is from CEIC (Table CN.BD03: Gross Industrial Output: By Industry). GIOV of the state enterprises is from National Bureau of Statistics (NBS) Yearbook because CEIC does not have this data. Also, GIOV of the state enterprises is missing from NBS yearbook for years 1998, 2002, and 2004. Note also that in the table "Main Indicators by Industrial Sector of State portion", NBS has changed the definition of the state enterprises back and forth. NBS uses "state-owned industrial enterprises" in 1995-1997; "state-owned and state holding industrial enterprises" in 1999-2003 and 2005-2008.In Figure 2b, we report the share of state enterprises as a percentage of its 1995 value.



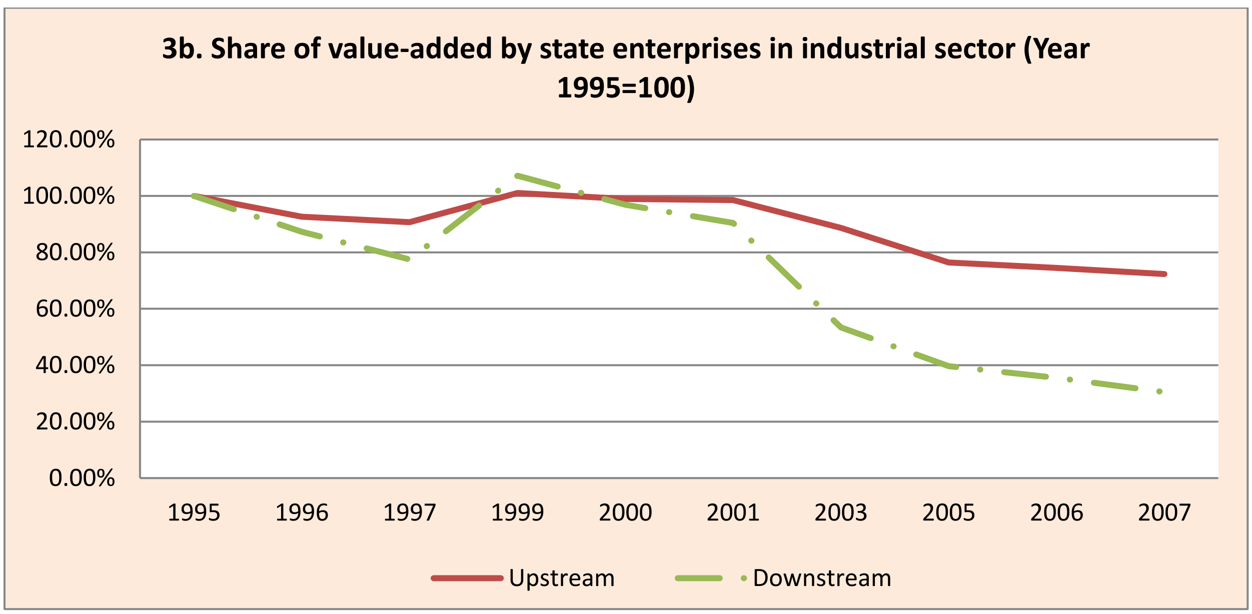


Figure 3: SOE share in the industrial sector. Figures 3a-3b report share of state enterprises in industrial value added with the data from National Bureau of Statistics (NBS) of China, Table 14-2, and Table 14-6. Note that NBS has changed the title of state related enterprises over time. NBS uses "state-owned industrial enterprises" in 1995-1997; "state-owned and state-holding" in 1999-2003 and 2005-2007. The data are missing for 1998, 2002, and 2004.

Table 1a. SOE Shares and Upstream Indices

SOE Share	(1) Industrial Output	(2) Employees	(3) Industrial Value	(4) Sales Revenue	(5) Fixed Asset	(6) Total Asset
UpDummy	0.175***	0.199***	0.183***	0.188***	0.233***	0.223***
	(3.232)	(3.531)	(3.344)	(3.491)	(4.093)	(3.962)
Capital Intensity	0.001***	0.001**	0.001***	0.001***	0.001**	0.001**
	(3.171)	(2.493)	(2.711)	(3.302)	(2.164)	(2.101)
Constant	0.297***	0.339***	0.314***	0.289***	0.392***	0.388***
	(9.383)	(10.252)	(9.763)	(9.144)	(11.712)	(11.773)
N	373	407	373	407	407	407

Table 1b. Stream Classification for Industrial Sectors

Industries	Profit Margin	Export Exposure	Herfindahl-Hirschman Index
Average across all enterprises in upstream	0.0257	0.0554	0.0065
Average across all enterprises in midstream	0.0153	0.0324	0.0024
Average across all enterprises in downstream	0.0073	0.2188	0.0028

Table 1c. Comparison of Fortune Global 500 Firms in 2011 from China, U.S., and France

Country	Total #	SOE #	SOE %	Upstream #	Upstream %	Down-stream #	Down-stream %	Misc. Number	Misc. %
China	57	53	93	25	46	11	20	3	5
US	133	4	3	17	14	64	51	8	6
France	35	4	11	3	9	16	46	0	0

In Table 1a, *, **, and *** indicates that t-statistics in parentheses are significant at the 10%, 5% and 1% level, respectively. The data are from National Bureau of Statistics (NBS) of China. In Table 1c, the classification criterion for SOEs and Non-SOEs is whether the government owns at least 50% of the firm. The upstream classification of industries is according to Table A2 in the Online Appendix which is based on the scores computed with Chinese input-output table following the methodology of Antras et al. (2012). Misc. refers to those companies whose industries are miscellaneous such as aerospace or defense, which cannot be classified into any stream based on the IO table.

Internet Online Appendix

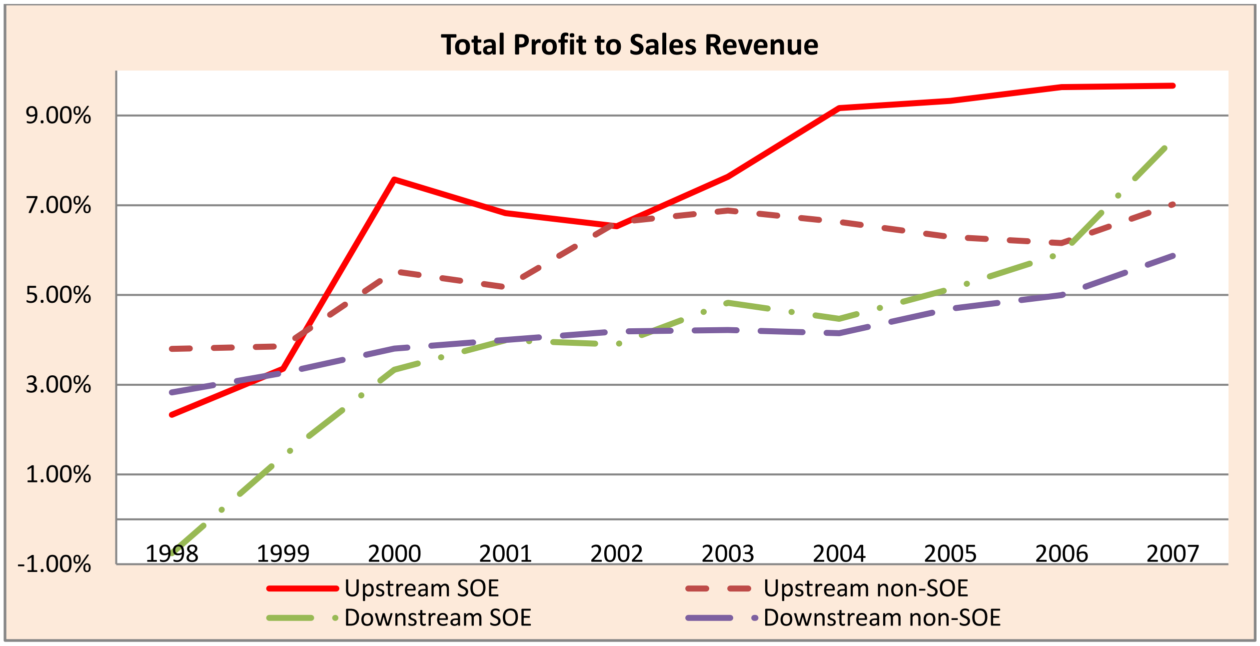
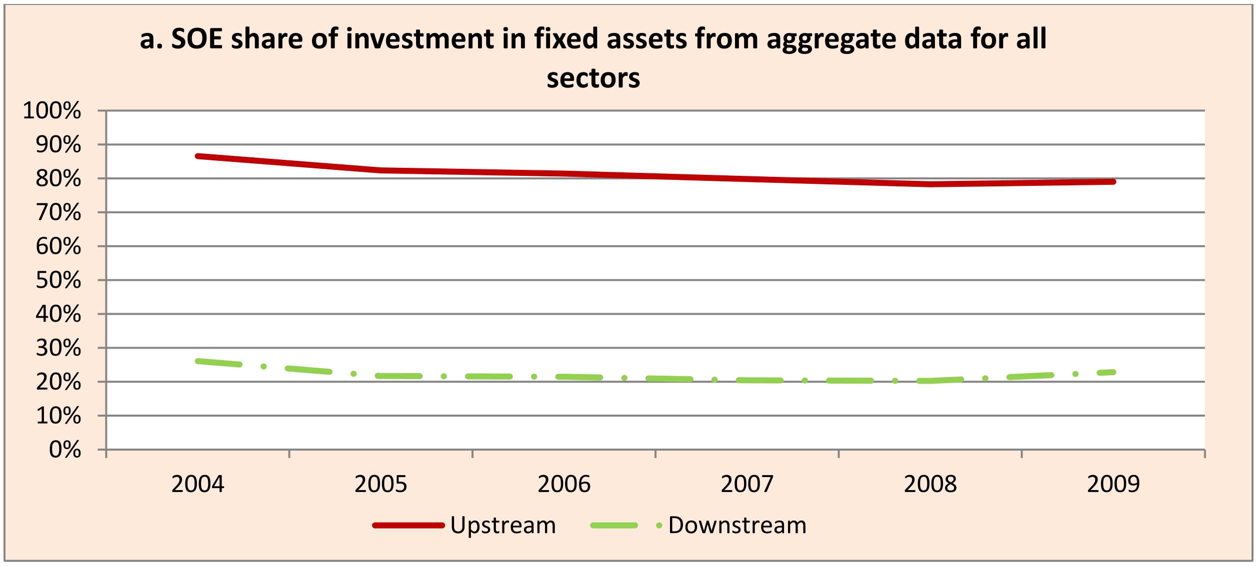


Figure A1: Total profit to sales revenue of Chinese enterprises in the industrial sector. We use NBS industrial enterprises data to obtain total profit to sales revenue and divide all the industrial enterprises into state owned & holding and the rest.



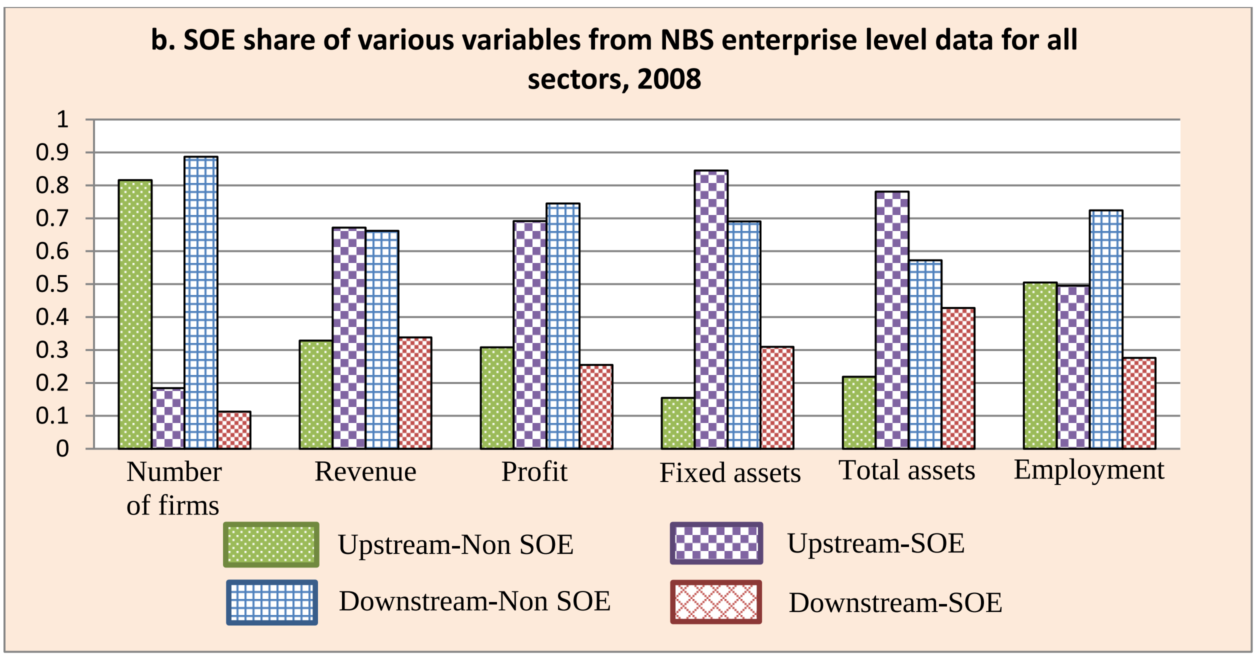


Figure A2: SOE share of all sectors: Figure A2a reports the investments in fixed assets in urban areas by ownership for all sectors using data from the following tables of National Bureau of Statistics (NBS) of China: Investment in Urban Area by Sector, Source of Funds, Jurisdiction of Management and Registration Status. Note that NBS has changed the column title of state related ownership over time. NBS uses "state-owned and state-controlled" in Tables 6-14 of 2004; "state-owned and state-holding" in Tables 6-14 of 2005; "state-holding" in Tables 6-14 of 2006; and "state-holding" in Tables 5-14 of 2007-2008. Before year 2004, data for the state enterprises are not available. Figure A2b reports for various variables using NBS enterprise level all sector data available for 2008.

Table A1. Stream Classification for Industrial Sectors

Ind #	Industries	2007 Stream Score	Profit Margin	Export Exposure	Herfindahl-Hirschman Index
	Upstream				
1	Coal	5.64	0.0613	0.0175	0.0096
2	Petroleum and Natural Gas	5.83	0.1589	0.0103	0.1016
3	Ferrous Metal Ores	5.60	0.0733	0.0086	0.0065
4	Non-Ferrous Metal Ores	5.60	0.0654	0.0092	0.0081
6	Other Ores	4.23	0.0296	0.0077	0.2250
17	Paper and Paper Products	4.42	0.0207	0.0386	0.0031
20	Petroleum, Nuclear fuel	4.91	0.0228	0.0072	0.0200
21	Raw chemical materials	4.71	0.0251	0.0979	0.0024
27	Smelting Ferrous Metals	4.58	0.009	0.048	0.0099
28	Smelting and Pressing of Non-ferrous Metals	4.58	0.0172	0.0478	0.0045
38	Electric Power and Heat Power	5.22	0.0045	0.0375	0.0111
39	Gas	5.83	-0.0284	0.0106	0.0224
	Average across all enterprises in upstream		0.0257	0.0554	0.0065
	Middle Stream				
5	Nonmetal Ores	4.23	0.0353	0.0075	0.0042
34	Communication Equipment, computer	4.22	0.012	0.0276	0.0057
29	Metal Products	4.11	0.0223	0.017	0.0008
16	Furniture	3.43	0.0251	0.0665	0.0026
33	Electrical Machinery and Equipment	3.35	0.0313	0.0227	0.0029
30	General Purpose Machinery	3.09	0.0224	0.0449	0.0014
31	Special Purpose Machinery	3.09	0.0039	0.0454	0.0020
15	Wood, Bamboo, Rattan etc.	3.43	0.0208	0.0662	0.0025
22	Medicines	3.38	0.0097	0.005	0.0038
40	Water	3.71	-0.0504	0.0023	0.0082
	Average across all enterprises in midstream		0.0153	0.0324	0.0024
	Downstream				
8	Food from Agricultural Products	2.57	-0.0026	0.2555	0.0013
9	Foods	2.57	-0.0126	0.4934	0.0028
10	Beverages	2.57	-0.0304	0.4935	0.0060
13	Textile Wearing Apparel	2.48	0.0209	0.5405	0.0010
14	Leather, Fur, etc.	2.48	0.0217	0.5376	0.0018
18	Printing, Media	2.48	-0.0045	0.0289	0.0019
19	Articles for culture, education	1.22	0.0201	0.0474	0.0024
26	Non-metallic Mineral Products	3.03	0.0162	0.0244	0.0005
32	Transport Equipment	2.75	0.0068	0.0705	0.0086
35	Machinery	3.09	0.0004	0.0465	0.0067
36	Artwork and other manufacturing	2.66	0.0177	0.0575	0.0045
37	Recycling	2.58	0.0162	0.0589	0.0032
	Average across all enterprises in downstream		0.0073	0.2188	0.0028

Note: Stream scores are calculated by following Antras et al. (2012) using China's IO table. More details are available upon request as to how various adjustments are appropriately made. Data Source: NBS.

Table A2. Stream Classification for All Sectors

Ind #	Industries	2008 Stream Score
	Upstream	
7	Extraction of petroleum and natural gas	5.83
8	Mining and processing of ferrous metal ores	5.60
44-45	Production and distribution of electric power and heat power and gas	5.22
43	Recycling and disposal of waste	5.16
25	Processing of petroleum, coking, processing of nuclear fuel	4.91
26/29	Manufacture of chemical raw materials and chemical products / Manufacture of rubber	4.71
33	Smelting and processing of non-ferrous metals	4.58
22/23 /24	Manufacture of paper and paper production / Printing and recorded / Manufacture of articles for culture, education and sport activity media	4.42
10	Mining and processing of nonmetal ores	4.23
34	Manufacture of metal products	4.11
	Middle Stream	
46	Production and distribution of tap water	3.71
51-55, 57-58	Railway transport / Road transport / Urban public transport / Water transport / Air transport / Loading/unloading, removal, and other transport services / Storage	3.63
68-71	Banking / Securities / Insurance / Other financial activities	3.62
73	Leasing	3.60
59	Postal services	3.44
20-21	Processing of timber, manufacture of wood, bamboo, rattan, palm, and straw products / Manufacture of furniture	3.43
39	Manufacture of electrical machinery and equipment	3.35
1	Farming	3.17
35-36, 41	Manufacture of general purpose machinery / Manufacture of special purpose machinery / Manufacture of measuring instruments and machinery for cultural activity and office work	3.09
31	Manufacture of non-metallic mineral products	3.03
	Downstream	
63-65	Wholesale trade / Retail trade	2.94
37	Manufacture of transport equipment	2.75
66-67	Accommodation / Catering	2.67
42	Manufacture of artwork and other manufacturing	2.66
60-62	Telecommunications and other information transfer services / Computer services / Software	2.62
82-83	Resident services / Other services	2.58
13-15	Processing of food from agricultural products / Manufacture of foods / Manufacture of beverages	2.57
18-19	Manufacture of textile, apparel, footwear, and caps / Manufacture of leather, fur, feather and related products	2.48
92	Entertainment	2.48
72	Real estate	1.76
47-50	Construction of buildings, and civil engineering / Renovation / Decoration / Other construction	1.06

Note: There are various adjustments. For example, some industries are deleted because there is no match from I/O table or they are non-commercial sectors, which are not relevant for this paper. Details are available upon request.

Appendix: Proofs

Proofs of Lemma 1 and Propositions 1-2: The proofs are straightforward based on the discussion in the main text and hence are omitted.

Results under horizontal structure: This is to show that SOE profit is hurt by an increase in the TFP of private firms under horizontal structure, which is opposite to the prediction in the vertical structure. For ease of comparison, we adopt a horizontal-structure setup similar to Song et al. (2011). Suppose households' utility function is a strictly increasing function of the aggregate consumption. The final output Y is produced by "horizontally" combining the output of the private firm product Y_p and that of the SOE product Y_s in a CES form with substitution elasticity σ:

$$Y = (Y_p^{\frac{\sigma-1}{\sigma}} + Y_s^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}, \sigma > 1.$$

Suppose labor is the only input that the technologies are given by

$$Y_p = A_p L_p; Y_s = A_s L_s.$$

Furthermore, assume perfect competition and free entry in the private sector but a monopoly market structure in the sector that produces Y_s. Labor market clears in this autarky general equilibrium

$$L_p + L_s = L,$$

where L is the total labor endowment. It can be shown that the profit of the SOE is given by

$$\Pi = \frac{WL}{\sigma\left[\left(\frac{A_s}{A_p}\frac{\sigma-1}{\sigma}\right)^{1-\sigma} + 1\right] - 1}.$$

Suppose we normalize wage to be unity. Clearly, $\frac{\partial \Pi}{\partial A_p} < 0$. That is, an increase in private TFP hurts the monopoly profit of the SOE when private firms and the SOE are producing horizontally differentiated goods. The intuition is that the demand for the SOE product declines as the private good becomes cheaper due to its productivity increase, hence the SOE profit goes down. It is diametrically different from the prediction under vertical structure ($\frac{\partial \Pi_m}{\partial A} > 0$), as highlighted in

Proposition 2.

Suppose, instead, we choose the final output as the numeraire, then we have

$$W = \left[\left(\frac{1}{A_s} \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} + \left(\frac{1}{A_p} \right)^{1-\sigma} \right]^{-\frac{1}{1-\sigma}},$$

and therefore,

$$\Pi = \frac{\left[\left(\frac{1}{A_s} \frac{\sigma}{\sigma-1} \right)^{1-\sigma} + \left(\frac{1}{A_p} \right)^{1-\sigma} \right]^{-\frac{1}{1-\sigma}} L}{\sigma \left[\left(\frac{A_s}{A_p} \frac{\sigma-1}{\sigma} \right)^{1-\sigma} + 1 \right] - 1}.$$

We can show that $\frac{\partial \Pi}{\partial A_p} < 0$ holds whenever $\sigma \geq 2$. It also holds when $\sigma \in (1, 2)$ and

$$\frac{A_s}{A_p} > \frac{\sigma}{\sigma - 1} \left[\frac{(\sigma - 1)^2}{\sigma(2 - \sigma)} \right]^{\frac{1}{1-\sigma}}. \tag{.1}$$

The intuition is as follows. When A_p increases, it has a positive income effect on the demand for SOE product, which increases the SOE profit. On the other hand, it also has a negative substitution effect on the demand for the SOE product, which reduces the SOE profit. When the substitution elasticity between the SOE product and the private product is sufficiently large ($\sigma \geq 2$), the substitution effect dominates, so $\frac{\partial \Pi}{\partial A_p} < 0$. When $\sigma \in (1, 2)$, the productivity of private firms has to be sufficiently small (that is, (.2) is satisfied) so that the substitution effect still dominates the income effect.

Proof of Proposition 3: One set of sufficient conditions is that the upstream technology is sufficiently capital intensive whereas the downstream technology is sufficiently labor intensive. More precisely, $\gamma = 1$, $\alpha > 0$, and β is sufficiently large such that

$$\left[1 + \frac{1}{(1 - \alpha - \beta)(\epsilon - 1)} \right]^{\alpha} < \left(1 + \frac{\frac{\alpha}{1-\beta}}{(1 - \alpha - \beta)(\epsilon - 1)} \right)^{1-\beta}. \tag{.2}$$

The key results (i.e., predictions for upstream and downstream prices, total industrial employment, industrial output, welfare, etc.) also hold when capital is not needed for production at all, namely, $\gamma = \alpha = 0$, even though now the rental price is always $R = 0$.

Now we provide the proof for the above claim and also the characterization for the general case.

Consider the general case in which everything is identical to the setting in Section 3.1 except that the upstream industry has N symmetric SOEs, where N can be any positive integer. In particular, when $N = 1$, it returns to the original setting with only one firm monopolizing the upstream industry. When $N \to \infty$, the upstream becomes perfectly competitive. It is straightforward to show that for any arbitrary N the markup μ is now given by

$$\mu \equiv \frac{N\left[(1-\alpha-\beta)(\epsilon-1)+1\right]}{N\left[(1-\alpha-\beta)(\epsilon-1)+1\right]-1},$$

which obviously decreases with N. For Proposition 3, it suffices to compare the two cases when $N = 1$ and $N = \infty$. To avoid the trivial cases, we always assume that the upstream intermediate input is crucial for downstream production, i.e., $1 - \alpha - \beta > 0$.

[1] We can show that R strictly decreases with μ if and only if $\alpha > 0$ or $\gamma > 0$ or both. So R strictly increases after upstream liberalization. $R = 0$ always holds if $\alpha = \gamma = 0$.

[2] We can show that p_m strictly increases with μ when $\alpha > 0$ or $1 > \gamma > 0$, or both. More precisely,

$$p_m = p_n \cdot \frac{\mu \varkappa^{\xi\gamma} A_n^{1-\gamma} A_m^{-1}}{\gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}} \propto \mu \varkappa^{\xi\gamma} \propto \left[\gamma\left(1-\alpha-\beta\right)+\alpha\mu\right]^{\xi\gamma} \mu^{[(1-\alpha-\beta)(1-\epsilon)-1]\xi\gamma+1}$$

so $\frac{\partial p_m}{\partial \mu} > 0$ if and only if

$$\xi\gamma\alpha\mu + \left[\gamma\left(1-\alpha-\beta\right)+\alpha\mu\right]\left\{\frac{\alpha\left(\epsilon-1\right)+1-\gamma}{1+\alpha\left(\epsilon-1\right)+\gamma(1-\alpha-\beta)(\epsilon-1)}\right\} > 0,$$

which is always true when $\alpha > 0$ or $1 > \gamma > 0$, or both. For binary comparison, p_m becomes strictly smaller after the full liberalization of the upstream if and only if

$$\begin{aligned}
\left[\gamma\left(1-\alpha-\beta\right)+\alpha\mu\right]^{\xi\gamma} \mu^{[(1-\alpha-\beta)(1-\epsilon)-1]\xi\gamma+1} &> \left[\gamma\left(1-\alpha-\beta\right)+\alpha\right]^{\xi\gamma}, \\
\left[\gamma\left(1-\alpha-\beta\right)+\alpha\mu\right]^{\xi\gamma} \mu^{\frac{1-\gamma+\alpha(\epsilon-1)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}} &> \left[\gamma\left(1-\alpha-\beta\right)+\alpha\right]^{\xi\gamma}
\end{aligned}$$

which is always true except when $1 - \gamma = \alpha = 0$. It is also true when $\alpha = \gamma = 0$, because in that case p_m drops from $\mu \frac{A_n}{A_m} p_n$ to $\frac{A_n}{A_m} p_n$.

[3] We can show that p_d becomes strictly smaller after the full liberalization of the upstream

industry if and only if

$$\left[\frac{(1-\alpha-\beta)(\epsilon-1)+1}{(1-\alpha-\beta)(\epsilon-1)}\right]^{\alpha+(\gamma-1)(1-\alpha-\beta)} < \left[\frac{\gamma(1-\alpha-\beta)+\alpha+\frac{\alpha}{(1-\alpha-\beta)(\epsilon-1)}}{\gamma(1-\alpha-\beta)+\alpha}\right]^{\alpha+\gamma(1-\alpha-\beta)}. \quad (.3)$$

In particular, it holds when $\gamma = 1$, $\alpha > 0$, and β is sufficiently large ($\frac{1-\beta}{\alpha}$ is sufficiently small) such that

$$\left[1+\frac{1}{(1-\alpha-\beta)(\epsilon-1)}\right] < \left[1+\frac{\frac{\alpha}{1-\beta}}{(1-\alpha-\beta)(\epsilon-1)}\right]^{\frac{1-\beta}{\alpha}}.$$

In addition, p_d also becomes strictly smaller after the full liberalization when $\alpha = \gamma = 0$, because $p_d = \frac{W^\beta p_m^{1-\beta}}{A\beta^\beta(1-\beta)^{1-\beta}}$, where p_m decreases and W remains constant (equal to $A_n p_n$).

[4] Downstream industrial output in equilibrium strictly decreases with p_d. So the total output for downstream good d strictly increases after the full liberalization of the upstream if and only if (.2) is true.

[5] Total industrial employment is given by

$$\begin{aligned}
&\overline{L}(A_n, A, A_m, K) \\
\propto\ & [\gamma(1-\alpha-\beta)+\alpha\mu]^{\xi-1}\,\mu^{[(1-\alpha-\beta)(1-\epsilon)-1]\xi}\,[(1-\gamma)(1-\alpha-\beta)+\beta\mu] \\
=\ & [\gamma(1-\alpha-\beta)+\alpha\mu]^{-\frac{\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}\,\mu^{\frac{\alpha-(1-\gamma)(1-\alpha-\beta)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}(\epsilon-1)}\left[\frac{(1-\gamma)(1-\alpha-\beta)+\beta\mu}{\mu}\right],
\end{aligned}$$

which becomes strictly larger after the upstream full liberalization if and only if

$$\begin{aligned}
&\left[\frac{(1-\alpha-\beta)(\epsilon-1)+1}{(1-\alpha-\beta)(\epsilon-1)}\right]^{\alpha+(\gamma-1)(1-\alpha-\beta)}\left[1-\frac{\frac{(1-\gamma)(1-\alpha-\beta)}{(1-\gamma)(1-\alpha-\beta)+\beta}}{1+(1-\alpha-\beta)(\epsilon-1)}\right]^{\frac{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}{(\epsilon-1)}} \\
<\ & \left[\frac{\gamma(1-\alpha-\beta)+\alpha+\frac{\alpha}{(1-\alpha-\beta)(\epsilon-1)}}{\gamma(1-\alpha-\beta)+\alpha}\right]^{\alpha+\gamma(1-\alpha-\beta)}.
\end{aligned}$$

In particular, the above inequality is equivalent to (.2) when $\gamma = 1$ and $\alpha > 0$. When $\alpha = \gamma = 0$, $\overline{L}(A_n, A, A_m, K) \propto \mu^{(1-\beta)(1-\epsilon)-1}[(1-\beta)+\beta\mu]$, which strictly decreases with μ, so it becomes strictly larger after full liberalization.

[6] GDP (per capita) Y strictly increases with $\frac{\alpha\mu+(1-\alpha-\beta)(\gamma+\mu-1)}{(1-\gamma)(1-\alpha-\beta)+\beta\mu}\overline{L}(A_n, A, A_m, K)$, or

$$\left[\frac{\gamma(1-\alpha-\beta)+\alpha\mu}{\mu}\left\{\mu^{1-\alpha-\beta}\right\}^{1-\epsilon}\right]^{\xi}\frac{(1-\beta)\mu-(1-\alpha-\beta)(1-\gamma)}{\gamma(1-\alpha-\beta)+\alpha\mu},$$

which becomes strictly larger after full liberalization if and only if

$$\begin{aligned} & \left[\frac{\gamma(1-\alpha-\beta)+\alpha\mu}{\mu}\left\{\mu^{1-\alpha-\beta}\right\}^{1-\epsilon}\right]^{\xi}\frac{(1-\beta)\mu-(1-\alpha-\beta)(1-\gamma)}{\gamma(1-\alpha-\beta)+\alpha\mu} \\ < \quad & \left[\gamma(1-\alpha-\beta)+\alpha\right]^{\xi-1}\left[(1-\beta)-(1-\alpha-\beta)(1-\gamma)\right], \end{aligned}$$

which is equivalent to (.2) when $\gamma = 1$ and $\alpha > 0$. However, Y becomes smaller after full liberalization when $\alpha = \gamma = 0$, because, without capital, we have $Y = WL + \Pi_m$, where W stays unchanged but Π_m becomes zero after upstream liberalization.

[7] Welfare. We can derive the welfare of an average household (assuming equal income across all the agents after lump-sum transfer from elite to grass roots):

$$\begin{aligned} u(c_n, c_d) &= c_n + \frac{\epsilon}{\epsilon-1}c_d^{\frac{\epsilon-1}{\epsilon}} = \frac{WL+RK+\Pi_m}{p_n} - \left(\frac{p_n}{p_d}\right)^{\epsilon-1} + \frac{\epsilon}{\epsilon-1}\left[\left(\frac{p_n}{p_d}\right)^{\epsilon}\right]^{\frac{\epsilon-1}{\epsilon}} \\ &= A_n L + \frac{\not{\varkappa}^{\xi}\left[(1-\alpha-\beta)(\mu-1)+\frac{\mu}{\epsilon-1}\right]}{\gamma(1-\alpha-\beta)+\alpha\mu}\left[A_n^{\alpha+\gamma(1-\alpha-\beta)-1}A_m^{1-\alpha-\beta}AK^{\alpha+\gamma(1-\alpha-\beta)}\right]^{\xi(\epsilon-1)}, \end{aligned}$$

which becomes strictly larger after full liberalization when γ and α are not both zero if and only if

$$\begin{aligned} \frac{\left[(1-\alpha-\beta)(\mu-1)+\frac{\mu}{\epsilon-1}\right]}{\gamma(1-\alpha-\beta)+\alpha\mu} &< \frac{\frac{1}{\epsilon-1}}{\gamma(1-\alpha-\beta)+\alpha}, \\ (1-\alpha-\beta)(\epsilon-1)+1 &< \frac{\alpha}{\gamma(1-\alpha-\beta)+\alpha}, \end{aligned}$$

which is never possible.

The welfare of a representative grass-roots household is given by

$$\begin{aligned} & A_n L + \frac{\varkappa^{\xi}\left[(1-\alpha-\beta)(\mu-1)+\frac{\mu}{\epsilon-1}\right]}{\gamma(1-\alpha-\beta)+\alpha\mu}\left[A_n^{\alpha+\gamma(1-\alpha-\beta)-1}A_m^{1-\alpha-\beta}AK^{\alpha+\gamma(1-\alpha-\beta)}\right]^{\xi(\epsilon-1)} - \frac{\Pi_m}{p_n} \\ = \; & A_n L + \frac{\varkappa^{\xi}\left[(1-\alpha-\beta)(\mu-1)+\frac{\mu}{\epsilon-1}\right]}{\gamma(1-\alpha-\beta)+\alpha\mu}\left[A_n^{\alpha+\gamma(1-\alpha-\beta)-1}A_m^{1-\alpha-\beta}AK^{\alpha+\gamma(1-\alpha-\beta)}\right]^{\xi(\epsilon-1)} \\ & -\frac{(1-\alpha-\beta)(\mu-1)}{(1-\gamma)(1-\alpha-\beta)+\beta\mu}\overline{L}(A_n, A, A_m, K)A_n \end{aligned}$$

which strictly increases with

$$[\gamma(1-\alpha-\beta)+\alpha\mu]^{-\frac{\alpha+\gamma(1-\alpha-\beta)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}\,\mu^{\frac{\alpha+(\gamma-1)(1-\alpha-\beta)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}},$$

which becomes strictly larger after full liberalization when γ and α are not both zero iff

$$[\gamma(1-\alpha-\beta)+\alpha\mu]^{-[\alpha+\gamma(1-\alpha-\beta)]}\,\mu^{\alpha+(\gamma-1)(1-\alpha-\beta)} < [\gamma(1-\alpha-\beta)+\alpha]^{-[\alpha+\gamma(1-\alpha-\beta)]}$$

or

$$\left[1+\frac{1}{(1-\alpha-\beta)(\epsilon-1)}\right]^{\alpha+(\gamma-1)(1-\alpha-\beta)} < \left[1+\frac{\frac{\alpha}{\gamma(1-\alpha-\beta)+\alpha}}{(1-\alpha-\beta)(\epsilon-1)}\right]^{\alpha+\gamma(1-\alpha-\beta)},$$

which is equivalent to (.2) when $\gamma = 1$ and $\alpha > 0$. When $\alpha = \gamma = 0$, the grass-roots welfare also becomes strictly larger after full liberalization because their income remains constant but p_d becomes strictly lower.

On the other hand, the welfare of a representative elite household becomes strictly worse off after upstream liberalization because each earns income $WL + RK + \frac{\Pi_m}{\theta}$, which is strictly larger than average income Y whenever $\Pi_m > 0$. We can derive the welfare of a household with the

average income level Y is given by

$$\begin{aligned} u(c_n, c_d) &= c_n + \frac{\epsilon}{\epsilon-1}c_d^{\frac{\epsilon-1}{\epsilon}} = \frac{WL+RK+\Pi_m}{p_n} - \left(\frac{p_n}{p_d}\right)^{\epsilon-1} + \frac{\epsilon}{\epsilon-1}\left[\left(\frac{p_n}{p_d}\right)^{\epsilon}\right]^{\frac{\epsilon-1}{\epsilon}} \\ &= A_n L + \frac{\varkappa^{\xi}\left[(1-\alpha-\beta)(\mu-1)+\frac{\mu}{\epsilon-1}\right]}{\gamma(1-\alpha-\beta)+\alpha\mu}\left[A_n^{\alpha+\gamma(1-\alpha-\beta)-1}A_m^{1-\alpha-\beta}AK^{\alpha+\gamma(1-\alpha-\beta)}\right]^{\xi(\epsilon-1)}, \end{aligned}$$

which becomes strictly smaller after full liberalization when γ and α are not both zero iff

$$(1-\alpha-\beta)(\epsilon-1)+1 > \frac{\alpha}{\gamma(1-\alpha-\beta)+\alpha},$$

which is always true. So the welfare loss of an elite household is even larger after full liberalization. When $\alpha=\gamma=0$, each of the elite households' welfare also becomes strictly smaller after full liberalization when θ is sufficiently small, because their income drops too much despite the decrease in p_d.

Proof of Lemma 2: The necessary and sufficient conditions for this equilibrium pattern are the following:

$$A^{*1-\epsilon} < \frac{\mu\overline{\overline{L}}(A,A_m,K)}{2\left[(1-\gamma)(1-\alpha-\beta)+\beta\mu\right]}, \tag{.4}$$

$$\frac{\mu\overline{\overline{L}}(A,A_m,K)}{2\left[(1-\gamma)(1-\alpha-\beta)+\beta\mu\right]} < L^*A^*, \tag{.5}$$

and

$$L > \frac{\frac{\mu}{2}-\gamma(1-\alpha-\beta)-\alpha\mu}{(1-\gamma)(1-\alpha-\beta)+\beta\mu}\overline{\overline{L}}(A,A_m,K), \tag{.6}$$

where $\overline{\overline{L}}(A,A_m,K)$ is the total industrial employment in country H and is given by

$$\overline{\overline{L}}(A,A_m,K) \equiv 2^{\xi}\overline{L}(1,A,A_m,K), \tag{.7}$$

where ξ is given by (15).

Condition (.4) ensures that country H has a comparative advantage in producing good d so that only country H produces good d and country F only produces and exports good n. Condition (.5) ensures that country F consumes both good n and downstream good d. Condition (.6) guarantees that each agent in country H, even the grassroots, consumes a positive amount of good n (i.e., $I_g > p_n^{\epsilon}p_d^{1-\epsilon}$). For simplicity, assume the following is true:

$$(\epsilon-3)(1-\alpha-\beta)+1 \leq 0, \tag{.8}$$

in which case condition (.6) automatically implies $L > \overline{\overline{L}}(A,A_m,K)$, ensuring that country H produces a positive amount of good n in equilibrium.

To ensure the trade pattern in equilibrium as described earlier, we require that $\frac{p_d}{p_n} < A^*$, or equivalently

$$\frac{1}{A\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}\left(\frac{\mu}{A_m\gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}}\right)^{1-\alpha-\beta}\left(\frac{K}{2b}\right)^{\frac{-[\alpha+\gamma(1-\alpha-\beta)]}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}} < A^*,$$

where $b \equiv \left[A_m^{(1-\alpha-\beta)}A\right]^{\epsilon-1}\varkappa$. The positive production of good n in country H requires $L > \overline{\overline{L}}$, where $\overline{\overline{L}} \equiv 2^{\frac{1}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}\overline{L}(1, A, A_m, K)$. $\overline{\overline{L}}$ is the total industrial employment in country H. Positive consumption of good n in country F requires $D_n^* = A^*L^* - \frac{p_d D_d^*}{W} > 0$,or equivalently

$$A^*L^* - \left(A\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}\left(\frac{A_m\gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}}{\mu}\right)^{1-\alpha-\beta}\left(\frac{K}{2b}\right)^{\frac{[\alpha+\gamma(1-\alpha-\beta)]}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}\right)^{\epsilon-1} > 0.$$

The individual consumption in country H is given by

$$\begin{aligned}
c_n^e &= L + \left(\frac{K}{2b}\right)^{\frac{-1}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}} \cdot K + \frac{\left[\frac{1}{A\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}\right]^{1-\epsilon}}{\left[\frac{\mu}{A_m\gamma^{\gamma}(1-\gamma)^{1-\gamma}}\right]^{(1-\alpha-\beta)(\epsilon-1)}} \\
&\quad \cdot\left(\frac{K}{2b}\right)^{\frac{\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}} \cdot \left[\frac{1}{\theta}\frac{2(1-\alpha-\beta)}{\left(1-\alpha-\beta\right)\left(\epsilon-1\right)+1} - 1\right], \\
c_n^g &= L + \left(\frac{K}{2b}\right)^{\frac{-1}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}} \cdot K - \frac{\left[\frac{1}{A\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}\right]^{1-\epsilon}}{\left[\frac{\mu}{A_m\gamma^{\gamma}(1-\gamma)^{1-\gamma}}\right]^{(1-\alpha-\beta)(\epsilon-1)}} \cdot \\
&\quad \cdot\left(\frac{K}{2b}\right)^{\frac{\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}, \\
c_d^j &= \left\{\frac{1}{A\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}\left(\frac{\mu}{A_m\gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}}\right)^{1-\alpha-\beta}\left(\frac{K}{2b}\right)^{\frac{-[\alpha+\gamma(1-\alpha-\beta)]}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}\right\}^{-\epsilon}, \\
\forall j &\in \{e, g\}.
\end{aligned}$$

The aggregate consumption of the numeraire good in country H is

$$\begin{aligned}
C_n &= L + \left(\frac{K}{2b}\right)^{\frac{-1}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}} \cdot K + \frac{\left[\frac{1}{A\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}\right]^{1-\epsilon}}{\left[\frac{\mu}{A_m\gamma^{\gamma}(1-\gamma)^{1-\gamma}}\right]^{(1-\alpha-\beta)(\epsilon-1)}} \\
&\quad \cdot\left(\frac{K}{2b}\right)^{\frac{\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}\left[\frac{2(1-\alpha-\beta)}{\left(1-\alpha-\beta\right)\left(\epsilon-1\right)+1} - 1\right].
\end{aligned}$$

For completeness, the total (or individual) consumption in country F is given by

$$c_n^* = A^*L^* - [\frac{1}{A\alpha^\alpha\beta^\beta(1-\alpha-\beta)^{1-\alpha-\beta}}]^{1-\epsilon}[\frac{\mu}{A_m\gamma^\gamma(1-\gamma)^{1-\gamma}}]^{(1-\alpha-\beta)(1-\epsilon)}(\frac{K}{2b})^{\frac{\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}$$

and

$$c_d^* = \left\{\frac{1}{A\alpha^\alpha\beta^\beta(1-\alpha-\beta)^{1-\alpha-\beta}}(\frac{\mu}{A_m\gamma^\gamma(1-\gamma)^{1-\gamma}})^{1-\alpha-\beta}(\frac{K}{2b})^{\frac{-[\alpha+\gamma(1-\alpha-\beta)]}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}\right\}^{-\epsilon}.$$

The second condition guarantees that $c_n^* > 0$. The total GDP in country F is $I^* = L^*W^* = L^*A^*W$. To ensure that even the grassroots in country H consumes a positive amount of good n, we require $RK + WL > p_n^\epsilon p_d^{1-\epsilon}$, which is equivalent to $L > \frac{\frac{\mu}{2}-\gamma(1-\alpha-\beta)-\alpha\mu}{(1-\gamma)(1-\alpha-\beta)+\beta\mu}\overline{\overline{L}}(A, A_m, K)$. Therefore, condition $\frac{\frac{\mu}{2}-\gamma(1-\alpha-\beta)-\alpha\mu}{(1-\gamma)(1-\alpha-\beta)+\beta\mu} \geq 1$ means that $(1-\alpha-\beta)(\epsilon-3)+1 \leq 0$. The capital market clearing condition implies

$$R = p_n \cdot \left[A_m^{(1-\alpha-\beta)}A\right]^{\frac{(\epsilon-1)}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}(\frac{K}{2\varkappa})^{\frac{-1}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}.$$

Observe that R is still given by (11) except that K is replaced by $\frac{K}{2}$. To understand why, first notice that the demand functions for good d are identical in the two countries ($D_d = D_d^* = \left(\frac{p_n}{p_d}\right)^\epsilon$, due to the lack of income effect implied by the quasi-linear utility function), so the monopolist SOE charges the same markup as in the autarky case. As the world total demand for good d doubles the domestic demand in country H, the demand for the intermediate good is also scaled up (recall that good d is produced only in country H). Labor is abundant in country H but only half of the capital endowment is used to serve domestic demand for good d, plus the fact that all the technologies are constant returns to scale, so in equilibrium K is replaced by $\frac{K}{2}$. Similarly, we have

$$p_m = p_n \cdot \frac{\mu}{A_m\gamma^\gamma(1-\gamma)^{1-\gamma}}\left[A_m^{(1-\alpha-\beta)}A\right]^{\frac{(\epsilon-1)\gamma}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}(\frac{K}{2\varkappa})^{\frac{-\gamma}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}},$$

The same is true for the price of downstream good d:

$$p_d = p_n \cdot \left\{\frac{\left[\frac{\mu}{\gamma^\gamma(1-\gamma)^{1-\gamma}}\right]^{1-\alpha-\beta}}{\alpha^\alpha\beta^\beta(1-\alpha-\beta)^{1-\alpha-\beta}}\right\}\left[A_m^{(1-\alpha-\beta)}A\right]^{\frac{-1}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}(\frac{K}{2\varkappa})^{\frac{-[\alpha+\gamma(1-\alpha-\beta)]}{1+\alpha(\epsilon-1)+\gamma(1-\alpha-\beta)(\epsilon-1)}}.$$

Proof of Proposition 4: The proof is straightforward based on the discussion in the main text.

Proof of Proposition 5 Consider any industry j that is monopolized by an SOE. This firm faces the following demand function $D(j) = \left(\frac{p_n}{P}\right)^{\epsilon}\left[\frac{p(j)}{P}\right]^{-\eta}$, where $p(i)$ denotes the market price of good $i \in [0,1]$ and the price index P is defined as $P \equiv \left(\int_0^1 p(i)^{1-\eta} di\right)^{\frac{1}{1-\eta}}$. The aggregate price P and p_n are taken as given by the SOE, so it would choose $p(j) = \frac{\eta}{\eta-1}\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{A_s\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}$. On the other hand, $p(j') = \frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{A_p\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}$for any liberalized industry j', so the aggregate price level

$$
\begin{aligned}
P &= \left(\int_0^1 p(i)^{1-\eta} di\right)^{\frac{1}{1-\eta}} \\
&= \left((1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta} + \phi\left[\frac{1}{A_p}\right]^{1-\eta}\right)^{\frac{1}{1-\eta}} \frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}. \qquad (45)
\end{aligned}
$$

The induced demand for the intermediate good from the SOE monopolist in industry j is $D(j)\frac{(1-\alpha-\beta)}{p_m}\frac{p(j)}{\frac{\eta}{\eta-1}}$. The total demand for the intermediate good is

$$
\begin{aligned}
&\phi\frac{(1-\alpha-\beta)\,p(j')}{p_m}\left(\frac{p_n}{P}\right)^{\epsilon}\left[\frac{p(j')}{P}\right]^{-\eta} + (1-\phi)\left(\frac{p_n}{P}\right)^{\epsilon}\left[\frac{p(j)}{P}\right]^{-\eta}\frac{(1-\alpha-\beta)}{p_m}\frac{p(j)}{\frac{\eta}{\eta-1}} \\
= \; & p_n^{\epsilon}\frac{(1-\alpha-\beta)}{p_m}\frac{\phi\left(\frac{1}{A_p}\right)^{1-\eta} + (1-\phi)\left[\frac{1}{A_s}\right]^{1-\eta}\left(\frac{\eta}{\eta-1}\right)^{-\eta}}{\left[(1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta} + \phi\left[\frac{1}{A_p}\right]^{1-\eta}\right]^{\frac{\epsilon-\eta}{1-\eta}}}\left[\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}\right]^{1-\epsilon},
\end{aligned}
$$

so the total profit of the upstream SOE is

$$
p_n^{\epsilon}\frac{\mu-1}{\mu}(1-\alpha-\beta)\frac{\phi\left(\frac{1}{A_p}\right)^{1-\eta} + (1-\phi)\left[\frac{1}{A_s}\right]^{1-\eta}\left(\frac{\eta}{\eta-1}\right)^{-\eta}}{\left[(1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta} + \phi\left[\frac{1}{A_p}\right]^{1-\eta}\right]^{\frac{\epsilon-\eta}{1-\eta}}}\left[\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}\right]^{1-\epsilon},
$$

and the total revenue of the upstream SOE is

$$
p_n^{\epsilon}(1-\alpha-\beta)\frac{\phi\left(\frac{1}{A_p}\right)^{1-\eta} + (1-\phi)\left[\frac{1}{A_s}\right]^{1-\eta}\left(\frac{\eta}{\eta-1}\right)^{-\eta}}{\left[(1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta} + \phi\left[\frac{1}{A_p}\right]^{1-\eta}\right]^{\frac{\epsilon-\eta}{1-\eta}}}\left[\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{\alpha^{\alpha}\beta^{\beta}(1-\alpha-\beta)^{1-\alpha-\beta}}\right]^{1-\epsilon}.
$$

The total downstream SOE profit is

$$
\begin{aligned}
&(1-\phi)\left(\frac{p_n}{P}\right)^{\epsilon}\left[\frac{p(j)}{P}\right]^{-\eta}\left(\frac{\eta}{\eta-1}-1\right)\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{A_s\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}\\
=\;& p_n^{\epsilon}\frac{(1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{-\eta}\left(\frac{1}{\eta-1}\right)\frac{1}{A_s}}{\left((1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta}+\phi\left[\frac{1}{A_p}\right]^{1-\eta}\right)^{\frac{\epsilon-\eta}{1-\eta}}}\left[\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}\right]^{1-\epsilon},
\end{aligned}
$$

and the total downstream SOE revenue is

$$
\eta p_n^{\epsilon}\frac{(1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{-\eta}\left(\frac{1}{\eta-1}\right)\frac{1}{A_s}}{\left((1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta}+\phi\left[\frac{1}{A_p}\right]^{1-\eta}\right)^{\frac{\epsilon-\eta}{1-\eta}}}\left[\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}\right]^{1-\epsilon}.
$$

Therefore, the aggregate profit of SOE is

$$
\begin{aligned}
&\left[\frac{(\mu-1)\left(1-\alpha-\beta\right)}{\mu}\frac{\phi\left(\frac{1}{A_p}\right)^{1-\eta}+(1-\phi)\frac{\eta-1}{\eta}\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta}}{\left[(1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta}+\phi\left[\frac{1}{A_p}\right]^{1-\eta}\right]^{\frac{\epsilon-\eta}{1-\eta}}}+\frac{\frac{1}{\eta}(1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta}}{\left((1-\phi)\left[\frac{\eta}{\eta-1}\frac{1}{A_s}\right]^{1-\eta}+\phi\left[\frac{1}{A_p}\right]^{1-\eta}\right)^{\frac{\epsilon-\eta}{1-\eta}}}\right]\\
&\cdot p_n^{\epsilon}\left[\frac{R^{\alpha}W^{\beta}{p_m}^{1-\alpha-\beta}}{\alpha^{\alpha}\beta^{\beta}\left(1-\alpha-\beta\right)^{1-\alpha-\beta}}\right]^{1-\epsilon},
\end{aligned}
$$

which is maximized when $\phi=1$ if $\frac{A_p}{A_s}>\left(\frac{\eta-1}{\eta}\right)\left[\frac{\eta-1}{\eta}+\frac{\mu}{\eta(\mu-1)(1-\alpha-\beta)}\right]^{\frac{1}{\eta-1}}$ given all the factor prices (R and W) and optimal price choice of upstream intermediate input p_m.