Essays on Capital Flows, Saving, and Growth Acceleration

by

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Abstract

This dissertation examines the relationship between international capital flows and saving in periods of growth acceleration. High productivity growth is generally associated with capital outflows in developing countries—a phenomenon called allocation puzzle by Gourinchas and Jeanne (2013), who showed that it is due to the behavior of saving rather than investment.

The first chapter paper adds habit formation to an otherwise-standard small open economy Balassa-Samuelson model with frictions in an attempt to explain why countries generally increase saving and have a current account surplus when economic growth accelerates. With plausible parameters, the model with habits can generate an increase in saving and a current account surplus in the medium run. In contrast, the standard model without habits predicts a sharp decrease in saving and a large current account deficit. The higher saving in the model with habits also dampens the real exchange rate appreciation compared with the no-habit model, because habit-forming consumers cut the consumption of tradable goods in order to save.

High economic growth usually leads to high saving later. The second chapter revisits the growth and saving nexus studied by Carroll and Weil (1994). The robustness of the Granger causality from growth to saving found by Carroll and Weil (1994) is tested using data from different versions of the Penn World Table. This chapter also examines the Granger causality from growth to saving in periods of empirically defined growth accelerations. Saving increases in years within a growth acceleration episode. However, the general statistical dependence of saving on growth is not driven by those growth acceleration episodes.

Using provincial data from China, the third chapter (coauthored with Liuchun Deng) examines the pattern of capital flows in relation to the transition of economic regimes. We show that fast-growing provinces experienced less capital inflows before the large-scale market reform, contrary to the prediction of the neoclassical growth theory. As China transitioned from the central-planning economy to the market economy, the negative correlation between productivity growth and capital inflows became much less pronounced. From a regional perspective, this finding suggests domestic institutional factors play an important role in shaping the pattern of capital flows.

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ABSTRACT

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Dedication

This thesis is dedicated to my mom and dad.

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Chapter 1

Consumption Habits, Growth Acceleration, and Capital Flows

1.1 Introduction

The standard model would predict that capital should flow from low-growth developed countries to high-growth developing countries, the opposite of what data suggest (Gourinchas and Jeanne, 2013 [2]). Instead of saving at high rates and running a current account surplus, fast-growing economies should borrow aggressively to finance their investment and consumption needs, according to the textbook model. Furthermore, the real exchange rate appreciation is much more gradual in the data than predicted by the Balassa-Samuelson model in those fast-growing countries during their growth acceleration periods (Harberger, 2003 [3]; Gente, 2006 [4]; Chuah, 2013 [5]).

CHAPTER 1. CONSUMPTION HABITS, GROWTH ACCELERATION, AND CAPITAL FLOWS

As an attempt to close the gap between the predictions of the standard model and the empirical facts, this paper introduces habit formation into an otherwise-standard small open economy model with nontradable goods. To explain the negative correlation between economic growth and net capital inflows, a strong positive correlation between growth and saving is needed.[1] In this paper, we add consumption habits as a way of generating the positive correlation between growth and saving.[2] The model with habits also better explains the real exchange rate dynamics, since the increase in saving due to habit formation dampens the real exchange rate appreciation. To this extent, this paper extends the insights from the following two strands of literatures: Gourinchas and Jeanne (2013) [2] call the upstream capital flows the "allocation puzzle", and argue that it is in fact a saving puzzle; Carroll, Overland, and Weil (2000) [6] show that a model with consumption habits is able to generate causality from high growth to high saving.[3]

This paper is mainly motivated by the discussion of the upstream capital flows and the imbalances in the global economy observed since 2000. High saving and current account surpluses as in the emerging countries are among the key stylized facts in both the "allocation puzzle" and the global imbalances literature (Gourinchas and Jeanne, 2013 [2]; Von Hagen and Zhang, 2014 [10]; and etc.).[4] However, most existing studies

[1] Carroll, Overland, and Weil (2000) [6] show that habits have the potential to generate causality from growth to saving in an AK growth model. The applicability of their results to less specialized production structures has not been thoroughly explored.

[2] Precautionary saving could be another possible way to generate the positive correlation between growth and saving (Carroll and Jeanne (2013) [7]; Sandri, 2014 [8]; and etc.).

[3] Carroll and Weil (1994) [9] show that empirically growth Granger causes saving.

[4] In Section 1.3, we will examine this stylized pattern empirically by looking specifically at periods

have focused on the role played by financial development or financial market frictions in explaining the upstream capital flows (Caballero, Farhi, and Gourinchas, 2008 [11]; Mendoza, Quadrini, and Ŕıos-Rull, 2009 [12]; Angeletos and Panousi, 2011 [13]; and etc.). This paper adds one more perspective to the discussion by showing that consumption habits can help explain the puzzle. Another dimension of the puzzle is that the real exchange rate appreciates only gradually or even depreciates in the fast-growing emerging countries.[5] Increases of saving could depreciate the real exchange rate and make it deviate from what the Balassa-Samuelson model would predict.[6] As we will show in this paper, adding habits is a way of bringing the model closer to the observed behavior of the real exchange rate in growth acceleration episodes.

The main intuition why the habit model is capable of better matching the empirical data compared with the model without habits is as follows. If the productivity of the tradable goods sector in the economy increases, saving will increase as a consequence of consumption habits formation. Unlike the consumer in a standard model, a habit-forming consumer not only cares about the level of consumption but also cares about the growth of consumption. Therefore, consumption will increase less than the output, saving will increase, and the economy will run a current account surplus.

of fast economic growth.

[5]The New Mercantilism's view is that the depreciated real exchange rate promotes economic growth, either because it helps shift resources to manufacturing (Rodrik, 2008 [14]; Korinek and Serven, 2010 [15]; Rabe, 2013 [16]; Wlasiuk, 2013 [17]; and etc.), or because it increases saving and capital formation (Montiel and Luis Servén 2008, [18]; Levy-Yeyati, Sturzenegger, and Gluzmann, 2013 [19]; and etc.).

[6]For a discussion on this argument see Gente (2006) [4]; Du and Wei (2011) [20]; Christopoulos, Gente, and Leon-Ledesma (2012) [21]; and etc.

In addition, increases in saving will slow down the appreciation of the real exchange rate predicted by the Balassa-Samuelson model. In the tradable-nontradable goods model, the real exchange rate is the relative price of the nontradable goods in terms of the tradable goods. Because nontradable goods have to be consumed domestically, increases in saving will dampen the increase in tradable goods consumption. As a result, the relative price of nontradable goods will rise only gradually, and the real exchange rate will appreciate gradually.

The main contribution of this paper is to provide a formal and plausible model which allows for habit formation to shed light on why high economic growth is associated with high saving, positive current account balance and gradual appreciation of the real exchange rate. To be specific, we introduce consumption habits as modeled in Carroll, Overland, and Weil (2000) [6] to a standard small open economy model with nontradable goods. Another feature of our model is that we model the fact that some countries' growth takes off but other countries remain poor. There are two regimes in the economy: In the convergence regime, the productivity of the tradable goods sector will converge towards a fraction of the world technology frontier; in the non-convergence regime, the productivity will stagnate relative to the world technology frontier. The two regimes evolve according to a two-states Markov process. Although the model is very stylized, it is rich enough that we can examine the dynamics of both the current account and the real exchange rate if economic growth accelerates. We then calibrate the model to growth acceleration episodes in emerging markets and developing countries. Comparing the results from the calibrated model with the stylized facts, we show that the model which allows for habit formation is able to predict the qualitative pattern of current account surpluses in periods of high economic growth. In contrast, the predictions from the simple model without habits are wildly off.[7]

The remainder of the paper is organized as follows. Section 1.2 briefly reviews the related literature; Section 1.3 provides stylized facts about saving, the current account and the real exchange rate; Section 1.4 describes the small open economy model with consumption habits and its solutions; Section 1.5 calibrates the model, and compares the model predictions with the actual data; Section 1.6 concludes the paper.

1.2 Literature Review

The paper is related to a number of different strands of literature. The first is on the upstream capital flows (Lucas, 1990 [23]; Verdier, 2008 [24]; Gourinchas and Jeanne, 2013 [2]; and etc.). It is also related to the research on global imbalances (Caballero, Farhi, and Gourinchas, 2008 [11]; Mendoza, Quadrini, and Ríos-Rull, 2009 [12]; and etc.). Capital flows from the fast-growing developing economies to the developed economies. The seminal paper in this string of literature is that by Lucas

[7] If a model without habits was used, one would easily predict that China should be a debtor instead of a creditor. For instance, Dollar, and Kraay (2006) [22] predicted that China's Net Foreign Asset (NFA) should be -17%.

(1990) [23], in which he points out that there were too few capital flows from rich countries to developing countries. There is, however, a subtle difference between the "Lucas puzzle" and the "allocation puzzle". To some extent, the "Lucas puzzle" is more static, and a succinct description of it could be that the marginal products of capital should be high in poor countries and should equalize;[8] the "allocation puzzle" is more dynamic, and the puzzle is that the fast-growing economies should borrow from their future high income according to the neoclassical growth model. To put it differently, the "allocation puzzle" is about the question of why high-growth countries do not receive more capital inflows given that they grow faster. Recently, people have renewed interest in the topic as the positive correlation of economic growth and capital outflows for non-OECD countries rises sharply and becomes higher than for OECD countries (Yu, 2013 [26]). Yu (2013) [26] examines capital flows in both OECD and non-OECD countries for the past three decades and finds that the correlation between capital flows and economic growth changes over time. The positive correlation of economic growth and capital outflows is actually more pronounced for OECD countries, especially in the 80s. Chinn and Prasad (2003) [27] also find that there is a strong positive relationship between GDP growth and the current account for industrial countries using a sample between 1971-1995; Prasad, Rajan, and Subramanian (2007) [28] find that capital outflows are positively correlated with economic growth in non-industrial countries. Alfaro, Kalemli-Ozcan, and Volosovych (2014) [29] decom-

[8] Caselli and Feyrer (2007) [25] find that marginal products of capital are remarkably similar across countries if natural capital is separated from reproducible capital.

pose the capital flows into private and public flows and find that the upstream capital flows are mainly driven by public flows. Reinhardt, Ricci, and Tressel (2013) [30] show that the key assumption of freely flowing capital is not supported in the data. They also find that mainly private capital flows downhill in financially open economies. Alfaro, Kalemli-Ozcan, and Volosovych (2008) [31] find that the "allocation puzzle" is correlated to differences in the institutions of countries. Countries' borders may also be an important factor. Reinhardt (2012) [32] looks at the "allocation puzzle" from a sectoral perspective. Kalemli-Ozcan, Reshef, Sorensen, and Yosha (2010) [33] find that capital flows are consistent with the neoclassical models within the states of America.

Various explanations of the "allocation puzzle" and the global imbalances have been discussed in the literature. The majority of the explanations focuses on the roles played by the financial market. Von Hagen and Zhang (2014) [10] argue that the differences in financial development explain the upstream capital flows. Caballero, Farhi, and Gourinchas (2008) [11] argue that lacking the ability to supply financial assets is the reason why capital flows from developing countries to the US. Mendoza, Quadrini, and Ŕıos-Rull (2009) [12] think that the financial integration of countries with different levels of financial development is the reason behind the global imbalances. Angeletos and Panousi (2011) [13] show how introducing idiosyncratic entrepreneurial risk could explain the global imbalances. Sandri's (2014) [8] explanation is about precautionary saving and the entrepreneurial risk associated with economic growth.

When growth produces business opportunities, entrepreneurs with risky investment contribute to the rise in saving. Because entrepreneurs face the uninsurable risk of losing their investment, they have to rely on self-financing, and they increase their own precautionary saving (Sandri, 2014 [8]). Coeurdacier, Guibaud, and Jin (2015) [34] find that differential household credit constraints—more severe in fast-growing countries help explain the large net upstream capital flows and the divergence in private saving rates between advanced and emerging economies. Other papers offer diverse alternative perspectives.[9] Buera and Shin's (2009) [36] explanation for the "allocation puzzle" is that a reform lifts the financial frictions and capital outflows are driven by domestic saving seeking higher returns. Tornel and Velasco's (1992) [37] story about why capital flows from the poor countries to the rich countries explains that it is because rich countries have safe bank accounts. Carroll and Jeanne (2013) [7] explain the capital outflows from high-growth countries by the lack of social insurance which stimulates precautionary saving. Jin (2012) [38] finds that a competing force that capital tends to flow toward countries that are more specialized in capital-intensive industries may explain the upstream capital flows if it dominates the standard force that capital flows to where it is scarcer. Ju, Shi, and Wei (2012) [39] argue that trade reform in a developing country would generally lead to a current account surplus.

[9] China's current account surplus is an important contributor to the global imbalances. Thus, people also consider Chinese-specific factors. For example, Song, Storesletten, and Zilibotti (2011) [35] argue that the financial frictions and reallocation of resources across firms account for the current account surpluses in China. State-owned firms have access to credit but are overrun by domestic private firms. And as those state-owned firms shrink, a larger proportion of the domestic savings is not channeled to them, but instead, invested in foreign assets.

To understand why capital flows from the fast-growing developing countries to developed countries is to understand why the fast-growing developing countries have high saving and high current account surpluses. As argued by Gourinchas and Jeanne (2013) [2], the "allocation puzzle" is, in fact, a saving puzzle. There are a few explanations as to why growth causes saving. Consumption habits proposed by Carroll, Overland, and Weil (2000) [6] is a prominent one.[10] Saving increases when growth is higher because, with consumption habits, consumers only adjust their consumption slowly. Life-cycle models and demographics changes have also been used to explain how high growth leads to higher saving. The basic intuition is if the number or the income of savers in the economy increases relative to the dis-savers, saving in the economy could rise. But the explanation is not very successful in matching the data. Using demographics changes is, at best, possible to produce a positive link from growth to saving, but the size of this effect is small (Deaton and Paxson, 1997 [42], 2000a [43], 2000b [44]; Paxson, 1996 [45]). When Coeurdacier, Guibaud, and Jin (2015) [34] shut down the channel of demographics changes, their calibrated model predicts essentially the same level of saving and current account surpluses, confirming that the size of the demographics effect is small.

The paper is also related to papers that study the determinants of real exchange rates. In the Balassa-Samuelson model, the real exchange rate is determined solely by

[10] Higher saving could lead to higher international reserves and international reserves could be desirable. In Benigno and Fornaro (2012) [40], the reserve provides liquidity in crises time; and in Aguiar and Amador's (2011) [41] model, the economy accumulates international reserves due to political economy frictions.

the supply side: the relative productivity growth. There is an enormous amount of literature that studies the Balassa-Samuelson effect (Lee and Tang, 2007 [46]; Choudhri and Schembri, 2010; [47]; Chong, Jordà, and Taylor, 2012 [48]; and etc.). But saving may make the real exchange rate deviate from the level predicted by the Balassa-Samuelson model. In Christopoulos, Gente, and Leon-Ledesma (2012) [21], as the economy is constrained in the international capital market, domestic saving will affect how real exchange rate depends on net foreign assets and productivity. A rise in domestic savings will loosen the constraints. Gente (2006) [4] argues that falling age dependency ratios offset partly the Balassa-Samuelson effect in Asian countries such as China, Indonesia, Malaysia, Thailand, and Singapore as they face constraints on capital inflows, resulting in a small appreciation or even a depreciation. Du and Wei (2011) [20] provide yet another novel and controversial theory as well as some empirical evidence. They argue that an unbalanced sex ratio contributes to the real exchange rate undervaluation by increasing saving and labor supply. Another part of this strand of the literature examines how factor allocations between sectors affect the real exchange rate (Morshed and Turnovsky, 2004 [49]; Chen and Hsu, 2009 [50]; and etc.). Morshed and Turnovsky (2004) [49] develop a model with intersectoral adjustment cost and analyze its implications for the dynamics of the real exchange rate. Their model with sectoral adjustment cost is able to generate much more plausible real exchange rate dynamics compared with empirical data. In general, with less than perfect factor mobility, saving is linked to the real exchange rate.

Lastly, the paper is also related to the literature about the consumption habits. Consumption habits are introduced in a wide range of economics problems, and are a key ingredient of this paper's model.[11] Ravn, Schmitt-Grohe, and Uribe (2010) [56] study the persistent impact of monetary policy shocks on aggregate consumption and inflation persistence. Ravn, Schmitt-Grohe, and Uribe (2007) [57] find that pricing to habits that firms charge different markups across markets exhibiting different ratios of current to habitual demand can explain the deviation from the law of one price. Gruber (2004) [58] adds consumption habits in studying the volatility of actual current accounts. Wu (2011) [59] shows that all existing explanations to the Chinese high saving fail if rising optimism about growth is incorporated, and suggests that consumption habits model may help explain the rising Chinese saving.

1.3 Stylized Facts

What motivates this research in the first place are the stylized facts found in cross-country empirical data that can not be explained by the textbook neoclassical model. As we will show in this section, the cross-country data suggest that there are, in fact, some general patterns about our key variables: saving, the current account, and the real exchange rate, which apply to a large number of countries. To summarize,

[11]Fuhrer (2000) [51] uses consumption habits to better fit empirically the responses of consumption and inflation to various shocks. Consumption habits are also used to explain the equity premium puzzle (Sundaresan, 1989 [52]; Abel, 1990 [53]; Constantinides 1990 [54]; Campbell and Cochrane, 1999 [55]; etc.).

there are three stylized empirical facts about saving, the current account and the real exchange rate which will be discussed in this paper. The third fact is relatively less well-known when people discuss the “allocation puzzle”.

1. High-growth countries typically run current account surpluses.
2. High-growth countries also experienced an increase in saving and investment.
3. The real exchange rate appreciated only gradually or even depreciated for high-growth countries after the high growth started.

We examine the stylized facts mentioned above by studying the dynamics of saving, the current account and the real exchange rate in growth acceleration episodes as identified by Hausmann, Pritchett and Rodrik (2005) [1]. Increased saving and current account surpluses in emerging economies have been part of the main motivating facts behind many papers in the literature. A growth acceleration episode is an eight-year period when per-capita growth rate increases by more than 2 percentage points, and the per-capita growth rate is more than 3.5 percent per year. In addition, post-acceleration output needs to exceed the pre-episode peak level of income so that pure recoveries are ruled out.[12] This empirical definition is as close as possible to the theoretic experiment of an increase in the tradable sector productivity which we will consider in our model. The other data are from Penn World Table 7.1. The construction of the measure of real exchange rate follows Rodrik (2008) [14]. Real exchange

[12] The list of episodes are in the appendix (Table A.1).

rate (RER) is calculated using exchange rates (XRAT) and purchasing power parity conversion factors (PPP). Real exchange rate (RER) greater than one means that the currency is more depreciated than indicated by purchasing power parity. In other words, the log of real exchange rate (RER) greater than zero means that the currency is more depreciated than indicated by the purchasing power parity.

$$\ln RER = \ln XRAT/PPP$$

The Balassa-Samuelson effect predicts that when a country has rapid productivity improvement in the tradable goods sector, the real exchange rate will appreciate. The changes of saving, investment, the current account, and log real exchange rate in growth acceleration episodes are plotted in Figure 1.1.[13] All the variables are changes relative to their own means during years before the growth accelerations. For example, saving rate is about 2.5% higher than before the growth acceleration i.e. if the saving rate were 20% before the growth acceleration, it became 22.5% five years after the growth accelerations. In growth acceleration episodes, saving increases more than investment increases, and the current account thus increases. Rapid growth is associated with both capital outflows and current account surpluses. Positive ln(RER) changes mean that the real exchange rate is more depreciated than in previous years;

[13] Averaged over fourteen growth acceleration episodes from Hausmann, Pritchett and Rodrik (2005) [1]. We also exclude episodes in which exogenous events which are not related to productivity growth are likely to be influential. For example, foreign aid and credits are important for Egypt in 1976; oil income is important for Algeria in 1975. Year 0 is the time when growth acceleration starts.

negative values mean that the real exchange rate is more appreciated. The figure shows that the real exchange rate depreciates during growth acceleration periods.[14]

1.4 A Small Open Economy Model with Consumption Habits

In this section, consumption habits are introduced to an otherwise-standard small open economy model. The model has a tradable goods sector and a nontradable goods sector. The model is then used as a tool to think about the dynamics of saving, the current account, and the real exchange rate in the period of productivity changes in the tradable goods sector.

1.4.1 Model Set-up

Consider a small open economy where there are two goods: a tradable goods (T) and a nontradable goods (N).[15] By definition, the nontradable goods can only be consumed domestically.

The representative consumer's problem is to maximize her lifetime expected utility

[14]We also plot a similar figure adding developed countries. The resulting Figure A.1 is in the appendix. The list of episodes are in the Table A.2

[15]Rabanal and Tuesta (2013) [60] show that adding nontradable goods is the key to understanding real exchange rate fluctuations.

subject to her budget constraint

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, H_t\right) \tag{1.1}$$

where C is an aggregate consumption index; H is the stock of consumption habits; β is the subjective discount factor.

The consumer cares not only about the level of the consumption but also about how it compares to her habits. When she thinks about increasing her consumption, though she likes more consumption, she does not like a sudden and huge deviation from the old consumption level as she has a "habit" that adjusts only gradually. Her stock of consumption habits evolves according to

$$H_{t+1} - H_t = \rho\left(C_t - H_t\right) \tag{1.2}$$

where ρ governs how quickly the stock of habits adjusts and how the past consumption contributes to the consumption habits; to simplify the notations, choose the tradable goods as the numeraire, and p is the price of the nontradable goods in terms of the tradable goods.

The aggregate consumption is a Cobb-Douglas aggregation of tradable goods consumption and nontradable goods consumption.

$$C = \left(\frac{C_T}{\theta}\right)^{\theta}\left(\frac{C_N}{1-\theta}\right)^{1-\theta}$$

where C_{Tt} is the tradable goods consumption; C_{Nt} is the nontradable goods consumption; coefficient θ gives the share of tradable goods consumption in the aggregate consumption.[16] The aggregate price index P_C thus is

$$P_C = p^{1-\theta}$$

The real exchange rate is defined as the relative price of the aggregate consumption index between the home country and the foreign country. After some standard calculations,[17] the real exchange rate is given by

$$RER = \frac{1}{p^{1-\theta}}$$

The real exchange rate is a monotonic transformation of the relative price p. For simplicity, in the later discussion we can analyze relative price or real exchange rate interchangeably when necessary without causing confusion. Whenever relative price p increases, real exchange rate appreciates.

The tradable and nontradable goods output Y_{Tt} and Y_{Nt} are produced with labor L_{Tt} and L_{Nt}, and capital K_t. Assume that the tradable good sector uses capital and labor but the nontradable goods sector only uses labor. Thus, the nontradable goods sector can be thought as the "traditional" sector in the Lewis model. This model

[16] Cobb-Douglas specification is used in Obstfeld and Rogoff (1996) [61] when they discuss the Balassa-Samuelson model. The Cobb-Douglas specification is also used in Morshed and Turnovsky (2004) [49].

[17] Detailed derivations are in the appendix.

setup allows the real exchange rate to be affected by demand factors. By definition, nontradable goods have to be consumed domestically i.e. $C_{Nt} = Y_{Nt}$. Tradable goods consumption can be larger or smaller than its domestic output. When tradable goods consumption is larger than its domestic output, the economy is a net importer; when tradable goods consumption is smaller than its domestic output, the economy exports. The production functions are given by

$$Y_{Tt} = A_{Tt} K_t^{\alpha} L_{Tt}^{1-\alpha} \tag{1.3}$$

$$Y_{Nt} = A_{Nt} L_{Nt}^{\eta} \tag{1.4}$$

where A_{Tt} and A_{Nt} are the exogenous productivity level in the tradable and nontradable goods sector; K_t is capital in the tradable goods sector.

If both the tradable and nontradable goods sector use Cobb-Douglas technology to combine capital and labor into output, and capital and labor are freely mobile, the real exchange rate or the relative price will be completely determined by the supply side only. This is the Balassa-Samuelson model treated in Obstfeld and Rogoff (1996) [61] and Rogoff (1992) [62].[18] The key assumption is that capital and labor can move freely across sectors. In order for demand to have an effect, some deviation from the Balassa-Samuelson model has to be introduced. This is why we model the nontradable goods sectors as the "traditional" sector which does not use capital.

[18]The details about the Balassa-Samuelson model are included in the appendix.

The labor can not move internationally but can move between the two sectors. Assume that the supply of labor is inelastic; and normalize total labor supply to 1. Therefore, the labor in the tradable goods sector and the labor in the nontradable goods sector in the domestic economy add up to 1,

$$L_{Tt} + L_{Nt} = 1. \tag{1.5}$$

Assume that the productivity A_{Tt} in the tradable goods sector follows equation (1.6), where v_t can take two values: in the non-convergence regime, v_t is equal to 1; in the convergence regime, v_t is equal to $g < 1$; $\bar{A}$ is a constant and represents the world technology frontier.[19] In the convergence regime, the tradable goods productivity converges towards the technology frontier $\bar{A}$.[20] ϕ is a constant, and is between 0 and 1. When $\phi < 1$, the tradable goods productivity of the economy will only converge towards a fraction of the world technology frontier $\bar{A}$.

$$A_{Tt+1} = \phi\bar{A} * (1 - v_t) + v_t A_{Tt} \tag{1.6}$$

Assume that v_t evolves according to a two-state Markov process, and the transition matrix for v_t is Q, where q_{11} is the probability of staying at the non-convergence regime; q_{12} is the probability of moving from the non-convergence regime to the

[19] One can think of this as the US level of tradable goods productivity.

[20] If $\bar{A}$ were allowed to grow at a constant level, all the steady-state variables will grow at the same rate. Then, everything can be normalized by $\bar{A}$. In the normalized model, the tradable goods technology will again be a constant.

convergence regime; q_{21} is the probability of moving from the convergence regime to the non-convergence regime; and q_{22} is the probability of staying at the convergence regime.

$$Q = \begin{bmatrix} q_{11} & q_{12} \\ q_{21} & q_{22} \end{bmatrix}$$

Only the tradable goods are used as investment goods. The investment law of motion is standard as the following

$$I_t = K_{t+1} - K_t + \delta K_t \tag{1.7}$$

Meanwhile, in order not to have jumps in capital and implausible numbers of high investment, there should also be some cost to adjust capital between periods. A rather standard assumption in the literature is to assume that capital accumulation is subject to a convex adjustment cost (Schmitt-Grohe and Uribe, 2003 [63]). The budget constraint with capital adjustment cost is written as follows:

$$B_{t+1} - B_t = Y_{Tt} - C_{Tt} - I_t + r_t B_t - \frac{\xi \left(K_{t+1} - K_t\right)^2}{2} \tag{1.8}$$

where parameter ξ controls the size of the adjustment cost; r_t is the interest rate faced by the small open economy if it borrows from the international capital market. The changes in the external balance is the difference between saving and investment.

To exclude the explosive solutions, we assume the transversality conditions:

$$\lim_{T\to\infty} \frac{1}{(1+r)^T} B_{t+T} = 0 \tag{1.9}$$

$$\lim_{T\to\infty} \frac{1}{(1-\rho)^T} H_{t+T} = 0 \tag{1.10}$$

To induce stationarity, we assume that the interest rate depends on the amount of external debt. From a technical point of view, this assumption makes the model stationary in the sense that the steady state level of external balance does not depend on its initial value and also is not path dependent. In addition, as argued in Schmitt-Grohe and Uribe (2015) [64], theoretically it represents a simple way to capture the presence of financial frictions; and empirically the debt-sensitive interest rates are supported by the data. In particular, the interest rate faced by the small open economy is

$$r_t = r + p(B_t) \tag{1.11}$$

where r is a constant world interest rate; $p(\bullet)$ is the country interest rate premium, and is decreasing in its argument. In particular, assume the following function form for $p(\bullet)$ as in Schmitt-Grohe and Uribe (2003) [63].

$$p(B_t) = \psi\left(e^{\bar{B}-B_t} - 1\right)$$

where $\bar{B}$ is the steady state level of the external balance, and ψ is a constant.

Although the introduction of the debt elastic interest rate is mainly for technical purposes, the resulting changes in the interest rate will affect the dynamics of the external balance, and therefore, also affect the dynamics of the current account. To better examine how the existence of the consumption habits will affect the current account and the external balance, a small value of ψ is chosen in the calibration so that the effects from changes in the interest rate in the medium run will be small. It is, however, worth to keep in mind of the existence of interest rate changes in the model.

1.4.2 Equilibrium

Assume the utility function is taking the simple CRRA form and consumption habits are multiplicative as in (1.12). As pointed out by Carroll (2000) [65], the multiplicative habits and CRRA utility function are more appealing than other combinations of specifications, for example, subtractive habits and quadratic utility function. Coefficient γ controls how the consumer cares about the consumption habits. If $\gamma = 0$, the consumer does not care about the consumption habits any more and the model collapses to the simple case; If $\gamma = 1$, the consumer only cares about the ratio of current consumption to habits. σ is the coefficient of relative risk aversion. $0 \leqslant \gamma < 1$ and $\sigma > 1$ is assumed.

$$U\left(C,H\right)=\frac{\left(C/H^{\gamma}\right)^{1-\sigma}}{1-\sigma} \tag{1.12}$$

Set up the Lagrangian

$$\mathcal{L}=E_0\sum_{t=0}^{\infty}\left\{\begin{array}{c}\frac{\left[\frac{\left(\frac{C_{Tt}}{\theta}\right)^{\theta}\left(\frac{C_{Nt}}{1-\theta}\right)^{1-\theta}}{H_t^{\gamma}}\right]^{(1-\sigma)}}{1-\sigma}+\lambda_t\left[\begin{array}{c}A_{Tt}K_t^{\alpha}L_{Tt}^{1-\alpha}-C_{Tt}-\\ \left(K_{t+1}-K_t+\delta K_t\right)+\\ p_tA_{Nt}L_{Nt}^{\eta}-p_tC_{Nt}+\left(1+r_t\right)B_t-\\ \frac{\xi\left(K_{t+1}-K_t\right)^2}{2}-B_{t+1}\end{array}\right]+\\ \mu_t\left[H_{t+1}-\rho\left(\frac{C_{Tt}}{\theta}\right)^{\theta}\left(\frac{C_{Nt}}{1-\theta}\right)^{1-\theta}-\left(1-\rho\right)H_t\right]\end{array}\right\} \tag{1.13}$$

The first-order conditions are the followings:[21]

[21]Detailed derivations are left in the appendix.

$$\lambda_t = \left(\frac{C_{Tt}}{\theta}\right)^{\theta-1-\sigma\theta}\left(\frac{C_{Nt}}{1-\theta}\right)^{(1-\sigma)(1-\theta)} H_t^{-\gamma+\gamma\sigma} - \mu_t\rho\left(\frac{C_{Tt}}{\theta}\right)^{\theta-1}\left(\frac{C_{Nt}}{1-\theta}\right)^{1-\theta} \tag{1.14}$$

$$\lambda_t p_t = \left(\frac{C_{Tt}}{\theta}\right)^{\theta-\sigma\theta}\left(\frac{C_{Nt}}{1-\theta}\right)^{-\sigma(1-\theta)-\theta} H_t^{-\gamma+\gamma\sigma} - \mu_t\rho\left(\frac{C_{Tt}}{\theta}\right)^{\theta}\left(\frac{C_{Nt}}{1-\theta}\right)^{-\theta} \tag{1.15}$$

$$\lambda_t\left(Y_{Nt} - C_{Nt}\right) = 0 \tag{1.16}$$

$$\lambda_t = \beta E_t\left[\lambda_{t+1}\left(1 + r_{t+1}\right)\right] \tag{1.17}$$

$$\mu_t = \beta E_t\left[\left(1-\rho\right)\mu_{t+1} + \gamma\left(\frac{C_{Tt+1}}{\theta}\right)^{\theta-\sigma\theta}\left(\frac{C_{Nt+1}}{1-\theta}\right)^{(1-\sigma)(1-\theta)} H_{t+1}^{-\gamma-1+\gamma\sigma}\right] \tag{1.18}$$

$$\lambda_t + \lambda_t\xi\left(K_{t+1} - K_t\right) = E_t\left\{\lambda_{t+1}\beta\left[\alpha A_{Tt+1}K_{t+1}^{\alpha-1}L_{Tt+1}^{1-\alpha} + 1 - \delta + \xi\left(K_{t+2} - K_{t+1}\right)\right]\right\} \tag{1.19}$$

$$\left(1-\alpha_T\right)A_{Tt}K_t^{\alpha}L_{Tt}^{-\alpha} = p_t\eta A_{Nt}L_{Nt}^{\eta-1} \tag{1.20}$$

The first-order conditions are slightly more complicated than in the model without consumption habits. If the consumption habits are removed, the above conditions become the standard ones. Equation (1.16) is the nontradable goods market clearing condition i.e. nontradable goods have to be consumed domestically. Equation (1.14) is derived from the derivative of the Lagrangian with respect to the tradable goods consumption. Equation (1.14) will not have the second term on the right-hand side in the simple model without habits i.e. μ_t is equal to zero. λ_t will be equal to the marginal utility of tradable goods consumption, the first term on the right-hand side. When λ_t is high, the marginal utility is high and the consumer is more willing to increase the tradable goods consumption. In the habit model, μ_t is positive, and the entire second term is negative. Thus, λ_t is lower in the habit model. The consumer is less willing to increase her consumption. Using equation (1.14) and (1.15), we can solve for the relative price p_t,

$$p_t = \frac{(1-\theta)\, C_{Tt}}{\theta C_{Nt}}, \tag{1.21}$$

Equation (1.21) gives the price of nontradable goods in terms of tradable goods, and carries the main intuition of how the real exchange rate is determined in the model. The same equation arises for the model without consumption habits as well. However, the existence of consumption habits will alter how tradable goods consumption C_{Tt} responds to different shocks. In equilibrium, the market clearing in the nontradable goods market means that the nontradable goods consumption is equal to nontradable goods output. When the nontradable goods output does not change, if the tradable goods consumption is lower, the relative price p will be lower as well. The existence of consumption habits lowers the tradable goods consumption compared to the case if there are no consumption habits, and that lowers the relative price p.

If there are no consumption habits, the jump in tradable goods consumption can be much bigger. When the productivity in the tradable goods sector increases, the increase in the tradable goods consumption will be higher than the increase in the tradable goods output and people will dis-save. This is the typical prediction of a neoclassical model. When future income is higher, people will consume out of their future income and saving will decrease.

The equilibrium of the small open economy consumption habits model is a set of stochastic process $\{B_t, H_t, K_t, C_{Tt}, C_{Nt}, Y_{Tt}, Y_{Nt}, I_t, L_{Tt}, L_{Nt}, r_t, p_t, \lambda_t, \mu_t\}$ satisfying the FOC equations (1.14) - (1.20), equation (1.11), equations (1.3) - (1.5), the transversality conditions equations (1.9) - (1.10) and budget equations (1.2) and (1.8) , and given equation (1.6) and $B_0, H_0, A_{T0}, \upsilon_0, K_0$.

1.4.3 Numerical Resolution

The model is solved using the method in Richter, Throckmorton and Walker (2014) [66]. They use policy function iteration with time iteration and linear interpolation and apply the method to a Markov switching RBC model. They make use of the MATLAB Parallel Computing Toolbox (PCT) and integrate Fortran through MATLAB executable functions (MEX) to significantly reduce the computing time. They have made their codes publicly available.

First, grids are established for each states variables, B_t, H_t, A_{Tt}, K_t. Second, a minimum set of variables required to solve for all time t variables are chosen as numerical policies i.e. L_{Tt}, I_t, μ_t. The Lagrangian μ_t is chosen as a numerical policy, which greatly simplifies the calculation. Third, initial conjectures for each policy function are obtained. After obtaining the initial guesses, all time t variables are solved using all of the equilibrium conditions i.e. $C_{Tt}, C_{Nt}, Y_{Tt}, Y_{Nt}, L_{Nt}, r_t, p_t, \lambda_t$. Next, the time $t+1$ values for each of the policy variables are calculated using linear interpolation. Then, the remaining time $t+1$ variables that need to calculate time t expectations are solved using the discrete Markov chain. Finally, then zeros of the equations with embedded expectations are solved. The output are values for the updated policy functions for the next iteration. When the distance between the initial policy values and the updated policy values is less than the convergences criterion on all nodes, the policies have converged to their equilibrium values.[22]

1.5 Calibration and Simulation

The calibration of the model is aimed to help illustrate the qualitative performance of the model, and to produce the baseline predictions and intuitions. Whether the model can generate numbers of plausible magnitudes is also examined.

1.5.1 Calibrating Model Parameters

First, let us start with the parameters whose calibration is more standard and need not much discussion. The time unit of the model is chosen to be a year. The world interest rate r is set to 4%. The subjective discount factor is set equal to

[22]More details of the numerical algorithm are in the appendix.

the constant world interest rate i.e. $\beta = \frac{1}{1+r}$. The capital share in the production function in the tradable sector α is chosen to be 0.32. This is a typical number chosen in the literature (Schmitt-Grohe and Uribe, 2003 [63]). The depreciation rate δ is 6%. The tradable consumption share is chosen to be 0.3526 from Benigno, Chen, Otrok, Rebucci and Young (2013) [67]. The productivities of the nontradable goods and tradable goods are normalized to be 1. The steady-state external balance level is assumed to be 0.

1.5.1.1 AT Process

Different values of g imply different convergence paths and time-varying growth rates of the tradable goods productivity A_T (Figure 1.2). For any given g, the value v_t takes in the convergence regime, the growth rate of A_T is high at the beginning and gradually decreases. When g is smaller, the initial growth rate is higher, and the mean growth rate is also higher. But there is a general trade-off between matching the initial growth rate and the mean growth rate. In the data, the average TFP growth in the growth acceleration episodes is less than 4%; the average TFP growth in the non-growth-acceleration years is close to zero and slightly negative. g is equal to 0.9 to roughly match the mean TFP growth rate difference between growth acceleration episodes and the non-growth-acceleration years. In Figure 1.3, the TFP growth in the data and in the model are compared. In the following numerical exercise, the initial level of tradable goods productivity A_{T0} is chosen to be 50% of the technology frontier level. In PWT 8.1, the mean and the median of the TFP at current PPPs for all the developing countries, real GDP per capita less than 6000 PPP dollars, are about 0.5. The US level is normalized to 1. q_{12} is the probability of moving from the non-convergence regime to the convergence regime. Hausmann, Pritchett and Rodrik (2005) [1] calculate that the unconditional probability of a country will experience a growth acceleration sometime during a decade is 0.25. q_{12} is the probability of a growth acceleration in a year. If the occurrence of a growth acceleration in any year is independent, the probability of a growth acceleration in a decade is $10q_{12}(1-q_{12})^9$. So q_{12} should be equal to 0.034. q_{21} is the probability of moving from the convergence regime to the non-convergence regime. The length of a growth acceleration episode is about 10 years on average in the data. q_{21} is therefore chosen to be 1/10. ϕ is chosen to be 0.85 i.e. the economy actually converges towards 85% of the technology frontier. In PWT 8.1, the mean and the median of the TFP at current PPPs for all the developed countries, countries with real GDP per capita more than 6000 PPP dollars, are about 0.85. If an average developing country converges toward an average developed country, the productivity will converge to about 85% of the US productivity which is considered to be at the world technology frontier.

1.5.1.2 Habit Parameters

The habit persistence parameter ρ is chosen to be 0.2 as in Carroll, Overland and Weil (2000) [6]. The coefficient of relative risk aversion σ is set to 2 for the model without habits, which is standard in the literature (e.g. Benigno and Thoenissen, 2008 [68]; Schmitt-Grohe and Uribe, 2003 [63]; Stockman and Tesar, 1995 [69]; and etc.). The habit parameter is $\gamma = 0.8$. Deaton (1994) [70] and Constantinides (1990) [54] both require the habit parameter γ to be around 0.8; Gruber (2004)'s [58] average estimate of γ is slightly over 0.8. Fuhrer (2000) [51]'s estimate of γ is 0.9 using GMM. To summarize, a value of γ around 0.8 or even higher has been considered as plausible in the literature. Consumption habits create a discrepancy between the short-horizon and the long-horizon intertemporal elasticity of substitution. Consumption habits increase the long-horizon intertemporal elasticity of substitution. When the habit parameter γ is changed, the choice of the coefficient of relative risk aversion σ will also need to be adjusted. Together, they determine the long-horizon intertemporal elasticity of substitution. The long-horizon intertemporal elasticity of substitution is bigger than the short-horizon intertemporal elasticity of substitution (the inverse of the coefficient of relative risk aversion $1/\sigma$) in the model with habit formation. In addition, the long-horizon intertemporal elasticity of substitution is larger if the habits are stronger. Given the same value of the habit parameter γ, a higher value of σ is more likely to generate a current account surplus because an increase in σ is going to increase the discrepancy between the long-horizon and the short-horizon intertemporal elasticity of substitution, the ratio of the long-horizon intertemporal elasticity of substitution to the short-horizon intertemporal elasticity of substitution.[23] Although

[23]However, it will only affect the transition since the steady state current account is always zero in this model.

a higher σ will decrease both the long-horizon intertemporal elasticity of substitution and the short-horizon intertemporal elasticity of substitution, it decreases the short-horizon intertemporal elasticity of substitution more. So relatively speaking, when σ is higher, the long-horizon intertemporal elasticity of substitution is larger compared to the short-horizon intertemporal elasticity of substitution. It actually increases the long-horizon intertemporal elasticity of substitution relatively. Thus, the consumer is more willing to cut consumption now and enjoy a better consumption growth in the short future. In the current model, there is not a simple analytical formula for the long-horizon intertemporal elasticity of substitution. The interest rate r_t is also time-varying. However, in Carroll, Overland, and Weil (2000) [6], the long-horizon intertemporal elasticity of substitution has an explicit analytical expression, which is equal to $\frac{1}{\gamma(1-\sigma)+\sigma}$. As a crude approximation, the coefficient of relative risk aversion σ is chosen to be 11 for the habit model using $\frac{1}{\gamma(1-\sigma)+\sigma}$.

1.5.1.3 Debt Elasticity of the Country's Interest Rate Premium

The debt elasticity of the country's interest rate premium ψ is another important parameter. It affects how quickly interest rate will respond to changes in the external balance. If the economy runs a current account surplus and accumulates more external balance, the interest rate will decrease to move the external balance back to the steady state level; and vice versa. A large value of ψ means that the interest rate changes will be large and it will take less time for the external balance to return to its steady state level. In the baseline calibration, ψ is chosen to be 0.00001 as in Schmitt-Grohe and Uribe (2001) [71]. A small ψ is desirable as it will mean that medium-run current account dynamics will not be affected much by the interest rate changes. Meanwhile, the external balance will return to the steady state slowly. The primary focus of the current paper is not how interest rate premium affects current account and the external balance.

1.5.1.4 Capital Parameters

The parameter η mainly determines the steady state employment share in the tradable goods sector.[24] η is 0.8535 and the implied steady state employment share in the tradable goods sector is 35%. Considering that the steady state technology is 85% of the US level approximately, 35% gives a number very close to the actual employment share in the tradable goods sector estimated in Hlatshwayo and Spence (2012) [73]. The parameter ξ determines how costly to accumulate capital over time. The calibrated value for ξ varies a lot in the literature ranging from 0.3 to 20 (Jin, 2012 [38]). In this paper, ξ is chosen so that approximately the changes of investment rate produced by the model are of similar magnitude compared with the changes of investment rates in Figure 1.1. The resulting ξ is 15.

[24] The employment share in the tradable goods sector in reality is changing and has important implications (Hlatshwayo and Spence, 2013 [72]; Hlatshwayo and Spence, 2012 [73]). But this is beyond this paper.

With the above calibrated parameters (Table 1.1), the time paths of all the key variables can be calculated numerically.

1.5.2 The Tradable Sector Productivity Convergence

Now, let us examine a permanent improvement in the tradable goods sector productivity. Suppose that at time 0, the economy has been in the steady state, and the tradable goods productivity of the economy is at a level of A_{T0}. Then because, for example, an exogenous economic reform happened, the economy moves to the convergence regime and stays in the convergence regime for the coming years. The tradable goods sector productivity thus will converge towards a fraction of the higher steady-state level $\bar{A}$ from the initial level A_{T0}. The experiment can be thought of an average developing country converging towards an average developed country. We want to compare how the current model's predictions are different from the predictions of the model without the consumption habits.

1.5.2.1 Baseline Calibration

The results using the baseline calibration are plotted in Figure 1.4. The red dash line is for the simple model without habits; and the blue solid line is for the model with habits and $\gamma = 0.8$. The consumption habits slow the adjustment of the tradable goods consumption, and this increases saving. The jump in the tradable goods consumption is smaller for the model with habits. In the habit model, as the demand for tradable goods is higher, labor will move to the tradable goods sector and the increase in investment is also larger.[25]

The dynamics for the model without habits and with habits differ in important ways. The current account dynamics are very different. The current account surplus reaches slightly more than 2.5% after six years in the habit model; the current account deficits reach nearly 20% initially, and remain more than 8% after ten years in the model without habits.[26] As a consequence of the current account dynamics, there is an increase in the external balance in the habit model but there is a big drop in the external balance for the model without habits. The reason that the responses of the current account and the external balance are different is because the tradable goods consumption adjusts differently. When there are consumption habits, the consumer increases tradable goods consumption by less.[27]

The intuition as to why the model with habits predicts a much more gradual increase in the tradable goods consumption is basically the same as in Carroll, Overland,

[25]Note only tradable goods are used as investment.

[26]In order for the external balance of the simple model to return to the steady state level, the economy has to run equal amount of current account surpluses some times in the distant future.

[27]The current account dynamics are also influenced by how the risk premium adjusted interest rate changes. The dynamics of the risk premium adjusted interest rate drive the external balance back to the long run steady state level. However, because a small value of debt elasticity of country interest rate premium ψ is chosen, it will take a long time for the external balance to return to its steady-state level. For example, in the case of the simple model, if the external balance decreases, the interest rate paid on the external balance will increase. A higher interest rate will then increase the accumulation of the external balance, and eventually drive the external balance to return to the steady state.

and Weil (2000) [6]. The reason that saving increases is because the habit-forming consumers not only smooth levels of consumption but also smooth growth of consumption . A different perspective is that consumption habits increase the long-horizon intertemporal elasticity of substitution. With stronger habits, the consumer is more willing to substitute today's consumption for future consumption growth. As a result, the simple model without habits predicts the sharpest increase of the tradable goods consumption, and therefore, the biggest current account deficit and the biggest drop of the external balance. The model predictions of the current account and other variables are compared with the data in Figure 1.5. The model with habits does a much better job in matching the data.

The real exchange rate appreciation is slower in the habit model. Or to put it differently, the increase of relative price is slower. The initial appreciation of the real exchange rate is 51% smaller in the model with habits compared with the simple model without habits. After ten years, the real exchange rate is still 6% more depreciated in the model with habits compared with the simple model without habits. Compared with the long-run steady state, the real exchange rate is 21% more depreciated in the model with habits than in the simple without habits.[28] The reason can be best understood using equation (1.21). The increase of tradable goods consumption is much smaller in the habit model. The increase of relative price is thus also smaller. Because the nontradable goods are consumed completely domestically, if the amount

[28]The data suggest that the real exchange rate actually depreciates slightly. One possibility is that other factors that are not considered in the stylized model also affect the dynamics of the real exchange rate, for instance, the New Mercantilism motives.

of tradable goods consumption is large, the nontradable goods are relatively more scarce, and its price will go up. On the contrary, when the demand of tradable goods is weaker and the amount of tradable goods consumption is smaller, the nontradable goods will be less expensive relatively.

1.5.3 Sensitivity Analysis

We vary a few key parameters in this section to see how they affect the resulting dynamics of our key variables. This exercise could also provide further intuition on the channels driving the dynamics of our key variables. In particular, we investigate the role played by the habit parameter γ, the capital adjustment cost parameter ξ, and the coefficient of relative risk aversion parameter σ. We also examine how the results may differ if the probability of growth acceleration is calibrated differently. Figure 1.6 plots the dynamics of saving, investment, current account, and real exchange rate if the habit parameter γ is different. It is not surprising that as habit parameter γ is closer to 0, the dynamics are more similar to the model without habits. The habit parameter γ needs to be big enough in order to produce a current account surplus.

Figure 1.7 plots the results if different capital adjustment cost parameters ξ are assumed. A higher value of ξ will lower the initial increase in investment as expected. However, the effect on the current account is relatively small. The model predicts a current account surplus after about five years in all cases.

Figure 1.8 shows how different coefficients of relative risk aversion parameters σ

would affect our results. As discussed in calibrating the habit parameter, higher σ increases saving and current account because it increases the long-horizon intertemporal elasticity of substitution relatively. The consumer becomes more willing to postpone her consumption.

Another possible concern is that the probabilities in the transition matrix might be inaccurately calibrated.[29] Our simple model specifes a tractable and stylied two-regime Markov process that growth accelerates in the convergence regime. On the one hand, the actual data generating process of the growth acceleration could be much more complicated; on the other hand, correctly identifying the growth acceleration in the data could be difficult. For example, there could be growth accelerations that last for only one or two years in the model.[30] But it will be difficult to identify short growth accelerations in the data as the influence of business cycles is hard to exclude. Figure 1.9 shows that how sensitive different calibrations of the probability of growth acceleration will affect the results. The dynamics do not change much.

1.6 Conclusion

This paper provides a formal small open economy model with consumption habits to describe the medium-run dynamics of saving, the current account and the real

[29] Our Monte Carlo simulations show that the unconditional probability of growth accelerations and the average length of growth accelerations produced by the Markov process in the model match the data counterpart as expected.

[30] This model feature may be very unrealistic. In reality, because building factories and infrastructures takes time, it is hard to imagine that growth acceleration that depends on productivity advancement could happen in one year and go away in the next.

exchange rate when economic growth accelerates. Our habit model shows that saving is key to study the dynamics of the current account and the real exchange rate in the course of economic growth acceleration, and therefore, it offers a possible perspective to connect different strands of the related literature. High growth leads to high saving and a current account surplus; and high saving slows down the real exchange rate appreciation.

Developing countries started to run current surpluses together at the same time when the economic growth in those countries took off. However, a rational representative consumer has a very strong incentive to borrow from the future to consume if she knows that she will be richer in the future. This is puzzling. The introduction of consumption habits into the small open economy model, at least, brings the standard model's predictions closer to the data. The habit model predicts a more positive external balance if the habits are strong enough. But, habits may only be able to bring us so far. For instance, the habit model is not able to generate the real exchange rate depreciation, though it predicts a more gradual appreciation.[31] To this extent, consumption habits might not be the complete answer to the question. The unanswered part of the question is, however, beyond this paper and therefore left out for future research.

[31] The New Mercantilism motive could be one reason for the real exchange rate depreciation.

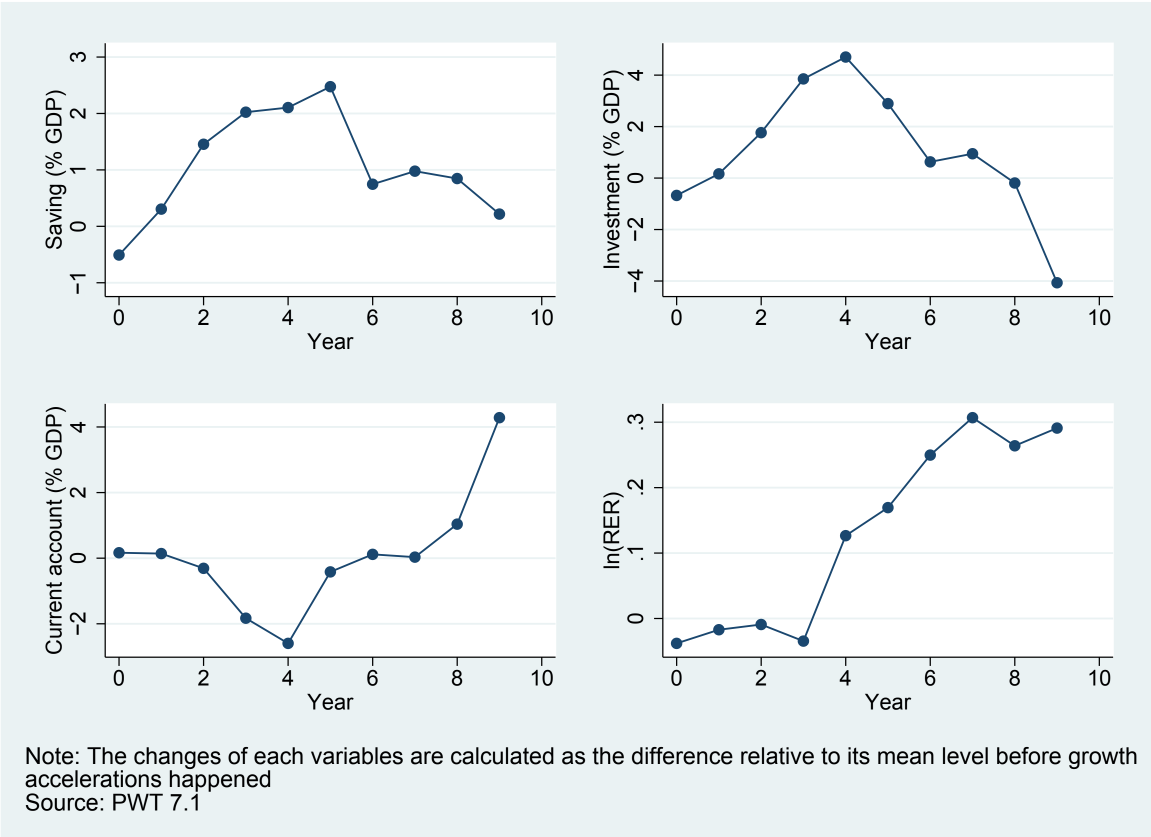


Figure 1.1: Changes in saving, investment, the current account, and ln(RER) during growth acceleration episodes (averages across 14 episodes)

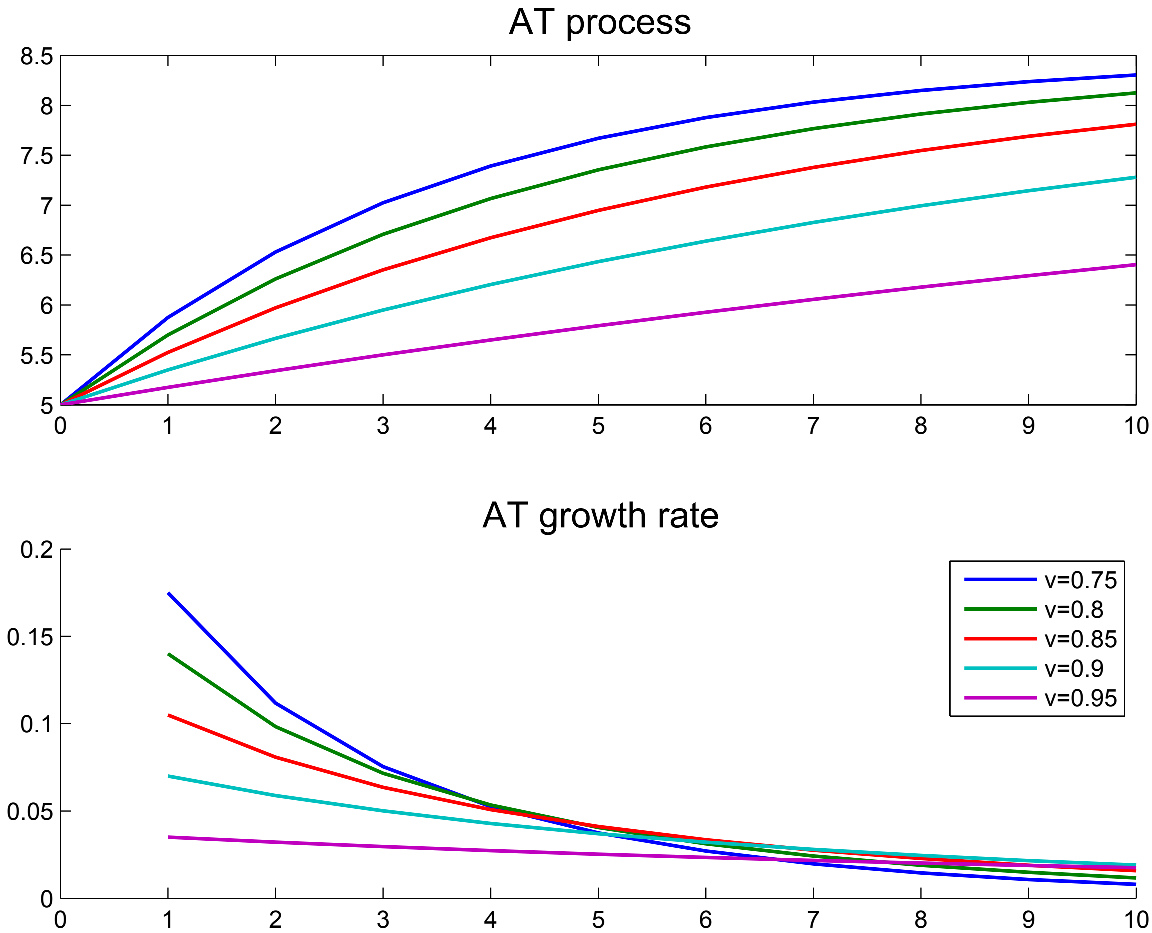


Figure 1.2: Calibrate A_T

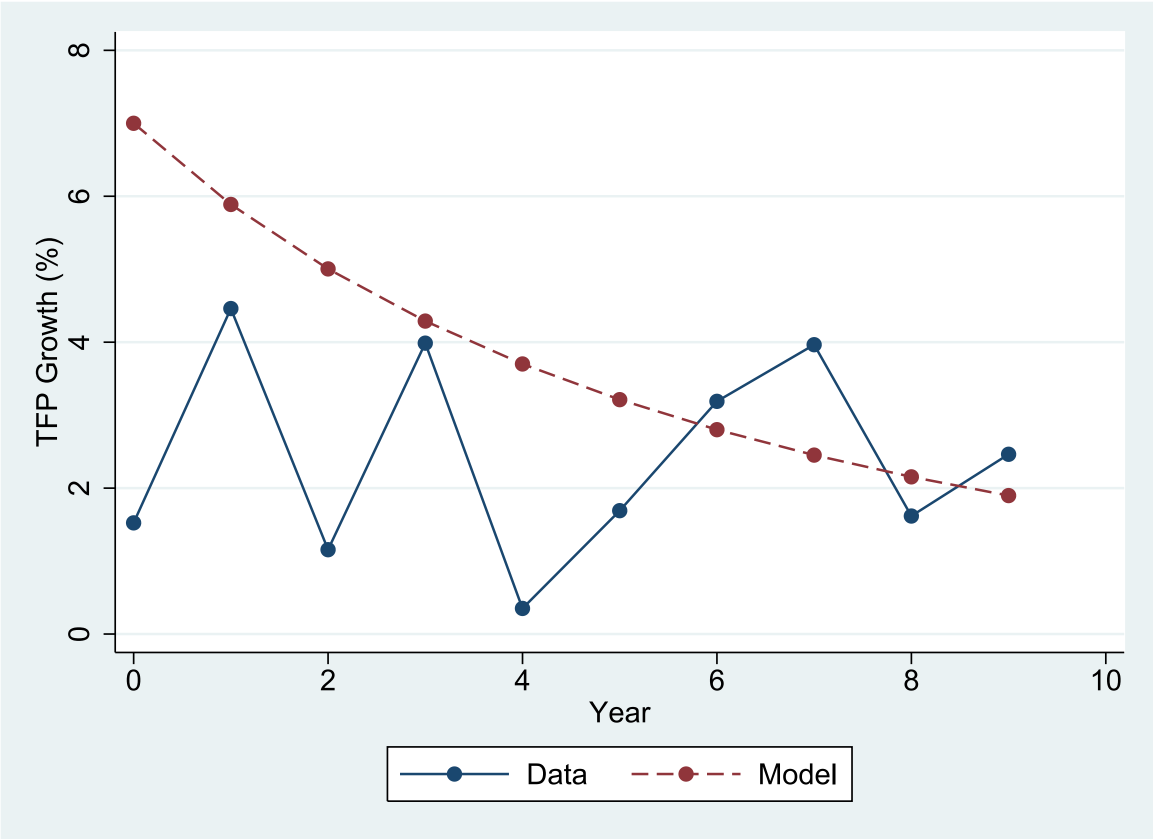


Figure 1.3: Compare TFP growth in the data and in the model

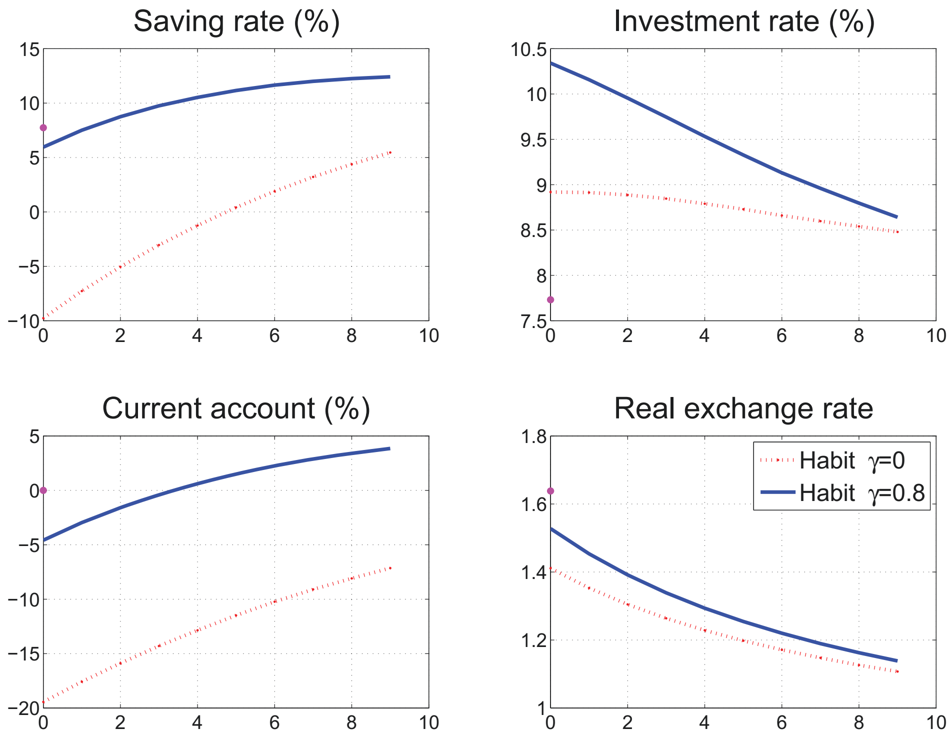


Figure 1.4: Saving, investment, current account and real exchange rate in convergence regime

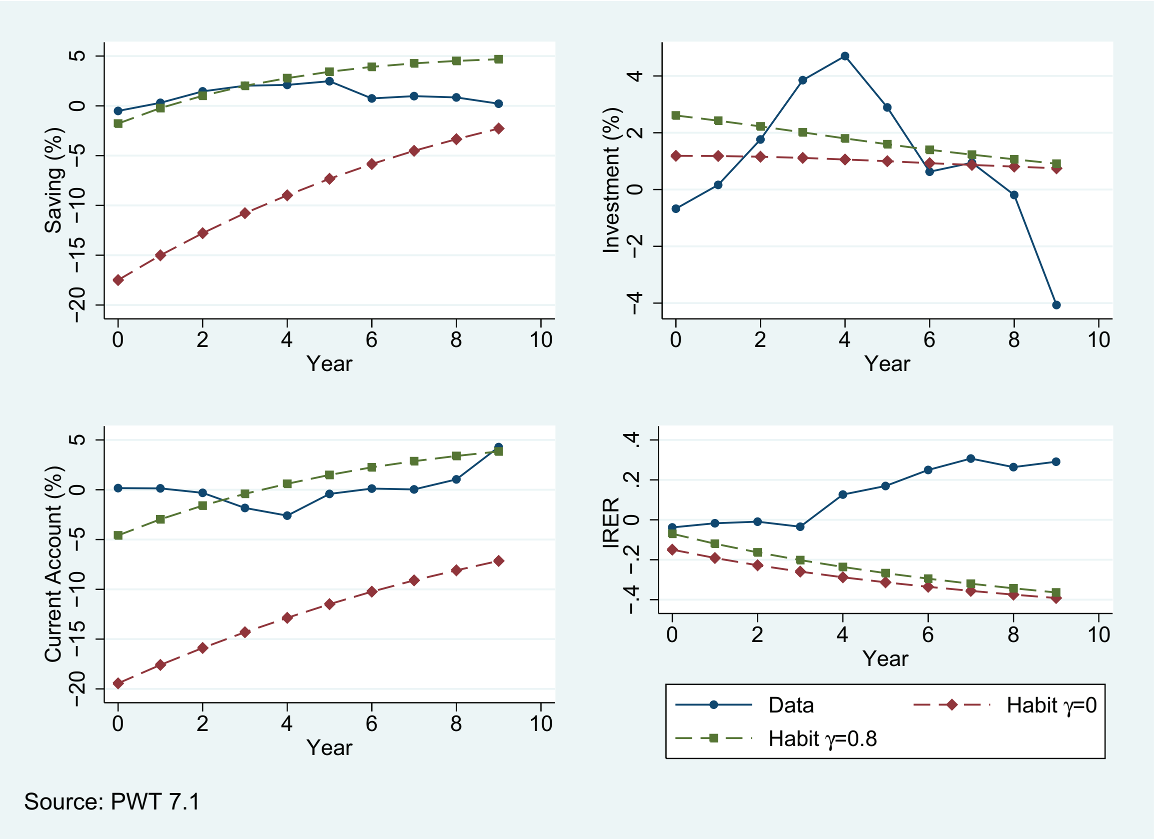


Figure 1.5: Compare saving, investment, current account, and real exchange rate in the model and in the data

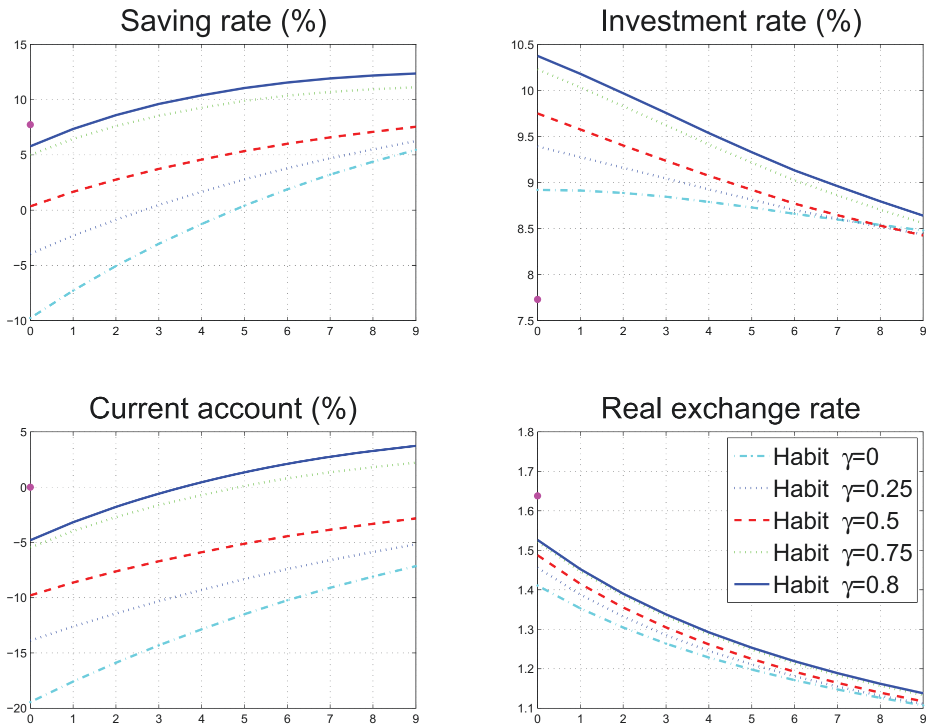


Figure 1.6: Sensitivity: different habit parameter γ

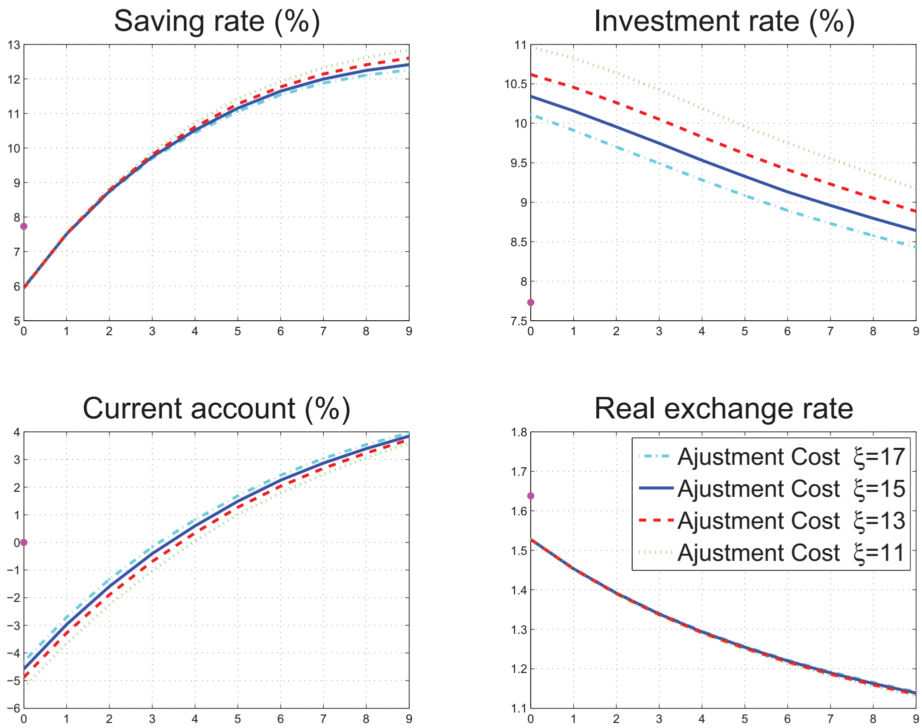


Figure 1.7: Sensitivity: different capital adjustment cost ξ

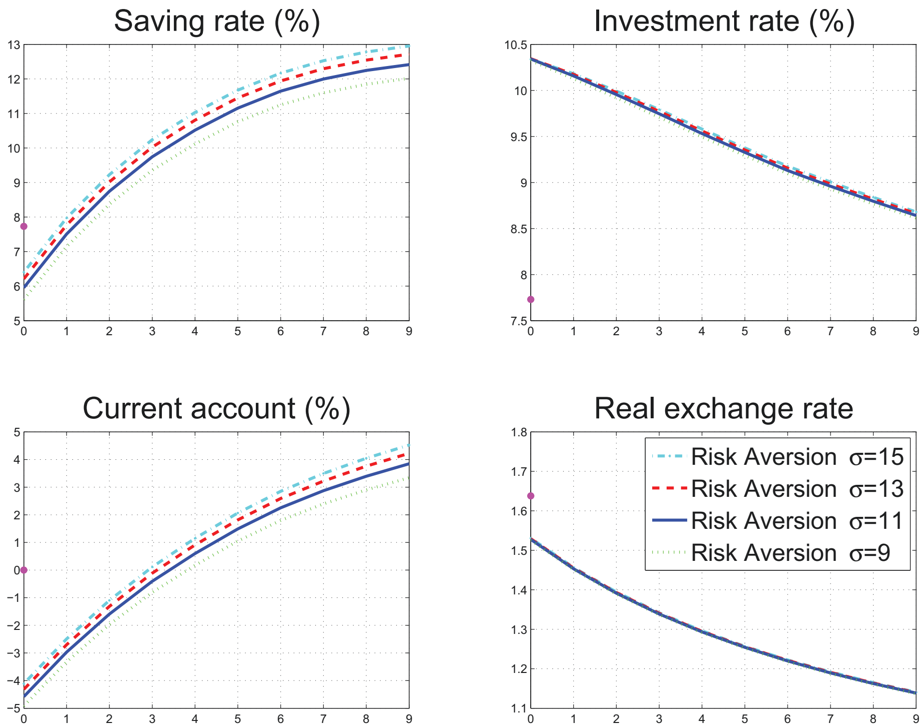


Figure 1.8: Sensitivity: different coefficient of relative risk aversion parameter σ

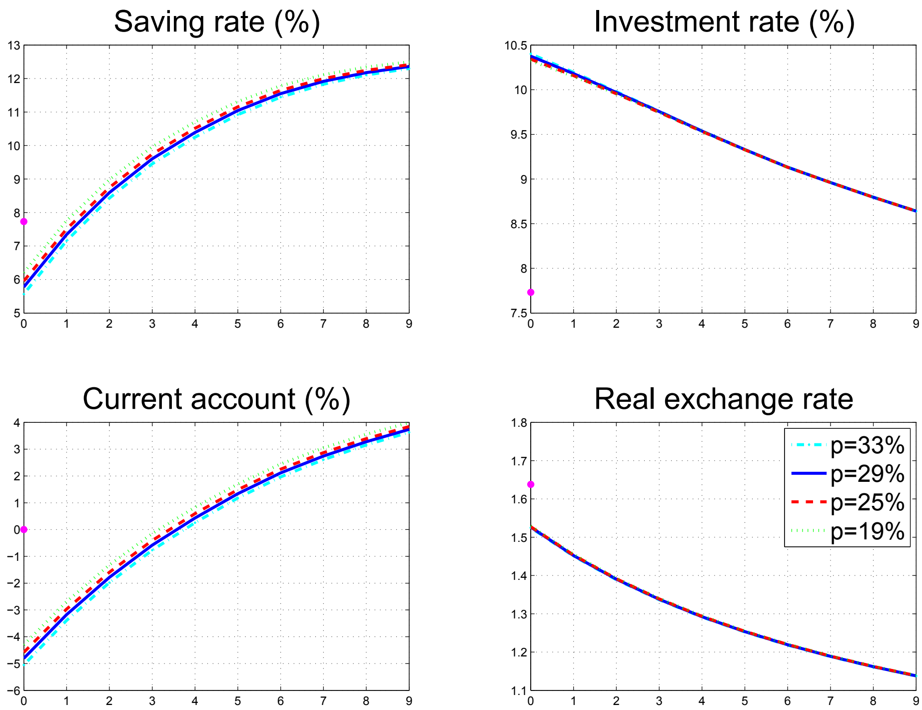


Figure 1.9: Sensitivity: different probability of growth acceleration

subjective discount factor	$\beta = 1/1.04$
relative risk aversion	$\sigma = 2, 11$
weights on habits	$\gamma = 0, 0.80$
tradable consumption share	$\theta = 0.3526$, Benigno et al. (2013) [67]
habit persistence	$\rho = 0.2$, Carroll, Overland and Weil (2000) [6]
world interest rate	$r = 0.04$
debt elasticity of country interest rate premium	$\psi = 0.00001$, Schmitt-Grohe and Uribe (2001) [71]
steady state external balance level	$\bar{B} = 0$
tradable and nontradable productivity	$A_T = A_N = 1$
non-convergence to convergence regime	$q_{12} = 0.034$
convergence to non-convergence regime	$q_{21} = 1/10$
fraction of technology frontier	$\phi = 0.85$
nontradable production parameter	$\eta = 0.8535$
capital adjustment cost	$\xi = 15$
capital income share	$\alpha = 0.32$, Schmitt-Grohe and Uribe (2003) [63]

Table 1.1: Calibration Parameters

Chapter 2

Growth Acceleration and High Saving

2.1 Introduction

It is a long-standing question for economists to understand the substantial increase in the national saving of an economy. Among various explanations of high saving, high economic growth is the explanation suggested by Carroll and Weil (1994) [9]. High growth is a good predictor of high saving later on. In this paper, we first repeat the analysis of Carroll and Weil (1994) [9] but use more recent data and test the robustness of their results. Then, we extend the results of the study of Carroll and Weil (1994) [9] by focusing on periods of empirically defined growth accelerations. We show that the statistical relationship that high growth is associated with high saving is not statistically different in growth acceleration episodes.

Almost all countries that experience high economic growth also have a high and rising saving rate during the high growth period. Carroll and Weil (1994) [9] document the cross-country statistical fact that high economic growth is associated with high saving. They show that growth Granger-causes saving but saving does not Granger-cause growth using macro data;[1] and that households with predictably high income growth save more than those with low income growth using micro data.[2]

The observation that a period of high economic growth is also a period of high saving leads us to directly look at those episodes where economic growth is high and accelerates. One may wonder whether the results of the research of Carroll and Weil (1994) [9] are driven by those special episodes. Hausmann, Pritchett, and Rodrik [1] provide an interesting and simple algorithm to empirically identify cross-country growth acceleration episodes. With those growth acceleration episodes at hand, we can study the relationship between growth and saving during those special periods of time. It would be interesting to know whether the relationship between growth and saving displays some nonlinearity that the causality going from growth to saving is different in growth acceleration episodes. Is the Granger causality driven by those growth acceleration episodes?

[1]They used the Summers and Heston (1991) Mark 5 data and then excluded all countries whose data received a grade of lower than "C−", communist countries, countries whose economies were dominated by oil production, and countries with 1985 populations of less than one million; they also used the OECD countries with 1985 populations of greater than one million.

[2]They used three household surveys, the Panel Study of Income Dynamics (PSID), the 1983 Survey of Consumer Finances (SCF), and the 1961–1962 Consumer Expenditure Survey (CEX).

To present our main results, we need to first define growth acceleration. Growth acceleration is defined empirically by Hausmann, Pritchett, and Rodrik (2005) [1]. A growth acceleration episode is an 8-year period where per capita growth increases by more than 2 percentage points, and the postacceleration growth rate is more than 3.5 percent per year. In addition, postacceleration output needs to exceed the pre-episode peak level of income so that pure recoveries are ruled out. Hausmann, Pritchett, and Rodrik's (2005) [1] method identifies most of the well-known episodes of growth acceleration, such as Argentina, 1990; Mauritius, 1971; Korea, 1962; Indonesia, 1967; Brazil, 1967; and Chile 1986; and so on.

Using the empirical definition of growth acceleration, the relationship between saving and growth is analyzed in those growth acceleration episodes. In summary, our basic results are as follows: First, saving increases by 2% in 9 years after growth accelerates (e.g, 20% to 22%). Second, the Granger causality of high growth to high saving is not statistically different in those growth acceleration episodes. There are no significant differences between the coefficient estimates on lagged growth in saving regressions using the full sample and using only observations after growth accelerates.

We also apply our general analysis and results to a few country cases, and discuss each country's history of growth and saving. Although various explanations that rely on countries' specifics could be proposed to explain their high saving, our results at least suggest that there might be more fundamental economic forces that explain the high saving. It is certainly true that countries' specifics are important, but it is equally likely that there are also common factors. In other words, if a general explanation is successful to account for part of one country's high saving, it hopefully will also explain part of the high saving in another country. Japan and Korea are two interesting country examples that experienced high growth and high saving in the past. We will take a closer look at these two countries. Further discussions are in Section 2.4.

The remaining sections are organized as follows: Section 2.2 briefly reviews the related literature. In Section 2.3, we present our main cross-country evidence. In Section 2.4, we discuss a few case examples to illustrate how results in Section 2.3 can apply to individual countries, and Section 2.5 concludes.

2.2 Literature Review

A famous quote by W. Arthur Lewis (1954, p. 155) [74] states that the "central problem in the theory of economic development is to understand the process by which a community which was previously saving...4 or 5 percent of its national income or less, converts itself into an economy where voluntary saving is running at about 12 to 15 percent of national income or more." There are two related but distinct motivations to study the relationship between saving and growth. The first one is to understand the low-frequency implications of the permanent income theory or the life cycle model. The second is to understand how important the factor accumulation is for economic development, which is more relevant here. In the Lewis model, when there are more capitalists in the dualism economy, the saving will rise and the standard of living will improve.

The main question is whether saving causes growth or growth causes saving. It is a well-known fact that growth and saving are positively correlated. The average saving and the average growth over many decades are plotted in Figure 2.1, which helps illustrate that saving and growth are positively correlated. If a linear line is fitted, the regression coefficient will be positive and highly statistically significant. However, whether putting growth or saving on the left-hand side of the regression does not make growth or saving more likely to cause the other. Modigliani is right that the key to saving is growth, not thrift; Modigliani (1987) [75] wrote "When a country needs capital to drive rapid growth, capital will be forthcoming." Carroll and Weil (1994) [9] find that growth is Granger-causing saving to increase. Attanasio, Picci, and Scorcu (2000) [76] and Yi and Yang (2014) [77] find similar results. Blomstrom, Lipse, and Zejan (1996) [78] provide similar evidence for investment that high growth precedes increase in fixed investment. Their regression is similar to that of Carroll and Weil (1994) [9] except that they use investment instead of saving. The conventional thinking of how saving causes growth implicitly assumes that saving will automatically translate into investment and investment will lead to growth. There is evidence that supports this view of saving and investment relation. Domestic saving rates even among industrial countries account for much of the differences in investment rates

(Feldstein and Horioka, 1980 [79]; Feldstein and Bacchetta, 1991 [80]).[3] Aghion, Comin, and Howitt (2012) [82] have made a recent effort to revive the idea that saving leads to growth. They provide an interesting theory model in which saving causes growth. The reason is that saving leads to more Foreign Direct Investment (FDI) by solving a moral hazard problem. However, the consensus is on the other direction of the causality. After reviewing the evidence in decades of past studies and practices, Easterly and Levine (2001) [83] reached the conclusion that the proposition of saving causing growth is decisively rejected. Most cross-country income differences and growth differences are explained by "something else"—the Total Factor Productivity (TFP)—rather than factor accumulation.

There are a number of reasons why growth could cause saving to rise. In a standard representative consumer model, higher future growth is going to reduce current saving because the consumer will want to borrow from the future to increase the current consumption. Carroll, Overland, and Weil (2000) [6] have introduced consumption habits into the standard model and offered one promising way to explain how growth can cause saving. Saving increases when growth is higher because, with consumption habits, consumers only adjust their consumption slowly. Evidence of consumption habits is found at the aggregate level. Carroll, Slacalek, and Sommer (2008) [84] find that aggregate consumption growth is sticky, which reflects consumption habits. But the difficulty is that there is no strong evidence to support consump-

[3] In a close economy, saving is equal to investment; in an open economy, domestic residents may have a significant "home-country bias" in investment portfolios (Tesar and Werner, 1995 [81]).

tion habits in the micro data (Dynan, 2000 [85]). There are a few other explanations why growth could cause saving to rise. Consumers may care about consumption as well as wealth (Cole, Mailath, and Postlewaite, 1992 [86]). The life cycle model and demographic changes have also been considered. A version of the life cycle model could generate the causality from growth to saving. If it is assumed that income growth happens between cohorts, theoretically, growth can increase aggregate saving. The basic intuition is simple and sensible. If the number or the income of savers in the economy increases relative to the dissavers, saving in the economy could rise. But Carroll and Summers (1991) [87] and Deaton (1989) [88] find that this explanation is not supported by empirical evidence. Demographic changes are another candidate. Although demographic changes can produce a positive link from growth to saving, the explanatory power is small. See, for example, Deaton and Paxson (1997) [42] (2000a) [43], (2000b) [44], and Paxson (1996) [45]. Jappelli and Pagano (1994) [89] provide an alternative story where liquidity constraints on household raise the saving rate and strengthen the effect of growth on saving. When growth is higher, people have more income when they are middle-aged, but they cannot borrow fully to consume this increase in income when they are young, resulting in the rise in saving. Sandri (2014) [8] offers another explanation based on precautionary saving from entrepreneurs. Entrepreneurs who face uninsurable risk of losing their investment have to rely on self-financing, and they increase their own saving when growth produces risky investment opportunities. Lack of social safety net and precautionary saving has also been proposed to explain rising saving, for example, in China (Chamon and Prasad, 2010 [90]).

2.3 Empirics

2.3.1 Data

The data we use come from various versions of the Penn World Table (PWT). Both data from the first-generation PWT and the second-generation PWT are used.[4] The sample selection criteria follow exactly Carroll and Weil (1994) [9] to enhance a direct comparison between our results and the results of Carroll and Weil (1994) [9]. We exclude all countries that have a most recent population of less than one million as well as countries with observations of less than 20. In the appendix of the PWT 6.0, countries' estimates in PWT 6.0 are given a letter grade to signal the relative reliability of the estimates according to three factors: (1) the number of benchmark comparisons a country had entered; (2) its income level, because within benchmarks it has been found that the margin of error is greater for low-income countries; and (3) for nonbenchmark countries, the sensitivity of their estimates. We include only countries that have a grade "C" or above. In addition, we exclude all communist countries and OPEC countries that are affected by the fluctuation of oil prices.[5] Although the

[4]The first generation includes PWT 6.1, 6.2, 6.3, 7.0 and 7.1; the second generation includes PWT 8.0 and 8.1.

[5]Whether China is included or not will not affect our conclusion.

data can go back to as early as 1950, we decide to restrict our sample period to from 1960 to the most recent data available given that the data in earlier years are less trustable.[6]

2.3.2 Granger Causality Test of Saving and Growth

The existing literature has pointed out that the Granger causality goes from growth to saving.[7] The formal empirical test follows exactly Carroll and Weil (1994) [9]. Since Carroll and Weil (1994) [9] published their paper, a number of new versions of the PWT data are now available, with more countries and more years. Possibly the data quality also improves over time. It will be good to know whether the Granger causality that goes from growth to saving found by Carroll and Weil (1994) [9] still holds when different versions of the PWT data are used. To test the robustness of the results of Carroll and Weil (1994) [9], the basic empirical strategy is to run the following pair of regressions:

$$G_{it} = \alpha_{Gi} + \eta_{Gt} + \gamma_G S_{it-1} + \varepsilon_{it}$$

$$S_{it} = \alpha_{Si} + \eta_{St} + \gamma_S G_{it-1} + \varepsilon_{it}$$

where S_{it-1} is lagged saving rate and G_{it-1} is lagged growth rate. The Granger causality test is to test whether γ is statistically different from zero. The subscript

[6]The results are not sensitive to sample periods, and results for 1950–2007 are also available.

[7]For example, Carroll and Weil (1994) [9] and Attanasio, Picci and Scorcu (2000) [76], and etc.

of γ labels whether the dependent variable of the regression is growth or saving. If γ_G is statistically different from zero, we say that S is Granger-causing G; if γ_S is statistically different from zero, we say that G is Granger-causing S. It is possible that neither variable Granger-causes the other, or that each of the two variables Granger-causes the other. The Granger causality is best thought as a test of predictability. For example, if γ_S is significantly different from zero, it means that past high economic growth will predict high saving later. To remove the business cycle influences, all the variables are in non-overlapping 5-year moving average. α_{Gi} and α_{Si} are country fixed effects; η_{Gt} and η_{St} are time fixed effects.

The regression results are reported in Table 2.1 and Table 2.2. Table 2.1 presents the saving regressions, and Table 2.2 presents the growth regressions. The column names indicate whether the dependent variable is saving or growth. Different columns report the pairs of Granger causality tests using data from all the different versions of the first-generation PWT. For example, Column 3 of Table 2.1 reports the saving regression using data from PWT 6.3. The coefficient for lagged growth is highly significant at 5%, which means that growth Granger-causes saving to rise. This finding is robust across all versions in the first-generation PWT. In addition, the coefficients are oftentimes more significant. For instance, the growth coefficients in the saving regressions are significant at 1% using data from PWT 6.2 and PWT 7.1. At the same time, all of the R-squares in the saving regressions are very high across different columns, suggesting that a large portion of the variations in saving rates is captured by the regressions. The R-square is around 0.9, and the smallest R-square is 0.886 in Column 4 of Table 2.1. On the other hand, the coefficient for lagged saving in the growth regression is insignificant for PWT 6.2; the coefficients are significant but negative for PWT 6.1, PWT 6.3, PWT 7.0, and PWT 7.1 (Table 2.2). Especially, they are significant at 1% for PWT 7.0 and PWT 7.1. Saving does not seem to Granger-cause growth to rise, and even Granger-causes growth to fall.[8] Results in Table 2.1 and Table 2.2 provide strong evidence to show that Carroll and Weil's (1994) [9] findings are robust. The finding that growth Granger-causes saving to rise is robust. The direct way to interpret the results is that high economic growth will predict high saving later. On the other hand, the alternative way to interpret the regression results is to use a model of habit formation. As shown by Alessie and Lusardi (1997) [91], in a consumption model with habit formation, current saving depends on past saving, and income changes under the assumption of quadratic preferences and additive consumption habits. Thus, the regression results can be thought of as also lending support for the consumption model with habit formation.

Table 2.3 reports results using data from the second-generation PWT. Column 1 through Column 4 report the same pair of Granger causality regressions as in Table 2.1 and Table 2.2. Column 1 reports saving regression, and Column 2 reports the growth regression using data from PWT 8.0; and Column 3 and Column 4 use data

[8]The result does not mean that high saving will decrease growth. The result suggests that high saving does not precede high growth.

from PWT 8.1. PWT 8.1 is the latest version of the PWT data. The coefficients of lagged growth in the saving regression are not significant in both Column 1 and Column 3. Column 5 and Column 6 provide one additional control, the income level in the previous 5 years as suggested by the regressions from Aghion, Comin, and Howitt (2012) [82]. The coefficient of lagged growth in the saving regression is not significant, either. The specifications are exactly the same. It is puzzling why the significance disappears in the second-generation PWT. We may start by excluding a few possible reasons. First, the regressions using PWT 7.1 and PWT 8.0 contain essentially the same set of countries. The reason is not that the second-generation PWT includes different sets of countries. Second, if we compare the regressions using PWT 7.1 and PWT 8.0, they also contain the same set of years. Although PWT 8.0 contains one additional year, the additional year did not enter the regressions because all variables are in a 5-year moving average. We can also exclude another possibility. The second-generation PWT did not include the shares of C, I, and G at constant prices (Feenstra, Inklaar, and Timmer, 2015 [92]). However, the results using the shares of C, I, and G at constant prices for the first-generation PWT do not change qualitatively. The coefficients of lagged growth in the saving regressions are still significant across different versions if the shares of C, I, and G at constant prices are used. The methodology for calculating the relative price is different from the first-generation PWT to the second-generation PWT, which drives the differences in other variables. Table 2.4 reports the saving regressions using different real GDP measures constructed from different relative prices in the second-generation PWT. Column 1 and Column 2 use real GDP at chained PPP; Column 3 and Column 4 use real GDP at current PPP; Column 5 and Column 6 use the $RGDP^{NA}$ variable which is constructed using growth rate of real GDP from the national accounts. As commented by Feenstra, Inklaar, and Timmer (2015) [92], $RGDP^{NA}$ is the closest to real GDP as reported in past versions of PWT. The coefficients of lagged growth are highly significant in Column 5 and Column 6 but not in other columns. Thus, it seems that the ways the second-generation PWT constructs the real GDP measures are the reason that changes the Granger causality results. However, the exact mechanism is not clear. On the other hand, Pinkovskiy and Sala-i-Martin (2016) [93] find that the newer generation of the PWT is not necessarily better. It could be an interesting separate paper to understand better why the results are no longer significant moving to the second-generation PWT.

Another interesting comparison is between the East Asian countries and the Eastern European countries. One important difference between these two sets of countries is the availability of credits. Table 2.5 and Table 2.6 report the saving regressions using only East Asian countries or using only Eastern European countries. The notable difference is that the coefficients of the lagged growth are positive and sometimes significant using only East Asian countries. In contrast, the coefficients are mostly negative using only Eastern European countries. The regression results are consistent with the idea that the Eastern European countries have much better credit access. It seems that saving decreases when growth is high if the countries have easy access to credits.

As we mentioned in the introduction, there are those special growth acceleration episodes. A natural question to ask is whether the Granger causality from growth to saving is different in those growth acceleration periods. Before we can answer that question, we first need to empirically define a growth acceleration. This is what we will do in the next section.

2.3.3 Definition of Growth Acceleration

Intuitively speaking, a growth acceleration episode is a period where growth increases significantly and stays high for a few years. Specifically, it is defined as follows.[9] The growth rate $g_{t,t+n}$ at time t over the horizon t to $t+n$, where n is equal to 7 throughout the paper, is defined by the least squares of GDP per capita (y) of the following:

$$ln\left(y_{i+t}\right) = a + g_{t,t+n} * t, i = 0, ..., n$$

[9] This is how a growth acceleration episode is defined by Hausmann, Pritchett, and Rodrik (2005) [1]. They define how to find a growth acceleration episode empirically in the data.

The change in the growth rate at time t is therefore simply the change of $g_{t,t+n}$ over horizon n:

$$\Delta g_{t,n} = g_{t,t+n} - g_{t-n,t} \tag{2.1}$$

The growth accelerations that an economy experiences have to satisfy three conditions:

- $g_{t,t+n} \geq 3.5$ppa, growth is rapid.
- $\Delta g_{t,n} \geq 2.0$ ppa, growth accelerates.
- $y_{t+n} \geq \max\{y_i\}, i \leq t$, post-growth output exceeds pre-episode peak.

The timing of the initiation of the growth acceleration is chosen by finding the year that maximizes the F-stats of a spline regression with a break at the relevant year. Using this method, there are 51 growth acceleration episodes in the sample. The reason that the number of episodes is smaller than the number in Hausmann, Pritchett, and Rodrik (2005) [1] is that Hausmann, Pritchett, and Rodrik (2005) [1] used a much larger sample of countries. But in our exercise, we select the sample countries using Carroll and Weil's (1994) [9] criteria. We are using Hausmann, Pritchett, and Rodrik (2005) [1]'s original data on growth acceleration episodes as our benchmark.

2.3.4 Saving Changes in Growth Acceleration Episodes

In this section, an event-study style of analysis is made in order to provide an intuitive illustration on how much saving increases after a growth acceleration. This simple exercise is a complement to the formal empirical test in the next section. Taking those growth acceleration episodes as given, we compare the pattern of saving before and after a growth acceleration happens. We first estimate the saving before growth acceleration by the mean of saving during 7 years before growth acceleration happens, and call it the pre-GA saving, where GA stands for "growth acceleration". Then we calculate the change in saving in the following 9 years against the estimated pre-GA saving. This saving change is calculated for every growth acceleration episode and later averaged over all the growth acceleration episodes. An example of the calculation for a single episode is going to help clarify the above procedure further. Argentina experienced a growth acceleration in 1990. The pre-GA saving is estimated by taking the average of the saving from 1983 to 1989. The changes in saving in the growth acceleration episodes are then calculated by subtracting post-GA saving year by year by the pre-GA saving average. The calculation is then repeated for all the identified growth acceleration episodes. Then take the average among all the growth acceleration episodes. The result is plotted in Figure 2.2.

Saving does increase in all of the post-growth acceleration years that is, all 9 years. Saving 9 years after the growth acceleration is higher than the pre-GA level by about 2%.

2.3.5 Granger Causality Test of Saving and Growth in Growth Acceleration Episodes

Now let us move to the formal empirical test. We want to know whether the Granger causality from growth to saving is statistically different in growth acceleration episodes. We add to the literature by looking at the relationship between saving and growth in growth acceleration periods. Our empirical strategy of testing whether saving is higher in growth acceleration episodes is to add a growth acceleration dummy variable and its interactions with lagged saving and lagged growth. Without the dummy variable and the interaction terms, the empirical specification is identical to that of Carroll and Weil (1994) [9]. With the dummy terms, we can test whether the Granger causality is different in the periods where growth accelerates. The basic empirical strategy is to run the following pair of regressions:

$$\begin{aligned} G_{it} &= \alpha_{Gi} + \eta_{Gt} + \beta_G D_{it-1} + \gamma_G S_{it-1} + \delta_G D_{it-1} \cdot S_{it-1} + \varepsilon_{it} \\ S_{it} &= \alpha_{Si} + \eta_{St} + \beta_S D_{it-1} + \gamma_S G_{it-1} + \delta_S D_{it-1} \cdot G_{it-1} + \varepsilon_{it} \end{aligned}$$

where D_{it-1} is a growth acceleration dummy variable that is equal to the ratio that describes how many years in the 5-year moving average window is within a growth acceleration episode. For example, if 2 years in a 5-year window are in a growth acceleration episode, D_{it} is equal to 2/5; α_i is the country fixed effect, which takes care of the cross-country differences in growth and saving; η_t is a full set of time dummies to control for time-varying factors that are common across countries; S_{it-1} is lagged saving; and G_{it-1} is lagged growth. The Granger causality test is to test whether γ is statistically different from zero. On top of the Granger causality test, we test whether the Granger causality is significantly different in periods of growth accelerations. If δ is statistically different from zero, there is a statistically significant difference between the Granger causality going from the independent variables to the dependent variable in growth acceleration episodes. To remove the business cycle influences, all the variables are in the non-overlapping 5-year moving average. When D_{it-1} and the interactions are not included, the empirical specifications are exactly the same as that of Carroll and Weil (1994) [9].

Adding the growth acceleration dummy D_{it} and its interactions with lagged saving and lagged growth, the effect of growth on saving in the growth acceleration periods can then be evaluated. The baseline regression results using non-overlapping 5-year average data are presented in Table 2.7 and Table 2.8. Table 2.7 reports the same saving regressions using different versions of the PWT data; Table 2.8 reports the growth regressions. The coefficients of lagged growth are statistically significant in all the columns using first-generation PWT; and are not significant in Column 6 and Column 7 using second-generation PWT. The magnitude of the coefficients estimated for the lagged growth in the saving regression is also slightly smaller in Column 6 and Column 7 when they are not significant. Meanwhile, the R-squares are high in all columns. Without the dummy terms, the results are just what are found in the study of Carroll and Weil (1994) [9]. Growth Granger-causes saving, but saving does not positively Granger-cause growth. The more interesting results are about the dummy terms. The coefficients on lagged GA dummy D_{it-1} are positive and significant using first-generation PWT except in Column 2. This is consistent with the result in Section 2.3.4, where saving increases within growth acceleration periods. The coefficients of the interaction of D_{it-1} with lagged growth are mostly insignificant or marginally significant, and as a consequence, the combined effect of growth on saving in a growth acceleration period is not statistically different. People seems to be able to consume their additional income from the accelerated economic growth, and the acceleration effect appears to be secondary. In addition, the changes in R-square by adding D_{it-1} and its interactions are tiny. One possible reason that the growth acceleration has a minimal effect could be the fact that the number of growth acceleration years is small relative to the number of country years. If the regressions do not include lagged saving and lagged growth, the growth acceleration dummies will not be significant either. Putting the above evidence together, it appears to us that the results suggest that the Granger causality going from growth to saving is not different in growth acceleration episodes. The Granger causality from growth to saving in normal periods is not driving by those growth acceleration episodes.

The coefficients of lagged saving in Table 2.8 are either insignificant or significantly negative. For example, the coefficients are statistically significantly negative in Column 1, Column 3, Column 4, Column 5, and Column 6 in Table 2.8. The coefficients of the growth acceleration dummy D_{it} are not significant in most of the columns. The coefficients of the interaction terms are not statistically significant in most of the columns either. The coefficients of the interaction terms are only marginally significant in Column 1, Column 4, and Column 5. The combined coefficients on lagged saving are still negative. Saving either does not Granger-cause growth to increase or Granger-causes growth to decrease. This is not changed in growth acceleration periods.

2.4 Cases

In the previous sections, we formally test the Granger causality from growth to saving. Growth Granger-causes saving to rise. Saving does not Granger-cause growth to increase and even Granger causes growth to decrease in some cases. The empirical evidence is in support of the view that high growth predicts high saving. In this section, we will examine this predictability using a few country examples.

2.4.1 Japan

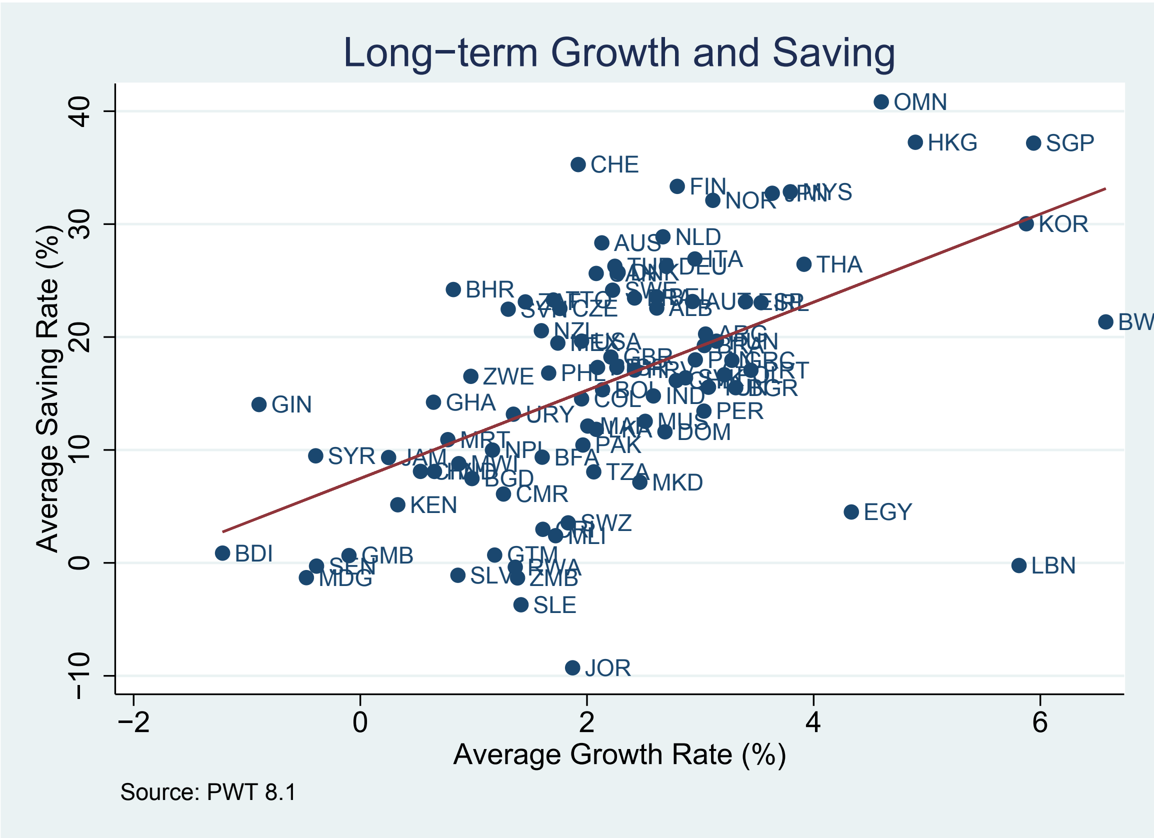
Japan is one good example of both high growth and high saving. After a high-growth period starting from the 1950s, Japan had seen its saving rate rising rapidly in the 1960s and 1970s, from about 15% to more than 35%. As a consequence, Hayashi (1986) [94] wrote the paper "Why Is Japan's Saving Rate So Apparently High?" It is an interesting coincidence that after he published the paper, Japan's economic growth slowed down. After the slowing down of the economic growth in Japan in the 1990s, the saving rate also stopped rising and started to decline. All of these interesting dynamics of saving and growth can be seen in Figure 2.3, where saving rate and lagged growth rate are plotted. The red solid line is the lagged 5-year moving window growth rate (left axis), and the dashed green line is the 5-year moving window saving rate (right axis).

2.4.2 Korea

Korea also experienced both high economic growth and high saving. Korea recorded very rapid economic growth in the 1960s and 1970s. At the same time, the saving rate steadily increased from less than 10% to 30%.

2.5 Conclusion

In this paper, we test the results of the study of Carroll and Weil (1994) [9] using more recent PWT data. In addition, we extend the results in the research of Carroll and Weil (1994) [9] by looking at periods of growth accelerations. Carroll and Weil's (1994) [9] results are robust. In growth acceleration episodes, the saving rate rises. But the Granger causality of growth on saving is not statistically different in those growth acceleration episodes. The empirical evidence does not support the view that the predictability of high growth on high saving is driven by those growth acceleration episodes. When we look at specific country examples, the high-growth and high-saving pattern captures well their historical experience. High economic growth precedes the rise of the saving rate. However, this paper is not an attempt to provide reasons behind the statistical relationships found in our results. Rather, the statistical relationship examined in this paper leads us to wonder what economic story is behind the high-growth and high-saving pattern. Consumption habit formation may be one good candidate. But this is still an open question that is left for future research.



Note: The changes of savings are calculated as the difference relative to its mean level before growth accelerations happened.

Figure 2.1: Long-term growth and saving

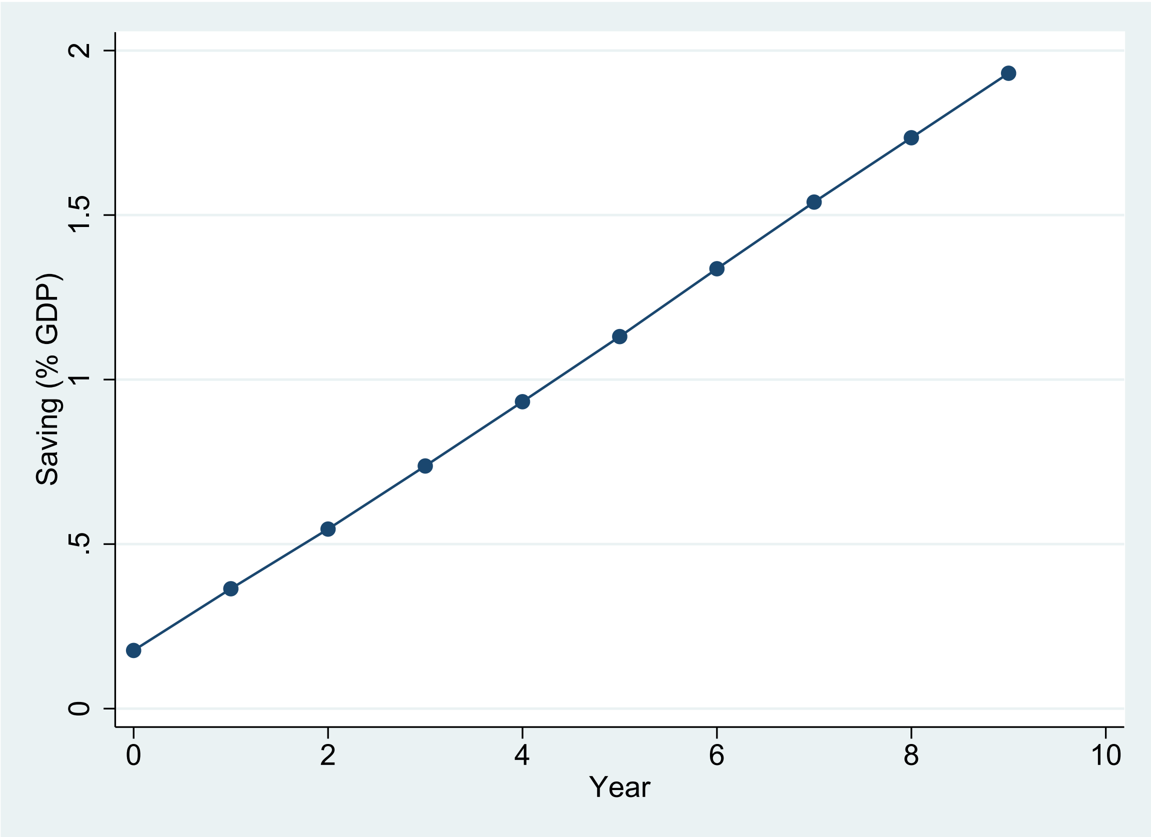


Figure 2.2: Saving changes after growth acceleration

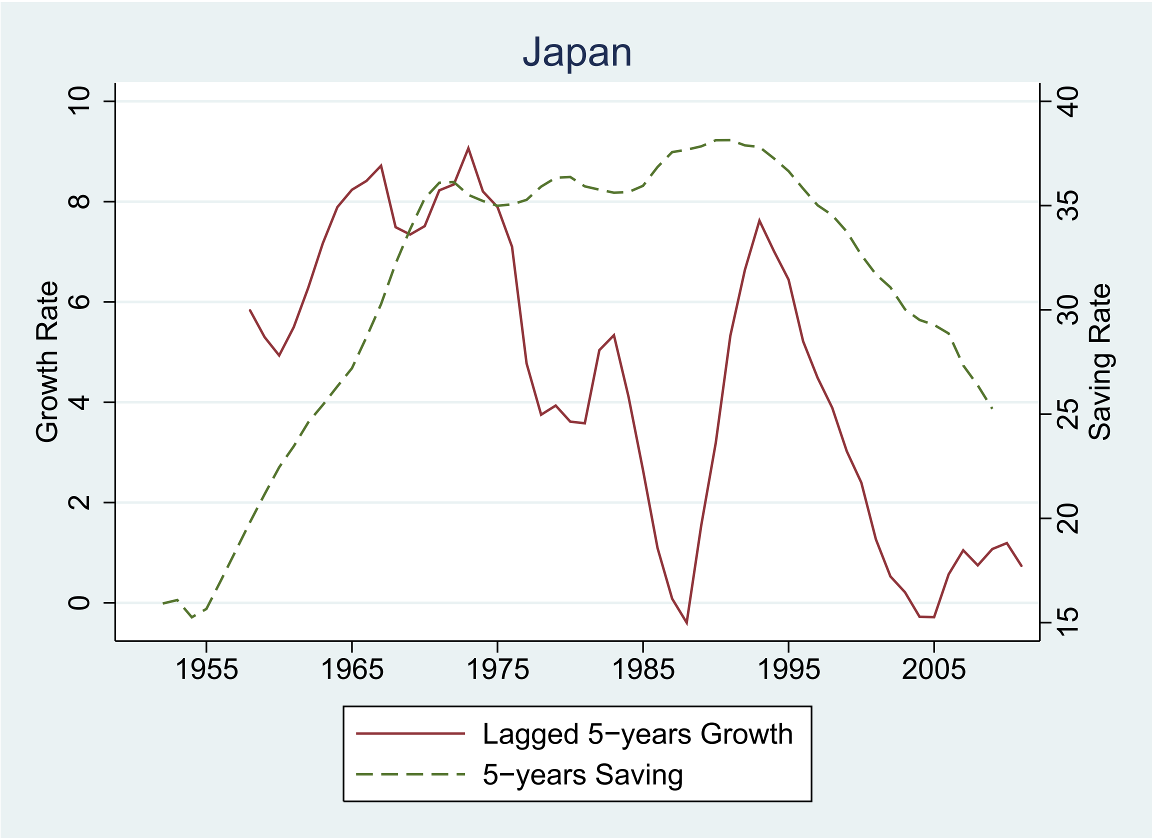


Figure 2.3: Japan

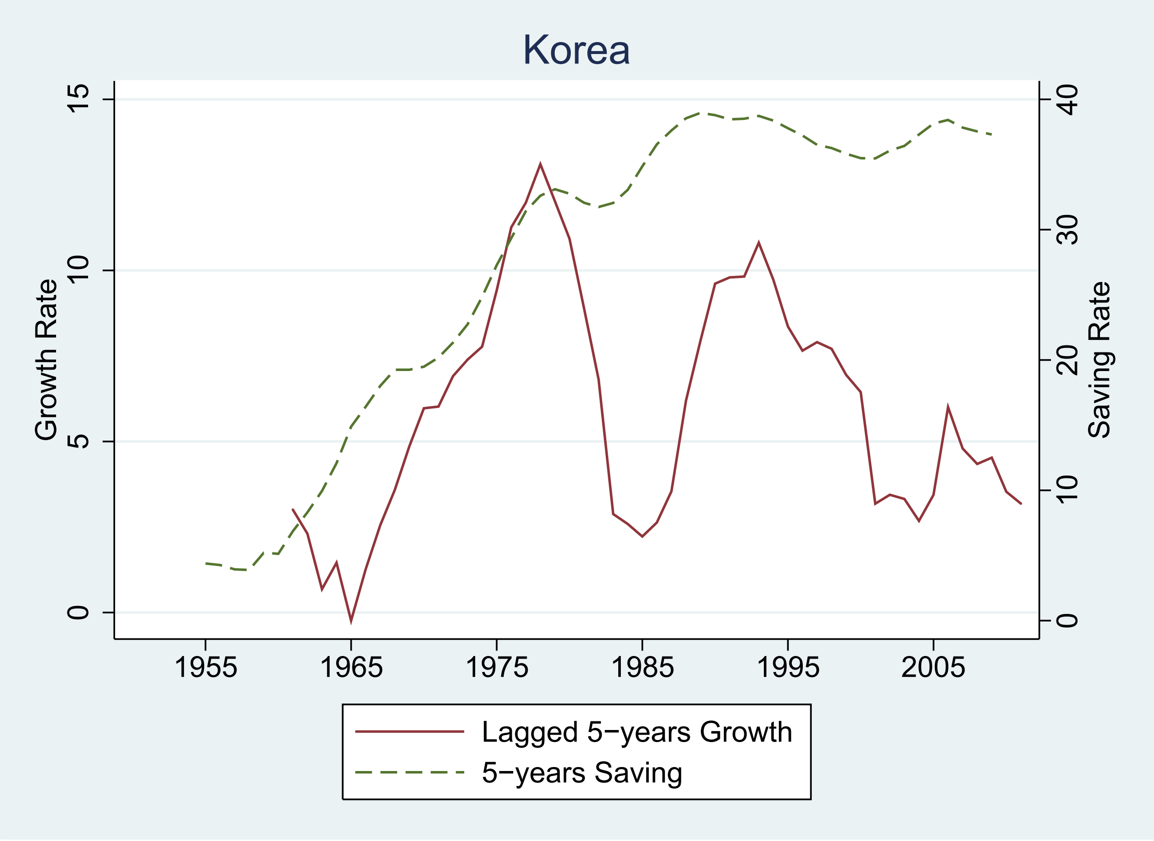


Figure 2.4: Korea

Table 2.1: Saving Regressions of the Granger Causality Test: 1st Gen PWT

VARIABLES	(1) S	(2) S	(3) S	(4) S	(5) S
Lagged 5-years Saving	0.566***	0.590***	0.620***	0.675***	0.688***
	(0.0376)	(0.0358)	(0.0347)	(0.0294)	(0.0295)
Lagged 5-years Growth	0.150*	0.240***	0.188**	0.173**	0.294***
	(0.0883)	(0.0805)	(0.0802)	(0.0769)	(0.0755)
Constant	8.931***	7.486***	7.545***	9.113***	7.865***
	(1.548)	(1.351)	(1.513)	(2.348)	(2.367)
Observations	470	522	571	653	667
R-squared	0.934	0.946	0.932	0.886	0.897
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
PWT	6.1	6.2	6.3	7.0	7.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.2: Growth Regressions of the Granger Causality Test: 1st Gen PWT

VARIABLES	(1) G	(2) G	(3) G	(4) G	(5) G
Lagged 5-years Saving	-0.0405*	-0.0229	-0.0422**	-0.0798***	-0.0819***
	(0.0236)	(0.0213)	(0.0191)	(0.0166)	(0.0171)
Lagged 5-years Growth	-0.0617	-0.0275	0.00139	0.0615	0.0520
	(0.0520)	(0.0504)	(0.0445)	(0.0446)	(0.0440)
Constant	6.182***	5.610***	5.709***	9.280***	9.512***
	(0.899)	(0.805)	(0.814)	(1.295)	(1.326)
Observations	447	498	550	628	647
R-squared	0.629	0.657	0.652	0.598	0.584
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
PWT	6.1	6.2	6.3	7.0	7.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.3: CW Granger Causality Test: 2nd Gen PWT

VARIABLES	(1) S	(2) G	(3) S	(4) G	(5) S	(6) G
5-years pre-episode initial income					0.518	0.327
					(0.436)	(0.247)
Lagged 5-years Saving	0.691***	-0.0360**	0.688***	-0.0239	0.681***	-0.0282
	(0.0306)	(0.0173)	(0.0307)	(0.0171)	(0.0313)	(0.0174)
Lagged 5-years Growth	0.0293	-0.0444	0.0679	-0.0696	0.0517	-0.0791*
	(0.0770)	(0.0458)	(0.0779)	(0.0458)	(0.0791)	(0.0463)
Constant	6.264***	4.804***	6.456***	4.605***	2.558	2.138
	(2.379)	(1.343)	(2.332)	(1.297)	(4.026)	(2.273)
Observations	654	633	657	637	657	637
R-squared	0.871	0.348	0.877	0.350	0.878	0.352
Country FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
PWT	8.0	8.0	8.1	8.1	8.1	8.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.4: Saving Regressions of the Granger Causality Test: 2nd Gen PWT Different Prices

VARIABLES	(1) S	(2) S	(3) S	(4) S	(5) S	(6) S
Lagged 5-years Saving	0.691***	0.686***	0.691***	0.688***	0.686***	0.691***
	(0.0307)	(0.0309)	(0.0306)	(0.0307)	(0.0307)	(0.0306)
Lagged 5-years Growth	0.0339	0.0760	0.0293	0.0679	0.308***	0.316***
	(0.0776)	(0.0791)	(0.0770)	(0.0779)	(0.102)	(0.0996)
Constant	6.251***	6.461***	6.264***	6.456***	4.827**	4.985**
	(2.378)	(2.333)	(2.379)	(2.332)	(2.390)	(2.335)
Observations	654	656	654	657	645	648
R-squared	0.871	0.878	0.871	0.877	0.874	0.882
Country FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
PWT	8.0	8.1	8.0	8.1	8.0	8.1
Price	Con	Con	Cur	Cur	NA	NA

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.5: Saving Regressions of Granger Causality Test: East Asia

VARIABLES	(1) S	(2) S	(3) S	(4) S	(5) S	(6) S	(7) S
Lagged 5-years Saving	0.670***	0.768***	0.788***	0.572***	0.670***	0.620***	0.456
	(0.110)	(0.103)	(0.0961)	(0.112)	(0.103)	(0.150)	(0.513)
Lagged 5-years Growth	0.600**	0.158	0.0422	0.489**	0.257	0.394*	0.441
	(0.266)	(0.231)	(0.213)	(0.239)	(0.216)	(0.218)	(0.477)
Constant	0.396	3.616	2.415	7.288*	6.937*	5.005*	11.84
	(2.016)	(2.857)	(2.475)	(3.626)	(3.525)	(2.951)	(8.318)
Observations	37	47	48	54	54	54	26
R-squared	0.939	0.923	0.917	0.848	0.857	0.847	0.863
Country FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
PWT	6.1	6.2	6.3	7.0	7.1	8.0	8.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.6: Saving Regressions of Granger Causality Test: Eastern Europe

VARIABLES	(1) S	(2) S	(3) S	(4) S	(5) S	(6) S	(7) S
Lagged 5-years Saving	1.376*	0.328	0.677**	0.767***	0.758***	0.534**	0.455**
	(0.470)	(0.278)	(0.243)	(0.167)	(0.176)	(0.211)	(0.208)
Lagged 5-years Growth	-0.406	1.534*	0.864	-0.130	-0.212	-0.290	-0.185
	(0.839)	(0.632)	(0.668)	(0.406)	(0.390)	(0.226)	(0.275)
Constant	5.247	2.822	-0.876	14.44*	16.01*	15.28***	15.99***
	(10.31)	(8.474)	(11.52)	(8.252)	(8.189)	(5.196)	(5.189)
Observations	14	20	27	36	36	36	34
R-squared	0.959	0.944	0.931	0.918	0.919	0.889	0.795
Country FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
PWT	6.1	6.2	6.3	7.0	7.1	8.0	8.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.7: Saving Regressions of the Granger Causality Test: Growth Acceleration Episodes

VARIABLES	(1) S	(2) S	(3) S	(4) S	(5) S	(6) S	(7) S
Lagged GA dummy	3.461**	2.039	2.806*	3.681***	3.476**	0.197	-0.00674
	(1.609)	(1.357)	(1.478)	(1.419)	(1.434)	(1.040)	(1.044)
Lagged 5-years Saving	0.564***	0.591***	0.620***	0.674***	0.688***	0.691***	0.688***
	(0.0375)	(0.0358)	(0.0346)	(0.0292)	(0.0294)	(0.0307)	(0.0308)
Lagged 5-years Growth	0.174*	0.232***	0.188**	0.159*	0.331***	0.0149	0.0698
	(0.0986)	(0.0878)	(0.0870)	(0.0848)	(0.0826)	(0.0875)	(0.0890)
Interact with g	-0.336*	-0.166	-0.236	-0.272*	-0.361**	0.0365	-0.00609
	(0.198)	(0.168)	(0.178)	(0.164)	(0.167)	(0.192)	(0.194)
Constant	8.403***	7.030***	6.922***	9.086***	7.485***	6.343***	6.447***
	(1.562)	(1.387)	(1.541)	(2.345)	(2.374)	(2.391)	(2.343)
Observations	470	522	571	653	667	654	657
R-squared	0.935	0.947	0.933	0.888	0.898	0.871	0.877
Country FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
PWT	6.1	6.2	6.3	7.0	7.1	8.0	8.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.8: Growth Regressions of the Granger Causality Test: Growth Acceleration Episodes

VARIABLES	(1) G	(2) G	(3) G	(4) G	(5) G	(6) G	(7) G
Lagged GA dummy	-0.120	0.697	0.541	-0.791	-0.609	1.626**	1.437*
	(0.703)	(0.560)	(0.617)	(0.816)	(0.747)	(0.809)	(0.791)
Lagged 5-years Saving	-0.0592**	-0.0216	-0.0425**	-0.0857***	-0.0906***	-0.0356**	-0.0242
	(0.0248)	(0.0217)	(0.0196)	(0.0169)	(0.0177)	(0.0175)	(0.0173)
Lagged 5-years Growth	-0.0882	-0.0546	-0.0206	0.0365	0.0341	-0.0659	-0.0914*
	(0.0539)	(0.0523)	(0.0462)	(0.0462)	(0.0453)	(0.0465)	(0.0466)
Interact with s	0.0572*	-0.00343	0.00304	0.0658*	0.0547*	-0.0293	-0.0200
	(0.0346)	(0.0278)	(0.0278)	(0.0340)	(0.0310)	(0.0380)	(0.0372)
Constant	6.361***	5.443***	5.564***	9.606***	9.873***	4.924***	4.736***
	(0.901)	(0.811)	(0.820)	(1.296)	(1.331)	(1.340)	(1.295)
Observations	447	498	550	628	647	633	637
R-squared	0.637	0.660	0.655	0.603	0.588	0.357	0.359
Country FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
PWT	6.1	6.2	6.3	7.0	7.1	8.0	8.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 3

Economic Regimes and Regional Capital Flows: Evidence from China

with Liuchun Deng

3.1 Introduction

Using Chinese data, this paper investigates how the pattern of capital flows at the provincial level evolves with the transition of economic regimes. According to the standard neoclassical growth theory, fast-growing economies should borrow aggressively to finance their consumption and investment, resulting in current account deficits. However, cross-country studies, Gourinchas and Jeanne (2013) [2] in particular, suggest the "allocation puzzle" of capital: capital flows out of developing countries with high productivity growth.[1] We take a regional perspective to explore the nexus between economic regimes and capital flows. Our model-based regression analysis reveals an intriguing picture of the evolving pattern of capital flows across Chinese provinces. The "allocation puzzle" became much less pronounced after the large-scale economic reform since 1978, while continued reform had little impact on further reversing the direction of capital flows.

This paper, to our knowledge, is the first paper that explores the dynamics of the "allocation puzzle" through the lens of regime change. This paper is closely related to a growing body of work that investigates the "allocation puzzle" using regional data. One advantage of taking a regional perspective is that cross-border frictions are less of concerns (Alfaro, Kalemli-Ozcan, and Volosovych, 2008 [31], and Reinhardt, Ricci, and Tressel, 2013 [30]). Based on a parsimonious dynamic general equilibrium model, Kalemli-Ozcan et al. (2010) [33] find that inter-state capital flows in US are consistent with the theoretical prediction. In contrast, using Chinese provincial data, Cudré (2014) [95] and Cudré and Hoffmann (2014) [96] document the "allocation puzzle" in the post-reform era and examine the underlying mechanism via the structural framework of Gourinchas and Jeanne (2013) [2]. They provide

[1] Various explanations have been proposed to rationalize the "allocation puzzle" of capital (among many others, Alfaro, Kalemli-Ozcan, and Volosovych, 2014, [29], Caballero, Farhi, and Gourinchas, 2008 [11], Coeurdacier, Guibaud, and Jin, 2015 [34], Jin, 2012 [38], and von Hagen and Zhang, 2014 [10]).

compelling evidence that domestic frictions could also give rise to the "allocation puzzle" of capital. Our work complements the existing regional studies by opening up the dimension of economic regimes, thus shedding further light on the importance of institutional factors in explaining the "allocation puzzle".

This paper is also related to the strand of literature that studies (in)efficiency of China's domestic capital allocation. As a seminal work, Boyreau-Debray and Wei (2005) [97] point out various pathological issues of the state-dominated financial system and argue that government intervention tends to reinforce capital flows in the "wrong" direction. Using data from 1984 to 2001, they find that capital tends to flow into less productive provinces. Li (2010) [98] further confirms that capital allocation is not efficient in China, which is suggested by the positive correlation between saving and investment at the provincial level. Armed with more sophisticated econometric tools, Chan et al. (2011) [99], Lai, McNelis, and Yan (2013) [100], and Chan, Lai, and Yan (2013) [101] provide systematic evidence that capital mobility, private capital mobility in particular, has been improved over the course of economic reform. Guided by the framework of Feldstein and Horioka (1980) [79], Chan et al. (2011) [99] document a significant improvement in capital mobility from 1978 to 2006. They separately estimate the relationship between saving and investment for two episodes, 1978-1992 and 1993-2006, and find that the change of the economic regime in 1992 has pronounced impact on the integration of regional capital market. In addition, their paper also documents the intriguing dynamics of regional capital mobility by employing rolling panel dynamic OLS estimation. In contrast, Lai, McNelis, and Yan (2013) [100] argue that a panel time varying coefficient model is more suitable for understanding the evolution of the regional capital mobility due to the gradualist nature of Chinese economic reform. Using this new approach, they find less significant improvement of the regional capital mobility over the sample period. Brandt, Tombe, and Zhu (2013) [102] measure productivity losses due to capital and labor misallocation. They find that misallocation between private firms and state-owned enterprises becomes more prominent since mid-1990s. By estimating a structural model, Song and Wu (2014) [103] confirm that capital misallocation results in substantial revenue losses for Chinese firms. Most of the existing work focuses on post-reform era, but our paper explores the pattern of capital flows back to pre-reform era by employing a model-based but parsimonious framework.

The rest of the paper is structured as follows. Section 3.2 briefly reviews the history of the Chinese economic reforms. This section describes how China's economic transition can be divided into three distinctive phases. Section 3.3 discusses empirical specification and sample construction. Section 3.4 presents the regression results and the discussion of the results. In Section 3.5, we conclude the paper.

3.2 China's Economic Reform: Three Regimes

After the establishment of the People's Republic of China, China has gone through waves of huge changes of its economic institutions.[2] There are three distinctive regimes: the central planning (1952-1978), the incremental reform (1978-1992) and the overall advance reform (1992-2007). After the victory in 1949, China first built a central planning economy of the Soviet style in the hope of catching up or even surpassing the Great Britain and the United States in a very short period of time. However, the good hope only turned into huge economic and political turmoil. The Great Leap Forward, which aimed to boost productivity growth, did not lead to rapid economic growth but to the Great Famine instead, which cost millions of lives (Yang and Li, 2005 [105]). The Cultural Revolution shifted the attention of the Communist Party of China (CPC) from economic development to political fights. The economic development and people's standards of living were stagnated.

After years of political chaos, the Communist Party of China (CPC) finally decided to shift its focus to economic development. The Third Plenary Session of the 11th Central Committee of Communist Party of China (CCCPC) in December 1978 was the turning point for China's economic development. A new approach to reform was found, the strategy of incremental reform (1978-1992). The new growth comes mainly from the nonstate sectors.[3] The bottom-up reform started to grow itself

[2] See Wu (2005) [104] for an excellent and comprehensive description of the China's economic reform.

[3] In some sense, what the meeting did was to plant the seed and the economic prosperity grew by itself. The economic success was largely driven by the growth of the nonstate sector.

from the rural sector in Anhui province.[4] Decollectivization and the introduction of the household-responsibility system greatly contributed to the improved total factor productivity and output growth (Lin, 1992 [106]). The government also lifted control and allowed peasants to sell their grain at the market after they fulfilled the required quotas. Later on the township-village enterprises (TVEs) started to take off. The number of peasants working in industrial and commercial township-village enterprises (TVEs) reached 100 millions between 1979 and 1988. The new entries and rapid growth of those township-village enterprises (TVEs) have been the main engine of China's growth until early 1990s (Qian, 2002 [107]). In a system where allocating resources by plan had not yet been changed, special institutional arrangement is needed for the nonstate sectors to survive. The dual-track system was introduced to solve the problem of the channels of supply and the pricing of products for nonstate sectors. Economists hold different views on the dual-track system. Murphy, Shleifer, and Vishny (1992) [108] think that the dual-track system will create misallocation. Controls of prices should be lifted all at once. Lau, Qian, and Roland (1997) [109] think that the dual-track price liberalization is Pareto-improving. There are also political economy reasons why dual-track system may be desirable because it makes the reform more acceptable for those nested interest groups. Lau, Qian, and Roland

[4]The local officials in Xiaogang village in Anhui province secretly tried out the system of contracting land, other resources, and output quotas to individual households because otherwise starvation was a real threat due to the low yields. Private contracting land to individual households at that time was considered to be opposed to socialist principles and could be subject to severe penalty. But this new contracting practice significantly increased the yields. Later, local and central authorities conceded this new form of production. This decollectivization spread like grass, growing from 1% in 1979 to 14% in 1980. Full official acceptance was not given until late 1981 (Lin, 1992 [106]).

(2000) [110] argue that the dual-track system created a reform without losers. The nonpublic sectors share of industrial output grew from 0% in 1978 to almost 10% in 1990. The share of retail sales grew even faster, from 2.1% in 1978 to 28.7% in 1990. Another important part of the reform is to open China to the rest of the world. Opening up the coastal port cities turned out to be an ingenious policy to make advantages of backwardness and introduce market and competition in China. Four special economic zones were set up in 1980, Shenzhen, Zhuhai, Shantou, and Xiamen. International trade prospered first. China's openness measured by the ratio of exports and imports to GNP increased from 9.9% in 1978 to 31.9% in 1990. Then, Foreign Direct Investment (FDI) started to flood in, totaled to US 18.6 billion between 1986 and 1991. Participation in the import and export market also accelerated the price reform. Overall, the incremental reform proved to be hugely successful. The GDP grew by 14.6 percent annually between 1978 and 1990.

But the drawbacks of the incremental reform are also obvious. Rent-seeking activities and corruption are rampant. There are intense conflicts between the state sectors and the nonstate sectors in the economic system, and the system could only run at enormous cost without the overall reforms. Thus, China moved to a reform strategy of overall advance (1992-2007), and the reform was deepened and accelerated. The southern tour of Deng Xiaoping marked the starting of this new round of reform. During the tour, he made the famous South China speeches to promote reform and opening up. Later on, the 14th National Congress of the Communist Party of China

(CPC) formally set the reform target of establishing a socialist market economy in October, 1992. A new reform strategy of overall advance with key breakthroughs was explicitly put forward. The Soviet viewpoint that "the higher the proportion of the state sector in the national economy, the better" was discarded at the 15th National Congress of the Communist Party of China (CPC) in 1997. In 1998, the decision of the 15th National Congress of the Communist Party of China (CPC) was incorporated into the Amendments to the Constitution of the People's Republic of China "In the primary stage of socialism, the State upholds the basic economic system of keeping public ownership as the mainstay of the economy and allowing diverse forms of ownership to develop side by side."[5] After the overall advance reform, the state sector no longer monopolized the whole economy. The GDP share of the state sector decreased to 38% by 2001.

3.3 Empirical Specification and Data

Based on a standard neoclassical growth model, Gourinchas and Jeanne (2013) [2] demonstrate that capital inflows of a country depend on productivity catchup, initial capital abundance, population growth, and initial external debt. Their model-based

[5] Hsieh and Song (2015) [111] is a recent effort in evaluating this "Grasp the large, let go of the small" way of reforming the state sector.

empirical specification is of the form

$$\frac{\triangle D_i}{Y_i^0} = \beta_0 + \beta_1 \pi_i + \beta_2 n_i + \beta_3 \frac{K_i^0}{Y_i^0} + \beta_4 \frac{D_i^0}{Y_i^0} + \varepsilon_i$$

where $\triangle D_i / Y_i^0$ is capital inflows normalized by initial output, π_i is productivity catchup, n_i is population growth, K_i^0 / Y_i^0 is normalized initial capital abundance, D_i^0 / Y_i^0 is normalized initial debt level, and ε_i is an error term. Parameter β_1 governs the relationship between capital flows and productivity growth. A negative estimate of β_1 implies the "allocation puzzle": fast growing economies see less capital inflows, opposite to the theoretical prediction.

One great advantage of using China's regional data is that the regional capital flows can be directed estimated. With US regional data, Kalemli-Ozcan et al. (2010) [33] has to use indirect methods to infer about capital flows.[6] Our sample is an unbalanced panel of 29 provinces from 1963 to 2007.[7] Chongqing and Tibet are dropped because of data availability. 2007 seems to be a natural break point as the financial turmoil started in 2008. The sample period is divided into three economic regimes (Wang and Yang, 2015 [112]): (1) 1963 - 1977 central-planning regime; (2) 1978 - 1992 transition regime; (3) 1993 - 2007 market regime. Two watersheds are

[6]China reports expenditure GDP broken down into consumption, investment, government purchase and net export at the provincial level. This makes it possible to calculate the current account at the provincial level in China, which can not be done using US regional data.

[7]These provinces are: Anhui, Beijing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Hebei, Heilongjiang, Henan, Hubei, Hunan, Inner Mongolia, Jiangsu, Jiangxi, Jilin, Liaoning, Ningxia, Qinghai, Shaanxi, Shandong, Shanghai, Shanxi, Sichuan, Tianjin, Xinjiang, Yunnan, and Zhejiang.

"Reform and Opening up" in 1978 and Deng Xiaoping's Southern Tour in 1992.[8] Our key departure from the existing empirical work is to open up the regime dimension. We achieve this by introducing two interaction terms into the baseline setting in Gourinchas and Jeanne (2013) [2]

$$\frac{\triangle D_{i,r}}{Y^0_{i,r}} = \beta_0+\beta_1\pi_{i,r}+\gamma_1\pi_{i,r}\times R^{Transition}_{i,r}+\gamma_2\pi_{i,r}\times R^{Market}_{i,r}+\beta_2 n_{i,r}+\beta_3\frac{K^0_{i,r}}{Y^0_{i,r}}+\beta_4\frac{D^0_{i,r}}{Y^0_{i,r}}+\varepsilon_{i,r},$$

where $R^{Transition}_{i,r} = 1$ if it is under the transition regime and $R^{Transition}_{i,r} = 0$ otherwise; $R^{Market}_{i,r} = 1$ if it is under the market regime and $R^{Market}_{i,r} = 0$ otherwise; subscript r stands for one of the three regimes. If γ_1 or γ_2 substantially differs from zero, we say regime change plays a role in shaping the regional capital flows.

Our provincial data is obtained from *China Compendium of Statistics: 1949 - 2008* published by National Bureau of Statistics. The construction of provincial total factor productivity (TFP henceforth) closely follows Gourinchas and Jeanne (2013) [2]. Provincial output (Y_t) is measured by gross regional product. Using annual fixed capital formation data, we construct capital stock (K_t) series by the perpetual inventory method with an annual depreciation rate of 6%. Labor supply (L_t) is measured by provincial total employment. We set capital share α to be 0.3. Therefore, provincial TFP can be calculated[9] by $Y_t/(K_t^\alpha L_t^{1-\alpha})$. Using Hodrick-Prescott filter (smoothing

[8] Our results are not sensitive to the specific timing of these three regimes.

[9] As a cross-check, we compare our provincial TFP estimates with that in Wu (2009) [113] and they are highly correlated.

parameter = 6.25)[10], we obtain the trend component of provincial TFP ($\overline{A}_t$), and the productivity catchup (π) is given by $\overline{A}_T/(\overline{A}_0 \cdot g)$, where g is the country-average TFP growth. Following Cudré (2014) [95], regional capital inflows are measured by the cumulative difference between provincial investment and saving over each regime. Initial debt is obtained as cumulative regional capital inflows.[11] We also create additional variables for robustness check. As a standard practice (Reinhardt, Ricci, and Tressel, 2013 [30]), financial development is obtained as the total deposits and loans. Provincial financial friction is proxied by the difference between deposits and loans. As most of the loans are channeled towards State-Owned Enterprises (SOE), the amount of remaining funds in the banking system can be viewed as a proxy of financial friction. Government expenditure is measured by the provincial general budgetary expenditure. All the variables in level terms (capital inflows, initial capital abundance, initial debt, financial development & friction, government expenditure) are normalized by regional gross output. Throughout our data construction, we use province-specific gross regional product implicit deflator.

Table 3.1 presents summary statistics for three economic regimes. Productivity catchup is adjusted by the country-average, so its mean is always zero.

[10] Suggested by Ravn and Uhlig (2002) [114], the appropriate value of the smoothing parameter is 6.25 for annual data when isolating fluctuations at the traditional business cycle frequencies.

[11] As is pointed out by Cudré (2014) [95], estimates of initial debt may not be quite reliable, so we re-estimate our model by excluding initial debt as a covariate and find our results are largely unchanged.

3.4 Results

Table 3.2 reports the results of our regression analysis. Column (1) is our baseline setting. The coefficient of productivity catchup, β_1, captures the effect of productivity catchup on capital inflows in the central-planning regime. The negative coefficient suggests that fast-growing provinces experienced less capital inflows in the pre-reform era. The estimate is statistically significant and economically sizable. A one-percentage-point increase of productivity catchup yields about 15-percentage-point decrease of normalized capital inflows. Positive coefficients of two interaction terms (γ_1 and γ_2) imply that the "allocation puzzle" became much less evident since 1978. The effect of productivity catchup on capital inflows during transition regime ($\beta_1 + \gamma_1$) and market regime ($\beta_1 + \gamma_2$) is also reported in the table and close to zero. Interestingly, by comparing γ_1 with γ_2[12], we find deepened economic reform since 1992 had limited effects on further adjusting the direction of capital flows. Throughout our sample period, capital inflows are estimated to be negatively correlated, or at best uncorrelated, with productivity catchup. This result echoes earlier findings by Gourinchas and Jeanne (2013) [2] using cross-country data and Cudré and Hoffmann (2014) [96] using post-reform Chinese data. The regression also includes the theoretically motivated set of regressors as in Gourinchas and Jeanne (2013) [2]: initial capital abundance, initial debt, and population growth. The coefficient of population growth is insignificant. Capital inflows increase with initial capital abundance

[12]The difference between these two estimates is statistically insignificant.

and initial debt. Column (2) through Column (6) summarize a battery of robustness checks. In light of Song, Storesletten, and Zilibotti (2011) [35], we control for differential access to external financing between private firms and state-owned enterprises by including provincial growth rate of State-Owned Enterprises (SOE) employment. Column (2) reports the regression when this control is included. The coefficient of the State-Owned Enterprises (SOE) employment growth is negative but not significant. According to Boyreau-Debray and Wei (2005) [97], capital allocation is heavily influenced by the government intervention, so we add provincial government expenditure into our regressions as well. The coefficient estimate is highly significant suggesting that government intervention is important. The results are in Column (3). Financial indicators are also included to capture heterogeneity of regional financial institutions. Column (4) and Column (5) show the regression results when measures of financial friction and financial development are controlled. In Column (6), we put all the controls in the regression together, and our main results still hold. To summarize the discussions above, under a wide range of additional controls, main results are largely unchanged. The coefficient of productivity catchup, β_1, and the coefficients of two interaction terms (γ_1 and γ_2) are highly significant across different specifications. The significance barely changes when different control variables are added either separately or jointly.

Our three-regime analysis reveals an interesting dynamic picture of regional capital flows. Consistent with the conventional wisdom, the large-scale market reform substantially alleviated the "allocation puzzle" at its outset. The coefficients of two interaction terms (γ_1 and γ_2) are highly significant and positive in all specifications. As a result, the coefficient of productivity catchup becomes much less negative after the reform compared with the central-planning period. There are two possible channels through which the market reform had a large impact on capital flows. First, the price reform, which was a major component of the market reform, rendered price signals more informative. Compared with the price system under the central-planning economy, creation of a dual-track price system allowed prices to be determined by supply and demand at the margin (Wu and Zhao, 1987 [115]). Gradual lifting of price controls reduced distortion, thus adjusting the capital flows more consistent to the prediction of a standard growth model. Second, pre-reform regional capital flows were exclusively determined by the central planning system. As collective and private enterprises were permitted to operate on a market base, decentralization of investment decisions allowed capital flows not to solely follow the preference of the central planner. Market forces started to have influence on the pattern of capital flows.

However, deepened market reform, marked by Deng Xiaoping's 1992 speech in particular, did not yield appreciable effect on further adjusting the direction of capital flows. A complete explanation of the evolving "allocation puzzle" is out of the scope of this paper, but we provide a tentative explanation in line with Song, Storesletten, and Zilibotti (2011) [35]. According to their theory, the negative correlation between productivity growth and capital inflows is driven by a specific channel of financial friction: State-Owned Enterprises (SOE) usually have preferential access to credit, while private firms have to rely on their own entrepreneurial saving to invest (Chong, Lu, and Ongena, 2013 [116]). For a province that hosts many private firms, it tends to achieve higher productivity growth accompanied by less capital inflows, because fast-growing private firms have limited access to external financing and thereby saving outgrows investment. In contrast, a province that is dominated by State-Owned Enterprises (SOE) tends to enjoy capital inflows because State-Owned Enterprises (SOE) are preferentially treated in the credit market. In their cross-province regressions, Song, Storesletten, and Zilibotti (2011) [35] document a positive correlation between provincial net surplus (capital outflows) and the employment growth of private firms. By adding State-Owned Enterprises (SOE) employment growth into our baseline model, we also find a negative estimated coefficient, but this coefficient is statistically insignificant and not robust under inclusion of a full range of controls. This suggests a complete understanding of the persistent "allocation puzzle" in the post-reform era, albeit to a lesser degree, calls for future research.[13]

Table 3.3 repeats our main regression analysis of Table 3.2 but uses the inter-provincial capital inflows as the dependent variable. When constructing our measure of inter-provincial capital inflows, we subtract the provincial net export from the difference between provincial investment and saving over each regime. The other procedures are the same as described in Section 3.3. Column (1) reports the baseline

[13] Other than composition of State-Owned Enterprises (SOE) and private firms, Cudré and Hoffmann (2014) [96] demonstrate that a province's integration into the global market and its sectoral composition also play a significant role in shaping the pattern of capital flows.

setting without additional controls. There are a number of differences between the results in Table 3.3 and Table 3.2. The coefficient of productivity catchup, β_1, is less significant and sometimes not significant in Table 3.3. The effect of productivity catchup on capital inflows during transition regime ($\beta_1 + \gamma_1$) is positive. The different results suggest that the pattern of the inter-provincial capital flows is closer to what the neoclassical theory predicts and that the international frictions also play a role in shaping the direction of the capital flows. Positive coefficients of two interaction terms γ_1 and γ_2 imply that the "allocation puzzle" became less evident since 1978. The interaction term γ_1 is marginally significant suggesting that the onset of the reform has an impact on the pattern of inter-provincial capital flows; however, the other interaction term γ_2 never is significant. This lends further support to our previous results that deepened reform seems to have limited effect on adjusting the direction of the capital flows further. The improvement is concentrated in the transition from central planning economy toward the market system. All regressions include the theoretically motivated set of regressors: initial capital abundance, initial debt, and population growth. Inter-provincial capital inflows decrease with the population growth as the coefficient of population growth is negative and highly significant. Compared with Table 3.2, the coefficients of initial capital abundance are much less significant. In Column (2) through Column (5), additional controls such as provincial growth rate of State-Owned Enterprises (SOE) employment, provincial government expenditure and two financial indicators are included separately; Column

(6) includes all the additional control variables. Adding additional control variables does not alter the baseline results. In Column (2), the coefficient of the State-Owned Enterprises (SOE) employment is positive and significant. This is consistent with that State-Owned Enterprises (SOE) received preferentially treatment in the credit market. This is also consistent with the story in Song, Storesletten, and Zilibotti (2011) [35] that the growth of private firms is associated with capital outflows. Similar to the results in Table 3.2, the coefficient of the provincial government expenditure is significant and positive in Column (4). In addition, the magnitude of the coefficient does not change much. The coefficients of two financial indicators are highly significant. The development and the friction of the financial system are important factors affecting the capital flows.

3.5 Conclusion

In this paper, we study the dynamic pattern of capital flows under different economic regimes. China's three-regime economic reform provides a natural experiment and the possibility to investigate this problem. China's provincial data makes it possible to analyze the "allocation puzzle" from a regional perspective. Though the "allocation puzzle" is estimated to become substantially less pronounced after the initial reform, continued and deepened economic reform seems to have limited effects on reversing the "wrong" direction of capital flows. This finding sheds further light on the nexus between capital flows and institutional factors of the economy. It is also an interesting direction for future research.

Table 3.1: Summary Statistics

VARIABLES	N	Mean	Std. Dev.	Min	Max
Central-planning Regime: 1963-1977					
Productivity catchup	24	0.000	0.213	-0.292	0.556
Population growth	29	0.402	0.160	0.012	0.701
Capital inflows	28	-1.246	6.190	-18.347	11.902
Initial capital abundance	25	2.205	1.250	0.280	6.843
Initial debt	25	-0.236	2.108	-5.017	5.005
SOE employment growth	26	0.394	0.270	-0.064	0.951
Financial development	27	0.939	0.317	0.604	2.220
Financial friction	27	-0.115	0.329	-0.559	1.291
Government expenditure	27	0.183	0.146	0.075	0.859
Transition Regime: 1978-1992					
Productivity catchup	28	0.000	0.185	-0.304	0.496
Population growth	29	0.229	0.054	0.130	0.356
Capital inflows	28	0.438	3.929	-7.144	11.023
Initial capital abundance	28	1.889	0.849	0.289	3.923
Initial debt	28	-0.381	2.344	-6.092	5.065
SOE employment growth	28	-0.028	0.105	-0.247	0.179
Financial development	29	1.306	0.315	0.949	2.508
Financial friction	29	-0.138	0.216	-0.500	0.720
Government expenditure	29	0.153	0.061	0.079	0.310
Market Regime: 1993-2008					
Productivity catchup	29	0.000	0.138	-0.188	0.400
Population growth	29	0.137	0.099	0.011	0.469
Capital inflows	29	0.707	4.165	-8.513	10.292
Initial capital abundance	29	1.983	0.593	0.400	3.503
Initial debt	29	0.081	1.612	-3.949	4.384
SOE employment growth	28	-0.521	0.097	-0.746	-0.311
Financial development	29	2.197	0.640	1.398	4.606
Financial friction	29	0.183	0.273	-0.202	1.356
Government expenditure	29	0.133	0.046	0.071	0.261

Source: China Compendium of Statistics 1949-2008

Table 3.2: Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)
Productivity catchup (β_1)	-15.05***	-14.07***	-10.50***	-15.08***	-14.11***	-7.768*
	(3.674)	(4.258)	(3.676)	(3.781)	(3.653)	(4.349)
Productivity catchup	12.71**	11.89**	10.12**	12.71**	12.00**	8.955*
$\times R^{Transition}$ (γ_1)	(5.029)	(5.567)	(4.767)	(5.120)	(4.960)	(5.170)
Productivity catchup	13.95***	13.09**	10.98**	14.03**	14.33***	10.92**
$\times R^{Market}$ (γ_2)	(5.246)	(5.650)	(4.958)	(5.382)	(5.170)	(5.208)
Population growth	-1.006	-0.00513	-3.277	-0.915	1.640	0.343
	(2.554)	(4.015)	(2.500)	(2.601)	(2.800)	(3.927)
Initial capital abundance	2.241***	2.329***	1.312**	2.210***	1.926***	0.378
	(0.560)	(0.637)	(0.589)	(0.571)	(0.571)	(0.671)
Initial debt	1.393***	1.368***	1.106***	1.401***	1.427***	1.250***
	(0.211)	(0.220)	(0.211)	(0.214)	(0.208)	(0.219)
SOE employment growth		-0.358				1.602
		(1.334)				(1.783)
Government expenditure			31.92***			31.42***
			(8.744)			(9.354)
Financial friction				-0.118		-4.456***
				(1.099)		(1.568)
Financial development					1.104**	3.369***
					(0.529)	(0.935)
Constant	-4.005***	-4.454***	-6.374***	-3.949***	-5.677***	-10.39***
	(1.138)	(1.404)	(1.240)	(1.159)	(1.394)	(1.674)
$\beta_1 + \gamma_1$	-2.344	-2.184	-0.380	-2.363	-2.109	1.187
	(3.144)	(3.271)	(2.974)	(3.186)	(3.094)	(2.872)
$\beta_1 + \gamma_2$	-1.096	-0.977	0.476	-1.050	0.220	3.153
	(4.213)	(4.365)	(3.951)	(4.270)	(4.187)	(3.810)
Observations	81	78	80	80	80	76
R-squared	0.674	0.668	0.725	0.675	0.694	0.775

Dependent variable = capital inflows. Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.3: Inter-provincial Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)
Productivity catch-up (β_1)	-14.66**	-17.33**	-10.43	-10.18*	-17.82***	0.514
	(6.581)	(7.461)	(6.999)	(6.000)	(6.191)	(7.873)
Productivity catch-up	17.10*	20.07**	14.82	13.44	19.45**	4.432
$\times R^{Transition}$ (γ_1)	(9.008)	(9.755)	(9.077)	(8.125)	(8.406)	(9.358)
Productivity catch-up	12.37	13.09	9.582	6.827	11.84	-2.614
$\times R^{Transition}$ (γ_2)	(9.395)	(9.901)	(9.439)	(8.541)	(8.762)	(9.427)
Population growth	-9.899**	-19.04***	-12.33**	-10.85**	-17.39***	-5.396
	(4.575)	(7.036)	(4.760)	(4.128)	(4.746)	(7.109)
Initial capital abundance	1.309	1.987*	0.447	1.207	2.138**	0.660
	(1.003)	(1.117)	(1.122)	(0.906)	(0.968)	(1.215)
Initial debt	1.414***	1.461***	1.132***	1.453***	1.340***	0.863**
	(0.378)	(0.386)	(0.402)	(0.340)	(0.353)	(0.397)
SOE employment growth		4.184*				
		(2.338)				
Government expenditure			30.92*			
			(16.65)			
Financial friction				-7.789***		
				(1.744)		
Financial development					-3.288***	-2.783
					(0.896)	(1.692)
Constant	0.391	1.659	-1.937	0.756	5.558**	-1.413
	(2.038)	(2.460)	(2.362)	(1.839)	(2.363)	(3.031)
$\beta_1 + \gamma_1$	2.443	2.734	4.387	3.260	1.626	4.946
	(5.631)	(5.732)	(5.663)	(5.055)	(5.244)	(5.198)
$\beta_1 + \gamma_2$	-2.288	-4.241	-0.850	-3.351	-5.977	-2.100
	(7.546)	(7.650)	(7.523)	(6.777)	(7.097)	(6.897)
Observations	81	78	80	80	80	76
R-squared	0.305	0.338	0.338	0.456	0.415	0.522

Dependent variable = inter-provincial capital inflows. Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix A

Appendix to Chapter 1

A.1 Growth Acceleration Episodes (Hausmann, Pritchett and Rodrik, 2005 [1])

Table A.1 reports the episodes if only developing countries are considered.

Table A.2 reports all the episodes if developed countries are also included.

A.2 Balassa-Samuelson Model

The tradable goods sector and nontradable goods sector both use capital and labor to produce its output and the production technologies are given by

$$Y_{Tt} = A_T K_T^{\alpha_T} L_T^{1-\alpha_T}; Y_{Nt} = A_N K_N^{\alpha_N} L_N^{1-\alpha_N}$$

Two assumptions are important to the Balassa-Samuelson model. First, capital and labor are perfectly mobile and earn their marginal products at all times; second, tradable goods price does not change.

Marginal product of capital is equal to the interest rate minus depreciation

$$MPK = R - \daleth$$

where $R = 1 + r$ is the interest rate factor; $\daleth = 1 - \delta$, and δ is the depreciation rate.

Marginal product of labor is equal to the wage rate, and the wage rate is equal in two sectors as labor is perfectly mobile. If the wage rate in the tradable goods sector is higher, workers will flood into the tradable goods sector driving down the wage rate until the wage rate is equal in two sectors.

$$MPL = W$$

The two marginal product conditions give us the following 4 equations

$$\alpha_T k_T^{\alpha_T - 1} A_T = p \alpha_N k_N^{\alpha_N - 1} A_N = R - \daleth$$

$$(1 - \alpha_T) A_T k_T^{\alpha_T} = W$$

$$p (1 - \alpha_N) A_N k_N^{\alpha_N} = W$$

where $k_N = \frac{K_N}{L_N}, k_T = \frac{K_T}{L_T}$. 4 equations and 4 unknowns k_T, k_N, p, W make sure that the relative price p can be solved.

Solving the above system of equations, the relative price is a function of the productivities in the two sectors. The changes of the relative price can be written as

$$\frac{p_{t+1}}{p_t} = \left(\frac{1 - \alpha_N}{1 - \alpha_T} \right) \frac{A_{Tt+1}}{A_{Tt}} - \frac{A_{Nt+1}}{A_{Nt}}$$

The Balassa-Samuelson model predicts that when tradable goods productivity increase, the real exchange rate will appreciate according to the above equation.[1]

If the nontradable goods productivity does not change $\frac{A_{Nt+1}}{A_{Nt}} = 1$, and the tradable goods sector is more capital intensive which implies $\frac{1-\alpha_N}{1-\alpha_T} > 1$, then the changes in the relative price are equal to, at least, the changes in the tradable goods productivity.

[1] In a different model, it is possible that when TFP increases in the tradable goods sector, the real exchange rate depreciates (Benigno and Thoenissen, 2003 [117]).

A.3 Real Exchange Rate Definition

To formally define real exchange rate in the model world, now consider another open economy, and call it the foreign country.[2] Denote the variables in the foreign country with an asterisk. Assume the same structure for this foreign country, and the only difference is the relative price p^*. Therefore, by an identical calculation, we have P_C^*.

$$P_C^* = p^{*1-\theta}$$

The definition of the real exchange rate is standard and straightforward. The real exchange rate is defined as the relative price of the aggregate consumption index in these two economies. That is

$$RER = \frac{P_C^*}{P_C} = \frac{p^{*1-\theta}}{p^{1-\theta}}$$

Therefore, other things being equal, if p increases, RER decreases i.e. The real exchange rate appreciates. The changes of relative price p are isomorphic to the real exchange rate. Further, without loss of generality, if the relative price p^* in the foreign country is normalized to one. The real exchange rate is given by

$$RER = \frac{1}{p^{1-\theta}}$$

[2]In later analysis, the foreign country is not analyzed. The only purpose of mentioning the foreign country is to define the real exchange rate explicitly. This is a small open economy model.

A.4 Derive FOCs from the Lagrangian

Differentiate the Lagrangian (1.13) with respect to $C_{Tt}, C_{Nt}, p_t, L_{Tt}, B_{t+1}, H_{t+1}, K_{Tt+1}$, and seven first order conditions are derived.

$$\frac{\partial \mathcal{L}}{\partial C_{Tt}} = \left(\frac{C_{Tt}}{\theta}\right)^{\theta-1-\sigma\theta} \left(\frac{C_{Nt}}{1-\theta}\right)^{(1-\sigma)(1-\theta)} H_t^{-\gamma+\gamma\sigma} - \lambda_t - \mu_t \rho \left(\frac{C_{Tt}}{\theta}\right)^{\theta-1} \left(\frac{C_{Nt}}{1-\theta}\right)^{1-\theta} = 0$$

$$\frac{\partial \mathcal{L}}{\partial C_{Nt}} = \left(\frac{C_{Tt}}{\theta}\right)^{\theta-\sigma\theta} \left(\frac{C_{Nt}}{1-\theta}\right)^{-\sigma(1-\theta)-\theta} H_t^{-\gamma+\gamma\sigma} - \lambda_t p_t + \mu_t \rho \left(\frac{C_{Tt}}{\theta}\right)^{\theta} \left(\frac{C_{Nt}}{1-\theta}\right)^{-\theta} = 0$$

$$\frac{\partial \mathcal{L}}{\partial p_t} = \lambda_t Y_{Nt} - \lambda_t C_{Nt} = 0$$

$$\frac{\partial \mathcal{L}}{\partial L_{Tt}} = \lambda_t (1-\alpha) A_{Tt} K_t^{\alpha} L_{Tt}^{-\alpha} - p_t \lambda_t \eta A_{Nt} L_{Nt}^{\eta-1} = 0$$

$$\frac{\partial \mathcal{L}}{\partial B_{t+1}} = E_t \left[\beta \lambda_{t+1} (1 + r_{t+1})\right] - \lambda_t = 0$$

$$\frac{\mathcal{L}}{\partial H_{t+1}} = E_t \left[-\gamma\beta \left(\frac{C_{Tt+1}}{\theta}\right)^{\theta-\sigma\theta} \left(\frac{C_{Nt+1}}{1-\theta}\right)^{(1-\sigma)(1-\theta)} H_{t+1}^{-\gamma-1+\gamma\sigma} - \beta(1-\rho)\mu_{t+1}\right] + \mu_t = 0$$

$$\frac{\partial \mathcal{L}}{\partial K_{t+1}} = -\lambda_t - \lambda_t \xi \left(K_{t+1} - K_t\right) + E_t \left\{ \lambda_{t+1} \beta \left[\alpha A_{Tt+1} K_{t+1}^{\alpha-1} L_{Tt+1}^{1-\alpha} + 1 - \delta + \xi \left(K_{t+2} - K_{t+1}\right) \right] \right\}$$

Rearranging terms gives the first order equations in the main text.

A.5 Deterministic Steady States

$$\frac{K}{L_T} \equiv k = \left[\frac{1-(1-\delta)\beta}{\alpha\beta A_T}\right]^{\frac{1}{\alpha-1}}$$

$$L_T = \frac{\theta\left(1-\alpha_T\right) A_T k^\alpha - \eta\left(1-\theta\right) r\bar{B}}{\eta\left(1-\theta\right)\left(A_T k^\alpha - \delta k\right) + \theta\left(1-\alpha_T\right) A_T k^\alpha}$$

$$K = kL_T$$

$$C_T = A_T K^\alpha L_T^{1-\alpha} - \delta K_T + r\bar{B}$$

$$C_N = A_N \left(1-L_T\right)^\eta$$

$$p = \frac{\left(1-\theta\right)\left(A_T K^\alpha L_T^{1-\alpha} - \delta K_T + r\bar{B}\right)}{\theta A_N \left(1-L_T\right)^\eta}$$

A.6 Numerical Resolutions

In every iteration, we start from the current guess of the policy functions L_{Tt}, I_t, μ_t given last period state variables. With the three policy functions, the other period t variables can be easily calculated. C_{Tt} is calculated from equation (A.1); Y_{Tt} from equation (1.3); Y_{Nt} from equation (1.4); λ_t from equation (1.14).

$$C_{Tt} = \frac{(1-\alpha_T)\,\theta A_{Tt} K_t^{\alpha} L_{Tt}^{-\alpha}\,(1-L_{Tt})}{(1-\theta)\,\eta} \tag{A.1}$$

Using the law of motions equation (1.8), equation (1.2) and equation (1.7), the calculations of the period t state variables are straightforward given last period state variables and the policy functions. Next period A_T depends on the next period regimes which evolves according to the Markov process. With the period t state variables at hand, period $t+1$ policy functions L_{Tt}, I_t, μ_t are obtained by linear interpolation for both regimes. For each regime, we calculate all the other period $t+1$ variables and other period $t+1$ state variables B_t, H_t and K_t in a similar way for both regimes. With the other period $t+1$ variables and the interpolated policy functions at hand, we can evaluate whether the equilibrium conditions with expectation are satisfied or not. Expectations of equation (1.17), equation (1.18) and equation (1.19) are calculated using the probability in the Markov transition matrix. Then Chris Sims's root finder is used to solve for the zeros of the expectation equations. The output from the root finder are the updated policy functions values for the next iteration. The program iterates until the distance between the guess and the updated policy functions values is less than the convergence criterion on all nodes.

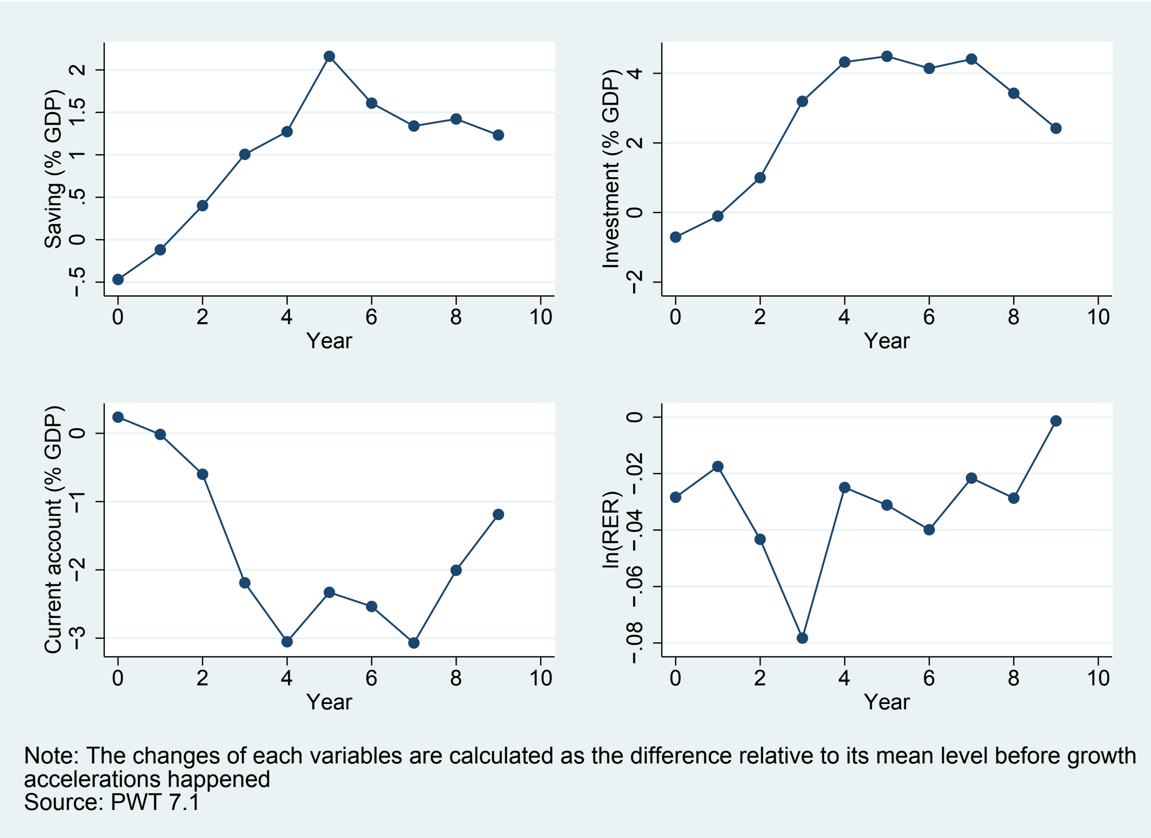


Figure A.1: All countries

Country	Year	Country	Year
Chile	1986	Mauritius	1983
China	1978	Malaysia	1988
China	1990	Pakistan	1979
Congo, Republic of	1978	Thailand	1986
Dominican Republic	1992	Uganda	1977
India	1982	Uganda	1989
Sri Lanka	1979	Uruguay	1974

Table A.1: Growth Acceleration Episodes

Country	**Year**	**Country**	**Year**
Argentina	1990	Mauritius	1983
Chile	1986	Malaysia	1988
China	1978	Norway	1991
China	1990	Pakistan	1979
Congo, Republic of	1978	Poland	1992
Dominican Republic	1992	Portugal	1985
Spain	1984	Romania	1979
Finland	1992	Thailand	1986
United Kingdom	1982	Trinidad & Tobago	1975
India	1982	Uganda	1977
Ireland	1985	Uganda	1989
Korea, Republic of	1984	Uruguay	1974
Sri Lanka	1979	Uruguay	1989

Table A.2: Growth Acceleration Episodes: Adding Developed Countries

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Vita

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