Making Sense of China's Excessive Foreign Reserves*

Yi Wen
Federal Reserve Bank of St. Louis
&
Tsinghua University

This Version: March 7, 2011

Abstract

Large uninsured risk, severe borrowing constraints, and rapid income growth can create excessively high household saving rates and large current account surpluses for emerging economies. Therefore, the massive foreign-reserve buildups by China are not necessarily the intended outcome of any government policies or an undervalued home currency, but instead a natural consequence of the country's rapid economic growth in conjunction with an inefficient financial system (or lack of timely financial reform). A tractable growth model of precautionary saving is provided to quantitatively explain China's extraordinary path of trade surplus and foreign-reserve accumulation in recent decades. Ironically, the analysis suggests that without a well-developed domestic financial market, the value of the renminbi (RMB) may significantly depreciate, instead of appreciate, once the Chinese government abandons the linked exchange rate and the massive amount of precautionary savings of Chinese households are unleashed toward international financial markets to search for better returns.

Keywords: Current Account, Foreign Reserve, Trade Deficit, Buffer Stock Saving, Global Imbalance, Incomplete Markets, Uninsured Risk.

JEL Codes: E21, F11, F30, F31, F32, F34, F40, F41, O16.

*I thank Chris Carroll, David Andolfatto, Coughlin Cletus, Silvio Contessi, Bill Gavin, Chris Neely, Juan Sanchez, Dan Thornton, David Wheelock, Xiaodong Zhu, and seminar participants at the St. Louis Fed and the 2010 Conference on Chinese Economy (Fudan) for comments, and Judy Ahlers for editorial assistance. The usual disclaimer applies. Correspondence: Yi Wen, Research Department, Federal Reserve Bank of St. Louis, St. Louis, MO, 63104. Phone: 314-444-8559. Fax: 314-444-8731. Email: yi.wen@stls.frb.org.

1 Introduction

China's trade balance has risen from a small deficit (-\$1.1 billion) in 1978 (the beginning year of economic reform) to a huge surplus (\$400 billion) in the first half of 2009. The bulk of the surplus results in trade with the United States. During the same period, China's foreign exchange reserves (mostly U.S. dollars) have increased even more dramatically from \$2 billion to \$2.4 trillion—a more than 1,000 fold expansion, making China the world's largest holder of foreign exchange reserves.[1] If every Chinese household had bought more American goods, trade between China and the United States would have been more balanced. Why don't Chinese people spend their dollars and buy more American goods?

Many annalists believe that the steady increase in America's trade deficit with China is the consequence of a significantly undervalued Chinese currency (the RMB). Namely, Chinese goods are too cheap relative to American goods. Hence, Americans can buy lots of Chinese goods while the Chinese can barely afford American goods. Indeed, some economists and politicians in the United States have alleged that the Chinese government has been manipulating its currency to deliberately achieve a large trade surplus and an excessive amount of foreign reserves.[2]

Why, let alone how, would the Chinese government do that? One popular argument is that an undervalued home currency promotes domestic employment. However, selling goods at significantly low prices to the United States and holding American dollars as a store of value is equivalent to lending goods to American consumers in return for cheap IOUs that pay negative interest (due to inflation). Chinese workers may be better off spending the dollars they earn instead of hoarding them. Why would the Chinese tighten their belts and lend to Americans when they are still struggling with very low per capita income? Shouldn't they borrow from Americans instead to increase their current consumption and pay back in the future when they all become rich?

The truth is that imbalanced trade may have nothing to do with the exchange rate. Even a layman can understand the following arithmetic: Suppose the real exchange rate between Chinese- and American-made products is 1:1—for example, 1 Chinese orange for 1 American apple. When China gives up 1 orange for 1 American apple, trade is balanced between the two countries because total Chinese exports (1 orange) equal total imports (1 apple) in value. Suppose the Chinese government is able to manipulate and depreciate the real exchange rate so that Chinese workers must give up 100 oranges for 1 American apple. Despite the extremely cheap Chinese products

[1] This is equivalent to 50% of China's GDP in 2009.

[2] A bipartisan group of 14 U.S. senators announced new legislation in March 2010 to punish China for unfair currency manipulation (see http://schumer.senate.gov/record.cfm?id=323135). Paul Krugman joined the ranks of many U.S. legislators in calling for substantial tariffs on Chinese imports "if sweet reason won't work" and the Chinese authorities fail to heed demands to revalue their currency (see Krugman, 2010).

with a real exchange rate of 100:1, trade between the two nations is still balanced—the total value of Chinese exports (worth 1 American apple) still equals the total value of Chinese imports (1 American apple). Therefore, trade can be always balanced regardless of the exchange rate.

Imbalances of trade (or current account surplus) would arise if the following situation occurs: Suppose Chinese workers gave up 100 oranges for 1 US dollar (USD), with which they could buy 1 American apple; but instead of spending the entire dollar by importing 1 American apple, Chinese workers bought only half an American apple and kept the remaining 50¢ as savings. In this case, China would incur a trade surplus of $\frac{1}{2}$ American apple, equivalent to lending 50 oranges to American consumers in return for 50¢ as IOUs. Again, why would Chinese workers do that—tightening their belts and lending to Americans when they are still struggling with a very low personal consumption level?

Standard economic theory of incomplete markets and precautionary saving provides one plausible explanation: Even though China has experienced impressive economic growth over the past 30 years since its economic reform and joining the globalization process, its financial reform has not kept pace with its economic growth. Because of the lack of social safety nets and severely underdeveloped insurance and financial markets, Chinese workers must save excessively to insure themselves against idiosyncratic uncertainty, such as bad income shocks, unemployment risk, accidents, and many unexpected spending needs in housing, education, health care, and so on.

Theory predicts that when households face large uninsured risk (—which does not diminish with economic growth) and are subject to severe borrowing constraints, not only do they save excessively, but their marginal propensity to save also *increases* with income growth. That is, the more income they earn, the larger portion of the income they will save—in sharp contrast to the conventional wisdom based on Friedman's (1957) permanent income hypothesis (PIH).

Indeed, during China's 30 years of rapid economic growth, its private consumption-to-GDP ratio has fallen from roughly 50% in 1980 to 35% in 2008 (see the C/Y ratio in Figure 1), while government spending as a fraction of total national income has remained roughly constant at about 14%.[3] Hence, Chinese consumers have reduced their propensity to consume significantly despite the rapidly rising per capita income and average GDP growth rate. Since trade surplus is part of national savings, China's national saving rate (private investment plus net exports) has also increased steadily over the past 30 years, from 34% to 51% (see the $(I + NX)/Y$ ratio in Figure 1).

[3] Data Source: China Statistical Year Book (2009).

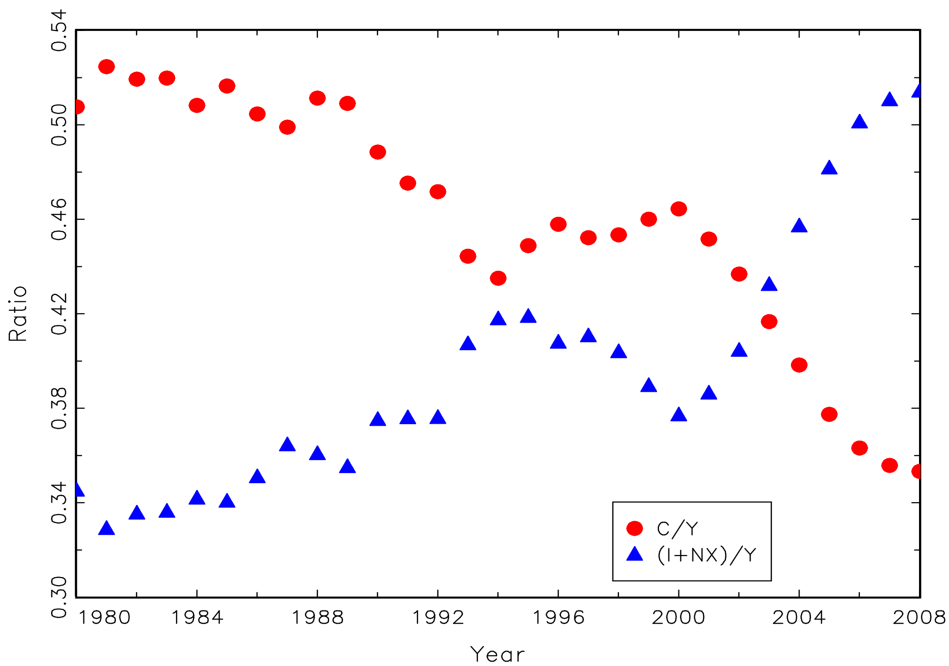

Figure 1. Aggregate Saving Rate (▲) and Consumption Ratio (●).

A similar pattern of saving behavior is also revealed at the household level. Figure 2 depicts the household saving ratio (blue diamonds, left axis) and the long-term growth rate of household income (red squares, right axis) for the period 1953-2006. The household saving rate is defined as the ratio between net wealth changes and disposable income, and the long-term income-growth rate is defined as the average growth rate of the past 14 years, following Modigliani and Cao (2004).[4] The figure shows that the household saving rate tracks the long-term income growth rate very closely and has increased steadily since 1978. The household saving rate peaked in 2006 at 37%. The bulk of the household saving consists of bank deposits despite low interest rates, suggesting that safe and low-yield assets are the primary saving vehicles for Chinese households.[5] The average real interest rates remained essentially at zero or negative values in the post-reform period. For example, the average nominal 3-month deposit rate was 3.3%, the average 1-year rate was 5.6% (green triangles, left axis), while the average inflation rate was about 6% in the 1991-2007 period.[6]

[4] Household wealth includes deposits, bonds, and individual investments. Excluding individual investments lowers the saving rate slightly but does not change the dynamic pattern of the household saving ratio. See Wen (2009a) for details of the data source.

[5] Wen (2009b) shows that in China and India the share of cash and bank deposits accounts for more than 90% of total household financial wealth.

[6] Data for the interest rates before 1990 are not available.

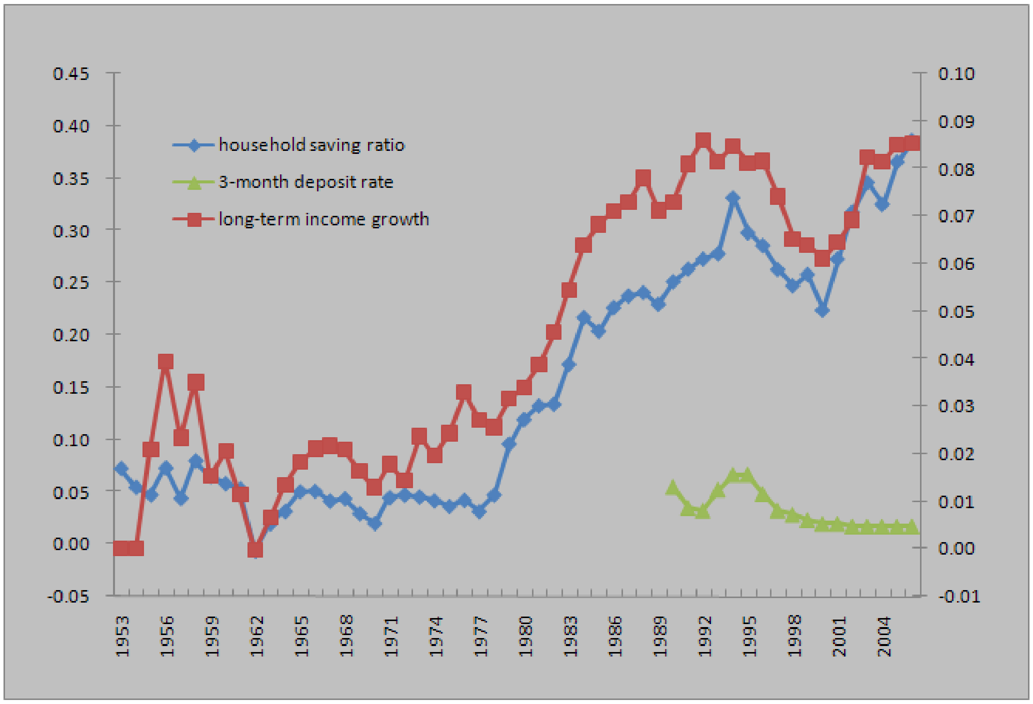

Figure 2. Household Saving Ratio (left scale) and Income Growth (right scale)

Consistent with the pattern of rising saving rates and declining consumption-to-income ratios, China's total imports-to-exports ratio has also fallen during the fast growth period, from 1.6 in 1985 to around 0.8 in 2008—cut in half in less than 25 years.[7] That is, while exports have grown at a double-digit annual rate, total imports have failed to catch up. As a result, China's trade surplus and foreign reserves have exploded.[8]

Therefore, data suggest that Chinese households have been saving an increasingly larger portion of their income (including dollars earned from international trade) maybe to provide the safety net and self-insurance unavailable to them from markets; and such precautionary saving behavior is perfectly consistent with economic theory. Similar patterns of excessive saving behaviors have also been observed in other emerging economies during their rapid growth periods, such as Japan in the 1960-70s, Hong Kong in the 1980s, and Taiwan and South Korea in the 1990s. But it is the gigantic size of the Chinese economy that has made the phenomenon so much more alarming and astonishing to trade economists and commentators.

The analysis suggests that the linked (or undervalued) exchange rate between the RMB and the USD is not necessarily the culprit in the trade imbalance between China and the rest of the world.[9] Rather, it is the rapid income growth and lagging financial development in China that have created the problem, and only financial development can ultimately resolve it.

[7] The first half of 2009 recorded an even much smaller number: 0.23.

[8] We defer the discussion of the trade data to a later section.

[9] Ironically, if Chinese savers were free to put their money anywhere in the world, there could be a large outflow of RMB into other currencies and a resulting depreciation rather than appreciation of the RMB.

2 A Brief Review of the Literature

The above arguments are formalized in this paper using a small-open-economy model featuring time-varying long-run growth, uninsured risk, and borrowing constraints. The analysis is related to the existing literature on global imbalances, most notably Caballero, Farhi, and Gourinchas (2008), Mendoza, Quadrini, and Rios-Rull (2009), and Ju and Wei (2010).[10] Caballero et al. (2008) attempt to explain the triple phenomena of the sustained rise in US current account deficits, the persistent decline in long-run world real interest rates, and the rise in US assets in global portfolios as an equilibrium outcome of an economic environment in which various regions of the world differ in their capacity to generate financial assets from real investments. They argue that fast growth in emerging economies, coupled with their inability to generate sufficient local store-of-value instruments, would increase their demand for saving instruments from the developed world. This leads to a rise in capital flows toward the United States, a decline in real interest rates in the world financial market, and an increase in the importance of American assets in global portfolios.

Mendoza, Quadrini, and Rios-Rull (2009) argue that persistent global imbalances and their portfolio composition could be the result of international financial integration among countries with heterogeneous domestic financial markets. In particular, countries with more advanced financial markets attract financial capital from countries with less developed financial markets and maintain positive net holdings of nondiversifiable equity and foreign direct investment (FDI).

Ju and Wei (2010) study how domestic institutions affect patterns of international capital flows. They argue that an inefficient financial system and poor corporate governance may be bypassed by two-way capital flows in which domestic savings leave the country in the form of financial capital outflows but domestic investment takes place through inward FDI from countries with more efficient financial systems and better corporate governance.

Aforementioned papers all emphasize differences in cross-country financial deepness in affecting the composition of asset portfolios and international capital flows. However, by focusing on financial deepness alone, the literature does not directly and quantitatively explain the excessively high saving rate and massive foreign reserves in China. In contrast, this paper explains why the Chinese saving rate is so high and that it is precisely this high propensity to save that has led to the large trade surplus and foreign reserve buildups, irrespective of exchange rates. However, this paper does use the key insight of the global-imbalance literature to argue that the Chinese currency may have been significantly *overvalued* instead of undervalued, despite the large trade surplus. One the one hand, the underdeveloped financial institutions in China are incapable of generating sufficient local store-of-value instruments to satisfy the strong asset demand of Chinese households, one the other hand

[10] For the related literature, also see Blanchard and Feldstein (2008), Engel and Rogers (2006), Dooley and Garber (2007), Giavazzi, and Sa (2005), Gourinchas and Jeanne (2007), Jeanne (2007), Jeanne and Rancière (2008), Jin (2008), Obstfeld and Rogoff (2005, 2009), and Yu (2007), among many others.

capital controls in China have effectively blocked the outflows of financial capital toward developed countries and insulated the RMB from depreciation. Therefore, the strong need of international risk diversification and demand for foreign assets imply that further revaluation of the RMB by the Chinese government may lead to a sharp depreciation and collapse in the value of the RMB once China's capital control is lifted in the future—which may be a catastrophic disaster because a sudden and large depreciation of the RMB can have destructive effects on Chinese asset markets, as occurred to many emerging economies during the 1997 Asian financial crisis.

A similar point linking precautionary saving motives to exchange reserve buildups is also made by Durdu, Mendoza, and Terrones (2007), Sandri (2008), and Carroll and Jeanne (2009), among others. Durdu, Mendoza, and Terrones (2007) use an open-economy neoclassical model with uninsured risk and borrowing constraints to study the increase in foreign assets due to optimal self-insurance against sudden stops. Sandri (2008) argues that growth acceleration in a developing country can cause a larger increase in saving than in investment because capital market imperfections induce entrepreneurs not only to self-finance investment but also to accumulate precautionary wealth outside their business enterprise.[11] Using a tractable model of precautionary savings due to unemployment risk, Carroll and Jeanne (2009) show that rapid income growth and an associated increase in unemployment risk can lead to a large buildup of domestic savings relative to domestic capital demand, and hence outflows of financial capital from developing countries to developed ones.

This paper complements this segment of the literature. However, it differs in focus, analytical approaches, and solution methods. For example, in contrast to Durdu, Mendoza, and Terrones (2007), this paper emphasizes idiosyncratic risk, rather than aggregate risk, in determining household saving rates and a nation's current account surplus. Also, in contrast to Sandri (2008), this paper deals explicitly with nominal foreign reserves and calibrates the model to quantitatively match Chinese data. On the solution-technique side, this paper relies on quasi-linear utility function to obtain closed-form solutions under uninsured idiosyncratic risk and borrowing constraints, in contrast to Carroll and Jeanne (2009).

Song, Storesletten, and Zilibotti (2011) provide a model of resource reallocation to explain China's rapid growth and economic transition, as well as its foreign reserve buildup.[12] They argue that because private firms face borrowing constraints and public firms have better access to credit markets in China, the downsizing of state-owned firms during the transition reduces aggregate demand for capital and forces the excess domestic savings to be invested abroad, generating a foreign surplus. However, their analysis does not take into account capital controls in China—

[11] For a similar approach, see Buera and Shin (2010).

[12] Resource reallocation and endogenous TFP growth in a transition economy are also emphasized by Buera and Shin (2010).

household savings in China cannot be converted or invested directly in foreign assets unless these savings are in the form of dollars. The way to obtain dollars is through exports, but most state-owned firms in China do not engage in exports. Therefore, their model does not explain why the export sector in China (consists mainly of private enterprises) opts to save so much by hoarding a large amount of foreign reserves (dollars) and running a large trade surplus.

The rest of the paper is organized as follows. Section 3 provides a benchmark model with only an export sector to illustrate the main points of the paper. Section 4 extends the benchmark model to a more general setting with capital accumulation. Important features such as nontradable goods, a linked exchange rate, and capital controls are explicitly introduced. The general model is meant to better capture the salient features of the Chinese economy and demonstrates the robustness of the results in the previous section. The determination of the exchange rate is also studied in the general model. It is shown that, even though China's domestic investment rate is already one of the highest in the world, it may never be high enough to completely absorb China's domestic savings when financial markets are incomplete, regardless of the exchange rate. Section 5 further establishes the robustness of the results by showing that China's trade surplus will likely remain even after relaxing capital controls and allowing for a floating exchange rate. Section 6 concludes the paper.

3 Benchmark Model

This is a small open-economy model where the home country (e.g., China) is denoted by H and the rest of the world by F. For simplicity, assume that (i) home-produced goods are for export only and home residents consume only foreign-produced goods, and (ii) F is large enough so that the price of tradable goods is not affected by H's exports and imports.[13] Denote P_t^* as the nominal price of goods sold in country F in terms of foreign currency (dollars), which is also the price that households of H pay for imported goods from abroad. So trade involves the same goods and the law of one price holds. The inflation rate, $\frac{P_t^* - P_{t-1}^*}{P_{t-1}^*}$, is assumed to be zero over time.[14]

Although a foreign currency exists in the model—which serves as the means of payment for tradable goods—it is not required for home-country residents to hold it. In other words, we do not impose the standard cash-in-advance constraint or the money-in-utility assumption to induce money demand. Instead, we motivate money demand by precautionary saving motives as in Bewley (1980) and Lucas (1980). Thus, if households opt to hold foreign currency, it is purely for precautionary saving reasons. This modeling strategy allows us to combine precautionary saving behavior with

[13] A salient feature of the Chinese economy is that Chinese currency is not internationally convertible. Because of such capital controls, domestic savings in China cannot be invested directly in foreign assets. Hence, the existence of an export sector is key for explaining the accumulation of foreign reserves in China.

[14] The results are not sensitive to this assumption.

money demand without making other additional assumptions about why people hold money.

There is a continuum of households in country H indexed by $i \in [0,1]$. Income earned from exports in the tradable sector can either be consumed or saved (in dollars). Foreign reserves are thus measured in dollars and are kept by households instead of by the government.[15] For simplicity, assume that holding foreign currency earns a zero nominal interest rate; hence, the real rate of return to foreign currency is the inverse of the inflation rate in country F.[16]

Households are borrowing- and short-sale constrained, as in Bewley (1980), Aiyagari (1994), and Huggett (1993). That is, they cannot hold negative amounts of any assets. Each household is subject to an idiosyncratic shock $\theta_t(i)$, which has support $\theta \in \left[\underline{\theta}, \overline{\theta}\right]$ and cumulative density function $F(\theta)$. Since the exact source of the idiosyncratic uncertainty does not matter for our main results, we consider idiosyncratic preference shocks to make the model analytically tractable. Such shocks represent unexpected consumption needs (e.g., illness and medical emergency) that are not insured by markets (as in Lucas, 1980). Considering such a simple and extreme form of idiosyncratic shocks helps sharpen the key insights of the model, yet without undermining realism.

Tradable goods are produced using the production technology $Y_t = A_t N_t$, where N_t denotes labor and A_t productivity, which grows over time according to[17]

$$A_t = A_0 \left(1 + \bar{g}\right)^t . \tag{1}$$

Perfect competition implies that the real wage is given by $W_t = A_t$. Since the economy has a balanced growth path, we can transform the model into a stationary economy by scaling (normalizing) all endogenous variables, except hours worked, by the growth factor, $\left(1 + \bar{g}\right)^t$. All normalized variables are denoted by lower-case letters (e.g., $x_t \equiv \frac{x_t}{(1+\bar{g})^t}$). Note that the rescaled real wage $w_t \equiv A_0$.

To make the model analytically tractable, we follow Wen (2009a) by assuming that (i) the utility function is quasi-linear (indivisible labor) and (ii) the labor supply is determined in each period before observing the idiosyncratic preference shock, $\theta_t(i)$.[18]

Denote $M_t(i)$ as the stock of money balances held by household i by the end of period $t-1$, $C_t(i)$ real consumption for imported goods in period t, and $N_t(i)$ hours worked in period t. Applying the transformation, we have $m(i) \equiv \frac{M_t(i)/P^*_{t-1}}{(1+\bar{g})^t}$, $m'(i) \equiv \frac{M_{t+1}(i)/P^*_t}{(1+\bar{g})^{t+1}}$, and $c_t(i) \equiv \frac{C_t(i)}{(1+\bar{g})^t}$. Household

[15] Alternatively, we can allow households to sell dollars to the government and use the proceeds to purchase local government bonds. In this way, all foreign reserves will then be held by the government in Country H instead of by households, but the results will be similar.

[16] The results would be similar if we let the government to bear the inflation risk by holding foreign reserves or paying households interest on their foreign currency accounts.

[17] For the sake of argument, ignore aggregate uncertainty for a moment.

[18] Because of quasi-linear preference, assumption (ii) is needed to ensure that agents cannot use perfectly elastic labor income to fully insure themselves against idiosyncratic risk. This assumption is not needed if the marginal cost of labor supply is increasing, but then closed-form solutions are not possible.

i's problem is to solve

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \theta_t(i) \log c_t(i) - aN_t(i) \right\} \tag{2}$$

subject to

$$c(i) + (1 + \bar{g})\, m'(i) \leq m(i) + wN(i) \tag{3}$$

$$m'(i) \geq 0, \tag{4}$$

and $N(i) \in \left[0, \bar{N}\right]$. Equation (3) is the budget constraint, which states that total wage income earned from working in the tradable-goods sector can be used to finance purchases of foreign-produced goods (c) and the accumulation of foreign currency (foreign reserve $m' - m$), subject to the borrowing constraint (4). Without loss of generality, we assume $\alpha = 1$ in the utility function.

Note the following implications of the model:

(i) If there were no idiosyncratic uncertainty, households would set consumption equal to wage income. Hence, trade would always be balanced and there would be no accumulation of foreign reserves.

(ii) If there were no borrowing constraints, households would set consumption equal to permanent income by borrowing from outside. Hence, country H would run a trade deficit with F, as predicted by the PIH.

3.1 Characterization of General Equilibrium

A general equilibrium is defined as a balanced growth path characterized by the following:

(i) A sequence of decision rules for each household i, $\{c_t(i), m_{t+1}(i), N_t(i)\}_{t=0}^{\infty}$, such that given the sequence of prices $\{P_t^*, W_t\}_{t=0}^{\infty}$, these decision rules maximize each household's lifetime utility subject to constraints (3)-(4.

(ii) A sequence of demand function for labor, $\{N_t\}_{t=0}^{\infty}$, such that given the sequence of prices $\{P_t^*, W_t\}_{t=0}^{\infty}$, the demand function maximizes firms' profits;

(iii) The law of large numbers holds and all resource constraints are respected:

$$\int N_t(i)di = N_t \tag{5}$$

$$\int C_t(i)di + \frac{\int M_{t+1}(i)di - \int M_t(i)di}{P^*} = Y_t, \tag{6}$$

where equation (5) represents the labor market-clearing condition, and equation (6) represents a balanced budget in the tradable-goods sector. Because this is a small open economy, there is no market-clearing condition for foreign currency. Hence, equation (6) states that all revenues generated from exports (P^*Y_t) are used to finance either imports ($P^* \int C_t(i)di$) or the accumulation of foreign reserves. In other words, the trade deficit is represented by net increase in foreign reserves, $M_{t+1} - M_t$.

(iv) The transversality condition holds: $\lim_{t\to\infty} \beta^t \frac{\frac{1}{P_t^*}\int M_{t+1}(i)di}{W_t} = 0$.

3.2 Household Decision Rules

Proposition 1 *Denoting $x_t(i) \equiv m_t(i) + w_t N_t(i)$ as cash-in-hand, the decision rules of consumption, asset demand, and cash-in-hand for household i are given by*

$$c(i) = \min\left\{\frac{\theta(i)}{\theta^*}, 1\right\} x \tag{7}$$

$$(1+\bar{g})\, m'(i) = \max\left\{\frac{\theta^* - \theta(i)}{\theta^*}, 0\right\} x \tag{8}$$

$$x = \theta^* \frac{(1+\bar{g})}{\beta} A_0, \tag{9}$$

where the cutoff θ^* is determined by the following equation,

$$1+\bar{g} = \beta R(\theta^*), \tag{10}$$

with the liquidity-premium function satisfying

$$R(\theta^*) \equiv \int_{\theta<\theta^*} dF(\theta) + \int_{\theta\geq\theta^*} \frac{\theta}{\theta^*} dF(\theta) > 1. \tag{11}$$

Proof. See Appendix I. ■

3.3 Discussion

The decision rules for consumption and saving in Proposition 1 are quite intuitive. Optimal consumption is a concave function of a target level of cash-in-hand, x_t, with the marginal propensity to consume given by the function, $\min\left\{\frac{\theta}{\theta^*}, 1\right\}$. When the urge to consume is low ($\theta(i) < \theta^*$), the marginal propensity to consume is less than 1; when the urge to consume is high ($\theta(i) \geq \theta^*$), the marginal propensity to consume equals 1 and the individual does not save in this period. Therefore, saving is a buffer stock: The household saves ($m'(i) > 0$) in the case of low consumption demand for a rainy day because consume demand may be high in the future. These properties are consistent with the buffer-stock saving literature (see, e.g., Deaton, 1991; Aiyagari, 1994, and Carroll, 1992, 1997), except here they are shown analytically instead of numerically.

Notice that both the cutoff θ^* and the optimal cash-in-hand x are independent of i (i.e., they are identical across households). The intuition that optimal cash-in-hand x is independent of i is that (i) it is predetermined before the realization of $\theta(i)$ and (ii) the labor supply $N(i)$ can adjust elastically to target any level of cash-in-hand under a constant marginal cost of leisure. That is, since all households face the same distribution of idiosyncratic shocks, the quasi-linear utility function makes it feasible and optimal that households adjust labor supply to target the same level of cash-in-hand regardless of the individual's history of asset holdings. That is, x is optimal *ex ante* given the distribution of $\theta(i)$ and the macroeconomic environment (e.g., the real wage, real interest rate, and inflation), regardless of initial wealth $\frac{m(i)}{P^*}$. This property is key to obtaining closed-form solutions but the main results of this paper do not hinge on this property.

Also notice that $R(\theta^*) > 1$ because it captures the liquidity value (premium) of the buffer stock saving under borrowing constraints. Hence, the effective rate of return to saving is determined by the real interest rate compounded by the liquidity premium R. The liquidity premium is decreasing in the cutoff θ^*: $\frac{\partial R}{\partial \theta^*} < 0$. That is, with a higher cutoff, the liquidity constraint is less likely to bind, so the liquidity value of savings is lower.

The left-hand-side (LHS) of equation (10) is the shadow marginal cost of saving: the opportunity cost of not consuming a rapidly rising income is proportional to the income growth rate. The right-hand-side (RHS) of the equation measures the effective rate of return to saving, including the real interest rate (β) and the liquidity premium (R). Hence, optimal saving of an asset is determined by equating the marginal cost with the marginal benefit, taking into account the liquidity premium of the asset. In equilibrium, the liquidity premium R is thus an increasing function of income growth $\bar{g}$.

The main intuition is that uninsured risk and borrowing constraints induce precautionary savings, even if the real interest rate is low or even negative ($\beta < 1$). Agents would want to maintain a stable buffer stock of savings relative to trend income because of the need for self-insurance. Since income is a flow and savings a stock, when income grows, the stock-to-flow ratio would decline if the saving rate remain unchanged—which would hinder the buffer-stock function of savings and reduce the extent of self-insurance when the degree of idiosyncratic uncertainty remains constant relative to trend consumption.[19] Thus, the liquidity premium R will rise with $\bar{g}$. A higher liquidity premium thus induces a higher saving rate.

[19] Multiplicative preference shocks imply that as consumption grows over time, the degree of uncertainty relative to trend consumption does not change (it neither increases nor shrinks). This is similar to the setup in Carroll and Jeanne (2009) where unemployment risk rises with income growth. Wen (2009a) argues that such assumptions are consistent with empirical data because consumption dispersion and income inequality do not show a declining trend as the economy grows over time, suggesting that idiosyncratic uncertainty rises proportionally with income growth.

3.4 Aggregation

Using letters without index i to denote aggregate variables and by the law of large numbers, aggregate (or average) consumption and saving are given, respectively, by

$$c = D(\theta^*)x \tag{12}$$

$$(1+\bar{g})\, m' = H(\theta^*)x, \tag{13}$$

where the functions $\{D(\cdot), H(\cdot)\}$ are defined by

$$D(\theta^*) = \int_{\theta<\theta^*} \frac{\theta}{\theta^*} dF(\theta) + \int_{\theta\geq\theta^*} dF(\theta) \in (0,1) \tag{14}$$

$$H(\theta^*) = \int_{\theta<\theta^*} \frac{\theta^* - \theta}{\theta^*} dF(\theta) \in (0,1)\,. \tag{15}$$

Note $D(\cdot)+H(\cdot) = 1$ because $D(\cdot)$ is the average marginal propensity to consume from cash-in-hand and $H(\cdot)$ is the marginal propensity to save. The equilibrium path of the model is characterized by the sequence $\{c, m', x, \theta^*\}$, which can be solved uniquely and explicitly from equations (9)-(13) once the distribution function $F(\theta)$ is specified.

3.5 Saving Behavior

Clearly, the cutoff θ^* determines the aggregate saving-to-income ratio. A higher cutoff implies a larger fraction of savers in the population versus non-savers since $\frac{\partial H}{\partial \theta^*} > 0$ and $\frac{\partial D}{\partial \theta^*} < 0$. More precisely, the saving rate τ in the economy is defined as the ratio of net changes in asset position to disposable income: $\tau_t = \frac{M_{t+1}-M_t}{P_t^* Y_t} = \frac{(1+\bar{g})m'-m}{x-m}$. Along a balanced growth path, equation (13) implies that the saving rate is given by

$$\tau = \frac{\bar{g}H(\theta^*)}{1+\bar{g}-H(\theta^*)}. \tag{16}$$

Proposition 2 *The saving rate τ is a hump-shaped function of income growth, increasing in $\bar{g}$ if $\bar{g} < \bar{g}^*$ and decreasing if $\bar{g} > \bar{g}^*$, where the threshold $\bar{g}^* \in (0,\infty)$ is strictly positive and bounded.*

Proof. See Appendix II. ■

For example, $\tau = 0$ and $\frac{d\tau}{d\bar{g}} > 0$ when $\bar{g} = 0$. By continuity, the saving rate increases with income growth for small values of $\bar{g}$. This proposition shows that higher income growth can lead to a higher saving rate instead of a higher marginal propensity to consume, in sharp contrast to the prediction of the conventional wisdom based on the PIH. The PIH predicts that forward-looking consumers should increase their marginal propensity to consume when they expect income to be permanently higher in the future. However, with uninsured uncertainty and borrowing constraints, this prediction is no longer necessarily correct when the growth rate of income is below a threshold level ($\bar{g}^*$).

The PIH is based on two critical assumptions: (i) Agents are able to consume their higher future income by borrowing, and (ii) agents do not face any uninsured risk. However, with borrowing constraints, people are not able to consume their future income; and with uninsured risk, they also need to keep a buffer stock as self-insurance against idiosyncratic demand shocks.[20] The key insight of Proposition 2 is that under both borrowing constraints and uninsured risk, the optimal saving rate will increase with income growth, consistent with much of the empirical evidence.[21] Since saving provides liquidity, it has a liquidity premium R (shadow rate of return), which determines the optimal buffer stock-to-income ratio. Since income is a flow, a higher growth rate of income will lead to a lower stock-to-income ratio if the saving rate remains unchanged. Consequently, the liquidity premium will increase with $\bar{g}$, and a higher liquidity premium will induce a higher saving rate.

On the other hand, since the function $R(\cdot)$ is bounded above by $R(\underline{\theta}) = \frac{E\theta}{\underline{\theta}} > 1$, there exists a maximum value of the growth rate $\bar{g}_{\max} = \beta\frac{E\theta}{\underline{\theta}} - 1$ such that if $\bar{g} \geq \bar{g}_{\max}$, the borrowing constraint (4) binds for all households and nobody saves. Hence, the saving function $\tau(\bar{g})$ must be hump-shaped near $\bar{g}^*$, increasing with $\bar{g}$ first and then decreasing with $\bar{g}$ for $\bar{g} \geq \bar{g}^* > 0$. So if the growth rate is sufficiently high, then the opportunity cost of not consuming the rapidly growing income out-weighs the benefits of precautionary savings, causing the optimal saving rate to decline, which is more consistent with the prediction of the PIH.

4 Predicting China's Foreign Reserves

4.1 Calibration

To compute the saving rate in the benchmark model, we need know the distribution of the idiosyncratic shocks $F(\theta)$. For tractability, we assume θ follows the Pareto distribution,

$$F(\theta) = 1 - \theta^{-\sigma}, \tag{17}$$

with $\sigma > 1$ and $\theta \in (1, \infty)$. A value of $\theta = \infty$ may indicate a life-threatening medical need. But the probability of such events is infinitely small or zero. The results remain robust to alternative

[20] That is, with uninsured risks, having a binding borrowing constraint by setting $s_{t+1}(i) = 0$ for all t is not optimal.

[21] See, e.g., Carroll and Weil (1994), Carroll, Overland, and Weil (2000) and the references therein.

distributions, such as lognormal and uniform distributions. With Pareto distribution, we have $R(\theta^*) = 1 + \frac{1}{\sigma-1}\theta^{*-\sigma}$, $D(\theta^*) = \frac{\sigma}{\sigma-1}\theta^{*-1} - \frac{1}{\sigma-1}\theta^{*-\sigma}$, and $H(\theta^*) = 1 - \frac{\sigma}{\sigma-1}\theta^{*-1} + \frac{1}{\sigma-1}\theta^{*-\sigma}$. Equation (10) then implies the cutoff $\theta^* = \left[(\sigma-1)\left(\frac{1+\bar{g}}{\beta} - 1\right)\right]^{-\frac{1}{\sigma}}$.

Let the time period t be a year and set $\beta = 0.96$. The most crucial parameter to calibrate is σ, which pertains to the degree of idiosyncratic risk (the variance of the idiosyncratic shocks) and hence the strength of precautionary saving motives. Limited by the availability of panel data for developing countries, we have to rely on information from the dispersion of consumption expenditure across households in developing countries to calibrate this parameter.

Table 1. Expenditure Inequality for Developing Countries*

Country	Burkina Faso	Guate-mala	Kazakh-stan	Kyrgyz-stan	Para–guay	South Africa	Thailand
C Gini	0.43	0.39	0.37	0.45	0.47	0.54	0.39
Country	Burkina Faso	Guate-mala	Kazakh-stan	South Africa	Para–guay	Zambia	Thailand
H Gini	0.43	0.42	NA	0.67	0.18	0.32	0.38

*Data source: Wen (2009b). C Gini measures inequality in consumption, and H Gini that in health care.

Table 1 shows the Gini coefficients for consumption expenditure (C Gini) and health-care expenditure (H Gini) in several developing countries. The average consumption Gini across those countries is 0.43 (with STD 0.05) and the average health-care Gini is 0.4 (with STD 0.15); these values are both significantly larger than the consumption Gini (0.28) in the United States, indicating far larger idiosyncratic risks in developing countries. Based on the information, a consumption Gini in the interval of $[0.3 \sim 0.5]$ seems reasonable for China. We choose $\sigma = 1.25$ as our benchmark value so that the model-implied consumption distribution has a Gini coefficient around 0.4.[22]

4.2 Predictions

With the calibrated parameter values, the relationship between the aggregate saving rate and the growth rate ($\bar{g}$) is graphed in Figure 3. It shows that a higher income growth induces a higher marginal propensity to save even if the real rate of return to foreign reserves is negative (the inverse of the inflation rate). In particular, when the income growth rate is 1% per year, the saving rate is about 8%; and when the income growth rises to 10% per year, the saving rate increases to 26%. This high level of household saving rate matches the Chinese data quite well.[23] The saving function has a maximum of 30% at $\bar{g} = 25\%$ per year, and gradually approaches zero afterwards as

[22] The exact Gini is 0.43 if the growth rate is 10% per year.

[23] See Wang and Wen (2010) for more discussions on Chinese household saving rate.

$\bar{g}$ increases. For example, the saving rate remains around 20% even if $\bar{g} = 100\%$ per year, and it becomes 0% only when $\bar{g} = 377\%$ per year.

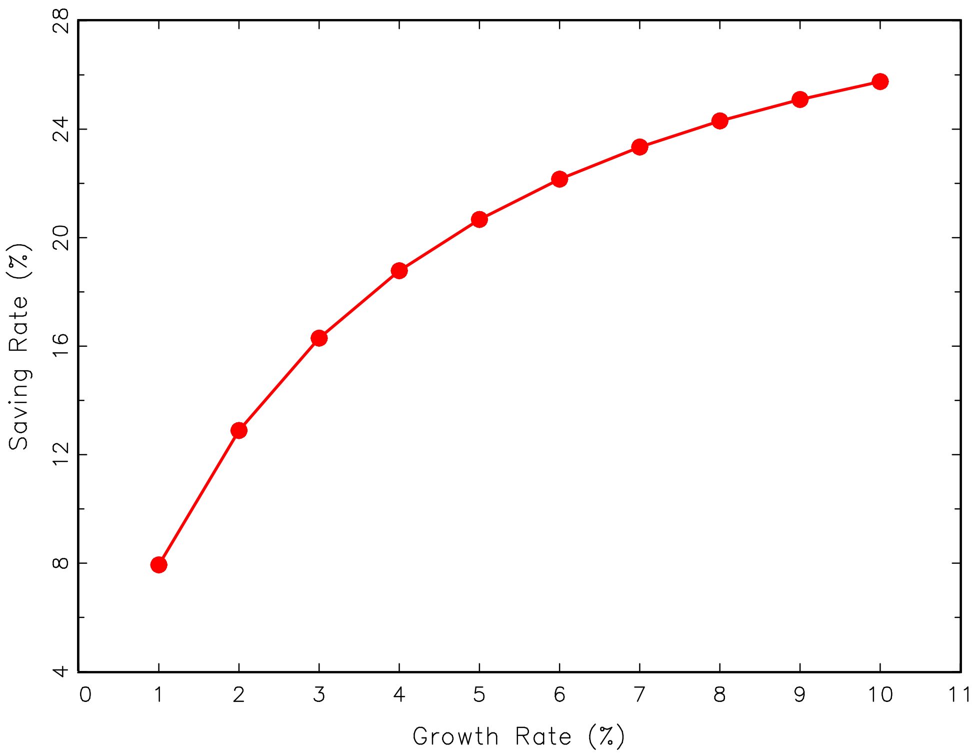

Figure 3. Saving Rate as a Function of Growth.

Data show that between 1978 and 2009, China's current account surplus has increased dramatically, reaching \$426 billion (USD) in 2008, as seen in the left panel in Figure 4 (blue circles).[24] The bulk of the increase in the current account is due to the rapidly rising trade surplus (red squares). Associated with the rising current account is the massive buildup of China's foreign reserves. For example, the year-to-year changes of foreign reserves (blue solid circles in the right panel) show magnitude and trends very similar to the annual current account, suggesting that the accumulation of foreign reserves is driven mainly by surpluses from foreign trade.

In our model, trade surplus is determined by households' precautionary saving. Because of uninsured risk and borrowing constraints, a substantial fraction of income earned from exports is saved, which leads to imbalances between exports and imports. Most importantly, the precautionary saving rate rises with the growth rate of income. Given that the average growth rate of export income in China is about 17% per year between 1978 and 2009, our model implies that the precautionary saving rate in the tradable-goods sector is 28.4%. In other words, the model predicts

[24] The worldwide financial crisis in 2008 had a large negative impact on China's net exports and foreign reserves in 2009.

that more than a quarter of the foreign currency (USD) earned from exports is saved each year. Based on this figure, we can conduct a preliminary test of the model by multiplying China's total exports by 0.284, which would generates a rough prediction from the model for the year-to-year changes in foreign reserves in China. The right panel of Figure 4 (see the line with open circles) shows that the predicted value tracks the trends of China's foreign reserves quite well, explaining the bulk of the data.

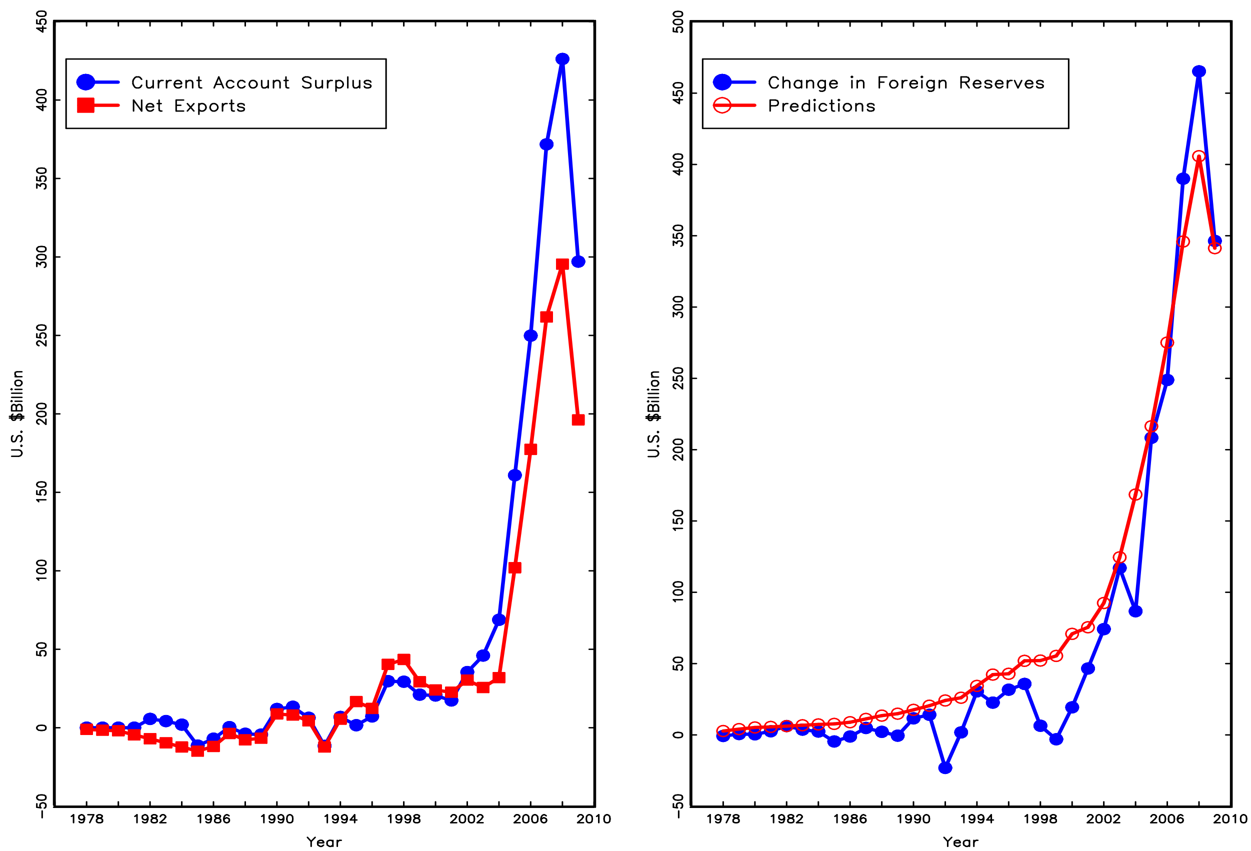

Figure 4. Current Account (Left) and Year-to-Year Changes in Foreign Reserves (Right).

4.3 A Dynamic Analysis

The relationship between saving and growth can also be analyzed under aggregate uncertainty with stochastic productivity growth. Suppose aggregate technology grows according to $A_t = (1+g_t)A_{t-1}$, where the stochastic growth rate g_t satisfies the law of motion

$$\log\left(\frac{1+g_t}{1+\bar{g}}\right) = \rho_g \log\left(\frac{1+g_{t-1}}{1+\bar{g}}\right) + \varepsilon_t, \tag{18}$$

where $\bar{g} \geq 0$ is the mean and ε_t is an i.i.d. process. To compute the stochastic equilibrium path of the model, we rescale all variables (except N_t) by the level of technology A_{t-1}. In order for the transformed stock variable m_t to remain as a state variable that does not respond to changes in A_t in period t, we use A_{t-1}, instead of A_t, as the scaling factor.[25] Using lower-case letters to denote the transformed variables, $x_t \equiv \frac{X_t}{A_{t-1}}$, the production function becomes $y_t = (1 + g_t) N_t$, the real wage becomes $w_t = 1 + g_t$, and the aggregate household resource constraint becomes

$$c_t + (1 + g_t) m_{t+1} = m_t + (1 + g_t) N_t. \tag{19}$$

Proposition 3 *In a dynamic equilibrium, the year-to-year changes in foreign reserves are given by*

$$M_{t+1} - M_t = \left[\frac{H(\theta_t^*)\theta_t^* R(\theta_t^*) - \frac{1}{(1+g_t)} H(\theta_{t-1}^*)\theta_{t-1}^* R(\theta_{t-1}^*)}{\theta_t^* R(\theta_t^*) - \frac{1}{(1+g_t)} H(\theta_{t-1}^*)\theta_{t-1}^* R(\theta_{t-1}^*)} \right] P_t^* Y_t \equiv \tau_t P_t^* Y_t, \tag{20}$$

which is proportional to total nominal exports $P_t^* Y_t$ with a time-varying saving rate τ_t.

Proof. See Appendix III. ■

To calibrate the process $\{g_t\}$, the data for aggregate exports, price deflator, and hours worked in the tradable-goods sector are needed. The growth rate of the nominal exports is given by

$$\frac{P_t^* Y_t}{P_{t-1}^* Y_{t-1}} = (1 + v_t)(1 + g_t) \frac{N_t}{N_{t-1}}. \tag{21}$$

Since data for price deflator $(1 + v_t)$ and hours worked in the tradable-goods sector N_t are not available and since TFP growth typically mimics output growth, we follow the methodology in Durdu, Mendoza, and Terrones (2007) by approximating the growth rate of technology in the tradable-goods sector by the growth rate of total exports adjusted by a constant inflation rate.[26] With the process $\{g_t\}$ in hand and assuming that g_t follows equation (18), the mean growth $\bar{g}$, the autocorrelation ρ_g, and the variance σ_g^2 can all be estimated.

To obtain closed-form solution for the model's dynamic equilibrium path, further assume that technology innovation ε_t follows lognormal distribution, $\log \varepsilon \sim N(0, \sigma_\varepsilon^2)$. Appendix III shows that the cutoff θ_t^* can then be solved explicitly as

$$\theta_t^* = (\sigma - 1)^{\frac{-1}{\sigma}} \left(\left[\beta \left(\frac{1 + \bar{g}}{1 + g_t} \right)^{\rho_g} \frac{e^{\frac{1}{2}\sigma_\varepsilon^2}}{1 + \bar{g}} \right]^{-1} - 1 \right)^{\frac{-1}{\sigma}}. \tag{22}$$

So given the shape parameter of the Pareto distribution (σ), all endogenous variables in the model can be solved explicitly in closed forms.

[25] The particular methods of transformation do not affect the dynamics of the original variables.

[26] We assume a 4% annual inflation rate but the results are not sensitive to this value.

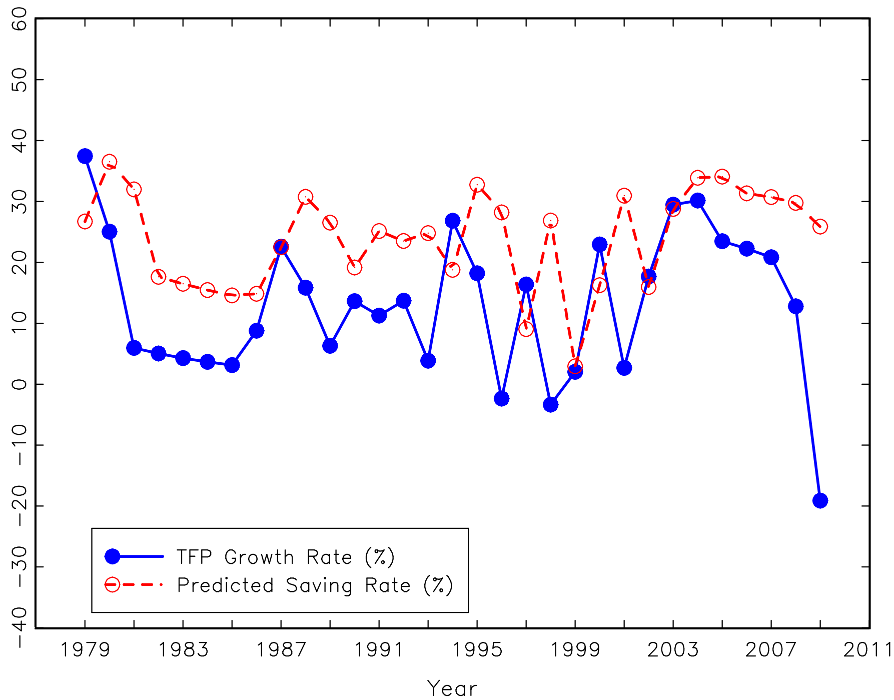

Figure 5. Dynamic Relationship between Growth and Saving.

Notice that when g_t is i.i.d. (i.e., $\rho_g = 0$), the cutoff is constant and the implied saving rate (τ_t) based on equation (20) would be highly contemporaneously correlated with g_t because $\frac{\partial R(\theta^*)}{\partial \theta^*} < 0$. On the other hand, if g_t is serially correlated, then the implied saving rate will not only be positively correlated with current g_t but also with lagged g_t because high growth in the last period also tend to induce high saving in the current period. Estimation of ρ_g based on the AR(1) assumption for $\{g_t\}$ gives $\rho_g = 0.21$ and $\sigma_\varepsilon^2 = 0.014$.

Given that the technology innovation ε_t may not follow lognormal distribution and the degree of risk facing Chinese households may not be exactly what is implied by the Gini coefficient, here we use the method of moments to reestimate the values of the structural parameters, $\{\beta, \sigma, \bar{g}, \rho_g, \sigma_\varepsilon^2\}$, so that the model can best match the time-series data of total exports and the changes in foreign reserves in China, given the TFP growth process $\{g_t\}$ in the export sector. It turns out that the reestimated parameter values under the method of moments are either identical or close to the original values previously stated. The reestimated parameter values are reported in Table 2.[27]

Table 2. Parameter Values

$\hat{\beta}$	$\hat{\sigma}$	$\bar{g}$	$\hat{\rho}_g$	$\hat{\sigma}_\varepsilon^2$
0.96	1.3	0.17	0.16	0.014

[27]The implied consumption Gini under these parameter values is 0.404 when the steady-state TFP growth is 10% per year.

Using the parameter values in Table 2 and feeding the implied sequence $\{\theta_t^*\}$ in equation (22) into equation (20) gives the predicted stochastic saving rate. Figure 5 shows that the predicted saving rate τ_t (dashed line) comoves with the productivity growth rate g_t (solid line). Most importantly, the predicted saving rate lags the income growth rate by about one period (year). This suggests that income growth Granger causes the saving rate, instead of the other way around. These predictions are consistent with much of the empirical evidence on the causal relationship between income growth and saving rates.[28]

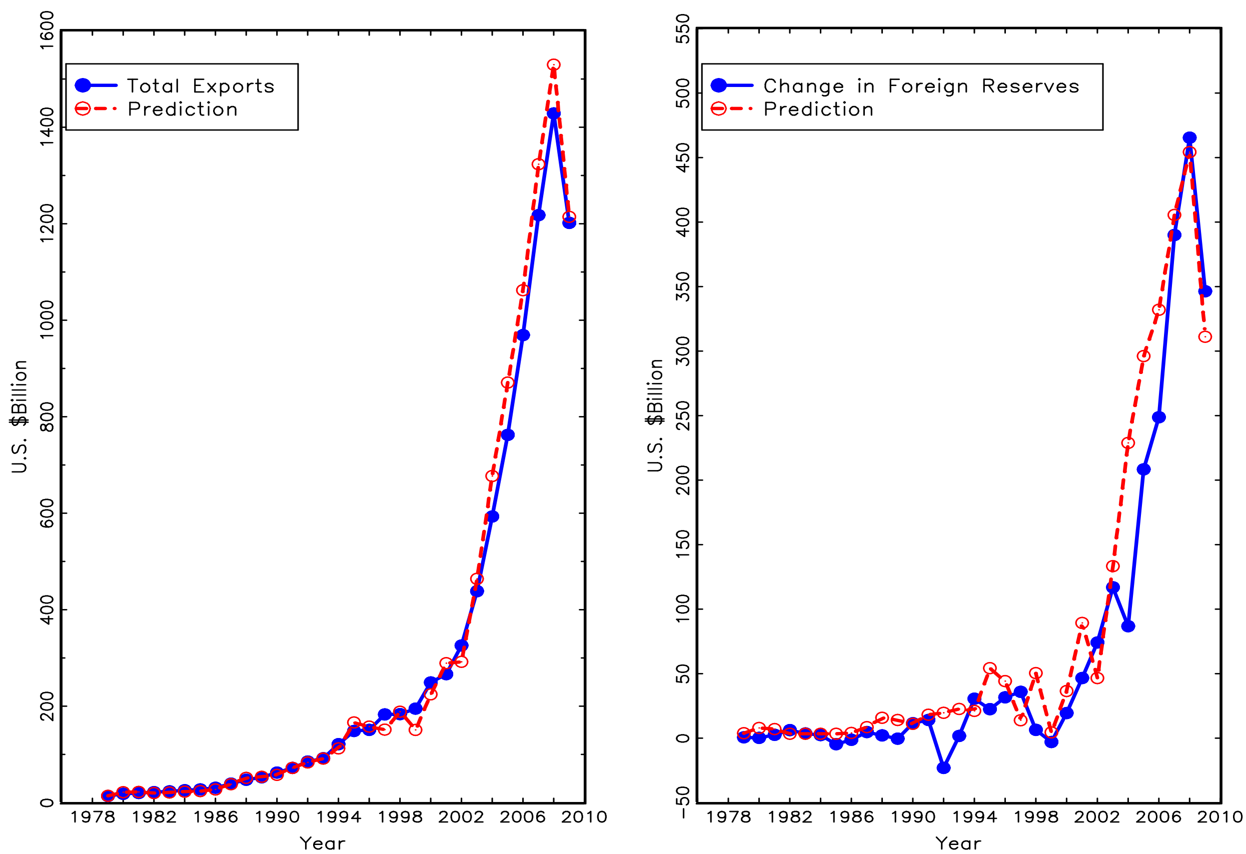

Figure 6. Predictions of Exports (left) and Foreign Reserves (right).

The predicted total exports ($P_t^* A_t N_t$) and year-to-year changes in foreign reserves ($M_{t+1} - M_t$) in the model are shown in the left and right panels in Figure 6, respectively, where the solid lines are data and dashed lines are predictions.[29] The model explains more than 90% of the data (e.g., the R^2 is 0.99 for total exports and 0.93 for exchange reserves). In particular, the model tracks

[28]See, e.g., Modigliani (1970), Carroll and Weil (1994), Attanasio, Picci, and Scorcu (2000), Carroll, Overland, and Weil (2000) and the references therein.

[29]Labor (N_t) is predicted using equation (86) in Appendix III and the inflation rate $\frac{P_{t-1}^*}{P_{t-1}^*}$ is assumed to be constant at 4% per year. The results are not sensitive to the inflation rate because only the ratio ($\frac{M_{t+1}-M_t}{P_t^* Y_t}$) matters.

the surge in total exports and foreign reserves since 2002 quite well (China joined the World Trade Organization in December 2001), mainly because unanticipated changes in productivity growth generate larger swings in the saving rate along a transitional path than anticipated changes in the steady state. The model also tracks well the slump in 2009 due to the current financial crisis.

The analysis shows that China's trade surplus and excessive foreign reserves can be explained by precautionary saving behavior without resorting to distorted exchange-rate policies. Namely, because of large uninsured risk and severe borrowing constraints, the saving rate is a positive function of income growth. Given the high growth rate of income, Chinese workers opt to save a substantial fraction (more than a quarter) of their income earned from trade, which leads to the massive buildup of China's foreign reserves. Therefore, the linked exchange rate between the RMB and the USD is apparently irrelevant for the trade imbalance between China and the United States, and Deardorff's (2010) paradox can therefore be resolved without assuming distortionary government policies.[30]

5 General Model

There are two production sectors in the home country—a domestic sector (sector 1) that produces nontradable goods and an export sector (sector 2) that produces tradable goods. Because of capital controls and an inconvertible home currency, residents of the home country cannot use foreign currency earned from the export sector to purchase domestic goods and assets, nor can them use income earned from the nontradable-goods sector to buy foreign goods and assets. In other words, non-tradable goods are purchased by home currency (RMB) and tradable goods are purchased by foreign currency (USD). However, households in country H can bypass the capital control though working in both nontradable and tradable sectors. Therefore, despite the capital control, households are able to adjust their baskets of consumption goods for tradable and nontradable goods by choosing an optimal mixture of hours worked in each sector.

Because of capital controls, firms in the domestic sector must use income earned from domestic sales to rent capital from a domestic rental market, while firms in the export sector can use foreign currency to rent capital from an international market with a constant world real interest rate $\bar{r}^w$. Capital is not mobile across sectors but labor is. This setup of segregated capital markets not only captures the reality but also allows us to study the Balassa-Samuelson effect of technology shock on the real exchange rate even though the rate of productivity growth in both the nontradable-goods and tradable-goods sectors are the same.

[30] Deardorff (2010) pondered the paradoxical phenomenon that countries (such as China) with a comparative advantage in future production are running trade surpluses while countries (such as the U.S.) with a comparative advantage in current production are running trade deficits. He argued that, from a standard trade theoretic viewpoint, China should be borrowing from the United States instead because China's production frontier will be much higher in the future than at the present, unless the real exchange rate is severely distorted by subsidiary policies.

In reality, Chinese workers in the export sector do not invest their savings of foreign currencies directly in foreign assets because of capital controls. The Chinese government buys dollars from residents by issuing bonds to retrieve the local currency. This practice (called sterilization) enables the government to absorb dollars without increasing the supply of local currency when trade surplus increases. This is essentially how the dollars earned by Chinese workers in the export sector end up in the central bank of China as foreign reserves.[31] Thus, sterilization is equivalent (in outcome) to a situation where the Chinese government meets the savings demands of its domestic residents by selling them Chinese government bonds and using the proceeds to purchase foreign (especially U.S.) bonds. If the private sectors want to increase spending on American goods, in principle they can exchange dollars back from the government by selling bonds. In this sense, the Chinese government is functioning like a bank, enabling savers to invest their foreign income. Therefore, foreign exchange reserves held by the Chinese government are effectively owned by the private sector in China and they reflect nothing but the private savings of Chinese households and firms.[32]

5.1 Technology

Sector j ($j = 1, 2$) has the following production technology:

$$Y_{jt} = K_{jt}^{\alpha} \left(A_t N_{jt}\right)^{1-\alpha}, \tag{23}$$

where A_t denotes a country's aggregate technology level with a stochastic growth rate specified in equation (18). The optimal demand for capital and labor in sector j are given by

$$r_{jt} + \delta = \alpha \frac{Y_{jt}}{K_{jt}} = \alpha \left(\frac{N_{jt}}{K_{jt}}\right)^{1-\alpha} A_t^{1-\alpha} \tag{24}$$

$$W_{jt} = (1-\alpha) \frac{Y_{jt}}{N_{jt}} = (1-\alpha) \left(\frac{K_{jt}}{N_{jt}}\right)^{\alpha} A_t^{1-\alpha}, \tag{25}$$

where

$$r_{2t} = \bar{r}^{w} \tag{26}$$

is a constant world interest rate in the international rental market.

Labor mobility across sectors implies $\eta_{1t} W_{1t} = \eta_{2t} W_{2t}$, where η_{jt} denotes the marginal utility of income received from sector j. Hence, the real price of tradable goods in terms of nontradable

[31] Officially, the government is also obligated to buy dollars from the private sector to maintain a fixed exchange rate.

[32] Caballero, Farhi, and Gourinchas (2008, p.361) also point out that "most of these reserves are indirectly held by the local private sector through (quasi-collateralized) low-return sterilization bonds in a context with only limited capital account openness."

goods—the real exchange rate in the economy—is given by $e_t \equiv \frac{\eta_{2t}}{\eta_{1t}} = \frac{W_{1t}}{W_{2t}}$. Equations (24) and (25) imply

$$e_t = \left(\frac{\bar{r}^w + \delta}{r_{1t} + \delta} \right)^{\frac{\alpha}{1-\alpha}}. \tag{27}$$

So the real exchange rate is influenced by aggregate technology shocks through changes in the domestic real interest rate. In particular, a higher productivity growth leads to a higher domestic interest rate, which implies that nontradable goods become more expensive relative to tradable goods, so the real exchange rate appreciates (e_t decreases). This captures the Balassa-Samuelson effect in an environment with identical productivity growth across tradable and non-tradable sectors.

Along a balanced growth path, the real wages $\{W_{1t}, W_{2t}\}$ and outputs $\{Y_{1t}, Y_{2t}\}$ in both sectors all grow at the rate of long-run productivity growth ($\bar{g}$) in the absence of aggregate uncertainty ($\varepsilon_t = 0$), while hours worked in both sectors are constant over time. To facilitate the analysis of a stochastic equilibrium path under aggregate uncertainty, we rescale all variables in the model by the level of technology A_{t-1} except for hours worked. Using lower-case letters to denote the transformed variables, $z_{jt} \equiv \frac{Z_{jt}}{A_{t-1}}$, the production functions become

$$y_{jt} = (1 + g_t)^{1-\alpha} k_{jt}^{\alpha} N_{jt}^{1-\alpha} \tag{28}$$

and the real wages become

$$w_{jt} = (1-\alpha) \frac{y_{jt}}{N_{jt}} = (1-\alpha) \left(\frac{k_{jt}}{N_{jt}} \right)^{\alpha} (1 + g_t)^{1-\alpha}. \tag{29}$$

5.2 Households

As in the benchmark model, there is a continuum of households in country H indexed by $i \in [0, 1]$. Each household has two members (husband and wife); one works in the nontradable sector and the other works in the exporting sector. Each household consumes two types of goods: nontradable goods produced at home and foreign goods produced abroad.

Households put their savings in banks and earn a real gross rate of return $1+r_t^a$. As documented by Wen (2009a), financial repression in China leads to a low and even negative real deposit rate for household savings; despite this, the bulk of household wealth is kept in the form of bank deposits because of underdeveloped financial markets in China. On the other hand, firms must borrow funds from monopolistic state-owned banks at market interest rate r_t. To capture this reality, we assume that the real rate of return to household savings is zero ($r^a = 0$), and state-owned banks earn monopoly profits $(r_t - r^a) s_t$, which are returned in a lump sum to households. We will show that households still save excessively despite the low real deposit rate, which captures the precautionary saving motive of households in China even more dramatically.

Denote $s_t(i) \equiv \frac{S_t(i)}{A_{t-1}}$ as the rescaled home asset and $m_t(i) \equiv \frac{M_t(i)}{A_{t-1}P_t^*}$ as the rescaled real money balances for foreign currency held by household i. Denote household i's consumption for home goods as $c_{1t}(i) \equiv \frac{C_{1t}(i)}{A_{t-1}}$, for imported goods as $c_{2t}(i) \equiv \frac{C_{2t}(i)}{A_{t-1}}$, and hours worked in sector j as $N_{jt}(i)$. For simplicity, assume $P_t^* = P_{t-1}^*$, as in the benchmark model. Household i's problem is to solve

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \theta_t(i) \left[\gamma_1 \log c_{1t}(i) + \gamma_2 \log c_{2t}(i) \right] - N_{1t}(i) - N_{2t}(i) \right\} \tag{30}$$

subject to

$$c_{1t}(i) + (1 + g_t)\, s_{t+1}(i) \leq x_{1t}(i) \tag{31}$$

$$s_{t+1}(i) \geq 0 \tag{32}$$

$$c_{2t}(i) + (1 + g_t)\, m_{t+1}(i) \leq x_{2t}(i) \tag{33}$$

$$m_{t+1}(i) \geq 0, \tag{34}$$

where $x_{1t}(i)$ is net wealth (cash-in-hand) in terms of income earned in sector 1:

$$x_{1t}(i) \equiv w_{1t} N_{1t}(i) + s_t(i) + \Pi_t, \tag{35}$$

and $x_{2t}(i)$ is cash-in-hand in sector 2:

$$x_{2t}(i) \equiv w_{2t} N_{2t}(i) + m_t(i), \tag{36}$$

where $\Pi_t = r_{1t} \int s_t(i) di$ denotes average profit income distributed from domestic banks. The parameter γ_j in the preference controls the relative equilibrium size of the domestic and export sectors.

Equation (31) is the budget constraint pertaining to domestic income, which states that total real wage income earned from the nontradable-goods sector can be used to finance consumption of nontradable goods (c_{1t}) and the accumulation of home assets ($(1+g)\, s' - s$) subject to the borrowing constraint (32). Analogously, equation (33) denotes the budget constraints pertaining to foreign income, which states that total real wage income earned from working in the tradable-goods sector can be used to finance purchases of foreign produced goods (c_{2t}) and the accumulation of foreign currency (real foreign reserves, $(1+g)\, m' - m_t$) subject to the borrowing constraint (34).

5.3 Household Decision Rules

Proposition 4 *Denoting $\xi_{1t} \equiv s_t$ and $\xi_{2t} \equiv m_t$, the decision rules of consumption, savings, and cash-in-hand for household i are given by*

$$c_{jt}(i) = \min\left\{\frac{\theta_t(i)}{\theta_t^*}, 1\right\} x_{jt} \tag{37}$$

$$(1+g_t)\,\xi_{jt+1}(i) = \max\left\{\frac{\theta_t^* - \theta_t(i)}{\theta_t^*}, 0\right\} x_{jt} \tag{38}$$

$$x_{jt} = \gamma_j w_{jt} \theta_t^* R(\theta_{1t}^*), \tag{39}$$

where the cutoff variables θ_{jt}^* are determined by the following equation,

$$\frac{1+g_t}{w_{jt}} = \beta R(\theta_{jt}^*) E_t \frac{1}{w_{jt+1}}, \tag{40}$$

where the function $R(\cdot)$ is given by $R(\theta^*) \equiv \int_{\theta<\theta^*} dF(\theta) + \int_{\theta\geq\theta^*} \frac{\theta}{\theta^*} dF(\theta)$.

Proof. See Appendix IV. ■

These decision rules are similar to those in the benchmark model. However, the optimal cutoff in each sector—determined by equation (40)—may differ because the real wage may differ across sectors (because of different capital markets and real interest rates).

Denoting aggregate variable $z_t \equiv \int z_t(i)di$, market clearing for the domestic capital market implies $\int s_t(i)di = k_t$. Hence, the general equilibrium path of the model can be characterized by the sequences of 14 variables, $\left\{c_{jt}, \xi_{jt+1}, \theta_{jt}^*, x_{jt}, w_{jt}, y_{jt}, N_{jt}; j = 1, 2\right\}_{t=0}^{\infty}$, which can be solved by the following system of 8 equations:

$$c_{jt} = D(\theta_{jt}^*) x_{jt} \tag{41}$$

$$(1+g_t)\,\xi_{jt+1} = H(\theta_{jt}^*) x_{jt} \tag{42}$$

$$\frac{1+g_t}{w_{jt}} = \beta E_t \frac{1}{w_{jt+1}} R(\theta_{jt}^*) \tag{43}$$

$$x_{jt} = \gamma_j \theta_{jt}^* R(\theta_{jt}^*) w_{jt} \tag{44}$$

$$c_{1t} + (1+g_t)\,k_{1t+1} - (1-\delta)\,k_{1t} = y_{1t} \tag{45}$$

$$c_{2t} + (1+g_t)\,m_{t+1} - m_t + (\bar{r}^w + \delta)\,k_{2t} = y_{2t} \tag{46}$$

where $\bar{r}^w + \delta = \alpha \frac{y_{2t}}{k_{2t}}$, plus equations (28) and (29) and standard transversality conditions. The profit income from financial intermediaries is given by

$$\Pi_t = (r_{1t} - r_t^a) \int s_t(i) di = r_{1t} k_{2t}. \tag{47}$$

Hence, equation (45) is also the goods market-clearing condition for the nontradable-goods sector. Equation (46) is the household's budget constraint in the export sector, where $(\bar{r}^w + \delta) k_{2t}$ is rental payment for capital services. So income from exports is used to finance imports of consumption goods (c_2), capital rental costs ($(\bar{r}^w + \delta) k_{2t}$), and foreign-reserve accumulation ($m_{t+1} - m_t$).

The model has a unique steady state. It can be easily confirmed by the eigenvalue method that the steady state is a saddle, so the general equilibrium path implied by the above system of dynamic equations is unique near the steady state.

Equations (41) and (44) imply

$$\frac{c_{1t}}{c_{2t}} = \frac{D(\theta_{1t}^*)\, \theta_{1t}^* R(\theta_{1t}^*)}{D(\theta_{2t}^*)\, \theta_{2t}^* R(\theta_{2t}^*)} \frac{\gamma_1 w_{1t}}{\gamma_2 w_{2t}} \equiv \varphi_t \frac{\gamma_1 w_{1t}}{\gamma_2 w_{2t}}, \tag{48}$$

where the coefficient $\varphi \neq 1$ measures efficiency loss (or deadweight loss) due to capital control. The allocation would be efficient if $\varphi = 1$. However, it is possible for $\varphi = 1$ under capital control if $\theta_1^* = \theta_2^*$, which would be true if $w_{1t} = w_{2t}$, according to equation (43). That is, there would be no efficiency loss under capital control if and only if the real exchange rate $e = \frac{w_{1t}}{w_{2t}} = 1$. This is unlikely to hold in general unless the production functions are identical in the two sectors and the domestic real interest rate equals the world interest rate ($r_{1t} = \bar{r}^w$).

Defining $\wp_j$ as the total real disposable income in sector j, which includes wage income plus real capital gains (i.e., interest income, if any), we have

$$\wp_{1t} = W_{1t} N_{1t} + \Pi_t = X_{1t} - S_t \tag{49}$$

$$\wp_{2t} = W_{2t} N_{2t} = X_{2t} - \frac{M_t}{P_t^*}. \tag{50}$$

The saving rate for each type of income in the economy is defined as the ratio of net changes in asset position to disposable income in the respective sector:

$$\tau_1 = \frac{S_{t+1} - S_t}{\wp_{1t}} = \frac{(1 + g_t)\, s_{t+1} - s_t}{x_{1t} - s_t} \tag{51}$$

$$\tau_2 = \frac{(M_{t+1} - M_t) / P^*}{\wp_{1t}} = \frac{(1 + g)\, m_{t+1} - m_t}{x_{2t} - m_t}. \tag{52}$$

Proposition 5 *The steady-state household saving rate in sector j is given by*

$$\tau_j = \frac{\bar{g} H(\theta_j^*)}{1 + \bar{g} - H(\theta_j^*)}. \tag{53}$$

Proof. Substituting equation (42) in equations (51) and (52) gives the result. ■

The saving rates in equation (53) are identical to equation (16) in the benchmark model. So, as before, higher income growth can lead to a higher saving rate instead of a higher propensity to consume, in sharp contrast to the prediction of the PIH. Also, the saving rates are independent of the exchange rates, suggesting that China's trade surplus and large foreign reserves are not related to an undervalued home currency, in contrast to the widely held belief in the profession and news media (see, e.g., Krugman, 2010).

The national saving rate (the ratio of investment and next exports to GDP) in the economy is given by $\frac{gk+egm}{y_1+eY_2}$, and the aggregate investment-to-GDP ratio is given by $\frac{gk}{y_1+ey_2}$. Because of trade surplus ($gm > 0$), the national saving rate exceeds domestic investment rate even if the investment rate is high. For example, under the following parameter values, $\beta = 0.96$, $\delta = 0.1$, $\gamma_1 = 0.8$, $\gamma_2 = 0.2$, $\sigma = 1.25$, and $\bar{g} = 0.05$, we have $\frac{gk}{y_1+ey_2} = 0.4$ and $\frac{gk+egm}{y_1+eY_2} = 0.44$. So aggregate investment is 40% of GDP and net exports account for 4% of GDP, consistent with Chinese data.

5.4 Exchange Rate Determination

The analysis so far indicates that trade imbalances between China and the rest of the world need not be attributed to a linked exchange rate and undervalued RMB. Even though the home country in our model runs a current account surplus and holds a large amount of foreign reserves, the linked nominal exchange rate is irrelevant to the results because the supply of dollars in the local exchange market ($= P_t^* Y_{2t}$) always equals the total demand of dollars ($= P_t^* C_{2t} + M_{t+1} - M_t + (\bar{r}^w + \delta) P_t^* K_{2t}$). Hence, there is no pressure for the RMB to appreciate. This conclusion holds true even if households do not want to use dollars as a saving device, because they can always opt to exchange the amount $M_{t+1} - M_t$ in each period with their government for home currency or bonds. In this case, the government becomes the holder of foreign reserves. Also, the government should have no fear of inflation even without sterilization because households will save, instead of spend, the home currency they exchanged with the government.

In contrast, the home currency may likely depreciate against foreign currency once capital controls in the model are lifted, in light of the analyses of the existing literature on global imbalances—most notably, Caballero et al. (2008), Mendoza et al. (2009), Ju and Wei (2010) all predict that savings in country H will flow out to developed regions (country F) in search of higher yields. Based on this literature, suppose that capital controls are lifted and households in country H (more specifically, workers in the nontradable sector) opt to convert $\eta \in [0,1]$ fraction of their net savings from domestic assets into country F's assets. This implies that the total demand for dollars in the exchange market of country H would become

$$P_t^* C_{2t} + \eta \frac{P_t \left(K_{1t+1} - K_{1t}\right)}{e^*} + \left(M_{2t+1} - M_{2t}\right) + \left(\bar{r}^w + \delta\right) K_{2t}, \tag{54}$$

which would exceed the total supply of dollars, $P_t^* Y_{2t}$, by the exact amount of $\eta \frac{P_t(K_{1t+1} - K_{1t})}{e^*}$. Thus, to clear the exchange market, the floating nominal exchange rate (e_t^*) must rise above the original linked exchange rate $(\bar{e})$ by an amount so that the following equation holds:

$$P_t^* C_{2t} + \eta \frac{P_t \left(K_{1t+1} - K_{1t}\right)}{e_t^*} + \left(M_{2t+1} - M_{2t}\right) + \left(\bar{r}^w + \delta\right) P_t^* K_{2t} = \frac{e_t^*}{\bar{e}} P_t^* Y_{2t}, \tag{55}$$

which implies that the market-clearing exchange rate of RMB relative to the initial linked exchange rate $(\bar{e})$ is determined by the following equation:

$$\frac{e_t^*}{\bar{e}} - 1 = \eta \frac{P_t \left(K_{1t+1} - K_{1t}\right)}{e_t^* P_t^* Y_{2t}}. \tag{56}$$

In the steady state, the above equation becomes

$$\frac{e^*}{\bar{e}} = 1 + \eta \left(1 - \alpha\right) \frac{\gamma_1}{\gamma_2} \frac{gH}{\left[1 + g - H\right]}. \tag{57}$$

Suppose $\eta = 0.5$ (i.e., 50% of net savings in the nontradable-goods sector are converted to dollars), $\alpha = 0.4$, the output ratio of the nontradable-goods sector and the tradable-goods sector is $\frac{\gamma_1}{\gamma_2} = 5$, the the saving rate is 25%.[33] Then $\frac{e^*}{\bar{e}} = 1.375$, so the RMB would depreciate by nearly 40% if capital controls are lifted under the assumption that households in the nontradable sector are willing to hold only half of their portfolio in foreign assets.

In contrast, if the precautionary saving demand for foreign assets is totally ignored in both the nontradable and tradable sectors, then the market-clearing exchange rate would be determined by

$$P_t^* C_{2t} + \left(\bar{r}^w + \delta\right) P_t^* K_{2t} = \frac{e_t^*}{\bar{e}} P_t^* Y_{2t}. \tag{58}$$

Given a 25% saving rate in the tradable-goods sector (i.e., $\frac{C_2 + (\bar{r}^w + \delta) K_{2t}}{Y_2} = 0.75$), the above equation suggests that $e_t^* = 0.75\bar{e}$, or in other words, the RMB would have to appreciate 25% to rebalance the

[33] In recent years, China's total exports account for 20%-25% of GDP while net exports account for 4%-5% of GDP. This suggests that the domestic sector is about five times larger than the export sector.

trade between country H and country F. This value of appreciation is close to what is proposed by the Peterson Institute for International Economics (e.g., Cline and Williamson, 2009) and Krugman (2010). Clearly, such an estimate is biased because it ignores the demand for international assets driven by precautionary saving motives in China.

The Balassa-Samuelson Effect. The Balassa-Samuelson effect says that if purchasing power parity (PPP) holds—that is, if the real price of tradable goods is equal across country borders and if productivity grows faster in the tradable-goods sector than in the nontradable-goods sector, then a country's real exchange rate will appreciate over time because the relative price of nontradable goods becomes more expensive relative to tradable goods.

Productivity growth is assumed the same across sectors in our model because the assumption of higher productivity growth in the tradable sector than in the nontradable sector would violate balanced growth in a two-sector model. Consequently, the Balassa-Samuelson effect is absent. However, if g increases over time, then the Balassa-Samuelson effect can re-emerge in the model even though the rate of productivity growth is the same across sectors.

To see this, recall that the relative price of tradable goods in terms of nontradable goods is given by equation (27) where $r_1 + \delta = \alpha \frac{1+g}{H(\theta_1^*)} - \alpha(1-\delta)$. Since $\frac{dH}{dg} < 0$, we have $\frac{\partial r}{\partial g} = \alpha \frac{H-(1+g)\frac{dH}{dg}}{H^2} > 0$ and $\frac{\partial e}{\partial g} < 0$. So higher productivity growth leads to a lower e through a higher domestic interest rate. That is, the real exchange rate will appreciate—non-tradable goods become more expensive relative to tradable goods when an emerging economy starts to take off.

This "secondary Balassa-Samuelson effect" exists because with segregated capital markets, the tradable-goods sector has an infinitely elastic supply of international capital, whereas the nontradable-goods sector has a finite supply of domestic capital. So a higher capital demand in the nontradable-goods sector due to a higher productivity growth will lead to a higher domestic real interest rate, making nontradable goods more expensive relative to tradable goods.

On the other hand, because of underdeveloped financial markets and financial repression in emerging economies, the tendency of continuous outflows of financial capital in these economies will exert a depreciating pressure on the home currency. To see this, notice that the term on the RHS of equation (57) is proportional to the household saving rate $\tau = \frac{gH}{[1+g-H]}$. Since the household saving rate is an increasing function of income growth, the excess demand for foreign assets rises with g. So if η is large enough, this asset-demand effect on the real exchange rate can dominate the "secondary Balassa-Samuelson effect."

Figure 7 shows the two opposing effects on the real exchange rate when the growth rate of the economy increases (under the assumption $\eta = 1$). The solid line (circles) represents the precautionary saving effect on the real exchange rate (defined as $\frac{e^*}{\bar{e}}$ based on equation (57)) under the normalization that the market-determined nominal exchange rate equals the linked exchange rate when $g = 0$.[34] The curve shows that the real exchange rate increases (depreciates) with the income growth rate because the outflow of domestic financial capital rises with the precautionary saving rate. The dashed line (squares) represents the secondary Balassa-Samuelson effect on the real exchange rate, as determined by equation (27). The curve shows that the real exchange rate decreases (appreciates) with the growth rate because a higher domestic real interest rate renders nontradable goods more expensive relative to tradable goods under segregated capital markets. For example, when the income growth rate jumps from 0% to 1% per year, the real exchange rate would depreciate by nearly 24% under the precautionary saving effect and would appreciate by 11% under the secondary Balassa-Samuelson effect. Even if $\eta = 0.5$, the real exchange rate would still depreciate by 12% under the precautionary saving effect, larger than the Balassa-Samuelson effect.[35]

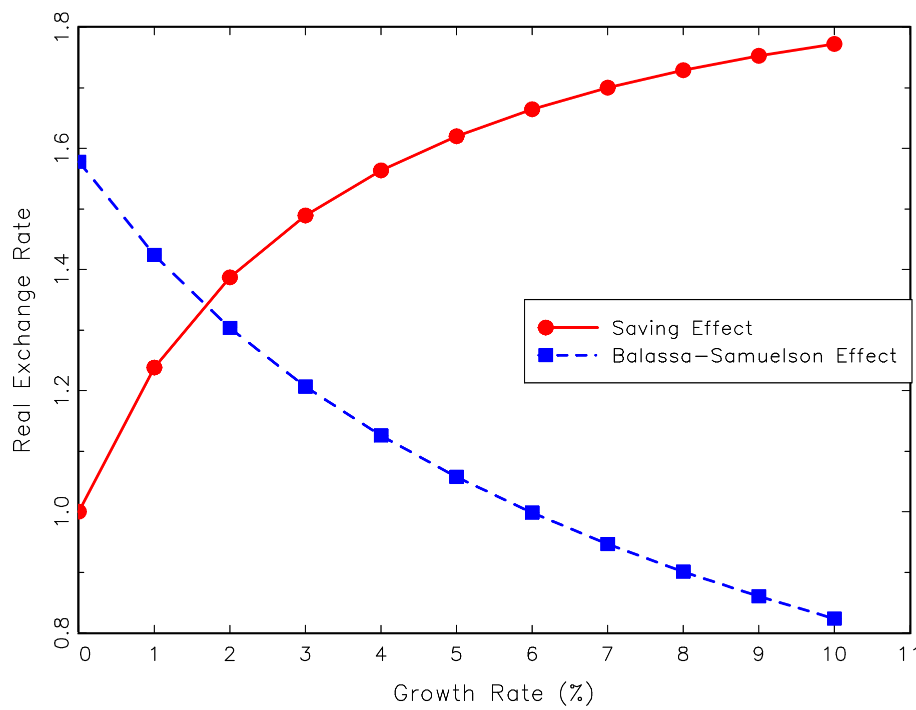

Figure 7. Growth Effects on Real Exchange Rate.

The basic message from the above analyses is that the market value of the RMB is determined not only by excess demand of tradable goods between China and the United States, but also by excess demand of foreign assets between the two countries. Given that China has an underdeveloped financial system that offers limited opportunities for households to invest their precautionary

[34] When $g = 0$, equation (57) implies $e^* = \bar{e}$ because the steady-state saving rate (τ) equals zero.

[35] A dynamic analysis under a transitory increase in the TFP growth rate g_t would generate similar results. To conserve space, such exercises are omitted in this paper.

savings, the demand for foreign assets by Chinese households is quite strong and such a strong asset demand can create extraordinary downward pressure on the RMB to depreciate against the dollar. Yet most of the existing literature about the determination of the exchange rate (including the Balassa (1964) and Samuelson (1964) analysis) has completely ignored the role of asset demand behind the exchange rate determination.

Even if the strong precautionary saving demand for foreign assets in an emerging economy is ignored, the Balassa-Samuelson effect may still be offset by the very fact that rapid productivity growth in China means that its tradable goods should become cheaper over time in the world market relative to goods produced by a slower-growing developed country. In reality, it may be precisely this counter Balassa-Samuelson effect that has caused (or partly caused) the empirical failure of the Balassa-Samuelson hypothesis.[36]

6 Further Robustness Analysis

A large trade surplus and foreign-reserve buildup are not unique to the Chinese economy. Other emerging economies, such as Japan in the 1960-70s, Hong Kong in the 1980s, and Taiwan and South Korea in the 1990s, also exhibited similar saving behaviors and registered large trade surpluses and exchange reserves during their rapid economic growth phase. However, because capital controls and a linked exchange rate are not universal features of all emerging economies, it is desirable to show that the previous results do not hinge on the assumptions of capital controls or a linked exchange rate.

This section assumes a floating nominal exchange rate with no capital controls. As in the general model, there are two production sectors in the home country. The nominal exchange rate is flexible and the real exchange rate (the relative price of the tradable goods in terms of the nontradable goods) is denoted by e_t. Households can choose to work in either sector and receive real wage W_{jt} in sector j. For simplicity and without loss of generality, there is no fixed capital in the model. The production technology in sector j is given by $Y_{jt} = A_t F(N_{jt})$, and the competitive real wage is given by $W_{jt} = \frac{dY_{jt}}{dN_{jt}}$. Applying the rescaling factor A_{t-1}, we have $y_{jt} = (1 + g_t) F(N_{jt})$ and $w_{jt} = (1 + g_t) F'(N_{jt})$.

Household i's problem is to solve

$$\max E \sum_{t=0}^{\infty} \beta^t \left\{\theta_t(i) \left[\gamma_1 \log c_{1t}(i) + \gamma_2 \log c_{2t}(i)\right] - N_{1t}(i) - N_{2t}(i)\right\} \tag{59}$$

[36] See Tica and Družić (2006) for a survey of the empirical literature on testing the Balassa-Samuelson hypothesis.

subject to

$$c_{1t}(i) + e_t c_{2t}(i) + (1 + g_t)\,\tilde{m}_{t+1}(i) \leq \tilde{m}_t(i) + w_{1t} N_{1t}(i) + e_t w_{2t} N_{2t}(i) + \Pi_{1t} + e_t \Pi_{2t} \tag{60}$$

$$\tilde{m}_{t+1}(i) \geq 0, \tag{61}$$

where $\tilde{m}_t$ denotes a portfolio of assets with a real gross rate of return equal to 1, and Π_{jt} denotes the profit income distributed from firms in sector j. Because currencies are fully convertible, the household faces only one budget constraint. The budget constraint implies that households can combine income received from either sector to finance consumption of both nontradable goods and tradable goods, as well as asset accumulations.

Proposition 6 *Denoting cash-in-hand as*

$$x_t \equiv \tilde{m}_t(i) + w_{1t} N_{1t}(i) + e_t w_{2t} N_{2t}(i) + \Pi_{1t} + e_t \Pi_{2t}, \tag{62}$$

the decision rules for consumption, imports, saving, and cash-in-hand are given, respectively, by

$$c_{1t}(i) = \frac{\gamma_1}{\gamma_1 + \gamma_2} \min\left\{1, \frac{\theta_t(i)}{\theta_t^*}\right\} x_t \tag{63}$$

$$e_t c_{2t}(i) = \frac{\gamma_2}{\gamma_1 + \gamma_2} \min\left\{1, \frac{\theta_t(i)}{\theta_t^*}\right\} x_t \tag{64}$$

$$(1 + g_t)\,\tilde{m}_{t+1}(i) = \max\left\{\frac{\theta_t^* - \theta(i)}{\theta(i)}, 0\right\} x_t \tag{65}$$

$$x_t = (\gamma_1 + \gamma_2)\,\theta_t^* R(\theta_t^*) w_{1t}, \tag{66}$$

where the cutoff and real exchange rate are determined by

$$\frac{1 + g_t}{w_{1t}} = \beta E_t \frac{1}{w_{1t+1}} R(\theta_t^*) \tag{67}$$

$$e_t = \frac{w_{1t}}{w_{2t}}. \tag{68}$$

Proof. See Appendix V. ■

Equations (63)-(68) imply that

$$\frac{c_{1t}}{c_{2t}} = \frac{\gamma_1}{\gamma_2} e_t. \tag{69}$$

Compared with equation (48), lifting capital controls implies efficient allocation here. However, this efficiency gain has no effect on the household saving rate, as the following proposition shows.

Proposition 7 *The current account surplus is given by*

$$CA_t = (\gamma_1 + \gamma_2) \left[(1 + g_t) \, \theta_t^* R(\theta_t^*) H(\theta_t^*) - \theta_{t-1}^* R(\theta_{t-1}^*) H(\theta_{t-1}^*) \right], \tag{70}$$

and the aggregate saving rate is given by

$$\tau_t = \frac{\left[(1 + g_t) \, \theta_t^* R(\theta_t^*) H(\theta_t^*) - \theta_{t-1}^* R(\theta_{t-1}^*) H(\theta_{t-1}^*) \right]}{\left[(1 + g_t) \, \theta_t^* R(\theta_t^*) - \theta_{t-1}^* R(\theta_{t-1}^*) H(\theta_{t-1}^*) \right]}. \tag{71}$$

Proof. See Appendix VI. ■

Notice that the saving rate is precisely the same as that in equation (20) in the benchmark model and is also identical to that in the general model (if $\alpha = 0$, or there is no capital in production). Clearly, both the current account and the national saving rate are independent of the exchange rate e_t. In the steady state, the current account surplus is given by

$$CA = g\theta R(\theta^*) H(\theta^*), \tag{72}$$

and the saving rate equals

$$\tau = \frac{\bar{g} H(\theta^*)}{1 + \bar{g} - H(\theta^*)}, \tag{73}$$

which is identical to equation (53) in the general model.

7 Conclusion

This paper offers two main insights:

- China's \$2.4 trillion foreign reserves can be a natural consequence of rapid economic growth in conjunction with an inefficient financial system (or lack of timely financial reform) that has hindered Chinese households from consuming their rapidly growing future income, instead of the intended outcome of any government policies or an undervalued home currency.

- The fundamental determinants of the exchange rate include not just excess demand for tradable goods but also excess demand for tradable assets. Taking into account the excessive amount of precautionary savings of Chinese households and capital controls, the current exchange rate of the RMB may have been *overvalued*, instead of undervalued.

The intuition is simple. Trade can always be balanced whether the exchange rate is "1 orange per apple", or "100 oranges per apple." A trade imbalance would occur if Chinese workers gave up 100 oranges in exchange for \$1 but then opt not to spend the entire dollar on American apples. Instead, they bought only half an American apple and saved the remaining 50¢ as IOUs. The question therefore is this: Why would Chinese workers do that when the real rate of return to American IOUs is so low (negative) and they expect to be much richer in the future than they are today? The answer is that Chinese workers have a much stronger need to save than do Americans due to large uninsured risks and severe borrowing constraints, and more paradoxically, the richer they expect to be in the future, the more they opt to save today. Such precautionary saving behavior seems to be in sharp contrast to conventional wisdom (Friedman, 1957), but is nonetheless perfectly rational when financial markets are incomplete.

Based on these insights, we can conclude that revaluing the RMB is unlikely to resolve the U.S. trade-imbalance problem with China and may prove counterproductive. First, the primary reason for developing countries to adopt a linked exchange rate is to facilitate trade by removing uncertainties in relative prices and returns to foreign investment, not to deliberately achieve trade surplus by selling low and buying high.[37] Thus, forcing China to appreciate its currency destroys the stability of the RMB and undermines the basic rationale of having a linked exchange rate. Second, such political pressure generates market expectations and leads to speculations and capital inflows to China, which in turn may result in inflation and asset bubbles in China.[38]

It is true that if the elasticity of American demand with respect to prices of Chinese goods is high—which is a big "if" because Chinese goods are labor intensive and not easily substitutable by American goods—then under the assumption of sticky prices, revaluing the RMB may reduce American demand for Chinese goods, thereby reducing the volume of trade between China and the United States. But the reduced imports of Chinese goods will be replaced by goods from other developing countries with similar comparative advantages in low labor costs and similar precautionary saving behaviors to Chinese workers because the high wage costs in the U.S. make it unprofitable to produce such goods domestically in America. Also, a revalued RMB is unlikely to change the precautionary saving motives of Chinese households. Thus, Chinese workers will not buy significantly more American goods simply because of a revalued RMB.

A more productive approach would be to (i) facilitate financial development in China and (ii) encourage Chinese firms to increase investment spending on capital goods both domestically and abroad. In this regard, the United States has much to offer because it excels at producing both financial products (diversified assets and efficient financial services) and capital-intensive goods (such as machinery).

[37] Krugman's (2010) argument suggests that Chinese firms have been selling their goods to American market at prices about 25%-40% percent below marginal costs. But without the well-known comparative cost-advantage in China, a persistently undervalued RMB of 25%-40% would have brought severe losses to Chinese exporting firms over the past 30 years. How could the firms have survived with such heavy losses for so long?

[38] Thus, a dramatic appreciation of the RMB may lead to potentially large economic disasters in the future given that the RMB may actually have been *overvalued*. Sudden collapses of domestic asset markets may occur when the capital controls are lifted (similar to the Asian financial crisis in 1997). Such outcomes will not benefit the world economy because a collapse of Chinese asset markets could trigger a worldwide recession larger than the aftermath of the Asian financial crisis, given the sheer size of the Chinese economy and its current integration with the world.

Appendix

A. I. Proof of Proposition 1.

Proof. Denote $\{\lambda_t(i), \pi_t(i)\}$ as the Lagrangian multipliers associated with equations (3) and (4), respectively. The first-order conditions for $\{c_t(i), N_t(i), m_{t+1}(i)\}$ are given, respectively, by

$$\frac{\theta_t(i)}{c_t(i)} = \lambda_t(i) \tag{74}$$

$$1 = A_0 \int \lambda_t(i) dF(\theta) \tag{75}$$

$$(1+\bar{g})\, \lambda_t(i) = \beta E_t \int \lambda_{t+1}(i) dF(\theta) + \pi_t(i), \tag{76}$$

where equation (75) reflects the fact that the labor supply must be determined before the realization of $\theta_t(i)$ in each period. The optimal decision rules are characterized by a cutoff strategy. In anticipation that the cutoff θ^* is independent of i, consider two possible cases as follow:

Case A. $\theta(i) \leq \theta^*$. In this case, the urge to consume is low. It is then optimal to save to prevent possible borrowing constraints in the future when the urge to consume may be high. So $m'(i) \geq 0$, $\pi(i) = 0$, and equation (76) implies that the shadow value of good $\lambda(i) = \frac{\beta}{(1+\bar{g})A_0}$. Equation (74) then implies that $c_t(i) = \theta(i)\frac{(1+\bar{g})A_0}{\beta}$. The household budget constraint then implies $(1+\bar{g})\, m'(i) = x(i) - \theta(i)\frac{(1+\bar{g})A_0}{\beta}$. The requirement $m'(i) \geq 0$ then implies

$$\theta(i) \leq x(i)\frac{\beta}{(1+\bar{g})\, A_0} \equiv \theta^*, \tag{77}$$

which defines the cutoff θ_t^*.

Case B. $\theta(i) > \theta^*$. In this case, the urge to consume is high. It is then optimal *not* to save, so $\pi_t(i) > 0$ and $m'(i) = 0$. By the household budget constraint, we have $c(i) = x(i)$, which by equation (77) implies $c(i) = \theta^* \frac{(1+\bar{g})A_0}{\beta}$. Equation (74) then implies that $\lambda_t(i) = \frac{\theta(i)}{\theta^*}\frac{\beta}{(1+\bar{g})A_0}$. Since $\theta(i) > \theta^*$, equation (76) confirms that $\pi(i) = \frac{\beta}{A_0}\left[\frac{\theta(i)}{\theta^*} - 1\right] > 0$.

The above analyses imply that $\lambda_t(i)$ takes two possible values, depending on the realization of $\theta_t(i)$. Hence, the expected value, $\int \lambda_t(i) dF(\theta)$, can be expressed analytically. That is, equation (75) implies

$$1 = \frac{\beta}{1+\bar{g}} R(\theta^*), \tag{78}$$

where the implicit function $R(\theta^*) \equiv \int_{\theta \leq \theta^*} dF(\theta) + \int_{\theta < \theta^*} \frac{\theta}{\theta^*} dF(\theta^*)$. As a result, the optimal cutoff, θ_t^*, is determined by equation (78), which determines the optimal labor supply. Equation (78) implies that the cutoff θ_t^* is independent of i because $\theta(i)$ is i.i.d. Hence, equation (77), which defines the cutoff, in turn implies that the optimal cash-in-hand (x_t) is also independent of i. ■

A. II. Proof of Proposition 2.

Proof. Differentiating the saving rate with respect to $\bar{g}$ gives

$$\frac{d\tau}{d\bar{g}} = \frac{H(1-H) + \bar{g}(1+\bar{g})\frac{\partial H}{\partial \bar{g}}}{(1+\bar{g}-H)^2}. \tag{79}$$

The definition of the function $R(\theta^*)$ in equation (11) implies $\frac{\partial R}{\partial \theta^*} < 0$, so equation (10) implies $\frac{\partial \theta^*}{\partial \bar{g}} < 0$. Given that $\frac{\partial H}{\partial \theta^*} > 0$, it must be true that $\frac{\partial H}{\partial \bar{g}} = \frac{\partial H}{\partial \theta^*}\frac{\partial \theta^*}{\partial \bar{g}} < 0$. Hence, the second term in the numerator of equation (79) is negative while the first term is positive. Because $\frac{d\tau}{d\bar{g}} > 0$ if $\bar{g} = 0$ and $\frac{d\tau}{d\bar{g}} < 0$ if $\bar{g} = \infty$, continuity implies there exists a threshold $\bar{g}^* \in (0, \infty)$ that renders $\frac{d\tau}{d\bar{g}} = 0$ or $\bar{g}^*(1+\bar{g}^*) = -H(1-H)/\frac{\partial H}{\partial \bar{g}}$, which has an interior solution for $\bar{g}^* \in (0, \infty)$ for any finite value of $\frac{\partial H}{\partial \bar{g}}$. So it must be true that $\frac{d\tau}{d\bar{g}} > 0$ if $\bar{g} < \bar{g}^*$ and $\frac{d\tau}{d\bar{g}} < 0$ if $\bar{g} > \bar{g}^*$. ■

A. III. Proof of Proposition 3.

Proof. When technology A_t is stochastic and follows the law of motion (18), the general equilibrium path of the re-scaled benchmark model can be characterized by the set of variables, $\{c_t, m_{t+1}, \theta_t^*, x_t, N_t, \}$, which can be solved uniquely by the following system of equations:

$$c_t = D(\theta_t^*)x_t \tag{80}$$

$$(1+g_t)\, m_{t+1} = H(\theta_t^*)x_t \tag{81}$$

$$\frac{1+g_t}{w_t} = \beta E_t \frac{1}{w_{t+1}} R(\theta_t^*) \tag{82}$$

$$x_t \equiv m_t + w_t N_t = \theta_t^* R(\theta_t^*) w_t, \tag{83}$$

plus equation (19) and standard transversality conditions.

In general equilibrium, $w_t = 1 + g_t$. So equation (82) solves implicitly for the cutoff θ_t^*. Given the cutoff, equations (80) and (83) solve for the optimal consumption path as

$$c_t = D(\theta_t^*)\theta_t^* R(\theta_t^*)(1+g_t), \tag{84}$$

and equations (81) and (83) solve for the optimal foreign reserves as

$$(1+g_t)\, m_{t+1} = H(\theta_t^*)\theta_t^* R(\theta_t^*)\,(1+g_t)\,. \tag{85}$$

Equation (83) implies $w_t N_t = \theta_t^* R(\theta_t^*) w_t - m_t$, which in turn implies employment in the tradable sector:

$$N_t = \theta_t^* R(\theta_t^*) - \frac{m_t}{(1+g_t)} = \theta_t^* R(\theta_t^*) - \frac{H(\theta_{t-1}^*)\theta_{t-1}^* R(\theta_{t-1}^*)}{(1+g_t)}. \tag{86}$$

Therefore, year-to-year changes in foreign reserves in period t are given by

$$(1+g_t)\, m_{t+1} - m_t = y_t \left[1 - \frac{c_t}{(1+g_t)\, N_t}\right] = y_t \left[1 - \frac{D(\theta_t^*)\theta_t^* R(\theta_t^*)}{\theta_t^* R(\theta_t^*) - \frac{1}{(1+g_t)(1+v)} H(\theta_{t-1}^*)\theta_{t-1}^* R(\theta_{t-1}^*)}\right]. \tag{87}$$

Multiplying the lower-case variables by A_{t-1} gives equation (20).

Using the law of motion in equation (18) and assuming lognormal distribution for ε_t with mean zero and variance σ_ε^2, equation (82) implies

$$1 = \beta R(\theta_t^*) E_t \frac{1}{1+g_{t+1}} = \beta R(\theta_t^*) \left(\frac{1+\bar{g}}{1+g_t}\right)^{\rho_g} \frac{e^{\frac{1}{2}\sigma_\varepsilon^2}}{1+\bar{g}}. \tag{88}$$

With θ following the Pareto distribution $F = 1 - \theta^{-\sigma}$, we have $R(\theta^*) = 1 + \frac{1}{\sigma-1}\theta^{*-\sigma}$, so the above equation solves for the cutoff explicitly as in equation (22). ■

A. IV. Proof of Proposition 4.

Proof. Denote $\{\lambda_{1t}(i), \pi_{1t}(i), \lambda_{2t}(i), \pi_{2t}(i)\}$ as the Lagrangian multipliers associated with equations (31)-(34), respectively. By the assumption that $\theta_t(i)$ is orthogonal to aggregate shocks, the first-order conditions for $\{c_{jt}(i), N_{jt}(i), \xi_{jt+1}(i)\}$ are given, respectively, by

$$\gamma_j \frac{\theta_t(i)}{c_{jt}(i)} = \lambda_{jt}(i) \tag{89}$$

$$1 = w_{jt} \int \lambda_{jt}(i) dF(\theta) \tag{90}$$

$$(1+g_t)\, \lambda_{jt}(i) = \beta E_t \left[\int \lambda_{jt+1}(i) dF(\theta)\right] + \pi_{jt}(i), \tag{91}$$

where equation (90) reflects the fact that the labor supply must be determined before the realization of $\theta_t(i)$ in each sector and each period. The household decision rules can then be derived straightforwardly following the same steps as in Appendix I. ■

A. V. Proof of Proposition 6.

Proof. The first-order conditions for $\{c_{1t}, c_{2t}, N_{1t}, N_{2t}, \tilde{m}_{t+1}\}$ are given, respectively, by

$$\frac{\gamma_1 \theta_t(i)}{c_{1t}(i)} = \lambda_t(i) \tag{92}$$

$$\frac{\gamma_2 \theta_t(i)}{c_{2t}(i)} = e_t \lambda_t(i) \tag{93}$$

$$1 = w_{1t} \int \lambda_t(i) dF(\theta) \tag{94}$$

$$1 = e_t w_{2t} \int \lambda_t(i) dF(\theta) \tag{95}$$

$$(1 + g_t)\, \lambda_t(i) = \beta E_t \lambda_{t+1}(i) + \pi_t(i). \tag{96}$$

These first-order conditions imply

$$e_t = \frac{w_{1t}}{w_{2t}} \tag{97}$$

$$\frac{c_{1t}(i)}{c_{2t}(i)} = \frac{\gamma_1}{\gamma_2} e_t. \tag{98}$$

Using the relation between c_{1t} and c_{2t}, the household decision rules can be derived following the same steps as in Appendix I. ■

A. VI. Proof of Proposition 7.

Proof. Aggregating by the law of large numbers, the household decision rules become

$$c_{1t} = \frac{\gamma_1}{\gamma_1 + \gamma_2} D(\theta_t^*) x_t \tag{99}$$

$$e_t c_{2t} = \frac{\gamma_2}{\gamma_1 + \gamma_2} D(\theta_t^*) x_t \tag{100}$$

$$(1 + g_t)\, \tilde{m}_{t+1} = H(\theta_t^*) x_t \tag{101}$$

$$x_t = (\gamma_1 + \gamma_2)\, \theta^* R(\theta_t^*) w_{1t}. \tag{102}$$

The budget constraint becomes

$$c_{1t} + e_t c_{2t} + (1 + g_t)\, \tilde{m}_{t+1} = \tilde{m}_t + w_{1t} N_{1t} + e_t w_{2t} N_{2t} + \Pi_{1t} + e_t \Pi_{2t}. \tag{103}$$

Since households own firms, wage income plus profit income should equal the value of output in each sector:

$$w_{jt}N_{jt} + \Pi_{jt} = y_{jt}. \tag{104}$$

Hence, market clearing in the nontradable-goods sector implies

$$c_{1t} = w_{1t}N_{1t} + \Pi_{1t}. \tag{105}$$

Equation (103) then implies

$$e_t c_{2t} + (1 + g_t)\,\tilde{m}_{t+1} = \tilde{m}_t + e_t y_{2t}. \tag{106}$$

So the current account surplus is given by

$$CA_t = e_t y_{2t} - e_t c_{2t} = (1 + g_t)\,\tilde{m}_{t+1} - \tilde{m}_t. \tag{107}$$

Using equation (101), we have

$$\begin{aligned} CA_t &= H(\theta_t^*)x_t - \frac{1}{1+g_{t-1}}H(\theta_{t-1}^*)x_{t-1} \\ &= (\gamma_1 + \gamma_2)\left[(1+g_t)\,\theta_t^* R(\theta_t^*)H(\theta_t^*) - \theta_{t-1}^* R(\theta_{t-1}^*)H(\theta_{t-1}^*)\right]. \end{aligned} \tag{108}$$

The aggregate saving rate is given by

$$\tau_t = \frac{y_{1t} + e_t y_{2t} - [c_{1t} + e_t c_{2t}]}{y_{1t} + e_t y_{2t}} = \frac{CA_t}{y_{1t} + e_t y_{2t}}, \tag{109}$$

where the denominator is given by

$$\begin{aligned} y_{1t} + e_t y_{2t} &= w_{1t}N_{1t} + \Pi_{1t} + e_t w_{2t} N_{2t} + e_t \Pi_{2t} \\ &= x_t - \tilde{m}_t \\ &= x_t - \frac{1}{1+g_{t-1}}H(\theta_{t-1}^*)x_{t-1} \\ &= (\gamma_1 + \gamma_2)\left[(1+g_t)\,\theta_t^* R(\theta_t^*) - \theta_{t-1}^* R(\theta_{t-1}^*)H(\theta_{t-1}^*)\right]. \end{aligned} \tag{110}$$

So we have

$$\tau_t = \frac{\left[(1+g_t)\,\theta_t^* R(\theta_t^*)H(\theta_t^*) - \theta_{t-1}^* R(\theta_{t-1}^*)H(\theta_{t-1}^*)\right]}{\left[(1+g_t)\,\theta_t^* R(\theta_t^*) - \theta_{t-1}^* R(\theta_{t-1}^*)H(\theta_{t-1}^*)\right]}. \tag{111}$$

■

References

[1] Aiyagari, R., 1994, Uninsured idiosyncratic risk and aggregate saving, Quarterly Journal of Economics 109(3), 659-684.

[2] Attanasio, O., L. Picci, and A. Scorcu, 2000, Saving, growth, and investment: A macroeconomic analysis using a panel of countries, Review of Economics and Statistics 82(2), 182-211.

[3] Balassa, B., 1964, The purchasing power parity doctrine: A reappraisal, Journal of Political Economy 72(6), 584-596.

[4] Bewley, T., 1980, The optimum quantity of money, in "Models of Monetary Economics," ed. by John Kareken and Neil Wallace. Minneapolis, Minnesota: Federal Reserve Bank, 1980.

[5] Buera, F. and Y. Shin, 2010, Productivity growth and capital flows: The dynamics of reforms, Working Paper.

[6] Caballero, Ricardo, Emmanuel Farhi and Pierre-Olivier Gourinchas, 2008, An equilibrium model of global imbalances and low interest rates, American Economic Review 98(1), 358-393.

[7] Carroll, C., 1992, The buffer-stock theory of saving: Some macroeconomic evidence, Brookings Papers on Economic Activity 23(2), 61-156.

[8] Carroll, C., 1997, Buffer-stock saving and the life cycle/permanent income hypothesis, Quarterly Journal of Economics, 112(1), 1-56.

[9] Carroll, C. and Weil, D., 1994, Saving and growth: A reinterpretation, Carnegie-Rochester Conference Series on Public Policy 40, 133-192.

[10] Carroll, C., J. Overland, and D. Weil, 2000, Saving and growth with habit formation, American Economic Review 90(3), 341-355.

[11] Carroll, C. and O. Jeanne, 2009, A Tractable model of precautionary reserves, net foreign assets, or sovereign wealth funds, Peterson Institute for International Economics Working Paper Series WP 09-10.

[12] China Statistical Year Book (2008, 2009).

[13] Cline, W and J. Williamson, 2009, Estimates of fundamental equilibrium exchange rates, Peterson Institute for International Economics, Policy Brief 09-10.

[14] Cooper, Richard N. , 2007, Living with global imbalances, Brookings Papers on Economic Activity 2, pp. 91-110.

[15] Deardorff, Alan, 2010, A trade theorist's take on global imbalance, in "The US-Sino Currency Dispute: New Insights from Economics, Politics and Law," ed. by Simon Evenett, A VoxEU.org Publication, Centre for Economic Policy Research, April 2010.

[16] Deaton, A., 1991, Saving and liquidity constraints, Econometrica. 59(5), 1221-1248.

[17] Dooley, Michael, David Folkerts-Landau, and Peter Garber, 2005, International financial stability: Asia, interest rates, and the dollar, (New York: Deutsche Bank Global Research).

[18] Durdu, Ceyhun Bora, Enrique G. Mendoza, and Marco E. Terrones, 2007, Precautionary demand for foreign assets in sudden stop economies: An assessment of the new mercantilism, FRB International Finance Discussion Paper No. 911.

[19] Engel, C. and Rogers, J.H., 2006, The US current account deficit and the expected share of world output, Journal of Monetary Economics 53, 1063-1093.

[20] Feldstein, M., 2008, Resolving the global imbalance: The dollar and the U.S. saving rate, The Journal of Economic Perspectives 22(3), 113-125.

[21] Friedman, M., 1957, A Theory of the Consumption Function. Princeton, NJ: Princeton University Press.

[22] Gourinchas, Pierre-Olivier, and Olivier Jeanne, 2007, Capital flows to developing countries: The allocation puzzle, NBER Working Paper No. 13602.

[23] Hugget, Mark, 1993, The risk free rate in heterogenous-agent, incomplete-insurance economies, Journal of Economic Dynamics and Control 17(5-6), 953-969.

[24] Jin, Keyu, 2008, Industrial structure and financial capital flows, Working Paper, Harvard University.

[25] Ju, Jiandong and Shang-Jin Wei, 2010, Domestic institutions and the bypass effect of financial globalization, NBER Working Paper 13148.

[26] Krugman, Paul, 2010, Taking on China, New York Times, 15 March 2010.

[27] Lucas, R.E. Jr., 1980, Equilibrium in a pure currency economy, Economic Inquiry 18(2), 203-220.

[28] Makinen, M. et al., 2007, Inequalities in health care use and expenditures: Empirical data from eight developing countries, Bulletin of the World Health Organization 78, 55-65.

[29] Mendoza, Enrique G., Vincenzo Quadrini, and José-Victor Rios-Rull, 2009, Financial integration, financial development, and global imbalances, Journal of Political Economy 117, 371-416.

[30] Modigliani, F., 1970, The life-cycle hypothesis of saving and intercountry differences in the saving ratio, in "Induction, Growth, and Trade: Essays in Honour of Sir Roy Harrod" (Clarendon Press, Oxford) 197-225.

[31] Modigliani, F. and S. Cao, 2004, The Chinese saving puzzle and the life-cycle hypothesis, Journal of Economic Literature 42(1), 145-170.

[32] Obstfeld, Maurice and Kenneth Rogoff, 2005, Global current account imbalances and exchange rate adjustments, Brookings Papers on Economic Activity 1: 67-146.

[33] Obstfeld, M. and K. Rogoff, 2007, The unsustainable U.S. current account deficit revisited, in "G7 Current Account Imbalances: Sustainability and Adjustment," ed. by Richard H. Clarida (Chicago: University of Chicago Press/National Bureau of Economic Research), February.

[34] Obstfeld, M. and K. Rogoff, 2009, Global imbalances and the financial crisis: Products of common causes, CEPR Discussion Paper No. DP7606.

[35] Prasad, E., R. Rajan, and A. Subramanian, 2006, Patterns of international capital flows and their implication for economic development, Federal Reserve Bank of Kansas, Jackson Hole conference paper.

[36] Samuelson, P., 1964, Theoretical notes on trade problems, Review of Economics and Statistics 46(2), 145-154.

[37] Sandri, Damiano, 2008, Growth and capital flows with risky entrepreneurship, Manuscript, Johns Hopkins University.

[38] Song, Z., K. Storesletten, and F. Zilibotti, 2011, Growing like China, American Economic Review 101, 202-241.

[39] Tica, J. and I. Družić, 2006, The Harrod-Balassa-Samuelson effect: A survey of empirical evidence, Working Paper.

[40] Wang, X. and Y. Wen, 2010, Can rising housing prices explain China's high household saving rate? Federal Reserve Bank of St. Louis Working Paper 2010-045A.

[41] Wen, Yi, 2009a, Saving and growth under borrowing constraints: Explaining the high saving rate puzzle, Federal Reserve Bank of St. Louis Working Paper 2009-045C.

[42] Wen, Yi, 2009b, Liquidity and welfare in a heterogeneous-agent economy, Federal Reserve Bank of St. Louis Working Paper 2009-019B.

[43] Yu, Yongding, 2007, Global imbalances and China, The Australian Economic Review 40(1), 3-23.