

Credit Constraints and Growth in a Global Economy

Nicolas Coeurdacier, Stéphane Guibaud, Keyu Jin

▶ **To cite this version:**

Nicolas Coeurdacier, Stéphane Guibaud, Keyu Jin. Credit Constraints and Growth in a Global Economy. 2012. hal-03473915

HAL Id: hal-03473915

https://sciencespo.hal.science/hal-03473915

Preprint submitted on 10 Dec 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

DISCUSSION PAPER SERIES

No. 9109

CREDIT CONSTRAINTS AND GROWTH IN A GLOBAL ECONOMY

Nicolas Coeurdacier, Stéphane Guibaud and Keyu Jin

INTERNATIONAL MACROECONOMICS



Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP9109.asp**

ISSN 0265-8003

CREDIT CONSTRAINTS AND GROWTH IN A GLOBAL ECONOMY

Nicolas Coeurdacier, Sciences Po, Paris and CEPR
Stéphane Guibaud, London School of Economics
Keyu Jin, London School of Economics

Discussion Paper No. 9109
August 2012

Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

This Discussion Paper is issued under the auspices of the Centre's research programme in **INTERNATIONAL MACROECONOMICS**. Any opinions expressed here are those of the author(s) and not those of the Centre for Economic Policy Research. Research disseminated by CEPR may include views on policy, but the Centre itself takes no institutional policy positions.

The Centre for Economic Policy Research was established in 1983 as an educational charity, to promote independent analysis and public discussion of open economies and the relations among them. It is pluralist and non-partisan, bringing economic research to bear on the analysis of medium- and long-run policy questions.

These Discussion Papers often represent preliminary or incomplete work, circulated to encourage discussion and comment. Citation and use of such a paper should take account of its provisional character.

Copyright: Nicolas Coeurdacier, Stéphane Guibaud and Keyu Jin

CEPR Discussion Paper No. 9109

August 2012

ABSTRACT

Credit Constraints and Growth in a Global Economy*

In a period of rapid integration and accelerated growth in emerging markets, three striking trends have been (1) a divergence in the private saving rates of emerging markets and advanced economies, (2) large net capital outflows from emerging markets, and (3) a sustained decline in the world interest rate. This paper shows that in a multi-period OLG model, the interaction between growth and household credit constraints --- more severe in emerging markets --- is able to account for all of the above facts. We provide micro-level evidence that corroborates our mechanism: saving behaviors across age groups in the U.S. and China are broadly supportive of the predictions of the model.

JEL Classification: F21, F32 and F41
Keywords: capital flows, credit constraints, globalization, life-cycle household savings and saving and current account imbalances

Nicolas Coeurdacier
Sciences Po
Rue des St Peres
75006 Paris
FRANCE

Email: ncoeurdacier@gmail.com

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=163809

Stéphane Guibaud
London School of Economics
Department of Economics
Houghton Street
London
WC2A 2AE
USA

Email: s.guibaud@lse.ac.uk

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=163082

Keyu Jin
London School of Economics
Houghton Street
London
WC2A 2AE

Email: k.jin@lse.ac.uk

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=171014

*We thank Philippe Bacchetta, Christopher Carroll, Pierre-Olivier Gourinchas, Emmanuel Farhi, Dirk Krueger, Marc Melitz, Fabrizio Perri, Tom Sargent, Cedric Tille, Eric van Wincoop, Michael Zheng, Dennis Yao, seminar participants at Boston University, CHKU, CREST, the Federal Reserve Bank of New York, Harvard University, GIIDS (Geneva), HEC Lausanne, HKU, INSEAD, LSE, MIT, UCLA, and conference participants at the Society for Economic Dynamics (Ghent), Tsinghua Macroeconomics Workshop, New Developments in Macroeconomics (UCL), and the NBER IFM Summer Institute (2011), UCL New Developments in Macro Workshop (2012) for helpful comments. Taha Choukhmane, Henry Lin, and Heng Wang provided excellent research assistance.

Submitted 25 July 2012

1 Introduction

Two of the most important developments in the global economy of the recent decades are the integration of emerging markets into world capital markets and their rapid growth, particularly in certain parts of Asia. Alongside these events are three striking and unprecedented trends: (1) a large and persistent increase in the private saving rate in emerging Asia against a steady decline in the private saving rate in advanced economies; (2) the emergence of global imbalances with developing countries running a large current account surplus and advanced economies a current account deficit; (3) a sustained fall in the world long-term interest rate. Recent theoretical advances have been designed to explain (2) and (3), with little emphasis placed on (1) despite its underlying centrality.

The striking divergence in saving rates emerges from Figure 1.1, which juxtaposes the saving rates of advanced economies against those of Emerging Asia. Differences between the private saving rates of these regions were rather small at the time of their integration around 1990. It is over the course of two decades, during which the world interest rate steadily declined, that saving rates widely diverged, their differences culminating at the end of that period. The pattern is even more obvious when it comes to household saving rates in countries such as the U.S. and China. In 1988, household saving rates were about the same in the two countries—at about 5 percent. By 2007 the household saving rate in China reached almost 30 percent while that of the U.S. declined to a level of about 2.5 percent. This begs the question as to why saving behaviors against common world interest rate movements can be diametrically opposite across economies. The caricature of a 'debt ridden' U.S. put into sharp relief against 'thrifty' Asia reflects this popular curiosity.

Part of the growing interest in these global patterns stems from the difficulty of standard open-economy growth models to explain them. Theories thereof predict that in a fast growing economy such as Asia, the saving rate should fall as agents borrow against their higher future income to augment consumption and investment. The rise in the world interest rate, as a result of the higher productivity of capital in Asia, will lead the saving rate to fall in other

parts of the world.[1] In face of high domestic investment needs, Asia becomes a net capital importer rather than a net exporter. And in the long run, there is nothing that prevents convergence in saving rates and investment rates across countries. The challenge for any theory to successfully capture the global phenomenon is then not only to explain why saving can outpace investment in a fast-growing economy, but also to elucidate why the global equilibrium can feature *asymmetric* reactions of saving rates in different countries to the common world interest rate.

In view of these issues, the paper makes three main contributions. First, we develop a theory of growth and asymmetric household credit constraints across large open economies. We ask the question of how the growth acceleration of emerging markets with tighter constraints impinge on the world economy, and show that it can generate the full set of aggregate facts (1)-(3). Second, we provide micro-level evidence that cohort behavior is consistent with the distinctive predictions of the model, using household data from the U.S. and China. Third, a full calibration of our model to the experience of these two economies indicates that our mechanism can explain about 40 percent of the divergence in aggregate saving rates of these two economies and also a significant portion of cohort-level saving behavior. Over the course of our micro-level investigation we are able to make an additional contribution: to lay bare the inherent biases underlying the cohort methods of previous empirical studies that find potentially misleading Chinese saving patterns.

The bifurcation of *household* saving rates across countries, especially striking in the data, motivates our theory. Our benchmark framework consists of multiple open economies, populated with overlapping generations of agents living for three periods. This structure provides scope for both international and intergenerational borrowing. In all economies, young agents are subject to borrowing constraints, but the tightness of the constraint is more severe in developing countries than in advanced economies. We show that a country's aggregate saving places a greater weight on the (dis)saving of the young for less credit-constrained economies, and greater weight on the middle-aged's saving for more constrained

[1]Standard parameters make the income effect associated with changes in the interest rate dominate the substitution effect.

economies. A fall in the world interest rate induces greater borrowing (lower savings) by the young—through a loosening of constraints—while leading to greater savings of the middle-aged—through a dominant income effect. The different weights on the young borrowers versus the middle aged savers translate into sharp differences in the response of an economy's aggregate saving rate. Slope differences in saving rates combined with initial levels-differences induce a permanent divergence in the long run.

In this framework the decline in the world interest rate is brought about by the increasing size of Asia relative to the rest of the world. Faster growth in Emerging Asia results in a greater weight being put on its (lower) autarkic interest rate in determining the world interest rate.[2] Thus, the *interaction* of growth and credit constraints is key. Without growth of these economies the world interest rate would not permanently decline—critical for the savings divergence. These effects are absent in the standard model without liquidity constraint, but also absent in a model where liquidity constraints are symmetric across countries. The open-economy assumption is also crucial, not only for the obvious reason that any discussions of external imbalances relies on it. Insofar as it is the precondition for advanced economies to face a declining interest rate, closed-economy versions of the analogous would not be able to generate the key patterns in question—and in particular, not the saving rate *divergence* which we emphasize.

Our model is an extension and variation of Jappelli and Pagano's (1994) closed-economy three-period OLG model with household credit constraints.[3] As in their model, the multi-period overlapping generation structure naturally and conveniently provides scope for borrowers and savers to coexist in a given economy. Although this common existence may arise from other sources of heterogeneity among agents, an additional rationale for adopting the OLG setup is that it offers an important avenue towards explaining the rise in aggregate household saving rate in China, as shown in Modigliani and Cao (2004). What is miss-

[2]The long-run world interest rate is a weighted average of the autarkic steady state interest rates, with the weights determined by relative country size. This follows directly from the proof of Proposition 2.

[3]Our baseline model differs in three main ways: (1) the open-economy aspect of our framework; (2) asymmetry in household credit constraints across countries; (3) more general preferences and life income profiles. They find empirical support for their key prediction: cross-country differences in household credit constraints can help explain international differences in saving rates.

ing, though, is the cohort-level evidence that would lend support to the life cycle motive of savings—something we establish in this paper. Moreover, the distinctive predictions of our model on cohort-level saving behavior both within an economy and across economies, both in terms of levels and change—provide clear empirical guidelines: the main supportive evidence is that the decline in the young's saving rate is larger in the U.S. than in China, and the rise in the saving rate by the middle-aged in China is larger than the rise in the U.S.

The empirical findings at cohort level, supportive of the qualitative implications of our model, also provide a natural barometer for its quantitative assessment. We show that a full calibration of the model to the experiences of the U.S. and China between 1970-2010, incorporating the evolution of demographics and income profiles in each economy, can explain about 40 percent of the divergence in aggregate saving rates between the two economies, and a significant fraction of the changes in saving rate at cohort level in each economy.

The cause of global imbalances in view of the mechanism highlighted above is thus differences in saving behavior across countries, driven by heterogenous credit constraints. There is convincing reason to believe that the recent emergence of global imbalances is mainly driven by savings. If one examines the experience of the U.S. over 1970-2009, it is clear from Figure 1.2 that there is a strong parallel between household saving and the current account, while there is hardly any relationship between investment and the current account. China echoes this experience (Figure 1.3), as do most other countries over the period of 1998-2007. Figure 1.4 makes evident the fact that the cross-country dispersion in saving rates accounts for most of the cross-country dispersion in the current account. Any theory of global imbalances would therefore need to be in accord with this observation.

It is in this sense that categorizing, when appropriate, related theories in terms of an investment-based or a saving-based account of global imbalances can be helpful. In important works, Buera and Shin (2009), Benhima (2012), and Song, Storesletten and Zilibotti (2011) show that financial frictions can bring about a suppression of investment demand from firms, leading to a capital outflow from developing countries. The point of contention from an empirical viewpoint may be that even though investment as a share of GDP declined

during the East Asian crisis, it quickly reverted to and subsequently exceeded its pre-crisis level (Figure 1.5). The recent period during which global imbalances were most pronounced saw an increase in investment-GDP in Asia rather than a fall.

On the other hand, models of global imbalances revolving around a saving story have emphasized a strong precautionary saving motive driven by uninsurable risk in developing countries. These countries which feature a lower autarkic interest rate can see a capital outflow upon opening up to capital markets, as forcefully shown in Mendoza, Quadrini and Rios-Rull (2009). In our view, the extraordinary growth experience of these emerging markets——and not just capital market liberalization—is very much a central part of the recent global experience and therefore should not be excluded. But in face of rapid productivity growth which raises the marginal productivity of capital, risk per se may then only have second-order effects. That is to say, the surge in investment due to the strong neoclassical effect can potentially dominate the effect driven by high precautionary saving in emerging markets, precipitating a current account deficit rather than a surplus.[4] Caballero, Gourinchas, and Farhi (2009) focus on the lack of ability to generate assets in developing countries, whose savings need to be largely channeled abroad. An essential difference is that their paper does not focus on endogenous motive for saving which is at the core of this paper. Also, saving rates fall globally under integration and fast growth in emerging economies.

Another strand of the literature holds that corporate saving behavior is pivotal in accounting for global imbalances. Firms may increase their savings for precautionary motives in the presence of uninsurable investment risk (Sandri (2010)), or to build up liquidity to finance investment in periods of high productivity growth (Benhima and Bacchetta (2011)). However, levels of corporate savings have risen uniformly in both developing and advanced economies, with China actually experiencing a fall in its corporate saving *rate*— making corporate saving behavior less likely to be the main factor of divergence.[5] Still, the corporate

[4]This result can be remedied if growth is accompanied by a strong increase in idiosyncratic uncertainty, as in Carroll and Jeanne (2009), but the empirical validity of this assumption is unclear.

[5]A close look at firm level data in Bayoumi, Tong, and Wei (2011) casts doubt on corporate savings being the main driver of global imbalances, especially for China. First, corporate savings have increased in many countries—in developing and in advanced—so that its rise is not unique to the emerging markets running a current account surplus. Bayoumi et al (2011) show that Chinese firms do not have a significantly higher

saving channel can be viewed as complementary to the household saving rationale which we draw particular attention to in the current work.

In essence, the key departure of this paper from others in the existing literature is the ability of this framework to explain the divergence in saving rates—that is, the differential response of saving rates to interest rate changes that leads to their greater dispersion in the long run. The above models with a saving-based account of global imbalances tend to focus on differences in the *levels* of saving rates, and the outflow of capital from the high-saving rate country to the low-saving rate country upon integration of these economies. Over time however, differences in levels do not become more pronounced — whereas in the data, initial differences in saving rates in 1990 are dwarfed by their differences in 2010. Moreover, when incorporating the growth experiences of countries, the above papers tend to predict the opposite patterns.

The paper proceeds as follows. Section 2 develops the theoretical framework and provides some key intuitions and analytical results. Section 3 employs numerical experiments to illustrate the impact of fast growth and integration of emerging markets on the global economy. Section 4 investigates micro-level evidence on cohort saving behavior in China and the U.S. Section 5 examines the quantitative predictions of a fully-calibrated model for these two economies, allowing for a bequest motive and incorporating heterogeneous demographic and income profile evolutions. Section 6 concludes.

2 Model

The world economy consists of large open economies, populated with overlapping generations of consumers who live for three periods. We let $\gamma \in \{y, m, o\}$ denote a generation. Consumers supply one unit of labor when young ($\gamma = y$) and when in middle age ($\gamma = m$), and retire when old ($\gamma = o$). In youth, consumers are credit-constrained, but the severity of that constraint differs across countries. In all other aspects our framework is standard: all countries use the same technology to produce one homogeneous good, which is used for

saving rate than the global average.

consumption and investment, and is traded freely and costlessly. Preferences and production technologies have the same structure and parameter values across countries. Technologies only differ to the extent that labor input in each country consists of only domestic labor, and firms are subject to changes in country-specific productivity levels and labor force.

2.1 Production

The production technology, identical across countries, uses capital and labor to produce a homogeneous good. Let K_t^i denote the aggregate capital stock at the beginning of period t in country i, and $e_t^i L_{y,t}^i + L_{m,t}^i$ the total labor input employed in period t, where $L_{\gamma,t}^i$ denotes the size of generation γ and e_t^i the relative productivity of young workers ($e_t^i < 1$). The gross output in country i is

$$Y_t^i = \left(K_t^i\right)^{\alpha} \left[A_t^i \left(e_t^i L_{y,t}^i + L_{m,t}^i\right)\right]^{1-\alpha}, \tag{1}$$

where $0 < \alpha < 1$, and A_t^i is country-specific productivity. The capital stock in country i depreciates at rate δ and is augmented by investment goods, I_t^i, with law of motion

$$K_{t+1}^i = (1-\delta)K_t^i + I_t^i. \tag{2}$$

Factor markets are competitive so that each factor, capital and labor, earns its marginal product. Thus, the wage rates per unit of labor in youth and middle age for country i are

$$w_{y,t}^i = e_t^i (1-\alpha) A_t^i \left(k_t^i\right)^{\alpha}, \tag{3}$$

$$w_{m,t}^i = (1-\alpha) A_t^i \left(k_t^i\right)^{\alpha}, \tag{4}$$

where $k_t^i \equiv K_t^i / [A_t^i (e_t^i L_{y,t}^i + L_{m,t}^i)]$ denotes the capital-effective-labor ratio. The rental rate earned by capital in production equals the marginal product of capital, $r_{K,t}^i = \alpha \left(k_t^i\right)^{\alpha-1}$.

The gross rate of return earned between period $t-1$ and t in country i is therefore

$$R_t^i = 1 - \delta + r_{K,t}^i. \tag{5}$$

Let $g_{A,t}^i$ and $g_{L,t}^i$ denote the the growth rate of productivity and of the young cohort size, respectively, so that

$$A_t^i = (1 + g_{A,t}^i) A_{t-1}^i, \tag{6}$$

$$L_{y,t}^i = (1 + g_{L,t}^i) L_{y,t-1}^i. \tag{7}$$

2.2 Households

A consumer born in period t earns the competitive wage rate $w_{y,t}^i$ when young and $w_{m,t+1}^i$ in the following period. Let $c_{\gamma,t}^i$ denote the consumption of an agent in country i belonging to generation γ. The lifetime utility of a consumer born in period t in country i is

$$U_t^i = u(c_{y,t}^i) + \beta u(c_{m,t+1}^i) + \beta^2 u(c_{o,t+2}^i),$$

with standard isoelastic preferences $u(c) = (c^{1-\frac{1}{\sigma}} - 1)/(1 - \frac{1}{\sigma})$. The discount factor β satisfies $0 < \beta < 1$ and the intertemporal elasticity of substitution coefficient satisfies $\sigma \leq 1$.

Let $a_{\gamma,t+1}^i$ denote the net asset holdings at the end of period t of an agent belonging to generation γ. An agent born in period t faces the following sequence of budget constraints:

$$c_{y,t}^i + a_{y,t+1}^i = w_{y,t}^i, \tag{8}$$

$$c_{m,t+1}^i + a_{m,t+2}^i = w_{m,t+1}^i + R_{t+1}^i a_{y,t+1}^i, \tag{9}$$

$$c_{o,t+2}^i = R_{t+2}^i a_{m,t+2}^i. \tag{10}$$

When young, individuals can borrow in order to consume ($a_{y,t+1}^i < 0$). When middle-aged, they earn the competitive wage, repay their loans, consume and save for retirement. When old, they consume all resources available. A bequest motive is omitted for convenience but

is introduced later on in the quantitative analysis (Section 5).

We assume that young agents are subject to credit constraints: they can only borrow up to a fraction θ^i of the present value of their future labor income,

$$a^i_{y,t+1} \geq -\theta^i \frac{w^i_{m,t+1}}{R^i_{t+1}}. \tag{11}$$

The tightness of credit conditions, captured by θ^i, can differ across countries. We are interested in the case in which (11) is binding for all countries.

Assumption 1 *Credit constraints for the young are binding at all times in all countries.*

This assumption is satisfied if two conditions hold: (1) θ^i is small enough— smaller than the fraction of intertemporal wealth that the young would consume in the absence of credit constraints; (2) the wage profile is steep enough—and steeper the higher the θ^i.[6] When credit constraints are binding, the net asset position of the young is

$$a^i_{y,t+1} = -\theta^i \frac{w^i_{m,t+1}}{R^i_{t+1}}. \tag{12}$$

The net asset position of a middle-aged agent at the end of period t is obtained from the Euler condition that links $c^i_{m,t}$ and $c^i_{o,t+1}$, yielding

$$a^i_{m,t+1} \quad = \quad \frac{1}{1+\beta^{-\sigma}(R^i_{t+1})^{1-\sigma}}(1-\theta^i)w^i_{m,t}. \tag{13}$$

Changes in R^i_{t+1} affects middle-aged asset holdings through a substitution and income effect, the latter dominating when $\sigma < 1$.

[6] Formally, the conditions are $\theta^i < \eta^*_t$ and $\frac{w^i_{m,t+1}}{R^i_{t+1}w^i_{y,t}} > \frac{1-\eta^*_t}{\eta^*_t-\theta^i}$, for all t, where

$$\eta^*_t \equiv \frac{\beta^{-2\sigma}(R^i_{t+1}R^i_{t+2})^{1-\sigma}}{1+\beta^{-\sigma}(R^i_{t+2})^{1-\sigma}[1+\beta^{-\sigma}(R^i_{t+1})^{1-\sigma}]}.$$

In the case of log utility, the conditions amount to $\theta^i < \frac{1}{1+\beta+\beta^2}$, and $\frac{w^i_{m,t+1}}{R^i_{t+1}w^i_{y,t}} > \frac{\beta(1+\beta)}{1-\theta^i(1+\beta+\beta^2)}$.

2.3 Closed-Economy Equilibrium

The autarky equilibrium reveals the impact of the tightness of credit constraints on the accumulation of capital and on the long run autarky interest rates. The capital market equilibrium condition requires that total capital stock accumulated at the end of period t in country i is equal to the aggregate wealth of that country:

$$K^i_{t+1} = L^i_{y,t} a^i_{y,t+1} + L^i_{m,t} a^i_{m,t+1}, \tag{14}$$

which, combined with (12) and (13), gives the law of motion for k^i, the capital-effective-labor ratio in country i. In the full depreciation case where $\delta = 1$, the dynamic of k^i is given implicitly by[7]

$$(1 + g^i_{A,t+1})(1 + g^i_{L,t}) \left[1 + e^i_{t+1}(1 + g^i_{L,t+1}) + \theta^i \frac{1-\alpha}{\alpha}\right] k^i_{t+1} = \frac{(1-\theta^i)(1-\alpha)}{1 + \beta^{-\sigma} \left\{\alpha (k^i_{t+1})^{\alpha-1}\right\}^{1-\sigma}} (k^i_t)^\alpha.$$

All else equal, the less-constrained economy (higher θ^i) is on a lower autarkic path of capital than the more-constrained economy (lower θ^i), as illustrated in Figure 2.1, which plots the law of motion for capital for different values of the credit constraint parameter.

The following theorem characterizes the impact of θ^i on the steady state of the economy. To zero in on the effect of differences in credit constraints, we assume constant and identical productivity and labor force growth rates g_A and g_L across countries, and a fixed relative productivity of young workers e.

Theorem 1 *Suppose that $\delta = 1$. There exists a unique, stable, autarky steady state. All else equal, more constrained economies have a higher capital-to-efficient-labor ratio k^i and a lower interest rate R^i:*

$$\frac{dk^i}{d\theta^i} < 0, \qquad \frac{dR^i}{d\theta^i} > 0.$$

[7]Most of our theoretical results are derived for $\delta = 1$. We show in our subsequent numerical analyses that these results hold when $\delta < 1$.

Proof. See Appendix B.

More constrained economies (higher θ) accumulate more capital as a result of less dissaving of the young and lower debt repayment of the middle-aged, and hence feature a lower rate of return. In the special case of $\sigma = 1$, the autarky steady state interest rate in country i can be expressed as

$$R^i = (1+g_A)(1+g_L)\frac{1+\beta}{\beta}\frac{\alpha[1+e(1+g_L)]+\theta^i(1-\alpha)}{(1-\alpha)(1-\theta^i)}. \tag{15}$$

It shows that the rate of return is also increasing in higher aggregate productivity and labor force growth g_A and g_L, as well as higher relative efficiency e —all of which increase the marginal productivity of capital. Demographics matter not only through its impact on labor force growth, but also on the population composition: a higher proportion of young agents relative to middle-aged agents due to high g_L increases the proportion of borrowers relative to savers and hence puts upward pressure on the rate of return to capital.

2.4 Open-Economy Equilibrium

Under financial integration, capital flows across borders until rates of return are equalized across countries. Financial integration in period t implies that $R^i_{t+1} = R_{t+1}$ and $k^i_{t+1} = k_{t+1}$, for all i. The capital market equilibrium condition becomes

$$\sum_i K^i_{t+1} = \sum_i \left(L^i_{y,t}a^i_{y,t+1} + L^i_{m,t}a^i_{m,t+1}\right), \tag{16}$$

which, along with (12) and (13), gives the law of motion for k_t. Next, we characterize the integrated steady state in which the growth rates of productivity and labor, g_A and g_L, and the relative productivity e of young workers, are identical across countries. Let λ^i denote the contribution of country i to the world supply of effective labor in steady state, i.e.,

$$\lambda^i \equiv \frac{A_{i,t}(eL^i_{y,t} + L^i_{m,t})}{\sum_j A_{j,t}(eL^j_{y,t} + L^j_{m,t})}.$$

Proposition 2 *Suppose that $\delta = 1$. Let $\theta_L \equiv \min_i\{\theta^i\}$, $\theta_H \equiv \max_i\{\theta^i\}$, with $\theta_L \neq \theta_H$. The steady state world interest rate R satisfies*

$$R(\theta_L) < R < R(\theta_H), \tag{17}$$

where $R(\theta)$ denotes the autarky steady state interest rate in a country with credit constraint parameter θ.

Proof. See Appendix B.

This proposition illustrates the first factor causing a decline in the rate of return faced by less-constrained economies (high θ): financial integration with the more constrained economy. Figure 2.1 plots the law of motion for the capital-effective-labor ratio k under integration in a two-country case, lying in between the autarkic laws of motion. Suppose that the high θ country starts from its initial autarkic steady state $k(\theta_H)$, whereas the low θ economy is capital scarce, and such that the two economies have identical capital-effective-labor ratios at the time they integrate.[8] Upon integration, the two economies jump to the integrated path of capital stock. The convergence from $k(\theta_H)$ to the integrated steady state $k(\bar{\theta})$ translates into a sustained decline in the world interest rate (where $\bar{\theta}$ refers to the 'world aggregate level of credit constraints', determined as a weighted average of country-specific θ's).

The second factor that can lead to a decline in the world interest rate is faster growth in the more constrained economy. To demonstrate this, first observe that in the special case where $\sigma = 1$, the interest rate in the integrated steady state is

$$R = (1+g_A)(1+g_L)\frac{1+\beta}{\beta}\frac{\alpha[1+e(1+g_L)]+\bar{\theta}(1-\alpha)}{(1-\alpha)\left(1-\bar{\theta}\right)}, \qquad \bar{\theta} \equiv \sum_i \lambda^i \theta^i. \tag{18}$$

where $\bar{\theta}$ replaces θ^i in the autarky steady state rate of return given by Equation 15. The world interest rate is determined by the weighted-average level of credit constraints across countries. Equation 18 implies that when the more constrained economies account for a

[8] One can also think of this as the more constrained economy already in steady state experiencing faster productivity growth that reduces its capital efficiency ratio to $k(\theta_H)$ at the time of integration.

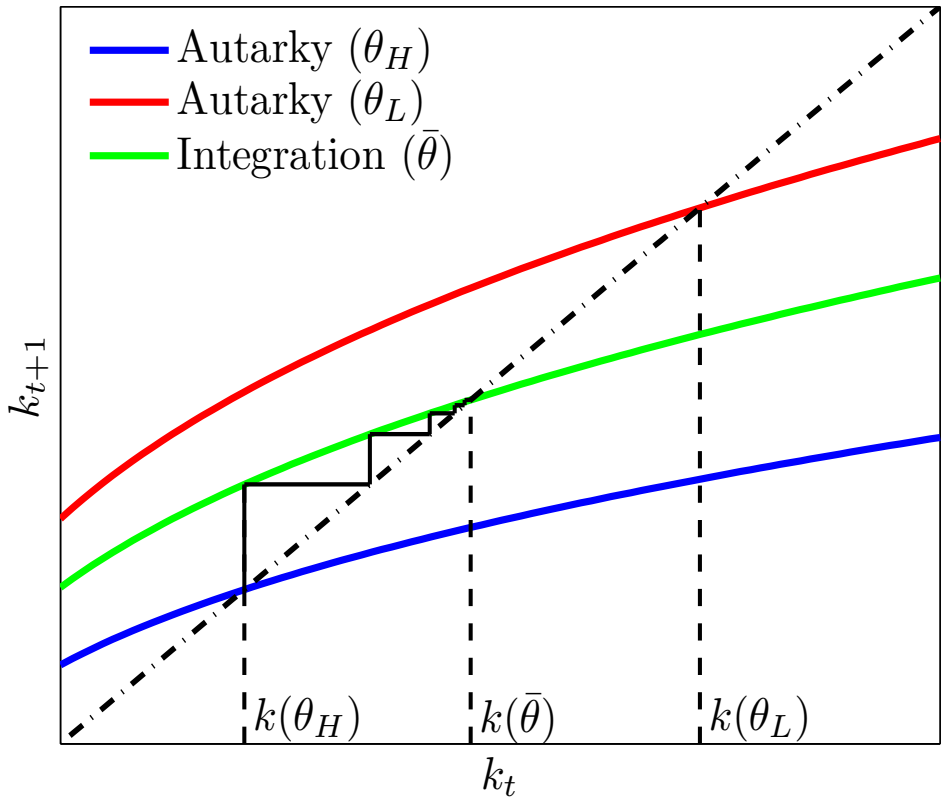


Figure 2.1: Law of Motion and Steady State: Autarky and Integration.
The parameter values taken are $\sigma = 0.5$, $\beta = 0.97$ (annualized), $\alpha = 0.28$, $\delta = 9\%$ (annualized), $\theta_H = 0.2$, $\theta_L = 0.05$, $g_A = 1.5\%$ (annualized), $g_L = 1\%$, $e = 0.33$.

greater share of the world economy, causing a decrease in $\bar{\theta}$, the world interest interest rate falls. This result can be generalized for any $\sigma \leq 1$ in the following proposition:

Proposition 3 *A relative expansion of the more constrained economies (i.e., an increase in the share λ^i of a country with low θ^i) causes a fall in the world interest rate, while an expansion of less-constrained economies does the opposite.*

Proof. See Appendix B.

2.5 Savings and Investment

We next show that the heterogeneity in credit constraints leads to differential responses of saving rates to a fall in the world interest rate across countries, both at the national and

cohort level. Formal definitions of aggregate and cohort-level savings and the current account are relegated to Appendix A.

In the integrated steady state, the aggregate saving to GDP ratio of country i is

$$\frac{S^i}{Y^i} = -\frac{g}{1+e(1+g_L)}(1-\alpha)\frac{\theta^i}{R} + \frac{g}{1+g}\frac{1}{1+e(1+g_L)}(1-\alpha)\frac{1-\theta^i}{1+\beta^{-\sigma}R^{1-\sigma}} + \delta k^{1-\alpha}, \quad (19)$$

where R and k are at their steady-state values, and $g \equiv (1+g_A)(1+g_L) - 1 > 0$. The first observation one can make is that the *levels* of saving rates differ across countries under integration— the saving rate is higher in more constrained economies (lower θ^i), which place greater weight on the middle-aged savers than on young borrowers. Second, the *interaction* between growth and credit constraints is critical — in the absence of growth ($g = 0$), the net saving rate is zero, and there are no cross-country differences in the levels of saving rates. Third, Equation 19 leads to the following proposition:

Proposition 4 *In an integrated global economy with heterogenous credit constraints, a fall in the world rate of return induces a greater dispersion in saving rates across countries.*

This follows from the fact that

$$\frac{\partial^2(S/Y)}{\partial\theta\partial R} > 0.$$

In response to a fall in the common world interest rate R, the saving rate increases by more in the more constrained economy. The fall in R can be brought about by financial integration or accelerated growth in the more constrained economies, following Proposition 2 and 3. Therefore, initial differences in saving rates across countries combined with the slope differences induce a *divergence* in saving rates across countries when R falls.

The dynamic response of savings to changes in the interest rate is apparent when examining cohort-level saving (as a share of GDP), which summed across generations is just the

aggregate saving rate. We show in Appendix A that[9]

$$\begin{aligned}
\frac{S^i_{y,t}}{Y^i_t} &= -(1+g^i_{A,t+1})\frac{1+g^i_{L,t}}{1+e^i_t(1+g^i_{L,t})}\frac{\theta^i(1-\alpha)}{k^\alpha_t}\left(\frac{\alpha}{R_{t+1}}\right)^{\frac{\alpha}{1-\alpha}}, \\
\frac{S^i_{m,t}}{Y^i_t} &= \frac{1}{1+e^i_t(1+g^i_{L,t})}\left[\frac{1-\theta^i}{1+\beta^{-\sigma}R^{1-\sigma}_{t+1}}+\frac{\theta^i}{R_t}\right](1-\alpha), \\
\frac{S^i_{o,t}}{Y^i_t} &= -\frac{1}{1+g^i_{A,t}}\frac{1}{1+g^i_{L,t-1}}\frac{1}{1+e^i_t(1+g^i_{L,t})}\frac{1}{1+\beta^{-\sigma}R^{1-\sigma}_t}(1-\theta^i)(1-\alpha)\left(\frac{k_{t-1}}{k_t}\right)^\alpha+\delta k^{1-\alpha}_t.
\end{aligned}$$

These equations demonstrate that the partial effect of a fall in R_{t+1} is more borrowing of the young—the combined effect of a lower discount rate and associated higher future wage rate—and also more saving by the middle-aged if $\sigma < 1$. Moreover, they illustrate the asymmetric responses of the same cohort across countries to a common fall in the world interest rate. Specifically, the increase in borrowing by the young is larger in the less constrained economy (high θ^i), while the increase in savings of the middled-aged is larger in the more constrained economy (low θ^i). The net response of the aggregate saving rate depends on θ^i: higher θ^i gives more importance to the young borrowers' larger dissavings, whereas lower θ^i gives more importance to the middle-aged's rising savings. Note also that the presence of credit constraints moderates the impact of future growth $g^i_{A,t+1}$ on the saving rate: the dissavings of the young can only increase up to the extent permitted by the binding credit constraints. This mitigates the standard wealth effects of growth on savings when growth is experienced by a country with a low θ.

Investment behavior is governed by the same forces that underlie a neoclassical growth model. Under financial integration, differences in investment-output ratios across countries are largely determined by their relative growth prospects. With full depreciation ($\delta = 1$), investment to GDP ratios obey

$$\frac{I^i_t/Y^i_t}{I^j_t/Y^j_t} = \frac{1+\tilde{g}^i_{t+1}}{1+\tilde{g}^j_{t+1}}, \tag{20}$$

where $1+\tilde{g}^i_{t+1} \equiv (1+g^i_{A,t+1})\frac{1+e^i_{t+1}(1+g^i_{L,t+1})}{e^i_t+(1+g^i_{L,t})^{-1}}$ denotes the combined growth rate in productivity

[9]Cohort-level saving normalized by each generation's factor income is omitted, but yields similar expressions (i.e., up to some multiplicative terms common across countries) to cohort savings normalized by GDP.

and effective labor input in country i.

3 Numerical Illustrations

In this section, we conduct numerical experiments to analyze how two of the most important developments of the recent decades — financial integration of emerging markets and their faster growth— impinge on the world economy in our framework. These experiments are meant to help build intuition for the mechanism at hand, and to illustrate the qualitative implications of the model both at the aggregate and micro level, rather than to assess its ability to quantitatively match the data. A quantitative evaluation of the fully-calibrated model is taken up later in Section 5, where aggregate and micro-level predictions of the model are both compared to the data. Our experiments concern two economies H and L with heterogenous credit constraints ($\theta_H > \theta_L$). These can be thought of as Advanced economies and Emerging Asia, respectively. In order to fully understand the workings of the model, especially along the transition path, we proceed incrementally by first exploring the impact of faster growth in the more constrained economy in a *fully-integrated* environment (Section 3.1), then turning to a more realistic scenario where an Advanced economy starting at its own steady state integrates with a capital-scarce Emerging Asia (Section 3.2).[10]

Preference and technology parameters are standard. In a three-period OLG model each period is equivalent to 20 years. The intertemporal elasticity of substitution is taken to be $\sigma = 0.5$, and the discount factor $\beta = 0.54$ reflects an annual discount factor of 0.97. The depreciation rate is set at 9 percent per year which gives $\delta = 0.88$ over a 20 year period. The capital share α is set at 0.28 and the relative productivity of young workers is fixed at $e = 0.33$.[11] For illustrative purposes, we set $\theta_H = 0.21$ and $\theta_L = 0.03$. We later discipline these parameters by matching them to the cross-section of cohort saving rates in the U.S.

[10] An early version of the paper also considers a three-country experiment. We find that a realistic cross-section of aggregate saving rates and current accounts can emerge from the interaction of a cross-section of differences in credit constraint tightness and growth. Hence our model could also potentially account for heterogeneity in saving rates and current account imbalances among Advanced economies.

[11] We match the income share for the U.S. over the period 1990-2008, using the adjustment of Gollin (2002) for mixed and proprietary income. The relative productivity of young workers is chosen to match life income profile data for the U.S. (see details in Section 5).

and China in the full calibration exercise of Section 5.

3.1 Faster Growth in Emerging Asia

We first examine the impact of faster growth in Asia, which features tighter credit constraints. This experiment assumes that capital markets are already integrated, and that both countries start from their integrated steady state. This shuts off the potential confounding effect of capital market integration and also the effect of transitional dynamics from emerging markets on the aggregate economy. These assumptions are relaxed in the subsequent exercise in Section 3.2. It is important to emphasize that all growth rate changes are fully expected.

We assume productivity and labor force growth rates at the steady state are $g_A = 1.5\%$ and $g_L = 1\%$ (annually). Labor grows at its steady-state growth rate throughout. The effective labor of Asia relative to Advanced economies in the initial steady state is chosen to match the GDP of Asia relative to Advanced economies in 1970 (21%). Subsequently, the growth rate of productivity in Advanced economies is assumed to stay at its steady state value, whereas Asia's productivity grows at 5% (annually) between $t = 2$ and $t = 4$, to match the rise in the relative size of Asia's output from 21% to 82% over the last forty-year period. Productivity and labor in Asia are assumed to be growing at their steady-state growth rates thereafter.

Figure 3.1 displays the behavior of key variables. The rate of return initially rises, between $t = 1$ and $t = 3$, as a result of expected faster growth in Asia. It subsequently declines to a permanently lower level. This long-run decline in the world interest rate is a consequence of the large increase in the relative weight of Emerging Asia, which draws the world interest rate closer towards its lower, autarkic steady-state value (Proposition 3). The initial rise in interest rate is counterfactual, but we show later that this result is overturned when Asia is initially capital-scarce.

Figure 3.1 also shows that after a period of fast growth in credit-constrained Asia, the saving rates diverge across regions, with the initial gap in saving rates smaller than their post-growth difference. The sharp rise in the aggregate saving rate in Asia between $t = 2$ and

$t = 4$ contrasts with the decline in that of advanced economies. Focusing on the period of falling interest rate between $t = 3$ and $t = 4$, the rise in saving rate in Asia appears mostly driven by the middle-aged, while the fall in saving rate in Advanced economies is driven by the young. Notably, changes in saving rates across age groups exhibit a hump-shaped pattern in both regions.[12]

Whereas the aggregate saving rates diverge over time, investment rates converge in the long run. The divergence in aggregate saving rates therefore carries over to the current account. In the long run, Asia runs a permanent current account surplus and advanced economies a permanent deficit, with larger imbalances than in the initial period. The current account in Asia is in deficit in period $t = 2$, due to the initial sharp rise in the investment rate, but then sees a dramatic improvement of more than 7 percentage points, against the decline in the advanced economies' current account by about 4 percentage points. This arises from the steep rise in saving relative to investment—the consequence of which is a net capital outflow in Asia.

3.2 Integration and Growth Experiment

The previous experiment makes the unrealistic assumptions that capital markets are integrated from the outset and that emerging Asia starts from a steady state. The following exercise assumes that both regions are in autarky in period $t = -1$ (corresponding to 1970) and financial opening only occurs in period $t = 0$ (corresponding to 1990). Emerging Asia is capital-scarce initially (at $t = -1$), while advanced economies are at their own steady state. Productivity in Advanced economies always grows at its constant steady-state growth rate of 1.5%, while productivity in Emerging Asia grows faster between $t = -1$ and $t = 1$ (corresponding to the 1970-2010 period). We calibrate the initial relative values of effective labor and capital-effective-labor ratios (k^L_{-1}/k^H_{-1}), along with the productivity growth path of Asia, to match Asia's relative output share in 1970 and 2010, as well as the relative

[12]We focus on the period between $t = 3$ and $t = 4$, which corresponds to the years 1990-2010, since this is the period for which we explore cohort-level data in Section 4. Similar patterns hold over the entire growth period between $t = 2$ and $t = 4$. The decline in the saving rate of Asia in period $t = 5$, and the small rise in that of advanced economies, are driven by the behavior of the old cohort.

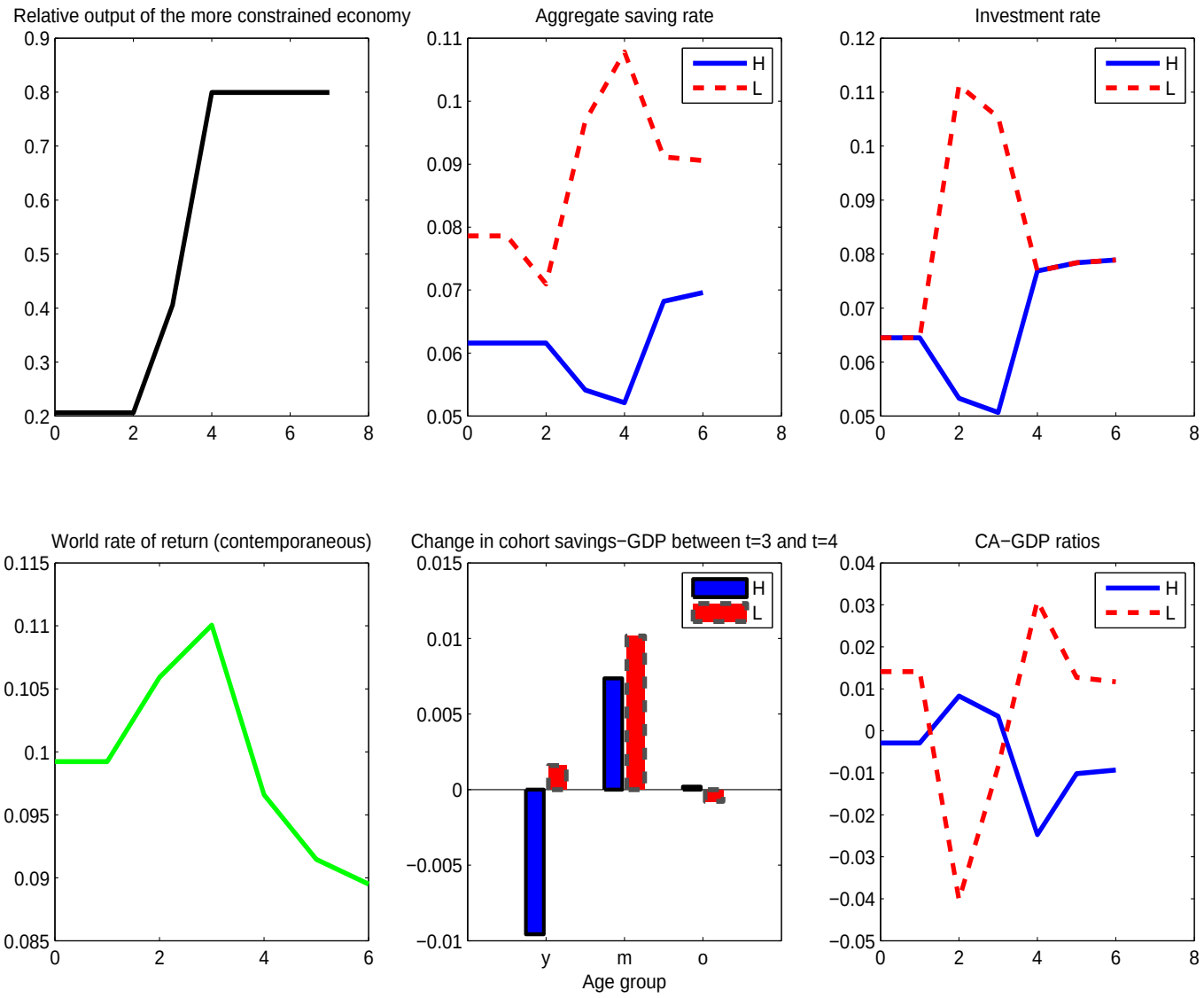


Figure 3.1: First Experiment: Fast Growth in Asia.

capital-effective labor ratios, k_0^L/k_0^H, as measured by Hall and Jones (1999) for 1990.

Figure 3.2 displays key results. Since Asia is still on a transition path towards its steady state, it features a higher autarkic rate of return than Advanced economies in the initial period $t = -1$. Rates of return across the two regions are equalized when capital markets integration occurs in period $t = 0$. There are three factors determining the dynamics of the interest rate faced by each economy. Since the world interest rate lies in between the autarkic interest rates at each point in time, we first explore the two factors governing the autarky interest rate. The first is the 'growth effect', which tends to raise the interest rate in Asia due to higher marginal productivity of capital; the second is the 'transition effect', which

tends to lower the interest rate in Asia as it rapidly accumulates capital from a capital-scarce starting point. Then, the 'integration' effect determines the world interest rate according to the relative size of each economy. In this case, the transition effect dominates the growth effect in Asia, and the rapid decline of its autarky interest rate, combined with its increasing weight in the economy, leads the world interest rate to decline from the very outset. The integrated steady-state interest rate is lower than either of the initial autarkic interest rates.

In this experiment, the saving rates across regions diverge between $t = 0$ and $t = 1$ (corresponding to the period 1990-2010), consistent with the data.[13] Over that period, the rise in saving rate in China is again mostly driven by the middle-aged while the fall in the U.S. is driven by the young, and changes in saving rates across age groups exhibit a hump-shaped pattern in both countries. These predictions of the model provide guidance for our empirical analysis of micro data on cohort savings in Section 4. Finally, due to a large rise in its investment rate at the time of integration, Asia temporarily runs a small current account deficit in period $t = 0$ before running a current account surplus of more than 3 percent of GDP in the subsequent period. The dynamics of the current account in Asia resembles the one observed in the data, with small deficits in the early 1990's and large surpluses in the 2000's.

Comparisons with alternative models. In the absence of credit constraints, the aggregate saving rate would fall in the fast-growing economy as the young borrow more against their higher future income. Investment would rise and the country would run a large current account deficit. World interest rates would rise as a result of the higher marginal product of capital before reverting to the steady state level interest rate. A simulation of the model with the same degree of credit constraints across countries generates similar qualitative dynamics of saving and investment to a model without constraints. In fact, in the absence of asymmetry in credit constraints, saving rates tend to converge across economies over time as cohorts respond similarly to changes in the interest rate. Thus, both the presence of credit constraints and their heterogeneity across countries is vital for our main results.

[13]The convergence in saving rates in later periods is mostly driven by the behavior of the old cohort, as in the previous experiment.

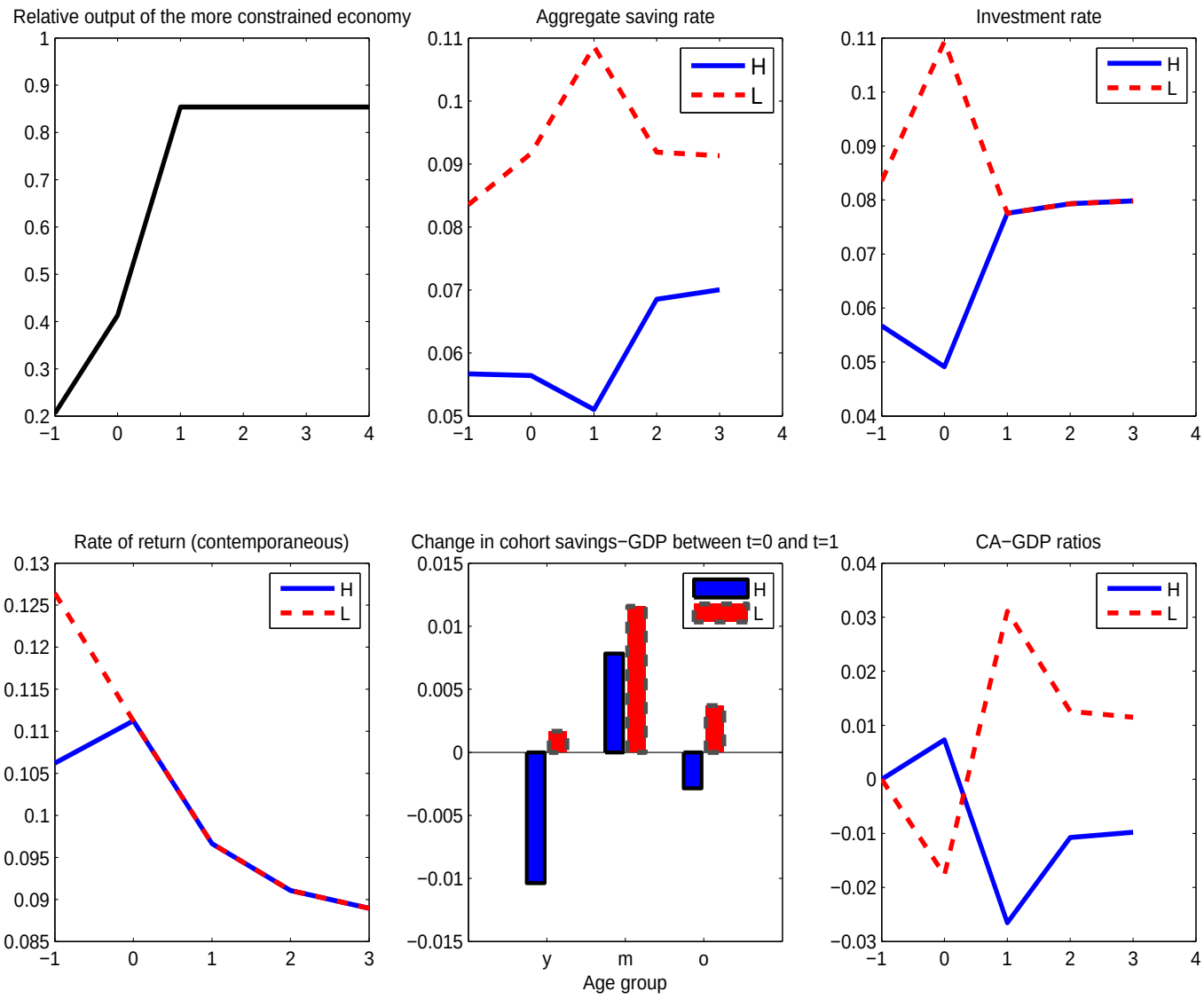


Figure 3.2: Second Experiment: Fast Growth in Asia (Capital-Scarce) and Integration.

4 Empirical Evidence on Cohort Savings

In this section, we provide direct evidence on cohort-level saving behavior and their evolution over the last two decades, corresponding to predictions of the model. We consider the two most important countries from each of the two groups of advanced economies and emerging Asia—U.S. and China.

4.1 Evidence from the U.S.

The Consumer Expenditure Survey (CEX) offers the most comprehensive source of disaggregated consumption data, and is therefore our primary data source for the U.S.. Annual data from 1986 to 2008 covers a total of six age groups: under 25, 25-34, 35-44, 45-54, 55-64, 65 and above. Details of the data are provided in Appendix C.2.

4.1.1 Underreporting Biases

The main issue involved in using CEX data is its sharp discrepancy with the National Income and Product Account (NIPA) data when it comes to measuring income and consumption. This discrepancy is well-documented in works such as Slesnick (1992), Battistin (2003), Laitner and Silverman (2005), Heathcote, Perri and Violante (2010), and arises from an underreporting of both consumption and income in the CEX data (Figure 4.1). The degree of underreporting has become more severe over time for consumption but not for income, the consequence of which is a stark rise in the aggregate saving rate as computed from CEX data, compared to an actual decline as measured by NIPA data (Figure 4.2).

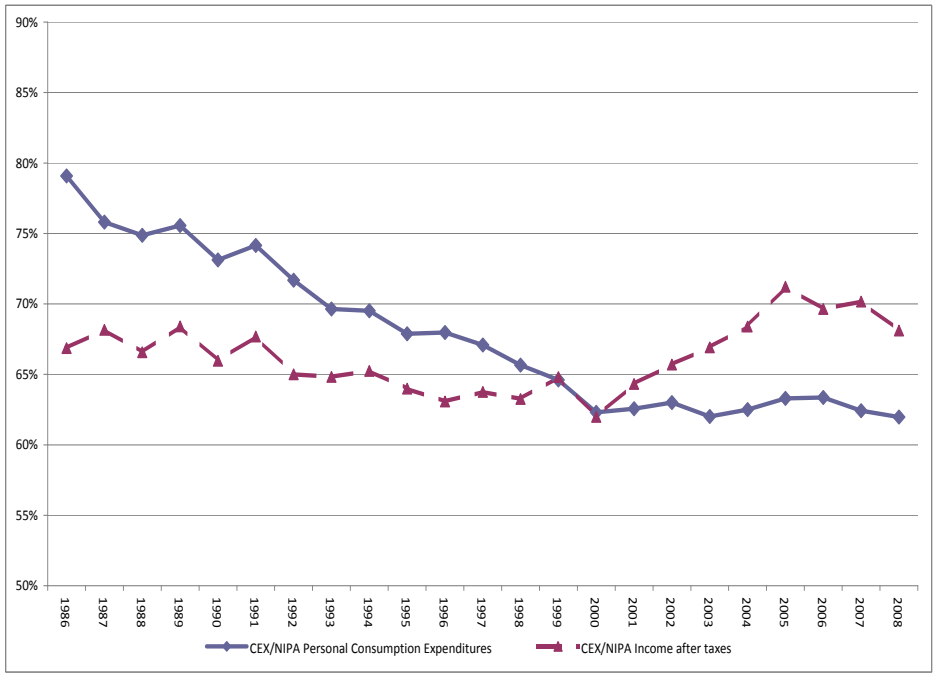


Figure 4.1: U.S. Aggregate Consumption and Income (CEX/NIPA ratios).

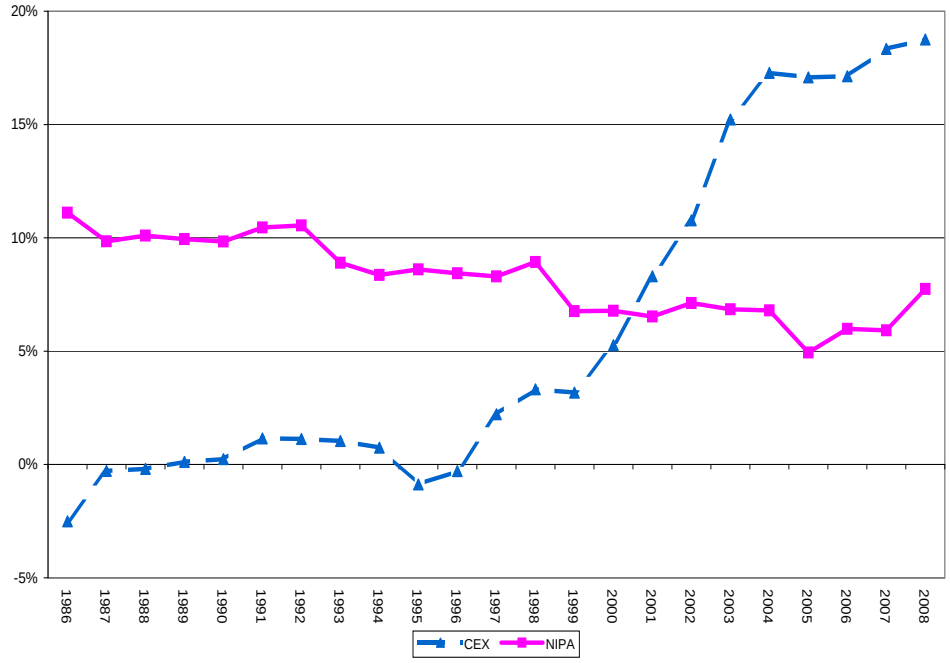


Figure 4.2: U.S. Aggregate Saving Rate: NIPA vs. Unadjusted CEX.

4.1.2 Addressing the Biases

Inspired by previous works (Parker et al. (2009) among others), we assume that NIPA data is well measured, and propose three correction methods to bring consistency between CEX data and NIPA. The first correction method adjusts income and consumption reported in CEX uniformly across all age groups so as to match NIPA in the aggregate. The second correction method recognizes that the degree of consumption underreporting may vary across goods, which becomes an issue if the composition of the consumption basket differs across age groups. It therefore applies sector-specific adjustment factors to CEX sectoral consumption data. One problem, however, is that the substantial differences between the types of medical expenditures included in CEX and NIPA may lead to biases — especially in estimating the consumption of the old. Our third method is meant to address this problem while still matching NIPA consumption data in the aggregate.

Method 1: using aggregate data

Let $c_{a,t}^{CEX}$ and $y_{a,t}^{CEX}$ denote average consumption and income reported in CEX for age a in year t, and let $C_t^{\mathcal{D}}$ and $Y_t^{\mathcal{D}}$ denote aggregate consumption and income in dataset $\mathcal{D}$. We

adjust consumption and income for all ages according to

$$\hat{c}_{a,t} = \frac{C_t^{NIPA}}{C_t^{CEX}} c_{a,t}^{CEX},$$
$$\hat{y}_{a,t} = \frac{Y_t^{NIPA}}{Y_t^{CEX}} y_{a,t}^{CEX}.$$

By construction, consumption expenditures and income match NIPA in the aggregate.[14] The corrected saving rate for age a in period t becomes

$$s_{a,t} = \frac{\hat{y}_{a,t} - \hat{c}_{a,t}}{\hat{y}_{a,t}}. \tag{21}$$

Method 2: using sectoral expenditure data

Our second method uses CEX and NIPA data on aggregate consumption by sectors (indexed by $j = 1, ..., 15$) to compute sector-specific adjustment factors defined as,[15]

$$\chi_{jt} = \frac{C_{jt}^{NIPA}}{C_{jt}^{CEX}}.$$

For all sectors, χ_{jt} is greater than 1, and rises over time as the underreporting bias in CEX consumption becomes more severe. The sector-specific factors are then used to adjust CEX sectoral consumption data by age:

$$\hat{c}_{ajt} = \chi_{jt} c_{ajt}^{CEX},$$

where c_{ajt}^{CEX} denotes the average consumption of goods of sector j by age a as reported in CEX. The adjusted consumption expenditure for age a is then obtained as $\hat{c}_{a,t} = \sum_j \hat{c}_{ajt}$. Finally, with the same (corrected) income net of taxes as before, the new saving rate for age

[14] A small discrepancy remains since NIPA includes some expenditures (e.g., 'Net foreign travel and expenditures abroad by U.S. residents' and 'Final consumption expenditures of nonprofit institutions serving households') which cannot be matched with CEX categories.

[15] The 15 sectors are: Food and alcoholic beverages, Shelter, Utilities and public services, Household expenses, Clothing and apparel, Vehicles purchases, Gas and motor oil, Other vehicle expenses, Public transportation, Health, Entertainment, Education, Tobacco Miscellaneous and cash contributions, Life/personal insurance.

a is computed according to (21).

Method 3: sectoral data, correcting for health expenditures

One issue with the previous method is that health expenditures in NIPA and CEX are treated differently. Specifically, health expenditures are restricted to 'out-of-pocket' expenses, but NIPA also includes health contributions (Medicare and Medicaid), leading to very large adjustment factor $\chi_{\text{health}} \approx 5$, which primarily affects our consumption estimates for the old, for whom 'out-of-pocket' health expenditures constitute a large share of their consumption basket in CEX ($\approx 12\%$). Method 2 could therefore lead us to under-estimate the saving rate of the old. To address this concern, we adapt the previous method by computing sectoral adjustment factors as follows:

$$\chi_{health,t} = \frac{\sum_{j \neq health} C_{jt}^{NIPA}}{\sum_{j \neq health} C_{jt}^{CEX}},$$

and for other sectors $k \neq health$,

$$\chi_{k,t} = \frac{C_{kt}^{NIPA}}{C_{kt}^{CEX}} \left[1 + \frac{C_{health,t}^{NIPA}}{\sum\limits_{j \neq health} C_{jt}^{NIPA}} - \frac{C_{health,t}^{CEX}}{\sum\limits_{j \neq health} C_{jt}^{CEX}} \right].$$

Compared to the previous method, this method reduces the adjustment factor for health to its average across other sectors while slightly increasing the adjustment factor of other goods in order to match NIPA aggregate consumption.

4.1.3 Results for the U.S.

Figure 4.3 displays the estimated changes in saving rates over the twenty-year period 1988-2008 using the adjusted income and consumption measures for CEX, $\hat{y}_{a,t}$ and $\hat{c}_{a,t}$, under all three methodologies. The three methods yield similar results. According to the third method, the group of young people (under 25) saw a decline of 11.4 percentage points in their saving rate, while those between 35-44 a small increase of about 3.7 percentage points, and the eldest group a large decline of about 18 percentage points. Changes in saving rates

across age groups exhibit a hump-shaped pattern, as predicted by the model.

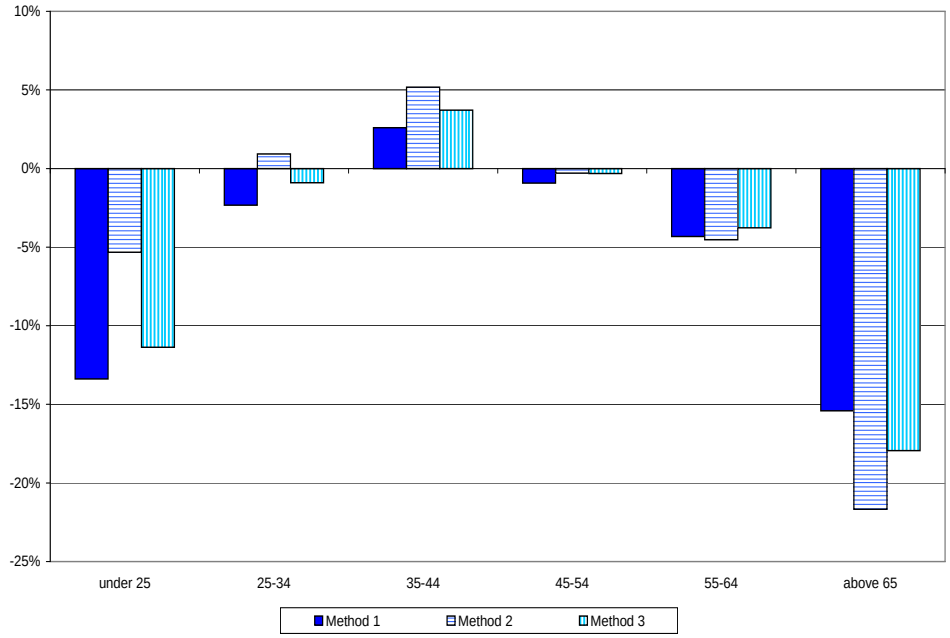


Figure 4.3: Change in Saving Rates in the U.S. Across Age Groups.
Notes: CEX data, 1988-2008; estimates of saving rates are obtained under the three correction methods described in the text.

4.2 Evidence for China

The primary data source for China is the annual Urban Household Survey (UHS) conducted by the National Bureau of Statistics, available for the period between 1992-2009. Households are expected to stay in the survey for 3 years and are chosen randomly, based on several stratifications at the provincial, city, country, township, and neighborhood levels. The sample covers all 31 provinces, with an overall coverage of 5,450 households in 1992 and 17,200 by 2009. The UHS data records detailed information on income, consumption expenditures, and demographic characteristics of urban households and other household characteristics. It also provides employment, wages and other characteristics of individuals in the household. Details of the data can be found in Appendix C.3.

Existing work using UHS data to study cohort-level saving rates include Song et al. (2010), Chamon and Prasad (2010), and Chamon, Liu and Prasad (2010), which all find strong evidence against standard life-cycle motives of saving. In particular, they find that

the traditional hump-shaped age-savings profile is replaced by a U-shape profile in recent years, with saving rates being highest for the young and the retired, and lowest for the middle-aged. Moreover, Song and Yang (2010) find that the increase in national saving rate is driven primarily by those below 40 and those above 50.[16] This would run counter to our prediction that the middle-aged savers in China contributed the most to the rise in household saving rate in the last two decades.

4.2.1 Aggregation and Selection Biases

The common approach that all of these papers adopt, out of data limitation at the individual level, is to work with household income and consumption data. That is, the saving rate imputed to a certain age is the average *household* saving rate computed over all households whose *head* is of this age. Deaton and Paxson (2000) have forcefully shown the problems associated with this approach in the presence of multi-generational households. If a large fraction of households comprise members that are at very different life-cycle stages, the age-saving profile obtained from household data will be obscured by an *aggregation bias*. For instance, suppose that middle-aged individuals have a high saving rate as they save for retirement, but middle-aged household heads live with children or elderly members who have negative saving rates. In this case, the household approach would lead to an under-estimation of the saving rate of the middle-aged. More generally, the aggregation bias tends to flatten the true age-saving profile. A second potential bias arises from the possibility that the selection of household headship is not random. If being a head at a certain age is correlated with certain characteristics (such as income) that affect saving behavior, the age-saving profile estimated by the household approach would suffer from a *selection bias*. Moreover, the time-variation in these two biases would affect the estimated *changes* in cohort-level savings over time.

A multi-generational household is the norm in the case of China, thus making the ag-

[16] They report that the saving rate for the cohort under 40 increased on average by 11.2 percent between 1992-1993 and 2006-2007, while that of those above 50 increased on average by 10.9 percent, in contrast to the rise by only 8.3 percent on average for the middle-aged group between 40-50.

gregation bias a serious concern (Table 1). In urban households, more than 50 percent of households are multigenerational (defined as households in which the maximum age difference between two adults is above 18 years), and roughly one out of six includes three different generations—in both 1992 and 2009.[17] The evolution of the household composition patterns over time could also bias estimates of changes in saving rates.[18]

Table 1: Frequency of Multi-Generational Households in China

	UHS 1992	UHS 2009
2 generations	41%	37%
3 generations	15%	18%

Figure 4.4 plots the average age of each individual's household head against the age of the individual, for years 1992 and 2009. If everyone were a household head or lived with persons of the same age, the plot would be the 45-degree line. The plot instead lies above the 45-degree line for young people (many of whom live with their parents), then more or less runs along the line for those aged between 40-60, and then falls below the line for the elderly—many of whom live with their children. Again, the fact that the degree of the disconnect at various ages changes over time suggests that the household method could lead to biases in estimating changes in saving rates.

Potential selection biases that arise from the fact that household heads in China are not selected at random comes through in Figure 4.5, which displays the income premium of household heads (as a percentage of average individual income), by age. Both young and elderly household heads are significantly richer than their non-household head counterparts. The explanation is simple: only the richer individuals can afford to live independently when young or in old age. But the problem then is that if high individual income is correlated with high individual saving rate, the household method would tend to over-estimate the saving rates of the young and of the elderly. The evolution of the income premium over time

[17] Any household with one adult or several adults belonging to the same generation, possibly with a child, is considered as uni-generational. Children are defined as individuals aged less than 25 with no income.

[18] Young individuals are leaving their parents' households on average later in 2009 than in 1992. Similarly, as a result of an increase in life expectancy, the elderly join their children's households at a later age in 2009 than in 1992.

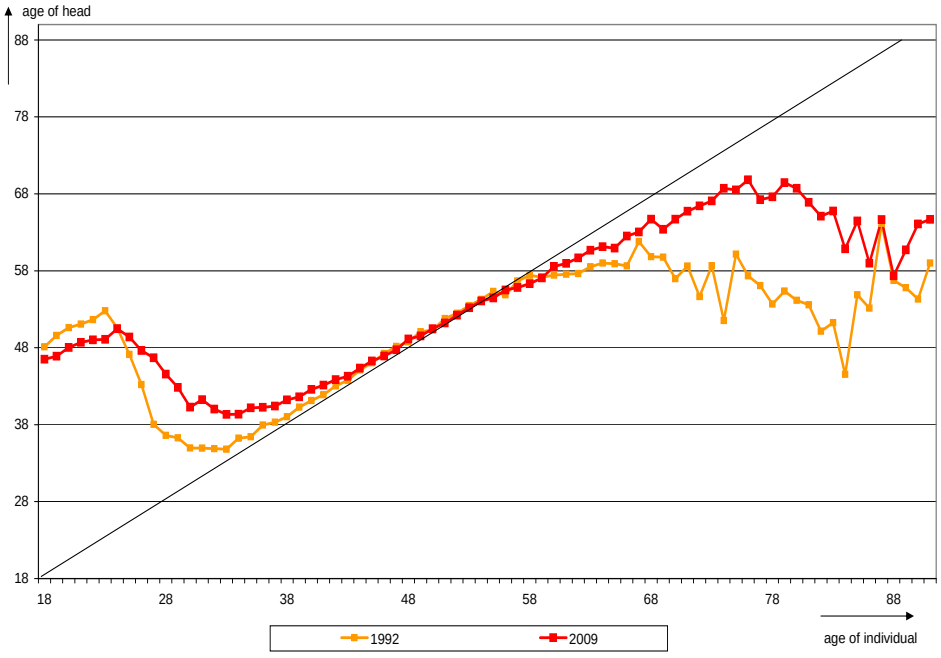


Figure 4.4: Average Age of Household Head By Age of Individual.

suggests that the selection bias is likely to be more severe for the elderly in 1992, and more severe for the young in 2009.[19] In particular, by focusing on young household heads, one might overestimate the growth rate of the income of the young and thus overestimate the increase of their savings.

4.2.2 Addressing Biases

What is key for improving upon the household approach is data availability. UHS data provide detailed information on individual income, but consumption is only available at the household level. What remains is therefore to dentify individual consumption. We propose two alternative methodologies to disaggregate household consumption into individual consumption—thereby estimating new age-savings profile.[20] The first method considers only the restricted sample of uni-generational households in order to address the aggregation bias,

[19]The reason is most likely because young people enter the job market at a later age in 2009 than in 1992 and stay for a longer period of time with their parents.

[20]A fundamental remaining problem is that some goods consumed by a household, such as housing, are difficult to divide between household members. Similarly, household savings display public-good properties, in the sense that household savings can be mobilized for one member in need regardless of the member's contribution to household savings.

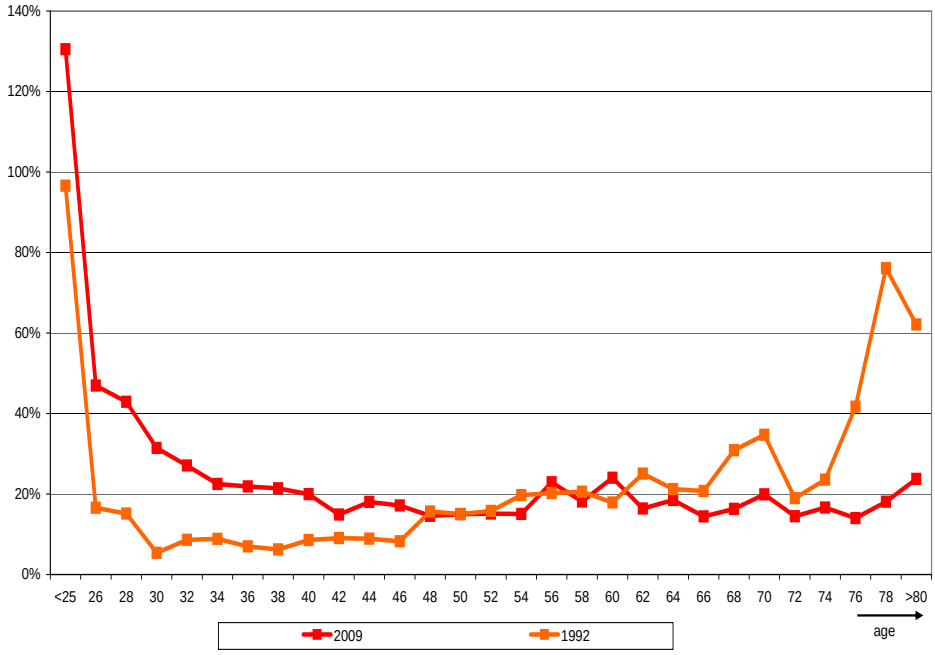


Figure 4.5: Income Premium of Household Heads in China (in log).

while controlling to the extent possible selection issues. The second approach applies the projection method proposed by Chesher (1997, 1998) and Deaton and Paxton (2000). We find that these two methodologies, which use two different samples of households, yield very similar results.

Method 1: Uni-Generational Households

To address the aggregation bias, our first approach focuses on the sub-sample of uni-generational households, which are more than 40% of the entire sample (see Table 1).[21] Individual consumption is inferred from household consumption by applying an equal-sharing rule.[22] The main problem that arises from this approach is that individuals of a certain age who live in a uni-generational household may differ systematically, along a number of characteristics, from individuals of the same age living in multi-generational households. Attempting to identify such characteristics leads us to find find that individuals in uni-generational house-

[21]Restricting the analysis to uni-generational households can also minimize the issue of intrahousehold transfers that can cloud actual savings behavior. Unfortunately we cannot account for interhousehold transfers among relatives that could also be important. See Appendix C.3 for further details on this issue.

[22]Some aggregation bias remains if the equal-consumption rule does not apply to husband and wife, for example, but it is reasonable to believe that consumption sharing is more equal within a generation than across generations.

holds differ from the whole sample in terms of income, gender, and marital status.[23] To address potential selection biases, we resample our data to match the distribution of these attributes in the whole sample, for each age.[24] Given the limited number of uni-generational households for the youngest and oldest cohorts, it is difficult to re-sample the data to match all three attributes simultaneously for the extreme age groups. Since income and gender appear to be the variables having the greater impact on saving rates, we focus on these two variables to control for selection issues (see Appendix C.3 for details).[25]

Method 2: Projection Method

An alternative way to recover individual consumption from household data is the disaggregation procedure proposed by Chesher (1997), which is applied to the entire sample of households. A non-linear least squares estimation of the following model is conducted for identification:

$$C_h = \exp(\boldsymbol{\gamma}.\boldsymbol{Z}_h)\left(\sum_{a=18}^{99} c_a N_{h,a}\right) + \epsilon_h,$$

where C_h is the aggregate consumption of household h, $N_{h,a}$ is the number of members of age a in household h, and $\boldsymbol{Z}_h$ denotes a set of household-specific controls (household composition, income group, number of adults, number of children, etc.). The estimated consumption of an individual of age a living in a household with characteristics $\boldsymbol{Z}_h$ is then equal to $\exp(\hat{\boldsymbol{\gamma}}.\boldsymbol{Z}_h)\hat{c}_a$. Details of the method and refinements are explicated in Appendix C.3. A robustness check of this method is to apply it to estimating the individual income distributions by age from

[23] We find that individuals who live in uni-generational households tend to be richer than average, and tend to be over-represented by women among the young and men among the old. The gender bias may come from the fact that young women marry and leave their parents at an earlier age than men, and that widows are more likely to live with their children than widowers. In terms of marital status, young and old individuals who live in uni-generational households are more likely to be married, the reason being that young people tend to move out of their parents' household early when they get married, and the elderly are more likely to move back to their offsprings' household when they lose their spouse. We also examine differences in the number of children, but find very little difference between the two samples.

[24] A caveat is that there might be unobservable variables correlated both with saving patterns for a given age group and with the decision to live in a uni-generational household.

[25] Resampling to match either the income distribution, the gender/income distribution or the marital status/income distribution gives similar age saving profiles. The only difference is that the dissavings of the youngest cohort is overestimated when gender is not taken into account.

household income data, and then to confront these results with the actual distributions—which we observe. The estimated income distributions are very close to the observed ones.

4.2.3 Results for China

Age-Saving Profile

Figure 4.6 shows the estimated age-savings profiles under the two methods, at the beginning and at the end of the sample period. Estimates of individual age-savings profile are very similar across the two methods, despite using different samples of households.[26] Our estimates are in stark contrast to the ones one would obtain by applying the household approach based on the age of the household head—as displayed in Figure 4.7. The age-saving profiles computed on individual data are clearly more in accord with the life-cycle theory of saving.[27] These results echo the findings of Deaton and Paxton (2002) for Taiwan and Thailand. They show that the age-saving profiles estimated from individual methods exhibit a hump shape, whereas household methods produce an essentially flat profile. In the case of China, we do find that the young saves less than the middle-aged in both years, but especially in 2009. What is peculiar though is that at the end of the sample period, the saving rate of the old is very high, at odds with the prediction of the life-cycle hypothesis.

Changes in Cohort Savings

Figure 4.8 displays changes in saving rates by age groups over the period 1992-2009. For the middle-aged, with either of the two methodologies, we find a large increase in saving rate between 15 to 20 percentage points. For the youngest, the saving rate exhibits a slight decrease over the sample period. Overall, estimates of changes in saving rates per age obtained from the two separate methodologies exhibit a hump-shaped pattern, except for the large increase in the saving rate of the very old (> 65).

[26] This suggests that our re-sampling procedure to control for income and gender characteristics in the first method takes care of selection issues reasonably well.

[27] Using the same two methods, we find similar individual age-saving profiles with alternative Chinese survey data (CHIP) for the two years (1995 and 2002) where these data are available.

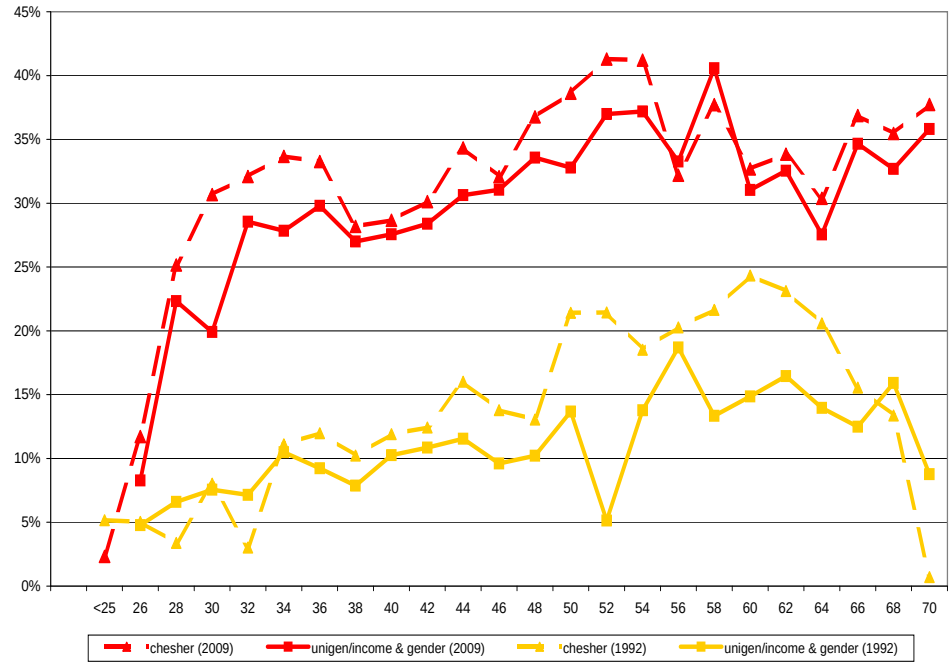


Figure 4.6: Estimated Age-Saving Profile for China in 1992 and 2009, Individual Methods.
Notes: The uni-generational method resamples the data to match gender and income distributions by age group in the full sample. The youngest cohort are taken to be those < 26 under this method due to lack of observation for individuals younger than 24 in the sample of uni-generational households. Chesher method controls for household characteristics as described in Appendix C.3.

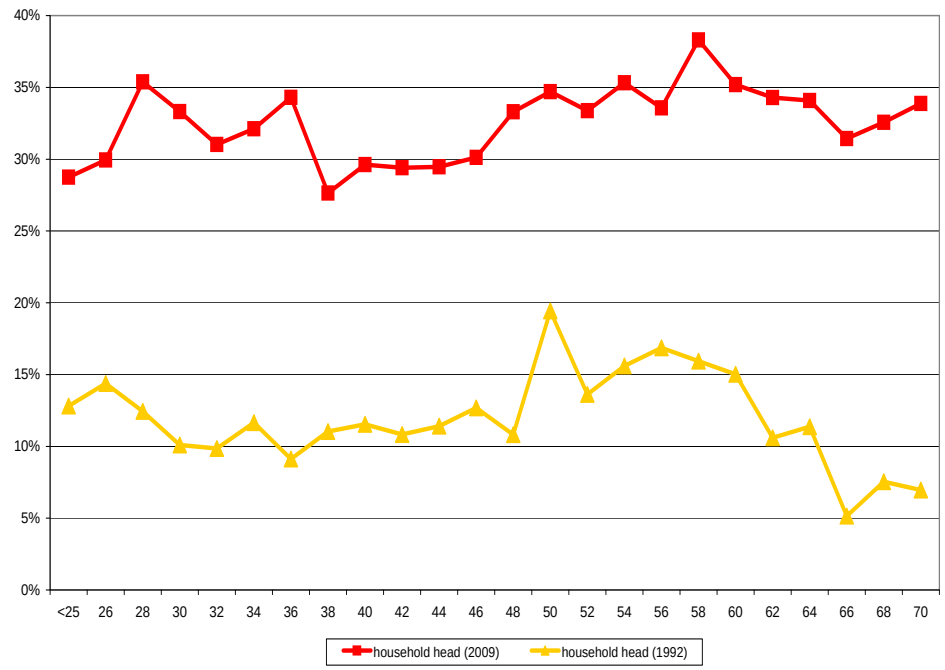


Figure 4.7: Estimated Age-Saving Profile for China in 1992 and 2009, Household Method.
Notes: The saving rate for a given age is obtained as the average household saving rate for households whose head is of that age.

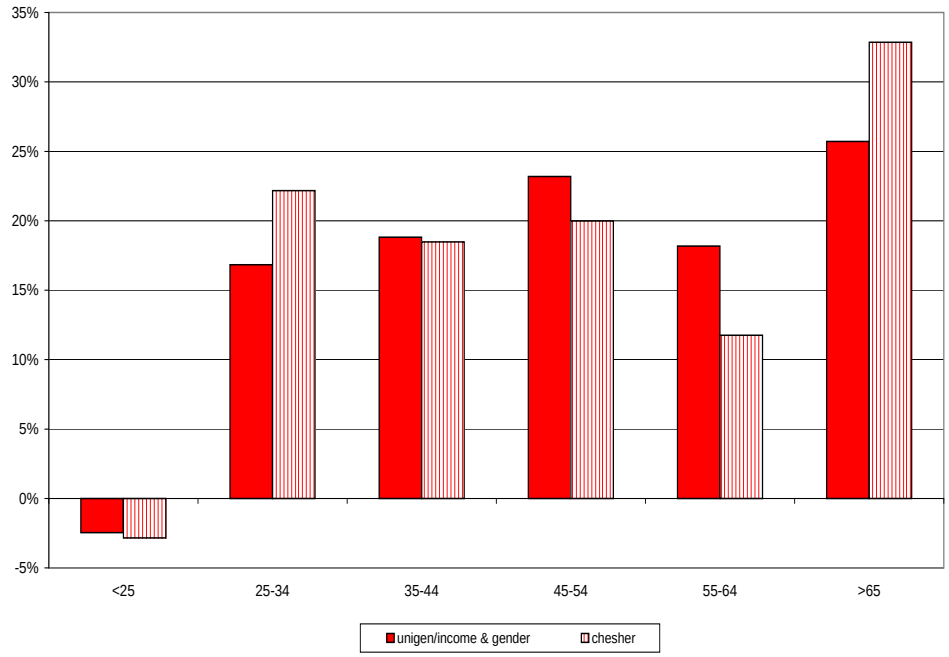


Figure 4.8: Change in Saving Rate by Age Groups in China: 1992-2009.
Notes: Estimates of changes in savings from data for China are reported for both methodologies. The unigenerational method resamples the data to match gender and income distributions by age group in the full sample. The youngest cohort are taken to be those < 26 under this method, for the reason that there are two few observations for those younger than 24. Chesher method controls for household characteristics.

4.3 Summary of Micro Evidence

The evidence presented thus far for the U.S. and China is in line with the prediction that in face of a fall in the world interest rate caused by capital markets integration and fast growth in Asia, the saving rate of the young falls and the saving rate of the middle-aged rises. But what brings to bear the distinctive predictions of our theory are the cross-country/cohort predictions: (1) the saving rate of the young falls by less in China than in the U.S., (2) the saving rate of the middle-aged increases by more in China than in the U.S.

Figure 4.9 compares the change in saving rate by age group across the two economies over the last two decades.[28] Indeed, the saving rate of the young fell by about 10 percentage points more in the U.S. than in China, whereas the middle-aged in China (35-54) rose by about 17 percentage points more in China than in the U.S.

Figure 4.10 shows the changes in savings by age group as a share of national output in

[28]For the U.S., changes are computed over the twenty-year period 1988-2008. For China, changes in saving rates are computed over the entire period (1992-2009) for which data are available.

each country over the same sample period.[29] Of the total 20.2 percentage point increase in aggregate household savings (as a share of output) in China, the middle-aged (35-54) contributed about 60 percent, the young (under 34) 15 percent, and the old (above 55) the remaining 25. Turning to the U.S., which saw a 1.79 percentage point decline in aggregate savings-to-GDP, the young's savings-to-GDP declined by 1.24 percentage points, while the middle-aged total savings-to-GDP increased by about 1.51 percentage points. The old's savings as a share of output saw a significant fall of 2.06 percentage points. Worth noting is that despite the large rise in the saving rate of the old in China over our sample period (see Figure 4.8), the old people as a group have not contributed the most to the rise in the aggregate saving rate in China. On the contrary, consistent with the model, the middle-aged group was the most important contributor to its large rise.

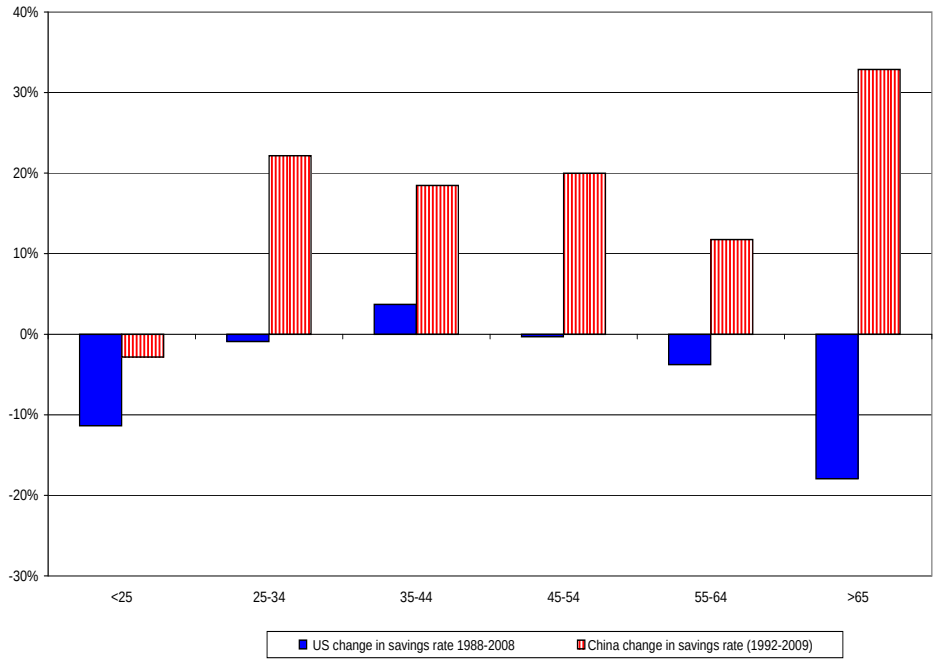


Figure 4.9: Change in Saving Rate by Age Group in the U.S. and China.
Notes: Changes in saving rates for China are estimated over the period 1992-2009 with Chesher method (controlling for household characteristics), and over the period 1988-2008 with Method 3 for the U.S. (sectoral-specific adjustment factors and correcting for health expenditures).

[29]National output is proxied by national income, measured as the sum of disposable income over all individuals.

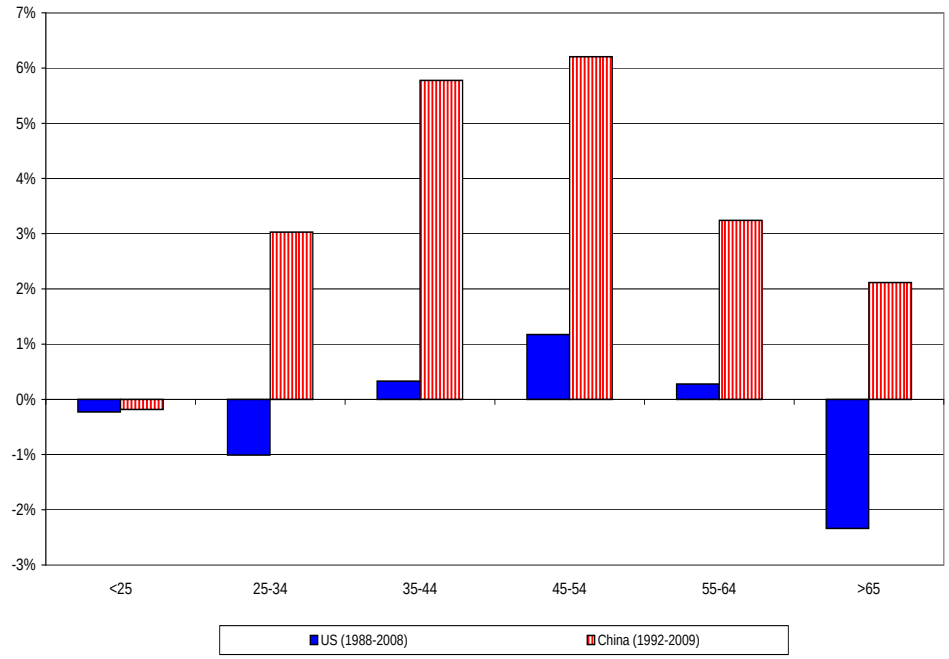


Figure 4.10: Change in Aggregate Savings as a Share of Aggregate Income by Age Group in the U.S. and China.
Notes: Changes in saving rates for China are estimated over the period 1992-2009 with Chesher method (controlling for household characteristics), and over the period 1988-2008 with Method 3 for the U.S. (sectoral-specific adjustment factors and correcting for health expenditures). Aggregate income is computed as the sum of disposable income over all individuals.

5 Model vs. Data: Aggregate and Micro-level Behavior in the U.S. and China

The numerical experiments of Section 3 help build intuition and illustrate the key mechanisms at work. In order to assess the ability of the model to match the evolution of saving rates in China and the U.S. over the last two decades, both on the aggregate level and by cohort, we turn to a more comprehensive calibration of the model for these two economies in this section. The baseline model and its calibration are enriched along two dimensions. First, a motive for bequest is introduced to allow for a savings initiative by the old. Second, we incorporate heterogeneous developments in both demographics and income profiles in both economies. We then compare the model-predicted saving rates at the aggregate and cohort level in both economies with those observed from the data.

In our benchmark theoretical model, the old consumers are passive and decumulate all

capital stock at the end of the period. In order to obtain a more realistic savings behavior for the old, we augment the model by introducing a motive for bequest (as in Abel (2001)). A consumer born at the beginning of period t in country i has a lifetime utility of

$$U_t^i = u(c_{y,t}^i) + \beta u(c_{m,t+1}^i) + \beta^2 u(c_{o,t+2}^i) + \phi^i \beta^2 u(b_{t+2}^i), \tag{22}$$

where $\phi^i > 0$, and b_{t+2}^i is the bequest that the consumer in old age leaves to his $1 + g_{L,t+1}^i$ children, shared equally amongst them. Thus, the consumer in period t chooses consumption in each period, and bequest in old age, to maximize lifetime utility, subject to the sequence of budget constraints

$$\begin{aligned} c_{y,t}^i + a_{y,t+1}^i &= w_{y,t}^i, \\ c_{m,t+1}^i + a_{m,t+2}^i &= w_{m,t+1}^i + R_{t+1}^i a_{y,t+1}^i + \frac{b_{t+1}^i}{1 + g_{L,t}^i}, \\ c_{o,t+2}^i + b_{t+2}^i &= R_{t+2}^i a_{m,t+2}^i. \end{aligned}$$

All other elements of the model remain unchanged.[30]

5.1 Calibration

We simulate the model under a scenario similar to the one explored in the experiment of Section 3.2. Namely, we consider a situation where China is capital scarce initially, grows fast over two consecutive periods (corresponding to 1970-2010) and integrates with the U.S. after one period of rapid growth (i.e., 1990). The calibration methodology is the same as before—albeit more comprehensive—and applied to the U.S. and China rather than Advanced economies and Emerging Asia. Only the calibrated values that have changed or are new are reported. Table 2 provides a complete summary of the calibration procedure.

Demographics

The initial age distribution is taken from the data in World Population Prospects (2010

[30]The definition of cohort savings in Appendix A still applies in the augmented model with bequests. In particular, the bequests of the old contribute to their savings.

revision), for the year 1970. We calculate the implied growth rates $g^i_{L,t}$ that yield the actual age group distribution in 1990 and 2010.[31] The implied population growth rate for the period 1970-1990 is 3.7% in China and 1.5% for the U.S., while the implied population growth rate for 1990-2010 is 0.2% in both countries. Finally, for the period 2010-2030, we assume a population growth rate of 0% in China and 0.7% for the U.S.[32]

Age-Income Profile

The evolution of the relative productivity parameter, e^i_t, in both countries is matched to the ratio of the average income (net of taxes) of individuals under 25 to the average income of those between 45-54. Owing to data limitations, we assume that the parameter takes the same value in the initial period as in the subsequent period — namely, 0.33 for the U.S. (as measured in 1988) and 0.61 for China (as measured in 1992). The corresponding values in the following period are 0.32 in the U.S. (as measured in 2008) and 0.52 in China (as measured in 2009). We assume that after 2010, the efficiency parameter in China slowly converges to the steady state level of the U.S. (0.33), and takes on a value of 0.38 twenty years from now. Our calibration therefore takes into account the fact that the age-income profile has not changed in the U.S. but has *steepened* in China over time.[33]

Initial Conditions and Productivity Growth

Given the calibrated population growth rates and income profiles, we set the initial relative capital-effective-labor ratios and relative productivity levels, along with the subsequent productivity growth rates, to match the output of China relative to the U.S. (i.e., 20.7%, 36.6%, and 93.9% in 1970, 1990, and 2010), and to allow the capital-effective-labor ratio in China to reach about 0.70 of that of the U.S. in 1990, per Hall and Jones (1999). The resulting annual productivity growth rate for China is 3.7% between 1970-90, and 5% between 1990-2010. We

[31] The model does not have enough degrees of freedom to perfectly match the observed age distribution, but still produces a very close match.

[32] 0.7% is the average population growth in the U.S. over the last 40 years. We assume that the one child policy in China will remain in place—leading to a further fall in population growth in line with the most recent years.

[33] The selection bias applies also to constructing the age-income profile when taking only household head income. Once using individual income data, we find a steepening profile in China rather than a flattening profile over the sample period as found in previous studies using household methods.

assume that U.S. productivity grows at an annual rate of 1.5% throughout, and that China grows at the same rate after 2010.

Calibrated Parameters

We choose the credit constraint and bequest parameters to match data on cohort-level savings rate observed at the beginning of our sample period. Setting $\theta^{US} = 0.20$ matches the saving rate of the young in the U.S. in 1988. Our benchmark estimate under the Chesher method of the savings rate of the young in China is slightly positive in 1992 which is somewhat inconsistent with our model. Other estimates give slightly positive or slightly negative numbers depending on the methodology or the years considered at the beginning of the sample.[34] Setting $\theta^{China} = 0.02$ produces a saving rate for the young that is in the ballpark of our estimates.[35] Note that our results are not very sensitive to the value of θ^{China} as long as it is an order of magnitude smaller than θ^{US}. The value of the bequest parameter for the U.S. is chosen to match the saving rate of the old in the U.S. in 1988, which gives $\phi^{US} = 1.25\%$. Two different ways of calibrating ϕ^{China} are considered. Model 1 imposes symmetric bequest motives across countries, i.e. $\phi^{China} = \phi^{US} = 1.25\%$. Model 2 allows for country-specific bequest parameters, and ϕ^{China} is chosen to match the saving rate of the old in China at the beginning of the sample period, with an implied value $\phi^{China} = 2\%$. Given the calibrated credit constraint and bequest parameters, we then let the model determine independently the saving rates of the middle-aged in 1990. The model-predicted saving rates come close to the data in both countries — 18.4% against 14.1% in the data for the U.S., and 16.1% (Model 1) or 15.2% (Model 2) against 14.2% in the data for China.[36] Overall, our calibration allow us to match fairly well the age-saving profile across countries in 1990.

[34] In non-reported robustness checks, we investigate a different treatment of inter-household transfers (see Appendix C.3), different sets of controls in the Chesher and uni-generational methods, and a different treatment of zero incomes in the Chesher method. We also tried dropping the top 1% and top 5% income earners from the sample. Estimated age-saving profiles were similar across all procedures. Estimates of the saving rate of individuals under 25 in 1992-1993 are less precise (varying between -5% and $+5\%$) due to fewer observations for this age-group at the beginning of the sample period.

[35] Alternatively, the ratio of θ's could be matched to the relative household debt-to-GDP ratios. The ratio of household debt-to-GDP in China is about 1/8 of that in the the U.S. This would give $\theta^{China} = 0.025$ (source: McKinsey&Company). We obtain almost identical results under this alternative calibration.

[36] For China, we match the saving rates obtained with the Chesher method (method 2).

Table 2: Summary of Calibration.

Time discount factor (β)	(annual basis)		0.97
Elasticity of intertemporal substitution (σ)			0.5
Share of capital (α)			0.28
Depreciation rate (δ)	(annual basis)		0.09
Initial Conditions			
Relative productivity in 1970 (A^L_{-1}/A^H_{-1})			0.15
Relative capital-efficient labor in 1970 (k^L_{-1}/k^H_{-1})			0.95
Age-Income Profile (e^i_t)		U.S.	China
	1970	0.33	0.61
	1990	0.33	0.61
	2010	0.32	0.52
	2030	0.33	0.38
Labor Force Growth ($g^i_{L,t}$), in %		U.S.	China
	1970-1990	1.5	3.7
	1990-2010	0.2	0.2
	2010-2030	0.7	0.0
Productivity Growth ($g^i_{A,t}$), in %		U.S.	China
	1970-1990	1.5	3.7
	1990-2010	1.5	5.0
	2010-2030	1.5	1.5
Other Calibrated Parameters		U.S.	China
Credit constraint parameter (θ^i)		0.20	0.02
Bequest motive parameter (ϕ^i), in %	Model 1	1.25	1.25
	Model 2	1.25	2.0

5.2 Results

Figures 5.1 and 5.2 juxtapose the model-implied change in saving rates across age groups with estimates from the data, for the U.S. and China. For the U.S., the model slightly overpredicts the fall in the young's savings rate and the rise in the middle-aged savings rate (Figure 5.1). Though it falls short of explaining the large drop of the saving rate of the old, the model generally matches reasonably well the evolution of the saving behavior of the different age groups in the U.S. For China (Figure 5.2), the model can account for 50 percent of the rise in the middle-aged saving rate, and about 30 percent of the rise for the

old, explaining about 40 percent of the rise in the aggregate saving rate. Unsurprisingly, the model cannot explain the large rise of the saving rate of the old in China. The model does predict a decline in the saving rate of the young, although slightly smaller than the one observed in the data. Across countries, on the aggregate level, the model can explain about 40 percent of the divergence in saving rates between the U.S. and China.[37]. This divergence in saving rates corresponds to an improvement of the Chinese current account balance over GDP of 11% over 1990-2010 that is quantitatively in line with the data (Figure 1.3) (and a worsening of 6% of the U.S. current account over GDP).

It is well-known that matching the high rise in saving rate (and levels) in China has been a major challenge to existing models thus far. The point here is that one mechanism in a relatively simple framework can explain a significant portion of the change in saving rate both at the aggregate and at the cohort level. Where the model fails is to explain the saving behavior of the old, both in the U.S. and in China. Plausible explanations such as pension or health expenditures, fall outside of this model. Since their savings do not contribute significantly to aggregate savings, we relegate a more intricate study to future research.

[37]China's saving rate rises by about 8 percentage points more than that of the U.S., whereas in the data the difference is about 20 percentage points.

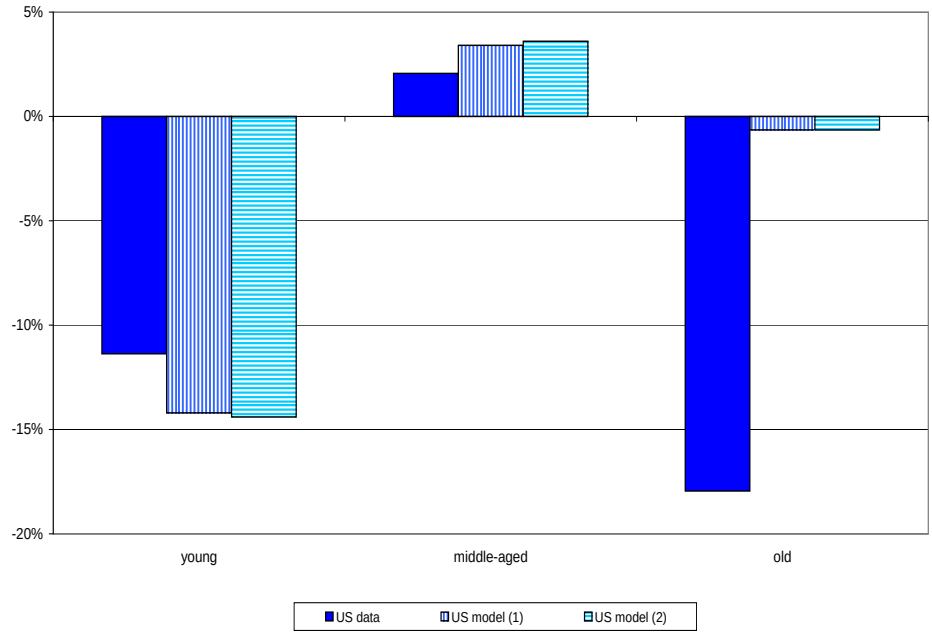


Figure 5.1: Model vs. Data in the U.S.: 1988-2008.

Notes: Estimates of savings for the U.S. are obtained under Method 3 (sectoral-specific adjustment factors and correcting for health expenditures) and are compared with predictions from the model with symmetric (Model 1) and asymmetric bequests (Model 2). The young correspond to ages < 25, the middle-aged to ages 35-54, and the old to ages > 65.

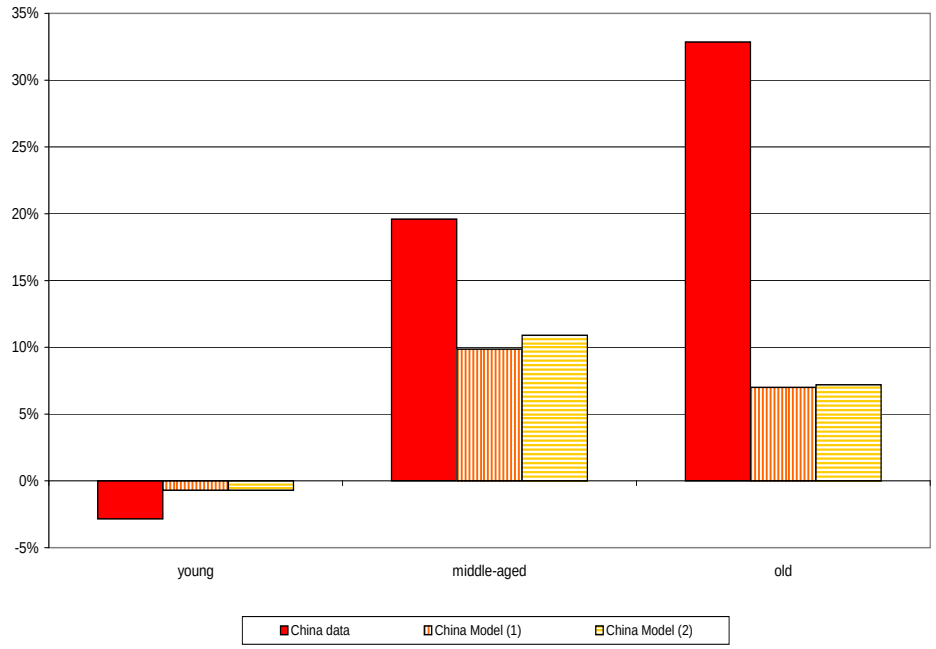


Figure 5.2: Model vs. Data in China: 1992-2009.

Notes: Estimates of savings for China are obtained under the Chescher method (controlling for household characteristics) and are compared with predictions from the model with symmetric (Model 1) and asymmetric bequests (Model 2). The young corresponds to ages < 25, the middle-aged to ages 35-54, and the old to ages > 65.

6 Conclusion

This paper develops a theory based on heterogeneous credit constraints across countries and their interaction with growth. We show that important developments in the past two decades such as the fast growth and integration of emerging markets can lead to a persistent decline in the world interest rate, causing a divergence in saving rate across economies with different levels of credit constraints. Broad stylized facts can be jointly accounted for by a single mechanism in a general-equilibrium model applicable to the spectacular experience of the last decades.

Cohort-level evidence is consistent with the life cycle hypothesis in China and the U.S., but more importantly, lends empirical support to the key and distinctive predictions on the contrasting cohort behaviour between these two economies. Over the course of our micro-level empirical work, we point out the inherent biases of past empirical work on cohort level savings that employ household methods to construct age-saving profiles. Improvements we endeavour to make upon previous works reveal drastically different results on the profile of saving and also for the change in savings in the recent two decades in China.

Our framework displays substantial quantitative power in explaining the change in savings across cohorts in both China and the US over the last two decades, as well as a large part of the divergence in aggregate household saving rates. The evidence we provide also points to future directions of research— a more thorough investigation of the behaviour of the old's saving promises to be fruitful, and the incorporation of different social security systems across countries and their interaction with demographics may further our understanding of cross-country savings behaviour and current account patterns.

A Model Accounting

A.1 Cohort-Level Savings

The level of savings of a generation is defined as the difference between net disposable income and consumption. The level of savings of the young in country i and period t is

$$\begin{aligned} S^i_{y,t} &= L^i_{y,t} w^i_{y,t} - L^i_{y,t} c^i_{y,t} \\ &= L^i_{y,t} a^i_{y,t+1} \\ &= -L^i_{y,t} \frac{\theta^i}{R_{t+1}} w^i_{m,t+1}. \end{aligned}$$

Normalizing by GDP, we get

$$\frac{S^i_{y,t}}{Y^i_t} = -(1+g^i_{A,t+1}) \frac{1+g^i_{L,t}}{1+e^i_t(1+g^i_{L,t})} \frac{\theta^i}{R_{t+1}} (1-\alpha) \left(\frac{k_{t+1}}{k_t} \right)^{\alpha}.$$

The level of savings of the middle-aged in country i and period t is

$$\begin{aligned} S^i_{m,t} &= L^i_{m,t} \{ w^i_{m,t} + (R_t - 1) a^i_{y,t} - c^i_{m,t} \} \\ &= L^i_{m,t} \{ (w^i_{m,t} + R_t - c^i_{m,t}) - a^i_{y,t} \} \\ &= L^i_{m,t} \{ (a^i_{m,t+1} - a^i_{y,t} \} \\ &= L^i_{m,t} \left\{ \frac{1}{1+\beta^{-\sigma} R^{1-\sigma}_{t+1}} (1-\theta^i) + \frac{\theta^i}{R_t} \right\} w^i_{m,t}. \end{aligned}$$

Normalizing by GDP, we get

$$\frac{S^i_{m,t}}{Y^i_t} = \frac{1}{1+e^i_t(1+g^i_{L,t})} \left[\frac{1-\theta^i}{1+\beta^{-\sigma} R^{1-\sigma}_{t+1}} + \frac{\theta^i}{R_t} \right] (1-\alpha).$$

The level of savings of the old in country i and period t is

$$\begin{aligned} S^i_{o,t} &= r_{K,t}K^i_t + (R_t - 1)[L^i_{m,t-1}a^i_{m,t} - K^i_t] - L^i_{o,t}c^i_{o,t} \\ &= (R_t - 1 + \delta)K^i_t + (R_t - 1)L^i_{o,t}a^i_{m,t} - (R_t - 1)K^i_t - L^i_{o,t}R_t a^i_{m,t} \\ &= -L^i_{o,t}a^i_{m,t} + \delta K^i_t \\ &= -L^i_{o,t}\frac{1}{1+\beta^{-\sigma}R_t^{1-\sigma}}(1-\theta^i)w^i_{m,t-1} + \delta K^i_t. \end{aligned}$$

Normalizing by GDP, we get

$$\frac{S^i_{o,t}}{Y^i_t} = -\frac{1}{1+g^i_{A,t}}\frac{1}{1+g^i_{L,t-1}}\frac{1}{1+e^i_t(1+g^i_{L,t})}\frac{1}{1+\beta^{-\sigma}R_t^{1-\sigma}}(1-\theta^i)(1-\alpha)\left(\frac{k_{t-1}}{k_t}\right)^{\alpha} + \delta k_t^{1-\alpha}.$$

A.2 Aggregate Savings and Current Account

Aggregate savings is GNP less aggregate consumption

$$S^i_t \equiv Y^i_t + (R_t - 1)NFA^i_t - C^i_t,$$

where the net foreign assets of country i at the end of period $t-1$ is given by

$$NFA^i_{t+1} = L^i_{y,t}a^i_{y,t+1} + L^i_{m,t}a^i_{m,t+1} - K^i_{t+1}.$$

Alternatively, we have $S^i_t = S^i_{y,t} + S^i_{m,t} + S^i_{o,t}$, and the aggregate saving rate can be computed as

$$\frac{S^i_t}{Y^i_t} = \frac{S^i_{y,t}}{Y^i_t} + \frac{S^i_{m,t}}{Y^i_t} + \frac{S^i_{o,t}}{Y^i_t}.$$

The current account of country i in period t, defined as the change in net foreign asset position in period t, can be equivalently written as the difference between aggregate savings

and investment:

$$\begin{aligned} CA_t^i &\equiv NFA_{t+1}^i - NFA_t^i \\ &= S_t^i - I_t^i. \end{aligned}$$

B Proofs

Proof of Theorem 1: Consider a country i characterized by θ^i. Note that for $\delta = 1$, we have $R_t^i = \alpha \left(k_t^i\right)^{1-\alpha}$. The law of motion for k_t^i satisfies:

$$k_{t+1}^i + \beta^{-\sigma}\alpha^{1-\sigma}\left(k_{t+1}^i\right)^{\alpha(1-\sigma)+\sigma} = \frac{(1-\theta^i)(1-\alpha)}{(1+g_{A,t+1}^i)(1+g_{L,t}^i)\left\{1+e_{t+1}^i(1+g_{L,t+1}^i)+\theta^i\frac{1-\alpha}{\alpha}\right\}}\left(k_t^i\right)^{\alpha}.$$

If a steady-state level of capital k^i exists, it satisfies

$$k^i + \beta^{-\sigma}\alpha^{1-\sigma}\left(k^i\right)^{\alpha(1-\sigma)+\sigma} = \frac{(1-\theta^i)(1-\alpha)}{(1+g_A)(1+g_L)\left\{1+e(1+g_L)+\theta^i\frac{1-\alpha}{\alpha}\right\}}\left(k^i\right)^{\alpha}.$$

Substituting $R^i = \alpha\left(k^i\right)^{1-\alpha}$, we can write

$$1 + \beta^{-\sigma}\left(R^i\right)^{1-\sigma} = C\left(\theta^i\right)R^i,$$

with $C\left(\theta^i\right) = \frac{(1-\alpha)\left(1-\theta^i\right)}{(1+g_A)(1+g_L)\{\alpha[1+e(1+g_L)]+\theta^i(1-\alpha)\}}$. Note that $\partial C/\partial\theta^i < 0$. If $\sigma = 1$, the steady-state exists, is unique, and satisfies

$$R^i = \frac{1+\beta}{\beta C\left(\theta^i\right)} = (1+g_A)(1+g_L)\frac{1+\beta}{\beta}\frac{\alpha[1+e(1+g_L)]+\theta^i(1-\alpha)}{(1-\alpha)\left(1-\theta^i\right)}.$$

For $\sigma < 1$, R^i is such that $v_{\theta^i}(R^i) = 0$, where $v_\theta(R) \equiv 1 + \beta^{-\sigma}R^{1-\sigma} - C\left(\theta\right)R$ for $R > 0$. We will now show that $v_\theta(R) = 0$ has a unique solution $R(\theta)$. Differentiating with respect to R, we get

$$\frac{\partial v_\theta}{\partial R} = \beta^{-\sigma}\left(1-\sigma\right)R^{-\sigma} - C\left(\theta\right).$$

This implies

$$\frac{\partial v_\theta}{\partial R} \geq 0 \quad \Leftrightarrow \quad R \leq \frac{1}{\beta}(1-\sigma)^{\frac{1}{\sigma}} C(\theta)^{-\frac{1}{\sigma}}.$$

Hence v_θ is increasing for $R \in]0; \frac{1}{\beta}(1-\sigma)^{\frac{1}{\sigma}} C(\theta)^{-\frac{1}{\sigma}}]$ and decreasing for $R \in [\frac{1}{\beta}(1-\sigma)^{\frac{1}{\sigma}} C(\theta)^{-\frac{1}{\sigma}}; \infty[$. We also have $\lim_0 v_\theta(R) = 1 > 0$ and $\lim_\infty v_\theta(R) = -\infty$. It follows that $v_\theta(R) = 0$ has a *unique* solution $R(\theta)$ (v_θ is a continuous function). This is our first result. We note in passing that

$$R < R(\theta) \Leftrightarrow v_\theta(R) > 0. \tag{23}$$

Now consider $\theta^i < \theta^j$ and let R^i (resp. R^j) denote the well defined solution of $v_{\theta^i}(R) = 0$ (resp. $v_{\theta^j}(R) = 0$). Since $\frac{\partial C}{\partial \theta} < 0$, we know $C(\theta^i) > C(\theta^j)$. Therefore

$$v_{\theta^j}(R) - v_{\theta^i}(R) = \left(C\left(\theta^i\right) - C\left(\theta^j\right)\right) R > 0, \qquad \forall R > 0.$$

In particular:

$$v_{\theta^j}(R^i) - v_{\theta^i}(R^i) = v_{\theta^j}(R^i) > 0.$$

By the remark above (23), this is equivalent to:

$$R^i < R^j.$$

We have shown:

$$\theta^i < \theta^j \Rightarrow R^i < R^j.$$

This our second result: $\frac{\partial R^i}{\partial \theta^i} > 0$. Countries with higher θ have a higher rate of return in autarky steady state. $\frac{dk^i}{d\theta^i} < 0$ follows immediately. The theorem also holds for $\sigma > 1$, and the proof naturally extends to that case. ∎

Proof of Proposition 2: For $\delta = 1$ and any $\sigma \leq 1$, one can easily show that the steady

state world interest rate satisfies

$$F(R^w) = \sum_i \frac{\lambda^i(1-\theta^i)}{\sum_j \lambda^j(1-\theta^j)} F(R^i), \tag{24}$$

where $F(R) \equiv R/\left(1+\beta^{-\sigma}R^{1-\sigma}\right)$ and R^i denotes the autarky steady state interest rate in country i. The bounds on R^w in (17) follow from $F'(R) > 0$. Note that the proposition also holds for $\sigma > 1$. ∎

Proof of Proposition 3: The result follows immediately from Equation (24). ∎

C Data

C.1 Aggregate data

This part of the Data appendix describes the data used for the figures shown in the Introduction. Developed countries comprise Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States. Asian countries comprise Bangladesh, Cambodia, China, Fiji, Hong Kong SAR, China, India, Indonesia, Kiribati, Korea, Lao P.D.R., Malaysia, Maldives, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Vanuatu, Vietnam.

Savings, private savings, investment and current account (% of GDP) for Emerging Asia and Developed Countries

Data are from World Development Indicators (World bank), Penn World Tables and Asian Development Bank (ADB). Private savings is computed as the difference between Aggregate Savings and Primary Government Surplus. Data for Primary Government Surplus in Asian countries are only available starting 1988 for a large sample of Asian of countries.

Household saving rates

Data for Developed Countries are from OECD (NIPA personal savings rate for the U.S.). Data for India are from the Central Bank of India. Data for China are from Song and Yang (2010).

Cross-section of Savings and Current Accounts (over 1998-2007)

Data are from World Development Indicators (World bank) and Penn World Tables and cover a sample of 89 countries. The list of countries is available on request.

C.2 Data for the U.S.

Definitions

Household disposable income: the sum of individual income net of taxes (in USD).

Household expenditure: household consumption expenditures (in USD).

Household savings: the difference between household disposable income and consumption expenditure (in USD).

Household saving rate: Household savings divided by disposable income.

Consumer expenditures survey (CEX) data

Annual data over the period 1986-2008 for consumption expenditures and income. Disaggregated by age groups (6 age groups): under 25, 25-34, 35-44, 45-54, 55-64, 65 and above. Disaggregated by sectors of expenditures. The disaggregated sectors given in the CEX data are : Food and alcoholic beverages, Shelter Utilities and public services, Household expenses, Clothing and apparel, Vehicles purchases, Gas and motor oil, Other vehicle expenses, Public transportation, Health Entertainment, Education, Tobacco, Miscellaneous and cash contributions, Life/personal insurance.

NIPA data

Consumption and income data for 1986-2008. Consumption expenditures data are disaggregated by sectors of expenditures. We match sectors in NIPA with the corresponding sectors in CEX. Only two categories in NIPA consumption expenditures do not appear in CEX data (Net foreign travel and expenditures abroad by U.S. residents and Final consumption

expenditures of nonprofit institutions serving households).

Aggregate consumption expenditures from CEX data does not match aggregate NIPA data, as a result of underreporting of consumption in CEX—a bias which has increased over time. Income displays a similar bias but with no trend over time. As a consequence, the aggregate saving rate measured from CEX appears to have increased over time while it is decreasing as measured by NIPA.

Correction methodology

Since the degree of bias is likely to differ for different types of goods, and since different age groups potentially have different consumption baskets, we implement sector-specific adjustments. Let $C_{jt}^{\mathcal{D}}$ be the aggregate consumption expenditures of goods from sector j at date t from dataset $\mathcal{D}$. Define the following sector-specific weight:

$$\chi_{jt} = \frac{C_{jt}^{NIPA}}{C_{jt}^{CEX}}.$$

For all goods, $\chi_{jt} > 1$, due to underreporting in CEX (and increasing over time as the bias gets larger). Consider consumption of good j by age-group a in CEX, denoted by c_{ajt}^{CEX}). Our corrected measure of consumption expenditures in sector j for group a is:

$$\hat{c}_{ajt} = \chi_{jt} c_{ajt}^{CEX}.$$

Total consumption expenditures of group a is then

$$\hat{c}_{at} = \sum_j \hat{c}_{ajt} = \chi_{jt} c_{ajt}^{CEX}.$$

The corrected income net of taxes $\hat{y}_{at}$ of group a is:

$$\hat{y}_{at} = \frac{Y_t^{NIPA}}{Y_t^{CEX}} y_{at}^{CEX}.$$

The corrected saving rate of group a is obtained as

$$s_{at} = \frac{\hat{y}_{at} - \hat{c}_{at}}{\hat{y}_{at}}.$$

Adjustments made to address the mis-measurement of health expenditures in CEX are described in the main text.

C.3 Data for China

Definitions

Household disposable income: the sum of individual disposable income net of taxes within a household.

Household consumption expenditures: the sum of consumption expenditures within a household.

Household savings: the difference between household disposable income and household consumption expenditure.

Individual savings: the difference between individual disposable income and individual consumption expenditure (non directly observable).

Urban Household Survey Data (UHS)

Annual data over the period 1992-2009 for consumption expenditures, income and household characteristics (number of household members, age of household members, employment status of household members...), for a large sample of urban households in China. Households are expected to stay in the survey for 3 years and are chosen randomly, based on several stratifications at the provincial, city, country, township, and neighborhood levels. The sample covers all 31 provinces, with an overall coverage of 5,450 households in 1992 and 17,200 by 2009. Data for consumption expenditures are given at the household level. Disposable income is provided at the individual and household level. We check the consistency of the dataset by comparing it to CHIP (Chinese Households Income Project) which exists for 2 cross-sections (1995 and 2002). Income and consumption by age are very similar across the

two datasets.

Sample restriction: to compute individual consumption expenditures and savings we restrict our attention to income earners aged above 19 or adults above 25. Equivalently, individuals under 25 without income are considered as children (i.e., they do not take independent saving decisions).

Method 1: Uni-generational households, resampled to match aggregate distributions

Income: young and old individuals who live alone tend to be richer than average. To address this issue observations are reweighed so that the distribution of individual income for each age in the truncated sample matches the aggregate income distribution. We first regroup individuals in 2 year age-bins, and then assign weights to match the income decile distribution for each of the 2-year bins. When the number of observations is insufficient (especially at the ends of the age distribution), we use quintile income groups. One potential problem with the approach is that very high weights are assigned to individuals in the lowest quintile group for the young, and that these young individuals may not be representative of the low-income youth who live with their parents. Another source of bias may arise from the fact that data on detailed intergenerational transfers is not available. Elderly living alone are more likely to receive monetary transfers from their children than those living in the household. Since only aggregate income is available, the income difference between the old in uni-generational households and those in multi-generational households may be overestimated. Using detailed income data from CHIP 2002, where inter-household transfers are more detailed, shows that this discrepancy exists but is small.

Gender: to correct for the gender bias among uni-generational households, we re-sample observations by income separately for men and women, and then combine the two distributions in such a way to match the gender distribution by age in the original sample. We proceed in the same way for marital status but this does not affect our age-saving profile so we do not report results when controlling for income distribution and marital status.

Method 2: Chesher (1997) projection method

We estimate the model

$$C_h = \exp(\boldsymbol{\gamma}.\boldsymbol{Z}_h) \left(\sum_{a=18}^{99} c_a N_{h,a} \right) + \epsilon_h,$$

where C_h is the aggregate consumption of household h, $N_{h,a}$ is the number of members of age a in household h, and $\boldsymbol{Z}_h$ denotes a set of household-specific controls, including:

- Household composition: number of children aged 0 to 10, 10-18, and number of adults, and depending on the specification, the number of old and young dependents. The coefficient associated with the number of children is positive—more children leads to more consumption for the parent in charge of their expenses.

- Household income group: households are separated into 5 income groups (from the lowest 20% to the top 20%). The sign of this control variable is, as expected, positive: individuals living in richer households will consume more (independently of their individual income).

Control variables enter in an exponential term, and multiplicative separability is assumed to limit the number of degrees of freedom, following Chesher (1997). A roughness penalization term is introduced in the estimation to guarantee smoothness of the estimated function $c_a = c(a)$. This term is of the form:

$$P = \kappa^2 \int \left[c''(a) \right]^2 da,$$

where κ is a constant that controls the amount of smoothing (no smoothing when $\kappa = 0$ and forced linearity as $\kappa \to \infty$). We fix $\kappa = 10$. The discretized version of P, given that a is an integer in $[18; 99]$ can be written $\kappa^2 (\boldsymbol{A}\boldsymbol{c}_a)'(\boldsymbol{A}\boldsymbol{c}_a)$, where the matrix $\boldsymbol{A}$ is the 80×82 band

matrix

$$\boldsymbol{A} = \begin{bmatrix} 1 & -2 & 1 & 0 & \dots & 0 & 0 & 0 \\ 0 & 1 & -2 & 1 & \dots & 0 & 0 & 0 \\ 0 & 0 & 1 & -2 & \dots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \dots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & \dots & -2 & 1 & 0 \\ 0 & 0 & 0 & 0 & \dots & 1 & -2 & 1 \end{bmatrix},$$

which produces second differences of the vector $\boldsymbol{c}_a = (c_a)_{a=18,\dots,99}$ when it is applied.

Treatment of intra-household and inter-household transfers

Intra-household transfers are not directly observable but these should affect our estimates to a lesser extent when focusing on uni-generational households. Among information about individual income, the UHS includes information on positive income transfers received from other households or the government (gifts to relatives, alimony, pensions and grants). The UHS also measures household transfer expenditures, i.e., transfer payments to other households (gifts to relatives, alimony, family support). The latter are only observed at the household level. One can add transfer expenditures to consumption expenditures and define household expenditures as the sum of the two items and perform method 1 and 2 to this new measure of expenditures. Doing so gives however a significantly lower estimate of household saving rates than estimates found in the literature. The reason is the following: transfer expenditures do not match income transfers, the latter being an order of magnitude smaller. In other words, transfers to households seem to be better measured on the expenditure side than on the income side (similar measurement issue is found in CHIP data). This is the reason why we ignore transfer expenditures in the measurement of saving rates presented in the main text. However, when adding transfer expenditures to household consumption expenditures in order to compute age-saving profiles, we find a similar age-saving profile but translated 3 to 4% below the age-saving profile shown in the paper (Figure 4.6). The change of saving rates across age groups over the period 1992-2009 are very similar.

References

[1] Abel, A., 2001. Will Bequests Attenuate The Predicted Meltdown In Stock Prices When Baby Boomers Retire?," The Review of Economics and Statistics, MIT Press, vol. 83(4), pp 589-595.

[2] Battistin, E., 2003. Errors in Survey Reports of Consumption Expenditures, IFS Working Papers W03/07, Institute for Fiscal Studies.

[3] Bayoumi, T., Tong H., and Wei S.J., 2011. The Chinese Corporate Savings Puzzle: A Firm-level Cross-country Perspective, NBER Chapters, in: Capitalizing China National Bureau of Economic Research.

[4] Benhima, K., 2012, A Reappraisal of the Allocation Puzzle through the Portfolio approach, 2012, Journal of International Economics, forthcoming.

[5] Benhima, K., and Bacchetta P., 2011, The Demand for Liquid Assets, Corporate Saving, and Global Imbalances, mimeo HEC Lausanne.

[6] Buera, F. and Shin, Y., 2010, Productivity Growth and Capital Flows: The Dynamics of Reforms. Manuscript, UCLA.

[7] Caballero, R., Gourinchas P-O. and Farhi E., 2008. An Equilibrium Model of 'Global Imbalances' and Low Interest Rates, American Economic Review, 98(1), pp. 358-93.

[8] Carroll, C. and Jeanne O., 2009. A Tractable Model of Precautionary Reserves, Net Foreign Assets, or Sovereign Wealth Funds. Manuscript, Johns Hopkins University

[9] Chamon, M., Liu K., and Prasad, E.S., 2010. Income Uncertainty and Household Savings in China. NBER Working Paper No. 16565

[10] Chamon, M. and Prasad, E.S., 2010. Why are Saving Rates of Urban Households in China Rising?, American Economic Journal: Macroeconomics, 2(1), pp. 93-130.

[11] Chesher, A., 1997. Diet Revealed?: Semiparametric Estimation of Nutrient Intake-Age Relationships. Journal of the Royal Statistical Society Series A, Royal Statistical Society, vol. 160(3), p 389-428.

[12] Chesher, A., 1998. Individual demands from household aggregates: time and age variation in the composition of diet," Journal of Applied Econometrics, vol. 13(5), pp. 505-524.

[13] Deaton, A. and Paxson C., 2000. Growth and Saving Among Individuals and Households, The Review of Economics and Statistics, MIT Press, vol. 82(2), p 212-225, May.

[14] Gollin, D., 2002, Getting Income Shares Right, Journal of Political Economy, 110(2), pp. 458-474.

[15] Hall, R.E and Jones C., 1999. Why Do Some Countries Produce So Much More Output Per Worker Than Others?, The Quarterly Journal of Economics , Vol. 114, No. 1, pp. 83-116

[16] Heathcote, J., Perri, F., Violante, G., 2010. Unequal We Stand: An Empirical Analysis of Economic Inequality in the United States: 1967-2006," Review of Economic Dynamics, Elsevier for the Society for Economic Dynamics, vol. 13(1), pp 15-51.

[17] Jin, K., 2012, Industrial Structure and Capital Flows, American Economic Review, forthcoming.

[18] Laitner, J. and Silverman, D. 2005. Estimating Life-Cycle Parameters from Consumption Behavior at Retirement. NBER Working Papers 11163, National Bureau of Economic Research

[19] Mendoza E., Quadrini V. and Rios-Rull V., 2009. Financial Integration, Financial Development and Global Imbalances, Journal of Political Economy, 117(3).

[20] Modigliani, F. and Cao, S.L., 2004. The Chinese Saving Puzzle and the Life-Cycle Hypothesis. Journal of Economic Literature, American Economic Association, vol. 42(1), pages 145-170.

[21] Jappelli, T. and Pagano, M., 1994. Saving, Growth, and Liquidity Constraints. The Quarterly Journal of Economics, MIT Press, vol. 109(1), pp 83-109,.

[22] Parker, J., Vissing-Jorgensen, A. and Ziebarth, N., 2009, Inequality in Expenditure in the Twentieth Century. mimeo.

[23] Sandri, 2010. Growth and Capital Flows with Risky Entrepreneurship, Working Paper, International Monetary Fund.

[24] Slesnick, D.T, 1992. Aggregate consumption and saving in the United States. Review of Economics and Statistics 74:58597.

[25] Song, M. and Storesletten K. and Zilibotti F., 2011. Growing like China. American Economic Review, American Economic Association, vol. 101(1), pp 196-233.

[26] Song, M. and Yang D.T., 2010. Life Cycle Earnings and Saving in a Fast-Growing Economy, mimeo, Chinese University of Hong Kong.

Figures to be inserted in the Introduction. See appendix C.1 for data description

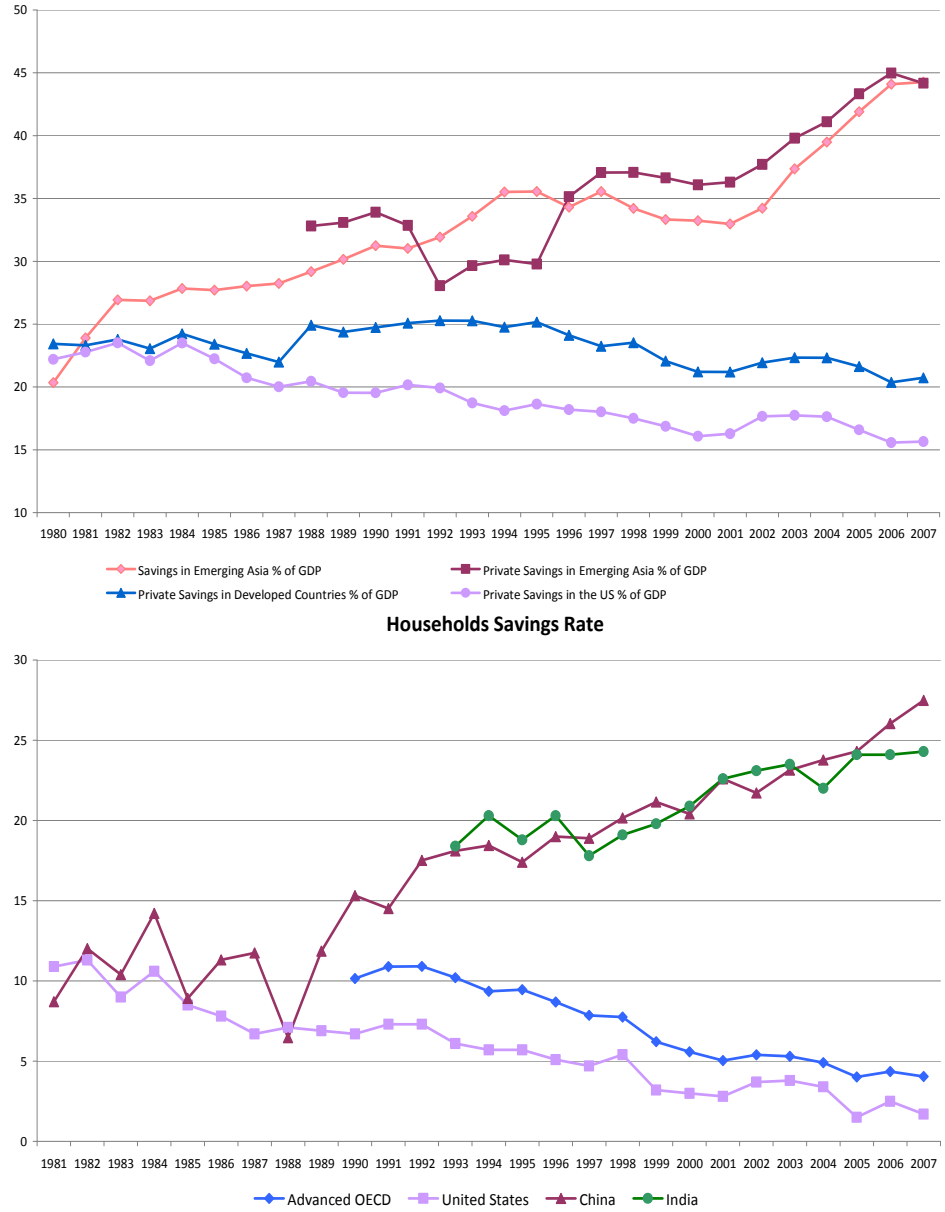
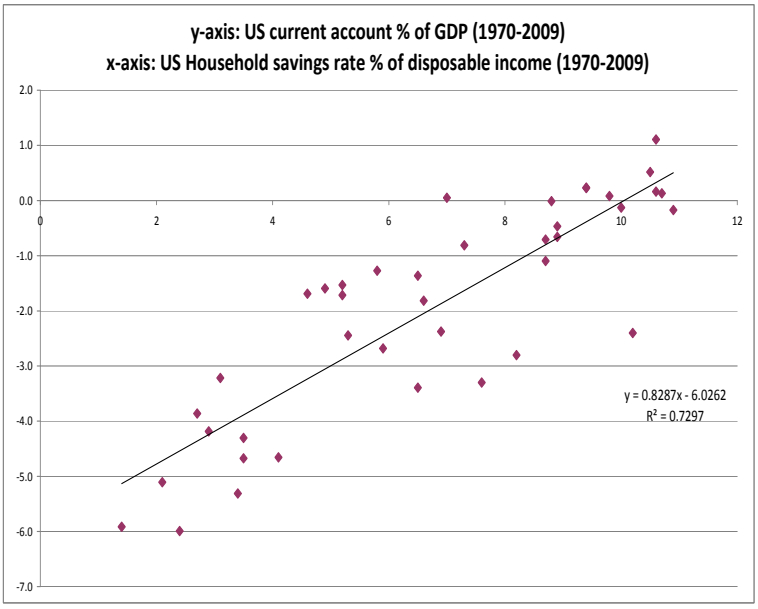


Figure 1.1: Private savings and household savings



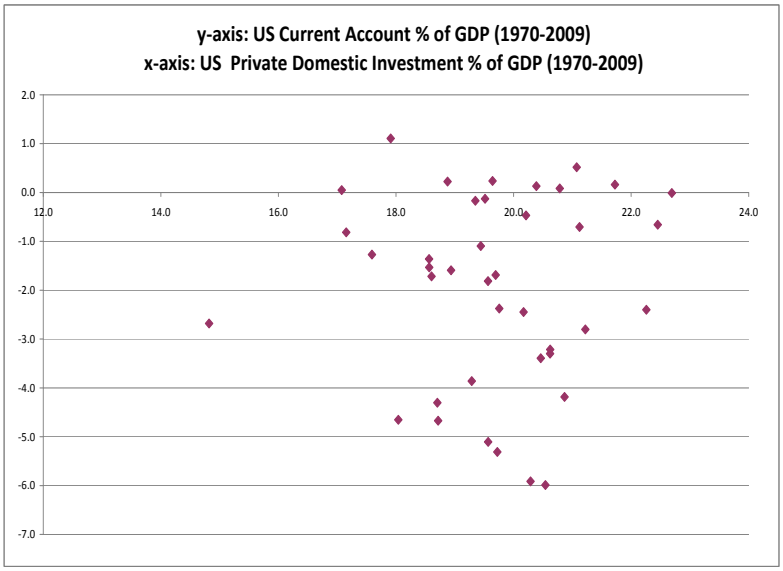


Figure 1.2: US current account, savings and investment

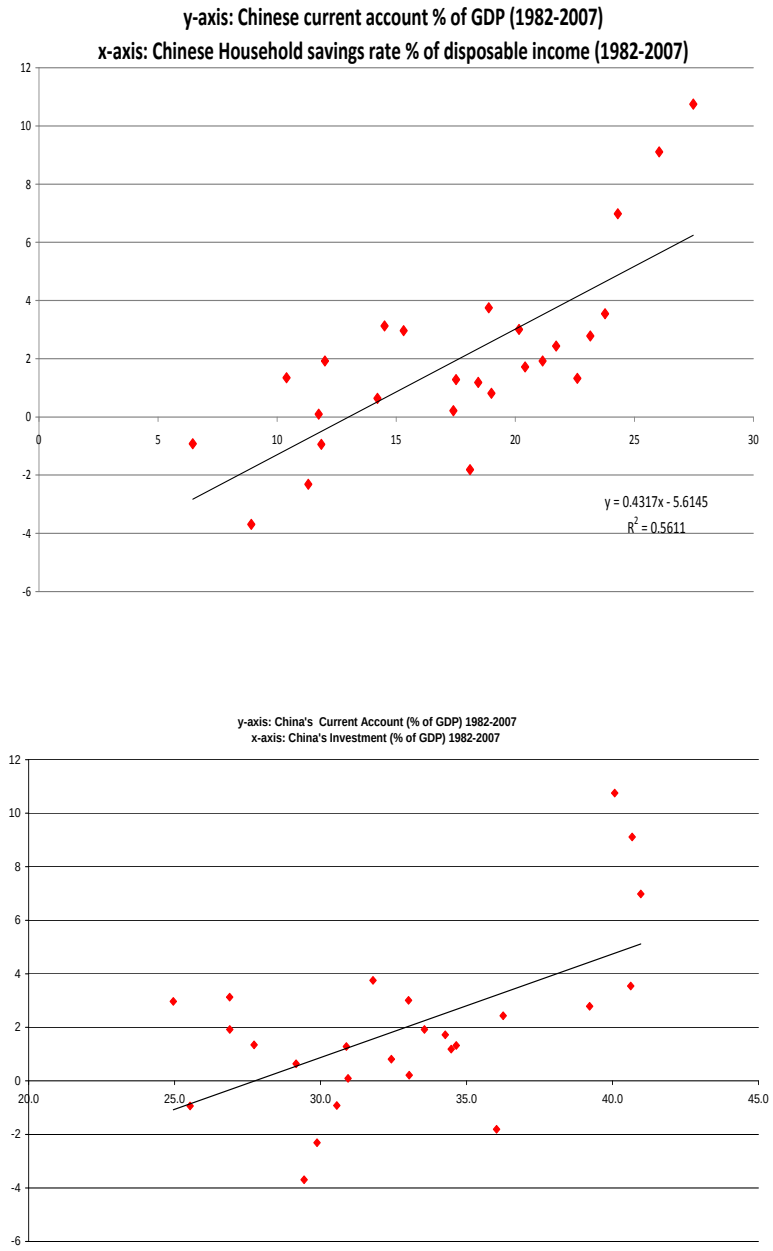


Figure 1.3: China current account, savings and investment



Figure 1.4: Current account and savings in the cross-section

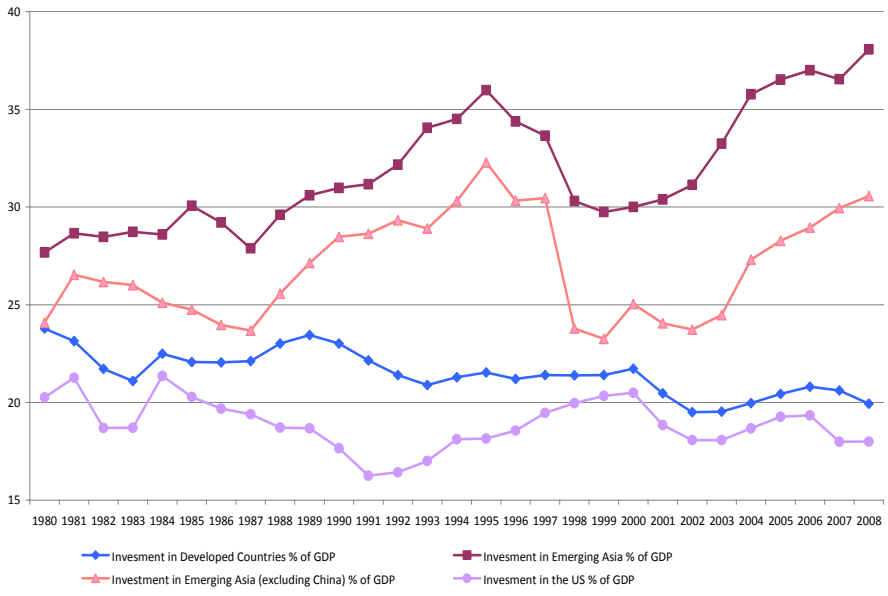


Figure 1.5: Investment