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Rebalancing in China: a taxation approach

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The Chinese economy, tax reforms, financial intermediation, consumption, investment, welfare, foreign assets

JEL codes:

E20, F20, F30, H20, H30, P20, P30

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1 Introduction

The rebalancing of the Chinese economy is a widely debated topic, with regard to both the types of reforms and the method to establish them. This study uses a two-country dynamic general equilibrium model to address policy reforms relying on heterogeneous taxation across firms. The goal of this analysis is twofold.

First, the paper aims at establishing reforms that raise consumption (one priority of the Chinese government), reduce the huge investment rate of some firms (thus the induced overcapacities, debt dependency and financial instability), and increase the level of welfare (the requirement for social stability). Indeed, firms' investment rate is high in China (46% of GDP in 2015, and 24% for the world average) and many Chinese firms have issues such as overcapacities, over-indebtedness or even defaults (Fukumoto and Muto, 2011; Aglietta and Bai, 2012; Lee et al., 2012; Borst and Lardy, 2015; IMF, 2015; Artus, 2016a; Ding et al., 2016). Thus, one question can be raised: would a lower investment rate solve these issues? And would it be associated with welfare gains for households? Moreover, the consumption share is one of the lowest in the world (37% of GDP in 2015, and 58.3% for the world average) and China's growth is relying on foreign demand. Thus, the government aims at increasing consumption to have a growth that depends more on domestic demand and also to increase household welfare (with a higher purchasing power).

Second, the paper aims at taxing firms differently according to their production, labor cost and access to credit. Indeed, in both countries in the model, firms are differentiated between SOEs, private domestic and foreign firms, with specific characteristics (concerning initial technology, TFP growth, credit constraints, or capital share and depreciation). This firms' structure allows for a correction of the distortions in factor costs (labor and capital, see Aglietta and Bai, 2012) that lead to domestic and external imbalances. When taxes on loan repayments are combined with taxes on firms' production and/or labor cost¹, SOEs' loan repayments increase and the wage differential between domestic and foreign firms is reduced. Thus, the initial better access to credit for SOEs (Boyreau-Debray, 2003; Dollar and Wei, 2007; Poncet et al., 2010; Song et al., 2011) is offsetted, and the wage gap between public, private and foreign firms in China (Chen et al., 2005; Yang et al., 2010; Chen et al., 2011; Hale and Long, 2011) is reduced. Moreover, these reforms also emphasize that a reallocation of the labor force from SOEs to private firms, to overcome some SOEs' overcapacity (which is due to overinvestment), is necessary to rebalance the economy. This reallocation is currently in progress in China but is a critical issue because of the large consequences on migration and employment (IMF, 2015; Artus, 2016a). This analysis also highlights the strong link between the rise in households' consumption and the decrease in firms' investment rate through financial intermediation. Indeed, the rise in firms' credit cost is a key channel because in addition to reduce firms' investment, it also increase returns on savings and thus household consumption in the

¹These two taxes are equivalent to business/sales taxes and social security contributions.

model.

The work is close to [Bénassy-Quéré et al. \(2013\)](#) but has different methods of rebalancing and taxing the economy. Indeed, [Bénassy-Quéré et al.](#) show that an improvement in China's social safety net can reduce global imbalances (regardless of the exchange-rate regime but requiring some relaxation of capital controls), and that the monetary reform is not so crucial. In our paper, the focus is on the heterogeneous structure of firms, with a larger set of taxes for reforms and a deeper welfare analysis. Our work is also in line with the descriptive study of [Fukumoto and Muto \(2011\)](#), who analyze the correction of distortions in the factor costs in China and highlight that external rebalancing is not necessary for domestic rebalancing. Indeed, on one hand, in our theoretical framework firms' profits and the household propensity to save remain large. On the other hand, after the reforms, the supply of domestic bonds is reduced because of firms' lower investment rates, increasing the purchases of foreign bonds. Therefore, the net foreign assets position remains high and can even increase. This work also deepens the welfare analysis of the Chinese rebalancing in the literature. It emphasizes that the tax reforms bring welfare benefits to households, by correcting distortions in lending and deposit rates, by increasing wages in specific firms, and thus by enhancing consumption. Finally, an extension of the model is developed, which includes nominal rigidities and heterogeneous taxes on the consumption of home and foreign goods during the reforms that increase the consumption share.

The next section describes the evolution of the tax system in China since the 1970s. Then, the model and its calibration are developed in section 3, and tax reforms are analyzed in section 4. The Appendix presents the model extension and the corresponding tax reforms.

2 A review of the taxation system in China

To understand the challenges of taxation in China, let us go back in time to the 1970s. Taxation was difficult in the agricultural sector, that is, where 80% of the population worked. Therefore, the government collected implicit agricultural taxes using price distortions and monopolistic positions that led to high profits ([Gordon and Li, 2005](#)); then, taxable surpluses were channeled to the state-owned sector. However, this implicit tax was reduced by agricultural reforms that gradually raised procurement prices in the 1980s. For this reason, the main source of taxation became high taxes and dividends collected from large capital-intensive firms (mainly SOEs), in addition to many supplementary taxes and fees.² Note that the Chinese economy was still mainly relying on agriculture, preventing these high tax rates on capital-intensive SOEs from raising government revenue (which was also reduced by corruption and

²Two other important sources of revenue were high tariffs on imports and high seigniors due to a rapid growth in the money supply.

high rates of evasion). To offset the high tax rates, to support firms' investment, and also to ensure the payment of taxes, the government compensated through a state-controlled banking system that provided cheap credit to SOEs (Gordon and Li, 2005). Thus, a first issue emerged: as soon as the privatization process started, a credit bias toward SOEs appeared to the detriment of private firms (Boyreau-Debray, 2003; Boyreau-Debray and Wei, 2005; Dollar and Wei, 2007; Poncet et al., 2010), creating capital-intensive SOEs and labor-intensive private firms (Song et al., 2011). Another issue could have appeared if the government slowed the entry of firms that were more difficult to tax and that were able to compete with SOEs (which provide tax revenues). However, this issue did not occur because China established fiscal decentralization.

Indeed, substantial fiscal autonomy was given to regional and local governments starting in 1980: local governments were allowed to collect and retain taxes from any firms within their jurisdiction (Gordon and Li, 2005). This autonomy enabled the national government to collect revenue from smaller firms through local governments (a sector that is less taxed or untaxed in most underdeveloped or developing countries). Local governments were more effective in collecting revenue from both taxes on income and sales from these smaller firms. This decentralization led to strong local government support for firm entry and intense competition (for example, through tax incentives in Special Economic Zones (SEZs) to increase inward FDI and exports).

However, the central government did not succeed in maintaining high tax revenues because control over the local bureaucracy was lost with decentralization: the misappropriation of tax collection, corruption, bureaucrats leaving the state sector to go to the private sector, etc. For this reason, the tax system was largely reformed in 1994. The main goal was to recentralize fiscal power to strengthen state control over local authorities (Aglietta and Bai, 2012). In addition to restructuring the fiscal administration, one crucial element of the 1994 reform was the tax sharing plan covering state and non-state sectors. Value Added Taxes (VATs) and income taxes appeared and were uniformly applied. These were the premises of a modern tax system, with a central fiscal authority succeeding in collecting taxes from the economy out of the planned system. The tax revenue was a success, with the share of tax revenues from the central authority increasing from 22% in 1993 to 50% in 1994 (Aglietta and Bai, 2012).

Many tax reforms occurred in the 1980s, and the broad lines of the 1994 tax system are the current lines. All of these reforms are not detailed in this work; however, the link with the investment rate may be further explained. The "old" tax system in the 1980s provided substantial subsidies to investments that were financed by loans, and substantial taxes were imposed on investments that were financed by retained earnings (Brean, chapter 4, 1998). These subsidies and taxes have been reduced to a large extent under the 1994 system. However, taxes remained high for investments financed by retained earnings, and subsidies to loan-financed investments could appear when inflation increased. These distortions could partly explain why China kept such a high (aggregate) investment rate even at the end of its transition (apart from the fact that SOEs had a better access to credit and that private firms used the shadow banking system, see Tsai, 2002, Krugman, 2011, Li, 2014, and Funke et al., 2015). For this reason, in this work, one reform aims at reducing the investment rate, by setting heterogeneous taxes on production and credit costs across firms.

3 The model

A model of two large countries labeled d (domestic) and f (foreign) is built, with infinite horizon. To fit our issue and context, the domestic country is China and the foreign country is the U.S. Each country has households and firms. Households work, consume and save; their savings finance investments of domestic and foreign firms.³ Firms accumulate capital and use a share of their capital to produce abroad, which is assimilated to FDI. SOEs are added to private domestic and foreign firms. Firms are credit constrained and produce utilizing a standard Cobb-Douglas technology. TFP growth is considered to model growth differentials between the U.S. and China. In China, SOEs have a higher TFP growth⁴ (Hsieh and Song, 2015) and have better access to credit (credit constraints for SOEs are relaxed, making them capital-intensive whereas private firms remain labor-intensive, as in Song et al., 2011). This first model focuses on real factors and abstracts from nominal rigidities to keep the framework simple, so relative prices are assumed to be one. The nominal exchange rate cannot be considered without prices of goods, nominal rigidities, or value function for bonds prices. As for the real exchange rate, the relative marginal costs give an idea of its evolution. Finally, the model applies a calibration based on 2014 and 2015 data.

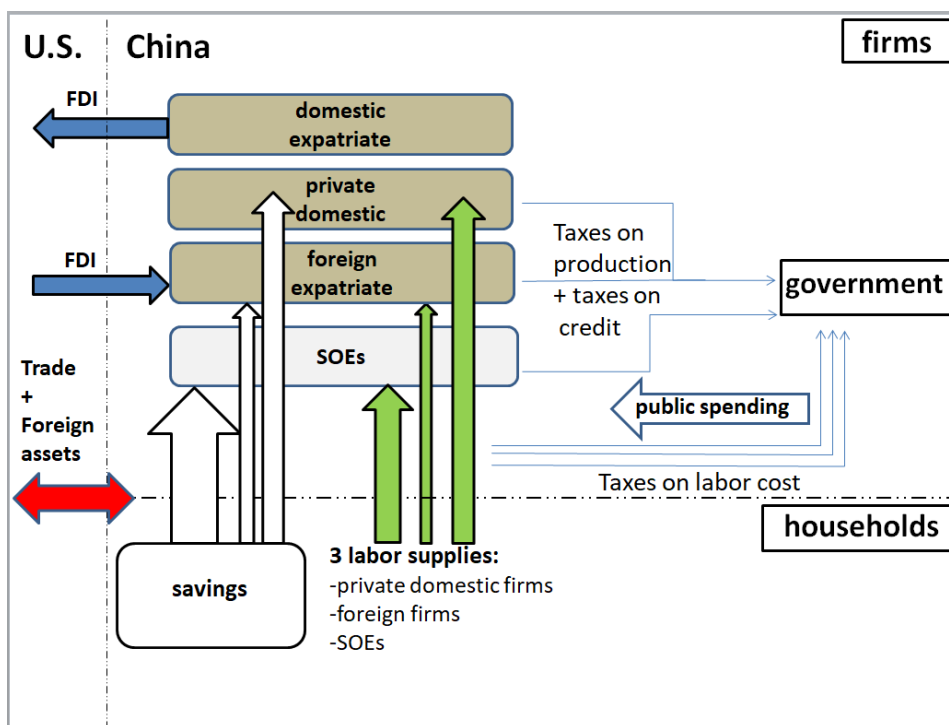


Figure 1: Diagram of the model

³Actually, Chinese savings are invested in foreign bonds through foreign reserves and sovereign wealth funds, but it is not the main focus here. In the model this step is skipped to maintain a simple framework and it is assumed that household and corporate savings directly finance foreign firms (and of course domestic ones), as in Benhima (2013).

⁴According to Hsieh and Song (2015), there is a recent catch-up process of TFP *growth* by SOEs against private firms (particularly for large SOEs). However, SOEs' TFP *level* remains low against private firms (particularly against foreign firms).

3.1 Households

Domestic households maximize a welfare index:

$$\begin{cases} \text{Max} E_0 \sum_{t=0}^{\infty} \beta_d^t \left(\frac{C_{d,t}^{1-\sigma}}{1-\sigma} - \frac{N_{S,t}^{1+\psi} + N_{d,t}^{1+\psi} + N_{f,t}^{*1+\psi}}{1+\psi} \right) & \sigma \neq 1, \\ \text{Max} E_0 \sum_{t=0}^{\infty} \beta_d^t \left(\log(C_{d,t}) - \frac{N_{S,t}^{1+\psi} + N_{d,t}^{1+\psi} + N_{f,t}^{*1+\psi}}{1+\psi} \right) & \sigma = 1. \end{cases}$$

subject to the budget constraint:

$$C_{d,t} + B_{d,t} + B_{S,t} + \left[FB_{d,t} + \frac{\chi_d}{1+\mu_d} (FB_{d,t} - FB_{d,t-1})^{1+\mu_d} \right] = \pi_{d,T,t} + W_{d,t}N_{d,t} + W_{S,t}N_{S,t} + W_{f,t}^*N_{f,t}^* \\ + (1+r_{f,t})(1-\gamma_f)FB_{d,t-1} + (1+r_{d,t})[(1-\gamma_S)B_{S,t-1} + (1-\gamma_d)B_{d,t-1}] \quad (1)$$

β is the discount rate, ψ the inverse of the Frisch elasticity of labor supply, and σ the inverse of the intertemporal elasticity of substitution. $N_{d,t}$ (resp. $N_{f,t}^*$) represents hours of work supplied by domestic households in the domestic firms (resp. foreign expatriate firms), $N_{S,t}$ labor supply in SOEs, and $C_{d,t}$ consumption.

Household incomes ($W_{d,t}N_{d,t}$ from domestic firm, $W_{f,t}^*N_{f,t}^*$ from foreign expatriate firms, and $W_{S,t}N_{S,t}$ from SOEs) are partly consumed in a single good and saved utilizing bonds. Household savings finance firms, thus, households can choose between bonds issued by firms of country d ($B_{d,t}$ for private firms, $B_{S,t}$ for SOEs) and foreign bonds ($FB_{d,t}$), considering that financial markets are incomplete. Various degrees of financial integration are modeled with varying trading costs on the purchase of foreign bonds $\frac{\chi_d}{1+\mu} (FB_{d,t} - FB_{d,t-1})^{1+\mu}$; these costs are a proxy for capital controls. Parameter χ_d controls for the magnitude of costs and μ for their curvature.⁵

In Equation (38), $r_{d/f,t}$ are domestic and foreign real interest rates, and $\pi_{d,T,t}$ are profits paid by firms (because firms belong to households).

Taxation. $\gamma_{d/f/S}$ are taxes on firms' loan repayments, which also affects households' returns on bonds.

⁵Chinese financial integration is more complex. Indeed, there are various restrictions and taxes on financial capital movements depending on the direction and type of financial capital, and it was varying during the transition (Kimball and Xiao, 2006, and the *Annual Report of Exchange Arrangements and Exchange Restrictions* (AREAER)). Note that trading costs are based on new bonds' purchase at time t and not on the divergence from the steady state. Indeed, deterministic simulations are conducted and the transition changes the steady state. With stochastic shocks, trading costs should be: $\frac{\chi_d}{1+\mu} (FB_{d,t}^* - \overline{FB}_d^*)^{1+\mu}$.

First ordinary conditions are:

$$N_{d,t} = [W_{d,t} C_{d,t}^{-\sigma}]^{\frac{1}{\psi}} \quad (2)$$

$$N_{f,t}^* = [W_{f,t}^* C_{d,t}^{-\sigma}]^{\frac{1}{\psi}} \quad (3)$$

$$N_{S,t} = [W_{S,t} C_{d,t}^{-\sigma}]^{\frac{1}{\psi}} \quad (4)$$

$$C_{d,t}^{-\sigma} = \beta E_t [C_{d,t+1}^{-\sigma} (1 + r_{d,t+1}) (\mathbf{1} - \gamma_d)] \quad (5)$$

$$\lambda_{d,t} [1 + \chi_d (FB_{d,t} - FB_{d,t-1})^{\mu_d}] = \beta E_t [\lambda_{d,t+1} (1 + r_{f,t+1}) (\mathbf{1} - \gamma_f)] \quad (6)$$

Equations (2), (3) and (4) are the labor supplies of households to firms, and Equation 5 is the usual Euler equation. Although there are important frictions on the Chinese labor market, for simplicity the latter is modeled as competitive and frictionless because such frictions would only change the speed and magnitude of reallocation and the evolution of wages, but not the qualitative behavior of all variables.⁶ By combining Equations (5) and (6), the trade-off between domestic and foreign bonds is obtained, once the amount of domestic bonds is fixed through firms' credit constraints (more details are in the subsection on firms).

$$E_t \left[\frac{(1 + r_{d,t+1}) (1 - \gamma_d) (1 + \chi_d (FB_{d,t} - FB_{d,t-1})^{\mu_d})}{(1 + r_{f,t+1}) (1 - \gamma_f)} - 1 \right] = 0 \quad (7)$$

China buys foreign bonds $FB_{d,t}$ (resp. become indebted to the U.S.) when returns on foreign bonds are higher (resp. lower) than those on domestic bonds:

$$(1 + r_{f,t+1}) (1 - \gamma_f) > (1 + r_{d,t+1}) (1 - \gamma_d) [1 + \chi_d (FB_{d,t} - FB_{d,t-1})^{\mu_d}].$$

Foreign households solve the same problem but they do not buy foreign bonds ($FB_{f,t} = 0$). Indeed, foreign liabilities in China were negligible (up to 4% of GDP during the last years of the transition) compared to foreign assets (approximately 50%).⁷

The list of all variables is in Table 1.

⁶Zuo and Wang (1999) explain that despite the huge flow of rural migrants to cities that followed reforms during the transition, the access of rural migrants to urban labor markets is selective (*Hukou* system). Even if these restrictions on migrations were still present in the second part of the transition, they were considerably reduced (Wang, 2004).

⁷Source: IMF database.

3.2 Firms

The population of firms comprises private domestic firms, private foreign firms and SOEs.

Domestic firms accumulate capital, produce, and maximize their stream of profits:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \lambda_{d,t} \pi_{d,T,t} \quad (8)$$

with

$$\begin{aligned} \pi_{d,T,t} = \pi_{d,t} + \pi_{d,t}^* + \pi_{S,t} = & Y_{d,t}(\mathbf{1} - \tau_{yd}) + Y_{d,t}^*(\mathbf{1} - \tau_{yd}^*) + Y_{S,t}(\mathbf{1} - \tau_{yS}) \quad (9) \\ & + D_{d,t} - (1 + r_{d,t})(\mathbf{1} - \gamma_d)D_{d,t-1} + D_{d,t}^* - (1 + r_{f,t})(\mathbf{1} - \gamma_f)D_{d,t-1}^* + D_{S,t} - (1 + r_{d,t})(\mathbf{1} - \gamma_S)D_{S,t-1} \\ & - (W_{d,t}N_{d,t}(\mathbf{1} + \tau_{wd}) + I_{d,t}) - (W_{d,t}^*N_{d,t}^*(\mathbf{1} + \tau_{wd}^*) + I_{d,t}^*) - (W_{S,t}N_{S,t}(\mathbf{1} + \tau_{ws}) + I_{S,t}) \end{aligned}$$

Firms operate in both countries because a share of their capital is expatriated to produce abroad: it is equivalent to investing in the foreign country through FDI. $\pi_{d,T,t}$ represents the total profits of domestic firms, $\pi_{d,t}$ (resp. $\pi_{d,t}^*$) the profits of the capital invested locally (resp. abroad) by private domestic firms, and $\pi_{S,t}$ the profits of SOEs.

When expatriated, firms have their *home* country's initial level of TFP and share of capital in production, but the TFP growth, labor force, capital depreciation and funding are from the *host* (that is, *local*) country. Indeed, according to Du and Girma (2007), foreign firms in China were equally financed by the home and host countries' financial intermediation during the transition.⁸

Production and technology. Production combines labor and capital through Cobb-Douglas technology:

$$Y_{d,t} = A_{d,t} \cdot K_{d,t-1}^{\alpha_d} N_{d,t}^{1-\alpha_d} \quad (10)$$

$$Y_{d,t}^* = A_{d^*,t} \cdot K_{d^*,t-1}^{\alpha_d} N_{d^*,t}^{1-\alpha_d} \quad (11)$$

$$Y_{S,t} = A_{S,t} \cdot K_{S,t-1}^{\alpha_S} N_{S,t}^{1-\alpha_S} \quad (12)$$

where $Y_{d,t}$ is the production of a domestic firm locally, $Y_{d,t}^*$ the production of a domestic firm abroad, and $Y_{S,t}$ the production of SOEs. The technology parameter A_t grows at an exogenous rate g_A : $A_t = (1 + g_A)A_{t-1} = (1 + g_A)^t A_0$. $g_{A_d} > g_{A_f}$ to have a larger TFP growth in China than in the U.S. TFP growth and the initial TFP are not similar across firms in China: domestic private firms have a higher initial TFP than SOEs ($A_{d,0} > A_{S,0}$), but SOEs have a higher TFP growth ($g_{A_S} > g_{A_d}$).⁴ As described above, the initial level of technology of expatriate firms is from the home country; thus, foreign firms in China have a higher initial technology level than domestic firms ($A_{f^*,0} > A_{d,0}$) but have the same TFP growth.

⁸Feldstein (2000), Harrison and McMillan (2003), and Alfaro et al. (2009) also mention the role of the local credit market on FDI determinants.

Balanced growth. The model is solved along the balanced growth path to have stationarity: except interest rates and hours worked, each variable is computed against A_t to deflate by the state of technology.⁹

Taxation. The government levies taxes on the three types of labor income (τ_{w_d} , $\tau_{w_{d^*}}$ and τ_{w_s}). Initially, these taxes are equal ($\tau_{w_d} = \tau_{w_{d^*}} = \tau_{w_s}$); then, during the reforms, taxes can take distinct values across different types of firms. These taxes can be considered as directly paid by the firm as social security contributions. Therefore, the social security contribution paid by a public firm at the end of the transition would not be equal to the contribution paid by the private sector.

Then, γ is used as a tax to reduce loan repayments by firms and returns on household bonds. This tax enables the government to compensate any difference in the credit constraints between private and state-owned firms during the reform (then, the interest rate is naturally adjusted in the second steady state). The tax γ has only two values across the three types of firms (γ_d for private firms, domestic and foreign expatriate, and γ_S for SOEs); initially, $\gamma_d = \gamma_S$.

Finally, taxes are levied by the government on firms' production (τ_{y_d} , $\tau_{y_{d^*}}$, and τ_{y_s} ; in the data these taxes are equivalent to business or sales taxes). Before the reform, taxes are equal for all types of firms ($\tau_{y_d} = \tau_{y_{d^*}} = \tau_{y_s}$), but they can take different values across firms during the reform. We select taxes on firms' production and not taxes on firms' profits as instruments, because taxes on firms' production have a greater range of variation between private and public sectors. Indeed, the latter vary between sectors (such as construction, industry and agriculture) and between SOEs and private firms.¹⁰ Moreover, these taxes are much lower than taxes on profits, therefore, a large increase in their value could still be affordable.

Investment. Convex adjustment costs Φ_I on investment are added in the capital accumulation process (Christiano et al., 2005; Groth and Khan, 2010; Albonico et al., 2012) to limit excessively large adjustments in the first periods of the reform. Thus, the accumulation of capital in Chinese firms d , d^* and S has the following law of motion:¹¹

$$K_{d,d^*,S_t} = (1 - \delta_{d,f,S}) K_{d,d^*,S_{t-1}} + I_{d,d^*,S_t} + I_{d,d^*,S_{t-1}} \Phi_I \left[\frac{I_{d,d^*,S_t}}{I_{d,d^*,S_{t-1}}} - 1 \right]^2 \quad (13)$$

⁹For example, $Y_{d,t}^*$ and the dynamic of expatriate capital become $y_{d,t}^* = \frac{Y_{d,t}^*}{A_{d,t}^*}$ and $k_{d,t}^* = (1 - \delta_f) \frac{K_{d,t-1}^*}{A_{d,t-1}^*} \cdot \frac{A_{d,t-1}^*}{A_{d,t}^*} + \frac{I_{d,t}^*}{A_{d,t}^*} = (1 - \delta_f) \frac{k_{d,t-1}^*}{1 + g_{A_f}} + i_{d,t}^*$, with $A_{d,t}^* = (1 + g_{A_f})^t A_{d,0}$ for expatriate firms.

¹⁰According to China Statistical Yearbook database, in 2012 the ratio of "tax and extra charge from principal business" over "revenue of principal business" was, for example, equal to 6.68% in construction, 2.21% in industry and 0.5% in trade and whole sale sectors ("tax and extra charges from principal business" can refer to sales taxes; Source: CSY, 2013).

¹¹Along the balanced growth path, the accumulation of capital becomes (for the three types of firms d , d^* and S):

$$k_{d,d^*,S_t} = (1 - \delta_{d,f,S}) \frac{k_{d,d^*,S_{t-1}}}{1 + g_{A_{d,f,S}}} + i_{d,d^*,S_t} + \frac{i_{d,d^*,S_{t-1}}}{1 + g_{A_{d,f,S}}} \Phi_I \left[(1 + g_{A_{d,f,S}}) \frac{i_{d,d^*,S_t}}{i_{d,d^*,S_{t-1}}} - 1 \right]^2$$

where $K_{d,t}^*$ and $I_{d,t}^*$ are domestic capital and investment expatriated in the foreign country to produce $Y_{d,t}^*$. Capital depreciates at each period with a rate δ (δ_d for private domestic capital, δ_f for private expatriate capital, and δ_S for state-owned capital).

Debt and credit constraints. Firms can borrow additional capital. The total amount of deposits available in banks to lend to firms is the addition of household domestic savings (the purchase of domestic bonds, $B_{d,t}$ and $B_{S,t}$) and the purchase of bonds by the foreign country: $D_{d,T,t} = B_{d,t} + B_{S,t} + FB_{f,t}$ in China, $D_{f,T,t} = B_{f,t} + FB_{d,t}$ in the U.S. $B_{d,t}$ comprises bonds for private domestic and foreign firms, $B_{S,t}$ are bonds for SOEs. Then, total deposits are proportionally distributed between firms according to their capital size, and credit reimbursement varies between private and state-owned firms because of parameter γ .¹² The amount of purchases of foreign bonds is determined by Equation (7) in China (equal to 0 in the U.S.), and the amount of domestic bonds is determined with *borrowing constraints* ζ faced by firms:

$$B_{d,t} = \zeta_d (K_{d,t} + K_{f,t}^*) \quad (14)$$

$$B_{S,t} = \zeta_S K_{S,t} \quad (15)$$

$\zeta_S > \zeta_d$ because there are tighter credit constraints for private firms than for SOEs (Boyreau-Debray, 2003; Boyreau-Debray and Wei, 2005; Dollar and Wei, 2007; Poncet et al., 2010; Song et al., 2011). To bypass these credit constraints some private firms use FDI (Héricourt and Poncet, 2009; Ju and Wei, 2010; Poncet et al., 2010) or shadow banking (Tsai, 2002; Krugman, 2011; Li, 2014; Funke et al., 2015). These are not modeled here to maintain a simple framework. As explained above, firms' domestic branches borrow in the country of origin, whereas their expatriate branches borrow abroad (Du and Girma, 2007).

First order conditions imply:

$$(1 - \alpha_d) \frac{Y_{d,t}}{N_{d,t}} (\mathbf{1} - \tau_{yd}) = W_{d,t} (\mathbf{1} + \tau_{wd}) \quad (16)$$

$$(1 - \alpha_d) \frac{Y_{d,t}^*}{N_{d,t}^*} (\mathbf{1} - \tau_{yd^*}) = W_{d,t}^* (\mathbf{1} + \tau_{wd^*}) \quad (17)$$

$$(1 - \alpha_S) \frac{Y_{S,t}}{N_{S,t}} (\mathbf{1} - \tau_{ys}) = W_{S,t} (\mathbf{1} + \tau_{ws}) \quad (18)$$

$$E_t \left[\frac{\lambda_{d,t+1}}{\lambda_{d,t}} \left(1 - \delta_d + \alpha_d \frac{Y_{d,t+1}}{K_{d,t}} (\mathbf{1} - \tau_{yd}) - \zeta_d (1 + r_{d,t}) (\mathbf{1} - \gamma_d) \right) - \left(\frac{1 - \zeta_d}{\beta} \right) \right] = 0 \quad (19)$$

$$E_t \left[\frac{\lambda_{d,t+1}}{\lambda_{d,t}} \left(1 - \delta_f + \alpha_d \frac{Y_{d,t+1}^*}{K_{d,t}^*} (\mathbf{1} - \tau_{yd^*}) - \zeta_f (1 + r_{f,t}) (\mathbf{1} - \gamma_f) \right) - \left(\frac{1 - \zeta_f}{\beta} \right) \right] = 0 \quad (20)$$

$$E_t \left[\frac{\lambda_{d,t+1}}{\lambda_{d,t}} \left(1 - \delta_S + \alpha_S \frac{Y_{S,t+1}}{K_{S,t}} (\mathbf{1} - \tau_{ys}) - \zeta_S (1 + r_{d,t}) (\mathbf{1} - \gamma_S) \right) - \left(\frac{1 - \zeta_S}{\beta} \right) \right] = 0 \quad (21)$$

¹²Total deposits' distribution to each type of firms is $D_{d,t} = \left(\frac{K_{d,t}}{K_{d,t} + K_{f,t}^* + K_{S,t}} \right) D_{d,T,t}$, $D_{f,t}^* = \left(\frac{K_{f,t}^*}{K_{d,t} + K_{f,t}^* + K_{S,t}} \right) D_{d,T,t}$, and $D_{S,t} = \left(\frac{K_{S,t}}{K_{d,t} + K_{f,t}^* + K_{S,t}} \right) D_{d,T,t}$. Credit reimbursement is $(1 + r_{d,t}) (1 - \gamma_d)$ for private firms and $(1 + r_{d,t}) (1 - \gamma_S)$ for SOEs.

Equations (16), (17) and (18) are standard labor demands, and Equations (19), (20) and (21) capture the marginal returns on investment. Firms have the choice to invest in either the domestic country or the foreign country; thus, the share of capital invested abroad depends on the marginal product of capital compared to credit costs. The former depends on the initial technology, TFP growth, the capital and labor shares, and capital depreciation, whereas credit costs depend on the real interest rate, the tightness of credit constraints, and moral hazard. A firm makes the choice to invest *fixed capital* abroad when $1 - \delta_f + \alpha_d \frac{Y_{d,t+1}^*}{K_{d,t}^*} - \zeta_f (1 + r_{f,t}) (1 - \gamma_f)$ is larger than $1 - \delta_d + \alpha_d \frac{Y_{d,t+1}}{K_{d,t}} - \zeta_d (1 + r_{d,t}) (1 - \gamma_d)$.¹³

Lastly, in this type of model firms belong to households. Therefore, firms' profits are saved or not by households (who can potentially buy *financial assets* (bonds) abroad following the trade-off in Equation 7).

Foreign firms solve the same problem with similar equations for their domestic and expatriate private firms but without SOEs. Under the following calibration, $FB_{d,t} > 0$: there are purchases of foreign bonds by China in Equation (7); thus, firms in the foreign country are indebted to China. It is equivalent to the external financial deficit of the U.S. Note that Equations (17) and (20) are valid for domestic firms operating abroad. The foreign firms operating in China have the following labor demand and marginal returns on investments:

$$(1 - \alpha_f) \frac{Y_{f,t}^*}{N_{f,t}^*} (\mathbf{1} - \boldsymbol{\tau}_{\mathbf{y}f^*}) = W_{f,t}^* (\mathbf{1} + \boldsymbol{\tau}_{\mathbf{w}f^*}) \quad (25)$$

$$E_t \left[\frac{\lambda_{f,t+1}}{\lambda_{f,t}} \left(1 - \delta_d + \alpha_f \frac{Y_{f,t+1}^*}{K_{f,t}^*} (\mathbf{1} - \boldsymbol{\tau}_{\mathbf{y}f^*}) - \zeta_d (1 + r_{d,t}) (\mathbf{1} - \gamma_d) \right) - \left(\frac{1 - \zeta_d}{\beta} \right) \right] = 0 \quad (26)$$

with $Y_{f,t}^* = A_{f^*,t} K_{f^*,t-1}^{\alpha_f} N_{f^*,t}^{1-\alpha_f}$ and $A_{f^*,t} = (1 + g_{A_d})^t A_{f,0}$. Their capital share and initial level of technology remain national while their funding, TFP growth, labor force and capital depreciation are local.

The list of all variables is in Table 1.

¹³Along the balanced growth path, marginal returns on investments are:

$$mR_{I_{d,t}} = \left[\alpha_d \frac{y_{d,t+1}}{k_{d,t}} (1 + g_{A_d}) (\mathbf{1} - \boldsymbol{\tau}_{\mathbf{y}d}) + (1 - \delta_d - \zeta_d (1 + r_{d,t}) (\mathbf{1} - \gamma_d)) \right] - \left(\frac{1 - \zeta_d}{\beta} \right) \quad (22)$$

$$mR_{I_{d^*,t}} = \left[\alpha_d \frac{y_{d,t+1}^*}{k_{d,t}^*} (1 + g_{A_f}) (\mathbf{1} - \boldsymbol{\tau}_{\mathbf{y}d^*}) + (1 - \delta_f - \zeta_f (1 + r_{f,t}) (\mathbf{1} - \gamma_f)) \right] - \left(\frac{1 - \zeta_f}{\beta} \right) \quad (23)$$

$$mR_{I_{S,t}} = \left[\alpha_S \frac{y_{S,t+1}}{k_{S,t}} (1 + g_{A_S}) (\mathbf{1} - \boldsymbol{\tau}_{\mathbf{y}S}) + (1 - \delta_S - \zeta_S (1 + r_{d,t}) (\mathbf{1} - \gamma_S)) \right] - \left(\frac{1 - \zeta_S}{\beta} \right) \quad (24)$$

3.3 Government and aggregation

Both domestic and foreign governments collect their revenue from firms' labor costs, production, and loan repayments; for simplicity and because there are already many different types of bonds, it is assumed that the government does not use domestic or foreign bonds to finance potential deficits.

$$G_{d,t} = \tau_{y_d} Y_{d,t} + \tau_{y_{f^*}} Y_{f^*,t} + \tau_{y_S} Y_{S,t} + \tau_{w_d} W_{d,t} N_{d,t} + \tau_{w_{f^*}} W_{f^*,t} N_{f^*,t} + \tau_{y_S} W_{S,t} N_{S,t} \quad (27)$$

$$+ \gamma_d (1 + r_{d,t}) (B_{d,t} + FB_{f,t}) + \gamma_S (1 + r_{d,t}) B_{S,t}$$

$$G_{f,t} = \tau_{y_f} Y_{f,t} + \tau_{y_{d^*}} Y_{d^*,t} + \tau_{y_{S_f}} Y_{S_f,t} + \tau_{w_f} W_{f,t} N_{f,t} + \tau_{w_{d^*}} W_{d^*,t} N_{d^*,t} + \tau_{y_{S_f}} W_{S_f,t} N_{S_f,t} \quad (28)$$

$$+ \gamma_f (1 + r_{f,t}) (B_{f,t} + FB_{d,t}) + \gamma_{S_f} (1 + r_{f,t}) B_{S_f,t}$$

Then, the government uses fiscal receipts to finance public expenditure on the goods and services market:

$$Y_{d,t} + Y_{f,t}^* + Y_{S,t} + Y_{f,t} + Y_{d,t}^* + Y_{S_f,t} = C_{d,t} + C_{f,t} + G_{d,t} + G_{f,t} + I_{d,t} + I_{f,t} + I_{d,t}^* \quad (29)$$

$$+ I_{f,t}^* + I_{S,t} + I_{S_f,t} + \frac{\chi_f}{1 + \mu_f} (FB_{f,t} - FB_{f,t-1})^{1 + \mu_f} + \frac{\chi_d}{1 + \mu_d} (FB_{d,t} - FB_{d,t-1})^{1 + \mu_d}$$

Concerning labor market clearing conditions, they are already implicitly imbedded in the households section: total labor supply in the domestic country is $(N_{d,t} + N_{f,t}^* + N_{S,t})$, and $(N_{f,t} + N_{d,t}^* + N_{S_f,t})$ in the foreign country.

As explained in the previous subsection, bonds market clearing conditions are total deposits available in each country: the addition of household domestic savings and bonds purchases from abroad, which are nil from U.S. to China ($FB_{f,t} = 0$ under the assumption of negligible reserve assets accumulation in the U.S.):

$$D_{d,T,t} = B_{d,t} + B_{S,t} + FB_{f,t} \quad (30)$$

$$= \zeta_d (K_{d,t} + K_{f,t}^*) + \zeta_S K_{S,t} + FB_{f,t}$$

$$D_{f,T,t} = B_{f,t} + B_{S_f,t} + FB_{d,t} \quad (31)$$

$$= \zeta_f (K_{f,t} + K_{d,t}^*) + \zeta_S K_{S_f,t} + FB_{d,t}$$

There is one firm of each type by country in the model. It is the aggregation of n firms of type $d/f^*/S$ in the domestic country, and m firms of type $f/d^*/S_f$ in the foreign country. Each type of firm has a share s of employment in the total of firms; it is fixed at the steady state but evolves endogenously after. It corresponds to the share of SOEs and inward/outward FDI (coefficients η_{Soe} , η_{Soef} , ω_{in} and ω_{out}). So for output, capital and investment, we get:

-with $s_k < 1 \in \{1 - \omega_{in} - \eta_{Soe}, \omega_{in}, \eta_{Soe}\}$ the employment share of firms of type k in the domestic country ($\forall k \in \{d, f^*, S\}$):

$$Y_{k,t} = \int_0^{s_k} \int_0^n Y_{k,t}(i) di dj \quad K_{k,t} = \int_0^{s_k} \int_0^n K_{k,t}(i) di dj \quad I_{k,t} = \int_0^{s_k} \int_0^n I_{k,t}(i) di dj$$

-with $s_l < 1 \in \{1 - \omega_{out}, \omega_{out}, \eta_{Soe_f}\}$ the employment share of firms of type l in the foreign country ($\forall l \in \{f, d^*, S_f\}$):

$$Y_{l,t} = \int_0^{s_l} \int_0^m Y_{l,t}(u) du dv \quad K_{l,t} = \int_0^{s_l} \int_0^m K_{l,t}(u) du dv \quad I_{l,t} = \int_0^{s_l} \int_0^m I_{l,t}(u) du dv$$

Firms belong to households so profits are transferred to households' budget constraint. Thus, the Net Foreign Assets position is obtained consolidating households and firms' budget constraints:

$$\begin{aligned} NFA_{d,t} &= FB_{d,t} - FB_{f,t} = I_{f,t}^* - I_{d,t}^* + \alpha_d Y_{d,t}^* - \alpha_f Y_{f,t}^* \\ &+ (1 + r_{f,t})(1 - \gamma_f) FB_{d,t-1} - (1 + r_{d,t})(1 - \gamma_d) FB_{f,t-1} \\ &- \frac{\chi_d}{1 + \mu_d} (FB_{d,t} - FB_{d,t-1})^{1+\mu_d} + \frac{\chi_f}{1 + \mu_f} (FB_{f,t} - FB_{f,t-1})^{1+\mu_f} \end{aligned} \quad (32)$$

with:

$$NFA_{d,t} + NFA_{f,t} = 0.$$

The current account is defined as the sum of the trade balance and net incomes from abroad:

$$\begin{aligned} CA_{d,t} &= TB_{d,t} + NIC_{d,t} = Y_{d,t} + Y_{f,t}^* + Y_{S,t} - C_{d,t} - I_{d,t} - I_{f,t}^* + I_{S,t} \\ &+ r_{f,t}(1 - \gamma_f) FB_{d,t-1} - r_{d,t}(1 - \gamma_d) FB_{f,t-1} \\ &+ \frac{\chi_f}{1 + \mu_f} (FB_{f,t} - FB_{f,t-1})^{1+\mu_f} - \frac{\chi_d}{1 + \mu_d} (FB_{d,t} - FB_{d,t-1})^{1+\mu_d} \end{aligned} \quad (33)$$

It can also be expressed as a function of savings and investments: $CA_{d,t} = S_{d,T,t} - I_{d,T,t}$.

name	definition	name	definition
	In the domestic country (China):		In the foreign country (the U.S.):
$C_{d,t}$	consumption	$C_{f,t}$	consumption
$N_{d,t}$	labor supply in domestic private firms	$N_{f,t}$	labor supply in foreign firms
$N_{f,t}^*$	labor supply in expatriate U.S. private firms	$N_{d,t}^*$	labor supply in expatriate Chinese private firms
$N_{S,t}$	labor supply in domestic SOEs	$N_{S_f,t}$	labor supply in foreign SOEs
$W_{d,t}$	wages in domestic private firms	$W_{f,t}$	wages in foreign firms
$W_{f,t}^*$	wages in expatriate U.S. private firms	$W_{d,t}^*$	wages in expatriate Chinese private firms
$W_{S,t}$	wages in domestic SOEs	$W_{S_f,t}$	wages in foreign SOEs
$B_{d,t}$	bonds financing private firms in China	$B_{f,t}$	bonds financing private firms in the U.S.
$B_{S,t}$	bonds financing domestic SOEs	$B_{S_f,t}$	bonds financing foreign SOEs
$D_{d,T,t}$	total deposit	$D_{f,T,t}$	total deposit
$FB_{d,t}$	China's foreign bonds purchases	$FB_{f,t}$	U.S.' foreign bonds purchases
$r_{d,t}$	real interest rate	$r_{f,t}$	real interest rate
$\pi_{d,t}$	profits of domestic private firms	$\pi_{f,t}$	profits of foreign firms
$\pi_{f,t}^*$	profits of expatriate U.S. private firms	$\pi_{d,t}^*$	profits of expatriate Chinese private firms
$\pi_{S,t}$	profits of domestic SOEs	$\pi_{S_f,t}$	profits of foreign SOEs
$\pi_{d,T,t}$	total profits in the domestic country	$\pi_{f,T,t}$	total profits in the foreign country
$Y_{d,t}$	production in domestic private firms	$Y_{f,t}$	production in foreign firms
$Y_{f,t}^*$	production in expatriate U.S. private firms	$Y_{d,t}^*$	production in expatriate Chinese private firms
$Y_{S,t}$	production in domestic SOEs	$Y_{S_f,t}$	production in foreign SOEs
$K_{d,t}$	capital in domestic private firms	$K_{f,t}$	capital in foreign firms
$K_{f,t}^*$	capital in expatriate U.S. private firms	$K_{d,t}^*$	capital in expatriate Chinese private firms
$K_{S,t}$	capital in domestic SOEs	$K_{S_f,t}$	capital in foreign SOEs
$I_{d,t}$	investment by domestic private firms	$I_{f,t}$	investment by foreign firms
$I_{f,t}^*$	investment by expatriate U.S. private firms	$I_{d,t}^*$	investment by expatriate Chinese private firms
$I_{S,t}$	investment by domestic SOEs	$I_{S_f,t}$	investment by foreign SOEs
$G_{d,t}$	public expenditures	$G_{f,t}$	public expenditures
$NFA_{d,t}$	net foreign assets	$NFA_{f,t}$	net foreign assets
$CA_{d,t}$	current account	$CA_{f,t}$	current account

Note: parameters are described in Tables 2 and 3 (in the calibration subsection).

Table 1: Variables

3.4 Calibration

The model is annual. The calibration is based on the 2014 and 2015 data, on the literature on China using DGE models, and the calibration targets some main variables' steady states. Indeed, the first crucial issue is to reach the following: a low consumption rate (approximately 42% of GDP), a high investment rate (approximately 40% of GDP¹⁴), a high NFA position (approximately 45% of GDP), a trade balance surplus (close to 3% of GDP), and a 3% real deposit rate. Moreover, even if it is not the main purpose, we attempt to obtain realistic values for FDI flows (less than 5% of GDP).

Another crucial element is to have quite accurate values of the initial level of technology (compared to the U.S.) and of TFP growth across each type of firm. Indeed, the Chinese transition was based on the huge TFP growth over the last 30 years ($g_{A_d} > g_{A_f}$ to have a larger TFP growth in China than in the U.S.), but there is still a large gap with developed countries regarding the level of technology ($A_{f,0} = 1$ and $A_{d,0} = 0.53$, according to St Louis Fed Stats 2011 and author's calculations). Moreover, the recent catch-up process of TFP growth by SOEs versus private firms may be taken into account (Hsieh and Song, 2015). Thus, private firms have a higher initial TFP level than SOEs ($A_{d,0} = 0.53$; $A_{S,0} = 0.5$), but TFP has a higher growth rate in SOEs ($g_{A_S} = 0.33$; $g_{A_d} = 0.3$). A_0 of expatriate firms is from the home country, which means that foreign firms in China have a higher initial technology level than domestic firms ($A_{f,0} > A_{d,0}$) but have the same local TFP growth. Note that some authors attempt to account for China's TFP growth across sectors and ownership but the variance is high across studies; here, the calibration is particularly based on Brandt and Zhu (2010) and Hsieh and Song (2015) ($g_{A_d} = 0.3$ and $g_{A_S} = 0.33$).

Credit constraints are slightly higher in China ($\zeta_d = 0.385$) than in the U.S. ($\zeta_f = 0.42$) but are heavily relaxed for SOEs ($\zeta_S = 0.57$).¹⁵ Their calibration, coupled to the capital shares' calibrations (0.285 in private firms; 0.45 in SOEs), attempts to match the highest investment rate in China possible in this model (46% in the 2014 data). The calibration of the other parameters (capital depreciation (0.08), adjustment costs (0.2), inverse of Frisch elasticity (0.43), etc.) remains close to the literature, while setting the main variables' steady states close to the data. The share of SOEs in China ($\eta_{SOe} = 0.47$) and the share of China's GDP ($\varrho_Y = 0.37$) are initially fixed, and then evolve endogenously.¹⁶ The calibration and its justification are summarized in Tables 2 and 3.

¹⁴In this model, it is very difficult to obtain the 46% investment rate in the 2014 data. Therefore, the aggregated investment rate does not exceed 38% of GDP.

¹⁵Firms can borrow a share ζ of their capital stock ($B_t = \zeta K_t$), see Equations 14 and 15.

¹⁶Note that the initial share of SOEs is assigned to the hours worked, and the initial share of GDP to all household variables (which then impact all variables): $\left[\frac{N_{d,t}}{(1-\eta_{SOe})e_Y} \right]^\psi \left[\frac{C_{d,t}}{e_Y} \right]^\sigma = w_{d,t}(1 + \tau_{w_d})$ (in domestic private firms in China, for example). Thus, these parameters adjust the labor supply but can not force the labor supply to have a precise specific value. With $\eta_{SOe} = 0.47$, the share of employment in SOEs at steady state is 53%, which remains very close to the data (China Statistical Yearbook, 2013).

Parameters		China	Justification	U.S.	
Households					
β	discount rate	0.97	to match a 3% steady-state real deposit rate (annual basis)	0.97	
σ	risk aversion	1	constrained by the balanced growth path ¹	1	
ψ	inverse of Frisch elasticity	0.43	Reichling and Whalen (2012) and to reach a low consumption-to-output ratio	0.9	
μ	curvature of bonds' trading costs	1	to have quadratic costs ($1+\mu$)	1	
χ	bonds trading costs	0.85	to reach a high NFA position	0 ($B_f^* = 0$)	
Firms					
A_0	initial technology	private firms SOEs	0.53 0.5	St Louis Fed Stats 2011, Hsieh and Song (2015), and author's calculations	1 1
gA	TFP growth	private firms SOEs	0.03 0.033	Brandt and Zhu (2010) and Hsieh and Song (2015)	0.02 0.02
α	share of capital in production	private firms SOEs	0.285 0.45	Bénassy-Quéré et al. (2013), Funke et al. (2015), and to reach a high investment rate	0.3 0.3
δ	capital depreciation rate		0.08	Bénassy-Quéré et al. (2013)	0.1
Φ_I	investment adjustment costs		0.2	Albonico et al. (2012)	0.2
ζ	credit constraint	private firms SOEs	0.385 0.57	close to Coeurdacier et al. (2015), to match differences between private firms and SOEs (Poncet et al., 2010; Song et al., 2011, ...), to reach high investment rates in China, and to target other steady-state values	0.42 0.42

¹ It is well known that with separable preferences, because the model is solved along the balanced growth path, labor supply equations force the risk aversion parameter to be equal to 1.

Table 2: Calibration of the benchmark model

	Parameters	China	Justification	U.S.
η_{Soe}^2	initial share of SOEs	0.47	China Statistical Yearbook (CSY)	$\frac{1}{7}$
ϱ_Y^2	initial share of GDP	0.37	World Bank	0.63 ($= 1 - \varrho_Y$)
Government				
τ_{w_d}	tax on labor cost (social security contribution) ³ in private domestic firms	0.29	State Administration of Taxation of the People's Republic of China, social insurance law ("China Labour Bulletin") and "China Taxation and Investment 2016" (Deloitte)	0.25
$\tau_{w_{f^*}}$	tax on labor cost (social security contribution) ³ in private foreign firms	0.29	""	0.25
τ_{w_s}	tax on labor cost (social security contribution) ³ in SOEs	0.29	""	0.25
γ_d	tax on credit reimbursement in private firms	0.03	to match a 3% steady state real deposit rate	0
γ_S	tax on credit reimbursement in SOEs	0.03	""	0
τ_{y_d}	tax on production (business or sales tax) in private domestic firms	0.0278	China Statistical Yearbook (CSY) and author's calculations ⁴	0.02
$\tau_{y_{f^*}}$	tax on production (business or sales tax) in private foreign firms	0.0278	""	0.02
τ_{y_s}	tax on production (business or sales tax) in SOEs	0.0278	""	0.02

² The initial share of SOEs is assigned to the hours worked, and the initial share of GDP to all household variables, which then impact all variables; for example, in domestic private firms in China we have: $\left[\frac{N_{d,t}}{(1-\eta_{Soe})\varrho_Y}\right]^\psi \left[\frac{C_{d,t}}{\varrho_Y}\right]^\sigma = W_{d,t}(1+\tau_{w_d})$.

³ It is the sum of all social security contributions levied on labor cost (pension, unemployment and medical insurance).

⁴ According to CSY, taxes on firms' production (business or sales taxes) vary by sectors (manufacturing and tertiary); thus it is the weighted mean of all sectors.

Table 3: Calibration of the benchmark model (2)

3.5 Taxes' impact on steady state

	Steady state	Variation of steady state (%)		
	All taxes	$\tau_{y_d, f^*, S}$ loosened	$\tau_{w_d, f^*, S}$ loosened	
$(\bar{x}_y$ are variables in % of GDP at steady state; \bar{n} is a fraction of time; \bar{w} is a wage index)				
\bar{y} ($\bar{y}_d = 0.080, \bar{y}_{f^*} = 0.052, \bar{y}_S = 0.174$)	0.31	$\frac{\Delta \bar{y}}{\bar{y}}$	31.19	-0.29
\bar{s}_y	50.30	$\frac{\Delta \bar{s}_y}{\bar{s}_y}$	-28.18	0.29
\bar{g}_y	16.26	$\frac{\Delta \bar{g}_y}{\bar{g}_y}$	-11.05	-86.70
\bar{tb}_y	4.00	$\frac{\Delta \bar{tb}_y}{\bar{tb}_y}$	567.74	40.09
\bar{nfa}_y	45.31	$\frac{\Delta \bar{nfa}_y}{\bar{nfa}_y}$	-23.76	0.30
\bar{Welf}	-71.06	$\frac{\Delta \bar{W}}{\bar{W}}$	-5.01	16.14
Households				
\bar{c}_y	42.43	$\frac{\Delta \bar{c}_y}{\bar{c}_y}$	-28.38	43.50
\bar{n} ($\bar{n}_d = 37.8\%$ total, $\bar{n}_{f^*} = 9.6\%$ total, $\bar{n}_S = 52.6\%$ total)	0.37	$\frac{\Delta \bar{n}}{\bar{n}}$	28.65	-0.30
\bar{w} ($\bar{w}_d = 0.32, \bar{w}_{f^*} = 0.80, \bar{w}_S = 0.38$)	0.43	$\frac{\Delta \bar{w}}{\bar{w}}$	4.41	≈ 0
Firms				
\bar{i}_y ($\bar{i}_d = 26.02, \bar{i}_{f^*} = 27.10, \bar{i}_S = 45.9$)	37.31	$\frac{\Delta \bar{i}_y}{\bar{i}_y}$	3.36	0 (-0.31 for \bar{i})
$\bar{fdi}_{in,y}$	4.59	$\frac{\Delta \bar{fdi}_{in,y}}{\bar{fdi}_{in,y}}$	0.65	0 (-0.31 for $\frac{\Delta \bar{fdi}_{in}}{\bar{fdi}_{in}}$)
$\bar{fdi}_{out,y}$	3.79	$\frac{\Delta \bar{fdi}_{out,y}}{\bar{fdi}_{out,y}}$	-28.76	0 (-0.34 for $\frac{\Delta \bar{fdi}_{out}}{\bar{fdi}_{out}}$)
$\bar{\Pi}$	0.0156	$\frac{\Delta \bar{\Pi}}{\bar{\Pi}}$	34.44	-0.66
$\bar{\Pi}_y$	4.98	$\frac{\Delta \bar{\Pi}_y}{\bar{\Pi}_y}$	2.48	-0.37

Table 4: Taxes' contribution to steady state

In this subsection, we are interested in the changes in variables' steady state (including public expenditure) when a specific tax is loosened while the other taxes remain constant.

When τ_{y_d} (levied on firms' production in China) is loosened (from 2.78 to 0%), firms' output, profits and investment rate increase (because sales are no more reduced by τ_{y_d}), and public spending mechanically decreases (Table 4). The changes in firms' output also lead to an increase in labor demand and wages. Note that the effect on inward FDI is negligible whereas outward FDI are widely impacted. Indeed, with this calibration, taxes on production are lower in the foreign country: outward FDI are a way to escape

the local taxation at the rate τ_{y_d} in the domestic country; thus, when the latter is loosened, capital is repatriated. On the household side, the rise in firms' indebtedness (due to the rise in output and investment) mechanically increases the amount of domestic bonds that are purchased by households in this model. The consequences are a negative effect on consumption through two channels. On one hand, the increase in the supply of domestic bonds mechanically raises household savings, and thus decreases consumption. On the other hand, it also mechanically reduces the purchase of foreign bonds, thus revenue generated by the latter is lowered. Therefore, because the wealth effect is high with the utility function that is used in this model, the decrease in the net foreign assets position reduces consumption. Concerning the trade balance, its high sensitivity is due to the sum of all of the changes in output, investment, consumption and public spending, which follow the same direction.¹⁷

When τ_{w_d} (levied on household income in China) is loosened (from 30 to 0%), there is a direct and large negative effect on public spending (Table 4). Consumption and welfare are positively and highly impacted but the negative effect on public spending is larger than the positive effect on consumption, which is why the trade balance mechanically increases.¹⁷ Finally, the effects on firms variables are negligible.

Concerning the loosening of γ_d , the changes in steady state are not reported in Table 4. Indeed, it only has an effect on the dynamics of corporate debts and not on changes in other variables' steady states. The real interest rate falls quite substantially over time to adjust to the change in γ_d .

4 Tax reforms

The first reform is to decrease the overinvestment rate of some Chinese firms (Ding et al., 2016). Indeed, the latter is close to 46% of GDP in the data (above 45% of GDP in SOEs in the model) and lead to huge indebtedness, default or overcapacities (Aglietta and Landry, 2007; Zhou, 2013; Borst and Lardy, 2015; IMF, 2015; Artus, 2016a).

Second, the recent main goal of Chinese government policy is to raise domestic consumption and reduce the dependence on foreign demand. By implementing different combinations of taxes, the model is computed to target a second steady state with a higher consumption-output ratio (which is below 40 % in the data between 2012 and 2016); first, by only taxing firms' production and credit refunding and, second, by adding a taxation of firms' labor cost. The response function of other key variables (trade balance, net foreign assets position, FDI, investment rate, etc.) is also analyzed.

Note that with a lower investment rate (targeted by the first tax reform), the government can also stimulate consumption in this model. Indeed, the decrease in firms' investment is obtained by higher credit costs for firms and by a reallocation of the labor force. The former increases returns on household savings and the latter raises the share of employment in firms with higher wages. These two elements increase the share of consumption in GDP.

¹⁷In this framework, the trade balance is obtained with the aggregation of domestic and foreign clearing conditions on the goods and services markets (Equation 29).

Then, one main goal of Chinese government policy is to increase social welfare. For this reason, the welfare benefits of the policy reforms are computed and analyzed. Here, welfare benefits are represented by the percentage of consumption ξ that would offset households' welfare losses between the reform and the initial steady state, as in [Auray et al. \(2015\)](#). It is the value of ξ , which solves the following:

$$\sum_{t=0}^i \beta^t U(C_{d,t}(1-\xi), N_{d,t}, N_{f^*,t}, N_{S,t}) = U(\bar{C}_d, \bar{N}_d, \bar{N}_{f^*}, \bar{N}_S) \sum_{t=0}^i \beta^t, i = 1 \dots \infty \quad (34)$$

When ξ is negative (resp. positive) the reform brings welfare losses (resp. gains): households must be compensated during the reform to maintain the same level of welfare. The welfare benefits are observed either at short horizons (2 to 10 years) or at 20 years and infinite horizon (across steady states); they are computed during the consumption and investment reforms. Finally, a direct welfare maximization reform is implemented, and the Appendix develops an extension of the model that includes prices of goods and heterogeneous Value Added Taxes (VATs) across home and foreign goods (during the reforms that increase the consumption ratio).

4.0.1 Reduce overinvestment

The first reform is to reach a lower aggregate investment rate, and thus reduce overinvestment in firms that have lower credit constraints. To establish the reform, we seek the transition path of all variables $\left\{ X_{1,t}, X_{2,t}, \dots, X_{n,t} \right\}_{t=0}^T$ that solves:

$$\underset{\tau_{y_d,T}, \tau_{y_d,T}, \tau_{y_d,T}, \tau_{y_d,T}, \tau_{y_d,T}, \tau_{y_d,T}}{\text{Min}} \left[\bar{I}_y - \bar{I}_{y,reform} \right] \quad (35)$$

with $\bar{I}_y < 0.37$ and *subject to* steady state equations, market clearing conditions and aggregation. Each tax follows a first-order autoregressive process during the reform: $\tau_t = \rho_\tau \tau_{t-1} + (1 - \rho_\tau) \bar{\tau}$, where $\bar{\tau}$ is the tax value at the final steady state of the reform.

The model is computed with a target of the investment rate below the initial steady state. We recall that the investment rate varies a lot between the different types of firms in the model (47% for SOEs versus 26% and 27% for private domestic and foreign firms, respectively) and that SOEs represent approximately half of the labor supply in China (10% and 40% for foreign and domestic private firms, respectively). The reform is initially computed with taxes on production and credit, and then with all taxes (production, credit and labor cost). For each combination of taxes, we ensure that the solution is unique by running again the algorithm and excluding the first solution (if the solution is unique, the algorithm does not find any solution after the second set of iterations).

With the taxation of production and credit: $\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S$ (Table 5)

Taxes on credit refunding are nearly equal to zero for SOEs (0.0013, against 0.03 before tax reforms), which is equivalent to an increase in their credit costs during the transition path ($\Delta_- \gamma_{S,t} \Rightarrow \Delta_+ r_{d,t}(1 - \gamma_S)$). Thus, it leads to a drop in SOEs' investment rate (to 38%, against 46% initially, Figure 2, panel (a)), whereas the latter remains broadly constant in private domestic and foreign firms (panels (b) and (c)). Regarding the tax on production, it increases in private firms (τ_{y_d}) and offsets the decrease in their credit costs ($\Delta_- r_{d,t}(1 - \gamma_d)$).

Instruments				
$\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S$				
	Initial	Reform	Horizon	Welfare benefits
τ_{y_d}	0.0278	0.0473	2	0.0058
$\tau_{y_{f^*}}$	0.0278	0.0207	5	0.0087
τ_{y_S}	0.0278	0.0210	10	0.0088
γ_d	0.03	0.0362	20	0.0073
γ_S	0.03	0.0013	across steady states	0.0029

Table 5: Taxes and welfare benefits - Reform 1: investment - Set of taxes 1

With the taxation of labor cost, production and credit: $\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S, \tau_{w_d}, \tau_{w_{f^*}}, \tau_{w_S}$ (Table 6) When computed with all taxes, the taxation of firms' product is higher in SOEs (0.0355) than in private domestic and foreign firms (0.0317 and 0.0294, respectively). The result is consistent with firms' characteristics because SOEs benefit from relaxed credit constraints, high TFP growth, and low wages (thus, they have the highest investment rate (47%)). Moreover, wages in SOEs are taxed more heavily (Table 6), which is equivalent to increase social security contributions of SOEs and to reduce social security contributions of private domestic firms and particularly of foreign firms.¹⁸ Thus, the labor supply in SOEs is largely reduced (Figure 2, panel (d)): the reform with all taxes, through the high taxation of wage and production in SOEs, is equivalent to a reallocation of the labor force toward private firms (in addition to hindering investment in SOEs). It is currently the case in China: the government shuts down some state-owned factories because of overcapacities due to overinvestment, and then reallocates the labor force.¹⁹

As expected, a low investment rate target leads to a higher consumption-to-GDP ratio (Figure 3, panel

¹⁸We recall that initially, taxes on income are equal for all households; then, during the reform, they can take different values across households that work in different types of firms. Indeed, in this theoretical framework, we consider that these taxes are similar to social security contributions that are directly paid by the firms. Therefore, the social security contribution paid by a public firm is not equal to the contribution paid by the private sector.

¹⁹It is particularly the case in the steel sector in 2016, in which low prices are a means to sell the output but the latter create tensions with the European Union.

(g)). First, firms' deleveraging reduces the household holdings of domestic bonds, which decreases the share of savings directed to bonds with low returns. Then, the reallocation of the labor force to private firms with higher wages, through the taxation of wages in SOEs, further raises the consumption ratio. Welfare benefits are observed under the reforms that lower the investment rate (Tables 5 and 6) but they are substantially smaller than under the reforms that increase the consumption ratio (Tables 7 and 8). One explanation is a smaller decrease in hours spent at work: the labor force is largely reallocated, contrary to the reform that increases consumption (during which aggregate hours spent at work widely decrease).

Concerning external positions, even if the investment rate falls, the large increase in consumption creates a trade balance deficit (Figure 3, panel (i)). Moreover, the large and positive Net Foreign Asset position cannot be corrected despite the domestic reform (panel (h)), as in [Fukumoto and Muto \(2011\)](#). Indeed, firms' profits and the household propensity to save remain large, and then the domestic investment rate decreases, which lowers the supply of domestic bonds. Thus, a higher share of aggregate savings finances foreign investments (this mechanism is also highlighted as a current fact in [Artus, 2016b](#)). Regarding FDI, the positive effect of the credit tax (reducing credit refunding for private firms) overturns the slight negative effect of the taxation of production. Thus, U.S. firms are even more attracted by a relocation to China (Figure 3, panel (k)).²⁰ However, the outward FDI-to-GDP ratio decreases during the transition because of the difference in the balanced growth path between output and investment (panel (l)).²¹

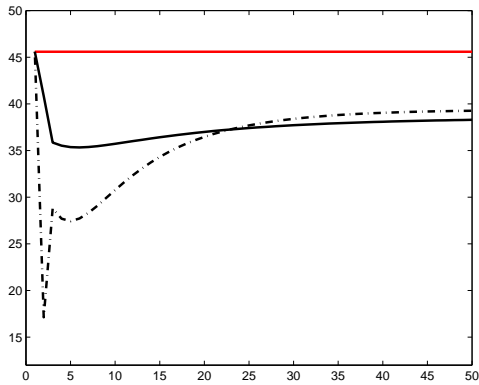
Instruments		Horizon	Welfare benefits (ζ_c)	
$\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S, \tau_{w_d}, \tau_{w_{f^*}}, \tau_{w_S}$	Initial			Reform
τ_{y_d}	0.0278	0.0317	2	0.0104
$\tau_{y_{f^*}}$	0.0278	0.0294	5	0.0179
τ_{y_S}	0.0278	0.0355	10	0.0189
γ_d	0.03	0.0347	20	0.0170
γ_S	0.03	0.0075	across	0.0126
			steady states	
τ_{w_d}	0.3	0.2888		
$\tau_{w_{f^*}}$	0.3	0.3049		
τ_{w_S}	0.3	0.3732		

Table 6: Taxes and welfare benefits - Reform 1: investment - Set of taxes 2

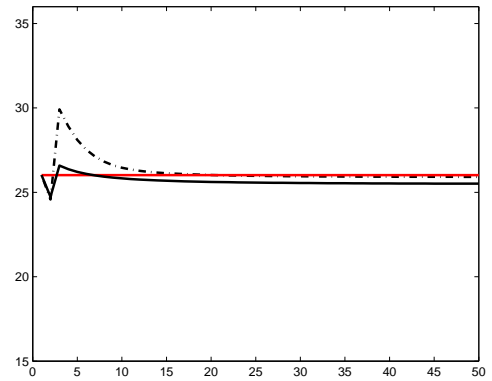
²⁰In the model and in reality, intward FDI can benefit from local funding in China ([Du and Girma, 2007](#)).

²¹Outward FDI benefit from the TFP growth of the U.S., whereas China's TFP growth, which is higher, is accounted for in GDP.

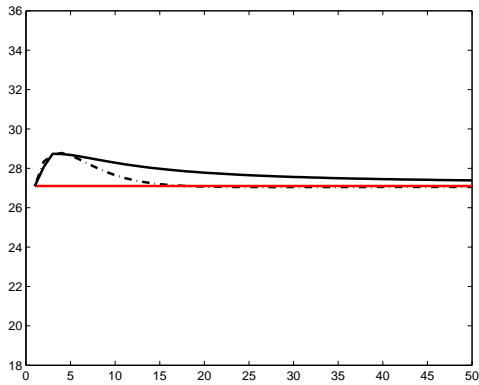
Investment rate - SOEs (a)
(% GDP of SOEs)



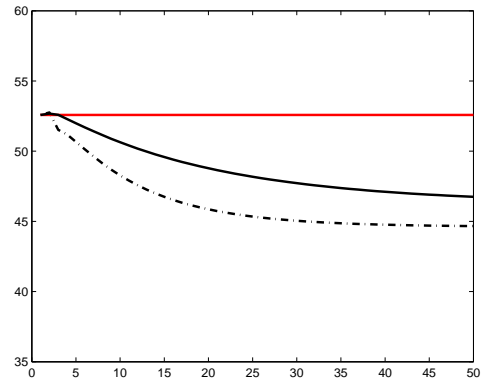
Investment rate - domestic private firms
(b) (% GDP of domestic private firms)



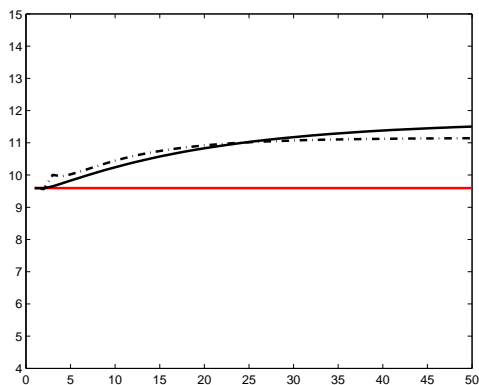
Investment rate - foreign firms (c)
(% GDP of foreign firms)



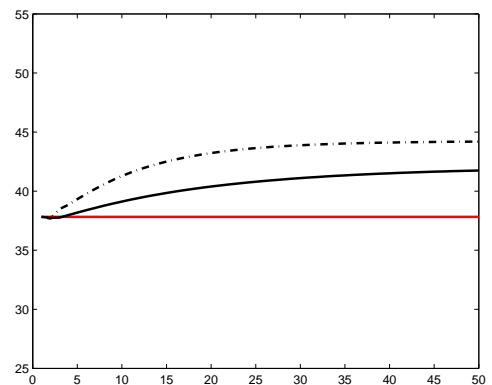
Labor supply - SOEs (d)
(% total)



Labor supply - foreign firms (e)
(% total)



Labor supply - domestic private firms (f)
(% total)



Legend

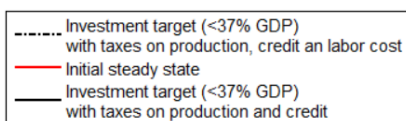


Figure 2: Investment rates and labor supplies - Investment reforms

4.0.2 Increase the consumption ratio

To establish the reform that increases the consumption share in GDP, we seek the transition path of all variables $\left\{ X_{1,t}, X_{2,t}, \dots, X_{n,t} \right\}_{t=0}^T$ that solves:

$$\underset{\tau_{y_d,T}, \tau_{y_d^*,T}, \tau_{y_S,T}, \gamma_d,T, \gamma_S,T}{Min} \quad [\bar{C}_y - \bar{C}_{y,reform}] \quad (36)$$

with $\bar{C}_y > 0.43$ and *subject to* steady state equations, market clearing conditions and aggregation. Each tax follows a first-order autoregressive process during the reform: $\tau_t = \rho_\tau \tau_{t-1} + (1 - \rho_\tau) \bar{\tau}$, where $\bar{\tau}$ is the tax value at the final steady state of the reform. Similar to the reforms that target a low investment rate, we ensure that the solution is unique for each combination of taxes (taxes on firms and credit; taxes on firms, credit and households) by running again the algorithm and excluding the first solution.²²

With the taxation of production and credit: $\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S$ (Table 7)

In the first step, the reform is computed using taxes on firms' production and credit refunding. In the final steady-state, the tax on production is higher in private foreign firms ($\tau_{y_{f^*}}$) than in private domestic firms (τ_{y_d}) and SOEs (τ_{y_S} , the lowest); the tax on credit refunding is higher in private firms (γ_d) than in SOEs (γ_S , Table 7). The implication is that credit refunding in private firms (resp. SOEs) decreases (resp. increases) during the transition ($(1+r)(1-\gamma)$), which offsets the higher credit constraints in private firms compared to SOEs. Thus, returns on households' SOE bonds (resp. private firm bonds) increase (resp. decrease), and the increase in returns on SOE bonds is higher than the decrease in private firm bonds returns ($\Delta_- \gamma_{S,t} > \Delta_+ \gamma_{d,t} \Rightarrow \Delta_+ r_{d,t}(1 - \gamma_S) > \Delta_- r_{d,t}(1 - \gamma_d)$). Therefore, the aggregate returns on households' bonds increase, which enhances their consumption through a wealth effect. Concerning the higher taxation of production in foreign firms, the consequence is that foreign firms become less profitable, which slows the increase in the wages they offer, whereas wages increase slightly faster in domestic private firms. Thus, there is a slight adjustment in the increase in labor costs between domestic and foreign firms, which strengthens the rise in consumption.

Then, the adjustment in credit costs ($\Delta_+(1+r_{d,t})(1-\gamma_S)$ and $\Delta_-(1+r_{d,t})(1-\gamma_d)$) does not correct financial external surpluses: similar to the reforms that target a low investment rate, the NFA position remains positive and can even increase (Figure 3, panel(h)). Indeed, with the rise in loan repayments for SOEs and the increase in the taxation of production for private firms, the aggregate investment rate falls. Thus, domestic savings (which are still high) are even more reallocated to foreign bonds. The returns on foreign bonds are higher than on domestic bonds, increasing household's financial income and consumption in this model.

The higher consumption level mechanically increases welfare benefits (Table 7) with the utility function $\frac{C_{d,t}^{1-\sigma}}{1-\sigma} - \frac{N_{S,t}^{1+\psi} + N_{d,t}^{1+\psi} + N_{f,t}^{*1+\psi}}{1+\psi}$. Indeed, consumption is higher whereas time spent at work decreases because

²²Thus, if the solution is unique, the algorithm does not find any solution after the second set of iterations.

the taxation slows production and investment (Figure 3). The positive impact of the decrease in aggregate labor supply on welfare is high with this calibration because the scale factor in the utility function is equal to one. Concerning other variables, this reform, which leads to a high domestic demand, clearly decreases the trade balance: a trade deficit progressively appears during the reform (Figure 3, panel (i)). As for FDI, firms' expatriation from China to the U.S. rises at the beginning of the transition, but then, similar to the investment reform, the outward FDI-to-GDP ratio decreases during the transition path (panel (l)). The reason is the difference in balanced growth path between output and foreign investment.²¹ The positive change in inward FDI (panel (k)) is due to the reduction in credit distortions in China (expatriate firms can benefit from local funding) and the rise in domestic consumption, which compensate for the higher taxation of firms' production.

Instruments			Horizon	Welfare benefits
$\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S$	Initial	Reform		
τ_{y_d}	0.0278	0.0309	2	0.0145
$\tau_{y_{f^*}}$	0.0278	0.0352	5	0.0289
τ_{y_S}	0.0278	0.0282	10	0.0332
γ_d	0.03	0.0368	20	0.0342
γ_S	0.03	0.0131	across steady states	0.0332

Table 7: Taxes and welfare benefits - Reform 2: consumption - Set of taxes 1

With the taxation of labor cost, production and credit: $\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S, \tau_{w_d}, \tau_{w_{f^*}}, \tau_{w_S}$ (Table 8)

With this set of instruments, taxes in the new steady state are broadly the same as those in the initial steady state, except taxes on wages in foreign firms, which are lower.¹⁸ Given that wages are to a large extent higher in foreign firms in the initial steady state, computation simply reduces taxation on the highest wage index to reach the consumption target. Hence, welfare benefits are more than two times higher than in the previous set of taxes (Table 8). Another consequence is the rise in the labor supply in private foreign firms and a reduction in the labor supply in the two other types of firms (there is a minor reallocation of the labor force where wages and taxation allow for higher consumption and welfare). However, the aggregate time spent at work decreases. The reaction of other variables (trade balance, NFA, FDI, see Figure 3) is approximately similar to the reaction with the first set of taxes.

Instruments			Horizon	Welfare benefits (ζ_c)
$\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S, \tau_{w_d}, \tau_{w_{f^*}}, \tau_{w_S}$	Initial	Reform		
τ_{y_d}	0.0278	0.0285	2	0.0436
$\tau_{y_{f^*}}$	0.0278	0.0281	5	0.0707
τ_{y_S}	0.0278	0.0295	10	0.0759
γ_d	0.03	0.0332	20	0.0763
γ_S	0.03	0.0291	across steady states	0.0755
τ_{w_d}	0.3	0.3177		
$\tau_{w_{f^*}}$	0.3	0.2165		
τ_{w_S}	0.3	0.3228		

Table 8: Taxes and welfare benefits - Reform 2: consumption - Set of taxes 2

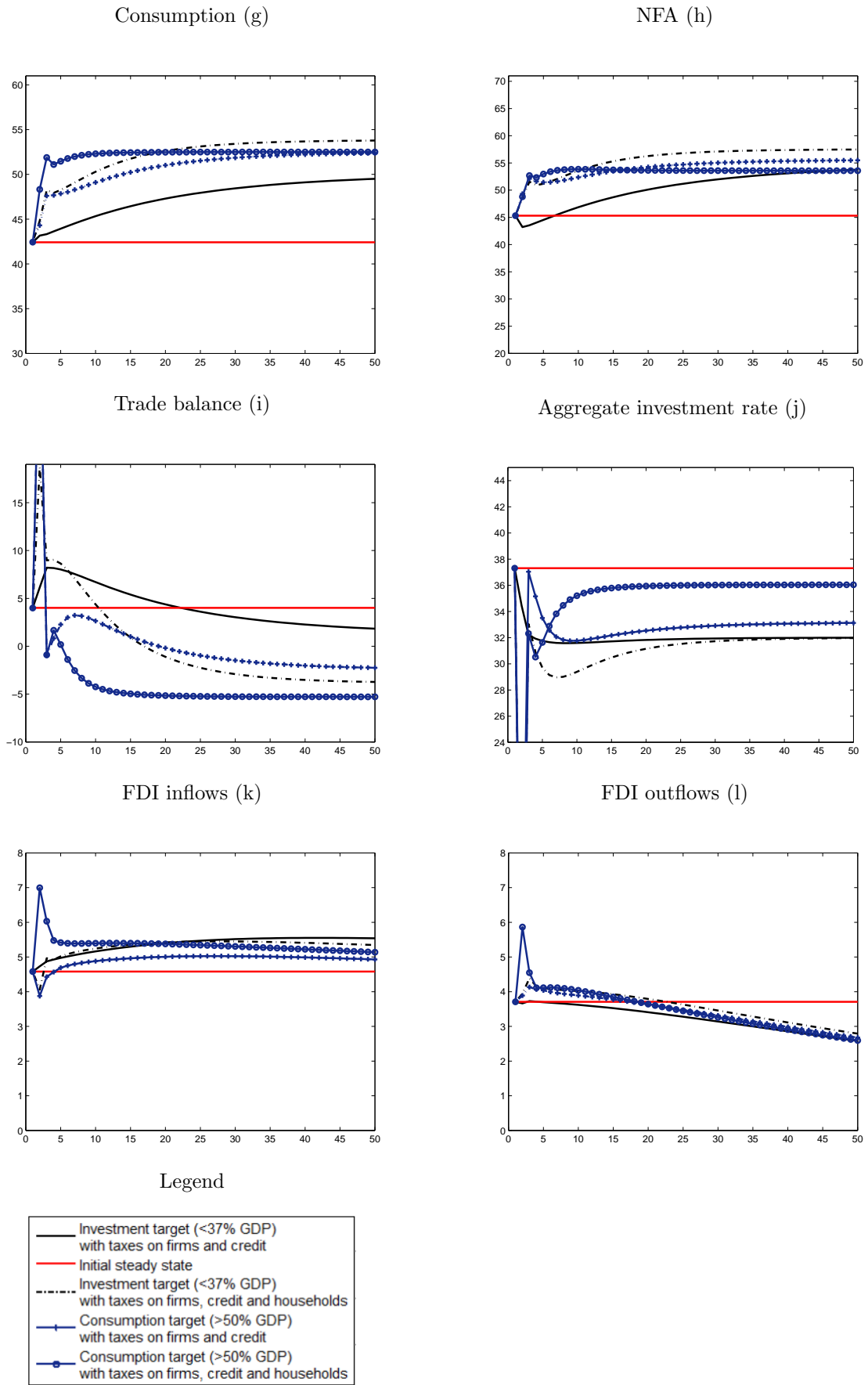


Figure 3: Main variables transition (% GDP) - Investment and consumption reforms

4.0.3 Welfare maximization

For this welfare maximization exercise (at the steady state and not along the transition), taxation is bounded to avoid unrealistic taxation. Indeed, computation would, for example, grants large subsidies to households to reach the highest welfare level. Given that the welfare index is defined by $Welf_t = E_t \sum_{t=T}^{\infty} U_t (C_t, N_{d,t}, N_{f,t}^*, N_{S,t}) + \beta.W_{t+1}$, the algorithm solves the following program for the welfare steady state:

$$\begin{aligned} \underset{\bar{w}_d, \bar{w}_{f^*}, \bar{w}_S, \bar{\tau}_{y_d}, \bar{\tau}_{y_{f^*}}, \bar{\tau}_{y_S}, \bar{\gamma}_d, \bar{\gamma}_S}{Max} \quad \overline{Welf} &= Max \left[\frac{\bar{U}(\bar{C}, \bar{N}_d, \bar{N}_f^*, \bar{N}_S)}{1 - \beta} \right] \\ &= Max \left[\frac{\bar{C}^{1-\sigma}}{(1-\sigma)(1-\beta)} - \frac{\bar{N}_S^{1+\psi} + \bar{N}_d^{1+\psi} + \bar{N}_f^{*1+\psi}}{(1+\psi)(1-\beta)} \right] \end{aligned} \quad (37)$$

subject to steady state equations, market clearing conditions and aggregation.

With taxes on firms' product and credit				With taxes on firms' product, credit and labor cost			
Change in welfare: 6.75 % ($\frac{\Delta W}{W}$)				Change in welfare: 14.44 % ($\frac{\Delta W}{W}$)			
Instruments $\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S$				Instruments $\tau_{y_d}, \tau_{y_{f^*}}, \tau_{y_S}, \gamma_d, \gamma_S, \tau_{w_d}, \tau_{w_{f^*}}, \tau_{w_S}$			
	Initial	Reform	Contribution in the change in welfare (cumulative, in %)	Initial	Reform	Contribution in the change in welfare (cumulative, in %)	
τ_{y_d}	0.0278	-0.0825	-8.069	τ_{y_d}	0.0278	0.0290	0.034
$\tau_{y_{f^*}}$	0.0278	0.1603	85.723	$\tau_{y_{f^*}}$	0.0278	0.0576	19.039
τ_{y_S}	0.0278	0.0101	84.107	τ_{y_S}	0.0278	0.0403	19.609
γ_d	0.03	0.1283	98.909	γ_d	0.03	0.0385	20.845
γ_S	0.03	-0.0061	100	γ_S	0.03	0.0372	19.816
				τ_{w_d}	0.3	0.3557	20.538
				$\tau_{w_{f^*}}$	0.3	0	100
				τ_{w_S}	0.3	0.2880	100

Table 9: Welfare maximization

Similar to the tax reforms that target a higher consumption ratio, welfare maximization leads to a lower taxation of labor cost in foreign firms (Table 9) because wages are to a large extent higher in these firms at the initial steady state (Table 4). With this welfare index, welfare maximization is logically close to a consumption maximization, all things being equal in the labor market ($\frac{C_{d,t}^{1-\sigma}}{1-\sigma} - \frac{N_{S,t}^{1+\psi} + N_{d,t}^{1+\psi} + N_{f,t}^{*1+\psi}}{1+\psi}$): a low taxation of the highest wages is a means of directly raising consumption and thus increasing welfare. Thus, the tax change on labor cost in foreign firms has the highest impact on the welfare variation (Table

9). Note that the values without bounds would be large subsidies to households who work in foreign firms, which is why taxation is bounded to avoid unrealistic taxation.

During this welfare maximization exercise, there is a reallocation of the labor force to the firms in which wages are the highest. The low taxation of wages in these firms are also a means to offset the rise in the disutility of work compared to other firms; indeed, the disutility of work has a low convexity with this calibration and thus quickly increases with larger hours worked. The aggregate labor supply is lower at the second steady state than at the initial steady state because with this calibration the scale factor in the utility function is equal to one, thus raising the weight of the negative impact of time spent at work in households' welfare index.

Concerning other taxes, the credit allocation between private and state-owned firms is rebalanced in the first reform with a strong decrease (resp., increase) in credit cost for private firms (resp., SOEs). It explains roughly 15 percentage points of the welfare change. The main part of the variation is explained by the high taxation of production in the most profitable firms that are then redistributed to households. The latter mechanism also explains a significant part (roughly 20 percentage points) of the welfare change in the reform with all taxes.

5 Conclusion

This paper identifies policy reforms in China that may enhance consumption, reduce some firms' over-investment and increase the level of welfare, by taxing firms differently according to their production, access to credit and labor costs. Several results emerge from the dynamic general equilibrium model analysis.

First, for some reforms, it is necessary to correct the distortions in factor costs (capital and labor) that lead to domestic imbalances, that is, to increase SOEs' loan repayments and to reduce the wage differential between domestic (public and private) and foreign firms. Firms' credit cost is a key channel because it impacts both firms' investment and household consumption (through returns on savings).

Second, a reallocation of the labor force from SOEs to private firms can significantly lower the investment rate (which was mainly due to SOEs) and thus overcapacities. This reallocation of the labor force is currently in progress in China (to reduce overcapacities), but it is a critical issue because it creates significant shifts in migrations and in unemployment rates in some sectors (IMF, 2015). Thus, the restructuring of SOEs becomes a major challenge (IMF, 2015; Artus, 2016a; Leutert, 2016) that will allow reducing the magnitude of this labor force reallocation.

Third, reforms that enhance consumption or reduce the investment rate both raise welfare benefits for households.

Finally, the particularity of the reforms in this framework is that domestic rebalancing does not neces-

sarily require an external rebalancing of the financial position, as in Fukumoto and Muto (2011) (the aggregate savings rate remains high and the supply of domestic assets is reduced). Furthermore, the reforms that maintain and even increase the positive net foreign assets position can enhance consumption through wealth effect in this model.

The *Appendix* proposes another theoretical framework with price of goods, nominal rigidities, and heterogeneous taxes on consumption between foreign and home goods. The main reform that increases consumption is the tax rebate on the domestic consumption of foreign goods. Moreover, we can notice that the government even more uses taxes on consumption as instruments to enhance consumption when nominal rigidities are high. Lastly in this other framework, a rise in firms' credit cost is still a key channel that both reduces the investment rate and increases the consumption ratio (through returns on savings).

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6 Appendix: An extension with price of goods, nominal rigidities and VATs

6.1 The model

The previous model is extended by adding prices of goods, the consumption of foreign and home goods, the exchange rate and price rigidities. There are still two countries, however, we consider that there is *only one type of firm* in each country. Indeed, this analysis focuses on the reforms that increase consumption, on taxes on consumption (VATs) of home and foreign goods, but not on the characteristics of each firm and their investment rate.

Households. Household budget constraint becomes as follows:

$$p_{c,t}C_t(1 + \tau_C) + B_{d,t} + \frac{FA_{d,t+1}}{(1 + r_{f,t+1})} = \pi_{d,t} + FA_{d,t} + (1 + r_{d,t})(1 - \gamma_d)B_{d,t-1} + W_{d,t}N_{d,t} \quad (38)$$

where $p_{c,t}$ denotes the consumption price index (CPI). Household incomes, $W_{d,t}N_{d,t}$, are partly consumed and C_t denotes the global consumption index (consumption of domestic and foreign goods). Households save utilizing bonds; they can choose between bonds issued by firms of the domestic country, $B_{d,t}$,²³ and $FA_{d,t}$, which is a portfolio of state contingent assets in this framework (in consumption units, first assuming that financial markets are complete). Considering that firms belong to households, their profits $\pi_{d,t}$ are redistributed to households.

Taxation. The tax on returns on bonds (γ_d) is maintained, and a tax on consumption τ_C (VAT) is added. The goal of the latter is twofold. First, this tax allows for a heterogeneous taxation between the domestic consumption of home and foreign goods ($\tau_{C_d}p_tC_{d,t}$ and $\tau_{C_f}\varepsilon_t p_t^*C_{f,t}$, respectively) and the exports of domestic goods ($\tau_{C_d^*}p_tC_{d,t}^*$). Second, it enables to adjust consumption by another method than taxes on household incomes, firms' production or taxes on credit.

With first order conditions we obtain the labor supply function $N_{d,t} = \left[\frac{W_{d,t}C_t^{-\sigma}}{(1 + \tau_C)p_{c,t}} \right]^{\frac{1}{\psi}}$, which becomes (with real wages $w_{d,t} = \frac{W_{d,t}}{p_t}$):

$$N_{d,t} = \left[\frac{w_{d,t}p_t C_t^{-\sigma}}{(1 + \tau_C)p_{c,t}} \right]^{\frac{1}{\psi}}. \quad (39)$$

The Euler equation is $\frac{C_t^{-\sigma}\Pi_{c,t+1}}{1 + \tau_C} = \beta E_t [C_{t+1}^{-\sigma}(1 + r_{d,t+1})(1 - \gamma_d)]$ with $\Pi_{c,t} = \frac{p_{c,t}}{p_{c,t-1}}$ the inflation dynamic for consumer prices (see Equation 61).

As in [Benigno and Benigno \(2003\)](#), a continuum of goods are produced in the two countries (indexed on

²³As explained below, the bonds market clearing condition force $B_{d,t} = D_{d,t}$ (the purchase of bonds by households is equal to the amount firms borrow at time t) and thus $B_{d,t} = \zeta_d p_t k_{d,t}$ because firms face credit constraints.

the interval $[0, n]$ in the domestic country and on $]n, 1]$ in the foreign country):²⁴

$$C_t = \left(h^{\frac{1}{\varphi}} C_{d,t}^{\frac{\varphi-1}{\varphi}} + (1-h)^{\frac{1}{\varphi}} C_{f,t}^{\frac{\varphi-1}{\varphi}} \right)^{\frac{\varphi}{\varphi-1}} \quad (40)$$

$$C_t^* = \left(h^{*\frac{1}{\varphi}} C_{d,t}^{*\frac{\varphi-1}{\varphi}} + (1-h^*)^{\frac{1}{\varphi}} C_{f,t}^{*\frac{\varphi-1}{\varphi}} \right)^{\frac{\varphi}{\varphi-1}} \quad (41)$$

where $C_{d,t}$ and $C_{f,t}$ (respectively, $C_{d,t}^*$ and $C_{f,t}^*$) are consumption of domestic and foreign goods by domestic (respectively, foreign) households. In these expressions $\varphi > 1$ is the elasticity of substitution between domestic and foreign goods, and $\theta > 1$ the elasticity of substitution across goods produced within a country. $C_{d,t}$, $C_{f,t}$, $C_{d,t}^*$, and $C_{f,t}^*$ are standard [Dixit and Stiglitz \(1977\)](#) consumption subindexes:

$$C_{d,t} = \left[\left(\frac{1}{n} \right)^{\frac{1}{\theta}} \int_0^n C_{d,t}(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \quad C_{f,t} = \left[\left(\frac{1}{1-n} \right)^{\frac{1}{\theta}} \int_n^1 C_{f,t}(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}} \quad (42)$$

$$C_{d,t}^* = \left[\left(\frac{1}{n} \right)^{\frac{1}{\theta}} \int_0^n C_{d,t}^*(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \quad C_{f,t}^* = \left[\left(\frac{1}{1-n} \right)^{\frac{1}{\theta}} \int_n^1 C_{f,t}^*(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}} \quad (43)$$

All goods are traded and the law of one price holds, with ε_t the nominal exchange rate defined as the price of the foreign currency in terms of domestic currency. Thus, consumption prices are (with h and h^* the home biases in the domestic and foreign countries, respectively):

$$p_{c,t} = \left(h p_t^{1-\varphi} + (1-h)(\varepsilon_t p_t^*)^{1-\varphi} \right)^{\frac{1}{1-\varphi}} \quad (44)$$

$$p_{c,t}^* = \left(h^* (\varepsilon_t^{-1} p_t)^{1-\varphi} + (1-h^*) p_t^{*1-\varphi} \right)^{\frac{1}{1-\varphi}} \quad (45)$$

and production prices:

$$p_t = \left[\left(\frac{1}{n} \right) \int_0^n p_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}, \quad p_t^* = \left[\left(\frac{1}{1-n} \right) \int_n^1 p_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}. \quad (46)$$

The terms of trade s_t are defined as a function of the nominal exchange rate:

$$s_t = \varepsilon_t \frac{p_t^*}{p_t} \quad (47)$$

with the real exchange rate $\varepsilon_{r,t} = \varepsilon_t \frac{p_{c,t}^*}{p_{c,t}}$ and $\varepsilon_{r,t} \frac{s_t}{s_{t-1}} \frac{\Pi_t}{\Pi_t^*} = 1$.

First assuming that financial markets (of state contingent assets in consumption units) are complete,

²⁴The population size of economic agents in each country is a continuum with set equal to the range of produced goods: domestic households lie on the interval $[0, n]$ and foreign ones on $]n, 1]$.

the risk sharing condition is obtained combining both domestic and foreign Euler conditions:

$$\frac{U_{c,t}^*}{U_{c,t}} = \frac{\lambda_{f,t}}{\lambda_{d,t}} = \Psi \varepsilon_t \frac{p_{c,t}^*}{p_{c,t}} = \Psi \left(\frac{h^* + (1-h^*)s_t^{1-\varphi}}{h + (1-h)s_{t-1}^{1-\varphi}} \right)^{\frac{1}{1-\varphi}} \quad (48)$$

with Ψ the initial condition on net foreign assets.

The demands of goods d and f are given by:

$$C_{d,t}(i) = \frac{h}{n} \cdot \left(\frac{p_t(i)}{p_t} \right)^{-\theta} \left(\frac{p_t}{p_{c,t}} \right)^{-\varphi} C_t(i), \quad C_{d,t}^*(i) = \frac{1-h^*}{1-n} \cdot \left(\frac{p_t(i)}{p_t} \right)^{-\theta} \left(\frac{p_t}{\varepsilon_t p_{c,t}^*} \right)^{-\varphi} C_t(i)^* \quad (49)$$

$$C_{f,t}(i) = \frac{1-h}{n} \cdot \left(\frac{p_t^*(i)}{p_t^*} \right)^{-\theta} \left(\frac{\varepsilon_t p_t^*}{p_{c,t}} \right)^{-\varphi} C_t(i), \quad C_{f,t}^*(i) = \frac{h^*}{1-n} \cdot \left(\frac{p_t^*(i)}{p_t^*} \right)^{-\theta} \left(\frac{p_t^*}{p_{c,t}^*} \right)^{-\varphi} C_t(i)^* \quad (50)$$

When combined with 44, 45, and 47, they become:

$$C_{d,t} = h[h + (1-h)s_t^{1-\varphi}]^{\frac{\varphi}{1-\varphi}} C_t, \quad C_{d,t}^* = (1-h^*)s_t^\varphi [(1-h^*) + h^*s_t^{\varphi-1}]^{\frac{\varphi}{1-\varphi}} C_t^* \quad (51)$$

$$C_{f,t} = (1-h)s_t^{-\varphi} [h + (1-h)s_t^{1-\varphi}]^{\frac{\varphi}{1-\varphi}} C_t, \quad C_{f,t}^* = h^* [(1-h^*) + h^*s_t^{\varphi-1}]^{\frac{\varphi}{1-\varphi}} C_t^* \quad (52)$$

Firms. The structure of firms is simplified with one type of firm in each country, the taxes on production (τ_{y_d}) and on loan repayments (γ_d) that were applied in the previous model are maintained, and production prices are considered. p_t denotes the production price index (PPI) in the domestic country, which is set with Calvo (1983) pricing contracts (see Subsection 6.4). Firms' profits become as follows:

$$\pi_{d,t} = p_t y_{d,t} (1 - \tau_{y_d}) + D_{d,t} - (1 + r_{d,t}) (1 - \gamma_d) D_{d,t-1} - (W_{d,t} N_{d,t} (1 + \tau_{w_d}) + p_t i_{d,t}) \quad (53)$$

with credit constraints $D_{d,t} = \zeta_d p_t k_{d,t}$. The law of motion of capital comprises adjustment costs ($k_{d,t} = (1 - \delta_d) k_{d,t-1} + i_{d,t} + i_{d,t-1} \Phi_I \left[\frac{i_{d,t}}{i_{d,t-1}} - 1 \right]^2$) and aggregate production utilizes a standard Cobb-Douglas technology: $y_{d,t} \Upsilon_t = (A_{d,0} + A_{d,t}) \cdot k_{d,t-1}^{\alpha_d} N_{d,t}^{1-\alpha_d}$ with $A_{d,t} = \rho_A A_{d,t-1} + \xi$ an i.i.d. productivity shock with constant variance. Contrary to the previous model, TFP growth is not modeled because the balanced growth path cannot be computed with the definition of marginal costs in Equation 56. Υ_t is the price dispersion (Equation 62), which is defined below with the Calvo pricing.

The first order condition with respect to labor demand gives the efficiency conditions for input prices:

$$\alpha_d w_{d,t} N_{d,t} (1 + \tau_{w_d}) = (1 - \alpha_d) m p K_{d,t} k_{d,t-1} \quad (54)$$

with $mpK_{d,t} = \alpha_d \frac{y_{d,t+1}(1-\tau_{y_d})}{k_{d,t}}$ (considering the real output defined as $y_{d,t} = \frac{Y_{d,t}}{p_t}$). Then, we obtain real marginal costs:

$$mc_{d,t} = \frac{mpK_{d,t}^{\alpha_d} (w_{d,t}(1+\tau_{w_d}))^{1-\alpha_d}}{\alpha_d^{\alpha_d} (1-\alpha_d)^{1-\alpha_d} (A_{d,0} + A_{d,t})} \quad (55)$$

Firms set their production prices with Calvo (1983) pricing contracts. Only a fraction $1-\eta$ of randomly selected firms is allowed to set new prices in each period:

$$p_t = [(1-\eta)\bar{p}_t^{1-\theta} + \eta p_{t-1}^{1-\theta}]^{\frac{1}{1-\theta}} \quad (56)$$

Firms select their optimal reset price to maximize the expected present discounted values of real profits all along their price contract (see Subsection 6.4, Fernández-Villaverde and Rubio-Ramírez, 2009, Auray et al., 2011, and Whelan, 2015), and then obtain the first-order condition:

$$\bar{p}_{d,t} = \frac{\theta}{(1-\theta)(1-\tau_{y_d})} \frac{\sum_{\tau=0}^{\infty} (\eta)^\tau E_t \{ \lambda_{t+\tau} y_{d,t+\tau} mc_{d,t+\tau} \}}{\sum_{\tau=0}^{\infty} (\beta_d \eta)^\tau E_t \{ y_{d,t+\tau} \}} \quad (57)$$

After recursive transformations (detailed in Subsection 6.4), we obtain:

$$\tau_{1,t} - \beta \eta E_t \{ \tau_{1,t+1} \Pi_{t+1}^{1+\theta} \Pi_{c,t+1}^{-1} \} = C_t^{-\sigma} y_{d,t} mc_{d,t} \quad (58)$$

$$\tau_{2,t} - \beta \eta E_t \{ \tau_{2,t+1} \Pi_{t+1}^\theta \Pi_{c,t+1}^{-1} \} = C_t^{-\sigma} y_{d,t} \quad (59)$$

where $\Pi_t = \frac{p_t}{p_{t-1}}$ is the inflation dynamic for production prices (which is obtained combining Equations 56 and 57 in Subsection 6.4):

$$\eta \Pi_t^{\theta-1} + (1-\eta) \left(\frac{\theta}{(\theta-1)(1-\tau_{y_d})} \frac{\tau_{1,t}}{\tau_{2,t}} \right)^{1-\theta} = 1 \quad (60)$$

and $\Pi_{c,t} = \frac{p_{c,t}}{p_{c,t-1}}$ is the inflation dynamic for consumer prices (which is obtained combining Equations 44 and 47):

$$\Pi_{c,t} = \Pi_t \left(\frac{h + (1-h)s_t^{1-\varphi}}{h + (1-h)s_{t-1}^{1-\varphi}} \right). \quad (61)$$

The price dispersion (which appears in the production function) is obtained with Equations 44, 47 and 60:

$$\Upsilon_t = \eta \Upsilon_{t-1} \Pi_t^\theta + (1-\eta) \left(\frac{\theta}{(\theta-1)(1-\tau_{y_d})} \frac{\tau_{1,t}}{\tau_{2,t}} \right)^{-\theta}. \quad (62)$$

Equilibrium. The bonds market clearing condition forces $B_{d,t} = D_{d,t}$ (the purchase of bonds by

households is equal to the amount firms borrow at time t) and thus $B_{d,t} = \zeta_d p_t k_{d,t}$ because firms face credit constraints. Then, both domestic and foreign governments collect their revenue from firms' production, wages, loan repayments and consumption through the set of taxes. For simplicity and because there are already many different types of bonds, it is assumed that the governments do not use domestic or foreign bonds to finance potential deficits. The government use fiscal receipts to finance public expenditure on the goods and services markets:

$$\begin{aligned} y_{d,t} &= C_{d,t} + C_{f,t} + G_{d,t} + i_{d,t} \\ &= [h + (1-h)s_t^{-\varphi}][h + (1-h)s_t^{1-\varphi}]^{\frac{\varphi}{1-\varphi}} C_t + G_{d,t} + i_{d,t} \end{aligned} \quad (63)$$

$$\begin{aligned} y_{f,t} &= C_{d,t}^* + C_{f,t}^* + G_{f,t} + i_{f,t} \\ &= [h^* + (1-h^*)s_t^{\varphi}][(1-h^*) + h^*s_t^{\varphi-1}]^{\frac{\varphi}{1-\varphi}} C_t^* + G_{f,t} + i_{f,t} \end{aligned} \quad (64)$$

6.2 Calibration

Similar to the previous calibration in Subsection 3.4, we target, at the initial steady state, a high investment rate (approximately 37% in this model) and a low consumption rate (approximately 39%), which are close to the 2014-2015 data.

The calibration of the new parameters of this second model follows the literature on China and on two-country models with nominal rigidities, and the calibration of the previous model.

Concerning *taxation*, the initial value of VAT on the domestic consumptions of home and foreign goods (τ_{C_d} and τ_{C_f} , respectively) is initially set at 0.17 (see Figure 4, Source: State Administration of Taxation of the People's Republic of China), and VAT on exports of domestic goods ($\tau_{C_d}^*$) is initially nil (because of tax rebates, Source: State Administration of Taxation of the People's Republic of China). The initial calibration of the other taxes is similar to the previous model, that is, $\tau_{y,0} = 0.0278$ for the tax on firms' production (Source: CSY, 2013, and author's calculations), $\tau_{w,0} = 0.3$ for the tax on household incomes (Source: State Administration of Taxation of the People's Republic of China) and $\gamma_0 = 0.03$ for the tax on firms' loan repayments/returns on households' bonds (to match a 3% real deposit rate).

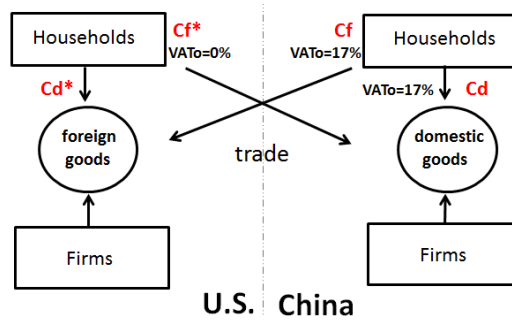


Figure 4: Taxes on the consumptions of domestic and foreign goods

Regarding *nominal rigidities*, we set the price rigidity parameter η at 0.55 in China for the benchmark calibration; this value goes up to 0.65 during certain reforms (which is close to B nassy-Qu r  et al., 2013, where $\eta = 0.67$ in China).

As for *preferences*, the elasticity of substitution across domestic goods is set at 7 (close to the calibration of Funke et al., 2015, and as in Rotemberg and Woodford, 1997, and B nassy-Qu r  et al., 2013), the elasticity of substitution between domestic and foreign goods is fixed at 1.5 (as in Backus et al., 1994, and Auray et al., 2011), and the share of imports in China’s consumption is equal to 0.2 (B nassy-Qu r  et al., 2013). The households’ intertemporal elasticity of substitution is equal to that of Funke et al. (2015), that is, 1.

Concerning *firms*, the capital share α_d and the depreciation rate of capital δ_d are fixed at 0.6 (to reach the highest investment rate possible in the model) and 0.14 (close to Funke et al., 2015), respectively. The initial level of technology remains equal to 53% of the U.S. level (Source: St Louis Fed Stats 2011 and author’s calculations), and credit constraints are more relaxed than those in Coeurdacier et al. (2015). Indeed, in this second model, there is only one type of firm, which thus comprises both SOEs (which are well financed by state-owned banks) and private firms (which can benefit from alternative finance).

6.3 Tax reforms

In this analysis, we focus on the reforms that target a higher consumption ratio (55% of GDP), and on the heterogeneous taxation of home and foreign goods’ consumption. The instruments of the reforms are VATs on the domestic consumption of home (τ_{C_d}) and foreign goods (τ_{C_f}), VAT on the exports of the domestic good ($\tau_{C_d^*}$), and also taxes on firms’ production (τ_y), household incomes (τ_w) and loan repayments (γ). During the reform each tax follows a first-order autoregressive process: $\tau_t = \rho_\tau \tau_{t-1} + (1 - \rho_\tau)\bar{\tau}$, where $\bar{\tau}$ is the tax value at the final steady state of the reform.

		Instruments $\tau_y, \tau_w, \gamma, \tau_{C_d}, \tau_{C_f}, \tau_{C_d^*}$		
Price rigidities		$\eta = 0.55$	$\eta = 0.6$	$\eta = 0.65$
	Initial	Reform C_y	Reform C_y	Reform C_y
τ_y	0.0278	0.0353	0.0413	0.0446
τ_w	0.3	0.3404	0.3485	0.4613
γ	0.03	0.0227	0.0161	0.0287
τ_{C_d}	0.17	0.1668	0.1290	0.1376
τ_{C_f}	0.17	0.1812	0.1675	0.1089
$\tau_{C_d^*}$	0	0.0001	0.0000	-0.0024

Table 10: Taxes and price rigidities - Consumption reform (55% of GDP)

The results in Table 10 give some insights about the methods the government can use to raise consumption while maintaining sufficient fiscal receipts. In this theoretical framework, the government operates through two channels to reach a higher consumption ratio.

First, the same channel than in the previous model is used: returns on bonds. Indeed, γ is lower, which raises returns on household bonds ($\Delta_- \gamma_{d,t} \Rightarrow \Delta_+ r_{d,t}(1 - \gamma_d)$). Thus, household income and consumption increase through wealth effect (the utility function, $\log(c_t) - \frac{N_{d,t}^{1+\psi}}{1+\psi}$, allows for a strong wealth effect). The second channel through which the government raises consumption in this framework is consumption taxes. Indeed, during tax reforms the consumption of home and foreign imported goods is often less taxed than in the initial steady state ($\tau_{C_{d/f}} < 0.17$, Table 10). This decrease in consumption taxes is stronger when nominal rigidities are high: when inflation cannot be adjusted downward, the government may lower taxes on domestic consumption of foreign and home goods. We can also observe that VAT on foreign imported goods declines more than VAT on home goods when nominal rigidities are high. Indeed, a strong reduction in τ_{C_f} directly offsets the losses due to higher foreign prices and thus enhances consumption.

The two channels through which the government raises consumption, VATs (τ_{C_d} and τ_{C_f}) and the tax on bonds' returns (γ), interact with each other: when VATs strongly decrease, γ returns to its initial value (Table 10, reform with $\eta = 0.65$). As a matter of fact, low VATs are more effective under high price rigidities and the corresponding rise in γ is a means to maintain sufficient fiscal receipts. Another point is that surprisingly, the government does not use the tax on firms' production to impact consumption. Indeed, in this theoretical framework, firms belong to households. Therefore, looser taxes on firms' production would directly increase household income. An explanation is that the government uses taxes on firms' production and labor cost to compensate the drop in VATs and/or in the tax on loan repayments (τ_y and τ_w significantly increase when $\tau_{C_{d/f}}$ or γ decrease).

Finally, these reforms confirm the fact that VAT rebates on exports ($\tau_{C_f}^* = 0$) is a key tool to maintain low prices on exported home goods. Moreover, these VAT rebates on exports have a negative effect on the production price of home goods, which slows the inflation dynamic of domestic consumer prices between the two steady states.

Even if this analysis allows for richer effects with prices of goods, the exchange rate, and a large set of taxes on consumption, the work may be improved to be compared to the previous model. First, by relaxing the assumption that financial markets are complete. Thus, the model would capture the behaviour of the external financial position; it is not the case in this version that only comprises state contingent assets (in consumption units). Then, so as to implement tax reforms that lower the investment rate, a heterogeneous population of firms could be considered (as in the previous model). It would, however, significantly complexify the trade patterns.

6.4 Further details on production pricing contracts

Only a fraction $1 - \eta$ of randomly selected firms is allowed to set new prices at each period (Calvo, 1983):

$$p_t = [(1 - \eta)\bar{p}_t^{1-\theta} + \eta p_{t-1}^{1-\theta}]^{\frac{1}{1-\theta}}$$

Firms select their optimal reset price to maximize the expected present discounted values of real profits all along this price contract (Fernández-Villaverde and Rubio-Ramírez, 2009):

$$Max_{\bar{p}_t} E_t \sum_{\tau=0}^{\infty} (\beta\eta)^\tau \frac{\lambda_{t+\tau}}{\lambda_t} \left\{ \left(\prod_{s=1}^{\tau} \Pi_{t+s-1} \frac{\bar{p}_t}{p_{t+\tau}} (1 - \tau_{y_d}) - \frac{mc_{d,t+\tau}}{p_{t+\tau}} \right) \left(\frac{\bar{p}_t}{p_{t+\tau}} \right)^{-\theta} y_{d,t+\tau} \right\},$$

that is,

$$Max_{\bar{p}_t} E_t \sum_{\tau=0}^{\infty} (\beta\eta)^\tau \frac{\lambda_{t+\tau}}{\lambda_t} \left\{ \left(\prod_{s=1}^{\tau} \Pi_{t+s-1} p_{t+\tau}^{\theta-1} \bar{p}_t^{1-\theta} (1 - \tau_{y_d}) - mc_{d,t+\tau} p_{t+\tau}^{\theta-1} \bar{p}_t^{-\theta} \right) y_{d,t+\tau} \right\}$$

With a zero inflation rate the solution \bar{p} implies the first order condition:

$$E_t \left\{ \sum_{\tau=0}^{\infty} (\beta\eta)^\tau \lambda_{t+\tau} \left((1 - \theta) p_{t+\tau}^{\theta-1} \bar{p}_t^{-\theta} (1 - \tau_{y_d}) + \theta mc_{d,t+\tau} p_{t+\tau}^{\theta-1} \bar{p}_t^{-\theta-1} \right) y_{d,t+\tau} \right\} = 0$$

which can be re-written:

$$\bar{p}_t = \frac{\theta}{(1 - \theta)(1 - \tau_{y_d})} \frac{\sum_{\tau=0}^{\infty} (\eta)^\tau E_t \{ \lambda_{t+\tau} y_{d,t+\tau} mc_{d,t+\tau} \}}{\sum_{\tau=0}^{\infty} (\beta_d \eta)^\tau E_t \{ y_{d,t+\tau} \}}.$$

Using recursive transformations we obtain:

$$\frac{\bar{p}_t}{p_t} = \frac{\theta}{(1 - \theta)(1 - \tau_{y_d})} \frac{\tau_{1,t}}{\tau_{2,t}}$$

where

$$\begin{aligned} \tau_{1,t} - \beta\eta E_t \{ \tau_{1,t+1} \Pi_{t+1}^{1+\theta} \Pi_{c,t+1}^{-1} \} &= \frac{y_{d,t} mc_{d,t}}{C_t} \\ \tau_{2,t} - \beta\eta E_t \{ \tau_{2,t+1} \Pi_{t+1}^\theta \Pi_{c,t+1}^{-1} \} &= \frac{y_{d,t}}{C_t} \end{aligned}$$

and

$$\tau_{1,t} = \sum_{\tau=0}^{\infty} (\beta\eta)^\tau E_t \{ \lambda_{t+\tau} y_{d,t+\tau} m c_{d,t+\tau} \} \cdot \frac{p_{c,t}}{p_t^{1+\theta}}$$
$$\tau_{2,t} = \sum_{\tau=0}^{\infty} (\beta\eta)^\tau E_t \{ \lambda_{t+\tau} y_{d,t+\tau} \} \cdot \frac{p_{c,t}}{p_t^\theta}$$