THE WALTER H. SHORENSTEIN
ASIA-PACIFIC RESEARCH CENTER

SHORENSTEIN
APARC
STANFORD

ASIA HEALTH POLICY PROGRAM

FREEMAN SPOGLI INSTITUTE
FOR INTERNATIONAL STUDIES

Stanford University
Walter H. Shorenstein Asia-Pacific Research Center
Asia Health Policy Program

Working paper series
on health and demographic change in the Asia-Pacific

Do Chinese Really Save Too Much? Aspects from Total Factor Productivity Growth in China since 1952

Chong-En Bai, School of Economics and Management, Tsinghua University, Beijing
Qiong Zhang, School of Economics, Central University of Finance and Economics, Beijing

Asia Health Policy Program working paper #25

December 2011

http://asiahealthpolicy.stanford.edu

For information, contact: Karen N. Eggleston (翁笙和)
Walter H. Shorenstein Asia-Pacific Research Center
Freeman Spogli Institute for International Studies
Stanford University
616 Serra St., Encina Hall E311
Stanford, CA 94305-6055
(650) 723-9072; Fax (650) 723-6530
karene@stanford.edu

STANFORD UNIVERSITY
ENCINA HALL, E301
STANFORD, CA 94305-6055

T 650.725.9741
F 650.723.6530

Do Chinese Really Save Too Much? Aspects from Total Factor Productivity Growth in China since 1952

Chong-En Bai

School of Economics and Management, Tsinghua University, Beijing

Qiong Zhang

School of Economics, Central University of Finance and Economics, Beijing

December 2011

Abstract

China's economic growth over the past three decades is unprecedented. Although this growth is commonly attributed to a high domestic savings rate among "thrifty" Chinese, savings alone cannot promote economic growth unless productivity has continuously grown for such a long period. This article uses a one-sector, neoclassical growth model to calibrate the economy to Chinese data since 1952 and finds that measuring changes in total factor productivity between 1952 and 2005 can well capture the secular movements in the Chinese savings rate. Far from supporting the widespread belief that China's savings rate is too high, this article argues that even thrifty Chinese "under-saved" for most of the years during this period; furthermore, the fiscal reforms of 1983 and 1985 further suppressed saving behavior, especially when initially implemented. In presenting such findings, this article at least partly solves the so-called "Chinese savings puzzle."

JEL codes E21 E62 O40

Keywords Growth model, savings rate, total factor productivity, capital tax rate

Introduction

China experienced a stagnant or small savings rate for about thirty years following the establishment of the People's Republic in 1949. Not until the economic reforms of 1978 did the national savings rate and incomes begin to rise very fast (as shown in figure 1). [1] Actually the Chinese save more than half (the national savings rate approximates to 51.4%) of current income in 2008, which is almost the highest in the world. Figure 1 also indicates that even compared to Japan and the United States during their boom years, the savings rate in China looks very high. The same conclusion holds when compared to other Asian economies such as South Korea and Taiwan during their boom years too; only Singapore experienced such high national savings rate around 1998 before its decline until recently.

The high Chinese savings rate has caused considerable controversy. Some scholars attribute it to great increases in Chinese income (Wang and Gong [2007]) of which seems to be contradict to permanent income hypothesis (PIH) theory (Wen [2009]),[2] while there are many other writers that try to figure out this contradiction from aspects of great precautionary savings motive due to incomplete social security system and liquidity constraint (Shi and Zhu [2004]; He *et al.* [2008]; Wen [2009]), relative more and more saving individuals (adults) compared to dissavers (children and retirees) as implied by declines in the total dependency rate (Modigliani and Cao [2004]; Zhong and Li [2009]), abundant rural residual labor force absorbed by China's recent industrialization and urbanization and high return to capital due to relative scarce in capital (Harbaugh [2004]).[3] The situation in contemporary China is quite similar to that of Japan in 1970s: Japan also saw significant increases in its national savings rate in 1960s and peaked up to 40% in 1970 (also see figure 1), a trend that motivated much research for several decades since then. While only recently has the literature tended to conclude that changes in total factor productivity (TFP)—rather than demographic change, household preferences, or the social security system—were the most important drivers of the rapid increase in Japan's savings

---

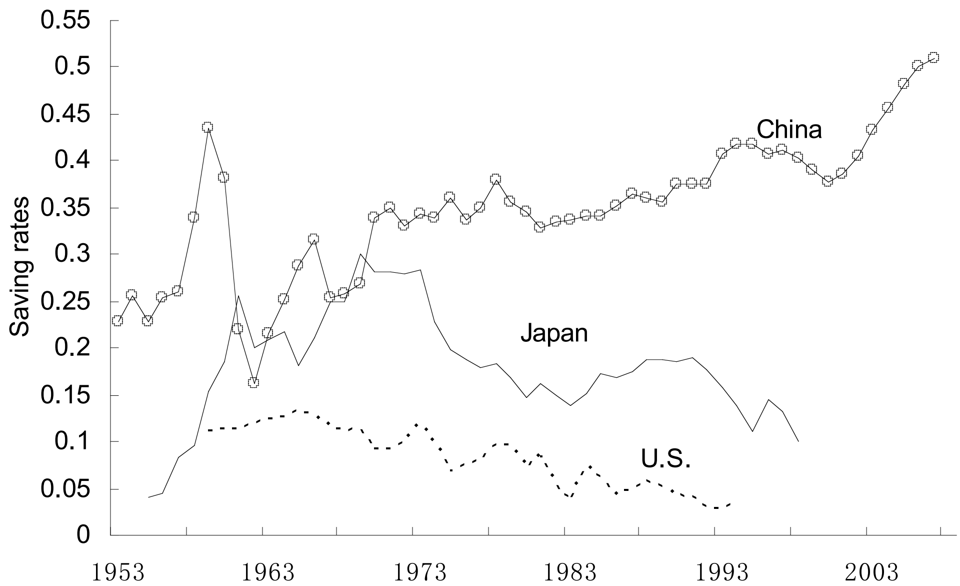
[1] The national savings rate is defined as one minus the sum of private and government consumption to gross domestic product ratios as commonly cited. Data for China are calculated by authors, whereas those for Japan and the United States are from Chen *et al.* (2006). While there may be errors comparing the data due to the various methods used, the overall trends can still be assured.

[2] China's experience of high savings accompanying high growth is quite common among rapidly growing economies in East Asia (Kraay [2000]).

[3] Refer to Zhang (2007) for an excellent literature review.

rate and therefore Japan's income between the 1960s and the 1970s, and that lower growth of productivity more closer to the U.S. economy has led to the decline in Japan's savings rate since the 1980s.[4] Leaving alone the indeterminate causality between savings and income (Aghion *et al.* [2006]), savings can promote economic growth and the savings rate can increase over a long period only when the TFP of the economy grows continually. Otherwise, ongoing growth in savings is unlikely since the return on capital will diminish due to increasing capital stock. This trend will eventually lead to a stable national savings rate that holds even in the case of existing exogenous constant progress in productivity. In other words, we argue that changes in the savings rate result from changes in the return to capital, which in turn varies with changes in productivity growth.

Figure 1 Savings rates in China, Japan, and the United States



Besides, another more important question with more hot debate to be answered is whether the Chinese save too much. Most of aforementioned articles empirically argue that China's savings rate is too high compared with that of other countries. This account firstly needs further analysis in two aspects. First, China may not be comparable to other countries, as it may be in a different developmental stage, and it may need high investment therefore high savings rate during its Rostovian take-off period, of which itself is consistent with the capital accumulation

[4] Refer to Horioko (1990) for an excellent literature review and Chen *et al.* (2006, 2007) for more recent arguments; Perkins and Rawski (2007) further support this assumption and even think the same story was to be observed in South Korea and Taiwan during the rapid-income-growth era of the "Asian Miracle."

or capital-deepening progress (Perkins [2005]; Liang [2006]; He and Cao [2007]). Also China may have a different national accounting system as well.[5] Second, even if the Chinese indeed save more than others (which may not necessarily indicate they save excessively), a theoretical benchmark is needed to see whether the Chinese have saved rationally, namely whether they have "oversaved" or "undersaved" for any given period. As Liang (2006) and Song (2006) guess that China may as well actually invest too less rather than too much according to great gaps between the high return to capital and the low interest rate. The conclusion is problematic, of course, as the official interest rate in China is regulated, while these two researches do reasonably provide evidence for not decreasing high return to capital among recent years, of which is also confirmed by Bai *et al.* (2006) and Sun *et al.* (2010). In addition, even under the situation that China has watched very high savings and investment rates for so many years while does not seemingly cause high inflation for such a long time (AMR [2007]), which again implies there must be improvement in productivity (Perkins [2005]) to continuously absorb the increasing wealth and result in a virtuous cycle of high income growth, high savings and investment rates.

Contrast to numerous empirical literature on China's high savings rate, very little one does theoretically consider the level of optimal national savings rate in the special background of China except Yuan and Song (2000) and Lu and McDonald (2006).[6] Yuan and Song (2000) simulate an over-lapping generations (OLG) model to analyze the effects of changes in population age structures among different social security systems while they only quantitatively describe that the Chinese may save too much according to the increasing deposit-loan differences and capital outflows. Lu and McDonald (2006) later simulate an open economy model of China and incorporate the major factors that influence optimal saving, including demographic change and the catch-up of TFP in China to the level of high-income OECD countries, and then justify current savings rate in China is too high. These two articles both simulate the economy of China under a framework of comparative static analysis on changes in steady states, of which is more appropriate for long-run effects of related exogenous factors, and in our opinion it is just the dynamic transition path along with changes in steady states that would be more instructive and interesting for China's

[5] Refer to Ren and Qin (2006) for more discussion of China and the United States, and also Hayashi (1986) for Japan.

[6] Refer equivalently to discussions on optimal investment rate in a closed economy such as Qiao and Dong (2005).

special case of fast growing and transiting economy.

Two recent works done by Chen *et al.* (2006) and Perkins and Rawski (2007), together with above hot debates on China's "unusually high" savings rate (see Fehr *et al.* [2005] and Kuijs [2005], among others, for more discussions), give us this point of view. Chen and his colleagues conclude that differences in preferences, high housing prices, high educational costs, and high marriage costs cannot fully explain why Japan has such high savings rate comparing to the United States. These factors are also commonly used to explain China's case (Xie [1993]; Wan *et al.* [2001]; Harbaugh [2004]; He *et al.* [2008]; Zhong and Li [2009]). But if Chen and his colleagues can convincingly show that the Japanese savings rate mimicked variations in total productivity in the 1956–2000 period, could the same have happened in China? Data from Perkins and Rawski (2007), discussed in detail later, indicate almost the same overall trends in TFP growth and changes in per capita real income for China between 1953 and 2005. They also argue that "it was the jump in productivity growth leading to a higher gross domestic product (GDP) growth rate that made possible the greater contribution of capital. Put differently, the story of the 1979–2005 period in China is a story of reforms generating high TFP growth that in turn led to a higher level of capital formation growth than would otherwise have been the case" (p. 23). This indirectly explains the Chinese savings puzzle by showing how China's high savings rate (therefore a high level of capital formation) was closely related to higher GDP growth due to an increase in TFP growth.

Further considering the optimal savings rate in China from aspects of TFP is closely related to economic growth theory. Though TFP growth has been called ''a measure of our ignorance'' by Abramovitz (1986), this measure covers many factors including innovation-based and imitation-led technological progress, institutional and efficiency change, omitted variables, and measurement errors; and TFP plays key roles in economic growth (Solow [1956]; Klugman [1997]; World Bank [2005]) especially for developing countries (Aghion *et al.* [2006]). Again this is supported by recent researches on estimating TFP growth in China that tend to be consistent with each other even they use different estimating methods or data sources (see those of Chow and Lin [2002], Wang and Yao [2003], Perkins and Rawski [2007], among others, for example).

Another related question to be answered is whether the Chinese have changed their incentives or preferences for saving during the transition from a centrally planned economy to a market-oriented one. Much literature (Kraay [2000]; Perkins and Rawski [2007]) has implied that urban Chinese had only modest incentives to save during the planned era, as they received generous cradle-to-grave benefits through employment in state-owned enterprises or by being collective entrepreneurs, while rural Chinese were unable to accumulate substantial savings during this time. In recent years both urban and rural Chinese have been forced to save in order to pay higher out-of-pocket expenses for health care, housing, and education, as well as their retirement. If China's current high savings were really caused by these factors, we should expect some structural differences in savings rates before and after the reform in 1978, of which has partly empirically identified by significant breakpoints of consumption around 1984 (Zhang and Wan [2004]) or savings rate around 1978 (Ma [2008]). While a unified growth framework is still required to see whether such differences are really present, and maybe these breakpoints are spurious results as they may be caused by some other factors.

We follow the example of Chen and his colleagues and calibrate a one-sector, neoclassical growth model using the Chinese data for the 1953–2005 period, and find that measuring changes in the TFP in this period can well capture the secular movements in the Chinese savings rate, and find that even thrifty Chinese somehow "undersaved" for most years since the new reforms. In addition, the fiscal reform implemented at the beginning of 1980s, which initially introduced several types of turnover taxes that reduced after-tax return on capital, significantly suppressed the savings rate, especially during the mid-1980s.

The next section presents the model. We then address computational issues, calculating methods of parameters, calibration, and quantitative findings and presenting tests on robustness based on sensitivity analysis. The final section contains concluding remarks.

Methods

The growth model

In this section, we begin with a multiperiod OLG model used by Sadahiro and Shimasawa (2002) and Kulish *et al.* (2010) and then derive a one-sector, neoclassical growth model similar to Chen *et al.* (2006) with additional assumptions.

The closed economy is populated by a finite number of generations and a representative profit-maximizing firm at period t. Each generation enters the labor market at age 15 (1st period), retires at age 60 (45th period), and dies at age 70 (55th period).[7] It consumes and supplies capital and labor to competitive factor markets and also has perfect foresight. Individuals within a generation are equal in all aspects, and start and end life with no wealth. Formally an agent enters the labor market and maximizes his lifetime utility $\sum_{j=1}^{55}\beta^{j-1}\left(\log c_{i,j}+\alpha\log\left(T-h_{i,j}\right)\right)\alpha>0$ (where β is the subjective discount rate) by choosing sequences of consumption and labor input, $\left\{c_{i,j},h_{i,j}\right\}$, subject to his/her intertemporal budget constraint of the form $a_{i,j}=\left[1+\left(1-\tau_t^{\,r}\right)\left(r_t-\delta_t\right)\right]a_{i,j-1}+\left(1-\tau_t^{\,w}\right)w_t h_{i,j}-c_{i,j}$ (where $\tau_t^{\,r}$ and $\tau_t^{\,w}$ are [flat] capital and labor income tax rate, respectively).

With Euler equations $c_{i,j}=\beta\left[1+\left(1-\tau_t^{\,r}\right)\left(r_t-\delta_t\right)\right]c_{i,j-1}$ and optimal time allocation to labor input $\frac{\alpha}{T-h_{i,j}}=\frac{\left(1-\tau_t^{\,w}\right)w_t h_{i,j}}{c_{i,j}}$, we get the aggregate forms of per capita consumption and savings at period t as $c_t=\frac{1}{N_t}\sum_{j=1}^{55}N_{t,j}c_{i,j}$ (where $N_t=\sum_{j=1}^{55}N_{t,j}$) and $s_t=\frac{1}{N_t}\sum_{j=1}^{55}N_{t,j}a_{i,j}$. Together with aggregate labor supply $H_t=\sum_{j=1}^{45}N_{t,j}h_{i,j}$, we also define per capita labor input at time t as $h_t\equiv\frac{H_t}{N_t}=\frac{1}{N_t}\sum_{j=1}^{45}N_{t,j}h_{i,j}$.

With assumption of a stable population age structure and an overall exogenous population growth rate of n_t-1 (where $n_t=N_{t+1}/N_t$), the above problem is equivalent to the one-sector, neoclassical growth model (as per Chen *et al.* 2006), which has a representative household that maximizes its utility

$$\sum_{t=0}^{\infty}\beta^t N_t\left(\log c_t+\alpha\log\left(T-h_t\right)\right)$$

, subject to its budget constraint $C_t+S_t\le\left(1-\tau_t^{\,w}\right)w_t H_t+\left(1-\tau_t^{\,r}\right)r_t K_t$, where *t* = 0, 1, … given some initial capital stock $K_0>0$. Here $c_t=C_t/N_t$ is consumption per capita at time *t*, T is time endowment at each period and exogenously assumed to be constant, and $h_t=H_t/N_t$ is working hours per individual. We also assume there is a disutility of working, and assign α to represent the weight individuals put on their leisure time. The household as a whole allocates its disposable income, which

[7] These are the basic assumptions for China's current social security system.

equals the sum of after-tax labor income $\left(1-\tau_t^{\,w}\right)w_t H_t$ of its members from working (where w_t is the real wage) and capital income $\left(1-\tau_t^{\,r}\right)r_t K_t$ from renting capital (where r_t is the rental rate of capital),[8] between current consumption C_t and saving S_t.

A representative firm uses labor and capital to produce a single product with a constant returns-to-scale Cobb-Douglas producing technology $Y_t = K_t^{\theta}\left(A_t H_t\right)^{1-\theta}$, where Y_t is aggregate output; K_t and H_t are, respectively, aggregate capital and labor inputs; $A_t^{1-\theta}$ is TFP and is assumed to grow at a rate of $\gamma_t - 1$, where $\gamma_t = \left(A_{t+1}/A_t\right)^{\frac{1}{1-\theta}}$; and θ is the time-invariant capital income share in this economy. The motion law of capital stock satisfies $K_{t+1} = \left(1-\delta_t\right)K_t + I_t$, where I_t is aggregate investment (which would be equal to S_t with an assumption of market-clear conditions) and δ_t is the depreciation rate of capital at period *t*.

The government collects income tax to finance an exogenous given stream of government consumption G_t, and its budget constraint satisfies $G_t = \tau_t^{\,w} w_t H_t + \tau_t^{\,r} r_t K_t$ in each period.

Therefore the steady-state savings rate (s^*) and the path of savings rates over time (s_t) are, respectively,

$$s^* = (\gamma n + \delta - 1)\frac{K^*}{Y^*} \qquad (1)$$

$$s_t = \frac{Y_t - C_t - G_t}{Y_t} \qquad (2)$$

, where $\frac{K^*}{Y^*}$ is the capital-output ratio at the steady state and γ, n, and δ are related parameters.

Results and discussion

We calibrate the model to the 1952–2005 Chinese economy using data from Bai *et al.* (2006),[9] and the websites of the National Bureau of Statistics of the People's

---

[8] Although some literature conclude that there were no significant personal income taxes until the last decade in China (Modigliani and Cao [2004]), we still make the assumption of a tax system. We will discuss how we calculate the annual effective labor and capital tax rates since the 1950s.

[9] The original data file used is only for 1952 to 2005, but the authors have updated this file to

Republic of China (NBS), the Ministry of Finance of the People's Republic of China (MOF), the State Administration of Taxation of the People's Republic of China (SAT), and *China Finance Statistics: 1950–1988*, edited by the General Planning Department of the MOF (referred to as GPD [1989] hereafter). We start by discussing the calculating methods and data we need for the computational analysis, and then we display the findings.

Total factor productivity (TFP)

Since the annual nominal total investment in capital can be divided into construction and equipment, we first separately estimate the annual real construction and equipment capital stock and then use the sum to be the total real capital stock.[10] The estimation is based on the famous perpetual inventory method (Goldsmith [1951]). Annual deflating factors for real construction and equipment capital stock are, respectively, the annual implicit price deflators implied by the nominal-to-real industry and construction ratios.[11] Therefore, we have both the total amount and the structure of total capital stock for each year. With the latter we then get the annual depreciation rate for aggregate capital stock by assuming the depreciation rates for construction and equipment to be 0.0803 and 0.2381, respectively, which are different from the assumptions of constant depreciation rates for the real aggregate capital stock that others use (Chow and Li [2002]; Zhang *et al.* [2004]; Perkins and Rawski [2007]).[12]

For data of annual employment, we use the total labor force (*jiuye renshu*) at the end of each year to proxy this variable (data are from NBS).

Rather than calculating the annual growth rate of TFP from residuals of

---

2007 and made it publicly available on their websites.

[10] Levels of initial stock values for construction and equipment are chosen to be 442.71 and 172.47 in 1952 (all in 100 million RMB in 1952 prices), which means an initial total capital stock of 615.17 (which is much smaller than 2,213 as chosen by Chow [1993] but in the range of 323.6 and 647.2, as chosen by Perkins and Rawski [2007]). Besides this, there are many other assumptions of initial capital stock (in 1952) while capital stock in later years are progressively less sensitive to the initial rate and almost converge to the same levels in recent years (Lv 2008). We also find that changes in assumptions of initial capital stock have negligible effects on our later results.

[11] This method of deflating nominal data by using implicit price deflators is quite common in the literature, such as in Chow and Li (2002). Construction and industry are two industries of the secondary industry in the System of China's National Accounts.

[12] Perkins and Rawski (2007) assume this to be 0.096 between 1952 and 2005 (as Zhang *et al.* [2004]). Chow and Li (2002) assume this to be 0.04 between 1978 and 1992 (compared to ours, 0.0886, for the same period), and then relax this assumption, estimating depreciation rates for each from 1993 to 1998 to be 0.0451, 0.0480, 0.0508, 0.0550, 0.0606, and 0.0642, respectively (a bit lower than ours for this period).

estimating an aggregate production function, which is quite common in the literature,[13] we estimate it in an alternate way. As Perkins and Rawski (2007) argue, "in China and other nations that experience major economic or institutional reforms, the growth of capital is itself in part the result of acceleration in TFP growth" (p. 6). This is problematic in the empirical analysis for the endogeneity of capital investment, which is theoretically sensitive to the return on capital, which in turn is significantly affected by changes in productivity. Therefore "the estimates of TFP growth become indeterminate in the absence of information about the elasticity of substitution and the degree of bias in the rate of technical change (. . . a consequence of Diamond *et al.*'s '*impossibility theorem*')" (Felipe and McCombie 2002: 18). Hence, first we avoid estimating an aggregate production function and instead use the average of capital income share between 1978 and 2007 as the long-term time-invariant capital component ratio of aggregate income, [14] and then we derive annual TFP growth from the related growth accounting residuals by using real capital stock and employment for each year.[15]

Figure 2 shows that the according series of TFP growth rate (referring to the left vertical axis), estimated using the aforementioned method (labeled "Ours"), is quite consistent with the results (also on the left vertical axis) from Perkins and Rawski (2007) (labeled "Perkins_Rawski").[16] The actual growth rate of per capita income (real GDP per capita in 1952 renminbi [RMB]) is also included in figure 2, with scaling to the right vertical axis to make the trends more clear. We first find that our estimate of TFP growth is quite similar to that of Perkins and Rawski, even if we use different data on employment and real capital stock.[17] Another salient feature is

[13] See Chen *et al.* (1988), Chow (1993), and Chow and Li (2002) among others.

[14] Chen *et al.* (1988) use a method of estimating production functions and find that capital income shares range from 0.4661 (revised data) to 0.5189 (original data) for China between 1953 and 1985. Chow (1993) estimates a capital exponent range of 0.5848 to 0.6952 for China during the period 1952 to 1985, and with evidence supports this conclusion: labor shares for four nonagricultural sectors in 1953, 1967, and 1970 were 0.53, 0.44, and 0.32, respectively, which means an average capital income share of 0.57 in the 1950s and 1960s. Chow and Li (2002) use a similar method and find a capital income share of 0.6136 for China's aggregate production function between 1952 and 1998. The authors also find that a consistent aggregate production function can consistently apply to this whole period, which means that the capital income share is almost constant both in the planned and market-oriented economies.

[15] Where real gross domestic product (GDP) is proportional to the index of real GDP converted to 1952 prices using the 1952 nominal GDP (data are from NBS).

[16] Perkins and Rawski actually calculate four series of TFP growth rates based on different assumptions of initial capital stock and depreciation rates. We only show the scenario of initial capital stock equal to real GDP in 1952 (at 1952 prices) and a depreciation rate of 0.07, while the four series of TFP growth rates are quite similar over the entire period.

[17] Perkins and Rawski (2007) estimate real capital stock by assuming initial capital stock to

that changes in TFP seem to correlate well with per capita income growth during this period. This is why we think it may be feasible and instructive to mimic the actual trends over time in the Chinese savings rate for the past fifty years by changes in the TFP growth rate.

Figure 2 TFP and per capita income growth rate: 1952–2005

Effective capital and labor tax rate

The average effective tax rate on capital or labor, defined as the total direct and indirect tax revenue over tax base on the related factor input, is one of the best and most popular measures of the tax burden, and it is used to compare tax burdens all over the world (Koester and Kormendi [1989]; Mendoza *et al.* [1997]; Padovano and Galli [2002]). But aside from Liu and Ma (2002), Liu (2004), and Li (2006), few researchers have estimated the average effective tax rates on capital and labor in China, and even these consider only the years between 1985 and 2003, in part because there is no consensus on how to estimate tax revenues and tax bases for earlier years because of data problems. We here use the method in Li (2006) to calculate the average annual effective capital and labor tax rate between 1952 and 2005 for later simulation analysis.

Tax on capital, which is the main source of China's tax revenue, includes the direct tax burden (such as urban and township land use tax, land appreciation tax,

satisfy the initial capital-output ratio in 1952 to be 1 or 2, and then by adding annual new capital investment by assuming a constant depreciation rate of 0.904. They also get data on total human capital stock in each year by estimating the education-enhanced labor force by multiplying Mincer-coefficients.

arable land use tax, house property tax, vehicle acquisition tax, vehicle and vessel usage tax, adjusting tax on fixed-asset investment,[18] stamp duty, resource tax, city maintenance and construction tax,[19] fuel tax,[20] transaction tax on livestock, deed tax, and corporate income tax[21]) and the indirect tax burden (accrual parts of individual income tax and turnover tax, including product tax,[22] value added tax [VAT],[23] and business tax[24]). The VAT and product tax in China mainly relate to the production process and are partly accrued into capital, as was the case for the business tax before 1994. Later business tax was treated fully as a capital tax due to its being mainly levied on the transfer of intangible assets or the sale of real estate. Therefore, the turnover tax levied on capital is estimated as $TT^c = \left(product\ tax + VAT + business\ tax\right) capital\ formation\ rate$ (before 1994) or $TT^c = VAT\ capital\ formation\ rate + business\ tax$ (after 1994). Similarly, individual income tax, which is simultaneously levied on individual labor income (such as wages and salaries) and capital income (such as interest, dividends, and bonuses), is respectively decomposed into capital and labor tax according to the relative weights of wages and net operating income and financial income as a proportion of total income.[25]

Tax levied on labor includes agricultural and livestock tax, accrual parts of personal income tax, and social insurance contributions which is seemingly not a form of tax (Li [2006]).

There are no corresponding statistical data for annual capital and labor income for the entire period between 1952 and 2005. Unlike Li (2006), Liu and Ma (2002) and Liu (2004), we estimate these two series by multiplying capital and labor income shares which respectively are 0.5036 and 0.4964 with annual GDP, resulting.[26]

---

[18] This tax was implemented in 1983 (GPD 1989).

[19] This tax was implemented in 1985 (GPD 1989).

[20] This tax was implemented in 1982 (GPD 1989).

[21] This tax was levied on state-owned enterprises in 1983 (GPD 1989).

[22] This tax was levied on the sale of certain products between 1984 and 1994 (GPD 1989; SAT and NBS websites).

[23] This tax was put on trial in 1980 and formally implemented in 1984 (GPD 1989).

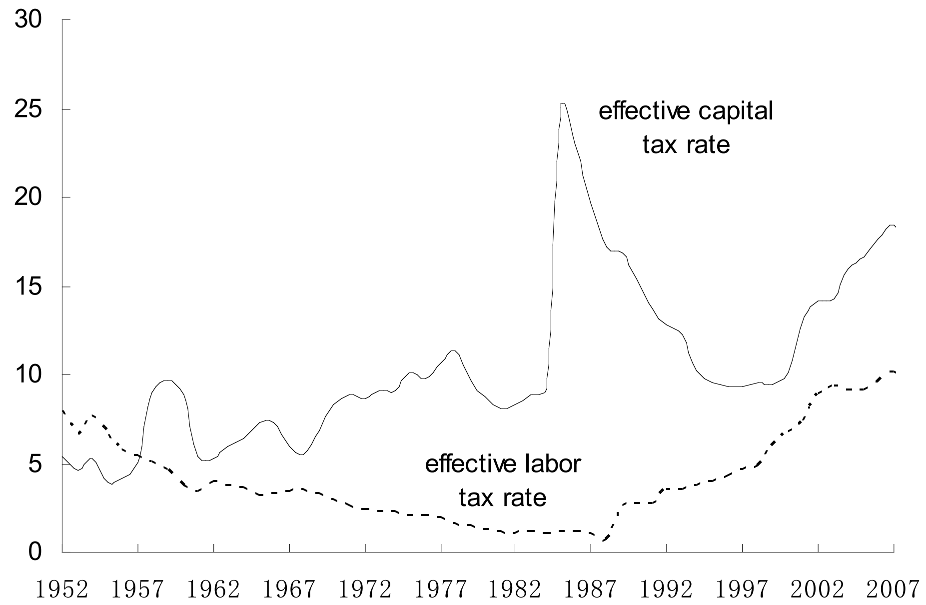
[24] This tax became a single-tax term in 1984 (GPD 1989).

[25] Data of weights for the years between 1985 and 2003 are from Li (2006). For the sake of simplicity, we apply the same weights for the years before 1985 as those in 1985 and for the years after 2003 as those in 2003.

[26] Though we can get data on capital and labor income from the NBS for those years, Wang (2007) suggests using the NBS statistics sparingly because of the question of "gray" income. Hot debates on this issue continue, with no agreement on how to adjust the official statistical data. Further analysis is strongly suggested.

Figure 3 displays the estimated annual effective capital and labor tax rates between 1952 and 2005. Note that while the capital tax rate shows an unusual increase between 1983 and 1985 due to fiscal reforms, the labor tax rate shows a modest decrease, then a modest increase, in the years since 1952.

Figure 3 Annual effective capital and labor tax rate



We then estimate the annual working-age population with data from the NBS and United Nations. The United Nations (2009) data contain estimates for every five years since 1950 and projections until 2050 for China, including estimates (for the period 1950–2005) and projections (for the period 2010–50) of percentages of population aged 0–14 and 65 or over.[27] We derive the annual age structure by the linearly imputing method and then estimating the annual working age (15–64 years) for the Chinese population for the period 1952–2005 using total population data from NBS (2010). Further, we compute the annual employment rate by dividing the total labor force by the total working-age population.

So far, we have collected actual Chinese time-series data for all the exogenous variables (see appendix table 1): TFP growth rate, population growth rate, share of government consumption in national income (G/Y), employment rate, and depreciation rate (δ). Data for annual real government consumption have been provided by the NBS.[28] Like Chen *et al.* (2006) and others who have used classical ways of calibrating macroeconomic models, we start from the actual capital-output

[27] The data set is divided into three scenarios: low, medium, and high variance. We use the data projected for the medium variant to get the age structure for China in 2010.

[28] Data of real government consumption are estimated by deflating the nominal one by the consumer price index (using 1952 as the base year).

ratio in 1953 and use a shooting algorithm to numerically compute the transition path generated by the model as it converges to its final steady state.

We set the capital share of output θ at 0.5036, which equals the average capital income share between 1978 and 2005. The subjective discount factor β is set at 0.947 to make the capital-output ratio 2.15 at the steady state which assumes to be that of empirical data in 2005. We calibrate the disutility parameter for working α to be 1.41 to obtain an average labor input of 43.9 to match the sample average weekly working hours in the empirical data for the period 1953–2005.[29]

For the steady-state calculations, we set the values for the exogenous variables so they are equal to their average values over 1953–2005. The resulting values are G/Y = 11.6%, δ =11.7%, τ^r =10.24%, and τ^w =3.77%. The growth rate of the TFP factor (γ -1) is set to 4.65 percent, and the growth rate of the working-age population is set to 1.85 percent.

In the benchmark simulation, we use the actual time-series data of the period 1953–2005 for the exogenous variables, and we assume the initial capital-output ratio in 1953 to be 0.836, which equals the actual ratio in 1953.

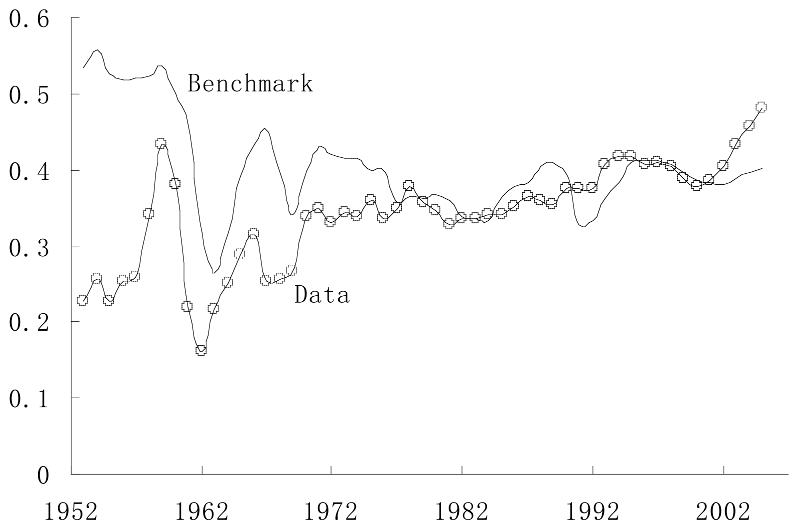
The results comparing the actual Chinese savings rates and those generated by the growth model, labeled "Benchmark," are shown in figure 4, which shows that theoretically simulating the savings rate between 1953 and 2005 seems to capture the movements in the empirical ones quite well, except for the beginning years.[30] China experienced several unusual events during this period, including the Great Leap Forward (GLF, 1958–1962), the Cultural Revolution (1966–1976), the Economic Reform (since 1978), and two fiscal reforms (in 1983–1985 and 1994, respectively).[31] Nevertheless, the benchmark model can still account for 27.4 percent of the actual savings rate, on average, between 1960 and 2005 and for about 62.8, 76.9, 60.9, and 95.6 percent for the 1960s, 1980s, 1990s, and 2000s, respectively. In general, Chinese save more when TFP growth is higher, and vice versa.

Figure 4 Benchmark economy

[29] To emphasize, we have no data for national aggregate weekly working hours until recent years. Data used here are from Wu and Yue (2010), who estimate labor input for Chinese industry and calculate weekly working hours adjusted for public holidays, working day systems, and the structures of various types of workers.

[30] The discrepancies between the simulated and actual data for the initial years are very sensitive to the initial capital stock assumption. Starting the economy with a higher initial capital stock in 1952 could simply shift the saving rates for the starting years closer to the actual series, while still holding the overall trends.

[31] Refer to earlier discussions on calculating the annual effective capital tax rate for this period.

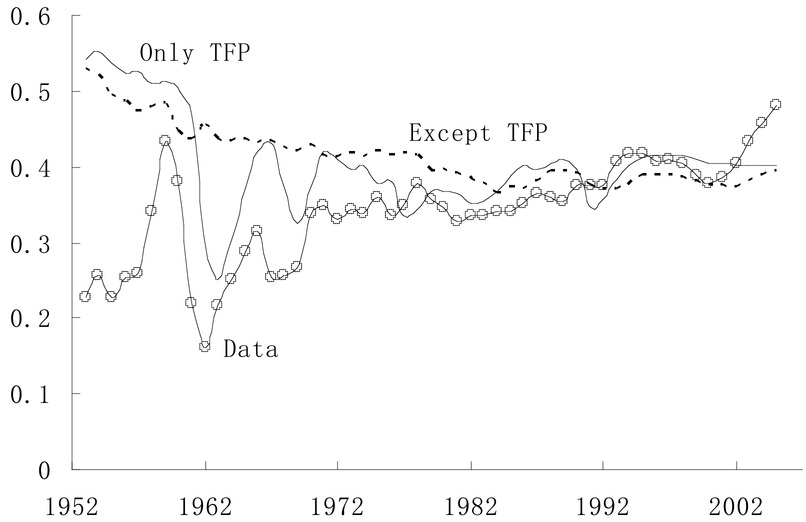


One more salient feature of figure 4 is that, contrary to commonly cited references to China's "unusually high" savings rate, the Chinese saved far less than those predicted by the theoretical model for most of the years except 2001–05. For the earlier years in 1950s we assume a stand-in household without any subsistence level of consumption and a complete financial market—in other words, theoretically, households could save and borrow any amount of output at the market interest rate whenever they wanted to, but in reality they did not do so because they needed to pay their basic living costs. This was true despite the fact that the return on capital was attractively high due to low initial capital stock and productivity growth was not too low because the income level at that time was low. The "oversaving" situation since 2001 may support the aforementioned argument that the Chinese are saving for their increasingly uncertain future, as well as to cover rising mandatory social insurance contributions due to conservative payouts. And we find no evidence for behavioral changes between the pre-reform "undersaving" years and the post-reform "oversaving" period—again inconsistent with existing literature.

Since all the exogenous variables show significant changes over this period, we have tried to simulate alternative scenarios by considering changes in some variables while holding all other exogenous variables constant at their steady-state levels to isolate the effects of the variables.

In figure 5 we display the results of two simulations: one is to use empirical time series data for all other exogenous variables holding TFP at its steady-state level (the dotted line labeled "Except TFP"), and the other is to use only the actual TFP growth rate while keeping other exogenous variables at their steady-state levels (the solid line labeled “Only TFP”).

Figure 5 Main determinants of the Chinese savings rate



It is very interesting that simulating the savings rate when considering only the actual TFP growth rate is quite similar to doing so when considering all the exogenous variables as empirical and co-moving well with the actual series or even a bit better than the *benchmark* scenario (now the simulated data can account for about 51.4 percent of the actual data for the period 1960–2005 on average), after eliminating the offset effects of other exogenous variables. Figure 5 shows the downward time series of the simulated savings rate caused by changes in the share of government consumption of GDP, employment rate, depreciation rate, and population growth rate, in contradiction to the upward trend in the actual savings rate. However, without displaying the relevant results of considering all exogenous variables empirical while holding TFP and capital income tax at their steady-state levels in figure 5, we find that the main differences between the situation of “Except TFP” and the benchmark are caused by sharp changes in capital income tax for the middle years of the 1980s due to the fiscal reform enacted in 1983 and 1985. We can further conclude that changes in the TFP growth rate between 1953 and 2005 are the main causes of this trend in the Chinese savings rate during this period.

The most problematic way of calculating parameters and time series of exogenous variables is to assume that the capital share θ is constant for the entire period between 1952 and 2005.[32] As discussed earlier, we have no official or reliable data series to estimate the time-variant capital shares, as China only recently began

[32] We thank Professor Yi Wen from Tsinghua University remind us of this.

to use the income approach to measure GDP, and estimating capital shares from aggregate production is inexact. Some researchers, such as Chen *et al.* (1988), have tried to estimate these series for the industry sector for the period 1953–85, but their data are much different from those used by Bai *et al.* (2006), who calculate time-variant θ for each year between 1978 and 2007, with an average of 0.5036, a figure we referred to earlier in this paper.[33] We then do sensitive analysis by using these annual shares to recalculate the corresponding series of the exogenous variables, and then recalibrate the benchmark model to the actual data between 1978 and 2005, a period in which data for all exogenous variables are available. Fortunately, the main conclusions we derived earlier in this paper still hold: the calibrated savings rate can still co-move well with the empirical data, and the Chinese have somehow "oversaved" only during recent years; besides, the significant increase in the capital tax burden during the middle years of the 1980s had a strong suppressing effect on savings, which in part explains why the savings rate for that period was stagnant despite high TFP growth.

Conclusion

There is a general consensus that China's savings rate is very high by international standards and that this is in part due to China's stable environment, economic restructuring, and rapid economic growth. At the same time, China's high savings rate has long been considered one of the most important factors of its high domestic investment rate, which is attributable to the rapid accumulation of physical capital stock and the corresponding increase in economic growth.

This paper revisits the determinants of China's savings rates since 1953, measuring changes in TFP, and uses a one-sector, neoclassical growth model to calibrate the economy to China's empirical data between 1953 and 2005. As implied by the strong association between annual TFP and economic growth, we find that changes in TFP closely track the movements in the savings rate for this period. The

[33] Actually, the capital or labor income shares vary a lot among literature. Chow (1993) used a value of 0.40 for the share of labor over 1952–1980. The labor shares estimated by Hu and Khan (1997) were 0.386 and 0.453 for the pre-reform and the reform periods, respectively. The study by Li *et al.* (1993) produced somewhat higher estimates for the labor income share in China, with average values of 0.462 and 0.536 for the pre-reform and reform periods, respectively. Young (2000) estimates the share attributable to labor using national income data and obtains a value of 0.60. Wang and Yao (2003) use a value of 0.50 for the share of labor for the period from 1953 to 1999. Chow and Lin (2002) find a constant labor exponent of about 0.35 from 1952 to 1998 for mainland China.

fiscal reform in 1983–85, while introducing several kinds of taxes and significantly expanding tax bases (thereby sharply increasing the average effective capital tax rate), also had a strong influence on China's savings rate in the mid-1980s.

In addition, our study points out that the savings rate was very high in China, especially in the post-reform years since 1978. While the so-called thrifty Chinese seem to have "undersaved" for most of the years since 1952, "oversaving" behavior became a problem only in the past decade. This may be attributed to an excess surplus in the social security system due to conservative payouts of social insurance plans. Also we also predict the national savings rate in China would finally fall in future accompanying with lower growth in TFP, which is consistent with other studies from aspects of a more complete capital market or an aging society in China (see CASS [2005], among others).

There can be no doubt, of course, that our study may miss some other important determinants of China's savings rate, as we neglect the heterogeneity of individuals. According to life-cycle models, for example, demographic transition and related changes in the age structure could play key roles in affecting consumption, investment, and labor input, which in turn would impact the savings rate. This and possibly other models would benefit from future research.

Acknowledgements

We would like to thank to Kaiji Chen of the University of Oslo; Mariano Kulish of the Reserve Bank of Australia; and Jiandong Ju, Qing Liu, Yi Wen, Xiaodong Zhu, and other seminar participants at Tsinghua University for their help and comments. All errors are the responsibility of the authors.

Financial supports from Asian Development Bank and Tsinghua University are gratefully acknowledged.

Appendix Table 1 Data for exogenous variables used in calibration

	Population growth rate	Depreciation rate	G/Y	TFP growth rate
1953	1.0105	0.1188	0.1370	1.3452
1954	1.0125	0.1166	0.1171	0.9644
1955	1.0073	0.1167	0.1257	1.0142
1956	1.0153	0.1178	0.1149	1.0875
1957	1.0221	0.1175	0.1099	0.9656
1958	1.0138	0.1218	0.0909	1.0570
1959	1.0114	0.1240	0.0843	0.9795
1960	0.9783	0.1245	0.1209	0.8449
1961	0.9920	0.1216	0.1338	0.5298
1962	1.0190	0.1178	0.1125	0.9075
1963	1.0251	0.1147	0.1256	1.1911
1964	1.0164	0.1132	0.1225	1.2949
1965	1.0261	0.1136	0.1161	1.2394
1966	1.0298	0.1148	0.1180	1.0823
1967	1.0267	0.1135	0.1062	0.8313
1968	1.0305	0.1132	0.1098	0.8658
1969	1.0294	0.1142	0.1120	1.2243
1970	1.0309	0.1167	0.1023	1.2312
1971	1.0278	0.1176	0.1119	0.9965
1972	1.0237	0.1180	0.1129	0.9791
1973	1.0241	0.1187	0.1075	1.0474
1974	1.0193	0.1195	0.1122	0.9388
1975	1.0180	0.1205	0.1077	1.0461
1976	1.0266	0.1205	0.1159	0.8810
1977	1.0259	0.1196	0.1128	1.0670
1978	1.0258	0.1192	0.1174	1.1229
1979	1.0255	0.1175	0.1389	1.0461
1980	1.0239	0.1162	0.1303	1.0348
1981	1.0294	0.1133	0.1309	1.0018
1982	1.0312	0.1115	0.1302	1.0639
1983	1.0284	0.1111	0.1270	1.1029
1984	1.0280	0.1125	0.1324	1.1522
1985	1.0290	0.1137	0.1255	1.1167
1986	1.0218	0.1145	0.1267	1.0374
1987	1.0228	0.1155	0.1169	1.0848
1988	1.0219	0.1162	0.1039	1.0825
1989	1.0212	0.1142	0.1009	1.0082
1990	1.0205	0.1126	0.1058	0.8770
1991	1.0119	0.1122	0.1193	1.1026
1992	1.0105	0.1130	0.1227	1.1786
1993	1.0103	0.1146	0.1226	1.1471
1994	1.0101	0.1160	0.1178	1.1185
1995	1.0095	0.1152	0.1027	1.0790
1996	1.0138	0.1149	0.1025	1.0607
1997	1.0134	0.1162	0.1027	1.0558
1998	1.0125	0.1168	0.1058	1.0327
1999	1.0115	0.1175	0.1106	1.0366
2000	1.0109	0.1185	0.1160	1.0541
2001	1.0158	0.1197	0.1200	1.0457
2002	1.0152	0.1209	0.1200	1.0554
2003	1.0146	0.1230	0.1162	1.0553
2004	1.0144	0.1256	0.1144	1.0498
2005	1.0144	0.1282	0.1167	1.0511

Notes: G/Y = government consumption in national income; TFP = total factor productivity.

References

Abramovitz M. 1986. Catching Up, Forging Ahead, and Falling Behind. *The Journal of Economic History* 46 (2): 385-406.

Academy of Macroeconomic Research of the National Development and Reform Commission (AMR, NDRC). 2007. China's High Investment Rate Is A Long-run Phenomenon. *China Economic Herald* (in Chinese), May 1, 2007.

Aghion P, Comin D, Howitt P. 2006. When Does Domestic Saving Matter for Economic Growth. National Bureau of Economic Research (NBER) working paper no. 12275. Online at: http://www.nber.org/papers/w12275.

Bai C, Hsieh C, Qian Y. 2006. The return to capital in China. *Brookings Papers on Economic Activity* 2: 61–88.

Barnett S, Brooks R. 2006. What's Driving Investment in China? International Monetary Fund working paper. Online at: http://www.imf.org/external/pubs/ft/wp/2006/wp06265.pdf.

Chen K, Imrohoroglu A, Imrohoroglu S. 2006. The Japanese saving rate. *The American Economic Review* 96(5): 1850–58.

Chen K, Imrohoroglu A, Imrohoroglu S. 2007. The Japanese saving rate between 1960 and 2000: productivity, policy changes, and demographics. *Economic Theory* 32(1): 87–104.

Chen K, Wang H, Zheng Y, Jefferson GH, Rawski TG. 1988. Productivity change in Chinese industry: 1953–1985. *Journal of Comparative Economics* 12: 570–91.

China Academy of Social Science (CASS). 2005. High Growth of Investment, Macro-cost and the Sustainability of Economic Growth. *Economic Research Journal* (in Chinese) 10: 12-23.

Chow GC. 1993. Capital formation and economic growth in China. *The Quarterly Journal of Economics* 108(3): 809–42.

Chow GC, Li K. 2002. China's economic growth: 1952–2010. *Economic Development and Cultural Change* 51(1): 247–56.

Chow GC, Lin A. 2002. Accounting for Economic Growth in Taiwan and Mainland China: A Comparative Analysis. *Journal of Comparative Economics* 30: 507–530.

Fehr H, Jokisch S, Kotlikoff LJ. 2005. Will China eat our lunch or take us out to dinner? Simulating the transition paths of the U.S., EU, Japan, and China. National Bureau of Economic Research (NBER) working paper No. 11668. Online at: http://www.nber.org/papers/w11668.pdf?new_window=1.

Felipe J, McCombie JSL. 2002. Productivity growth in China before and after 1978: revisited. *Zagreb International Review of Economics & Business* 5(1): 17–43.

General Planning Department of Ministry of Finance of People's Republic of China (GPD) (edited).

1989. *China Finance Statistics: 1950–1988*. Beijing: China Financial and Economic Publishing House.

Goldsmith RW. 1951. A perpetual inventory of national wealth. *Studies in Income and Wealth* 14: 5–74. Online at: http://www.nber.org/chapters/c9716.

Harbaugh R. 2004. China's high savings rates. Prepared for conference on "The Rise of China Revisited: Perception and Reality," National Chengchi University (published in Chinese in conference volume). Online at: http://www.bus.indiana.edu/riharbau/harbaugh-chuxu.pdf.

Hayashi F. 1986. Why is Japan's saving rate so apparently high? *NBER Macroeconomics Annual* 1: 147-210.

He L, Feng J, Hirosh S. 2008. Pension reform and household saving: the Chinese case. *Economic Research Journal* (in Chinese) 10: 117–30.

He X, Y Cao. 2007. Understanding High Saving Rate in China. *China & World Economy* 15(1): 1-13.

Horioko CY. 1990. Why is Japan's household saving rate so high? A literature survey. *Journal of the Japanese and International Economics* 4(1): 49–92.

Krugman P. 1997. The Age of Diminished Expectations: U. S. Economic Policy in the 1990s. Cambridge, Massachusetts: MIT Press.

Koester RB, Kormendi RC. 1989. Taxation, aggregate activity and economic growth: cross country evidence on some supply side hypotheses. *Economic Inquiry* 27: 367–87.

Kraay A. 2000. Household savings in China. *World Bank Economic Review* 14(3): 545–70.

Kuijs L. 2005. Investment and saving in China. World Bank Policy Research Paper Series No. 3633, Washington, DC.

Kulish M, Kent C, Smith K. 2010. Aging, Retirement, and Savings: A General Equilibrium Analysis. *The B.E. Journal of Macroeconomics* 10 (1) Topics), Article 18. Online at: http://www.bepress.com/bejm/vol10/iss1/art18.

Li Z. 2006. A calculation for effective tax rates of capital income, labor income and consumption expenditure. *Taxation Research Journal* (in Chinese) 4: 14–18.

Liang H. 2006. China's Investment Strength is Sustainable. Goldman Sachs Global Economics Paper 146. October 3, 2006. Online at: http://www2.goldmansachs.com/ideas/brics/book/BRICs-Chapter4.pdf.

Liu C. 2004. Evaluation and international comparison of average effective tax rate of consumption labour and capital of China. *Collected Essays on Finance and Economics* 4: 9–16.

Liu R, Ma S. 2002. On taxation and economic growth: the effects of taxation imposed on labor, capital and consumption. *Social Science in China* 1: 67–76.

Lu L, McDonald IM. 2005. Does China Save Too Much. *Singapore Economic Review* 51(3): 283-301.

Lv B. 2008. The dynamic efficiency of China's capital accumulation: 1978–2005. *China Economic Quarterly* (in Chinese) 7(2): 509–32.

Ma S. 2008. The Analysis of Chinese Saving Rate with Endogenous Structure Break: 1953-2005. *The Journal of Quantitative & Technical Economics* (in Chinese) 7: 118-127.

Mendoza EG, Milesi-Ferretti GM, Asea P. 1997. On the ineffectiveness of taxes policy in altering long-run growth: Harberger's superneutrality conjecture. *Journal of Public Economics* 66: 99–126.

Modigliani F, Cao SL. 2004. The Chinese saving puzzle and the life-cycle hypothesis. *Journal of Economic Literature* 42(1): 145–70.

National Bureau of Statistics (NBS) of People's Republic of China. 2010. *China Compendium of Statistics: 1949–2008.* Beijing: China Statistics Press.

Padovano F, Galli E. 2002. Comparing the growth effects of marginal vs. average tax rates and progressivity. *European Journal of Political Economy* 18: 529–44.

Perkins DH. 2005. China's Economic Growth in Historical and International Perspective. *China Economic Quarterly* (in Chinese) 4(4): 891-912.

Perkins DH, Rawski TG. 2007. Forecasting China's economic growth to 2025. In: Brandt L and Rawski TG (ed). *China's Great Economic Transformation*, Version of September 7, 2007, to appear as Chapter 20. Cambridge: Cambridge University Press, 2008.

Qiao W, Dong B. 2005. Determination of the Reasonable Capital Formation Rate in Chinese Economic Growth. *China Soft Science* (in Chinese) 7: 76-82.

Ren R, Qin X. 2006. Measuring the comparable household saving rates of China and USA, 1992–2001. *Economic Research Journal* (in Chinese) 3: 67–81.

Sadahiro A, Shimasawa M. 2002. The computable overlapping generations model with an endogenous growth mechanism. *Economic Modeling* 20:1-24.

Shi J, Zhu H.2004. Precautionary saving of Chinese urban households and its intensity: 1999–2003. China Center for Economic Research Working Paper No. C2004013, Beijing: Beijing University. Online at: http://www.usc.cuhk.edu.hk/webmanager/wkfiles/3444_1_paper.pdf.

Solow R. 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics* 36: 1–26.

Song G. 2006. China's Investment Rate is too Low? *Beijing Morning News* (in Chinese), July 31, 2006. Online at: http://finance.sina.com.cn/economist/jingjixueren/20060731/02102775991.shtml.

Sun W, Xiao G, Yang X. 2010. Effects of Return to Capital on Investment Rate: Comparing China with Japan and the United States. *World Economy* (in Chinese) 6: 3-24.

United Nations, Department of Economic and Social Affairs, Population Division. 2009. *World Population Prospects: The 2008 Revision*. New York: United Nations.

Wan G, Zhang Y, Niu J. 2001. Liquidity constraints, uncertainty and household consumption in China. *Economic Research Journal* (in Chinese) 11: 35–44.

Wang D, Gong L. 2007. On the Consumption and Savings in a Persisted-growth Economy. *Journal of Financial Researc*h (in Chinese) 12: 1-16.

Wang Y, Yao Y. 2003. Sources of China's economic growth 1952–1999: incorporating human capital accumulation. *China Economic Review* 14: 32–52.

Wang X. 2007. Grey income and income inequality in China. National Economic Research Institute (NERI) working paper. Online at: http://www.neri.org.cn/workpaper/82wxl.pdf.

Wen Y. 2009. Saving and Growth under Borrowing Constraints: Explaining the "High Saving Rate" Puzzle. Federal Reserve Bank of St. Louis Working Paper 2009-045C. Online at: http://research.stlouisfed.org/wp/2009/2009-045.pdf.

World Bank. 2005. A Better Investment Climate for Everyone. World Development Report.

Wu H, Yue X. 2010. Accounting for labor input in Chinese industry, 1949–2005. Paper prepared for the 31st IARIW General Conference, St. Gallen, Switzerland, August 22–28.

Wu Z. 2002. Consumption and Investment in Economic Growth in China. *Social Science in China* 3: 49-62.

Xie P. 1993. Individual saving behavior in China. *Journal of Financial Research* (in Chinese) 8: 23–27.

Yuan Z, Song Z. 2000. The age composition of population, the endowment insurance system and optimal savings ratio in China. *Economic Research Journal* (in Chinese) 11: 24–32.

Zhang J, Wu G, Zhang J. 2004. The estimation of China's provincial capital stock: 1952–2000. *Economic Research Journal* (in Chinese) 10: 35–44.

Zhang M. 2007. New Developments of the Research on Saving Rate after the 1990s. *The Journal of World Economy* 4: 86-95.

Zhong S, Li K. 2009. The impact of dependence ratio on household savings rate. *Chinese Journal of Population Science* (in Chinese) 1: 42–51.

Zhang Y, Wan G. 2004. Liquidity constraint, uncertainty and household consumption in China. *Applied Economics* 36: 2221-2229.