Privatization in vertical related markets: Insights from a general-equilibrium approach

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Abstract: A three-sector general equilibrium model is built to investigate how deepening privatization of an upstream state-owned enterprise(SOE) influences the whole economy in developing economy. The SOE, facing privatization, owns a monopolistic position in upstream market and offers an essential intermediate input for downstream manufacturing sector. After the privatization, the SOE improves its efficiency. We conclude the efficiency-enhancing effect is crucial for determining the impacts of privatization and provide a new perspective for analyzing this issue. Deepening privatization lowers (raises) price of the intermediate input and increases its output if the efficiency-enhancing effect is relatively large (small). When the effect is moderate, an increase in the privatization level raises the output of manufacturing and agricultural and improves social welfare.

1 Introduction

After the 1980s, the world has experienced a massive shift toward the privatization of state-owned enterprises (SOEs). This shift is especially apparent in transitioning and developing economies due to the momentum of economic liberalization[1]. During this shift towards privatization, new private firms entered a market monopolized by SOEs. This type of market is recognized as a "mixed oligopoly," where both public and private firms produce goods and compete in the same market (De Fraja and Delbono, 1989). Many attempts have been made to analyze the impact of (partial) privatization of SOEs (Matsumura, 1998; Fujiwara, 2007; Matsumura and Shimizu, 2010; Wang and Chen, 2011; Han and Ogawa, 2012; Xu et al., 2017). Most existing literature assumes that SOEs and non-SOEs compete in the same market and provide their goods directly to consumers. However, this assumption may not be valid for economic reality. After the global wave of privatization, the sectoral distribution of SOEs has changed noticeably. Privatization occurred mostly in unprotected and competitive sectors such as the food, tourism, and retail sectors. In many strategic and upstream sectors, for instance, energy, transportation, essential commodities, and high-end equipment, SOEs still hold a monopolistic position. A vertical structure has developed between SOEs and non-SOEs, where SOEs monopolize key upstream industries and provide essential intermediate inputs to downstream industries. In contrast, downstream industries are mostly open to private competition[2].

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[1] Most of this privatization occurred in Europe, Central and East Asia, and Latin America, while the scale of privatization in Africa and South Asia is rather small. For more stylized facts, see Estrin and Pelletier (2018).

[2] Li et al. (2012) introduced this vertical structure in China, which was formed around 2001. Additionally, the participation of SOEs in economic activity in many developing countries is substantial, and they usually have monopoly status, for instance, Zimbabwe and Ethiopia in Africa and Vietnam in Asia. Section 2 provides more information about the distribution of SOEs.

Since the vertical structure is becoming increasingly prominent, recently, scholars have explored the impacts of the privatization of upstream SOEs (Wen and Yuan, 2010; Yang et al., 2014; Chang and Ryu, 2015; Chang and Ryu, 2016; Wu et al., 2016; Liu et al., 2019). Previous literature, however, has focused on partial impacts of privatization in vertically related markets by employing the game theory. While the game theory approach is useful in realizing theoretical results, it is bound to be limited in analysis, as it ignores factor markets. And the privatization issue is often addressed in situations where goods markets and factor markets are interconnected. Generally, public firms are less efficient than private firms, and one of the main objectives of privatization is to promote their efficiency (Megginson and Netter, 2001). Privatization could help to correct inefficiency, such as managerial laxity, and raise productivity in public firms. After the efficiency improvement, public firms reduce the use of factors. Such action further affects factors' rewards in factor markets, which, in turn, influences factor employment and the output of private firms. When incorporating factor markets and employing the general equilibrium approach, we can "offset or even reverse sensible partial equilibrium conclusions" (Acemoglu, 2010). Fewer studies explore this issue from the general equilibrium approach (Beladi and Chao, 2006; Chao and Yu, 2006; Ghosh and Sen, 2012; Chao et al., 2016; Pi and Zhang, 2018). However, these papers do not consider the vertical structure and assume a horizontal market structure in which private and public firms produce and compete only in a final goods market.

This study aims to fill the current research gap by constructing a three-sector general equilibrium model to investigate the impacts of the privatization of SOEs. Compared with existing studies, our study provides a new perspective. When we incorporate the efficiency-enhancing effect due to privatization, we observe that

deepening the privatization of an upstream SOE may not raise its price if the effect is relatively large. The economic intuition behind the result is as follows. The implementation of privatization not only leads the SOE to focus more on its profit but also increases its efficiency. The efficiency improvement leads to downsizing, which reduces the equilibrium wage rate. A reduction in wage rate and efficiency improvement decreases the marginal cost. If the effect is relatively large, privatization reduces its price.

The magnitude of the efficiency-enhancing effect plays a crucial role in the following analysis. The effect is derived from a core assumption of the model: after (partial) privatization, the upstream firm becomes more efficient. Here, we make some justifications for this assumption. First, even though some industries gain little from privatization, this reform leads to positive impacts in most industries with the reform of the market system. In one review paper, Estrin and Pelletier (2018) summarize the recent evidence concerning the effects of privatization on efficiency in developing countries and hold that privatization reform alone does not automatically generate efficiency improvement. Privatization has more significant benefits on firm performance in a market that has friendlier legal and institutional systems. Since this paper does not consider this aspect and assumes privatization occurs in a fair and transparent environment, this assumption coincides with the real economy.

Second, when considering this issue from a macro perspective, privatization improves the efficiency of SOEs in the bulk of transitioning and developing economies. Even though some specific countries, such as Russia, could not obtain positive results from privatization in the short term, such reform brings a positive effect several years later. Brown et al. (2006) estimate the effect of privatization on productivity for state-owned manufacturing firms in four economies: Romania,

Hungary, Ukraine, and Russia. Privatization raises productivity in three of the four countries. Russia, which does not raise its productivity immediately, sees the positive effects of privatization five years later. Another example is illustrated in the recent performance of developing countries, such as Vietnam and China. Tran et al. (2015) measure the impact of privatization on firm performance in Vietnam and find significant efficiency increases. Shi and Sun (2016) study the effects of privatization of listed SOEs at the firm level in China. They find that privatization results in substantial downsizing of employment and increased labor productivity. Thus, when considering privatization from a broad viewpoint, these economic facts back the assumption.

Third, under the assumption, we do not confine the magnitude of the effect, and such an effect could be large or small. Except for a few counties and specific industries, privatization has a positive or insignificant effect on efficiency, as shown by most literature on the subject. Therefore, the assumption has full representation in a real-world situation. In addition to empirical evidence, Wen and Yuan (2010) theoretically examine the optimal level of privatization in vertical public utilities and assume privatization brings cost savings and improves efficiency in the public sector. Chen (2017) endogenizes efficiency improvement relating to the privatization level and assumes that an SOE's efficiency will improve after privatization in theoretical research. Thus, this assumption is also employed by theoretical research.

The remainder of this paper is organized as follows. Section 2 documents the stylized facts and introduces the motivations of the theoretical model. Section 3 presents the model. Section 4 shows the comparative results. Section 5 discusses the results, and Section 6 is the conclusion.

2 Stylized Facts and Motivations

This section first briefly documents the distribution of SOEs and highlights the vertical structure. It then introduces the previous privatization wave in China and highlights how the vertical structure came into existence. Finally, it discusses the current privatization in China and introduces the motivation for the following theoretical model.

2.1 The Sectoral Distribution of SOE

As we mentioned in the previous section, many developed countries have pushed ahead with privatization since the 1980s. After this wave of privatization, SOEs have not accounted for a high percentage of GDP in most developed countries. However, the remaining SOEs have an intense sectoral concentration in sectors either considered "strategically" essential or those on which other sectors depend. The Organization for Economic Co-operation and Development (OECD, 2014; OECD, 2017) reported that 51% of all SOEs by value and 70% of all SOEs by employment in OECD countries are in sectors such as transportation, telecommunications, power generation, finance, mining, manufacturing, and other energy industries—most of which can be classified as upstream industries. In short, following decades of privatization in developed economies, not only do SOEs remain significant, but they are also increasingly concentrated in a few upstream sectors of immense importance to the competitiveness of other sectors.

SOEs play a more critical role in many developing and emerging economies than in developed economies. In 2010, the OECD estimated that SOEs account for 30% of China's GDP, 38% of Vietnam's GDP, and 25% of India's GDP.[3] SOEs in developing countries not only engage in activities similar to those in developed

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[3] See http://www.oecd.org/daf/ca/corporategovernanceofstate-ownedenterprises/45639683.pdf

countries but also operate in industries that are traditionally occupied by the private sector in developed countries. Moreover, SOEs, primarily large corporations, play dominant roles in several key economic sectors, and governments in developing countries have the ability to control or influence the whole economy through these SOEs.[4]

2.2 Privatization in China

The reform of SOEs has been a core element of China's economic reform process since 1978. Unlike "shock therapy" advisers, reformers have favored incremental change, and the share of SOEs in industrial production has declined gradually. At the outset, the ownership remained intact, and the primary task was to give autonomy to SOEs and introduce a market mechanism. Ownership reform started much later (on a large scale around 1995 to 2002). Under the "grasping the large, letting go of the small" policy, the number of SOEs declined significantly, which resulted in the substantial transformation of SOEs. Throughout this wave of reform, the number of SOEs declined from 118,000 to about 34,000, and SOEs' labor force fell by 44 million people (Song, 2015). Meanwhile, the sectoral distribution of SOEs also changed dramatically. Low-productivity SOEs had already exited from most of the liberalized downstream industries, such as most of the manufacturing of consumer goods, accommodation, and catering industries. In contrast, the upstream industries were still monopolized by SOEs (Li et al., 2012).

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[4]   As reported by Ministry of Planning and Investment in Vietnam, the investment capital sourced from state-owned enterprises currently accounts for 79% of the mining sector, 91% of the electricity production and distribution sector, 65% of the water supply and wastewater treatment sector, and 80% of the information, communications, and technology (ICT) sector. The investment capital sourced from state-owned enterprises also accounts for 43% of the agriculture, forestry, and fisheries sector and 57% of the finance, banking, and insurance sector. For more information, please refers to https://vietnamnews.vn/economy/348704/soes-play-dominant-role-in-national-economy.html#3oHpIepfK2Bm0jG A.97.

2.3 Motivation of the model

After this wave of privatization, managing and changing the remaining SOEs has posed an issue for China. In 2003, the State-owned Assets Supervision and Administration Commission (SASAC) was established. SASAC's focus was on the preservation and increase of the assets of SOEs. SOE expansion was mainly conducted through two avenues: public listings on stock exchanges and mergers and acquisitions. As a result, the number of SOEs decreased and many SOEs became recognizable corporations.

The rapid growth in the size of assets and output could only make SOEs bigger. However, how stronger SOEs should be built still needs to be developed. To address the critical issues of SOE governance and operation structure, China is experiencing a new wave of SOE reform. Related SOEs are concentrated in strategic and critical industries (such as power generation, railway, oil, telecommunication, coal, civil aviation, and shipping) and essential and pillar industries (such as machinery, automobiles, IT, construction, steel, base metals, and chemicals). Since 2013, four rounds of reform have been conducted, and the latest round involved at least 160 SOEs and more than 2.5 trillion yuan in assets.[5]

Next, we take the reform of China Unicom (China's second-largest telecom carrier), which is a role model for subsequent reform, to illustrate this wave of privatization. The reform aims to improve efficiency by bringing private-sector investment and management into China Unicom. Through this reform, strategic investors acquired 35.19% of China Unicom's total shares, while the shareholder's

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[5] For detailed information, please visit http://www.xinhuanet.com/english/2019-05/17/c_138067229.htm

ratio of the previous largest shareholder decreased from 62.7% to 36.67%. The reform brought some notable changes.

First, the firm streamlines its organization, cuts redundant departments, and boosts efficiency. The number of departments in the headquarters was slashed from 27 to 18, and the number of employees at the headquarters was cut by half, from 1,781 to 865. Its local branches experienced similar changes, with 205 organizations closed. Such activities reduced costs; based on the annual report in 2017, operating costs fell by 2.2%.

Second, the firm introduces innovative products with its strategic investors at competitive prices. The firm and strategic investors, such as Tencent and Alibaba, introduced products like Tencent Wang Card and Ali Card, respectively. Those cards target specific groups and reduce network flow expenses substantially. The firm cooperated with its strategic investors (most of them are internet enterprises) and provided personal products, services, and solutions to the market.

Third, the firm's performance improved significantly. The reform raised the firm's productivity, and overall labor productivity rose 14% in 2018. Moreover, annual net profit increased from RMB 625 million in 2016 to RMB 1,828 million in 2018.

From the recent experience in China, we can make three conclusions. First, most SOEs are located in the upstream sector and offer essential intermediate inputs to downstream sectors. Second, along with the privatization process, SOEs improve efficiency and reduce redundant departments, and downsize employment. Third, after privatization, the price of SOEs may not always rise. These characterizations motivate

us to build a theoretical model to analyze the impacts of privatization under the vertical structure and explain the mechanism behind the phenomenon.

3 The Model

We consider a developing economy with urban and rural region. In the rural region, private firms in the agricultural sector produce agricultural good X under perfect competition. Within the urban region, there is a vertical structure with an upstream public firm, which is facing partial privatization, producing an intermediate input Z and the downstream manufacturing sector producing a consumption good Y. Consumers demand final goods X and Y. Following Chao et al. (2018), assume the utility function is quasi-linear: $U = X + aY - Y^2/2$, where a is sufficiently large and represents the scale of the market. The budget constraint is: $I = X + p_Y Y$, where I is total income, price of the good X is normalized to be unity, and p_Y is the relative price of good Y. Solving the utility maximization problem, we get the inverse demand for good Y, $p_Y = p_Y(Y) = a - Y$, with $p_Y'(Y) = -1 < 0$.

The agricultural good is produced by using labor and land with wage w and rental rate τ under the constant-returns-to-scale technology in the rural area. The corresponding unit cost function is denoted by $w^\alpha \tau^{1-\alpha}$, where α is a parameter in the range $(0,1)$. Under the condition that its market is perfectly competitive, we could obtain

$$w^\alpha \tau^{1-\alpha} = 1 \tag{1}$$

By Shephard's lemma, demands for labor L_X and land T are $L_X = \alpha X/w$ and $T = (1-\alpha)X/\tau$, respectively.

As for the urban region, downstream manufacturing sector Y is perfectly competitive with constant returns to scale, and firms in this sector are pricing-taking in both output and input markets. The manufacturing sector uses labor and intermediate good Z as inputs and the production function is $Y = L_Y^{1-\beta} Z^\beta$, where is L_Y the labor input and β is a parameter in the range $(0,1)$. To make the after analysis tractable, assuming β is relatively large. Considering the economic reality, the upstream SOEs play strategically significant roles in the developing economy by offering essential intermediate input; thus, the assumption here is acceptable. From the production function, the unit cost in the manufacturing sector c is given by

$c = Aw^{1-\beta} p^\beta$, where p is the price of intermediate input and $A = \dfrac{1}{1-\beta}\left(\dfrac{1-\beta}{\beta}\right)^\beta > 0$.

Since the manufacturing sector is price taking, it produces where price p_Y equals unit cost c. From the unit cost function of the manufacturing sector, we have

$$p = \left(\frac{a-Y}{A}\right)^{\frac{1}{\beta}} w^{\frac{\beta-1}{\beta}} \tag{2}$$

The equation (2) shows the amount that the downstream manufacturing sector pays for its intermediate input as a function of its output price and wage rate. At output level, the manufacturing sector's demand for labor and intermediate input are given by $L_Y = (1-\beta)(a-Y)Y/w$ and $Z = \beta(a-Y)Y/p$, respectively.

The upstream firm produces good Z with a technology which uses labor alone and has increasing returns to scale. Assume that the technology has fixed labor input f and marginal labor input b per unit output. The profit π, therefore takes the form, $\pi = pZ - w(f + bZ)$. Since the upstream is a public (partially privatized) firm, it cares not only in its profit, but also is welfare generated. The welfare is: $W = \pi + CS$, where

$CS = aY - Y^2/2 - p_Y(Y)Y = Y^2/2$ denotes consumers' surplus from good Y. The objective of the upstream firm is to maximize a weighted average of its profit and welfare, $\theta\pi + (1-\theta)W$, where θ is a parameter in the range $[0,1]$. θ represents the degree of private ownership: the more the private-owned, the larger the value of θ. Assume that once the upstream firm is (partial) privatized, its efficiency is improved in the variable cost. We thereby assume that $b = b(\theta)$, where $b'(\theta) < 0$, $b''(\theta) > 0$. We regard $-b'(\theta) > 0$ as the efficiency-enhancing effect if θ raises. The upstream firm chooses the output to maximize the objective and first order condition is:

$$p\left(1 - \frac{Y\theta}{a-Y}\right) = wb \qquad (3)$$

The left term expresses marginal benefits of producing good Z and the right side is the marginal cost. When $\theta = 0$ ($0 < \theta < 1$), the upstream firm is fully state-owned (partial privatized), and price is equal (larger) than the marginal cost. As expected, deepening privatization of upstream firm increases its price when such change does not affect the reward of labor and the firm's efficiency.

The equilibrium condition for labor, land and intermediate input are:

$$\alpha X/w + (1-\beta)(a-Y)Y/w + Zb + f = L \qquad (4)$$

$$(1-\alpha)X/\tau = T \qquad (5)$$

$$(a-Y)\beta Y/p = Z \qquad (6)$$

where L and T are endowment of labor and land.

The construction of the model has completed. There are six equations, from (1) to (6), determining six endogenous variables, namely w, τ, X, Y, Z, p. The whole model

can be solved as follows. (1) and (5) can determine the equilibrium values of τ and X, which are conditional on the equilibrium value of w. The equilibrium value of Y and p could be determined by (2) and (3), given the equilibrium values of w. Substituting Y and p into (6), we can easily get the equilibrium value of Z which is a function of w. Putting above results into (4), we can get the equilibrium value of w, from which we could obtain the equilibrium values of other endogenous variables.

4 Comparative Results

This section examines the impact of the deepening of privatization (an increase in θ) on the output of two final sectors and on social welfare.

First, we consider the agricultural sector. The agricultural sector minimizes its cost according to (1), and by completely differentiating equation (1), we have:

$$\hat{\tau} = -\frac{\alpha}{1-\alpha}\hat{w} \qquad (7)$$

where the notation "^" above a variable denotes the relative change. The zero profit in agriculture makes τ and w change in the opposite direction.

The rent of land is determined by (5). By completely differentiating (5) and using (7), we have:

$$\hat{X} = \hat{\tau} = -\frac{\alpha}{1-\alpha}\hat{w} \qquad (8)$$

From (8), a change in w causes τ and X to shift in the same direction. An increase in the wage rate reduces the labor demand, which lowers the marginal productivity of land and its output.

Next, we investigate the urban region. By completely differentiating equations (2) and (6), we obtain

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$$\hat{p} - \left(1 - \frac{1}{\beta}\right)\hat{w} + \frac{Y}{\beta(a - Y)}\hat{Y} = 0 \qquad (9)$$

and

$$\frac{a - 2Y}{a - Y}\hat{Y} - \hat{p} - \hat{Z} = 0 \qquad (10)$$

Where $a - 2Y > 0$ under the assumption that the market scale is sufficiently large. Obviously, more expensive intermediate input decreases manufacturing output from (9), and more provision of Z raises it from (10).

Next, we consider the impact of the partial privatization of an upstream public firm. Such effects can be derived from equations (3) and (4). Using equation (8) and completely differentiating equations (3) and (4) gives us

$$\hat{p} - \hat{w} - \frac{a\theta Y}{(a - Y)(a - Y - \theta Y)}\hat{Y} = \left(\frac{Y\theta}{(a - Y - \theta Y)} + \varepsilon_\theta\right)\hat{\theta} \qquad (11)$$

and

$$-\left(\frac{\lambda_{LX}}{1 - \alpha} + \lambda_{LY}\right)\hat{w} + \lambda_{LY}\frac{a - 2Y}{a - Y}\hat{Y} + \lambda_{LV}\hat{Z} = -\lambda_{LV}\varepsilon_\theta\hat{\theta} \qquad (12)$$

where $\lambda_{LX}(\lambda_{LY})$ represents the allocative share of labor in the production of product $X(Y)$ and λ_{LV} represents the allocative share of labor in the variable cost of production of product Z. $\varepsilon_\theta = \theta b'/b < 0$ expresses the marginal labor input elasticity of privatization. If the absolute value of ε_θ, which is mainly determined by the magnitude of the efficiency-enhancing effect, is large, then the marginal labor input decreases by a relatively large margin as a result of privatization. Conversely, if the absolute value of ε_θ is small, the deepening of privatization has a negligible impact on

the marginal labor input. From (11), the deepening privatization of an upstream public

firm may not increase its price if the efficiency-enhancing effect is relatively large.

Equation (12) states that the deepening privatization also leads to a reduction in a

firm's costs by lowering its wage rate.

To conduct a comparative static analysis of the impacts of privatization on the

economy, rewrite (9) to (12) into the matrix forms

$$
\begin{pmatrix}
1 & -\left(1-\dfrac{1}{\beta}\right) & \dfrac{Y}{\beta(a-Y)} & 0 \\[2mm]
1 & -1 & -\dfrac{a\theta Y}{(a-Y)(a-Y-\theta Y)} & 0 \\[2mm]
0 & -\left(\dfrac{\lambda_{LX}}{1-\alpha}+\lambda_{LY}\right) & \dfrac{\lambda_{LY}(a-2Y)}{a-Y} & \lambda_{LV} \\[2mm]
-1 & 0 & \dfrac{a-2Y}{a-Y} & -1
\end{pmatrix}
\begin{pmatrix}
\hat{p} \\[1mm] \hat{w} \\[1mm] \hat{Y} \\[1mm] \hat{Z}
\end{pmatrix}
=
\begin{pmatrix}
0 \\[1mm]
\dfrac{Y\theta}{a-Y\theta-Y}+\varepsilon_\theta \\[2mm]
-\lambda_{LV}\varepsilon_\theta \\[1mm]
0
\end{pmatrix}
\hat{\theta}
\quad (13)
$$

Denote the value of the determinant of the coefficient matrix of (13) as Δ, and

we have

$$
\Delta = \frac{1}{a-Y}\left\{\frac{1}{\beta}\left[(\lambda_{LY}+\lambda_{LV})(a-2Y)-\frac{a\theta Y\lambda_{LV}}{a-Y-\theta Y}\right]+\left(\frac{Y}{\beta}+\frac{a\theta Y\lambda_{LV}}{a-Y-\theta Y}\right)\left(\frac{\lambda_{LX}}{1-\alpha}+\lambda_{LY}+\lambda_{LV}\right)\right\}>0\,.
$$

Deepening privatization will affect the price of both intermediate input and

output directly, which further changes factors' price and the output of the final sectors

indirectly. We use Proposition 1 to summarize how the price and output of

intermediate input change due to the privatization of the SOE.

Proposition 1: *Deepening privatization lowers (or raises) its price and increases (or*

decreases) its output if the efficiency-enhancing effect is relatively large (or small). If

the efficiency-enhancing effect lies in the interval ($\frac{1}{\psi_2}$, $\frac{1}{\psi_1}$), an increase in

privatization raises the price and output simultaneously.

Proof: See Appendix 1.

      The economic intuition provided by Proposition 1 can be expressed as follows. The implementation of privatization corresponds to more commercial objectives, which is achieved by the firm reducing its output and raising the price of its product, as seen in most previous studies. With less provision for intermediate input, the downstream manufacturing sector also decreases its output, which in turn decreases employment in two sectors and, therefore, reduces the wage rate. When incorporating the impact of privatization on public firms' efficiency, an increase in the privatization level generates another effect: the efficiency-enhancing effect. Concerning this cost-reduction effect, privatization reduces employment in the unit production of an upstream firm, which decreases the wage rate in the labor market. Therefore, the upstream firm faces a lower marginal labor input, wage rate, and marginal cost after privatization. Furthermore, if the effect is relatively large (or small), which means a large (or small) reduction of marginal labor input, an increase in the privatization level reduces its marginal cost significantly (or insignificantly). Following (3), its price consequently decreases (or increases), and its output increases (or decreases). When the effect is moderate, an increase in the privatization level raises output due to efficiency improvement. However, a more commercial objective dominates the price change, resulting in raising the price.

Next, we investigate how the deepening privatization of a public firm exerts an impact on two final sectors, which are described by Propositions 2 and 3.

Proposition 2: *An increase in the privatization level expands (or shrinks) the output of the manufacturing sector if the efficiency-enhancing effect is relatively large (or small).*

Proof: See Appendix 2.

By calculation, the threshold of the efficiency-enhancing effect in Proposition 2 is less than that of Proposition 1. When the effect is large enough, that is, larger than $\frac{1}{\psi_1}$, an increase in the privatization level expands the output of the intermediate input and reduces its price and wage rate, which promotes manufacturing output. When the effect lies within $(\frac{1}{\psi_2}, \frac{1}{\psi_1})$, deepening the privatization level raises the intermediate output and reduces the wage rate, which contributes to the expansion of manufacturing output. When the effect lies within $(\frac{1}{\psi_3}, \frac{1}{\psi_2})$, the implementation of the privatization process reduces the intermediate output and wage rate. The contraction of the intermediate output harms the manufacturing output. However, if the intermediate input does not have an extremely significant role in manufacturing production, that is, β is not close to 1, an increase in the privatization level results in the expansion of manufacturing output. This expansion of manufacturing is driven by a lower wage rate effect that offsets the reduction of an intermediate output effect. When the effect is smaller than the threshold in Proposition 2, the reduction of the

intermediate output dominates the change of manufacturing output, and an increase in privatization level decreases manufacturing output.

Proposition 3: *In the established model, deepening the privatization level increases (or decreases) the output of the agricultural sector if the efficiency-enhancing effect is relatively small (or large enough).*

Proof: See Appendix 3

Concerning the impact of deepening privatization on agricultural output, the result depends on its impact on the wage rate from (8). Since the land factor is specific to the agricultural sector, when an increase in privatization level leads to a reduction (raise) in wage rate, the agricultural sector enlarges (reduces) its employment and expands (contracts) its output. As seen in the Appendix 3, the threshold of the efficiency-enhancing effect in Proposition 3 is the largest among the three propositions. When the effect is larger than the threshold in Proposition 3, an increase in privatization level expands intermediate output greatly, and the manufacturing sector expands its output significantly, which raises the demand for labor and wage rate. Except for this case, the implementation of privatization reduces the wage rate and increases agricultural output.

Next, we consider the impact of privatization on social welfare. We first establish the social welfare criterion, which is the basis for evaluating privatization. Following Beladi and Chao (2006), the social welfare of the economy is expressed by

the utility $U = X + aY - Y^2/2$. When we differentiate this utility entirely and substitute the results from Appendix 1 to 3, we get

$$\frac{\hat{U}}{\hat{\theta}} = \frac{I\theta}{U\Delta}\left\{\frac{X}{I}\frac{\alpha}{1-\alpha}\frac{\Psi_4\left(1+b'\psi_4/b\right)}{(a-Y)(a-Y-\theta Y)} - \frac{p_Y Y}{I}\frac{(\beta\Psi_3 - \lambda_{LV})}{(a-Y-\theta Y)\beta}\left(1+\frac{b'}{b}\psi_3\right)\right\}$$

Since the sign of the above equation is ambiguous, we consider the following three cases: (a) if $-b'/b$ is small enough (less than $1/\psi_3$), the sign of $\hat{U}/\hat{\theta}$ is ambiguous, depending on the values of X/I and $p_Y Y/I$. If X/I is relatively larger (or smaller) than $p_Y Y/I$, meaning agricultural occupies a relatively large (small) share in national income, then $\hat{U}/\hat{\theta} > 0$ ($\hat{U}/\hat{\theta} < 0$); (b) if $\frac{1}{\psi_3} < -\frac{b'}{b} < \frac{1}{\psi_4}$, then $\hat{U}/\hat{\theta} > 0$ is unambiguous; and (c) if $-\frac{b'}{b} > \frac{1}{\psi_4}$, the sign of $\hat{U}/\hat{\theta}$ also depends on the value of X/I and $p_Y Y/I$.

Proposition 4: *The impact of deepening privatization on social welfare depends on the magnitude of the efficiency-enhancing effect. If the effect is moderate, an increase in the privatization of an upstream firm raises social welfare unambiguously.*

Suppose that the efficiency-enhancing effect is small enough. An increase in the privatization level decreases the output of the intermediate sector and reduces the equilibrium wage rate. More labor will be employed in the agricultural sector, causing the agricultural output to increase. The expansion of the agricultural sector and the contraction of the manufacturing sector has an uncertain effect on social welfare. If

the share of the manufacturing sector is relatively large, the implementation of the privatization process harms the manufacturing sector and national income. If the share of the agricultural sector is large enough, the negative impact on the manufacturing sector is offset by the positive impact on the agricultural sector, resulting in raising social welfare.

Next, we consider a moderate efficiency-enhancing effect. An uptick in the privatization level raises the output of the upstream firm. Efficiency improvement in the upstream firm and substitution between intermediate input and labor reduce the labor demand, while the expansion of the upstream firm and manufacturing raise it. When the efficiency-enhancing effect is moderate, a rise in privatization level reduces the price of the intermediate input less severely, resulting in a smaller increase in the demand for labor in the manufacturing sector. Therefore, the demand for labor in the manufacturing sector and the upstream firm increases slightly, bringing down the wage rate. The agricultural sector employs more labor to increase its output. In this case, an increase in privatization increases the output of the two final sectors simultaneously. Consequently, deepening privatization increases social welfare.

When the effect is large enough, an increase in privatization expands the output of the manufacturing sector more noticeably, resulting in a significant increase in the demand for labor. As a result, the equilibrium wage rate rises. More labor is employed in the urban region, shrinking the output of the agricultural sector. The impact of deepening privatization on social welfare depends on the income share of the manufacturing sector and the agricultural sector. If the manufacturing share is relatively large (small), deepening (diminishing) privatization contributes to social welfare.

5 Discussion of results

In this section, we provide some discussions for our theoretical analyses from real-world experiences. When evaluating the efficiency effects of privatization, researchers face numerous methodological problems (Megginson and Sutter, 2006). Data availability and consistency, especially in developing countries, and sample selection bias, represent critical issues. Not to mention estimating the variation of cost, price, and employment due to privatization. In theory, once privatized, the firm will raise its price to seek more profit; meanwhile, its cost also decreases due to efficiency improvement, which could reduce its price. Thus, a rise in the privatization level will not always increase its price. Such a mechanism has been empirically examined by Konings et al. (2005). Konings et al. (2005) use representative panel data on 1,701 Bulgarian and 2,047 Romanian manufacturing firms to analyze how price-cost margins are affected by privatization and competitive pressure. Konings et al. (2005) conclude that privatized firms reduce costs rather than increase prices. Karlaftis and McCarthy (1999) examine the effect of privatization on the city of Indianapolis with its cost of providing mass transit. They find the city has experienced an annual 2.5% reduction in operating costs since privatizing the management of its public transit system. Boardman et al. (2009) use cost-benefit analysis to estimate the welfare gains from the privatization of Canadian National Railway, estimating them to be at least $4 billion (in 1992 dollars).

Regarding its effect on employment and wage rate, conventional wisdom and literature support the hypothesis that privatization cuts jobs and wages. Theoretical models imply that privatization increases efficiency and reduces costs, which potentially results in downsizing and wage cuts (Boycko et al., 1996; Aghion and Blanchard, 1998). The discussions implicitly assume that SOEs' output remains

constant. Among the extensive literature on privatization, the existing analysis on the employment and wage effects of privatization is limited both from theoretical and empirical perspectives. Haskel and Szymanski (1993) analyze 14 British SOEs, of which four were privatized, and the others were deregulated and find that employment fell following the change to more commercial objectives. Bhaskar and Khan (1995) use data to estimate employment effects in 62 Bangladeshi jute mills and find privatization led to sizable downsizing.

However, traditional findings have been challenged by Brown et al. (2006) and Brown et al. (2010) by utilizing large sample sizes and long time-series data. Brown et al. (2006) estimate the effects of privatization on employment and wages by using a sample of Ukrainian households. The results imply that privatization reduces wages by 5% and cuts the layoff probability in half. Brown et al. (2010) use comprehensive firm panel data in four transition economies to estimate the impact of privatization on employment and wages. The results reject job losses and never imply massive wage cuts from either domestic or foreign privatization. Brown et al. (2010) argue that the employment and wage effects of privatization are theoretically ambiguous, depending on underlying effects on productivity. The paper decomposes the employment impact into a productivity-improvement effect that tends to lower employment (for the given output) and a scale-expansion effect that tends to raise it (holding productivity constant) and decomposes the wage impact into cost-reduction and productivity-improvement effects, with expected negative and positive signs, respectively. Depending on the mechanisms' relative strength, determined by productivity effect, employment and wages may rise or fall as a result of privatization. Fewer empirical research studies consider developing economies, and the available evidence is ambiguous. For example, Guo and Yao (2005) examine firm-level panel

data in China and find privatization reduces redundancy in employment. By contrast, Bai et al. (2009) examine a comprehensive panel data set of China's SOEs and conclude that privatization has little impact on firms' employment.

From the above discussions, the effects of privatization on employment and wages are inconclusive from empirical evidence, and privatization may not raise prices following the change to more commercial objectives. Productivity improvement due to privatization, that is, the efficiency-enhancing effect, could explain the underlying mechanism (Brown et al., 2010). Thus, our theoretical model and results could provide new insights concerning the privatization issue.

6 Concluding remarks

The study explores the impacts of privatization of a public upstream firm on the developing economy through the general equilibrium approach. We concluded that the efficiency-enhancing effect of privatization is crucial for determining the impact of privatization and offers a new perspective for considering the privatization issue. We also find that deepening privatization lowers (or raises) its price and increases the output of the manufacturing sector if the efficiency-enhancing effect is relatively large (or small). When the effect is moderate, an increase in the privatization level increases the output of both the manufacturing and the agricultural sectors and raises social welfare.

To conclude our study, we propose possible directions for future research. First, for the purposes of this study, we assume that all market sectors employ homogeneous labor and that there is no unemployment in the economy. However, the upstream public sector holds a monopoly position, and unskilled labor may not be employed in

this sector. In further analysis, we can introduce heterogeneous labor—skilled and unskilled—into the model. Second, many developing countries experience massive rural labor migration and urban regions often have high unemployment. For this situation, we can incorporate unemployment and a rural labor migration mechanism into the model, which may result in different conclusions. Third, foreign competition is not considered in this study. In the future, we can introduce a foreign private firm in the upstream market to compete with the public firm.

Appendix 1 Proof of the Proposition 1

Solving (13), and we get the following results:

$$\frac{\hat{p}}{\hat{\theta}} = \frac{\theta \Psi_1 Y}{\Delta \beta (a-Y)(a-Y-\theta Y)} \left(1 + \frac{b'}{b} \psi_1\right) \text{ and } \frac{\hat{Z}}{\hat{\theta}} = -\frac{\theta \Psi_2 Y}{(a-Y)(a-Y-\theta Y)\Delta} \left(1 + \frac{b'}{b} \psi_2\right), \text{ where}$$

$$\Psi_1 = (1-\beta)(\lambda_{LY} + \lambda_{LV})(a-2Y) + Y\left(\frac{\lambda_{LX}}{1-\alpha} + \lambda_{LY}\right) > 0,$$

$$\psi_1 = \frac{a-Y-Y\theta}{Y} + \lambda_{LV}\frac{a-Y-\theta Y-(1-\beta)a\theta}{\Psi_1} > 0,$$

$$\Psi_2 = \left(\frac{Y}{\beta} + a - 2Y\right)\left(\frac{\lambda_{LX}}{1-\alpha} + \lambda_{LY}\right) - \lambda_{LY}(a-2Y)\left(1 - \frac{1}{\beta}\right) > 0, \text{and}$$

$$\psi_2 = \frac{a-Y-\theta Y}{Y} + \lambda_{LV}\frac{(a-Y)(a-Y-\theta Y)-a\theta Y(1-\beta)}{\beta \Psi_2 Y} > 0. \text{ By calculation, we have}$$

$$\frac{1}{\psi_2} < \frac{1}{\psi_1}. \text{ Therefore, if } -\frac{b'}{b} > \frac{1}{\psi_1}, \text{ then } \frac{\hat{p}}{\hat{\theta}} < 0 \text{ and } \frac{\hat{Z}}{\hat{\theta}} > 0. \text{ If } -\frac{b'}{b} < \frac{1}{\psi_2}, \text{ then } \frac{\hat{p}}{\hat{\theta}} > 0 \text{ and}$$

$$\frac{\hat{Z}}{\hat{\theta}} < 0. \text{ If } \frac{1}{\psi_2} < -\frac{b'}{b} < \frac{1}{\psi_1}, \text{then } \frac{\hat{p}}{\hat{\theta}} > 0 \text{ and } \frac{\hat{Z}}{\hat{\theta}} > 0.$$

Appendix 2 Proof of the Proposition 2

Solving (13) concerning on the change of manufacturing output , and we get:

$$\frac{\hat{Y}}{\hat{\theta}} = -\frac{\theta Y(\beta \Psi_3 - \lambda_{LV})}{\Delta(a-Y-\theta Y)\beta}\left(1+\frac{b'}{b}\psi_3\right), \text{where } \Psi_3 = \lambda_{LY} + \lambda_{LV} + \frac{\lambda_{LX}}{1-\alpha} > 0, \text{and}$$

$$\psi_3 = \frac{\beta\Psi_3(a-Y-\theta Y)}{Y(\beta\Psi_3 - \lambda_{LV})} > 0. \text{In addition, we have } \frac{1}{\psi_3} < \frac{1}{\psi_1}. \text{ Thus, if } -\frac{b'}{b} > \frac{1}{\psi_3}, \text{ then}$$

$$\frac{\hat{Y}}{\hat{\theta}} > 0 \text{ ;if} -\frac{b'}{b} < \frac{1}{\psi_3}, \text{ then} \frac{\hat{Y}}{\hat{\theta}} < 0. \text{ Through calculation, } \frac{1}{\psi_3} < \frac{1}{\psi_2} < \frac{1}{\psi_1} < \frac{Y}{a-Y-\theta Y}.$$

Appendix 3 Proof of the Proposition 3

Solving (13) concerning on change of wage rate, and we get:

$$\frac{\hat{w}}{\hat{\theta}} = -\frac{Y\theta\Psi_4}{\Delta(a-Y)(a-Y-\theta Y)}\left(1+\frac{b'}{b}\psi_4\right) \text{where } \Psi_4 = Y\left(\lambda_{LV}\frac{Y}{\beta} + (a-2Y)(\lambda_{LY}+\lambda_{LV})\right) > 0$$

$$\text{and } \psi_4 = \frac{a-Y-\theta Y}{Y} - \frac{\lambda_{LV}(a-Y-\theta Y)+a\theta\beta\lambda_{LV}}{\Psi_4} > 0. \text{ In addition, we can get}$$

$$\frac{1}{\psi_3} < \frac{1}{\psi_2} < \frac{1}{\psi_1} < \frac{Y}{a-Y-\theta Y} < \frac{1}{\psi_4}. \text{Then, if} -\frac{b'}{b} < \frac{1}{\psi_4}, \text{ then} \frac{\hat{w}}{\hat{\theta}} < 0 \text{ and } \frac{\hat{X}}{\hat{\theta}} > 0; \text{ if} -\frac{b'}{b} > \frac{1}{\psi_4},$$

$$\text{then} \frac{\hat{w}}{\hat{\theta}} > 0 \text{ and } \frac{\hat{X}}{\hat{\theta}} < 0.$$

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