China's Accession to the WTO: Implications for the State-Owned Sector *

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Abstract

In December 2001 China became a member of the World Trade Organization (WTO). By signing the accession protocol China not only agreed to reform its trade policy but it also accepted regulations that imply reductions on government subsidies to the state-owned sector. In this paper we claim that the latter, largely ignored in the literature, generate important welfare gains from WTO accession. We develop a dynamic general equilibrium model of a small open economy with state and private enterprises, we calibrate it to the Chinese economy, and we quantitatively assess the economic effects of reducing subsidies to the state sector as required by the WTO. We find the welfare benefits of such reduction in subsidies to be substantial. Using the context of China, this paper identifies a new channel through which WTO accession increases a country's welfare: induced reforms on the state sector and the subsequent increase in economic efficiency.

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1 Introduction

In December 2001, after fifteen years of negotiations, China became the 143rd member of the WTO in what was seen as an important step towards world economic integration. In signing the WTO accession protocol China committed to follow a set of rules and regulations aimed at facilitating international trade. Most of these regulations require changes in trade policy such as tariff reduction, elimination of quotas, and improved accessibility to domestic markets by foreign competitors. An extensive literature has focused on the potential effects of these reforms of trade policy on China and the rest of the world. See, for instance, World Bank (2004) and the studies cited therein.

Less attention has been given to another set of regulations, also included in China's accession documents, that involve provisions which will lead to deeper reforms in China's state-owned sector.[1] This second set of provisions may have substantial economic effects on the Chinese economy, due to its large, inefficient, and heavily subsidized state-owned enterprises (SOEs). We argue that the welfare benefits derived from reforms on the SOE sector promoted by WTO accession, are important and should be added to any welfare gains derived from the pure effects of trade policy reform. Assessing the welfare gains derived form this set of provisions is the objective of our study.

In this paper we develop a dynamic applied general equilibrium model in order to assess the welfare benefits of introducing the reforms on the SOE sector implied by China's WTO accession documents. The basis of our framework is a two-sector neoclassical growth model with exogenous technological change of a small open economy modified to allow for two types of producers in each sector to co-exist: SOEs and private enterprises. Our choice of model structure is in line with the literature studying the welfare effects of trade liberalization. Having an open economy model with multiple sectors allows us to capture the reallocation of resources across sectors and the trade effects of a change in policy, which are the main sources of welfare gains of trade reform in the existing literature.

SOEs and private enterprises in a given sector produce goods that are perfectly substitutable, using a constant returns to scale technology. SOEs differ from private enterprises in their productivity levels and in the fact that they have minimum employment levels required by the government.[2] In exchange for maintaining the employment level, SOEs receive subsidies from the government. We consider two types of subsidies: *direct subsidies* to the

[1] These provisions are mainly included in Annex 1A, Agreement on Subsidies and Countervailing Measures of the WTO's legal document on the Uruguay Round Agreements.

[2] See Yin (2001) for evidence of the government using SOEs to maintain employment levels.

SOE sector, which are used to cover production losses, and *capital subsidies* or low-interest loans from state banks. Given that the magnitude of the effects of WTO accession on capital subsidies is hard to assess, in this paper we mainly concentrate in studying the effects of WTO accession on direct subsidies to the SOE sector and give some estimates of the economic effects of reducing the capital subsidies. Regarding productivity levels, SOEs are found to be less efficient than private firms operating in the same industry. It is precisely this differences in efficiency that drive the results of this paper: as subsidies to SOEs are reduced, resources move to the private, more efficient sector, increasing overall productivity.

Notice that in this paper we take SOE policy and WTO accession as exogenous policy decisions. An interesting question, left for further research, is whether similar SOE reforms would occur in China independently of WTO accession. Using a political economy approach, Branstetter and Feenstra (2002) find that regional and local governments favor state-owned enterprises in their objective functions. We take their results as indicative of the existence of special interest groups that benefit from SOEs and that may create political pressures to keep the SOE subsidies high. Linking SOE reform to WTO accession may be a way to overcome these pressures.

We calibrate the parameters of our model to the Chinese economy and compare the transitional dynamics of an economy that reforms the SOE sector in the lines induced by China's WTO accession protocol with a benchmark economy that does not reform its SOE sector. We find that the welfare gains of WTO-induced reforms on direct subsidies to SOE are of 3.8 percent in terms of equivalent variation.[3] Real GDP per capita and total factor productivity (TFP) levels are respectively 2.2 percent and 4.2 percent higher in the reformed economy. If capital subsidies are also reduced during the reform period, welfare gains increase even further by means of two channels: a reduction in capital accumulation in the inefficient SOE sector and the need of deeper reductions in SOE employment in order to comply with WTO requirements.

Most of the welfare gains of SOE reform are derived from reallocation of productive resources within sectors, from inefficient SOEs to more efficient private enterprises, and the subsequent increase in total factor productivity. Therefore, calibrating the relative inefficiency of the SOE sector in each industry is crucial in our study. Our calibration procedure, which is explained in detail in section 4 and the appendix, delivers private firms that are 2.1 times more productive than SOEs in the traded industry and 1.2 times more productive in

[3]That is, the representative consumer in the benchmark economy would need a permanent increase in steady state consumption of 3.8 percent to be as well off as the representative consumer in the reformed economy.

the non-traded industry. These relative inefficiencies are consistent with results in Schmitz (1997), who finds private firms in industries like chemicals and machinery and equipment (which we include in the traded industry) to be between 2 and 3 times more productive than SOEs operating in the same industries. He also cites studies finding differences in productivity between the private sector and the state sector to be more similar in industries like electricity, which we classify as non-traded industries.

The overall welfare gains derived from the reforms in the SOE sector are smaller than welfare comparisons between balanced growths paths, which amount to 4.5 percent of GDP. An analysis of the transitional dynamics reveals that the discrepancy is due to the differences in the behavior of equilibrium paths. The reformed economy grows at a slower rate than the benchmark economy in the pre-reform periods, as individuals hold on their investments until the reforms start, grows faster during the reform periods, and gradually converges to a balanced growth path with higher welfare.

Our model economy does not capture the transitional costs of unemployment, which may be important as workers laid off as part of the SOE reform struggle to find jobs in the private sector (see Brooks 2004). In a first attempt to study the potential magnitude of these costs, we relax the assumptions of our model to allow for the employment level to decrease after reforms take place. We find that the transition costs of unemployment vary widely with the speed at which the employment level recovers during the transition. In the extreme case where employment levels are permanently reduced, the welfare gains from WTO-induced SOE reform are drastically reduced to less than .6 percent. If the employment level completely recovers after a period of ten years, the welfare gains are reduced to 3.6 percent (compared to welfare gains of 3.8 percent when unemployment costs are not taken into account).

Our paper's main message goes well beyond the case of China's WTO accession: benefits from trade liberalization can be much higher than the pure benefits derived from trade policy reform, especially in countries with large state sectors. The methodology developed in this paper can be applied to analyze the economic effects of liberalization in countries with large state sectors, such as Vietnam, or in countries with highly subsidized industrial sectors.

This paper relates to several existing literatures. First, it relates to the literature that investigates the economic effects of China's accession to the WTO (see, for instance, Fang and Zheng 2001, McKibbin and Tang 2000, Lardy 2002, Rumbaugh and Blancher 2004, Walmsley and Hertel 2001, Walmsley and Hertel 2001, Wang 1999, Wen 2000, and Ianchovichina and Martin 2001 and 2004, and the studies cited there in). These studies concentrate on the gains from pure changes in trade policy and do not consider the effects of WTO on the state sector. Our paper complements these studies by pointing out another source of benefits to China from WTO accession. To the best of our knowledge, our paper is the first one to quantitatively analyze the economic effects of China's WTO accession on SOE reform, even though other studies have mentioned the fact that the Chinese gains of economic liberalization derived from internal reforms may be important (see for instance Frazier 1999, Claro 2001, Cheng 2000, Rumbaugh and Blancher 2004, and Lardy 2002).

Second, our paper also relates to the vast literature that studies state-owned enterprises. Two papers in this literature are directly related to ours. Ghosh and Whalley (2000) in a different setting also conclude that tariff reduction may have different implications in economies with sizable state sectors. Schmitz (1997) is one of the few papers that presents measures of the relative productivity of the SOE sector with respect to the private sector. The paper studies the impact on average labor productivity of having SOEs in the investment sector using a general equilibrium framework. Even though the methodology used in his study is similar to ours, the papers differ in several aspects: Schmitz concentrates in the presence of SOEs in the investment sector, he does not study the link between trade liberalization and the SOE sector, and he does not study the case of China.

Finally, our paper relates to the literature analyzing China's state-owned sector. Most of these studies are concerned about the performance of China's SOE during the reform period (Hay, Morris, Lin and Yao 1994, Huang and Duncan 1997, Li 1997, Lin, Cai and Li 1998, Perkins 1994, Sicular 1995, and Wei, Varela and Hassan 2002, are some examples). Our paper is closer to Yin (2001) who studies the economic effects of reducing overstaff in China's SOEs. In Yin (2001), as in our study, the reallocation of workers from the SOE sector to the private sector is a source of economic growth. In contrast to our paper, his study is only theoretical and does not quantify the magnitude of the effects implied by his model.

This paper is organized as follows. In section 2 we briefly describe the Chinese economy and the conditions under which China acceded to the WTO. Section 3 presents the model economy. Section 4 contains the calibration of the model to the Chinese economy. Section 5 presents results from numerical experiments. Section 6 introduces transitional costs of unemployment. Sensitivity analysis on some of the parameters of the model is performed in section 7, and section 8 concludes.

2 China's SOE Reform and the WTO

The Chinese economy was centrally planned prior to 1978. That year, China's leader Deng Xiaoping introduced a series of reforms that gradually opened the economy, implemented a market-oriented reform, and allowed non-state ownership to exist and develop. Following the Soviet Union's economic structure, the Chinese industries were mostly state-owned at the beginning of the economic reform. The state sector dominated virtually all non-farm industries, accounting for 78 percent of industrial output in 1978. Reforming the SOE sector has been a crucial aspect of economic reform in China, with the government trying different approaches since 1983 in order to improve the efficiency and profitability of the sector. The task has proven difficult and, even though the SOEs' share of GDP had been reduced to 25.5 percent of GDP in 1997, their overall profitability deteriorated during this period.[4] Furthermore, SOEs remain less productive and less profitable than other types of ownerships.[5]

The existence of SOEs creates a dual market that affects the Chinese economy mainly by promoting an inefficient distribution of resources. Government subsidies, cheap loans from the state owned commercial banks, and laws that protect SOEs' workers against layoffs keep the SOEs operating even though half of them are loss-making enterprises.[6] Despite this inefficiency, the Chinese public sector still accounts for a big share of capital formation (over 65 percent in the period 1994-97) and consumes most of China's savings (in the order of 70-80 percent) through cheap loans from state banks. This represents a burden to the financial system, since as much as 40 percent of these loans may be non-performing.[7]

WTO requirements that explicitly target the SOE sector are stated in Annex B of the "Agreement on Subsidies and Countervailing Measures" (SCM), which lists subsidies that are to be phased out upon China's accession to the WTO. Part I of the Annex mentions the"subsides provided to certain SOEs which are running at a loss," given in the form of grants or tax breaks, that are to be phased out in a period of 5 years. For 1997 the amount of direct subsidies included under the provision is of 9.6 billion RMB, or about 25 percent of total direct SOE subsidies for that year.

SOE subsidies are also explicitly mentioned on paragraphs 172 and 173 of the Report of the Working Party on the Accession of China where, in response to concerns about the com-

[4] Lin, Cai and Li (1998).

[5] See Hay, Morris, Lin and Yao (1994) and Wei, Varela and Hassan (2002) for a description of the SOEs' economic performance.

[6] Lin, Cai,and Li (1998).

[7] Chen and Divan (2000).

prehensiveness of the subsidies listed in Annex B of the SCM, China pledges that "China's objective is for SOEs, including banks, to run on a commercial basis and be responsible for their profits and losses." Nevertheless, the report does not stipulate a timetable for the introduction of these capital market reforms, which damages its credibility. Furthermore, any measure induced by WTO accession that increases competition may have an implicit effect on the SOE sector. An important issue that we consider in this paper is the effect that the opening of the financial sector to foreign banks, required by the WTO agreement, will have on the preferential treatment of the SOE by state banks. According to the WTO accession agreement, China is to gradually open its financial sector to foreign banks, which should receive national treatment five years upon accession. The increase in competition in the financial sector brought by foreign banks will require state banks to be more profit-based in order to survive and, therefore, reduce their lending to non-performing SOE. In this paper, we take this pledge as a signal that SOE's subsidies will be reduced by more than the required 25 percent, but do not attempt to quantify by how much. To this extent, the results of this paper represent a lower bound of the effects of WTO on the SOE sector.

3 The Model

In this paper we develop a dynamic general equilibrium model to quantitatively assess the economic effects of SOE reforms in an economy where subsidized government enterprises coexist with private, competitive firms. We may interpret the competitive firms as foreign firms entering the domestic market or, as in the case of China, as a combination of foreign firms and domestic entrepreneurs who are not covered by government subsidies. The domestic economy is modelled as a small open economy that takes the world prices of the imported goods as given. We model the rest of the world (ROW) in a very simplified way: it consists of a demand function for the products of the domestic economy and a supply function that supplies any amount of imports to the domestic country at the prevailing world prices. For simplicity, we assume that international capital markets are closed.[8] In what follows, we omit the time subscripts when not needed.

We structure the production side of the economy following the applied general equilibrium (AGE) literature. First, the domestic country produces two types of goods: tradable goods and non-tradable goods, both of which are used in consumption, investment and as intermediate goods in production. Having two industries allows us to capture the effects that

[8]Given that Chinese citizens are not legally allowed to invest in foreign assets, this is not a very restrictive assumption. Opening the capital markets did not considerably change the results of the paper.

are due to reallocation of resources across industries, which are the source of gains from trade in most AGE models. Furthermore, we can account for the fact that the relative efficiency of the state-owned sector may differ across industries, with some non-traded services produced exclusively by the state sector, with no competition from private firms. Second, in order to match the two-way trade flows observed in the data, we consider traded goods produced in the domestic country and traded goods produced in the foreign country as being imperfect substitutes.

Following the Armington aggregator assumption, standard in the AGE literature, we assume that consumers and producers buy a *composite* of the traded goods. We denote this composite good by Y_1 and takes the form:

$$Y_1 = E\left(\mu X_D^{\zeta} + (1-\mu)M^{\zeta}\right)^{1/\zeta}$$

where X_D is the demand for the domestically produced good, and M is the import demand for the foreign-produced traded good. In this formulation, $1/(1-\zeta)$ is the elasticity of substitution between the domestically and the foreign produced traded goods, and E is the technology parameter. In what follows, we use the term "traded good", without specifying the origin of production, to refer to the composite of traded goods used in the domestic country (good one).

The innovative feature of this model is the introduction of two types of producers in each of the domestic industries: SOEs and private firms. In what follows we use the word *sector* to distinguish between private and state producers and we reserve the world *industry* to designate the set of firms that produce a given good. Private and state firms differ in three aspects: their technology levels, their ability to choose their labor input, and their cost of capital. Technology differences are taken as exogenous and calibrated to the data. The labor input and the cost of capital are determined by the market in the private sector, but are influenced by the government in the SOE sector. In particular, SOEs need to meet a *minimum labor requirement*, established by the government, and receive a discount on their rental rate of capital, which we denote by *capital subsidy.* In particular, if we denote by R_j the rental rate of capital in sector j, the state enterprises rent capital at a rate $(1-s_j)R_j$. Furthermore, any losses incurred by the SOEs are covered by the government through a *direct subsidy.* The restrictions on the SOE sector are designed to capture the SOEs' role as promoters of employment as well as the two main forms of subsidies to the SOE sector used by governments: direct subsidies and preferential treatment by state banks in form of lower interest rates and easy access to credit.

In this economy both the traded and non-traded industries use capital and labor, as well as the traded and non-traded inputs in their production process. The production function for a firm of ownership of type $s = P, G$ in industry $j = 1, 2$ is defined as:

$$Y_{Dsjt} = \min\left\{\frac{Z_{sj1t}}{v_{j1}}, \frac{Z_{sjt2}}{v_{j2}}, A_{sj}\gamma^{(1-\alpha_j)t}K_{sjt}^{\alpha_j}L_{sjt}^{1-\alpha_j}\right\}$$

where Y_{Dsjt} is the domestic production of good j by sector s at period t, Z_{sjit} is the use of good i by industry j in sector s, v_{ji} is the amount of good i need to produce one unit of good j, and $A_{sj}\gamma^{(1-\alpha_j)t}$ is the productivity parameter. The production function is, thus, Leontief relative to both the traded and non-traded goods, and Cobb-Douglas with respect to the capital and labor inputs. This choice of production function, standard in the literature of applied general equilibrium models, simplifies the calibration of the parameters from the input-output tables.[9] Notice that we allow for the technologies of the private and government enterprises to differ in the technology parameter in producing value added, $A_{sj}\gamma^{(1-\alpha_j)t}$. We take the unit requirements of the intermediate inputs and the labor share to be the same in both private enterprises and SOEs, which implies that in this model any differences that may exist in the capital-labor mixture used by the private and state sector are due to government policy.

We assume that the objective of the SOEs (as well as the private firms) is to maximize profits taking prices and government policies as given. We follow studies by Perkins (1994) and Yin (1998 and 2001) who argue that the contract management responsibility system introduced in China in 1984, which allows managers of SOEs to keep any above-target profits, has encouraged managers to seek profit maximization. Therefore, the SOE problem consists of maximizing profits given the labor requirement imposed by the government and the subsidy on capital. If the minimum labor requirement is not binding, the SOEs make zero profits. If the minimum labor requirement is binding, the SOEs may make negative profits. In this case, the government picks up the losses by passing a subsidy to the SOEs in exchange of their maintaining employment levels.

In our framework the goods produced by the state and the non-state enterprises are perfect substitutes. Therefore, the total amount of good j produced in the country, Y_{Dj}, is just the sum of the quantities produced by the state and the non-state firms. Notice that as long as the labor requirement is positive the state enterprises always produce a positive amount of output. Furthermore, given that private enterprises behave competitively, they only co-exist with state enterprises in a given industry if the minimum labor requirement

[9] In different settings, researchers calibrating more general production functions find elasticities of substitution between intermediate inputs and value added to be close to zero. See for instance Kouparistas (1998).

for the state enterprises is binding (that is, if the SOEs are inefficient relative to the private sector).

The investment good is a composite of the traded good and the non-traded good, which are combined in the following production function:

$$I = A_I Z_{I1}^{\nu} Z_{I2}^{1-\nu}.$$

Here, I is the investment good purchased in period t to be used as capital in period $t+1$. The variable Z_{Ij} represents the amount of good j used as an intermediate input in the investment industry. The inputs to investment are equipment (traded good) and structures (non-traded good). The investment good can be used by enterprises in any industry to increase their capital stock. An important issue often mentioned when dealing with the state enterprises is the quality of their capital. Government protection may keep firms using obsolete capital that is not readily transferable to the private sector. In order to capture this feature of the state sector, we introduce adjustment costs to capital. We follow the tradition of Lucas and Prescott (1971) and model the adjustment costs in the following way:

$$K_{sjt+1} = \phi\left(\frac{I_{sjt}}{K_{sjt}}\right) K_{sjt} + (1-\delta)K_{sjt}$$

where δ is the depreciation rate of capital, and the adjustment function $\phi(\cdot)$ is assumed to be strictly increasing and strictly concave in the investment-capital ratio, and to satisfy $\phi(n\gamma-1+\delta) = n\gamma-1+\delta$ and $\phi'(n\gamma-1+\delta) = 1$. These last two properties are necessary for capital to depreciate at a rate δ in the balanced growth path and, thus, for the adjustment costs not to have any effect in the long run. We use a one-parameter adjustment cost function that satisfies the properties mentioned above adapted from Fernández de Córdoba and Kehoe (1999) and modified to be used in an economy with exogenous technological change and population growth:

$$\phi(x) = \Big((n\gamma - 1 + \delta)^{1-\eta} x^{\eta} - (1-\eta)(n\gamma - 1 + \delta)\Big)/\eta, \quad 0 < \eta \leq 1.$$

In this specific function the $1/(1-\eta)$ is the elasticity of the investment-to-capital ratio with respect to the Tobin's q. Notice that having capital adjustment costs in our model slows down the transition to the balanced growth path and, therefore, it may reduce the welfare gains of policy reform. In the calibration section we do sensitivity analysis and show how our results change with the degree of the adjustment costs.

Given that we are interested in changes in TFP and output, it is important to summarize the different sources of growth in this model. The only source of long run growth is exogenous technological change, which we denote by γ. Deviations from trend during the transition are due to accumulation of capital, movements of resources between industries and, most importantly for our study, movements of resources within industries from SOE to private firms.

The consumption side of the economy, at any period, t, is characterized by N_t identical, infinitely-lived consumers who are endowed with one unit of time that they supply inelastically. We assume that population grows at a constant rate, so that $N_{t+1} = nN_t$. Consumers derive utility from the consumption of both the composite of the traded goods (good 1) and the non-traded good (good 2). The representative individual solves the following problem:

$$\begin{aligned}
\max \quad & \sum_{t=0}^{\infty} \beta^t \left(\varepsilon c_{1t}^{\rho} + (1-\varepsilon) c_{2t}^{\rho} - 1\right)/\rho \\
s.t. \quad & p_{1t}c_{1t} + p_{2t}c_{2t} + na_{t+1} = w_t + (1+r_t)a_t + TC_t/N_t \\
& a_t \geq -A \\
& a_t = q_{P1t-1}k_{P1t} + q_{G1t-1}k_{G1t} + q_{P2t-1}k_{P2t} + q_{G2t-1}k_{G2t} \\
& k_{P10}, k_{G10}, k_{P20}, k_{G20} \text{ given}
\end{aligned}$$

where c_{it} is the consumption of good i at period t, p_{it} is the price of good i at period t, a_t represents the assets held by the individual at period t, w_t and r_t are the wage rate and the return to savings at period t, and TC_t represents the net transfers from the government to consumers. Notice that in the utility function we are considering the elasticity of substitution between goods is the same as the intertemporal elasticity of substitution, $1/(1-\rho)$. We make this assumption for simplicity, and we do not expect the quantitative results to change much with a more general utility function.

The definition of a_t needs further explanation. Consumers in this economy can hold different types of assets, which are given by the different types of capital that exist in the economy: $k_{sit}, s = P, G$ and $i = 1, 2$. Here, q_{sit-1} is the return at period t of capital of type si invested at $t-1$ to be used in period t. By treating investment goods in different sectors as different goods we are able to introduce imperfect capital flows between industries and within sectors in each industry.

The government in this economy obtains revenue from taxes on producers of final goods, T, and from tariff revenue, TR. The tax rates t_{Pj} and t_{Gj} and the tariff rates τ_D are exogenously given. The government outlays are purchases of each of the goods in the economy, G_j, which are determined exogenously, and both types of subsidies to the SOE sector (interest subsidies, S_K, and direct subsidies, S_L). Any excess funds (costs) are transferred to (born by) consumers in the form of net government transfers, TC. Modelled this way, the government balances the budget every period. Net government transfers can be interpreted as the government surplus (deficit if negative). The budget constraint that the government faces is, thus:

$$p_1 G_1 + p_2 G_2 + S_K + S_L + TC = TR + T.$$

We model the rest of the world as an import demand function for the domestically produced traded good. The foreign demand, denoted by X_F, is modelled as:

$$X_{Ft} = D(n\gamma)^t \left((1 + \tau_{Ft}) p_{D1t}\right)^{-1/(1-\zeta)}$$

where p_{D1t} is the price of the domestically produced traded good, τ_{Ft} is the average world tariff rate on imports from the domestic country, and $(n\gamma)^t$ is the exogenous growth rate of export demand consistent with the existence of a balanced growth path for the model economy.

Feasibility in this economy implies that all markets clear and that the balance of payments account balances every period. The balance of payments account states that any trade deficit is counteracted by a capital account surplus of the same amount. Formally,

$$p_w M = p_{D1} X_F$$

Within the domestic country, feasibility implies that all markets clear. In the market for the domestically produced traded good the domestic and foreign demand have to add up to the total amount of good produced:

$$X_D + X_F = Y_{D1}.$$

The market for the non-tradable good and the market for the composite tradable good also have to clear. Formally,

$$G_{jt} + N_t c_{jt} + \sum_i (Z_{Pijt} + Z_{Gijt}) + Z_{Ijt} = Y_{jt}.$$

i.e., the consumption by the government, consumers, firms and the investment composite of a good j has to equal its total production in the country.

Market clearing in the investment composite implies that total investment in the country at a specific period equals the amount of investment composite produced in the country:

$$\sum_j (I_{Gj} + I_{Pj}) = I.$$

Feasibility in the factor markets implies that the demand for labor in the country equals the total amount of workers available in the country, and that the total capital used in the country equals its stock of capital:

$$\sum_j (L_{Gjt} + L_{Pjt}) = N_t$$

$$\sum_j (K_{Gj} + K_{Pj}) = K.$$

Finally, consistency between per-capita and total variables implies that $k_{jt} = K_{jt}/N_t$ for all j, t.

Definition 1 . *Given government policies, initial endowments of capital in each industry K_{Pj0}, K_{Gj0}, and the world price of imports, p_{wt}, the equilibrium of this economy is determined by a set of sequences: consumer's decisions $\{c_{jt}, a_t\}$, private firms' decisions, $\{Z_{Pj1t,} Z_{Pj2t}, K_{Pjt}, L_{Pjt}, Y_{DPjt}\}$, SOEs' production decisions, $\{Z_{Gj1t,} Z_{Gj2t}, K_{Gjt}, L_{Gjt}, Y_{DGjt}\}$, investment decisions, $\{Z_{I1t,} Z_{I2t}, I_t, I_{Pjt}, I_{Gjt}\}$, prices, $\{p_{jt}, p_{Djt}, w_t, r_t, R_{Pjt}, R_{Gjt}\}$, and import decisions $\{X_{D1t}, X_{Ft}\}$, such that the consumer and producers' (SOEs and private enterprises) problems are satisfied, all markets clear, the laws of motion for capital in each industry and sector are satisfied, and the consistency conditions are satisfied.*

In this study we restrict ourselves to equilibria that converge to a balanced growth path. Following standard procedure in models with exogenous technological change, we solve for equilibrium by constructing a stationary economy the solution of which is equivalent to the solution of our economy detrended by the exogenously given long run growth rate. That is, if $\hat{\nu}_t$ is an equilibrium variable of the stationary economy, the corresponding equilibrium variable in the model economy is $\nu_t = \hat{\nu}_t \gamma$ for quantity variables (except labor inputs) and the wage, and $\nu_t = \hat{\nu}_t$ for prices and labor inputs. The corresponding stationary economy is characterized by the same equations as our model economy, with the following changes:

(1) The production functions of the transformed economy become, for $s = P, G$:

$$\hat{y}_{Dsj} = \min\left\{\frac{\hat{z}_{sj1}}{v_{sj1}}, \frac{\hat{z}_{sj2}}{v_{sj2}}, A_{Pj}\hat{k}_{sjt}^{\alpha_j}\hat{l}_{sjt}^{1-\alpha_j}\right\}.$$

(2) The law of motion of capital in the transformed economy is:

$$n\gamma\hat{k}_{sjt+1} = \phi\left(\frac{\hat{i}_{sjt}}{\hat{k}_{sjt}}\right)\hat{k}_{sjt} + (1-\delta)\hat{k}_{sjt}.$$

(3) Finally, the discount factor of the stationary economy is $\hat{\beta} = \beta\gamma\rho$ and the budget constraint:

$$p_{1t}\hat{c}_{1t} + p_{2t}\hat{c}_{2t} + n\gamma\hat{a}_{t+1} = \hat{w}_t + (1 + r_t)\hat{a}_t + \hat{TC}_t/N_t.$$

4 Calibration

The data used for the calibration are from the *China Statistical Yearbook*, which is issued by the Chinese government. As in any study using Chinese data, the accuracy of the results depends on the accuracy of the reported data. The quality of the Chinese data is questionable, especially data on output and employment (see Young 2004). For example, SOE have people on their payrolls who are not used in production (but have not been laid off either); SOEs' employees may receive other benefits besides their wages, like housing and school benefits that are paid by the SOEs. Regarding data on the nature of ownership, government officials may have their own private firms and get the same benefits as the SOEs get due to their connections, or there may be some SOEs that effectively work as private enterprises. Regarding data on employment and output we cannot do much, unfortunately. In this sense, our paper suffers from the same problems as all papers using Chinese data. Regarding data on ownership, we take a conservative position and define SOEs as narrowly as possible. In particular, we classify "collective" enterprises as private, even though some of them receive benefits from state or local governments.

We calibrate the parameters of the model in order to match data on the Chinese National Income and Product Accounts, the Chinese input-output matrix, and the Chinese participation of SOEs in industry for 1997. Ideally, we would like to calibrate the model to 1978, when China started its economic reforms. Unfortunately, input-output matrices are not available for that year. Furthermore, China did not adopt standard accounting methodology until the 1990s. We chose to calibrate the model to 1997 data since 1997 is the first year for which a complete, meaningful input-output matrix for the Chinese economy exists.

The input-output matrix contains data on usage of intermediate goods, capital and labor disaggregated by industry, together with taxes paid and tariff revenue, as well as disaggregated expenditure data in each industry for each of the components of GDP. The Chinese input-output matrix for 1997 is disaggregated into fifteen industries, which we aggregate into a tradable and a non-tradable industry.[10] We adjust the input-output matrix so that trade is balanced (as assumed by our model), and normalize GDP to be 100, so that data are given as a percentage of GDP. Tariff revenue is not reported in the input-output matrix, so we separate it from tax revenue using data on government sources of tax revenue (table 8-4 in

[10]We aggregate the industries is the following way. We consider as traded goods agriculture, mining and quarrying, foodstuffs, textiles and garments, other manufacturing, coke gas and petroleum refining, chemicals, non-metal mineral products, metal products, machinery and equipment. The non-traded goods are electricity and hot water, construction, transport and communications, commerce and restaurants, public utilities, banking and insurance, and other services.

the China Statistical Yearbook). The resulting input-output matrix is reported in table 1.

Following standard procedures of the calibration of applied general equilibrium models (see, for instance, Kehoe and Kehoe 1994) we normalize all prices but the interest rate to one and choose units so that one unit of any good or factor corresponds to $1 worth of that good or factor in 1997. A complication arises when we try to adapt the input-output data to the specifics of our model: the input-output matrix does not distinguish between private enterprises and SOEs, reporting only aggregate output and inputs in each industry. Therefore, additional data is needed in order to determine the production and productivity parameters associated with the traded and non-traded industries. In what follows, we describe how we calibrate these parameters. Technical details of the calibration are given in the appendix.

Production and policy parameters. Due to the interdependencies between parameters given by the assumptions of the model and to data availability, we need to jointly calibrate some of the parameters in the model. In particular, the capital shares of income, α_j, technology parameters, A_{Pj}, A_{Gj}, labor constraints in the government sector, λ_j, taxes, t_j, and subsidies to capital, s_j, are jointly determined in order to match: *(i)* the output and labor inputs by industry from the input-output matrix, *(ii)* constructed values of the capital stock shares by ownership for 1997 (see below), *(iii)* the share of output in each industry produced by the SOE sector in 1997 (from the China Statistical Yearbook: 21 percent for the traded industry and 48 percent for the non-traded industry), *(iv)* the share of output in the traded industry produced by the SOEs in 1997 (urban employment in the SOE sector from the China Statistical Yearbook: 27 percent), and *(v)* the direct subsidies-to-GDP ratio for 1997 (from China Statistical Yearbook: 4.8 percent). The detailed relationship between the variables and the parameters of the model is shown in the appendix.

We obtain capital shares of income of .24 for the traded industry and .38 for the non-traded industry. Notice that since we have subsidies to capital in the state sector, this share is different from the aggregate capital share in the industry. The calibrated technology levels are 5.29 for the private sector and 2.45 for the state sector in the traded industry and 2.97 and 2.65 respectively in the non-traded industry. Therefore, the private sector in the traded industry is 2.1 times more productive than the state sector, whereas in the non-traded industry it is only 1.2 times more productive. Notice that SOEs are relatively less productive in the traded industry. There are several explanations for why this may be the case: first, SOEs tend to have monopoly power in the production of some goods, like provision of utilities or telecommunications, that we have aggregated under the non-traded industry. Therefore, due to aggregation issues we are actually comparing productivity in different industries. Second, most loss making SOEs are in the manufacturing sector, which is mainly included in our traded industry, implying that they are relatively less efficient than the corresponding private producers. The minimum labor requirement λ_j in the SOE sector is set to mimic the labor distribution of 1997. Therefore, SOEs sector need to employ at least 19 percent of the labor force in the traded industry and 18 percent in the non-traded industry. Given that we do not have independent tax data for SOEs and private enterprises, we assume an homogeneous tax rate in each industry. The values that we obtain from the joint calibration are 12 percent in the traded industry and 8 percent in the non-traded industry. Subsidies to capital in each industry are 82 percent in the traded industry and 15 percent in the non-traded industry.

The unit costs of intermediate goods in each industry, v_{ji}, which do not differ by ownership, and the production parameters in the investment sector are calibrated directly from the input-output matrix.

Chinese tariffs are difficult to calibrate, since the actual tariff rates applied to foreign goods are much lower than the official tariff rates. We obtain our parameters from Tiwari et al. (2002) who estimate an effective tariff rate for 1997 of 2.35 percent and an average tariff rate on Chinese exports to the rest of the world of 5.2 percent. Government purchases are obtained from the input-output matrix.

Capital stock and interest rate. We construct capital stock series by using the Harberger-type perpetual inventory method. We first calculate depreciation rates by using SOE's investment and capital stock data available from the China statistical yearbook.[11] We obtain an annual depreciation rate of 8 percent. Using this depreciation rate and investment data by ownership we construct capital stock series by ownership. By adding up the data on capital by ownership we obtain the aggregate capital stock.

We calibrate the initial rental rate of capital by using the estimated value of the capital stock and aggregate capital income from the input-output matrix. We obtain a value of 13.4 percent.

Armington aggregator. We set the elasticity of substitution between the domestic and foreign traded goods to be 2, which is within the range of values used in the applied general equilibrium literature. This implies $\zeta = .5$. We report results for a range of values of the elasticity parameter in the sensitivity analysis section. The rest of the parameters in the Armington aggregator are derived directly from data in the input-output matrix and first

[11] Since no good data sources were found on depreciation rates on other types of ownership, we use the depreciation rates we obtained for the state sector to approximate the depreciation rates at the aggregate level.

order conditions implied by the model.

Consumption parameters. We take the time period to be one year, so we set the discount factor β to .95 (which implies a long run interest rate equivalent to the one in the US). We set ρ equal to -1, which implies an intertemporal elasticity of substitution of .5, within the range considered by the real business cycle theory. First order conditions and consumption data from the input-output matrix determine the rest of the parameters.

Foreign demand. We calibrate the parameters for foreign demand directly from the input-output data.

Adjustment costs of capital. We take the depreciation rate δ to be 8 percent (the average depreciation rate for the period 1987-1997), which is the depreciation rate used to construct the series of capital stocks. The calibration of the parameter η requires further explanation. Given our choice of adjustment cost function, $1/(1-\eta)$ is the elasticity of the investment-capital ratio with respect to the Tobin's q. Since it is difficult to construct meaningful prices for capital in China, we chose to calibrate the parameter to U.S. data and to perform sensitivity analysis for a wide range of parameter values. The results are presented in the sensitivity analysis section. In the international real business cycle tradition, as reported by Kouparitsas (1998), we set this elasticity to 10, which makes it consistent with aggregate volatility levels of the U.S. investment-capital ratio. This implies a value of η of .9.

Finally, following Kehoe and Prescott (2002) we consider a long run output growth of 2 percent, common to all countries and equal to the secular growth rate of the US economy in the 20th century. This determines a value of γ equal to 1.02. Furthermore, we abstract from population growth issues, so we take the population growth parameter n to be equal to 1. Table 2 contains a summary of the calibrated parameters and sources.

5 Numerical experiments

In this section we simulate the calibrated model in order to assess the economic effects of reforms in China's SOE sector induced by China's accession to the WTO. It is important to notice that we have calibrated the economy to capital and investment numbers for 1997 without requiring these numbers to be consistent with the economy being in a balanced growth path in that year. Taking the capital value for 1997 as an initial condition and given the policy parameters for 1997, the economy will evolve to a particular balanced growth path through a transition path. Changing the policy arrangements would cause the economy to evolve to a different balanced growth path, through a different transition path.

The exercises that we perform in this section are comparisons of the evolution of the economy (transitional dynamics) under several policy scenarios that represent the effects of WTO accession on SOE subsidies. That is, we compare the transitional dynamics of several hypothetical economies that differ in their policy arrangements towards the SOE sector. We believe that this is the right methodology, since the Chinese economy was clearly in transition in 1997 and during its WTO accession.

We take as a *benchmark* an economy for which the SOE policies (direct subsidies and subsidies to capital) remain constant over time at the calibrated 1997 levels. The policy scenarios that we compare to the benchmark economy are the following: First, we consider an economy that implements the 25 percent reduction in direct subsidies required by the WTO accession documents. Second, we consider the economic effects of reducing the subsidies to capital (a likely result of the increase in competition in the financial sector derived from WTO accession). Third, we study the effects of combining both, reforms in direct subsidies and reductions in capital subsidies. The variables that we report are all in per-capita terms, with the level variables detrended.

5.1 Reduction in direct subsidies

In order to assess the effects of WTO accession on the SOE sector, we consider a scenario where the direct subsidies to loss-making SOEs are gradually reduced in a 5-year period starting in 2001, so that the long run ratio of direct subsidies to GDP is of the order of 25 percent lower than in the benchmark economy (see section 2). Notice that in our framework for any given level of capital subsidies, a reduction in direct subsidies is achieved through a reduction in the minimum labor requirement. We obtain that by gradually reducing the minimum labor requirement by 24 percent in a 5-year period starting in 2001 the long run direct subsidies to GDP ratio is about 25 percent lower than in the benchmark economy. We label the economy that implements this policy the *direct subsidies* economy. The effects of WTO accession induced by the reduction of direct subsidies to the SOE sector are obtained by comparing the *benchmark* economy to the *direct subsidies* economy.

In all numerical examples both the starting period and the phase out periods of the reforms are known by all economic agents. That is, we have perfect foresight. Notice that by waiting four periods before the reforms start, we are not taking into account any reforms implemented between 1997 and 2001 that were required during the negotiation period and which are also linked to the WTO agreement. Given that in our model (as seen in the sensitivity analysis reported in section 7) the earlier the reforms start, the higher the benefits, we are also being conservative in this assumption and our estimates are a lower bound of the actual benefits of WTO accession through reforms in the SOE sector.

Per-capita GDP levels in the balanced growth path can be expressed as $y_t = \gamma^t y_0$. Two things determine the balanced growth path of GDP: the *trend* (or growth factor), γ, and a *GDP level*, y_0. Given our assumptions, the trend is common to all scenarios whereas the GDP level varies with the different policy scenarios. Balanced growth path comparisons between both economies are reported in the first column of table 3. The figures in table 3 represent the differences in percentage terms between the *direct subsidies* economy and the *benchmark* economy. We observe that the long run welfare gains of reforming the economy are of 4.7 percent in terms of equivalent variation.[12] Notice that these welfare gains are substantial and of similar, if not higher, magnitude than the pure gains from trade obtained by most studies that use applied general equilibrium models.[13] Therefore, models that do not take into account China's welfare benefits derived from reforms in the SOE sector required by WTO accession highly underestimate China's benefits from becoming a WTO member.

The level of GDP in the balanced growth path is 2.2 percent higher in the direct subsidies economy, whereas productivity levels are of 4.2 percent higher. The productivity increase is obtained mainly through reallocation of resources from the SOEs to the private sector. The SOE shares of output in the reformed economy are 26 percent lower for the traded industry and 24.9 percent lower for the non-traded industry.

Transitional dynamics are represented in Figures 1-5, which summarize results for all the policy scenarios that we consider. In all figures except Figure 1 the data are expressed as deviations from the benchmark economy. Figure 1 presents the transition path for detrended real GDP per capita. Deviations from benchmark of real GDP per capita and GDP growth rates are plotted in Figures 2 and 3. Notice that in the initial periods, before reforms are implemented, the GDP level and the growth rate are higher in the benchmark economy than in the direct subsidies economy. In particular, pre-reform growth rates are 10 percent below benchmark. Once the reforms start, the growth rate is higher in the reforming economy, leading to a long run GDP level that is 2 percent above benchmark. The intuition for this result is the following: knowledge of future reforms in the SOE sector together with

[12]That is, the consumer in the benchmark economy would need a permanent increase in steady state consumption of 4.7 percent to be as well off as the consumer in the direct subsidies economy.

[13]Kouparistas (1998) using also a dynamic applied general equilibrium model finds that Mexico's welfare gains from the reduction of tariff and non-tariff barriers required by NAFTA to be of the order of 2 percent in terms of equivalent variation. Ianchovichina and Martin (2001) find gains of China's accession to the WTO derived from changes in trade policy of 2.2 percent of per capita income. Free trade in our model produces welfare gains of only .6 percent in terms of equivalent variation, the discrepancy being accounted for by the high level of aggregation of our modelling framework.

the adjustment costs of capital imply lower initial investment in the SOE sector for the reforming economy. This lower investment is not totally compensated by higher investment in the private sector due to the fact that capital is not subsidized in the private sector. The result is lower initial investment, lower GDP levels and lower growth. In the reform period, higher growth rates are achieved through reallocation of resources to the more efficient private sector. Labor is freed from the SOEs, which lose importance as sources of production. The relatively bigger private sector also captures a higher proportion of investment, increasing overall productivity in the economy.

TFP levels relative to benchmark are plotted in Figure 4. We observe that the TFP levels of the direct subsidies economy are always above benchmark, with deviations increasing rapidly during the reform period. The explanation of this faster TFP growth in the reforming economies relies on the fact that SOE reform reallocates productive resources from the SOEs to the more efficient private sector. This effect can be seen in the evolution of the SOE shares of output relative to benchmark, which are plotted in Figure 5a for the traded industry and Figure 5b for the non-traded industry. The reduction in output share for the SOE sector is directly related to the reduction of the minimum labor requirement in the sector. Once the five-year reform period is over, the deviation of the SOE shares remains roughly constant over time.

Finally, comparing lifetime welfare between both scenarios, we find that lifetime welfare (in terms of equivalent variation) is 3.8 percent higher in the direct subsidies economy. Notice that the difference in the welfare numbers is lower than in the balanced growth path comparisons, since here we take into account the transition costs of the reform derived from slower GDP growth in the pre-reform periods. These transition costs do not include the possibility of higher unemployment in the reformed economy: all labor dismissed in the state sector is absorbed by the private sector. We relax this assumption in section 6.

5.2 Reduction in subsidies to capital

The implicit effects of WTO accession on the SOE sector are difficult to assess. In particular, it is hard to quantify how much the preferential lending rates from state banks to the SOEs will change with the increasing competition in the financial sector driven by WTO provisions. Nevertheless, we believe that these effects are important and that it is worthwhile to present numerical experiments illustrating the scope of these effects. To this extent, we consider an economy that implements a 10 percent gradual reduction in capital subsidies to SOEs in a 5 year period following WTO accession. Minimum labor requirements are kept at the same levels as in the benchmark economy and, therefore, direct subsidies to SOE are endogenously determined. We believe that a 10 percent reduction in the subsidies to capital is a conservative estimate, given the fact that 40-50 percent of loans by state banks are believed to be non-performing and, therefore, major restructuring is needed for them to face the competition from foreign banks that comes with WTO membership. We label this new scenario as the *capital subsidies* economy.

The second column of table 3 presents the balance growth path comparisons between the reformed and the benchmark economy. The figures in the table are, again, in percentage differences from the benchmark economy. We observe that the welfare gains are of 1.4 percent in terms of equivalent variation and the TFP gains are of 2.9 percent, despite a relative increase in the SOE share of production in the non-traded industry.

It is worth noticing that the GDP level is lower in the capital subsidies economy than in the benchmark economy. This result is driven by the fact that the long run return to capital decreases with the subsidies, giving the economy less incentives for capital accumulation. The increase in overall productivity cannot offset the difference in total resources and the capital subsidies economy produces less than the benchmark economy. Notice, though, that the consumption of both goods (and, thus, welfare) is higher in the *capital subsidies* economy, reflecting the fact that the lower fraction of output needed to replace depreciated capital in steady state more than compensates for the lower GDP level.

Another important result that we obtain from this table is that in the capital subsidies economy the direct subsidies to GDP ratio is 20 percent higher than in the benchmark economy. Since the minimum labor requirement is the same in both economies, lower subsidies to capital imply that firms in the capital subsidies economy are making bigger losses and, therefore, need higher subsidies to sustain the same level of employment. Consequently, reductions in capital subsidies have a magnification effect in an economy implementing direct subsidy reforms. Smaller capital subsidies require deeper reforms in the minimum labor requirement in order to achieve a pre-determined reduction in direct subsidies. The results of reducing both types of subsidies are reported in the next section.

The transitional dynamics of the capital subsidies economy are plotted in Figures 1-5. The main effect of reducing subsidies to capital is a reduction in the rate of capital accumulation in the economy. Capital becomes relatively more expensive for the SOE after reforms are enacted and, therefore, the SOE shift their input mix in favor of labor. Given that capital cannot move freely across industries or sectors, SOEs respond to the future increase in the costs of capital by investing less in the pre-reform periods. Due to lower rates of capital accumulation, we observe that the real GDP levels remain below benchmark after the first period as does real GDP growth. The TFP levels are consistently above benchmark. Compared to the *direct subsidies* economy, the TFP levels increase faster in the pre-reform periods and slower afterwards. This result is driven, again, by the SOEs expectations of higher costs of capital in the future. Regarding SOE shares, they decrease in the traded industry but increase slightly in the non-traded industry. The main intuition for this result is the differences in the subsidy rate across industries: subsidies to capital are more important in the traded industry (subsidies of 82 percent) than in the non-traded industry (subsidies of 15 percent).

These results show that small reductions in capital subsidies can produce strong welfare effects. Therefore, quantifying the extent of the WTO induced increases in competition in the financial market on capital subsidies (which is out of the scope of this paper) is extremely important and it is the subject of further research.

5.3 Reduction in both direct subsidies and capital subsidies

In this section we combine the policies in section 5.1 and 5.2 in order to obtain the joint effect of both policy reforms. The rationale behind the experiment is that increasing competition in the financial market may require deeper reforms in the labor market for the country to comply with WTO-required reductions in direct subsidies, amplifying the welfare effects of the required reforms. We consider a policy scenario where an economy has to achieve a long run reduction in the direct subsidies-to-GDP ratio of 25 percent when at the same time is subject to a gradual 10 percent reduction in the capital subsidies to the SOE sector during the 5-year reform period. We label this economy the *both subsidies* economy.

It is important to notice that, for a given minimum labor requirement, reducing the subsidies to capital increases the amount of losses incurred by SOEs. Since capital is less subsidized, the SOEs hire less capital reducing the marginal product of labor in the SOE sectors. Therefore, a much larger reduction of the minimum labor requirement is needed in order to reduce the direct subsidies by the required amount. In particular, with a 10 percent reduction in the subsidies to capital, we need a 35 percent reduction in the labor requirement in order to reduce direct subsidies by 25 percent as required by the WTO agreement.

The balanced growth path deviations from benchmark for the *both subsidies* economy are listed in the second column of Table 3. Welfare and TFP gains are of 7.5 percent and 8.5 percent, respectively, both of which are higher than in the direct subsidies economy. Most of the increases in welfare and TFP are the result of deeper reductions in SOEs' employment that are needed in order to meet the reduction in direct subsidies established by the WTO. This fact is reflected in the output shares of the SOEs, which are 44 percent lower in the traded industry and 35.8 percent lower in the non-traded industry, compared to the benchmark case. Finally, the balanced growth path GDP level is 2.2 percent higher than in the benchmark economy.

Transitional dynamics for the *both subsidies* economy are also presented in Figures 1-5. We observe from Figures 1-3 that the path for detrended real GDP is similar to the path same path for the direct subsidies economy, except for the fact that it grows slightly below trend in the pre-reform periods, it catches up with the direct subsidies' economy after the reform period and converges to a slightly lower GDP level in the long run. This result is due to two factors: the reduction in the subsidies to capital in the SOE sector, which reduces investment in the inefficient sector (the state sector) and frees up resources to be invested in the private sector and to be consumed (increasing welfare), and the higher reduction in the minimum labor requirement consistent with SOEs making zero profits after subsidies.

TFP levels increase faster and converge to higher values than in the case where only direct subsidies are reformed. The discrepancy in initial periods is driven by the reduction in subsidies to capital: the knowledge of lower subsidies to capital in the SOE sector once the reform period starts produces an earlier distribution of investment towards the private sector.

Finally, the welfare gains in for the *both subsidies* economy are of 7.3 percent, well above the 3.8 percent obtained in the *direct subsidies* economy. Notice that this number is slightly lower than the steady state welfare gains of 7.5 percent, but the difference is smaller than for the direct subsidies economy. Two offsetting effects are in play: the lower growth in the pre-reform period, which tends to reduce welfare, and the faster convergence to the balanced growth path, which tends to increase welfare. In our case, the gains from faster convergence to steady state are slightly higher than the losses from relatively slow growth in the pre-reform periods.

6 Transitional costs of unemployment

The *transitional costs of unemployment* are an issue often mentioned when reforming the state sector. As SOEs are restructured large numbers of government workers are laid off. Some of them may not be able to find jobs in the private sector, due to their age or lack of skills. This reduction in employment may offset some of the welfare gains of domestic policy reform. The actual magnitude of the unemployment costs due to structural changes associated with trade liberalization is hard to assess. Papageorgiou, Choksi, and Michaely

(1992) after studying several liberalization episodes in developing countries conclude that the effects of trade liberalization on unemployment were small, with almost no net increase in unemployment, even at the industrial level. For the specific case of China, Brooks (2004) predicts much larger effects of SOE reform on unemployment. In particular, he estimates unemployment rates to increase from 2 or 3 percent in the mid 1990s to 10 percent in 2005 before they start declining again.

In our model economy we have assumed that all the workers laid off by the SOEs are absorbed by the private sector and there are no costs of unemployment. In this section we obtain some rough estimates of the importance of the transitional costs of unemployment. A more detailed analysis of the unemployment costs is left for further research. We introduce unemployment in the model in a very simple way. We assume an homogeneous reduction of the employed population during the reform periods. We interpret this net reduction in employment as laid off workers who cannot find jobs in the private sector. Complete asset markets within the country imply that the cost of a lower employment rate is shared equally among all individuals. Notice that our estimate is an upper bound of the unemployment costs during the transition, since we do not allow the individuals that are laid off from the SOE sector to work in the informal sector or to operate a home production technology.

Using data from China's Premier Zhu's 2003 press report, since 1998 nine million workers laid off from Chinese SOEs have not been re-employed. Assuming that these workers will be permanently out of the employed population, we obtain an average annual reduction of employment of .8 percent. Therefore, we assume that the employment level shrinks by .8 percent a year during the 5-year reform period.

We consider two scenarios. In the most radical scenario, we assume that the reduction in the employment rate is permanent, so we do not account for any new jobs created after the reform periods. This is clearly a very conservative upper bound of the unemployment costs, since employment usually expands after the implementation of economic reforms. Under this scenario we obtain welfare gains due to SOE reform instigated by the WTO treaty of .6 percent, compared to the 3.8 percent gains from our previous results. We define this difference in welfare gains of 3.2 percentage points as the *welfare costs of unemployment*. An important point to notice here is that this upper bound on the welfare costs of unemployment does not change much with the depth of the reforms. Therefore, the deeper the reforms, the lower the relative welfare costs of unemployment. In the second scenario, we assume that employment recovers gradually after the reform period, recovering its original level five years after the reform. In this scenario, we obtain welfare gains of reform of 3.6 percent, that is, welfare costs of unemployment of .2 percentage points.

Summarizing, the importance of the transitional costs of unemployment due to reforms in the SOE sector crucially depends upon the speed at which laid off workers in the public sector are absorbed by the private sector. According to our model economy, not taking into account unemployment costs will overestimate the welfare gains of reform by at most 3 percentage points. Our estimate becomes more accurate the faster employment recovers after the reform period.

7 Sensitivity analysis

In this section we study how sensitive our results are to the values of some of the parameters in the model. We consider three types of parameters: parameters the value of which we have taken from existing studies, policy parameters, and SOEs' relative inefficiency. The latter set of parameters is very important, since they determine the relative inefficiency of the SOEs. The higher the inefficiency of the SOEs, the higher the benefits of shrinking the SOE sector.

Regarding parameters taken from other studies, we consider sensitivity analysis on the elasticity of substitution between domestic and foreign traded goods, determined by the parameter ζ, and the capital adjustment costs, determined by the parameter η. Given the nature of our exercise, this sensitivity analysis involves solving for the benchmark economy and the direct subsidies economy under the new parameter values and compare their transitions paths and welfare levels. We obtain that higher elasticities of substitution slightly increase the welfare gains of reform. Considering an elasticity of substitution of 10 instead of 2 adds .2 percentage points to the welfare gains of liberalization.[14]

The capital adjustment cost parameter is more relevant. By limiting capital mobility, this parameter slows down the transition to the balanced growth path, but it also may reduce SOE's investment in the initial periods. High adjustment costs make reallocating capital more difficult and, therefore, increase the costs of committing capital to a specific industry or sector. In order to understand the effects that the adjustment costs have in our results, we reproduce our numerical experiments comparing the direct subsidies economy to the benchmark economy for a wide range of values of the parameters η. We find that the welfare gains of liberalization are pretty stable relative to the values of the adjustment costs of capital. Increasing the adjustment costs so that $\eta = .5$, which implies an elasticity of

[14]The elasticity of substitution between domestically produced and imported goods is a critical parameter for tariff reduction exercises. Since in our model we keep the tariff rates constant, the parameter's role is less important to our analysis, as the sensitivity analysis indicates.

the investment-capital ratio with respect to the Tobin's q of 2, would decrease the welfare gains of reform by .3 percentage points. Eliminating the adjustment costs of capital would increase welfare gains of reducing direct subsidies by .1 percentage points. By assuming adjustment costs of capital we allow for a smoother transition, which gives us slightly more conservative estimates of the gains from reform than we would have got if we had ignored such costs. Table 4 presents the welfare gains of liberalization for a wide range of values for the parameter η.

Given that in our model direct subsidies to SOE are equivalent to labor subsidies, we first consider the effects of changing the scope of the reforms. In particular, in order to get an idea on how the labor constraint drives the results, we consider the welfare effects of reducing the labor constraint first by 10 percent and then by 40 percent (instead of the 24 percent calibrated value). Reducing the labor constraint by 10 percent produces welfare gains of domestic reform of the order of 1.6 percent (compared to welfare gains of 3.8 percent obtained in our calibrated economy). The gains in steady state GDP and TFP levels are also smaller than in the calibrated case. Reducing the labor constraint by 40 percent produces welfare gains of 6.3 percent. These results suggest that the extent of the welfare gains derived from SOE reforms induced by WTO is mainly determined by their effects on SOE employment.

The last set of parameters on which we do sensitivity analysis are parameters that determine the relative inefficiency of the SOE sector. The relative inefficiency of the government sector is given by the ratio of productivity levels A_{Pj}/A_{Gj} for $j = 1, 2$. The higher the ratio, the more inefficient the state enterprises are. In order to understand how relative inefficiencies and the SOE shares affect the results of our paper, we change the productivity parameters A_{Gj} so that the difference between private and state productivity levels is 10 percent lower than in the calibrated economy. In this case, the private firms are 1.9 times more productive in the traded sector and 1.1 times more productive in the non-traded sector (compared to 2.1 and 1.2 in the calibrated economy). We compute the equilibrium of the benchmark economy and the direct subsidies economy under the new set of parameters and compare welfare levels. We obtain that gradually reducing the direct-subsidies to GDP ratio by 25 percent produces welfare gains of 3.6 percent, or .2 percentage points lower than in the calibrated economy. Reducing both direct and capital subsidies increases welfare gains by 7.9 percent (compared to 7.3 percent in the calibrated economy). The bigger welfare difference when considering both subsidies comes from the fact that with more productive SOEs, higher changes in the labor requirement are needed to reduce direct subsidies by the required amount. In particular, labor in the SOE sector needs to be reduced by 40 percent (by 35 percent in the calibrated economy).

8 Conclusion

By becoming a member of the WTO China accepted regulations that imposed reductions of government subsidies to its state-owned sector. In this paper we quantitatively assess the economic effects of these regulations. We develop a dynamic applied general equilibrium model where the state-owned sector is explicitly modelled. We find that the welfare effects of reducing the long run ratio of direct-subsidies to GDP by 25 percent (which is on the lines of China's WTO accession protocol) are in the order of 3.8 percent. This is a conservative measure, since it does not include effects on the SOE sector from provisions that may reduce the ability of state banks to subsidize SOE's capital. A reduction of subsidies to SOEs' capital by 10 percent that occurs at the same time as the provisions on direct subsidies are implemented increases the welfare gains to 7.3 percent. Most of the welfare benefits from the reduction in SOE subsidies are derived from reallocating productive resources, especially labor, from the SOEs to more efficient private enterprises operating in the same industry. Welfare gains remain important even when transitional costs of unemployment are taken into account.

One important implication of our study is that the analysis of the transitional dynamics is important in order to understand the full effects of SOE reform. Reforming economies grow below benchmark in the pre-reform periods and above benchmark after the reform has started. The faster growth after reforms are initiated more than offsets the slow initial growth, delivering positive welfare effects of SOE reform. Therefore, balanced growth path comparisons overestimate the benefits of reform.

Another important implication of this paper is that overall welfare benefits from trade liberalization may be significantly higher than the benefits derived from pure trade policy reform. Trade liberalization may induce a reallocation of resources from state firms to more efficient private firms, with the subsequent increase in overall productivity and welfare. This is especially the case in developing countries with large and highly inefficient state sectors. For such countries abstracting from modelling the state sector may lead to a significant underestimation of the benefits of trade liberalization. To understand these effects a more complete framework that explicitly models the SOE sector is needed. Our paper provides such a framework.

Our model has some limitations that we expect to address in future research. First, we include the agricultural sector together with the traded sector. Given that developed countries in general have a large share of the population working in a highly inefficient agricultural sector we believe that more accurate estimates would be obtained by considering the agricultural sector separately. Further disaggregation would also allow for bigger inter-industry effects. Second, we do not model the unemployment costs explicitly, and only offer some estimates of the possible range of such costs. Finally, we ignore monopoly power and agency issues that are often present state-owned sectors and may affect SOEs' productivity.

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A Appendix

In this appendix we give a detailed explanation of the calibration of our model. Most of our data comes from the Chinese input-output matrix for 1997. In what follows we denote by $\hat{x}$ any variable x the value of which is taken directly from the data. Table 1 in the text presents the input-output matrix and the correspondence between the data and the variables of the model. Given that we take units so that all prices except the initial rental rate of capital are normalized to one, we omit prices from table 1 and the equations below.

We first calibrate the rental rate of capital for 1997 by using the generated capital stock series by ownership and the capital income from the input-output matrix:

$$r = \frac{\hat{rk}_1 + \hat{rk}_2}{\hat{K}_P + \hat{K}_G}$$

Production parameters and government policies. The unit requirements of the intermediate goods, v_{Gji} are calibrated directly from the input-output matrix:

$$v_{Gji} = v_{Pji} = \frac{Z_{ji}}{Y_{Dj}}$$

The capital shares of income, α_j, technology parameters, A_{Pj}, A_{Gj}, labor constraints in the government sector, λ_j, taxes, t_j, and subsidies to capital, s_j, are jointly determined to match:

- Output and labor inputs by industry from the input-output matrix, $\hat{Y}_j, \hat{L}_j$.
- Constructed values of the capital stock by ownership for 1997, $\hat{K}_{Gj}, \hat{K}_{Pj}$.
- Share of output in each industry produced by the SOEs in 1997, $\hat{\theta}_{Yj}$.
- Share of output in the traded industry produced by the SOEs in 1997, $\hat{\theta}_{L1}$.
- Direct subsidies-to-GDP ratio for 1997, $\hat{\Pi}$.

Notice that any change in the calibration of the SOE shares of output or input usage may affect the value of all these parameters. In particular, it will affect the relative productivity of the SOE with respect to the private enterprises, which is a key ratio in our model.

Since the labor input of the SOEs in the non-traded sector is not taken directly from the data, the production and policy parameters are jointly determined by solving the following system of equations:

$$Y_{Gj} = \hat{\theta}_{Yj}\hat{Y}_j$$

$$Y_{Pj} = \hat{Y}_j - Y_{Gj}$$

$$\lambda_1 = \hat{\theta}_{L1}\hat{L}_1$$

$$\frac{\alpha_j}{1-\alpha_j} = \frac{\hat{r}\hat{K}_{Gj}}{L_{Pj}}$$

$$t_j = \left(Y_{Pj} - (\hat{v}_{Pj1} + \hat{v}_{Pj2})Y_{Pj} - \frac{\hat{r}\hat{K}_{Pj}}{\alpha_j}\right)\frac{1}{Y_{Pj}}$$

$$s_j = 1 - (\alpha_j(1-t_j)Y_{Gj} - (\hat{v}_{j1} + \hat{v}_{j2})Y_{Gj})\frac{1}{\hat{r}\hat{K}_{Gj}}$$

$$\Pi_j = (1-t_j)Y_{Gj} - (\hat{v}_{j1} + \hat{v}_{j2})Y_{Gj} - \lambda_{Gj} - \hat{r}(1-s_j)\hat{K}_{Gj}$$

$$\Pi_1 + \Pi_2 = \hat{\Pi}$$

$$L_{Pj} = \hat{L}_j - \lambda_j$$

$$A_{sj} = \frac{Y_{sj}}{K_{sj}^{\alpha_j} L_{sj}^{1-\alpha_j}}$$

Parameters from the investment sector are given by:

$$\nu = \frac{\hat{Z}_{i1}}{\hat{I}}$$

$$A_I = \frac{\hat{I}}{\hat{Z}_{i1}^{\nu} \hat{Z}_{i2}^{1-\nu}}$$

Armington aggregator. From the zero-profit condition for the Armington aggregator production function we obtain:

$$X_D = \hat{Y}_1 - (1 + \hat{\tau}_D)\hat{M}$$

Then,

$$\mu = \frac{X_D^{1-\zeta}}{(1+\hat{\tau}_D)\hat{M}^{1-\zeta} + X_D^{1-\zeta}}$$

$$E = \frac{\hat{Y}_1}{\left(\mu X_D^{\zeta} + (1-\mu)M^{\zeta}\right)^{1/\zeta}}$$

Here the parameter ζ is set to .5.

Consumption parameters. The weight that the individuals put in the traded industry is calibrated directly from the input-output matrix using first order conditions from the consumers' problem:

$$\epsilon = \frac{1}{1 + \left(\hat{C}_2/\hat{C}_1\right)^{1-\rho}}$$

where the parameter ρ is set to -1.

Foreign demand parameters. Foreign demand parameters are determined directly from the input-output matrix, once the parameter η and the tariff rate on exports to the rest of the world are set:

$$D = \hat{X}_F \left(1 + \tau_F\right)^{-1/(1-\zeta)}$$

	traded	non-traded	intermediate	consumption	government	investment	exports	final demand	total output
traded	97.7 (Z_{11})	30.9 (Z_{21})	128.6	37.4 (C_1)	0.0 (G_1)	14.3 (Z_{I1})	21.9 (X_F)	73.5	202.2
non-traded	19.1 (Z_{12})	16.2 (Z_{22})	35.4	14.0 (C_2)	11.5 (G_2)	23.3 (Z_{I2})	0.0	48.8	84.2
intermediate	116.8	47.1	164.0	51.4	11.5	37.6	21.9	122.4	286.3
labor income	35.3 (L_1)	19.6 (L_2)	54.9	0.0	0.0	0.0	0.0	0.0	54.9
capital income	18.9 (rK_1)	12.7 (rK_2)	31.6	0.0	0.0	0.0	0.0	0.0	31.6
net tax revenue	8.8	4.7	13.5	0.0	0.0	0.0	0.0	0.0	13.5
value added	63.0	37.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
imports	21.9 (M)	0.0	21.9	0.0	0.0	0.0	0.0	0.0	21.9
tariff revenue	0.5 ($\tau_D M$)	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5
total output	202.2 (Y_1)	84.2 (Y_2)	286.3	51.4	11.5	37.6 (Y_I)	21.9	122.4	408.7

Table 1: Adjusted input-output matrix for China, 1997.

Parameter	Symbol	Value		Source
Production Parameters		Traded	Non-Traded	Source
Capital Share	α_j	0.24	0.38	(a)
Productivity, Private Sector	A_{Pj}	5.29	2.97	(a)
Productivity, SOEs	A_{Gj}	2.45	2.65	(a)
Unit Cost, traded	v_{1j}	0.54	0.11	I/O
Unit Cost, not-traded	v_{2j}	0.37	0.19	I/O
Growth rate, productivity	γ	1.02		US trend
Armington Aggregator				
Elasticity Parameter	ζ	0.50		AGE literature
Share Parameter	μ	0.72		I/O equilibrium
Technology Parameter	E	1.67		Equilibrium
Investment Parameters				
Capital Share	ν	0.38		I/O
Productivity	A_I	1.94		Equilibrium
Depreciation	δ	0.08		Investment data
Adjustment Costs Parameter	θ	0.9		US I/K volatility
Preference Parameters				
Discount Rate	β	0.95		one-year period
Elasticity Parameter	ρ	-1.00		within RBC range
Share of traded good	ϵ	0.87		I/O
Foreign Demand	D	0.44		I/O
Policy Parameters		Traded	Non-Traded	
Production Tax	t	0.12	0.08	(a)
Government Consumption	G_j	0.00	0.21	I/O
Rental rate subsidy	s	0.82	0.15	(a)
Labor Restriction	l_{Gj}	0.19	0.18	(a)
Domestic Tariff	τ_D	0.02		Tiwari et al. (2001)
Foreign Tariff	τ_F	0.05		Tiwari et al. (2001)
Initial Values		Traded	Non-Traded	
Initial Private Capital	K_{Pj0}	0.65	0.52	K series
Initial Government Capital	K_{Gj0}	0.96	0.56	K series
Initial Interest Rate	r	0.13		I/O and K series

Table 2: Economic parameter values. (a) Jointly calibrated (see text).

	Direct subsidies	Capital subsidies	Both subsidies
Real GDP	2.19	-1.58	2.16
TFP	4.21	2.87	8.49
Capital subsidy/GDP	-25.76	-40.79	-63.03
Direct subsidy/GDP	-25.76	19.15	-25.60
SOE share (1)	-26.07	-9.92	-44.00
SOE share (2)	-24.93	1.53	-35.80
Equivalent variation	4.48	1.54	7.52

Table 3: Balanced Growth Path Comparisons (data as % change relative to benchmark)

η	.5	.7	.9	.99999
welfare gains	3.58	3.70	3.84	3.90

Table 4: Welfare gains for different adjustment costs. No adjustment costs corresponds to the situation $\eta = 1$.

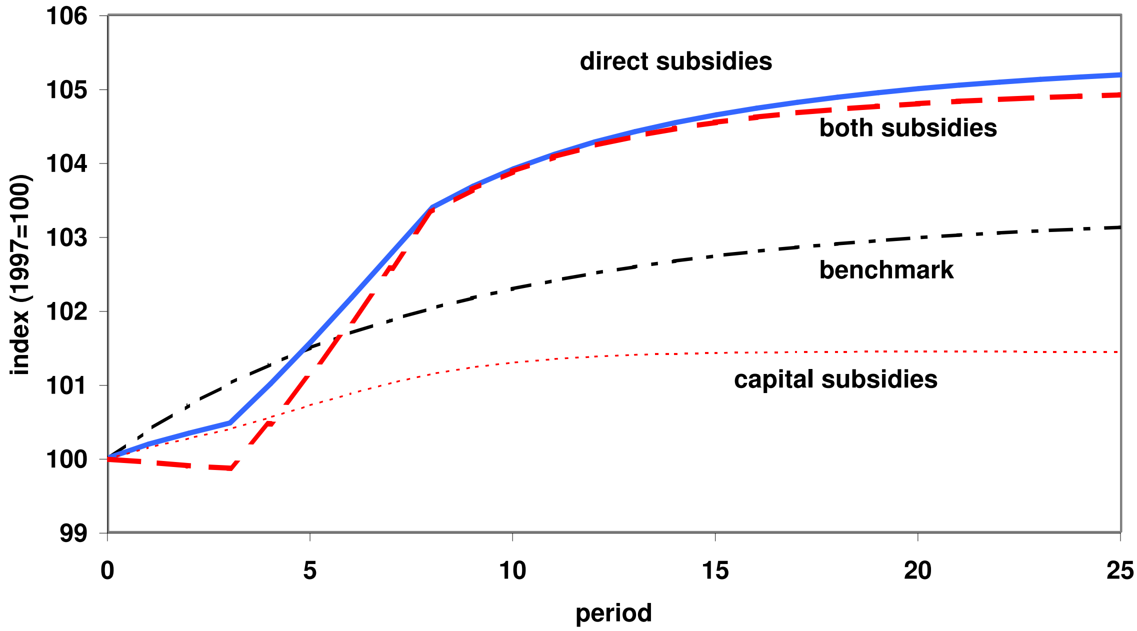

Figure 1. Index of real GDP levels.

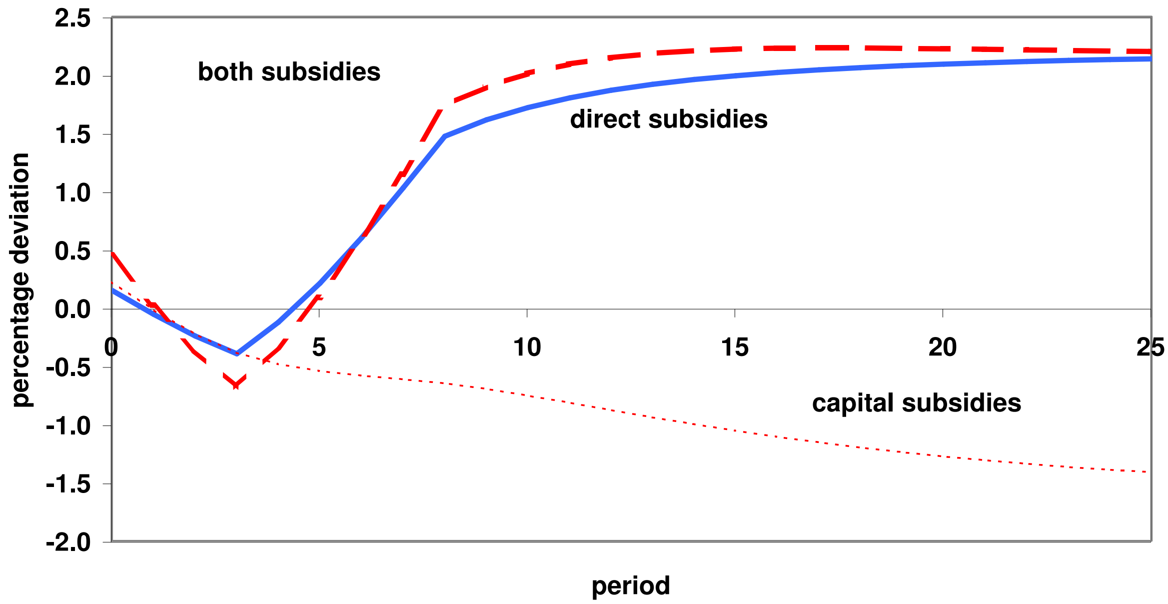

Figure 2. Real GDP levels. (Deviation from benchmark).

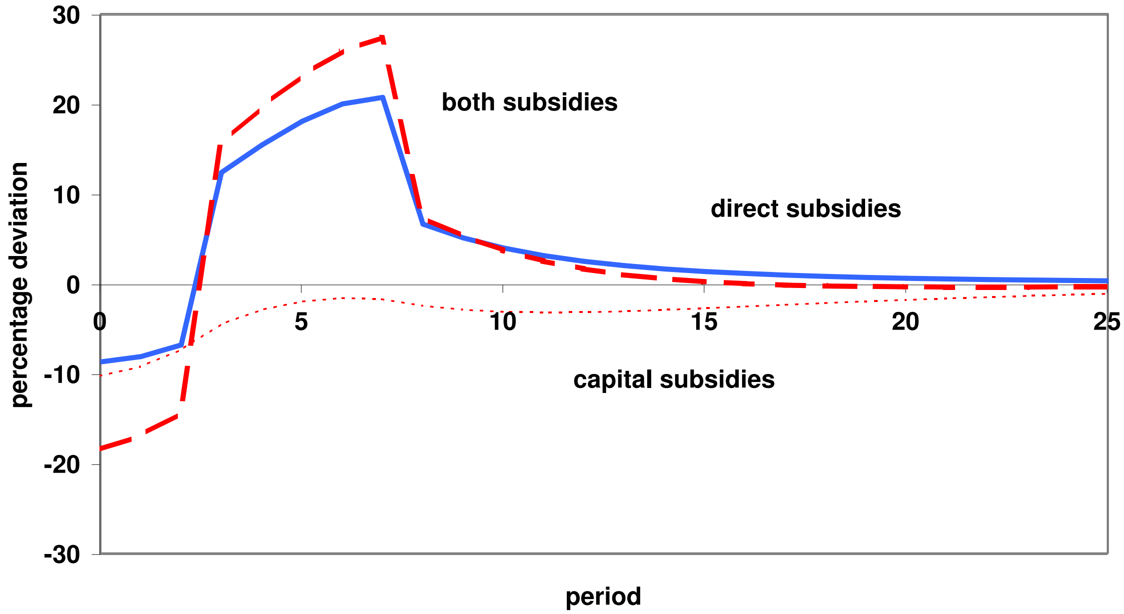

Figure 3. Real GDP growth. (Deviation from benchmark).

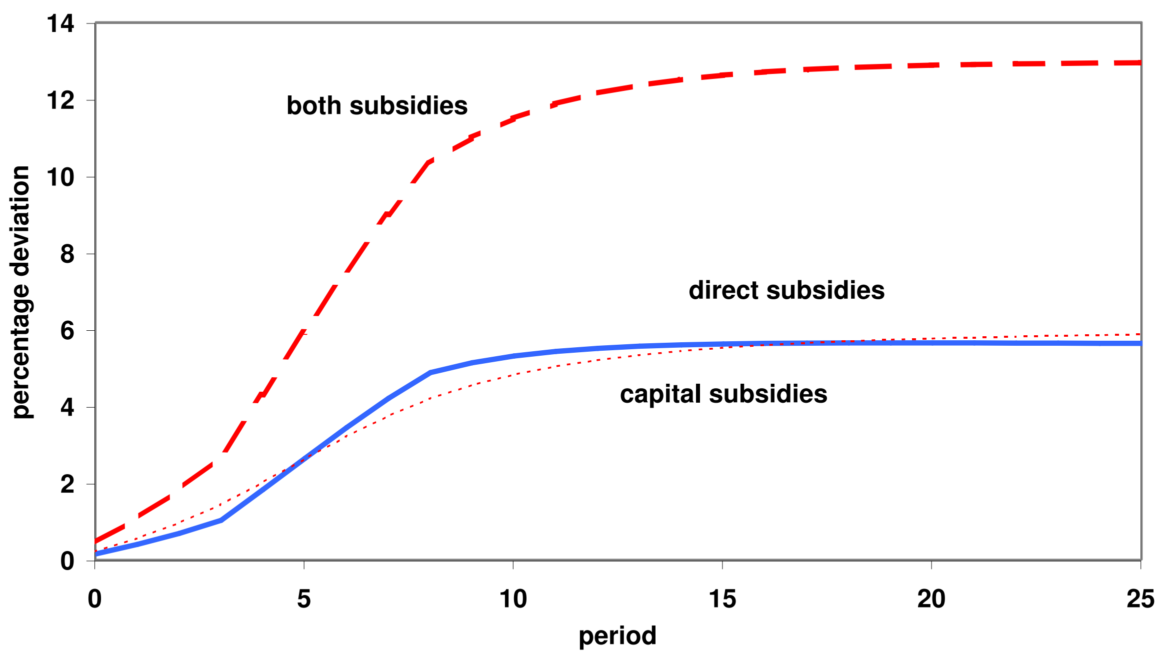

Figure 4. TFP levels. (Deviation from benchmark).

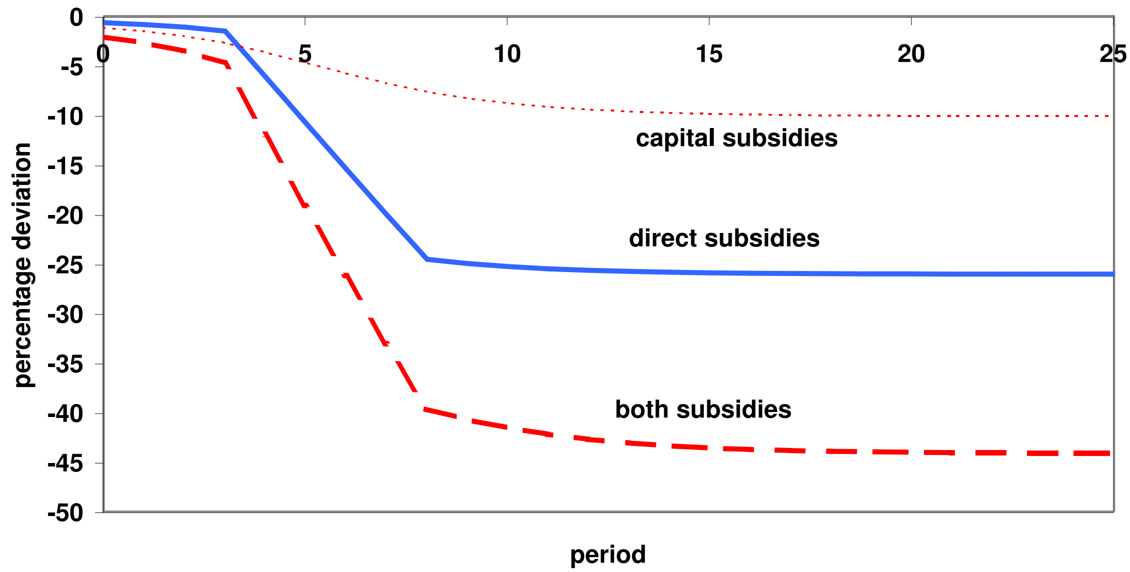

Figure 5a. SOE shares, traded good. (Deviation from benchmark).

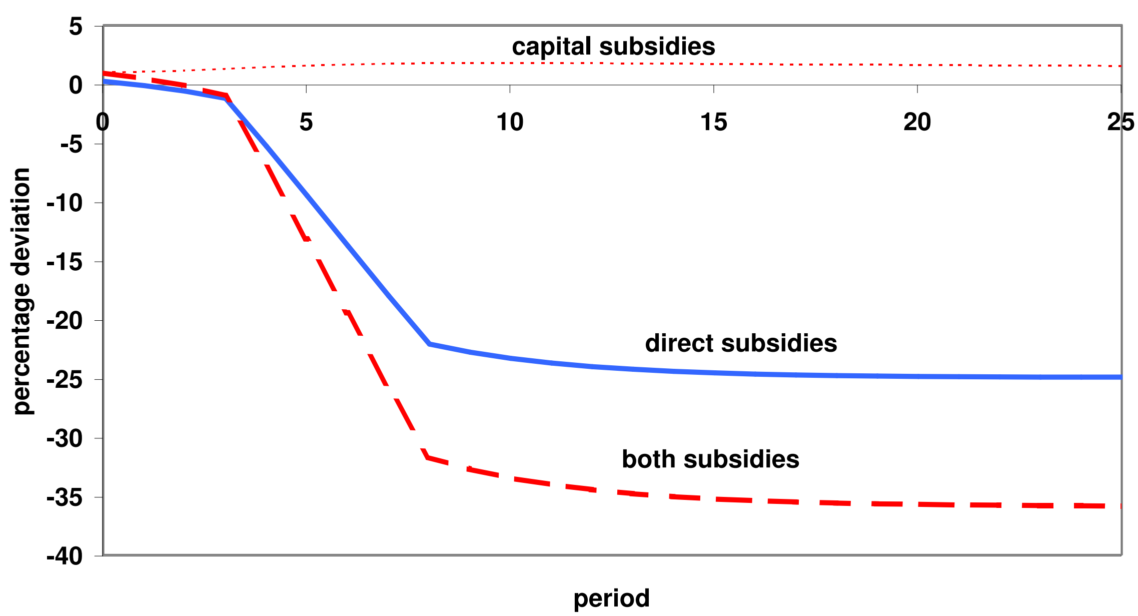

Figure 5b. SOE shares, non-traded good. (Deviation from benchmark).