The Effect of an Introduction of Retail Sales Tax in China*

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Abstract
This paper develops a dynamic equilibrium model of overlapping generations to study the effect of an introduction of a retail sales tax (RST) in China. Total government tax revenue is fixed, consumption-type value-added tax (VAT) is reduced in response to the introduction of RST, and an output tax exists. An introduction of RST accompanied by a decrease in VAT increases capital accumulation and welfare in the steady state. In the transition period, an introduction of RST accompanied by a decrease in VAT increases capital accumulation but decreases the current generation's welfare. Simulations based on the data from China show that introducing an 8 percent RST increases capital accumulation by 0.43 percent in the steady state.

1. Introduction

Many countries in the world have a value-added tax (VAT), whereas most states in the United States have a retail sales tax (RST). This paper simulates a tax experiment of

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introducing a RST, accompanied by a decrease in VAT, on capital accumulation and welfare based on the data from China.

VAT is collected at each stage of the production process, whereas RST is collected only at the time of the final sale to the consumer. It is generally believed that VAT and RST are equivalent (Zodrow 1999; Rosen and Gayer 2010).

Each of the two taxes has its own advantages and disadvantages. Countries with a RST, such as the United States, have debated whether a VAT should be established, and countries with a VAT, such as China, are interested in installing a general RST. Thus, further examination of the difference between these two taxes is necessary.

VAT is the most important tax in China. China does not have a general RST. The VAT is collected from producers at each stage of production. The VAT enables the Chinese government at each level to collect an enormous amount of revenue. For example, the ratio of VAT to total government tax revenue reached 38.1 percent for the first 11 months of 2017.[1] Fifty percent of the revenue from VAT goes to the central government and the other 50 percent goes to the local governments.

The debate over whether China should have a RST has already started. Several scholars have argued that China should have a RST (as a major local tax) to provide local governments with a major tax revenue source (see, for example, Lou [2013] and Guo and Lv [2013]).[2] Yang (2016), however, argued that VAT and RST are equivalent, and it is not necessary to establish a RST in China; instead, China should focus on the change of the rate of VAT. It is certainly possible to increase local government revenues by allocating more VAT revenue to local governments. However, the traditional view that VAT and RST are equivalent may not hold in a more complicated model. Thus, it is necessary to evaluate how an introduction of a RST, accompanied by a decrease in VAT (so that total revenue is unchanged), would affect the Chinese economy.

This paper develops a multi-period overlapping generations model with a VAT, a RST, an output tax, and a lump-sum tax, following the seminal work of Auerbach and Kotlikoff (1987). Taxes on output include production and turnover taxes (see Myles 1995). Resource

1 China Ministry of Finance, http://gks.mof.gov.cn/zhengfuxinxi/tongjishuju/201712/t20171211_2771156.html.

2 Business tax was the major local tax for a long time (since the establishment of the tax-sharing system in 1994). The ratio of business tax to local government tax revenue was 30 percent in 2014 and 31 percent in 2015, although the business tax no longer exists after the tax reform replaced business tax with VAT in May 2016.

taxes are usually imposed on gross output;[3] some consumption taxes in China (similar to the excise tax in the United States), however, are also based on the quantity of a product, and a pollution tax is essentially a tax on output, because as Stokey (1998, 4) noted, "No pollution is generated if no output is produced."

The paper shows that a VAT and a RST have different effects on capital accumulation and welfare. Specifically, we find that, with output being taxed, an introduction of RST accompanied by a decrease in VAT increases savings, capital accumulation, and welfare in the steady state. Simulations based on the data from China show that introducing an 8 percent RST increases capital accumulation by 0.43 percent in the steady state. In the transition period, however, an introduction of RST accompanied by a decrease in VAT will increase capital accumulation but decrease the current generation's welfare.

The paper proceeds as follows. Section 2 discusses the VAT in China. Section 3 develops a computable overlapping-generations model incorporating retail sales tax, value-added tax, output tax, and lump-sum tax. Section 4 analyzes the tax experiment of introducing a RST accompanied by a decrease in VAT on capital accumulation and welfare. Section 5 concludes.

2. VAT in China

VAT is a widely used tax. It was introduced in France in the 1950s and has been adopted by more than 160 countries, including all member states of the EU.[4] Most countries adopted the consumption-type VAT system, in which capital investment is deducted from the tax base in the year of purchase. VAT rates vary significantly among countries. For example, the standard VAT rates range from 27 percent (Hungary) and 25 percent (e.g., Denmark, Sweden, and Norway) to 5 percent (e.g., Canada).[5] Reduced rates and tax exemptions are applied to certain goods and services. Revenues from VAT account for a significant portion of government revenue in many countries.

3 For example, all entities and individuals engaged in the exploitation of mineral products (such as crude oil and natural gas) need to pay a resource tax in China, and the tax rate is 5 percent to 10 percent of the amount of sales. Canada, for example, collects natural resource taxes on extracting natural resources, harvesting timber, or owning mineral rights.

4 See Ebrill et al. (2002). In the United States, the VAT was proposed by economists and politicians, but has not been adopted because of concerns over the regressiveness of the tax and other issues. See Smith (1970), Musgrave (1972), Surrey (1970), Aaron (1987), and Metcalf (1996) for a review of debates over the introduction of VAT to the United States.

5 See OECD Tax database, http://www.oecd.org/tax/tax-policy/tax-database.htm.

The VAT system was introduced in China in 1984, and was significantly reshaped in 1994.[6] Usually an invoice method is used—each firm is liable for taxes on total sales but can claim the taxes already paid by suppliers as a credit against this liability. Special VAT invoices were adopted. VAT is self-policing and it is difficult to avoid taxes. In 2009, China reformed the VAT system by excluding investment from the tax base, and made the VAT a consumption-type VAT, as in many countries.[7] In May 2016, China replaced the business tax with VAT throughout the country and in all sectors. To avoid increasing the tax burden of the experimented enterprises (that used to pay business tax, but were now required to pay VAT), the VAT rates were increased from two to four levels: 17 percent, 13 percent, 11 percent, and 6 percent.[8] The tax rate for small-scale taxpayers is still 3 percent.

On 3 May 2017, the China Ministry of Finance and China State Administration of Taxation jointly announced that, beginning 1 July, the VAT rate levels would be reduced from four to three (17 percent, 11 percent, and 6 percent), and the rate of 13 percent applied to agricultural products, natural gas, cooking oil, books, newspapers, electronic publications, and so forth, would be cancelled.[9] The tax rate for small-scale taxpayers remained at 3 percent. The purpose of this tax reform was to reduce taxes on the affected products and simplify the tax system.

A consumption tax is also imposed on specific consumer goods; it constitutes an extra tax imposed on selected consumer goods (like the excise tax in the United States). In 1994, the consumption tax was imposed on 11 items including tobacco, wine and alcohol, cosmetics, and so on, and the tax was revised to cover 14 items in 2009.[10] The consumption tax is imposed either as a specific tax or an ad valorem tax, or as a composite of the two methods.[11] The tax is mainly collected at the production or import stages. The consumption tax rates

6 In 1994, the VAT in China was a GDP-type VAT in which the tax base is the GDP. The VAT rate was 17 percent for most products and 13 percent for some products (e.g., agricultural products). The tax rate for small-scale taxpayers is 3 percent. Imports to China are also subject to the VAT. Exporting enterprises receive VAT refunds as an export incentive (see China State Bureau of Tax Administration 1994).

7 Lin (2008) and Zhai and He (2008) investigated the macroeconomic and welfare effects of this VAT reform (i.e., from production-based to consumption-based) in China.

8 For example, the VAT rate is 11 percent for communications and transportation, construction, and sales of immovable, etc.; the VAT rate is 6 percent for finance and insurance, culture and sports, and entertainment, etc. (see Ministry of Finance 2016).

9 China Ministry of Finance (2017).

10 See China State Council (1994, 2008).

11 For example, the tax rate for white spirits is 20 percent, plus 0.5 yuan per 500 mL.

Table 1. Major taxes in China (100 million yuan)

Year	Total	Domestic VAT	Domestic consumption tax	VAT and consumption tax from imports	Business tax	Corporate income tax	Personal income tax	Tariffs
1994	5,127	2,308	487		670	708		273
1995	6,038	2,602	541		866	878		292
1996	6,910	2,963	620		1,053	968		302
1997	8,234	3,284	679		1,324	963		319
1998	9,263	3,628	815		1,575	926		313
1999	10,683	3,882	821		1,669	811	414	562
2000	12,582	4,553	858		1,869	1,000	660	750
2001	15,301	5,357	930		2,064	2,631	995	841
2002	17,636	6,178	1,046	1,886	2,450	3,083	1,212	704
2003	20,017	7,237	1,182	2,789	2,844	2,920	1,418	923
2004	24,166	9,018	1,502	3,700	3,582	3,957	1,737	1,044
2005	28,779	10,792	1,634	4,212	4,232	5,344	2,095	1,066
2006	34,804	12,785	1,886	4,963	5,129	7,040	2,454	1,142
2007	45,622	15,470	2,207	6,153	6,582	8,779	3,186	1,433
2008	54,224	17,997	2,568	7,391	7,626	11,176	3,722	1,770
2009	59,522	18,481	4,761	7,730	9,014	11,537	3,949	1,484
2010	73,211	21,093	6,072	10,491	11,158	12,844	4,837	2,028
2011	89,738	24,267	6,936	13,560	13,679	16,770	6,054	2,559
2012	100,614	26,416	7,876	14,802	15,748	19,655	5,820	2,784
2013	110,531	28,810	8,231	14,005	17,233	22,427	6,532	2,631
2014	119,175	30,855	8,907	14,425	17,782	24,642	7,377	2,843
2015	124,922	31,109	10,542	12,533	19,313	27,134	8,617	2,561
2016	130,354	40,712	10,217	12,781	11,502	28,850	10,089	2,603

Source: *Data for 1994–2015 are from China National Bureau of Statistics, http://data.stats.gov.cn/easyquery.htm?cn=C01; Data for 2016 are from China Ministry of Finance, http://gks.mof.gov.cn/zhengfuxinxi/tongjishuju/201701/t20170123_2526014.html. Accessed: 19 March 2017.*

range from 1 percent to 45 percent, based on values of goods and includes 12 rates.[12] Other rates are specific in nature and are based on quantities of goods.[13]

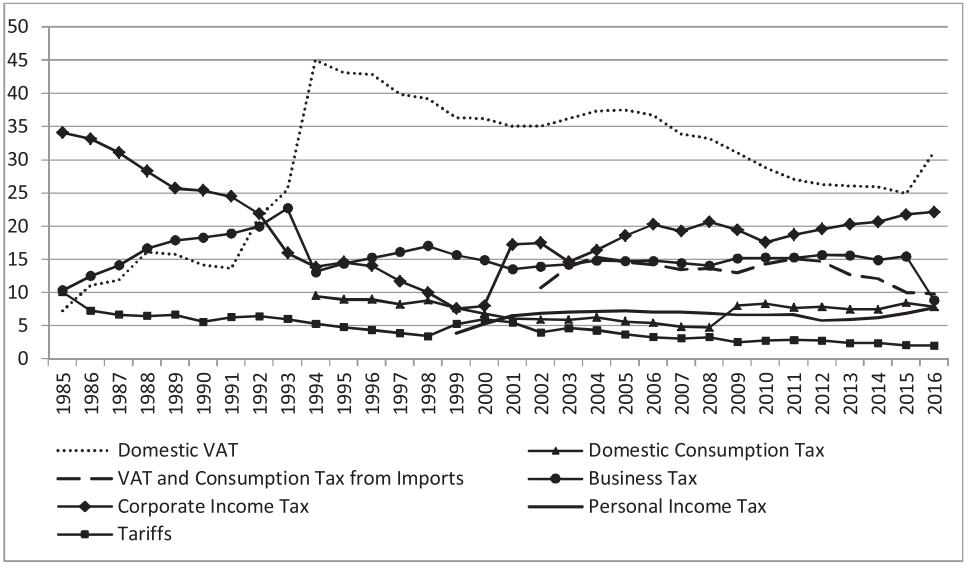
VAT is the most important revenue source for the Chinese government. Table 1 shows major taxes in China from 1994 to 2016. In 1994, the revenue from VAT was 230.8 billion yuan; the revenue from business taxes was 67 billion; and the revenue from consumption taxes was 48.7 billion yuan. These taxes on goods and services add up to 346.6 billion yuan, accounting for 67.6 percent of total tax revenue in 1994.

In 2016, the revenue from VAT was 4,071.2 billion yuan; the revenue from business taxes was 1,150.2 billion yuan; and the revenue from consumption tax was 1,021.7 billion yuan. These taxes on goods and services add up to 6,243.1 billion yuan, accounting for 47.9 percent of total tax revenue. In 2016 consumption tax and VAT on imports were 1,278.1 billion

12 For example, the tax rate is 1 percent for passenger vehicles with a cylinder capacity (i.e., emission capacity) of less than 1.0 liter (including 1.0 liter), 3 percent for motor vehicle tire, 5 percent for solid wood flooring, 10 percent for yacht, 15 percent for firecrackers and fireworks, 20 percent for high-end watches, 25 percent for cigars, 30 percent for cut tobacco, 45 percent for grade A cigarettes, etc.

13 For example, 240 yuan per ton for yellow spirits, 0.1 yuan per liter for diesel oil, etc.

Figure 1. Share of major taxes in total tax revenue (percent)



Source: *Data for 198–2015 are from China National Bureau of Statistics, http://data.stats.gov.cn/easyquery.htm?cn=C01; Data for 2016 are from China Ministry of Finance, http://gks.mof.gov.cn/zhengfuxinxi/tongjishuju/201701/t20170123_2526014.html. Accessed: 19 March 2017.*

yuan and tax refunds for exporting companies (mainly VATs) was −1,215.4 billion yuan.[14] Adding all these up, the taxes on goods and services would be 6,305.8 billion yuan, accounting for 48.4 percent of total tax revenue in 2016.

Figure 1 shows graphically the revenue shares of major taxes in China for the period 1985–2016. There were three major VAT reforms: imposing VAT on more products in 1994, changing from GDP-type VAT to consumption-type VAT in 2009, and replacing the business tax by VAT in 2016. From 1994 to 2015, the revenue share of VAT in total tax revenue declined from 45 percent to 24.9 percent, the revenue share of business tax increased from 13.07 percent to 15.46 percent, and the revenue share of the consumption tax decreased from 9.51 percent to 8.44 percent. The revenue share of VAT is still higher than any single tax.

After China substituted VAT for the business tax in May 2016, the revenue from VAT increased by 30.9 percent, while business tax declined by 40.4 percent. In 2016, the revenue from VAT was 4,071.2 billion yuan, accounting for 31.23 percent of total tax revenue;

14 China Ministry of Finance, http://gks.mof.gov.cn/zhengfuxinxi/tongjishuju/201701/t20170123_2526014.html. Accessed 19 March 2017.

revenue from business tax was 1,150.2 billion yuan, accounting for 8.82 percent of total tax revenue; revenue from consumption tax was 1,021.7 billion yuan, accounting for 7.84 percent of total tax revenue. VAT and business tax add up to 5,221.4 billion yuan, accounting for 40 percent of total tax revenue.

3. The model

3.1 Demographic structure

Each individual is assumed to live for 76 years (or periods), working and accumulating capital from age 21 to 60 and being retired at the beginning of age 61.[15] For simplicity, we ignore individuals' lives in childhood because they do not have earnings and don't make saving and investment decisions. Thus, in the model, each adult has a lifespan of 56 years (i.e., working for 40 years and being retired for 16 years), and there are 56 different-aged adults living at the same period of time. Population is assumed to be growing at an annual rate of n_t. Thus, population in period $t+1$ at age s is as follows: $N_{s,t+1} = (1+n_t)N_{s,t}$, where $N_{s,t}$ is the population at age $s(s = 21, 22, \ldots, 76)$ in period t.[16] The total labor force in period t can be expressed as $L_t = \sum_{s=21}^{60} N_{s,t}$.

3.2 Firms

The economy produces one good, which can be consumed or invested. Output is produced by identical competitive firms using a constant-returns-to-scale production technology, that is,

$$Y_t = (K_t)^{\beta}(L_t)^{1-\beta},$$

where Y_t is the aggregate output, K_t is the aggregate capital stock, and L_t is the aggregate labor force. Capital depreciates at the rate of φ. The capital stock of a firm in period $t+1$ is

$$K_{t+1} = (1-\varphi)K_t + I_t,$$

where I_t is investment.

VAT is collected from the producer, which is levied at the stage of production on a firm's value-added. The VAT rate is v_t, the tax base is $Y_t - I_t$ (where I_t is the new investment in

15 Note that the retirement age is 60 for men, 55 for female civil servants (Gan-bu), and 50 for female workers (Gong-ren). Many retired workers still take temporary jobs for extra money. Professionals, such as professors or medical doctors, can retire at 65. There is no official data for the number of individuals in these groups. For simplification, we assume that people retire at the beginning of age 61. Additionally China's life expectancy at birth is 76.34 in 2015, among which 79.43 for women and 73.64 for men (see China National Bureau of Statistics 2017). In our model, the life expectancy has been rounded down from 76.34 to 76.

16 For simplicity, following Altig et al. (2001), the model abstracts from mortality risks.

period t), and tax revenue is $\nu_t(Y_t - I_t)$. The government also collects taxes on output, with the tax rate being χ_t and the tax base being Y_t.

Thus, net cash flow in period t, Ω_t, can be written as follows:

$$\begin{aligned}\Omega_t &= Y_t - w_t L_t - I_t - \nu_t(Y_t - I_t) - \chi_t Y_t \\ &= (1 - \nu_t - \chi_t)Y_t - w_t L_t - (1 - \nu_t)I_t.\end{aligned}$$

The representative firm faces the following problem:

$$\text{Max} \sum_{t=1}^{\infty} \prod_{j=1}^{t} (1 + r_j)^{-1} \Omega_t = \frac{1}{1 + r_1}\Omega_1 + \frac{1}{(1 + r_1)(1 + r_2)}\Omega_2 + \frac{1}{(1 + r_1)(1 + r_2)(1 + r_3)}\Omega_3 + \ldots,$$

such that $K_{t+1} = (1 - \varphi)K_t + I_t$.

The Lagrangian function associated with this problem is as follows:

$$H = \sum_{t=1}^{\infty} \left\{ \prod_{j=1}^{t} (1 + r_j)^{-1} \right\} \{[(1 - \nu_t - \chi_t)Y_t - w_t L_t - (1 - \nu_t)I_t] + q_{t+1}[(1 - \varphi)K_t + I_t - K_{t+1}]\},$$

where q_{t+1} is the shadow price of installed capital.

$$\frac{\partial H}{\partial L_t} = \prod_{j=1}^{t} (1 + r_j)^{-1} \left[(1 - \nu_t - \chi_t)\frac{\partial Y_t}{\partial L_t} - w_t \right] = 0$$

$$\text{or} \qquad w_t = (1 - \nu_t - \chi_t)\frac{\partial Y_t}{\partial L_t} = (1 - \nu_t - \chi_t)(1 - \beta)k_t^{\beta}, \tag{1}$$

$$\frac{\partial H}{\partial I_t} = \prod_{j=1}^{t} (1 + r_j)^{-1}[-(1 - \nu_t) + q_{t+1}] = 0 \,\text{or}\, q_{t+1} = 1 - \nu_t, \tag{2}$$

$$\frac{\partial H}{\partial K_t} = \prod_{j=1}^{t} (1 + r_j)^{-1}[(1 - \nu_t - \chi_t)\frac{\partial Y_t}{\partial K_t} + q_{t+1}(1 - \varphi)] - \prod_{j=1}^{t-1} (1 + r_j)^{-1} q_t = 0$$

$$\text{or} \qquad r_t = \frac{(1 - \nu_t - \chi_t)\frac{\partial Y_t}{\partial K_t} + q_{t+1}(1 - \varphi) - q_t}{q_t} = \frac{(1 - \nu_t - \chi_t)\beta k_t^{\beta - 1} + q_{t+1}(1 - \varphi) - q_t}{q_t}, \tag{3}$$

where w_t is the after-tax wage rate, r_t is the interest rate (i.e., after-tax rate of return on capital),[17] and q_{t+1} is the shadow price of installed capital, i.e., $q_{t+1} = 1 - \nu_t$, ν_t is the VAT rate, and $k_t = K_t/L_t$ is the capital–labor ratio.

17 This return on capital includes its after-tax marginal product, $(1 - \nu_t - \chi_t)\partial Y_t/\partial K_t$, deflated by the cost of capital, q_t; less the depreciation of installed capital at rate φ; plus the rate of capital gain, $(q_{t+1} - q_t)/q_t$. See Barro and Sala-i-Martin (2004).

3.3 Consumers

The utility function of an individual is time-separable and of the nested, constant elasticity of the substitution (CES) form. Time separability means that lifetime utility, U_t, can be expressed as a function of individual functions at the age of s in period t, that is,

$$U_t = U(u_{21,t}, u_{22,t+1}, \ldots, u_{76,t+55})$$

where $u_{s,t+s-21}$ is the utility of an agent at age of s ($s = 21, \ldots, 76$) in period $t + s - 21$. The nested annual CES utility function for an individual at age s in period $t + s - 21$, $u_{s,t+s-21}$, is:

$$u_{s,t+s-21} = \frac{(c_{s,t+s-21})^{1-1/\gamma}}{1 - 1/\gamma},$$

where $c_{s,t+s-21}$ is consumption in year $t + s - 21$ of an agent at age s in period $t + s - 21$, γ is the inter-temporal elasticity of substitution in the consumption composite that governs the willingness to transfer income across time. The present discount value of the lifetime utility function in period t for an individual, emerged (or becomes independent) in period t is as follows:

$$U_t = \frac{1}{1 - 1/\gamma} \left\{ \sum_{s=21}^{76} \frac{1}{(1+\delta)^{s-21}} (c_{s,t+s-21})^{1-1/\gamma} \right\}, \tag{4}$$

where δ is the pure rate of time preference of an agent (if $\delta > 0$, then the current consumption is always more valuable to the agent than the future consumption). Each individual's earning ability changes as age and working experience increases. Letting ξ_s represent the earning ability, the wage rate for an agent at age s and in year t is $w_{s,\,t} = \xi_s w_t$, where w_t is the market wage rate. Their lifetime budget constraint is as follows:

$$\sum_{s=21}^{60} \left\{ \prod_{i=21}^{s} [1 + r_{t+i-21}]^{-1} \right\} (w_{s,t+s-21} - \tau_{t+s-21}) \geq \sum_{s=21}^{76} \left\{ \prod_{i=21}^{s} [1 + r_{t+i-21}]^{-1} \right\} (1 + \mu_{t+s-21}) c_{s,t+s-21}, \tag{5}$$

where μ_t is period t sales tax rate, and τ_t is period t lump-sum tax levied on working generation. $\sum_{s=21}^{60} \left\{ \prod_{i=21}^{s} [1 + r_{t+i-21}]^{-1} \right\} (w_{s,t+s-21} - \tau_{t+s-21})$ is the present value (period t value) of the life-time after tax income of the representative individual, $\sum_{s=21}^{76} \left\{ \prod_{i=21}^{s} [1 + r_{t+i-21}]^{-1} \right\} (1 + \mu_{t+s-21}) c_{s,t+s-21}$ is the present value of life time consumption of the representative consumer. Thus, the present value of lifetime income should not be smaller than the present value of lifetime consumption.

Maximizing the utility function in equation (4) subject to the budget constraint in equation (5) yields the first-order conditions that must be satisfied by the optimum values of consumption in each year.

Let $a_{s,t}$ be the capital of person at age s in period t. We obtain the equation of assets for an individual at each period:

$$a_{s+1,t+s} = \begin{cases} [1 + r_{t+s-1}]a_{s,t+s-1} + w_{s,t+s-1} - \tau_{t+s-1} - (1 + \mu_{t+s-1})c_{s,t+s-1}, & s = 21, \ldots, 60; \\ [1 + r_{t+s-1}]a_{s,t+s-1} - (1 + \mu_{t+s-1})c_{s,t+s-1}, & s = 61, \ldots, 76. \end{cases}$$

3.4 Government budget constraints

The government uses tax revenue to finance government expenditure.

$$\mu_t \sum_{s=21}^{76} c_{s,t}N_{s,t} + \chi_t Y_t + \nu_t(Y_t - I_t) + \tau_t L_t = G_t, \tag{6}$$

where the left side of equation (6) is tax revenue from retail sales tax, output tax, value-added tax, and lump-sum tax, and the right side of the equation is general government expenditure, G_t.

3.5 Equilibrium

The economy is in equilibrium if consumers' utilities and firms' profits are maximized and all markets are cleared. We have derived a number of conditions from solving the consumer's and the firm's optimization problems. In this economy there are 56 differently aged adults living together. They supply labor up to age 60. Individuals in different age groups have different amounts of capital. The capital market clearing conditions is

$$q_t K_t = \sum_{s=21}^{76} (a_{s,t}N_{s,t}), \tag{7}$$

recall that q_t is the shadow price of installed capital, namely, $q_t = 1 - \nu_{t-1}$.

We solve the model with a Gauss-Seidel algorithm following Auerbach and Kotlikoff (1987) and Altig et al. (2001). The calculation begins with guesses for certain key variables and then iterates on those variables until a convergence criterion is met. Specifically, aggregate variables of the model are solved with a forward-looking algorithm that iterates on the capital stock over the entire transition path. Initial guesses are made for (a) the time-path of aggregate demand for capital, and (b) the endogenous tax rate (for which the program

Table 2. Initial values of exogenous variables and parameters

Variable	Definition	Value
γ	Intertemporal elasticity of substitution	2.00[a]
δ	Pure rate of time preference	0.037
β	Intensity of business capital usage in production	0.50
φ	Depreciation rate	0.07[b]
υ	Value-added tax rate	0.153[c]
χ	Output tax rate	0.011[c]

Notes: *a. We also did a sensitivity analysis for $\gamma = 0.7$. We adjust δ to -0.005 to preserve the base year ratio of private consumption to output when changing γ.*

b. We also did a sensitivity analysis for $\varphi = 0.1$.

c. Calibrated in the base year to match the shares in total tax revenue.

is solving).[18] Given the initial guesses of the time-path of all these variables, the model calculates (a) the factor prices in each period, (b) the remaining lifetime consumption in each current and future cohort, and (c) the remaining lifetime assets in each current and future cohort. Households' assets are then aggregated across and within cohort for each period. This aggregation generates a new guess for the time-path of the aggregate supply of capital stock. To form a new guess of the time-path of aggregate factor demand, we form weighted averages of the initial guess and the supply time-path derived using the previous guess of the time-path of factor demand. The time-path of the tax rate for which we are solving are also updated to meet the government budget constraint. The algorithm then iterates in this way until the capital stock time path converge.

4. The quantitative analysis

In this section, we discuss quantitative results with the aid of a calibrated economy. Specifically, we calibrate the model to match China's national account data and examine the effect of an introduction of RST accompanied by a decrease in VAT in China.

4.1 Calibration

2016 is chosen as the base year and the 2016 national account data serves as the static benchmark equilibrium dataset for calibration. Table 2 summarizes the major elasticity and the other parameters needed to be determined extraneously for model calibration. Most of these parameters are selected by drawing on many prior empirical studies. Other parameters, like share parameters in production functions, tax rates, and so on, are calibrated to replicate the base year data.

18 In the baseline, the lump-sum tax is endogenous to maintain the government budget constraint, and in the reform cases, the VAT rate is endogenous to maintain the government budget constraint.

For the households sector, following Song, Storesletten, and Zilibotti (2011), we set the inter-temporal elasticity of substitution, $\gamma = 2$.[19] The pure rate of time preference in the base year ($\delta = 0.037$) is endogenously determined in the model calibration to match the base year ratio of private consumption to output in China, which is 39 percent in 2016. ξ_s, the parameter determining the income of a person at age s, is calibrated to match the data from China National Bureau of Statistics, *China Urban Household Survey* (2007).[20]

For the production sector, capital share in the aggregate output needs to be set. China National Bureau of Statistics uses the income approach to calculate the GDP for each province but it does not provide the GDP calculated by the income approach at the national level. We add up the regional data to obtain data in the aggregate economy level.[21] The average ratio of labor compensation to GDP in 1980 to 2016 is 49.1 percent. Thus, we set capital share in the aggregate output, $\beta = 0.5$, consistent with Song, Storesletten, and Zilibotti (2011). Finally, the annual depreciation rate of capital is set to $\varphi = 0.07$.[22]

In constructing the baseline scenario for model calibration, it is necessary to make some hypothetical assumptions on all exogenous variables for the period after 2016. We calibrate the model's demographics using population data and projections from the United Nations.[23] In our model, the ratio of the population 60 years old or above to the population 20–59 years old (old-age dependency ratio) is 41 percent in 2030, 54 percent in 2040, continues rising to 74 percent in 2060, decreases gradually to 69 percent in 2070, then increases gradually to 75 percent in 2090, and remains at this level thereafter.

The ratio of government tax revenue to GDP is 18 percent in 2016, and it is assumed to remain stable afterwards (i.e., 18 percent of GDP). All tax rates, which are calibrated from base year data, are held constant over the baseline, except lump-sum tax. In the base year (2016), the ratio of VAT to total taxes is 48.37 percent, the ratio of output tax to total taxes is 6.03 percent, and the other taxes account for 45.6 percent of total taxes, which is captured by the lump sum tax in the model.[24] The initial value of these tax rates in the baseline case

19 We also did a sensitivity analysis for $\gamma = 0.7$. We adjust δ to -0.005 to preserve the base year ratio of private consumption to output when changing γ. The results remain qualitatively unchanged.

20 See Li and Lin (2016) for the details.

21 China's nominal GDP by income approach (at the provincial level) is from China National Bureau of Statistics (1997, 2007, 2006–17). GDP by income approach includes compensation of employees, fixed asset depreciation, net production tax, and operating surplus.

22 We also did a sensitivity analysis for $\varphi = 0.1$. The results remain qualitatively unchanged.

23 See United Nations (2013).

24 Here, VAT revenue includes domestic VAT, domestic consumption tax (similar to excise tax in the United States), business tax, plus VAT and consumption tax from imports, and minus VAT and consumption tax rebate for exports. Since 2009, China excluded investment from the tax base of VAT, and the VAT became a form of consumption tax. With the reform of substituting VAT

Table 3. Key variables in the base year and China's data

Concept	Model (percent)	Calculation based on China's national account data[a] (percent)
Private consumption/GDP	38.8	39.2
Tax revenue/GDP	18.0	17.5
Value-added tax/Total tax	48.3	48.4[b]
Output tax/Total tax	6.1	6.0[c]
Other taxes/Total tax	45.6	45.6[d]

Notes: *a. If not specified, the figures are the actual data for 2016 from China National Bureau of Statistics (2017).*
b. Here value-added tax revenue includes domestic value-added tax, domestic consumption tax (similar to excise tax in the United States), business tax, plus VAT and consumption tax from imports, and minus VAT and consumption tax rebate for exports. Since 2009, China excluded investment from the tax base of value-added tax (VAT), and the VAT became a form of consumption tax. With the reform of substituting VAT for business tax, business tax was replaced by VAT in 2016.
c. Here output tax revenue includes resource tax, tariffs, and deed tax. They are all taxed on the amount of sales, and can be considered as a tax on output.
d. The other taxes are captured by the lump sum tax in the model.

is calibrated to match the ratios in the base year. The lump-sum tax is endogenous to maintain the total tax revenue to output ratio being 18 percent.

Table 3 provides summary statistics for the base year. Given our parameter choices, the model generates the following data: private consumption accounts for 38.8 percent of GDP and government tax revenue for 18 percent. These figures are close to their respective 2016 national account values. At the baseline, government does nothing to reform the tax system (i.e., collecting VAT, production tax, and lump-sum tax). All tax rates are held constant over the baseline, except lump-sum tax, which is endogenous determined to keep the tax revenue to GDP ratio at 18 percent over the baseline.

4.2 Introduction of RST in China and its effect

We are now ready to analyze the effect of an introduction of RST in China. We examine the effects of the reform on wage, capital accumulation, output, and welfare of various generations. From period 1, the government introduces a RST with tax rates of 6 percent, 8 percent, or 10 percent, and reduces VAT rate to keep the total tax revenue unchanged. Output tax rate and lump-sum tax remain unchanged as in the baseline.

Figure 2 shows the percentage changes of the VAT rate over the baseline as a RST is introduced. As soon as RST is introduced, the VAT rate decreases sharply. The higher the RST, the lower the VAT rate.

for business tax, business tax was replaced by VAT in May 2016. Output tax revenue includes resource tax, tariffs, and deed tax. They are all taxed on the amount of sales, and can be considered as a tax on output.

Figure 2. The effects of an introduction of RST on VAT rate (percent change over baseline)

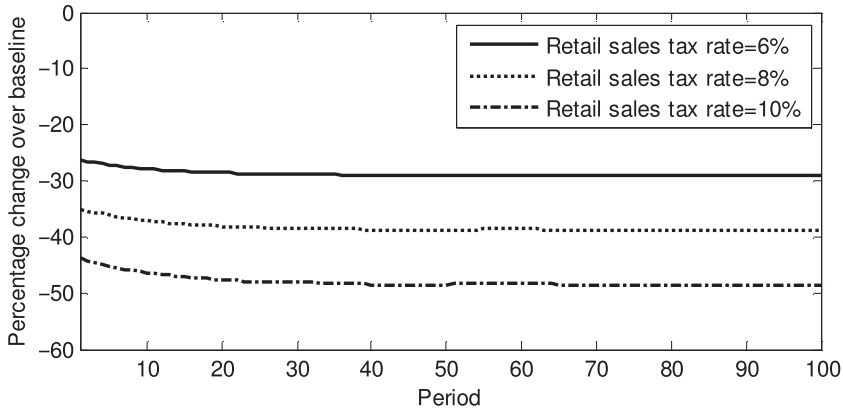


Figure 3. The effects of an introduction of RST on wage (percent change over baseline)

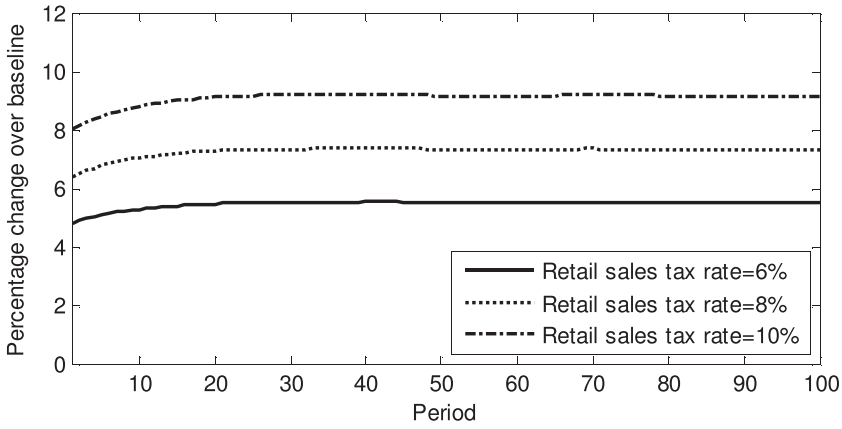


Figure 3 shows the percentage changes of the wage over the baseline as a retail sales tax is introduced. With the introduction of retail sales tax, the wage rate is higher than the baseline in the short run and the long run. Based on equation (1), a decrease in the VAT rate leads to an increase in the wage rate. The higher the retail sales tax rate (i.e., the lower the VAT rate), the more wage rate increases.

Figures 4 and 5 show the percentage changes of the capital stock and output over the baseline as a RST is introduced. With the introduction of RST, capital stock and output is higher than the baseline in the short run and the long run. Recall that equation (7) determines the

Figure 4. The effects of an introduction of RST on capital (percent change over baseline)

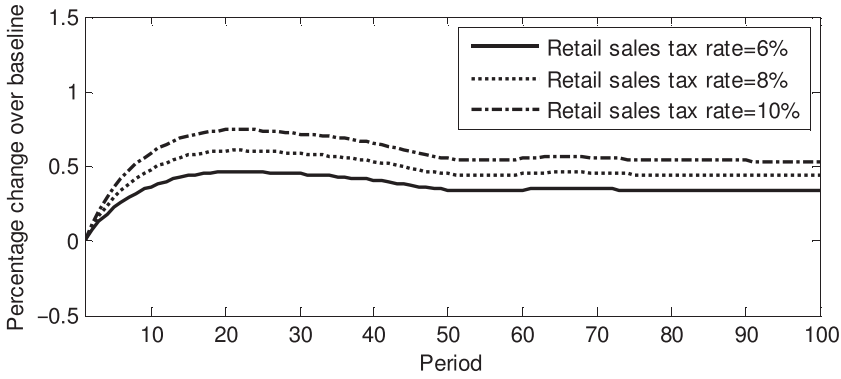
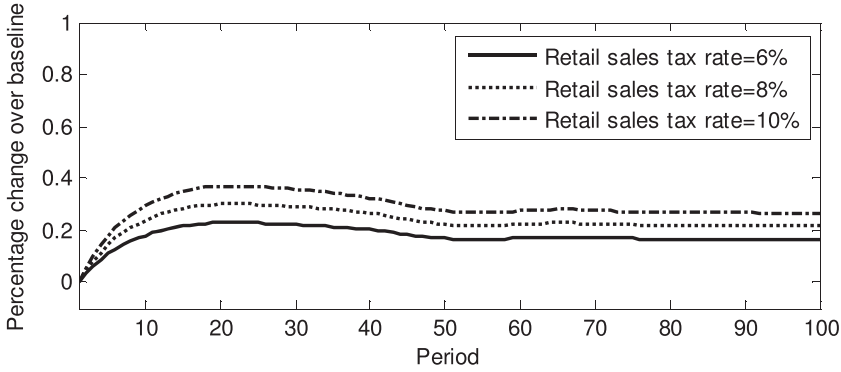


Figure 5. The effects of an introduction of RST on output (percent change over baseline)

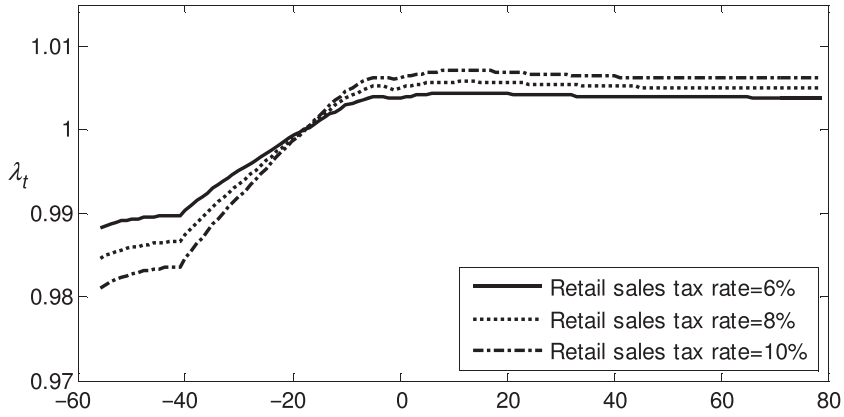


quantity of capital stock and can be rewritten as follows:

$$K_t = \sum_{s=21}^{76} (a_{s,t} N_{s,t})/q_t = \sum_{s=21}^{76} (a_{s,t} N_{s,t})/(1 - \upsilon_{t-1}).$$

On one hand, a decrease in the VAT rate, increasing the wage rate (as shown in Figure 3), will cause an increase in savings and hence capital stock, as shown as an increase in the numerator of this equation. On the other hand, a decrease in the VAT rate increases the shadow price of installed capital (denoted by q_t) from the second period, as shown as an increase in the denominator of the equation. The positive effect of a higher wage dominates the negative effect of a higher price, which causes a higher level of capital stock when

Figure 6. Effects of the tax reforms on individual utility



introducing a RST than that in the baseline.[25] The higher the RST rate, the more capital stock and output will increase. Specifically, capital accumulation increases 0.33 percent, 0.43 percent, and 0.53 percent when introducing 6 percent, 8 percent, and 10 percent sales tax, respectively. Output increases 0.17 percent, 0.22 percent, and 0.27 percent when introducing 6 percent, 8 percent, and 10 percent sales tax, respectively.

What about welfare effects when introducing RST? We compare the impacts of introducing RST with different tax rates on each generation's utility. In this model there are 56 generations living at the same time. Figure 6 shows the effects of introducing RST on an individual's utility. The horizontal line denotes the year that a person enters the workforce. For example, −55 means that the person began to work 55 years ago and retired 15 years

25 Analytically, the reason why capital stock will reach the levels higher than that in the baseline in the steady state can be proved in a simple two-period overlapping generations framework. Assume the utility function is: $u(c_t^t,\ c_{t+1}^t) = \ln(c_t^t) + \rho \ln(c_{t+1}^t)$, where ρ is the pure rate of time preference. Solving the problem of maximizing consumer's problem, we can obtain the optimal savings function: $s_t = \rho w_t/(1+\rho)$, where $w_t = (1-\nu_t-\chi_t)\partial Y_t/\partial L_t$ as indicated in equation (1). The capital market clearing condition is $q_{t+1}K_{t+1} = L_t s_t$, where $q_{t+1} = 1-\nu_t$. We can prove that $\partial k/\partial \upsilon < 0$, $\partial k/\partial \mu > 0$ in the steady state. The detailed derivations are available on request. In an extreme case, where the VAT is completely replaced by the RST, the steady-state capital–labor ratio is as follows. Assume in scenario 1 that there is a VAT but not a sales tax. Thus, in scenario 1 the capital–labor ratio in the steady state, denoted by k^{VAT}, is as follows: $k^{VAT} = \left[\frac{\rho(1-\beta)}{(1+\rho)(1+n)}\left(1-\frac{\chi}{1-\upsilon}\right)\right]^{1/(1-\beta)}$.

Assume in scenario 2 that there is a sales tax but not a VAT (i.e., $\nu_t = 0$ and $q_{t+1} = 1$). Thus, in scenario 2 the capital–labor ratio in the steady state, denoted by k^{Sale}, is as follows: $k^{Sale} = \left[\frac{\rho(1-\beta)}{(1+\rho)(1+n)}(1-\chi)\right]^{1/(1-\beta)}$. When $\chi > 0$ and $\nu > 0$, we have $1-\chi/(1-\nu) < 1-\chi$. Therefore, we have $k^{VAT} < k^{Sale}$ in the steady state. However, if $\chi = 0$ (i.e., there are no taxes levied on production), capital stock will be the same in the steady state.

ago; −20 means that the person began to work 20 years ago (i.e., has already worked for 20 years in period 1). The vertical line shows the change of utility. For example, a value of 1.05 means that the generation's remaining lifetime utility under a specific tax reform is 5 percent higher than it would have been in the baseline. To be precise, the percentage change in utility is measured as a consumption equivalent (Kotlikoff 1996; Kotlikoff, Smetters, and Walliser 2007). Specifically, let U_t denote utility level in the baseline, and $\tilde{U}_t$ denote utility under a reform.

$$U_t = \frac{1}{1-1/\gamma}\left\{\sum_{s=21}^{76}\frac{1}{(1+\delta)^{s-21}}\left(c_{s,t+s-21}\right)^{1-1/\gamma}\right\},$$

$$\tilde{U}_t = \frac{1}{1-1/\gamma}\left\{\sum_{s=21}^{76}\frac{1}{(1+\delta)^{s-21}}\left(\tilde{c}_{s,t+s-21}\right)^{1-1/\gamma}\right\}.$$

Think about how much consumption should be increased or decreased to have people in other reforms achieve the same utility level as people in the baseline. Define λ_t satisfying the following equation:

$$\begin{aligned}\tilde{U}_t &= \frac{1}{1-1/\gamma}\left\{\sum_{s=21}^{76}\frac{1}{(1+\delta)^{s-21}}\left(\lambda_t c_{s,t+s-21}\right)^{1-1/\gamma}\right\} \\ &= \left(\lambda_t\right)^{1-1/\gamma}\frac{1}{1-1/\gamma}\left\{\sum_{s=21}^{76}\frac{1}{(1+\delta)^{s-21}}\left[\left(c_{s,t+s-21}\right)^{1-1/\gamma}\right]\right\} = \left(\lambda_t\right)^{1-1/\gamma}U_t.\end{aligned}$$

Solving this equation, we obtain the value of λ_t. If $\lambda_t > 1$ (or $\lambda_t < 1$), it means that consumption and leisure should be increased (or decreased) by $\lambda_t - 1$ (or $1 - \lambda_t$) to have people in the base-case achieve the same utility level as those in other reforms.

Figure 6 provides the value of λ_t, indicating the effects of introducing RST on an individual's utility. The following results are obtained compared with the baseline. First, an introduction of a RST will decrease the current generations' utility. The intuition is clear. With an introduction of RST with a decrease in VAT, an individual obtains higher wages, but also needs to pay more for the same amount of consumption because they have to pay the RST. Specifically, consumption faced by an individual at age s in period t has changed from $c_{s,t}$ to $(1+\mu_t)c_{s,t}$ when introducing a RST. In the transition period, for current retirees, they need to pay the RST for their consumption, but they cannot obtain a higher wage because they already left the labor market; for current workers, the increased wage obtained during the remaining working years can't compensate for their loss from increased expenditure on consumption, which equals consumption plus RST ($c_{s,t} + \mu_t c_{s,t}$), during their remaining life span. Thus, the current generation is worse off in these reforms of introducing RST. Second, the reform will increase future generations' utility. Although future generations need to pay RST for their consumption, they do obtain a higher wage for their whole working

period. What's more, the capital stock and output is higher than baseline (as indicated in Figures 4 and 5). Thus, the positive effect from a higher wage dominates the negative effect from a higher expenditure on consumption, which causes a utility gain for future generations. Third, the higher the RST rate is (i.e., the lower the VAT rate is), the greater the utility loss for the current generation, and the greater the utility gain for future generations.

5. Conclusions

VAT is the most important tax in China, accounting for near 40 percent of total tax revenue. This paper has analyzed the effects of a tax experiment where the VAT is reduced in response to the introduction of RST (so that total revenues remain unchanged) in a multiperiod overlapping generations model.

The paper finds that, if output is taxed, VAT collected from producers and RST collected from consumers are not equivalent. Specifically, with output being taxed, an introduction of RST with a decrease in VAT increases capital accumulation and the welfare in the steady state. In the transition period, however, an introduction of RST with a decrease in VAT decreases the current generation's welfare, while increasing capital accumulation. Simulations based on the data from China show that introducing an 8 percent RST increases capital accumulation by 0.43 percent in the long run.

Of course, there are important questions that policymakers will have to consider before deciding whether or not to introduce the RST in place of an equivalent reduction in the VAT. Will the current generation be willing to accept a reduction in their welfare to ensure greater capital accumulation in a future they will not see or share? What might be the social and political consequences of trying to enforce a reduction in current welfare?

There are some possible extensions of the paper that might be considered. One is to introduce the costs associated with the collection of VAT and RST. In doing so, the effects of the tax reform on capital accumulation and welfare may be altered. Another possible extension is to allow the economy to grow endogenously. In this case, the tax reform of introducing RST with a decrease in VAT on economic growth can be examined. We leave these extensions for further research.

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