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Essays on Monetary Policy in Emerging Market Economies

by

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Phakawa Jeasakul

Abstract

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by
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Doctor of Philosophy in Economics
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This dissertation addresses a number of important monetary policy issues in emerging markets, which are primarily related to capital flows and exchange rate movements and largely motivated by Thailand's experience. Thus, Chapter 1 reviews background information on Thailand's macroeconomic developments in the context of large and rapid exchange rate appreciation during 2006-2008.

Chapter 2 develops a micro-founded macroeconomic model in which sterilized foreign-exchange (FX) interventions are effective in influencing currency movements as well as real allocations. The effectiveness of FX interventions rests on the existence of liquidity benefits from holding financial assets. The analysis shows that such sterilized FX interventions can affect the domestic interest rate relevant for the consumption-saving decision through the change in the financial system's liquidity condition even when the policy interest rate is held constant. Simulation exercises based on the calibration aiming to capture the Thai economy suggest that the reliance on sterilized FX interventions to deal with capital flows can be welfare-improving, mainly due to liquidity benefits. However, the effect of liquidity-based sterilized FX interventions on the exchange rate dynamics is small. Furthermore, an accommodative interest rate policy appears essential for sterilized FX interventions to be fully effective.

Chapter 3 examines the viability of capital controls on inflows following Thailand's experience which experienced a stock market crash in consequence of the introduction of the unremunerated reserve requirement measure in December 2006. Both theoretical analysis and empirical evidence suggest that the predominant factor for the stock market crash was the punitive implicit tax rate that made any new foreign investment in the domestic stock market unprofitable. Occurring as a result of limited foreign participation, a revaluation of systematic risks relevant for idiosyncratic risk pricing as well as a reduction in stocks' liquidity led to a sharp increase in the equity premium. Consequently, share prices declined substantially. The importance of these two channels in triggering the stock market crash was largely supported by the findings that difference in covariances and trading frequency appear as the most important explanatory variables for changes in share prices across firms during the stock market collapse and rebound. In

short, capital controls should remain a viable policy option provided that they are well-designed.

Chapter 4 illustrates how to apply the methodology developed by Obstfeld and Rogoff (2005) and (2007) to estimate the magnitude of exchange rate fluctuations required for absorbing changes in financial flows in addition to facilitating adjustments of the current account towards its medium-term position, with a particular focus on analyzing Thailand's exchange rate fluctuations in the past two decades. The simulation-based analysis points out that the Thai baht has been heavily influenced by the development of capital flows, and also suggests that some exchange rate misalignments were evident over certain time periods. Specifically, the Thai baht seemed relatively weak during 1999-2001, consistent with the export-led growth model propelled by a competitive exchange rate value, but it then appeared justifiably strong in 2006 when the Bank of Thailand seriously concerned about large and rapid currency appreciation. Nevertheless, the dynamics of the Thai baht over the past year has become more aligned with underlying factors that drive exchange rate movements.

Professor Maurice Obstfeld
Dissertation Committee Chair

To Mom and Dad

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Phakawa Jeasakul
Washington, D.C.
June 2011

Chapter 1

Introduction

1.1 Prologue

The notion that emerging markets need tailored macroeconomic policies, different from conventional prescriptions generally devised for advanced economies, has been well acknowledged.[1] Emerging markets historically have been more vulnerable to adverse developments as a result of their domestic economic environments being characterized by deficient institutions creating resource misallocations and market distortions as well as incompetent policymakers contributing to lacking fiscal discipline, improper exchange rate management and inadequate financial supervision. Furthermore, emerging markets have been exposed to significant macroeconomic instability triggered by various external factors, including major trading partners' business cycles, international financial markets' liquidity conditions and foreign investors' risk appetite.

Several emerging markets have successfully managed to mitigate risks of encountering financial crises. In fact, many of them had weathered fairly well through the recent global financial crisis rooted in sub-prime lending and financial over-leveraging in advanced economies. The accomplishment of these economies that once were highly vulnerable to financial crises coupled with severe recessions seems to be underlain by their strengthened institutional foundations and improved policymaking frameworks.

Nevertheless, emerging markets have become much more concerned about large and volatile capital flows, which can significantly undermine macroeconomic stability. In the age of globalization, the degree of capital mobility across national borders has been increasing markedly, primarily thanks to the liberalization of capital flows and the advancement of information technology. While providing resounding benefits such as improving risk sharing and funding investment activities in capital-scarce places, financial integration tends to be followed by such undesired consequences as problems associated with capital flows. On the one hand, an influx of foreign funds may cause

[1] See Montiel (2003) as a key reference in the literature.

sharp exchange rate appreciation, bubbles in asset prices, and excess in domestic liquidity. On the other hand, a sudden stop of international capital flows may create a financial crisis, a credit crunch, and a severe recession.[2] These problems are likely to be more serious when the magnitude of international capital flows is enormous relative to the size of the domestic financial system. As a minimum, large and volatile capital flows can generate sizeable exchange rate fluctuations, which may in turn put macroeconomic stability at risk. In fact, according to Calvo and Reinhart (2002), fear of floating appears evident even in countries that have adopted a de jure flexible exchange rate arrangement.

As a result, financial flows and currency movements tend to carry some influential weight in policy consideration. Monetary authorities usually rely on various policy tools to counteract large and volatile financial flows and ensuing, excessive exchange rate movements. Common policy actions generally involve altering policy interest rates as well as undertaking foreign-exchange (FX) interventions to limit undesired currency fluctuations. From time to time, capital controls are also imposed to address particular components of financial flows and preserve exchange rate stability.[3]

To a great extent, rigorous economic analyses on numerous crucial policy issues seem still missing. Primarily motivated by Thailand's recent experience (2006-2008),[4] this dissertation aims to contribute to the literature by addressing a number of important monetary policy issues in emerging markets, which are primarily related to financial flows and exchange rate movements.

Chapter 2 develops a well-articulated macroeconomic model based on micro-foundation to analyze the effect of sterilized FX interventions. In the literature, the modern monetary policy framework is largely characterized by a unique instrument, namely the policy interest rate.[5] This particular feature primarily results from a simplified model setup, which leads to a conclusion that other policy tools would not be useful for improving macroeconomic outcomes. However, the fact that many monetary authorities regularly undertaking sterilized FX interventions in addition to setting policy interest

[2] See Calvo (1998) for theoretical concepts; see Calvo et al. (2004), Hutchison and Noy (2006), and Jeasakul (2005) for empirical analyses.

[3] See Magud and Reinhart (2007) for a comparison of capital controls across various episodes.

[4] The next section of this chapter provides background information on Thailand's recent experience of large and rapid exchange rate appreciation driven by an influx of foreign funds to which the Bank of Thailand had responded by undertaking a combination of several policy actions such as tightening the measures to prevent currency speculation, engaging in large-scale sterilized FX interventions, imposing capital controls in the form of unremunerated reserve requirement (URR), lowering the policy interest rate, and liberalizing restrictions on domestic financial outflows.

[5] This statement is particularly true prior to the global financial crisis. However, the crisis pointed out the failure of models that ignore market imperfections especially those in the financial sector. Consequently, the literature now recognizes the necessity of additional policy tools for addressing the aforementioned issues.

rates raises a fundamental question on how these two policy instruments should be used together appropriately. This chapter presents a macroeconomic model that features effective sterilized FX interventions based on liquidity benefits from holding financial assets. Specifically, an adjustment of the central bank's holding of foreign reserves together with holding the policy interest rate constant can trigger a change in the interest rate relevant for the consumption-saving decision, which in turn induces the exchange rate to move. The model is also calibrated to reflect Thailand's experience, which is highlighted by continual, large-scale sterilized FX interventions being implemented under the inflation targeting regime to moderate exchange rate appreciation driven by an influx of foreign funds. Simulation results suggest that the effect of liquidity-based sterilized FX interventions on currency movements seems small and that an accommodative interest rate policy appears essential for sterilized FX interventions to be fully effective.[6] Furthermore, the reliance on sterilized FX interventions to deal with capital flows can be welfare-improving, chiefly due to liquidity benefits.

Chapter 3 examines the viability of capital controls on inflows following Thailand's experience which witnessed a stock market crash in consequence of the introduction of the unremunerated reserve requirement (URR) measure. Regardless of whether capital controls are effective in general, the stock market crash incidence should have increased the reluctance of policymakers who have not yet completely understood its causes to opt for imposing capital controls. This chapter illustrates that the underlying factor for the stock market crash was the punitive implied tax rate, which resulted from the interaction among the penalty on early withdrawal imposed as a part of the URR measure, certain existing institutional features owing to the measures to prevent currency speculation, and the transitory nature of portfolio equity investment. The theoretical analysis suggests that limited foreign participation, which arises when the implicit tax rate becomes sufficiently large to make any new foreign investment in the domestic stock market unprofitable, can trigger a sharp reduction in share prices through two major mechanisms encompassing an increase in systematic risks relevant for idiosyncratic risk pricing and a decline in stocks' liquidity. This theoretical supposition is also supported by the empirical evidence that difference in covariances and trading frequency are the most important explanatory variables for changes in share prices during the stock market collapse and recovery. Therefore, capital controls should remain a viable policy option. However, it is imperative to implement a well-designed capital control regime; otherwise, policymakers could significantly lose creditability by executing policies with extraordinarily undesired side effects.

Chapter 4 presents an analytical framework that can help simulate the expected exchange rate dynamics in response to changes in underlying economic forces such as capital

[6] In terms of influencing exchange rate movements, a sterilized FX intervention with the magnitude of 3 percent GDP is roughly as effective as a change in the policy interest rate by 100 basis points.

flows. Even though exchange rate management has become fairly common in several emerging markets, it remains unclear that their policymaking processes are effective because the task of determining whether the exchange rate value is aligned with macroeconomic fundamentals is not simple. Therefore, this chapter's main objective is to illustrate how to apply the methodology developed by Obstfeld and Rogoff (2005) and (2007) to estimate the magnitude of exchange rate fluctuations required for absorbing changes in financial flows in addition to facilitating adjustments of the current account towards its medium-term position. The central idea is that exchange rate movements must materialize to support current account adjustments induced by changes in capital flows, especially those that do not occur as an endogenous process determined by the consumption-saving decision of domestic agents. This chapter, in particular, focuses on analyzing Thailand's exchange rate fluctuations during the two periods occupied by the sudden stop of capital inflows associated with the financial crisis of 1997 and the revival of massive foreign funds since 2005. Simulation exercises highlight that the Thai baht has been heavily influenced by the development of capital flows. Furthermore, while its value seemed relatively weak during 1999-2001, consistent with the export-led growth model supported by a competitive exchange rate value, the Thai baht appeared justifiably too strong in 2006 when the Bank of Thailand (BoT) voiced its serious concern about large and rapid currency appreciation. Nonetheless, the dynamics of the Thai baht over the past year has become more aligned with underlying factors that generate exchange rate movements.

1.2 Thailand's Experience – Motivation for Research

This section presents background information on Thailand's recent experience of large and rapid exchange rate appreciation during 2006-2008, which was chiefly driven by an influx of foreign funds. This particularly interesting episode provides motivation for research carried out in this dissertation, mainly due to the mix of policy reactions undertaken by the BoT during the so-called URR regime.

1.2.1 Institutional Framework and Macroeconomic Management

Thailand's post-crisis macroeconomic institutional framework in the context of the trinity constraint can be generally characterized by monetary autonomy and capital mobility.[7] In May 2000, the BoT adopted inflation targeting as its monetary policy framework, embracing price stability as one of its principal policy objectives. Nevertheless, the BoT

[7] Based on Flemming (1962) and Mundell (1963), the trinity constraint refers to the situation in which all the three following choices, namely monetary autonomy, exchange rate management and capital mobility, cannot be attained at the same time.

has remained actively managing the exchange rate to limit undesired currency movements by implementing large-scale sterilized FX interventions, which can be reflected by massive accumulation of foreign reserves together with continual issuances of BoT bonds. Furthermore, the degree of capital mobility has been rising over time since financial liberalization in the early 1990s, although the limitation on residents to undertake investment abroad and the measures to prevent currency speculation, the two major restrictions on financial flows, have remained in place.

Inflation targeting has served as the BoT's monetary policy framework since May 2000. Under the inflation targeting arrangement, the BoT's leading objective is to maintain the quarterly average of year-on-year core CPI inflation (raw food and energy are excluded) currently in the range between 0.5 and 3 percent. At the onset of the regime, the BoT for the first time formulated policy decisions by setting the policy interest rate, which at that time was the 14-day repurchase rate in the BoT-operated repurchase market. In recent years, considerable efforts have been taken to improve the effectiveness of monetary policy implementation, including the adoption of the 1-day repurchase rate as the policy interest rate in January 2007 and the shutdown of the BoT-operated repurchase market in February 2008. Consequently, bilateral repurchase transactions with primary dealers became the principal channel of open market operations.

Macroeconomic stability with respect to price and output developments has been achieved under the inflation targeting regime over the past decade. The BoT's performance regarding to accomplishing its inflation target has been impressive, with the core inflation rate residing within the targeted band almost all the time (Figure 1.1).[8] Such a success especially in the early part of the decade could largely be attributed to economic slack induced by the severe recession associated with the financial crisis in 1997, the economic slowdown driven by the US recession in 2001 and the pandemic of Severe Acute Respiratory Syndrome throughout East Asia in 2003. Core inflation reached the bottom in January 2004 before high energy prices led to accelerating inflation since mid-2004. Several policy interest rate hikes from 1.25 to 5 percent between July 2004 and June 2006 successfully subdued inflationary pressure (Figure 1.2). Moreover, the unyielding commitment of the BoT to maintain price stability has not jeopardized output stability so far. The Thai economy has grown at the average rate of 4.7 percent over the period of 2000-2008, with a slight slowdown in 2001 and a moderate boom during 2003-2004 (Figure 1.3).

The Thai baht has been largely determined by market forces since July 2, 1997 when the BoT abandoned the fixed exchange rate arrangement. However, the BoT has always actively engaged in exchange rate management so that Thailand's de jure exchange rate regime was reclassified from independent floating to managed floating on June 30, 2001

[8] The only notable incidence that the core inflation rate was outside the targeted zone, though over a brief period, happened in mid-2009 as a result of the severe recession triggered by the global financial crisis.

(IMF's 2002 Annual Report on Exchange Arrangements and Exchange Restrictions). Prior to 2005, the magnitude of FX interventions remained relatively modest, with an increase in net foreign reserves from 30 to 56 billion US dollars between 2000 and 2005. Conceivably, the accumulation of foreign reserves over that period could reflect policymakers' prudent efforts to build buffers against potential adverse external developments. In contrast, large-scale FX interventions after 2005 became common policy responses to sizeable exchange rate movements, especially those in the strengthening direction. As a result, the level of net foreign reserves has risen sharply, reaching 118 billion US dollars by end-2008 and recently surpassing 190 billion US dollars (as of January 2011). Since almost all of these massive purchases of foreign reserves must be sterilized to maintain appropriate monetary conditions for achieving the targeted inflation rate, the BoT has accordingly issued bonds to absorb excess liquidity in the domestic financial system since 2003. BoT bond issuances became another key policy tool for managing liquidity in addition FX swap transactions and repurchase agreements (Figure 1.7).

The degree of capital mobility has been moderately high after financial liberalization in the early 1990s, as foreign funds can essentially move freely across the border. However, restrictions on financial transactions remain in two major areas. One comprises the limitation on residents to undertake investment in foreign counties, which primarily takes the form of ceilings on the amount of funds and restrictions on the types of investment. Prior to 2006, the amount of domestic outflows for direct investment and portfolio investment abroad had been very limited due to lacking liberalization efforts. Nonetheless, several measures have been introduced since 2007 in order to encourage residents to take up foreign investment opportunities. These liberalization policies have successfully triggered a sizeable amount of domestic outflows, which should help generate some exchange rate depreciation. Another involves the measures to prevent currency speculation, which are the set of regulations restricting transactions that domestic financial institutions can carry out with non-residents. The measures to prevent currency speculation emerged from policy formulation in the spirit of the non-internationalization of the Thai baht in the aftermath of the financial crisis of 1997. Originally, the BoT in January 1998 prohibited domestic financial institutions from providing baht credit facilities to non-residents in the attempt to make it more difficult to launch speculative attacks that induced exchange rate depreciation. In September 2003 amid the concern about sizeable currency appreciation, the BoT, on the contrary, imposed that domestic financial institutions could not borrow in baht from non-residents for maturity of less than 3 months, unless such borrowings supported trade or investment activities in Thailand. Since then, additional regulatory measures have been introduced, and they collectively have become known as the measures to prevent currency speculation. More details of restrictions on financial flows can be found in Annex 1.3.2.

In addition, capital mobility within the domestic economy has been far from perfect. The primary mechanism for channeling funds available from household and corporate savings to productive investment projects relies on the banking system rather than the capital market. Moreover, the financial sector has not been fully open to foreign competition.[9] The mutual fund industry has remained small, notwithstanding its rapid expansion in recent years. At end-2008, the amount of deposits at commercial banks slightly exceeded 7.1 trillion baht, while the amount of assets under management by mutual funds merely reached 1.5 trillion baht.[10] Hence, bank deposits have served as the leading venue of household savings. In addition, the bond market has not been well-developed, with the majority of transactions being completed over the counter rather than in the exchange established in November 2003. Issuances of corporate bonds as well as securitized instruments by domestic entities have been relatively limited so far,[11] while non-residents became able to raise funds in the bond market in April 2007. Similarly, few derivative products are currently traded in the bourse. All these aspects of financial underdevelopment could create unnecessary financial intermediation costs as well as imperfect market functioning, which may in turn provide a basis for the effectiveness of sterilized FX interventions.

1.2.2 Capital Flows and Exchange Rate Movements

The movement of the exchange rate has been closely linked to the development of the balance of payments especially at the time when major changes in the pattern of capital flows take place. For instance, in the aftermath of the financial crisis of 1997, the sudden stop of capital inflows induced substantial exchange rate depreciation by the magnitude conceivably far exceeding what would be required to accommodate adjustments of the current account to its new medium-term position.[12] Another vivid example could be the revival of massive foreign funds which has been the underlying factor for sizeable exchange rate appreciation surrounding the so-called URR regime, which is the focus of the discussion here.

Developments in the external sector had been broadly stable over the period of 2001-2004 during which fluctuations in both real and nominal effective exchange rates had

[9] According to the Financial Master Plan II, opening up the financial sector further to new entry of foreign financial institutions is scheduled in 2012.

[10] The mutual fund industry, however, has expanded rapidly in the past few years. By November 2010, the amount of assets under management rose to almost 2 trillion baht, while the amount of deposits increased marginally to 7.3 trillion baht.

[11] At end-2008, the stock of corporate bonds issued, which still remained slightly below 1 trillion baht, was markedly smaller than the amount of credits extended by financial institutions to non-financial companies, which stood around 4 trillion baht.

[12] This episode is discussed in Chapter 4.

been relatively small around their trends. The current account balance had been in surplus of 4.1 percent of GDP on average between 2000 and 2004. Furthermore, net capital outflows had remained the norm during 1998-2003, chiefly due to the repayment of external debt accumulated prior to the crisis (Figure 1.5 and 1.6).

However, the situation changed dramatically in 2005. A large bill of imported petroleum products, which was driven by high energy prices together with government subsidy programs, caused the current account balance to post a huge deficit of 9.1 percent of GDP in the first half of 2005.[13] At the same time, Thailand started experiencing an influx of foreign funds primarily trigged by international financial markets' excess liquidity as well as foreign investors' risk appetite. Meanwhile, the repayment of external debt came to an end. This surge in capital inflows mainly consisted of direct investment and portfolio equity investment, in contrast to the pre-crisis experience which was largely dominated by lending and investment in debt securities. Even though the volume of net financial inflows in 2005 reached such a high level similar to that of 1993-1994, the exchange rate remained stable as the development of different components of the balance of payments counteracted each other's effects on currency movements.

In 2006, massive capital inflows started placing significant pressure on the exchange rate, as the current account balance no longer remained in deficit. The huge volume of financial inflows continued amid ongoing political turmoil, which undermined both consumer confidence and business sentiment and thus contributed to a considerable decline in imports. Throughout 2006, the Thai baht had steadily appreciated from 41.1 baht per US dollar at the beginning of the year to 35.2 baht per US dollar right before the introduction of the URR measure, recording the magnitude of appreciation around 15 percent. Outsized appreciation of the real effective exchange rate also occurred by about 10 percent. Unsurprisingly, the Thai baht appreciated against major currencies as well as other currencies in the region (Figure 1.4). Such alarming developments, underlined by substantial currency appreciation together with weak private domestic demand due to the unstable political situation, led the BoT to undertake various policy actions to curb exchange rate appreciation. These policy responses featured tightening the measures to prevent currency speculation, undertaking large-scale sterilized FX interventions, imposing capital controls in the form of URR, lowering the policy interest rate, and liberalizing restrictions on domestic financial outflows. Since the implementation of the URR measure appeared as the central event (though, arguably not the most effective policy instrument) during this currency appreciation episode of 2006-2008, the episode is thus referred to as the URR regime.

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[13] The government originally viewed that the increase in energy prices was temporary, and thus implemented subsidy programs. As the funding of programs looked unsustainable and the increase in energy prices seemed permanent, the government eventually discontinued such subsidies. The marked decline in energy consumption led to a sharp current account improvement after subsidy programs were abandoned.

1.2.3 Policy Responses to Currency Appreciation during 2006-2008

Continual and sizeable exchange rate appreciation that occurred between January 2006 and March 2008 raised a serious concern because it could significantly undermine Thailand's competitiveness during the time that the country needed to rely on exports to act as the engine for economic growth. As a result, the BoT had endlessly employed various policy instruments to restrain currency appreciation.

Even though the Thai baht had continued appreciating since the beginning of 2006, policy actions seemed fairly limited in the early part of 2006. Sterilized interventions in the FX market appeared as the first line of policy responses, with an increase in net foreign reserves at the rate of 1.1 billion US dollars per month between January and September, in comparison to an increase at the rate of 4.3 billion US dollars per year during 2000-2005 (Table 1.1). However, when the currency strengthening trend became apparent and the Thai baht further gained appreciation momentum after the military coup in September, the scale of sterilized FX interventions became much larger. The BoT acquired net foreign reserves in the amount of 0.5 and 1.4 billion US dollars per week in October and November, respectively. Nonetheless, such sizable FX interventions seemed futile to slow down the pace of exchange rate appreciation.

In November, the BoT turned to regulatory measures by tightening the measures to prevent currency speculation. In particular, on November 3, domestic financial institutions were not allowed to issue bills of exchange in baht to non-residents. Furthermore, on December 4, additional measures were introduced. Accordingly, domestic financial institutions could neither engaged in repurchase agreements denominated in baht with non-residents at any maturity nor borrow in baht from non-residents for maturity of less than 6 months (previously, 3 months). In addition, non-residents might invest in public debt securities only if their holding would last longer than 3 months. At the same time, the BoT scaled down sterilized FX interventions in December, with an increase in net foreign reserves at the rate of 0.3 billion US dollars per week (Table 1.1). Such policy actions looked very surprising especially at the time when the pace of currency appreciation was accelerating.[14]

As all earlier policy responses seemed unsuccessful to moderate the pace of exchange rate appreciation, the BoT decided to introduce the URR measure on December 18 in

[14] One plausible explanation was that the BoT at that time concluded that sterilized FX interventions were ineffective in breaking down the strong currency strengthening trend, and thus considered introducing the URR measure. Moreover, the BoT's top management might be worried that they could become liable to the valuation loss associated with FX interventions, which was likely if the Thai baht continued to appreciate frenziedly against all major currencies. The concern could arise based on the earlier incidence that the Civil Court ordered Rengchai Maragonond, a former central bank governor who effectively became the sole scapegoat, to pay 186 billion baht for the loss incurred to the BoT as a result of defending the currency peg in a series of intense speculative attacks in 1997.

order to "safeguard the stability of the Thai baht and prevent currency speculation."[15,16] The measure stipulated that 30 percent of all incoming foreign-currency funds were subjected to the reserve requirement. The reserve in the currency of incoming funds must be deposited in a non-interest-bearing account at the central bank for the withholding period of one year after which the reserve would be returned. If such funds stayed in the country for less than one year, only two-thirds of the reserve would be returned; thus, any early withdrawal would entail a hefty penalty equivalent to 10 percent of incoming funds. Originally, the reserve requirement applied to all types of capital inflows except foreign direct investment.[17]

The URR measure triggered a stock market crash, but policymakers promptly relaxed capital controls to restore market confidence. On December 19, the day that the URR measure came in effect, Thailand's stock market experienced the largest one-day decline in its 31-year history. The SET index plunged by 8.9 percent at the market opening before continually tumbling to the daily trough which marked the dramatic fall of 19.5 percent. Then, the SET index rebounded moderately towards the end of the turbulent trading day, which recorded the historical decline of 14.8 percent. The severe stock market crash forced the BoT to lift the control on inflows to the stock market in the evening of December 19. On the next day, the stock market responded to the partial removal of capital controls with a strong rebound; the SET index rose 11.2 percent accordingly.

Although the URR measure seemed to succeed in breaking down the momentum of currency appreciation, the Thai baht soon returned to its strengthening trend. The URR measure immediately induced around 3 percent of exchange rate depreciation within one week. However, the Thai baht started appreciating again, and by March 2007 became even more appreciated than it was prior to the introduction of capital controls. Regardless of whether the URR measure helped safeguard the stability of the Thai baht,

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[15] The URR measure was a well-known form of controls on financial inflows, largely due to Chile's experience in the 1990s.

[16] According to Inflation Report (January 2007), the BoT considered various measures to reduce short-term capital inflows and curb exchange rate appreciation. Potential options included restrictions on the volume of inflows, requirements of the minimum stay, direct taxes on inflows or outflows, fees on FX transactions, and reserve requirements for incoming foreign funds. At the end, the Bank opted for the URR measure based on the rationale that its price-based approach should appear more market-friendly. Furthermore, the reserve requirement could be implemented in a timely manner since it was under the central bank's jurisdiction, while tax measures would require an approval from the Ministry of Finance. The BoT also viewed that requirements of the minimum stay would significantly hamper foreign investors' confidence because they could not repatriate their funds before the end of the specified period.

[17] Based on Chile's experience, which illustrated how capital controls had to be tightened several times to close down loopholes, the BoT originally worried that the URR measure might not be sufficiently effective if some types of incoming foreign funds received an exemption. Therefore, all incoming foreign-currency inflows with the amount of greater than 20,000 US dollars were subjected to the reserve requirement. However, foreign direct investment inflows were exempt upon presenting a valid document.

the BoT significantly lost its creditability after the stock market collapsed as a result of its implementation of capital controls. Moreover, consumer confidence and business sentiment deteriorated considerably, further depressing domestic demand that had remained weak due to ongoing political turmoil. Another undesired consequence was the emergence of a two-tier exchange rate market structure in which offshore currency movements sometime influenced onshore exchange rate dynamics reportedly through the channel underpinned by psychological factors (Figure 1.4).[18]

During the URR regime, the BoT relaxed capital control measures on a number of occasions by granting an exemption from the reserve requirement to certain types of financial inflows. The most important relaxation was to provide an alternative option of full hedging (see Table 1.2 for additional details). Specifically, people who brought foreign-currency funds into Thailand in the form of loans or in order to invest in debt securities and unit trusts could choose between depositing the reserve requirement and hedging against exchange rate risks completely. It turned out that the majority of financial inflows occurred under the full hedging scheme. Even though these relaxations could make the URR measure become largely ineffective, the BoT considered that such policy actions were necessary when private investment still remained weak. The underlying reasons were that a large portion of investment projects relied critically on foreign financing and that incoming foreign funds under the full hedging scheme should not generate additional exchange rate appreciation.[19]

Nevertheless, the BoT resorted to other policy instruments to mitigate currency appreciation. Particularly, the policy interest rate was cut, the scale of sterilized FX interventions was expanded, and the liberalization of domestic financial outflows was initiated. In its first meeting after the URR measure was introduced, the Monetary Policy Committee started lowering the policy interest rate based on the justification that inflationary pressure subsided while economic activity looked fragile. In 2007, the policy interest rate had been successively brought down from 5 percent in January to 3.25 percent in July (Figure 1.2). However, the BoT remained adamant on the view that reducing interest rates would neither help slow down capital inflows nor mitigate exchange rate appreciation.[20] At the same time, the BoT had engaged in massive sterilized FX interventions, with the stock of net foreign reserves rising substantially from 74 to 124 billion US dollars between December 2006 and February 2008 (Figure

[18] Fundamentally, the divergence should arise because the URR measure, which only applied to incoming foreign-currency funds, made offshore baht more valuable. However, no strong economic reasons existed for why the onshore currency movements should follow the offshore exchange rate dynamics, which were primarily driven by the day-to-day availability of offshore baht.

[19] Full hedging would trigger outflows by exactly the same amount of inflows so that the net impact on currency movements should be nil.

[20] Interestingly, this argument also appeared as one of the BoT's major reasons for maintaining the policy interest rate at a high level until then.

1.7). The magnitude of FX interventions was exceptionally large in September and October 2007 as well as all the three months in the first quarter of 2008, as the increase in net foreign reserves surpassed that of November 2006 (Table 1.1). Apparently, the BoT became much more reliant on sterilized FX interventions during the URR regime.[21] Furthermore, the BoT on a number of occasions relaxed restrictions on financial transactions among which the liberalization of domestic financial outflows was the most important (see Annex 1.3.2 for additional details). The underlying motivation was that the expanded freedom of residents to hold foreign currency and invest abroad should encourage additional capital outflows and lessen currency appreciation pressure. These liberalization measures seemed highly successful, as the outstanding stock of portfolio investment in foreign countries in 2007 rose from 5 to 15 billion US dollars in addition to an increase in outward direct investment by about 2 billion US dollars.

Notwithstanding various policy actions undertaken to limit currency appreciation, the Thai had continually appreciated by 10.3 percent against the US dollar and by 3.4 percent based on real effective exchange rate movements. Substantial exchange rate appreciation in 2007 was more likely to result from the correction of the gigantic current account surplus of almost 16 billion US dollars, equivalent to 6.2 percent of GDP. While the influx of foreign funds prevailed in 2007, it was largely offset by the huge outflow of domestic funds induced by liberalization policies so that the financial account was roughly in balance (Figure 1.6).

The removal of the URR measure occurred on February 29, 2008, mainly due to the political pressure from the newly elected government. In the first quarter of 2008, Thailand experienced a sizeable amount of net financial inflows, primarily resulting from the attempt by domestic banks to reduce their holding of overseas assets.[22] This repatriation alone induced an inflow amounting to 6.7 billion US dollars, which in turn accelerated exchange rate appreciation. Nonetheless, the BoT decided to revoke all restrictions implemented under the URR measure based on the justification that economic forces underpinning currency appreciation would diminish. In particular, an increase in domestic demand was projected as the political situation should improve after the

[21] These large-scale interventions in the FX market were mostly sterilized as the expansion in monetary base seemed fairly limited. Between December 2006 and February 2008, the outstanding amount of BoT bonds ballooned from 897 to 1,451 billion baht, the net FX forward position increased from 250 to 743 billion baht, and the net position of repurchase agreements from open market operations soared from 125 to 530 billion baht (Figure 1.7).

[22] Such development could reflect the attempt by banks to hedge against exchange rate risks resulting from their exposure to FX forward transactions with exporting firms that sold dollar in advance due to their fear of additional currency appreciation. Although the foreign asset position of banks increased markedly during 2006-2007 because of their acting as a counterparty of swap transactions primarily with the BoT and also possibly with people who brought funds under the full hedging scheme, the BoT's FX forward position (i.e. banks' sold position) though remaining sizeable became insufficient to match the sale of dollar by exporting firms (i.e. banks' bought position) in the first quarter of 2008.

election; consequently, the demand for imported capital goods used to expand the production capacity would rise, and the current account surplus would narrow.

The Thai baht actually became weaker after the URR measure was taken away, although such currency depreciation chiefly resulted from deteriorating conditions in international financial markets. Incidentally, the removal of the URR measure coincided with the beginning of strained liquidity condition and declining risk appetite that occurred after the collapse of Bear Sterns in March 2008. These adverse developments at the global level led to a slowdown in foreign direct investment as well as a reversal of non-resident portfolio investment, both of which helped generate some exchange rate depreciation.

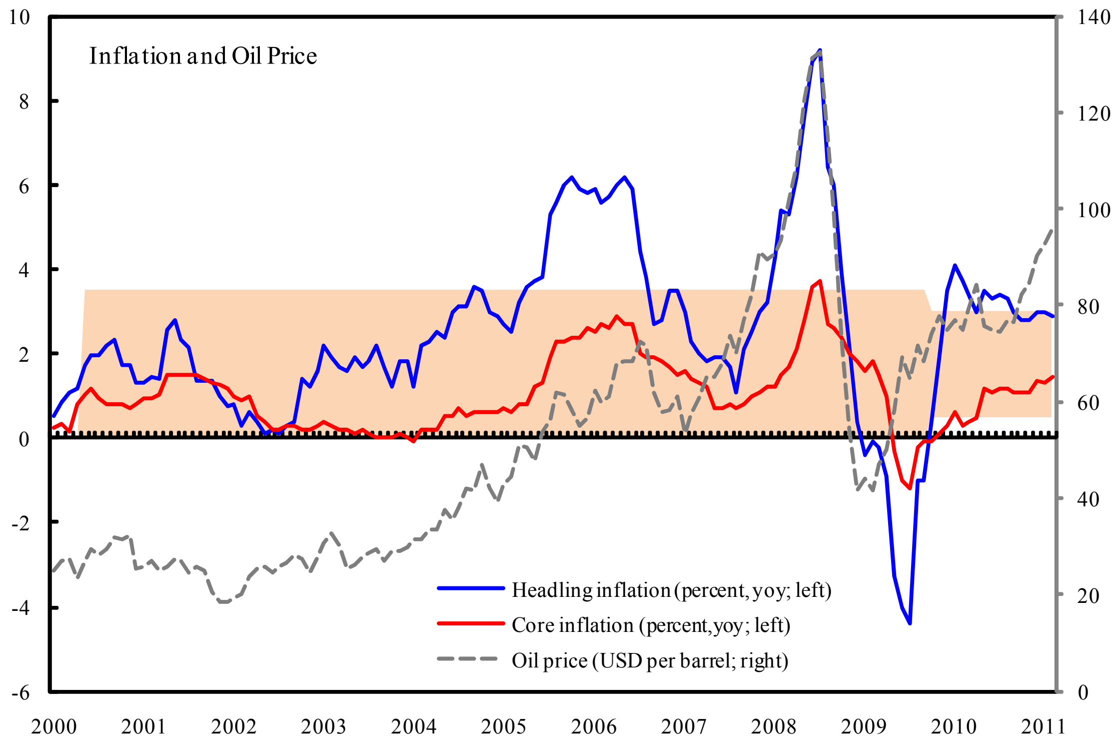
To sum up, the BoT had aggressively implemented various policy measures in response to sustained and sizeable exchange rate appreciation starting from early 2006. These policy actions included tightening the measures to prevent currency speculation, undertaking large-scale sterilized FX interventions, implementing the URR measure, lowering the policy interest rate, and liberalizing restrictions on domestic financial outflows. The mix of various policy instruments made this episode of currency appreciation driven by massive capital inflows particularly interesting and worth being studied.[23] Seemingly, these policies helped preserve Thailand's macroeconomic stability when the economy faced massive capital inflows in the presence of weak domestic demand due to ongoing political turmoil. The moderate economic growth by about 5 percent in 2007 was mainly supported by the strong expansion in exports, which might not have materialized without the BoT's policy responses that strived to mitigate exchange rate appreciation.

[23] For Thailand, there have been four episodes of substantial exchange rate appreciation, defined as occurring when the size of appreciation against the US dollar over the preceding year exceeds 10 percent (Figure 1.4). The first episode, which occurred briefly during April - August 2002, was largely welcomed as the strengthening baht helped reduce the country's burden to service external debt. The second episode, which took place during September 2003 - May 2004, prompted the BoT to tighten the measures to prevent currency speculation. In these two episodes, policy actions were very limited because large currency appreciation was short-lived. On the contrary, the third episode, which is the focus of the discussion in this chapter, spanned over May 2006 - June 2008. The ongoing fourth episode began in July 2010 right after the Thai economy started recovering from a severe recession caused by the global financial crisis. Conceivably, the disruption between the third and fourth episodes mainly resulted from the global financial crisis; otherwise the Thai baht could have been continually appreciating if massive foreign funds did not abate.

1.3 Annex

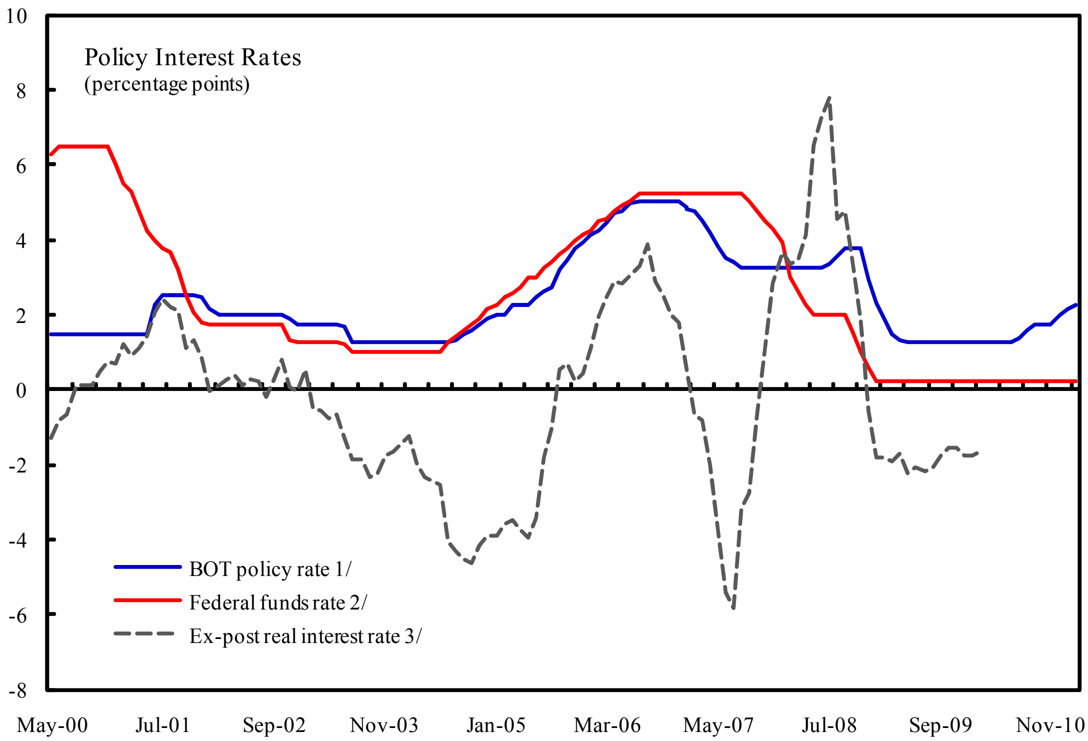
1.3.1 Figures and Tables

Figure 1.1 Thailand: Inflation



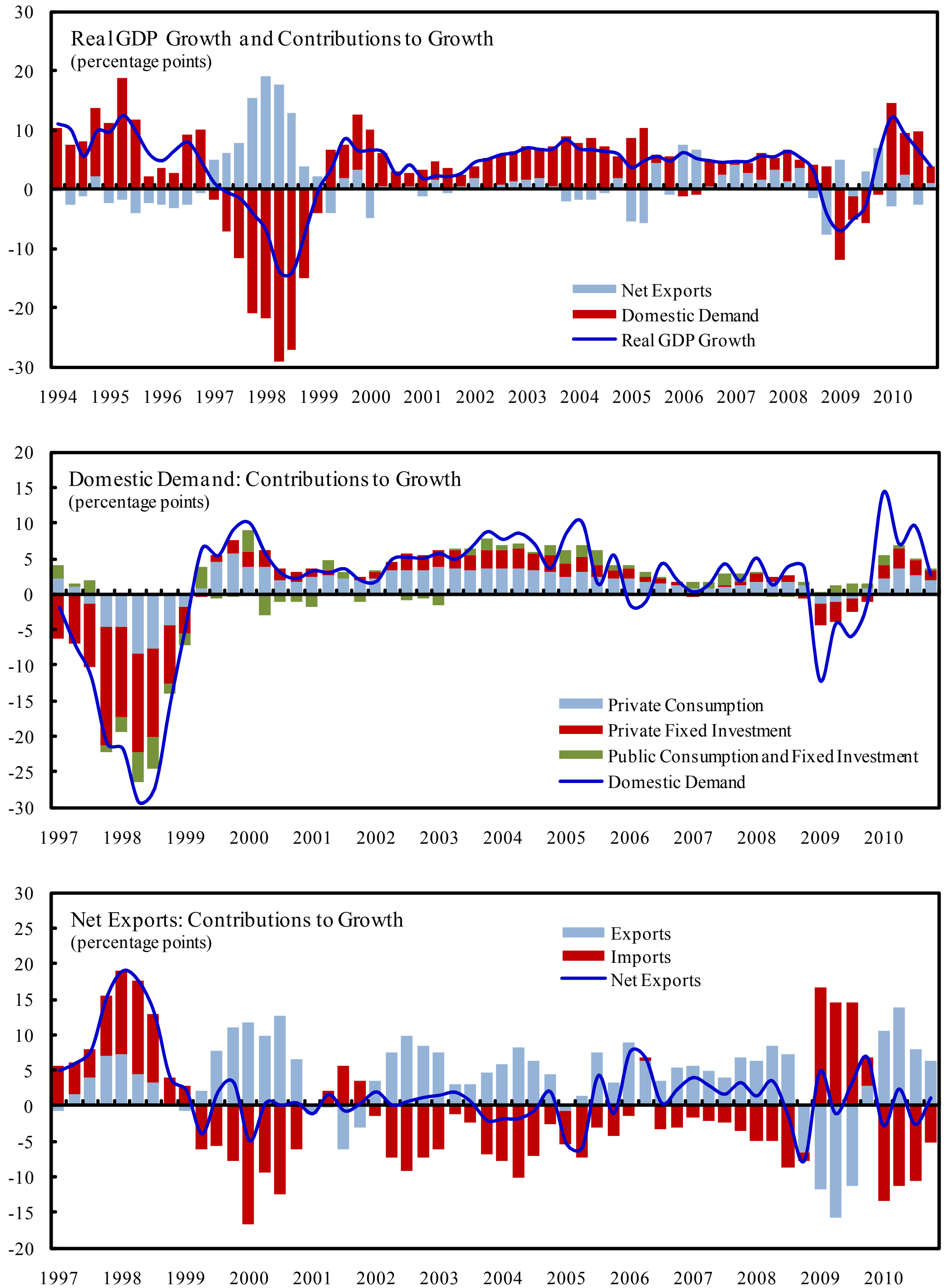
Sources: International Monetary Fund, World Economic Outlook; Ministry of Commerce (Thailand); and author's calculations.

Figure 1.2 Thailand: Policy Interest Rates



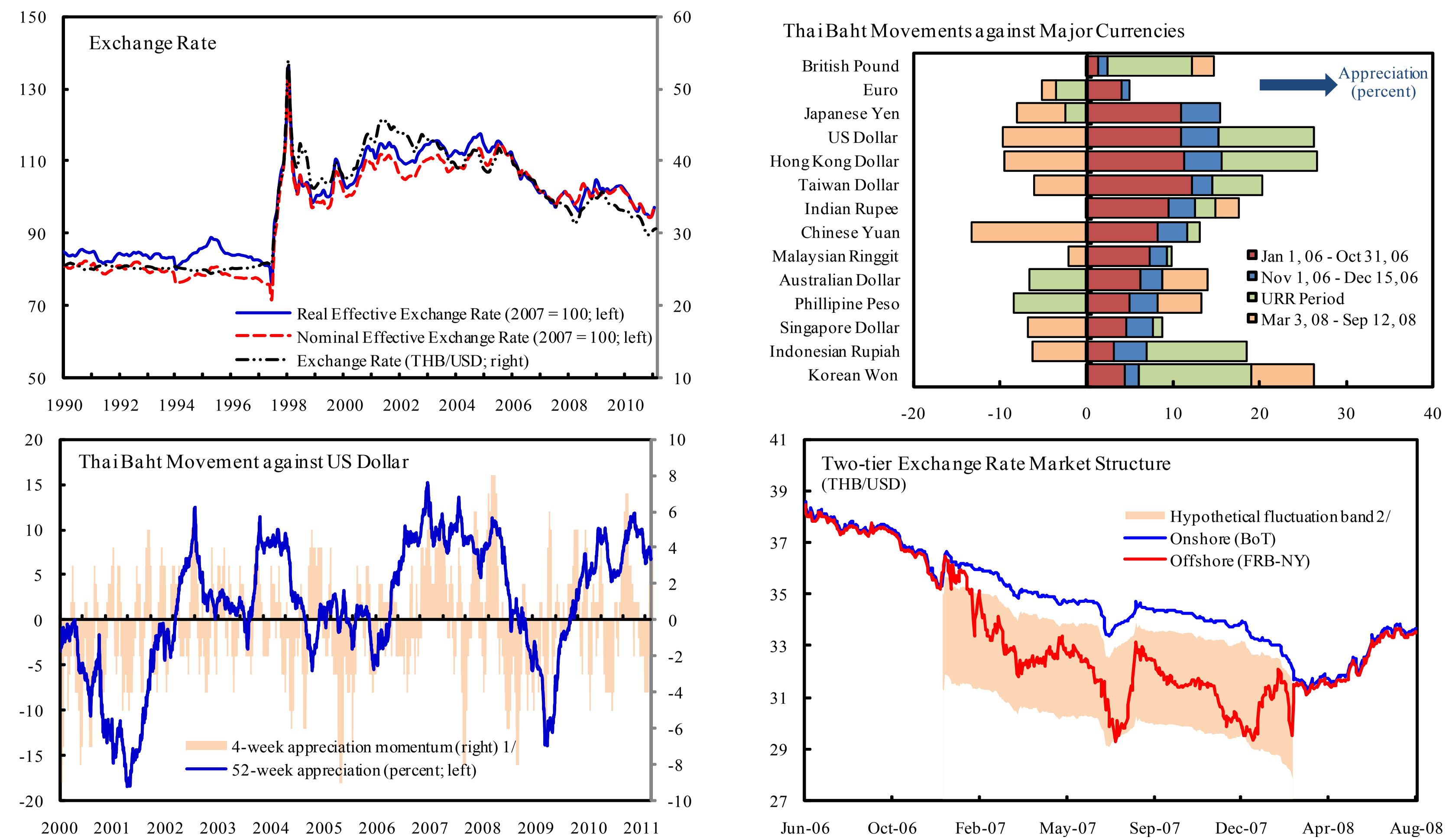
Sources: Bank of Thailand; Ministry of Commerce (Thailand); and author's calculations.
Note:
1. The 14-day repurchase rate until January 16, 2007; the 1-day repurchase rate afterwards.
2. The target rate until December 15, 2006; the maximum bound afterwards. The federal funds rate has been targeted between 0 and 25 basis points since December 16, 2006.
3. Based on the Bank of Thailand's policy rate and the headline inflation rate.

Figure 1.3 Thailand: Economic Growth



Source: National Economic and Social Development Board (Thailand); and author's calculations.

Figure 1.4 Thailand: Exchange Rate Developments

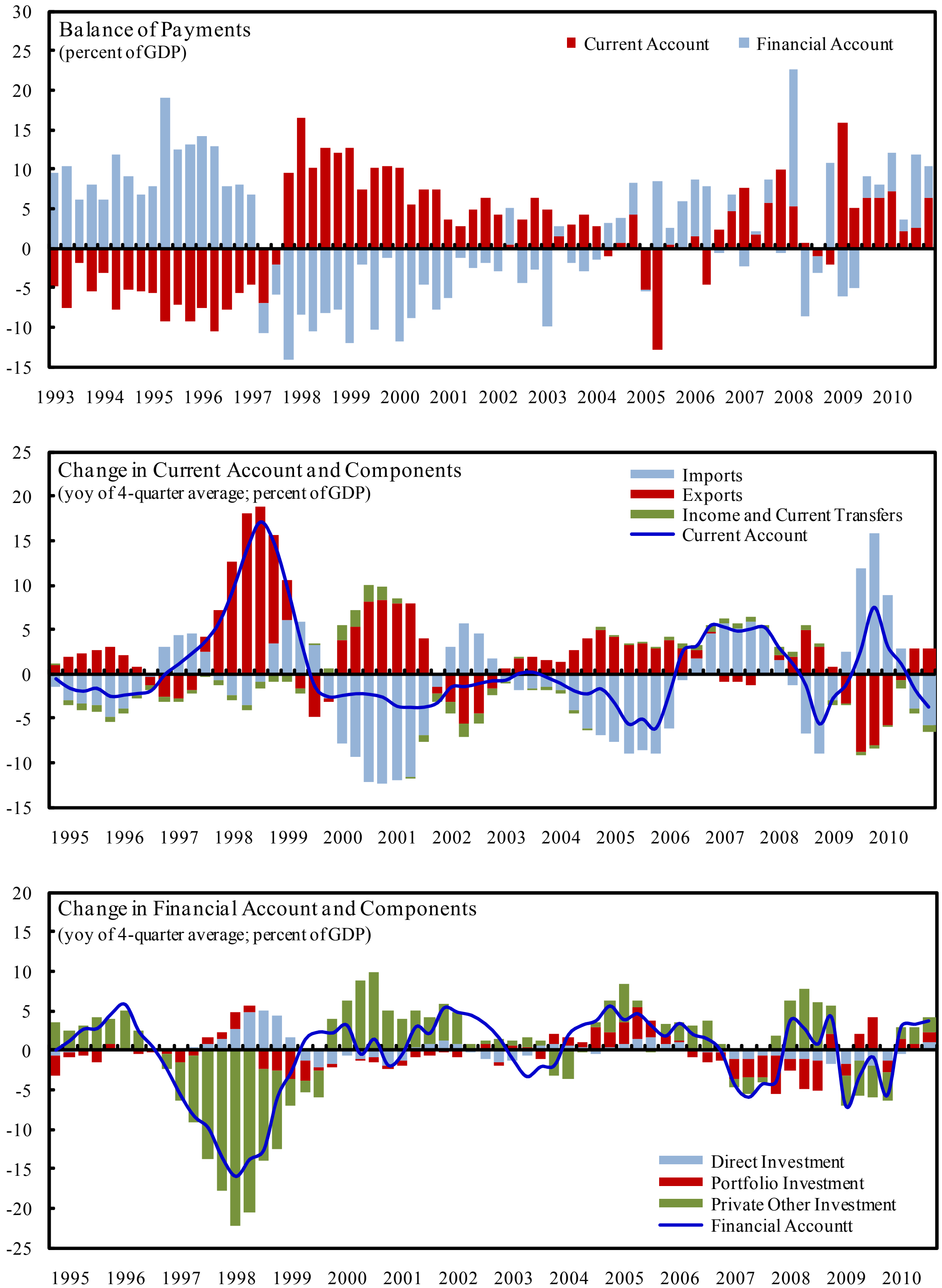


Source: Bank of Thailand; and author's calculations.

Note:

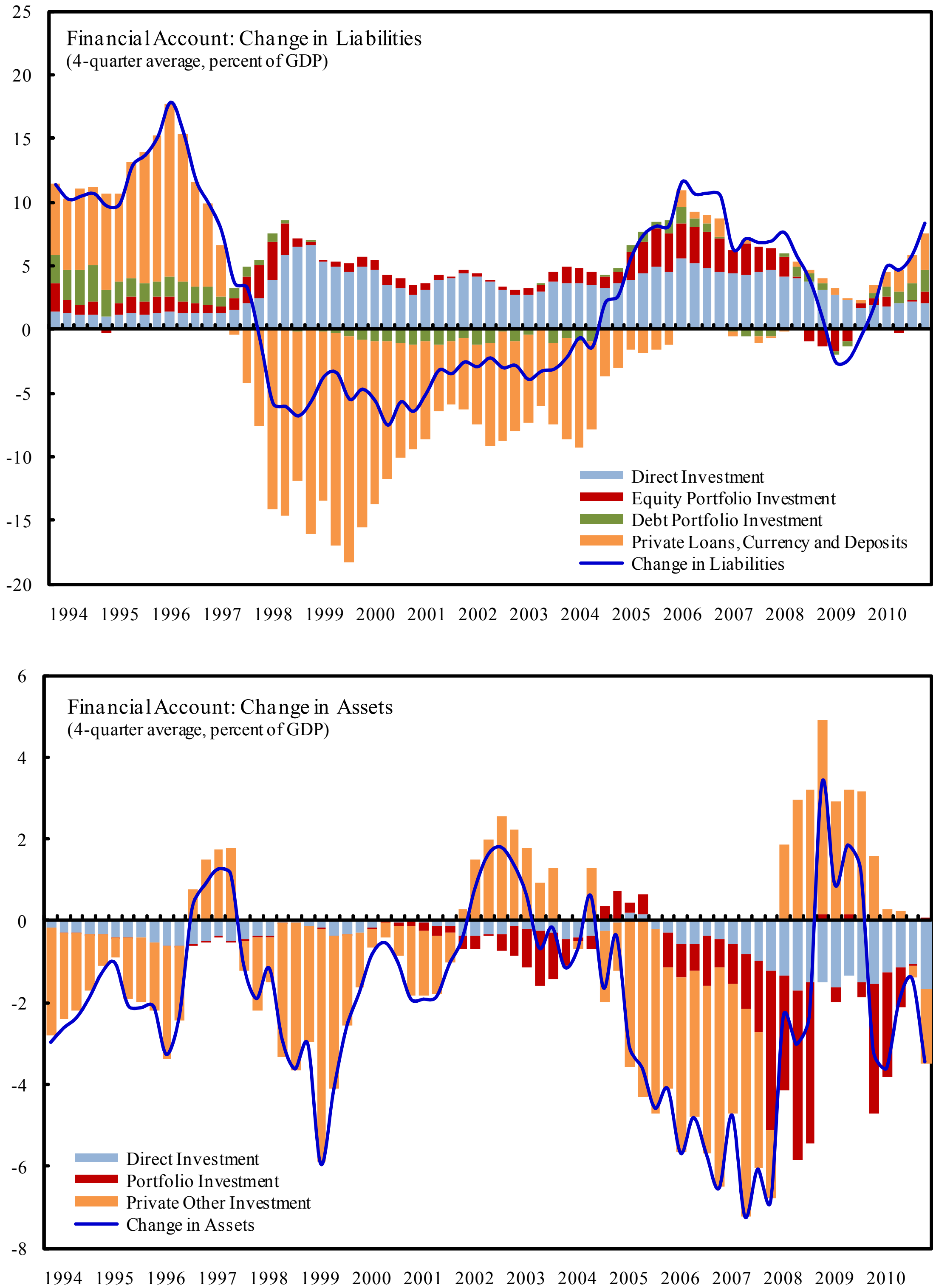
1. Based on the number of days with currency appreciation over the past 20 days (i.e. 4 weeks), with plotting on the scale of [-10, 10] rather than [0, 20].
2. Based on cost advantages from avoiding the reserve requirement and the penalty on early withdrawal.

Figure 1.5 Thailand: Balance of Payments



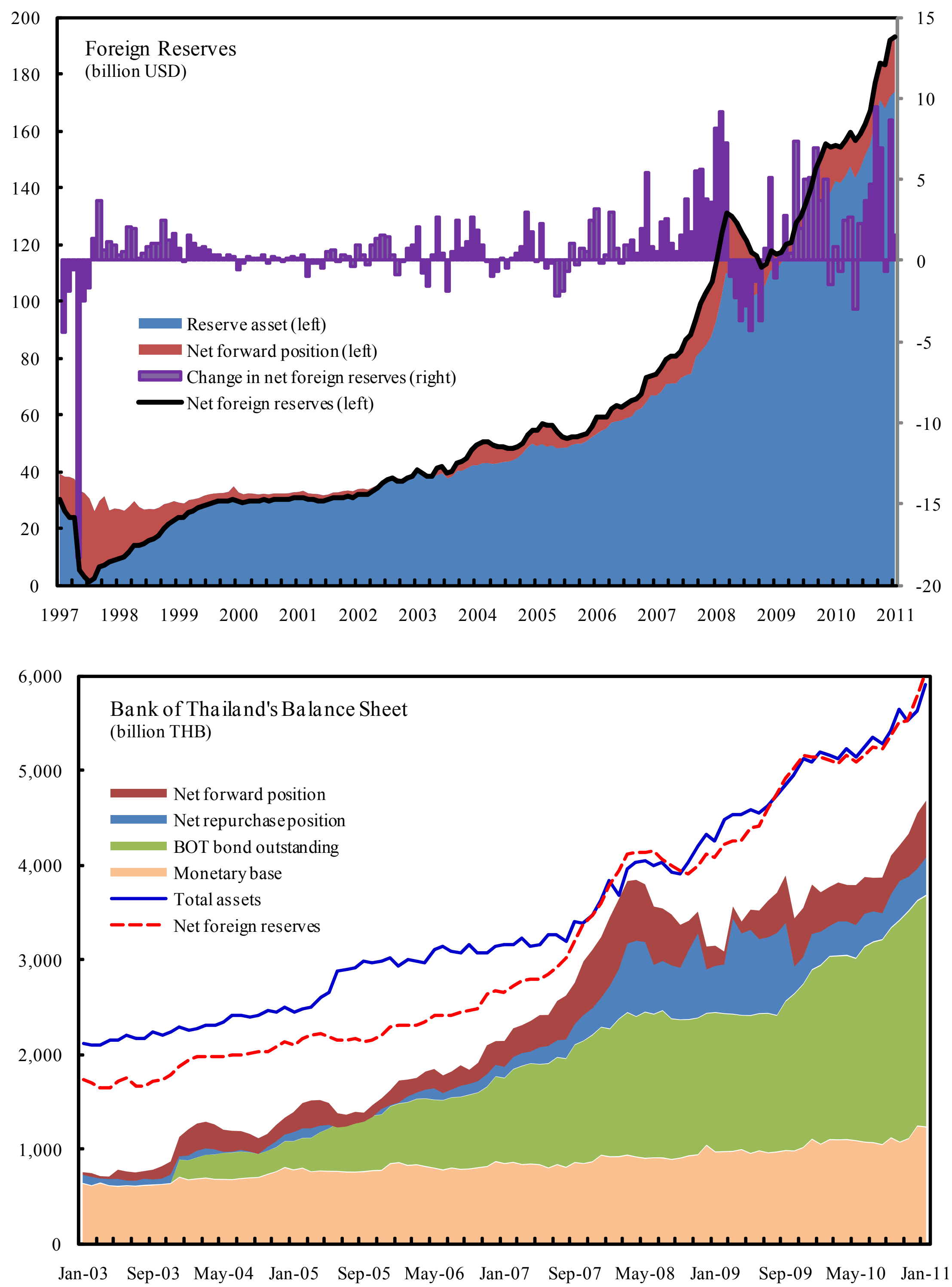
Sources: Bank of Thailand; National Economic and Social Development Board (Thailand); and author's calculations.

Figure 1.6 Thailand: Capital Flows



Sources: Bank of Thailand; National Economic and Social Development Board (Thailand); and author's calculations.

Figure 1.7 Thailand: Foreign-Exchange Interventions



Source: Bank of Thailand; and author's calculations.

Table 1.1 Bank of Thailand's Interventions in the Foreign Exchange Market

	Change in Reserve Asset (billion USD)	Change in Forward Position (billion USD)	Change in Net Foreign Reserves (billion USD)	Number of Months
Pre-URR period				
2000 - 2004	15,051	9,394	24,445	60
2005	2,234	-760	1,474	12
Jan - Sep 2006	9,527	145	9,672	9
Oct 2006	710	1,306	2,016	1
Nov 2006	2,186	3,245	5,431	1
Dec 2006 before URR	173	425	598	0.5
URR period				
Dec 2006 after URR	2,323	-2,020	303	0.5
2007	22,793	10,125	32,918	12
Jan - Feb 2008	13,084	4,234	17,318	2
Post-URR period				
Mar - Dec 2008	10,469	-16,365	-5,896	10
2009	27,410	8,715	36,125	12
2010	33,711	3,926	37,637	12

Source: Bank of Thailand; author's calculations.

Table 1.2 Details of the Unremunerated Reserve Requirement Measure

Timeline of the Unremunerated Reserve Requirement Measure

2006	
18-Dec	**General rule:** Unremunerated reserve requirement = 30 percent Withholding period = 12 months Penalty on early withdrawal = 2/3 of reserve withheld **Exemptions:** (1) Foreign currency not exceeding 20,000 USD or its equivalence at market prices (2) Foreign currency of residents from trade in goods and services and from repatriation of investments abroad (3) Foreign currency withheld as reserve requirement and subsequently refunded (4) Foreign currency as a consequence of foreign exchange transactions prior to December 19, 2006 (5) Foreign currency as part of interbank transactions for their own business (6) Foreign currency specially permitted on a case-by-case basis
22-Dec	**Additional Exemptions:** (1) Foreign currency for direct investment, government loans and investment in immovable assets (2) Foreign currency of embassies, consulates, international organizations and Thai government agencies abroad (3) Foreign currency loans with contracts signed prior to December 19, 2006 (4) The rollover of swap transactions hedging against exchange rate risk with the same counterparty (5) Traveler's checks and foreign banknotes (6) Foreign currency for investment in equity registered at the Stock Exchange of Thailand and the Market for Alternative Investment, as well as investment in Non-Voting Depository Receipt, the Thai Futures Exchange and the Agricultural Futures Exchange of Thailand **Notes:** (1) All additional exceptions applied to transactions prior to December 22, 2006. This announcement officially included only additional exceptions (1) to (5); however, additional exception (6) seemed effective since December 19. (2) Foreign currency for investment purpose based on additional exception (6) must be transacted through Special Non-resident Baht Account for Securities (SNS). The maximum limit of deposits in SNS is 300 million THB a consolidated entity.
2007	
29-Jan	**Additional Exemptions:** (1) Foreign currency loans for export (packing credit) (2) Foreign currency from loans or issuances of debt securities that specify maturity and are fully hedged (up to 1 year) in a Plain Vanilla form of FX swaps or cross-currency swaps (3) Foreign currency for investment in Depository Receipt, Warrants and Transferable Right Subscriptions (4) Foreign currency for purchasing debts under restructuring plans (5) Foreign currency for payments of guarantee obligations

2007	
1-Mar	**Additional Exemption:** (1) Foreign currency for investment in debt securities and unit trusts (i.e. mutual funds and property funds) for at least 3 months, which are fully hedged in a Plain Vanilla form of FX swaps or cross-currency swaps.
	Notes: (1) This relaxation did not include short-term debt instruments such as bills of exchange and negotiable certificates of deposit. (2) Foreign currency for investment purpose based on additional exception (1) must be transacted through Special Non-resident Baht Account for Debt Securities and Unit Trusts (SND). The maximum limit of deposits in SND is 300 million THB a consolidated entity.
9-Aug	**Additional Exemption:** (1) Foreign currency of residents from foreign-currency accounts
5-Sep	**Additional Exemption:** (1) Foreign currency for investment in exchange traded funds (ETF) registered at the Stock Exchange of Thailand
17-Dec	**Additional Exemptions:** (1) Foreign currency for investment in additional offerings of existing property funds (2) Foreign currency of (juristic person) residents from loans or debt instruments not exceeding 1 million USD (3) Foreign currency of (juristic person) residents from loans, which are naturally hedged (i.e. future foreign currency from trade)
2007	
Feb-29	**Removal of the Unremunerated Reserve Requirement**

Full Hedging Option by Types of Inflows

Type of Inflows	Original Measures on 18-Dec-08	Remaining Measures as of 29-Feb-08
Trade	Exempt	Exempt
Foreign direct investment	Exempt	Exempt
Portfolio investment: equity	URR	Exempt (SNS) 1/
Portfolio investment: debt	URR	URR or Full Hedging (SND) 2/
Portfolio investment: unit trust	URR	URR or Full Hedging (SND) 2/
Loan	URR	URR or Full Hedging 3/
Derivative (e.g. swap)	Exempt	Exempt
Non-resident baht account	Exempt	Exempt

Source: Author’s compilation based on Bank of Thailand’s various announcements
Note:
1. Exemption only applied to equity traded in the stock exchange.
2. Full hedging option began on March 1, 2007.
3. Full hedging option began on January 29, 2007.

1.3.2 Restrictions on Capital Flows in Thailand

The degree of capital mobility has been moderately high since financial liberalization in the early 1990s. Particularly, Thailand's macroeconomic institutional framework in the context of the trinity constraint can be generally characterized by capital mobility and currency peg in the pre-crisis period, and capital mobility and monetary autonomy in the post-crisis period. At present, while foreign funds can essentially move freely across the border after financial liberalization in the early 1990s, certain restrictions on financial transactions still remain in two major areas.

❖ Financial Liberalization in the Early 1990s

The degree of capital mobility markedly increased as a result of financial liberalization in the early 1990s. Financial liberalization in the domestic domain primarily involved removing ceilings on interest rates, expanding activities of financial institutions and eliminating repressive financial measures. In May 1990, Thailand made a commitment to remove restrictions on current payments by formally accepting Articles VIII of the International Monetary Fund's Articles of Agreement. Furthermore, financial liberalization enabled all other types of foreign funds in addition to foreign direct investment, which has always been an integral part of Thailand's economic development, to move freely across the border. Nevertheless, certain exchange controls as well as restrictions on residents to undertake investment abroad remained in place. In March 1993, the Bangkok International Banking Facility (BIBF) was established to facilitate residents to borrow foreign-currency funds from abroad via commercial banks located in Thailand. The setup of this new external borrowing arrangement led to a significant increase in private financial inflows, which in turn helped fuel the credit boom, support the development of asset price bubbles and finance the huge current account deficit. At the end, Thailand got hit severely by a financial crisis in 1997 mainly because financial liberalization was undertaken without appropriate prudential regulation and adequate financial supervision being put in place.

❖ Remaining Restrictions on Financial Flows

Remaining restrictions on financial flows can be categorized into three main groups: the limitation on residents to undertake investment abroad, the set of exchange controls, and the measures to prevent currency speculation. The following discussion addresses each category in turn.

The limitation on residents to undertake investment abroad imposes restrictions on non-financial domestic entities to engage in direct investment and portfolio investment in foreign countries. Since 2007, these restrictions have been relaxed for several times in order to accommodate the strategic expansion of Thai businesses in foreign countries and to generate additional domestic financial outflows to mitigate sustained and sizeable exchange rate appreciation. The liberalization process is summarized below in Table 1.3.

Table 1.3 Details of Restrictions on Residents to Undertake Investment Abroad

Restrictions on Direct Investment and Lending Abroad		
Date	Type of Investment §	Maximum Limit (million USD)
1-Apr-91	Direct investment and lending to affiliated companies	5
2-Feb-94	Direct investment and lending to affiliated companies	10
30-Jul-02	Direct investment and lending affiliated companies	10
12-Jan-07	Direct investment and lending to affiliated companies Direct investment and lending to parent companies	50 20
24-Jul-07	Direct investment Direct investment and lending to affiliated companies Direct investment and lending to parent companies	100 † 50 20
4-Feb-08	Direct investment Direct investment and lending to affiliated companies Direct investment and lending to parent companies	unlimited † 100 100
5-Oct-10	Direct investment and lending to intra-group companies	unlimited ξ 100 ξ

† Only for Thai public companies listed in the Stock Exchange of Thailand with positive net worth
ξ Unlimited for juristic persons; limited by 100 million USD for natural persons.
§ An affiliated company refers to a foreign company whose at least 10 percent (25 percent prior to July 30, 2002) of shares are held by a Thai parent company. A parent company refers to a foreign company which holds at least 10 percent of shares in a Thai subsidiary company. An intra-group company refers to a foreign company that is at least 50 percent owned by its mother company, with the domestic entity must be a part of the group.

Regulations on Portfolio Investment Abroad	
2000	Financial institutions could sell some types of foreign securities to institutional investors up with a limit of 10 million USD per institutional investor.
2001	The Securities Exchange Commission (SEC) announced the guideline on how mutual funds and provident funds could set up their foreign investment units. The aggregate limit administrated by the SEC was set at 200 million USD.
22-Jul-03	Six types of institutional investors were allowed to undertake portfolio investment abroad: government pension fund, social security fund, provident funds, mutual funds (excluding private funds), insurance companies, and specialized financial institutions. However, prior approval must be obtained from the Bank of Thailand (BoT). Securities allowed for investment included (1) Thai debt securities issued abroad prior to January 1, 2003 and (2) foreign sovereign or quasi-sovereign debt securities ranked by international credit rating agencies as investment grade.
2004	The aggregate limit administrated by the SEC increased to 500 million USD.

Regulations on Portfolio Investment Abroad (… continued)	
20-Apr-05	Securities allowed for investment included (1) Thai debt securities issued abroad, (2) foreign sovereign or quasi-sovereign debt securities ranked by international credit rating agencies as investment grade, and (3) foreign investment units supervised by agencies that were members of International Organization of Securities Commissions or were issued in security exchanges that were members of World Federation of Exchange, and such investment units must also invest in debt securities specified in (1) and (2) and must not be part of hedge funds.
12-Oct-05	Securities allowed for investment were expanded to include securities issued under the Asia Bond Fund program.
19-Dec-05	Undertaking investment in credit derivatives was allowed.
Jun-06	The aggregate limit administrated by the SEC increased to 1.3 billion USD.
12-Jan-07	Security companies were added to the list of institutional investors that could undertake portfolio investment abroad. Institutional investors could freely invest in Thai securities issued abroad with no limit and in foreign securities up to 50 million USD. Any investment above the prescribed limit must receive prior approval from both the BoT and SEC. Types of securities allowed for investment expanded. For example, the SEC allowed investment in investment grade debt securities, stocks and property funds.
20-Mar-07	Security companies could not serve as intermediaries that sold foreign securities to other institutional investors.
Apr-07	The BoT approved a quota of 3 billion USD to the SEC to be allocated to foreign juristic persons for issuing securities in Thai markets.
Aug-07	The aggregate limit administrated by SEC increased to 10 billion USD. This limit also applied to foreign securities issued in Thai markets. Individual investors could undertake portfolio investment abroad through private funds and security companies.
29-Feb-08	The aggregate limit administrated by the SEC increased to 30 billion USD.
20-Mar-08	Security companies could serve as intermediaries that sold foreign securities to other institutional investors. Undertaking investment in structure notes must get prior approval from the BoT.
4-Aug-09	Juristic persons whose total assets are greater than 5 billion THB were added to the list of institutional investors that could undertake portfolio investment abroad. Types of securities allowed for investment were expanded to include all securities acknowledged by the SEC. Undertaking investment in non-FX derivatives, repurchase agreements, and securities borrowing and lending was allowed.
1-Feb-10	The aggregate limit administrated by the SEC increased to 50 billion USD.

Source: Author's compilation based on Bank of Thailand's various announcements.

The set of exchange controls regulates current payments as well as financial transactions. In addition to the requirement on reporting important information of certain transactions, major regulations as part of exchange controls consist of restrictions on certain outward remittance, obligations to surrender and repatriate foreign currency receipts, and regulations on foreign currency deposits, all of which are presented below in Table 1.4. Since 2007, several relaxations on these exchange controls have been undertaken in order to provide businesses more flexibility in managing their transaction settlements and to induce residents to hold more foreign currency as well as overseas assets.

Table 1.4 Details of Major Exchange Controls

Restrictions on Certain Outward Remittance				
Type of Remittance	Maximum Limit (million USD per year)			
	22-May-90	30-Jul-02	24-Jul-07	4-Feb-08
To send money to emigrants whose permanent residence are overseas	1	1	1	1
To send money to relatives whose permanent residence are overseas	0.1	0.1	1	1
To purchase immovable assets	…	0.5	1	5 †
To invest in intra-group companies on behalf of the employee benefit scheme	…	0.1	1	1
For donations and gifts	0.1	0.1	1	1
† The limit further increased to 10 million USD on October 5, 2010.				

Regulations on Foreign Currency Deposits				
	Specification		Maximum Limit	
	Fund from Abroad	Future Obligation (within months)	Juristic Person (million USD)	Natural Person (million USD)
1-Apr-91	Yes	--	5	0.5
Sep-97	Yes	3	5	0.5
30-Jul-02	Yes	3	10	0.5
22-Jul-03	Yes	6	10	0.5
10-May-06	Yes	6	50	0.5
12-Jan-07	Yes	6	50	0.5
	Yes	--	2	0.05
24-Jul-07	Yes	12	100	1
	Yes	0	5	0.1
	No	12	50	0.5
	No	0	0.2	0.05
4-Feb-08	Yes	--	unlimited	unlimited
	No	12	100 or obligation	1 or obligation
	No	--	0.3	0.1
5-Oct-10	Yes	--	unlimited	unlimited
	No	12	100 or obligation	1 or obligation
	No	--	0.5	0.5

Surrender Requirement					
All foreign currency receipts from abroad must be surrendered by being sold or deposited at financial institutions within specified period. Beginning February 2, 1994, foreign currency receipts could be used to service obligations directly.					
Surrender Requirement (days)	Earlier	1-Apr-91	7-Jan-98	8-May-07	24-Jul-07
	7	15	7	15	--

Repatriation Requirement			
Thai exporters with foreign currency receipts must bring such receipts into Thailand within specified period.			
Repatriation Requirement (days)	Earlier	7-Jan-98	4-Feb-08
	180	120 †	360
† Over 120 days to less than 360 days, an approval from a financial institution was required; Over 360 days, an approval from the Competent Officer was required.			

Source: Author's compilation based on Bank of Thailand's various announcements, IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (various issues), and Vichyanond (2000).

The measures to prevent currency speculation are the collection of regulations restricting transactions that domestic financial institutions can carry out with non-residents. The measures to prevent currency speculation emerged from policy formulation in the spirit of the non-internationalization of the Thai baht in the aftermath of the financial crisis of 1997. Originally, the BoT in January 1998 prohibited domestic financial institutions from providing baht credit facilities to non-residents in the attempt to make it more difficult to launch speculative attacks that induced exchange rate depreciation. Since then, additional regulatory measures have been introduced, and they collectively have become known as the measures to prevent currency speculation. The measures consist of four main components whose objectives are to limit baht liquidity, to manage short-term capital inflows, to regulate non-resident baht accounts, and to prohibit non-deliverable forward transactions. Details of the measures to prevent currency speculation are presented in Table 1.5.

Table 1.5 Details of the Measures to Prevent Currency Speculation

Measures to limit Thai baht liquidity				
Guideline for providing baht credits				
General rule	Baht credits extended to non-residents are allowed primarily for trade or investment activities ("underlying"). However, financial institutions may provide baht credits for other purposes, up to a limit of 50 million THB per consolidated entity since January 29, 1998, and up to a limit of 300 million THB per consolidated entity since February 29, 2008.			
	With Underlying	With No Underlying	Date	
	√	[limit=50]	29-Jan-98	
	√	[limit=300]	29-Feb-08	
Specific provisions	With Underlying	With No Underlying	Date	Additional Comments
• Overdraft	[limit]	[limit]	29-Jan-98	
• Direct loan	X	X	4-Oct-99	Exceptions: • Direct loans with collateral may be extended to non-resident natural persons permitted to work in Thailand for longer than one year. Such loans are limited to 5 million THB per person and are for personal consumption purpose only (24-Sep-01). • Direct loans in the form of credit cards (24-Sep-01) • Direct loans for trade and investment activities may be extended to entities in neighboring countries with prior BoT approval (28-Dec-01).
• Purchase baht debt securities issued by non-residents	X	X	4-Oct-99	Exceptions: • Financial institutions may invest in baht debt securities issued by international organizations and foreign governments approved by the MoF (26-May-05). • Financial institutions may invest in baht debt securities issued by entities in ASEAN+3 countries approved by the MoF (3-Nov-06). • Financial institutions may invest in baht debt securities issued by entities approved by the MoF (22-Nov-07). Condition: • Baht from any debt security issuance must be transacted through SNA.

Measures to limit Thai baht liquidity (… continued)				
Guideline for providing baht credits (… continued)				
Specific provisions	With Underlying	With No Underlying	Date	Additional Comments
• Guarantee	X	X	28-Feb-01	Exceptions: • Financial institutions may issue letters of guarantee to non-residents if there is a stand-by credit line from a foreign financial institution (24-Sep-01). • Financial institutions may guarantee debt security issuance by entities in neighboring countries approved by the MoF (3-Nov-06).
• Repurchase agreement	X	X	4-Dec-06	
Guideline for undertaking derivative transactions				
General rule	All derivative transactions that are equivalent to providing baht credits or are obliged to deliver foreign currency in the future are governed by the measures. The measures cover Plain Vanilla and structured derivatives based on the BoT announcement (October 6, 2005). Undertaking other derivative transactions requires prior BoT approval.			
Specific provisions	With Underlying	With No Underlying	Date	Additional Comments
• Derivative wrt. exchange rates	[underlying]	[limit]	29-Jan-98	
• Derivative wrt. interest rates	√	√	3-Nov-06	Condition: • Financial institutions shall not receive any negative interest payment. Also, financial institutions shall pay non-residents in foreign currency.
• Derivative wrt. debt securities	X	X	3-Nov-06	
• Derivative wrt. equity securities	√	√	3-Nov-06	Condition: • Financial institutions shall not receive any negative interest payment. Also, financial institutions shall pay non-residents in foreign currency.
• Credit derivative				
− swap	√	√	3-Nov-06	
− note, deposit	X	X	3-Nov-06	
Guideline for purchasing foreign currency				
General rule	With Underlying	With No Underlying	Date	
• Value same day; value tomorrow	[BoT] [underlying]	X [limit]	24-Sep-01 29-Feb-08	

Measures to curb short-term capital inflows and Measures to manage capital inflows				
Guideline for borrowing in baht				
General rule	Short-term borrowings (by definition of maturity) in baht from non-residents are allowed primarily for trade or investment activities ("underlying"). However, financial institutions may borrow in baht for other purposes, up to a limit of 50 million THB from each consolidated entity since September 11, 2003, and up to a limit of 10 million THB from each consolidated entity since February 29, 2008.			
	With Underlying	With No Underlying	Date	Additional Comments
• Maturity ≤ 3 months Maturity > 3 months	[underlying] √	[limit = 50] √	11-Sep-03	Note: • Maturity definition for short-term capital inflows is 3 months.
• Maturity ≤ 6 months Maturity > 6 months	[underlying] √	[limit = 50] √	4-Dec-06	Note: • Maturity definition for short-term capital inflows is 6 months.
• Any maturity	[underlying]	[limit = 10]	29-Feb-08	Note: • Maturity definition for short-term capital inflows is 0 month.
Specific provisions (maturity ≤ definition)	With Underlying	With No Underlying	Date	Additional Comments
• Direct loan	[underlying]	[limit]	11-Sep-03	Exception: • Financial institutions may borrow in baht from non-residents that are allowed by the MoF to issue baht debt securities (26-May-05). Note: • Direct loans in baht (by financial institutions themselves) to domestic entities that are non-financial institutions may be considered as underlying (9-Jun-05).
• Issue baht debt securities to non-residents	[limit]	[limit]	11-Sep-03	
• Issue bills of exchange	X	X	3-Nov-06	Note: • Applicable to bills of exchange at any maturity
• Repurchase agreement	X	X	4-Dec-06	Note: • Applicable to repurchase agreements at any maturity
Guideline for undertaking derivative transactions				
General rule	All derivative transactions that are equivalent to borrowing in baht or are obliged to purchase foreign currency in the future are governed by the measures. The measures cover Plain Vanilla and structured derivatives based on the BoT announcement (October 6, 2005). Undertaking other derivative transactions requires prior BoT approval.			

Measures to curb short-term capital inflows and Measures to manage capital inflows (… continued)

Guideline for undertaking derivative transactions (… continued)

Specific provisions	With Underlying	With No Underlying	Date	Additional Comments
• Derivative wrt. exchange rates	[underlying]	[limit]	11-Sep-03	Note: • Derivatives with potential obligations to sell foreign currency to domestic entities that are non-financial institutions may be considered as underlying.
• Derivative wrt. interest rates	√	√	3-Nov-06	Note: • Financial institutions shall pay non-residents in foreign currency.
• Derivative wrt. debt securities	X	X	3-Nov-06	
• Derivative wrt. equity securities	√	√	3-Nov-06	Condition: • Financial institutions shall pay non-residents in foreign currency.
• Credit derivative				
– swap	√	√	3-Nov-06	Condition: • Financial institutions shall pay non-residents in foreign currency.
– note, deposit				
maturity ≤ definition	[limit]	[limit]	3-Nov-06	Note:
maturity > definition	√	√		• Derivatives in reference to bills of exchange are strictly prohibited.

Guideline for purchasing foreign currency

General rule	With Underlying	With No Underlying	Date	
• Value same day; value tomorrow	[underlying]	[limit]	11-Sep-03	

Measures to regulate non-resident baht accounts (NRBA and NRBS)

General rule: Non-resident baht accounts are for settlement purposes only, while deposits held for other purposes must have a maturity of at least 6 months. Financial institutions shall not pay interests on non-resident baht accounts except that depositors are foreign monetary authorities.

	With Underlying	With No Underlying	Date	Additional Comments
• Non-resident baht account (NRBA)	[BoT]	[300]	14-Oct-03	Condition: • Transactions through NRBA on account of purchases or sales of government bonds, treasury bills and BoT bonds can be undertaken only if holding such debt securities lasts longer than 3 months (4-Dec-06). Removed (Mar-1-07).

Measures to regulate non-resident baht accounts (NRBA and NRBS) (… continued)				
General rule	With Underlying	With No Underlying	Date	Additional Comments
• Non-resident Baht Account for Securities (NRBS)	[BoT]	[300]	29-Feb-08	Note: • NRBS results from consolidating SNS and SND accounts after the removal of the URR measure.

Measures to regulate non-deliverable forwards				
General rule	Financial institutions shall not undertake non-deliverable forwards reference to baht with non-residents.			
	With Underlying	With No Underlying	Date	Additional Comments
	X	X	7-Nov-03	Exception: • Rollovering existing transactions and unwinding existing transactions (because non-residents fail to acquire sufficient liquidity to settle contracts) are permitted.

Other relevant measures	
Guideline for dealing with liquidity problems	
General rule	If non-resident customers encounter problems of illiquidity in baht, financial institutions shall inform the BoT. The BoT may purchase foreign currency from such non-residents at the rate determined by the BoT (29-Jul-03).
Guideline for intra-bank transactions	
General rule	The measures to prevent currency speculation do not apply to intra-bank transactions in neighboring countries (except southern parts of China). However, intra-bank transactions on behalf of non-residents must comply with the measures (2-Dec-03).

Source: Author's compilation based on Bank of Thailand's various announcements.

Note:

1. Abbreviations are as follows: Bank of Thailand (BoT); Ministry of Finance (MoF); special non-resident baht account (SNA); special non-resident baht account for debt securities and unit trusts (SND); and special non-resident baht account for securities (SNS).
2. Notations are as follows: [underlying] means that transactions may not exceed "underlying;" [limit] means that transactions may not exceed the limit; [BoT] means that transactions require prior approval from the BoT.
3. A "(non-resident) consolidated entity" considers its head office, branches, representative offices and affiliated companies as one entity.
4. "Neighboring countries" include Cambodia, southern parts of China (Yunnan Province), the Lao People's Democratic Republic, Myanmar and Vietnam.

Chapter 2

Sterilized Foreign-Exchange Interventions in Modern Monetary Policy

2.1 Introduction

In recent years, inflation targeting has become a popular monetary policy framework across the globe. The adoption of inflation targeting in the world with a fairly high degree of capital mobility implies that policymakers are supposed to relinquish their control over exchange rate movements. Nevertheless, fear of floating, as pointed out by Calvo and Reinhart (2002), seems prevalent even in countries implementing a de jure flexible exchange rate arrangement. The fact that almost all emerging markets have experienced a substantial increase in foreign reserves over the past decade suggests that policymakers in these countries have extensively engaged in foreign-exchange (FX) interventions to manage their exchange rates (Figure 2.1).[1]

Given that intervening in the FX market as a regular policy action appears increasingly common in several countries, the lack of well-articulated macroeconomic models based on micro-foundation to analyze sterilized FX interventions seems quite surprising.[2] The development of such rigorous analytical frameworks appears essential for at least three reasons. First, the models would help identify conditions for which sterilized FX interventions can be effective in influencing the exchange rate dynamics. Second, the models would help understand the mechanisms through which currency movements occur as a result of sterilized FX interventions as well as the interaction among various policy actions that might include adjusting the policy interest rate, altering restrictions on financial flows and intervening in the FX market. Third, the models would help assess

[1] Although the self-insurance motive might lead countries to accumulate foreign reserves as buffers to counter potential crises, it cannot completely justify the enormous amount of foreign reserves currently observed.

[2] FX interventions must be largely sterilized when the macroeconomic institutional framework features monetary autonomy and capital mobility, which is the case for most emerging markets in recent years.

the impact of sterilized FX interventions in terms of both quantitative effects and welfare implications.

This chapter develops a macroeconomic model that features effective sterilized FX interventions based on liquidity benefits from holding financial assets. In particular, the model is largely calibrated to reflect Thailand's experience highlighted by continual, large-scale sterilized FX interventions being undertaken under the inflation targeting regime to moderate currency appreciation triggered by an influx of foreign funds. The key objective is to shed some light on how sterilized FX interventions work in the modern monetary policy framework which is primarily founded on setting policy interest rates to secure price and output stability.

The remainder of this chapter is organized as follows. Section 2.2 reviews the literature, with an emphasis on discussing the difficulty of incorporating sterilized FX interventions in a typical Dynamic New Keynesian (DNK) framework. Ricardian equivalence turns out to be the principal factor contributing to the ineffectiveness of sterilized FX interventions in influencing currency movements. Section 2.3 presents key stylized facts of Thailand's experience, which provides a basis for model formulation. Section 2.4 develops a macroeconomic model that features effective sterilized FX interventions based on liquidity benefits from holding financial assets. The effectiveness of sterilized FX interventions founded on liquidity benefits is chosen on both realistic and technical grounds,[3] with the mechanism that an adjustment of the central bank's holding of foreign reserves together with holding the policy interest rate constant can trigger a change in the interest rate relevant for the consumption-saving decision, which in turn induces the exchange rate to move. Section 2.5 calibrates the model to capture Thailand's economic structure and discusses how to solve the model by using a numerical method. Section 2.6 analyzes how sterilized FX interventions work in the modern monetary framework. Simulation results suggest that the effect of liquidity-based sterilized FX interventions on currency movements seems small and that an accommodative interest rate policy appears essential for sterilized FX interventions to be fully effective.[4] Furthermore, the reliance on sterilized FX interventions to deal with capital flows can be welfare-improving, chiefly due to liquidity benefits. Section 2.7 concludes with what can be learned from this study as well as what should be done in the future research.

[3] The existence of liquidity benefits from holding financial assets seems evident in the real world, and the technique to incorporate them in macroeconomic models also appears relatively straightforward.

[4] In terms of influencing exchange rate movements, a sterilized FX intervention with the magnitude of 3 percent GDP is roughly as effective as a change in the policy interest rate by 100 basis points.

2.2 Literature Review

In the modern macroeconomic literature, DNK models have become the workhorse for macroeconomic policy analysis. Essentially, DNK models are stochastic neoclassical growth models that feature the role of monetary policy and the existence of nominal rigidity, with the Calvo-styled price stickiness appearing as the most popular form of nominal rigidity. In particular, the aggregate supply curve embedded with the Calvo-styled staggered price setting is known as the New Keynesian Phillips curve.

Although the DNK literature originally focused on a closed economy setup, Obstfeld and Rogoff (1995) pioneered the incorporation of nominal rigidity in micro-founded macroeconomic models with an open economy environment. Since then, the literature has become blossomed with extensions in numerous aspects: the size of the economy (large or small), the level of international financial integration (complete market structure with Arrow-Debreu securities or incomplete market structure based on borrowing and lending via international bond), the segmentation in goods market (due to pricing to market in local currency), the form of rigidity (nominal rigidity in prices or wages, or real rigidity in wages), and the variation in production factors (e.g. labor only, capital and labor as conventional, and intermediate inputs sometime also incorporated). In several studies, additional features such as financial accelerator, liability dollarization, transaction dollarization and inaccessibility to financial markets are included. See Clarida, Gali and Gertler (2002) for a standard large open-economy model with perfect international risk sharing, Svensson (2000) for a standard small open-economy model with borrowing and lending via international bond, and Gertler, Gilchrist and Natalucci (2007) for a open-economy model with financial accelerator as examples among many others. All of these works have formed a new research area known as New Open Economy Macroeconomics (NOEM).

However, these existing models cannot be used to analyze sterilized FX interventions because a portfolio allocation problem is an implicit prerequisite. It is well-known that a macroeconomic model integrated with a portfolio allocation problem is analytically complicated. The main reason is that most macroeconomic models cannot be solved analytically. In particular, only a small number of models based on certain assumptions such as a complete market structure (i.e. the existence of Arrow-Debreu securities), a simple form of nominal rigidity (e.g. one-period-ahead price or wage setting), a production function with one factor (i.e. labor), and an appropriate distribution of disturbances (typically, the log-normal distribution) admit a closed-form solution. See Obstfeld and Rogoff (2000) as an example. Meanwhile, the majority of models can only be solved by using numerical methods which in turn require some approximation (e.g. first-order log-linearization). It turns out that first-order approximation makes financial assets become locally perfectly substitutable in the neighborhood of the steady state, even though imperfect substitution among financial assets exists originally. Consequently, a portfolio allocation problem is not plausible in models with first-order approximation.

Nonetheless, recent works by Devereux and Sutherland (2007) as well as van Wincoop and Tille (2007) developed a methodology to incorporate a portfolio allocation problem in an open-economy macroeconomic model. The key insight is that second-order approximation of Euler equations related to financial decisions is necessary to yield second-moment properties of returns on financial assets so that an optimal holding of financial assets can be determined. Their methodology thus essentially shares the spirit of solving an optimal portfolio allocation in the literature on international risk sharing. It is noteworthy that the optimal holding is deterministic in the neighborhood of the steady state. In other words, second-order approximation is not sufficient to generate a time-varying portfolio allocation; these authors point out that third-order approximation of Euler equations related to financial decisions in addition to second-order approximation of all other equations in the model is required to obtain a stochastic portfolio allocation.

At first glance, the methodological development described above seems useful since the ability to determine a portfolio allocation is critical for studying the effect of sterilized FX interventions. It turns out that the presence of Ricardian equivalence, a typical feature in standard DNK models, serves as the principal factor that makes sterilized FX interventions ineffective in influencing currency movements. Specifically, when Ricardian equivalence holds, sterilized FX interventions simply lead to a reshuffling of domestic-currency and foreign-currency financial assets held by households and the central bank. As a result, sterilized FX interventions have no impact (neither real nor nominal) on the economy as households would take any action to nullify whatever has been done by the central bank.[5] In short, in order that sterilized FX interventions can induce exchange rate movements, there must be some mechanisms that prevent households from completely offsetting the central bank's purchases or sales of foreign-currency financial assets.

In principle, there exist a variety of techniques that can cause Ricardian equivalence to fail in micro-founded models. However, this study only focuses on sterilized FX interventions with the effectiveness resting on liquidity benefits from holding financial assets. The reason is that liquidity benefits seem to provide the most promising basis for the effectiveness of sterilized FX interventions on both realistic and technical grounds.[6]

[5] While having no impact in a macroeconomic model in which Ricardian equivalence prevails, sterilized FX interventions could trigger some currency movements through signaling effects in models based on the microstructure approach, which focuses on the role of information, the interaction among different players and the mechanism of trading. See Lyons (2001) for the microstructure approach to exchange rates.

[6] At least, one can view that the effect of sterilized FX interventions based on liquidity benefits is relatively long-term. Particularly, in the presence of certain frictions, it may take some time for households to be able to offset adjustments of the central bank's holding of foreign reserves. However, households should have no incentives to completely counteract because liquidity benefits are no longer the same.

Particularly, the existence of such liquidity benefits in the real world seems evident, and the technique to incorporating them in macroeconomic models appears relatively straightforward. It is worth mentioning that the approach based on liquidity benefits shares the spirit of previous works by Lahiri and Vegh (2003) as well as Canzoneri et al. (2008).[7]

2.3 Stylized Facts of Thailand's Experience

This section presents stylized facts of Thailand's experience, which highlights large-scale sterilized FX interventions undertaken continually by the Bank of Thailand (BoT) to moderate exchange rate appreciation driven by the revival of massive foreign funds starting in 2005.[8] The discussion focuses on three issues, including the implementation of sterilized FX interventions by the BoT, the existence of liquidity benefits from holding financial assets in Thailand, and the role of restrictions on financial flows regarding the effectiveness of sterilized FX interventions.

In recent years, intervening in the FX market has become a much more common policy action under the BoT's inflation targeting regime. Between 2000 and 2005, the stock of net foreign reserves expanded moderately from 30 to 56 billon US dollars. However, when the Thai baht was appreciating steadily over a sustained period starting from 2006 in consequence of an influx of foreign funds for direct investment and portfolio equity investment, the BoT was accumulating a substantial amount of foreign reserves (Figure 1.4 and 1.6). During the period in which the BoT imposed controls on capital inflows in the form of unremunerated reserve requirement (URR) between December 2006 and February 2008, the stock of net foreign reserves increased substantially from 74 to 124 billion US dollars or at the average rate of 3.6 billion US dollars a month (Figure 1.7). The accumulation of foreign reserves was partially reversed during the global financial crisis as the influx of foreign funds took a temporary break and the Thai baht switched to be on the weakening side. However, large-scale sterilized FX interventions soon resumed in late 2009 once the exchange rate started appreciating again on the back of robust economic growth and massive capital inflows (Figure 1.3). The stock of net foreign reserves surpassed 150 billion US dollars by end-2009, and almost reached 200 billion US dollars by end-2010.

[7] In Lahiri and Vegh (2003), the central bank relies on issuances of liquid domestic-currency bond as an additional instrument to defend speculative attacks on the currency peg. Canzoneri et al. (2008) explored the role of liquidity in a Neo-Wicksellian framework based on differences in liquidity benefits among money, deposits and government bond.

[8] More complete details on Thailand's experience of substantial exchange rate appreciation as a result of massive capital inflows can be found in Chapter 1.

Since maintaining appropriate monetary conditions is essential for achieving the targeted inflation rate, interventions in the FX market have been largely sterilized.[9] In particular, the BoT relies on three instruments, which consist of BoT bond issuances, FX swap transactions and repurchase agreements, to manage liquidity. As a consequence of the BoT's efforts to sterilize large-scale FX interventions during the URR regime, the outstanding amount of BoT bonds ballooned from 897 to 1,451 billion baht, the net FX forward position increased from 250 to 743 billion baht, and the net position of repurchase agreements from open market operations soared from 125 to 530 billion baht (Figure 1.7). Furthermore, as the BoT has been undertaking gigantic sterilized FX interventions to mitigate currency appreciation since late 2009, the outstanding amount of BoT bonds reached 2,381 billion baht by end-2010. Meanwhile, the net FX forward position and the net position of repurchase agreements remained at 591 and 338 billion baht, respectively.

Liquidity benefits from holding financial assets are apparent in Thailand. Figure 2.2 displays existing interest rate differentials between bank deposits and government bonds. Since deposits had been fully guaranteed by the government, people should be indifferent between holding deposits at financial institutions and holding government bonds.[10] The wedge between these two interest rates thus suggests the existence of additional benefits from holding bank deposits relative to government bonds or certain frictions in the domestic financial system. All of these features might result from the under-developed bond market, the lack of alternative financial instruments to compete against bank deposits as the primary venue of household savings, and the liquidity requirement for financial institutions.[11,12] Moreover, such existing interest rate differentials have generally narrowed during the period of large-scale sterilized FX interventions starting from 2006.[13] The wedges between bank time deposit rates and Treasury bill rates over

[9] Figure 1.7 shows that monetary base has been growing at a much slower rate. Between 2006 and 2010, the level of monetary base increased from 843 to 1,243 billion baht (i.e. 38 percent), while the stock of net foreign reserves ballooned from 56 to 192 billion US dollars (i.e. 124 percent).

[10] Thailand adopted a new deposit insurance system in August 2008. The new scheme would eventually guarantee deposits of each individual at each bank up to 1 million baht after August 2012. However, the ceiling on guaranteed deposits would gradually decline over the transitional period of 4 years.

[11] Restrictions on residents to undertake investment abroad can be an important factor. Domestic financial institutions have not needed to compete aggressively against potentially available overseas investment opportunities. However, it is worth pointing out that borrowing from domestic financial institutions is subjected to more competition arising from the possibility of borrowing from abroad.

[12] The liquidity requirement might not play a significant role for Thailand (maybe important for other countries). For Thailand, the reserve requirement is 6 percent of deposits or liabilities. The reserve may consist of a minimum 1 percent in current balance at the Bank of Thailand, a maximum 2.5 percent in vault cash, and the rest in eligible public debt securities.

[13] Here, the purpose is to document general observations. It is difficult to assess whether the behavior of liquidity premiums is consistent with the implication of sterilized FX interventions generated by the model

maturity of 3, 6 and 12 months reduced from the range of 86-97 basis points in January 2006 to the range of 68-83 basis points in December 2010. The gap between bank saving rates and interbank overnight rate also declined from 172 to 130 basis points over the same period.

The existence of restrictions on financial flows may not serve as foundation for sterilized FX interventions being effective in influencing currency movements. In particular, controls on capital inflows may not provide a basis for the effectiveness of sterilized FX interventions in a model featuring Ricardian equivalence because additional costs induced by capital controls would eventually return to households. Here, the discussion aims to motivate that impediments on financial flows can contribute to the effectiveness of sterilized FX interventions in many circumstances. Although sterilized FX interventions with the effectiveness resting on restrictions on capital flows are not the main focus of this study, more complete analysis can be found in Annex 2.8.2.

Under the URR regime which overall imposed minimal restrictions on financial inflows, sterilized FX interventions with accumulation of foreign reserves are indeed supposed to generate some currency appreciation due to the negative wealth effect.[14] However, such restrictions may support an increase in foreign reserves to induce some exchange rate deprecation if they are instead excessively prohibitive to shut down potential borrowings.

On the other hand, control on capital outflows such as the limitation on Thai residents to undertake investment in foreign counties may provide a basis for the effectiveness of sterilized FX interventions. In the presence of substantial restrictions on domestic financial outflows, a suboptimal outcome may emerge when domestic investment opportunities decrease (i.e. households want to lend their excess savings abroad but they cannot). Under such circumstances, sterilized FX interventions with accumulation of foreign reserves could induce some currency depreciation since households would be satisfied with the central bank's actions that help them overcome existing barriers that limit their ability to invest abroad.

In summary, sterilized FX interventions have become an integral part of the BoT's policy landscape under the inflation targeting framework. Furthermore, the existence of liquidity benefits from holding financial assets seems evident in Thailand. Therefore, this study opts for modeling sterilized FX interventions with the effectiveness founded on liquidity benefits.

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since other developments (e.g. interest rate policy adjustments and government bond issuances) can also affect these liquidity premiums.

[14] The effectiveness of sterilized FX interventions provided by the URR measure existed to the extent that additional costs induced by the reserve requirement were borne by foreign investors, not domestic households. Otherwise, Ricardian equivalence would hold since the URR measure could be viewed as a tax measure.

2.4 Modeling Sterilized FX Interventions Based on Liquidity Benefits from Holding Financial Assets

This section develops a macroeconomic model that features effective sterilized FX interventions based on liquidity benefits from holding financial assets. The effectiveness of sterilized FX interventions in influencing exchange rate fluctuations arises as a result of the failure of Ricardian equivalence in some restricted sense.[15] Particularly, an adjustment of the central bank's holding of foreign reserves creates a marginal impact on household decisions owing to a change in liquidity benefits. The central mechanism driving exchange rate movements rests on changes in the interest rate relevant for the consumption-saving decision that occur in consequence of sterilized FX interventions even though the policy interest rate remains unchanged.

The presentation of the model is divided into three parts. Part 2.4.1 outlines the model's core component which is essential for analyzing the effect of sterilized FX interventions. Part 2.4.2 examines how liquidity benefits can provide foundation for sterilized FX interventions being effective in influencing currency movements. Part 2.4.3 specifies the model's remaining part which largely covers the production side.

2.4.1 Core Component Focusing on Financial Decisions

The model focuses on the home country which is a small open economy by taking key macroeconomic variables in the foreign country (i.e. the rest of the world) as given. There are five players in the model: households, financial intermediaries, the central bank, the foreign country, and firms. The behavior of all players except firms, which is central to the formulation of financial decisions relevant for analyzing the effect of sterilized FX interventions, is described here.

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[15] The effectiveness of sterilized FX interventions can generally be materialized on three bases. First, Ricardian equivalence fails in some restricted sense as a change in the central bank's holding of foreign reserves has a marginal impact on household decisions owing to the existence of liquidity benefits from holding financial assets or frictions in the domestic financial system. Second, restrictions on financial flows contribute to the effectiveness of sterilized FX interventions in the following circumstances: (i) minimal capital controls lead the central bank's holding of foreign reserves to have an independent impact on the combined budget constraint so that Ricardian equivalence fails due to the wealth effect; (ii) excessive capital controls create an environment of capital immobility so that a change in the central bank's holding of foreign reserves forces an exactly comparable adjustment of the current account balance; and (iii) excessive capital controls induce suboptimal outcomes so that households have no incentives to nullify the central bank's actions that help improve such suboptimal outcomes. Third, Ricardian equivalence fails in more general sense as some households are not totally liable for potential gain or loss (due to exchange rate movements) resulting from sterilized FX interventions. In this case, imperfect substitution among financial assets on account of exchange rate risks plays an important role in generating currency movements. Certain aspects of these additional bases for effective sterilized FX interventions are examined in Annex 2.8.2.

❖ Households

There is a continuum of households of length unity. Each household works, consumes and holds a portfolio of financial assets. The portfolio consists of five asset types: international foreign-currency bond, illiquid domestic-currency bond, liquid domestic-currency bond, deposits, and cash.[16] Furthermore, households completely own financial institutions and firms. A representative household maximizes the expected utility which is separable into two components. The standard component captured by $u(\cdot)$ depends on the amount of consumption and labor supply, while the liquidity benefit component represented by $v(\cdot)$ depends on the amount of money, deposits and liquid domestic-currency bond held by households. The separability assumption is taken to distinguish liquidity benefits from the standard utility specification. In short, a representative household maximizes:

$$(2.1) \quad U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ u(C_t, H_t) + v\left(\frac{M_{H,t}}{P_t^C}, \frac{D_{H,t}}{P_t^C}, \frac{B_{H,t}}{P_t^C} \right) \right\}$$

subject to the budget constraint:

$$\begin{aligned}(2.2) \quad P_t^C C_t + S_t F_{H,t} + A_{H,t} + B_{H,t} + D_{H,t} + M_{H,t} \\ = W_t H_t + (1 + \tau_{t-1})(1 + r_{t-1}^* + \Psi_{t-1}) S_t F_{H,t-1} + (1 + r_{t-1}^C) A_{H,t-1} \\ + (1 + r_{t-1}) B_{H,t-1} + (1 + r_{t-1}^D) D_{H,t-1} + M_{H,t-1} + \Gamma_t + T_t,\end{aligned}$$

where C_t is household consumption, H_t is household labor supply, P_t^C is the price of the consumption bundle (i.e. the consumer price index), and W_t is the nominal wage. The nominal exchange rate, denoted by S_t, is defined as the price of domestic currency per unit of foreign currency; thus, an increase in S_t means nominal exchange rate depreciation. Household holding of financial assets is denoted by $F_{H,t}$ for foreign-currency bond, $A_{H,t}$ for illiquid (typical) domestic-currency bond, $B_{H,t}$ for liquid (government) domestic-currency bond, $D_{H,t}$ for deposits at financial intermediaries, and $M_{H,t}$ for cash. The timing convention is such that $F_{H,t}$, $A_{H,t}$, $B_{H,t}$, $D_{H,t}$, and $M_{H,t}$ are predetermined in period $t-1$. Regarding returns on financial assets, illiquid domestic-currency bond pays the nominal interest rate r_t^C, liquid domestic-currency bond pays the nominal interest rate r_t, and deposits pay the nominal interest rate r_t^D. The ownership of financial institutions and firms is entitled to receive or make a transfer payment Γ_t (e.g. dividend payout or equity injection). In addition, there is a transfer payment T_t between households and the central bank.

[16] In Canzoneri et al. (2008), the last four asset types are fundamental for analyzing the central bank's open market operations. In this study, they are essential for examining the central bank's sterilization operations following the central bank's adjustments of its foreign-currency bond holding.

Households can borrow from or lend to the foreign country in the form of international bond denominated in foreign currency at the gross nominal interest rate $(1 + r_t^* + \Psi_t)$, where Ψ_t captures the country risk premium which consists of two components:

$$(2.3) \quad \Psi_t = \psi\left(\frac{F_t}{P_t^*}\right) + \varphi_t = \psi\left(\frac{F_{H,t} + F_{M,t}}{P_t^*}\right) + \varphi_t,$$

with $\psi'(\cdot) < 0$, where F_t is the home country's total holding of foreign-currency bond, $F_{M,t}$ is the central bank's holding of foreign-currency bond, and P_t^* is the foreign price level. The former part, following Schmitt-Grohe and Uribe (2001), is simply a technical device to assure that the home country's foreign indebtedness remains stationary.[17] The latter part is a stochastic process to capture the foreign country's willingness to lend.[18]

Furthermore, restrictions on capital flows may exist in the form of additional costs on international borrowing and lending.[19] Restrictions on foreign borrowing stipulate that households are subjected to additional costs at the rate of τ_t^B when borrowing funds from abroad (e.g. pay higher costs). The value of τ_t^B is some non-negative $\acute{\tau}^B$ when $F_{H,t} < 0$ (binding) and zero when $F_{H,t} \geq 0$ (otherwise, a positive τ_t^B would provide a subsidy on foreign lending). On the other hand, restrictions on foreign lending require that households are subject to additional costs at the rate of τ_t^L when lending funds to the rest of the world (e.g. receive lower returns). The value of τ_t^L is some non-positive $\acute{\tau}^L$ when $F_{H,t} > 0$ (binding) and zero when $F_{H,t} \leq 0$ (otherwise, a negative τ_t^L would yield a subsidy on foreign borrowing). Hence, the value of $\tau_t = \tau_t^B + \tau_t^L$, in principle, can vary based on the level of $F_{H,t}$.[20] However, the values of $\acute{\tau}^B$ and $\acute{\tau}^L$ are constant since the underlying factors for restrictions on financial flows, including tax regulations, quantitative limits and intermediation costs, are fixed in this study. It is noteworthy that restrictions on

[17] One could interpret the function $\psi(\cdot)$ as the cost for households to engage in international borrowing and lending. Intuitively, as a net borrower, the country is charged a premium; as a net lender, the country receives a discount. Benigno (2001) suggests that the existence of financial intermediaries (owned by foreign agents) in the international financial market can generate such costs.

[18] The foreign country's willingness to lend may vary for several reasons, e.g. liquidity condition in the foreign financial system, default risks of the home country, and foreign investors' panic that can generate sudden stops of capital flows. Note that one should view r_t^* as the policy interest rate in the foreign country; thus, r_t^* could be different from the interest rate relevant for the consumption-saving decision in the Euler equation. Thus, φ_t should reflect the liquidity condition, which partly depends on liquidity benefits from holding liquid foreign-currency bond (issued by the foreign government).

[19] Restrictions on foreign borrowing are a form of controls on capital inflows. It is important to recognize that households face no impediments on repatriating their foreign investment. Similarly, restrictions on foreign lending are a form of controls on capital outflows. Households remain free to repay their foreign debt.

[20] Restrictions on foreign borrowing and lending can be specified by the "tax" rate τ_t in a simple way as described above because gross flows are identical to net flows in this model. The reason is that the model lacks the ability to determine the portfolio allocation between domestic-currency and foreign-currency bonds when both provide the same liquidity benefits.

financial flows do not play any role in determining the effectiveness of sterilized FX interventions based on liquidity benefits; the model setup incorporates impediments on capital flows for facilitating the discussion in Annex 2.8.2.

The household preference is characterized by two separable utility components, with the $u(\cdot)$ part following King, Plosser and Rebelo (1988), and the $v(\cdot)$ part sharing the same spirit as Canzoneri et al. (2008):

(2.4) $$u(C,H) = \frac{1}{1-\gamma}\left(C^{1-\xi}(1-H)^{\xi}\right)^{1-\gamma},$$[21]

(2.5) $$v\left(\frac{M}{P^C},\frac{D}{P^C},\frac{B}{P^C}\right) = \frac{\phi_m}{1-\nu_m}\left(\frac{M}{P^C}\right)^{1-\nu_m} + \frac{\phi_d}{1-\nu_d}\left(\frac{D}{P^C}\right)^{1-\nu_d} + \frac{\phi_b}{1-\nu_b}\left(\frac{B}{P^C}\right)^{1-\nu_b},$$

where $1/\gamma$ is the elasticity of intertemporal substitution and ξ captures the importance of labor disutility relative to consumption utility. Meanwhile, the parameters ϕ_m, ϕ_d and ϕ_b reflect the relative importance of each type of liquidity benefits, and the parameters ν_m, ν_d and ν_b govern the curvature of the utility function pertinent to liquidity benefits.[22]

With the prescribed preference, the household's decision must conform to the following optimal conditions (when all of them are binding as usual):

(2.6) $$-\frac{u_{H,t}}{u_{C,t}} = \frac{1-\xi}{\xi}\frac{C_t}{1-H_t} = \frac{W_t}{P_t^C},$$

(2.7) $$u_{C,t} = \beta \mathbb{E}_t\left[u_{C,t+1}(1+r_t^C)\frac{P_t^C}{P_{t+1}^C}\right],$$

(2.8) $$u_{C,t} = \beta \mathbb{E}_t\left[u_{C,t+1}(1+\tau_t)(1+r_t^* + \Psi_t)\frac{S_{t+1}}{S_t}\frac{P_t^C}{P_{t+1}^C}\right],$$

(2.9) $$v_{B/P^C,t} = \phi_b\left(\frac{P_t^C}{B_{H,t}}\right)^{\nu_b} = u_{C,t}\frac{r_t^C - r_t}{1+r_t^C},$$

(2.10) $$v_{D/P^C,t} = \phi_d\left(\frac{P_t^C}{D_{H,t}}\right)^{\nu_d} = u_{C,t}\frac{r_t^C - r_t^D}{1+r_t^C},$$

[21] The King-Plosser-Rebelo preference has an advantage of being consistent with a balanced growth path. Another popular choice of preference is the Greenwood-Hercowitz-Huffman preference: $u(C,H) = \frac{1}{1-\gamma}\left(C - \xi\frac{H^{1+\varsigma}}{1+\varsigma}\right)^{1-\gamma}$, which makes the real wage independent of the level of consumption.

[22] In contrast to Conzoneri et al. (2008), the values of ν_M, ν_D and ν_B are allowed to be different from 1 as well as from each other in order to examine how the effect of sterilized FX interventions depends on the values of these parameters.

(2.11) $v_{M/P^C,t} = \phi_m \left(\frac{P_t^C}{M_{H,t}}\right)^{v_m} = u_{C,t} \frac{r_t^C}{1 + r_t^C},$

where the marginal utility of consumption $u_{C,t}$ is equal to:

(2.12) $u_{C,t} = (1 - \xi)(C_t)^{(1-\xi)(1-\gamma)-1}(H_t)^{\xi(1-\gamma)}.$

These optimal conditions have straightforward interpretations. Condition (2.6) and (2.7) determine the labor supply and the consumption-saving decision, respectively.[23] Condition (2.9), (2.10) and (2.11) specify that interest rate spreads arise to compensate for differences in liquidity benefits provided by liquid domestic-currency bond, deposits and cash. For example, according to equation (2.11), the marginal benefit of holding an additional unit of cash is equal to the marginal cost of holding illiquid domestic-currency bond instead of cash. Note that all of interest rate spreads are positive in equilibrium due to liquidity benefits; such results are based on standard properties of preference. Furthermore, combining equation (2.7) and (2.8) yields the UIP-typed condition:

(2.13) $\mathbb{E}_t \left[\Lambda_{t,t+1} \left\{(1 + r_t^C) - (1 + \tau_t)(1 + r_t^* + \Psi_t) \frac{S_{t+1}}{S_t}\right\}\right] = 0,$

where $\Lambda_{t,t+1}$ is the nominal stochastic discount factor, which is equal to:

(2.14) $\Lambda_{t,t+1} = \beta \left(\frac{u_{C,t+1}}{u_{C,t}}\right)\left(\frac{P_t^C}{P_{t+1}^C}\right).$

When condition (2.8) is binding, the UIP-typed condition (2.13) determines the dynamics of the nominal exchange rate. However, it seems plausible that condition (2.8) might not be binding when the magnitude of τ_t is sufficiently large. In particular, the left hand side could be greater when τ_t is sufficiently negative (e.g. excessive impediments on foreign lending) but smaller when τ_t is sufficiently positive (e.g. excessive impediments on foreign borrowing). Under such circumstances, borrowing from or lending to the foreign country might not occur, and condition (2.8) should be replaced by:

(2.8') $u_{C,t} \neq \beta \mathbb{E}_t \left[u_{C,t+1}(1 + \tau_t)(1 + r_t^* + \Psi_t) \frac{S_{t+1}}{S_t} \frac{P_t^C}{P_{t+1}^C}\right].$

The key implication is that the dynamics of the nominal exchange rate would no longer be determined by the UIP-typed condition (2.13). Instead, the real exchange rate must adjust to generate a current account balance consistent with the amount of financial

[23] Based on the assumption that no frictions exist in the labor market, wages are flexible and condition (2.6) specifies the amount of labor supply.

flows.[24] Specifically, in the presence of some price stickiness, the nominal exchange rate S_t must conform to:

(2.13') $CA_t(S_t) = -FA_t - MA_t,$

where CA_t is the current account balance, FA_t is the financial account balance, and MA_t is the monetary authority account balance which records changes in foreign reserves. It is noteworthy that condition (2.13') must always hold because it is simply the accounting of the balance of payments. When condition (2.8) holds, borrowing from or lending to the foreign country would occur to assure that condition (2.13') is satisfied; in other words, the financial account looks like a residual of what happen to the current account, which is chiefly driven by the saving-investment decision of households together with the change in foreign reserves determined by the central bank.

Furthermore, the household preference requires that the consumption bundle consists of both home goods C^H and foreign goods C^F:

(2.15) $C = \left(\varrho_c^{\frac{1}{\eta_c}} (C^H)^{\frac{\eta_c - 1}{\eta_c}} + (1 - \varrho_c)^{\frac{1}{\eta_c}} (C^F)^{\frac{\eta_c - 1}{\eta_c}} \right)^{\frac{\eta_c}{\eta_c - 1}}.$

Note that the superscript denotes the type of goods (e.g. home or foreign goods). It can be showed that the consumption bundle with the least-cost expenditure must satisfy the following conditions:

(2.16) $C_t^H = \varrho_c \left(\frac{P_t^H}{P_t^C} \right)^{-\eta_c} C_t,$

(2.17) $C_t^F = (1 - \varrho_c) \left(\frac{S_t P_t^*}{P_t^C} \right)^{-\eta_c} C_t,$

where P_t^H is the price of home goods and P_t^* is the price of foreign goods. Since P_t^* is in the unit of foreign currency, one implicit assumption (which is taken throughout this study where applicable) is that the law of one price holds for all traded goods. Note that the parameter ϱ_c captures the degree of home consumption bias and η_c is the elasticity of substitution between home and foreign goods in the consumption bundle (for households in the home country). Moreover, the price of the consumption bundle is given by:

(2.18) $P_t^C = \left(\varrho_c (P_t^H)^{1-\eta_c} + (1 - \varrho_c)(S_t P_t^*)^{1-\eta_c} \right)^{\frac{1}{1-\eta_c}}.$

[24] In any standard open-economy macroeconomic model, the differentiation between home and foreign goods generates the role of the real exchange rate. Moreover, the current account improves (or deteriorates) when the real exchange rate depreciates (or appreciates).

❖ Financial Intermediaries

There is a continuum of financial intermediaries of length unity. The domestic financial system operates in a perfectly competitive environment in which each financial intermediary raises funds from households, makes loans to firms, and holds domestic-currency financial assets. Financial intermediaries can borrow from households in two ways: accepting deposits $D_{B,t}$ at the nominal interest rate r_t^D (retail funding and short-term wholesale funding) or issuing illiquid domestic-currency bond $A_{B,t}$ at the nominal interest rate r_t^C (long-term wholesale funding).[25] At the same time, financial intermediaries may hold cash $M_{B,t}$, liquid domestic-currency bond $B_{B,t}$, and illiquid domestic-currency bond $A_{B,t}$; thus, the amount of illiquid domestic-currency bond held by financial intermediaries can be either positive or negative (or even zero).

Taking deposits requires some liquidity management; as a result, financial intermediaries need to hold cash and liquid domestic-currency bond to satisfy:

(2.19) $D_{B,t} = Z_D\left(M_{B,t}\right)^{\alpha_d}\left(B_{B,t}\right)^{1-\alpha_d}$,

where Z_D is the productivity parameter for liquidity management, (in reality, Z_D may critically depend on the reserve requirement), and α_d is between 0 and 1. This setup of financial intermediaries basically follows Canzoneri et al. (2008). For simplicity, frictions in the domestic financial system only take the form of liquidity management of deposits. In general, additional frictions may involve costs to create and monitor loans, as well as capital requirements to cushion losses potentially arising from risky investment; the former do not directly provide a basis for the effectiveness of FX interventions, while the latter might be. Due to perfect competition, there are no transfers between financial intermediaries and households, which are the owners of all financial intermediaries.[26]

Taking all interest rates as given, a representative banker maximizes the financial intermediary's value. Such a decision is equivalent to maximize the period-by-period expected profit:

(2.20) $\mathbb{E}_t\left[\Lambda_{t,t+1}\left\{(1+r_t^L)L_{B,t} + (1+r_t)B_{B,t} + M_{B,t} - (1+r_t^C)A_{B,t} - (1+r_t^D)D_{B,t}\right\}\right]$

subject to the liquidity management condition (2.19) and the balance sheet constraint:

25 Although all bonds in the model have maturity of one period, it seems appropriate to view illiquid domestic-currency bond as long-term funding. The key difference between the two is the need to manage liquidity. Generally speaking, banks still have to manage liquidity of funds raised by short-term money market instruments, whereas liquidity is not an issue for funds raised by long-term bond.

26 One plausible extension is to incorporate the role of endogenous balance sheet constraints faced by financial intermediaries as in Gertler and Karadi (2009) in order to capture the financial intermediary's inability (or unwillingness) to lend. Then, there would be some transfers between financial intermediaries and households.

(2.21) $L_{B,t} + B_{B,t} + M_{B,t} = A_{B,t} + D_{B,t}$,

where $L_{B,t}$ is loans extended to firms, and r_t^L is the nominal interest rate on loans. The financial intermediary's decision yields the following optimal conditions:

(2.22) $r_t^C = r_t^L$,

(2.23) $r_t^C = r_t + (r_t^C - r_t^D)(1 - \alpha_d)\dfrac{D_{B,t}}{B_{B,t}}$,

(2.24) $r_t^C = (r_t^C - r_t^D)\alpha_d \dfrac{D_{B,t}}{M_{B,t}}$.

Condition (2.22) states that the marginal cost of making a loan must be equal to the marginal revenue from that loan. Furthermore, condition (2.23) and (2.24) say that financial intermediaries hold liquid domestic-currency bond and cash to the point where the marginal cost of doing so is equal to the marginal benefit which consists of interest payments and/or liquidity benefits. It is worth mentioning that r_t^L should be viewed as the average return on loans that financial intermediaries would receive; when there exists an external financing premium χ_t, financial intermediaries would receive r_t^L on average while firms would be charged by $r_t^L + \chi_t$ as some firms would default.

Moreover, using condition (2.19), (2.23) and (2.24), it is straightforward to show that:

(2.25) $r_t^C - r_t^D = \dfrac{1}{Z_D {\alpha_d}^{\alpha_d}(1 - \alpha_d)^{1-\alpha_d}} (r_t^C)^{\alpha_d}(r_t^C - r_t)^{1-\alpha_d}$,

which implies that financial intermediaries raise funds by accepting deposits up to the point where the marginal cost of issuing illiquid domestic-currency bond is equal to the marginal cost of taking deposits. In other words, the difference in interest payments of the two fund-raising options is reflected by the difference in costs associated with liquidity management.

Few interesting points deserve some additional discussion.

First, the choice of the stochastic discount factor used for discounting the expected profit of financial intermediaries does not matter here even if financial intermediaries are allowed to be partly owned by foreign agents. The reason is that all interest rates central to the financial intermediary's decision are known at time t in this financial intermediary's problem. Nonetheless, the stochastic discount factor of domestic households $\Lambda_{t,t+1}$ is chosen based on the model's design that financial intermediaries are completely owned by domestic households.

Second, the necessity of financial intermediaries to manage liquidity of deposits is a critical component to make the model exhibit a well-behaved interior solution. Without such frictions, the model would become fairly complicated with many corner-solution features. For instance, financial intermediaries while taking deposits and making loans at the same nominal interest rate, i.e. $r_t^D = r_t^L$, would neither hold cash nor borrow from households in the form of illiquid domestic-currency bond. Financial intermediaries may hold some liquid domestic-currency bond only if $r_t = r_t^D = r_t^L$. Hence, the central bank's ability to set the policy interest rate r_t, i.e. the interest rate on liquid domestic-currency bond, is likely to rest on its interaction with households rather than financial intermediaries. These features make the model unrealistic. In brief, when financial assets provide liquidity benefits to households, it seems natural to assume that these financial assets provide liquidity benefits to financial intermediaries (in terms of managing liquidity of deposits) as well.

Third, the feature that financial intermediaries can raise funds by issuing illiquid domestic-currency bond at the nominal interest rate r_t^C has three important implications. One is that the loan-making decision is totally disconnected from the deposit-taking decision. In particular, financial intermediaries are willing to supply loans as long as $r_t^L = r_t^C$, i.e. the average return on loans is equal to the cost of funding raised in the form of illiquid domestic-currency bond. Furthermore, this setup implicitly enables financial intermediaries to borrow from or lend to the rest of the world indirectly through households. Lastly, the two policy actions, implementing sterilized FX interventions and altering the policy interest rate, in principle, can induce virtually identical outcomes primarily due to the tight link between r_t^L and r_t^C.[27]

❖ Central Bank

The central bank implements monetary policy under the inflation targeting framework by setting the interest rate on liquid domestic-currency bond according to the rule:

$$(2.26) \quad r_t = \rho_m r_{t-1} + \left(1 - \rho_m\right)\left\{\bar{r} + \theta_\pi(\pi_t^H - \bar{\pi}^H) + \theta_y\left(log(Y_t^H) - log(\bar{Y}^H)\right)\right\} + \varepsilon_{M,t},$$

where a bar ($-$) denotes the steady state, Y_t^H is the output level of home goods, π_t^H is the inflation rate for the price of home goods, and $\varepsilon_{M,t}$ captures deviations of monetary policy from the specified rule. It is noteworthy that the steady-state inflation rate $\bar{\pi}^H$ would be equal to the inflation rate targeted by the central bank. Though not optimal, the rule prescribed above should deliver some decent macroeconomic stability.[28] In order to

[27] The word "virtually" is used because portfolio allocations of financial assets could be different between the two policy actions owing to differences in liquidity premiums. Meanwhile, other real allocations could be the same.

[28] It is known that the central bank should target the weighted inflation rate for all prices and wages that exhibit some stickiness. However, targeting the inflation rate for the most sticky price or wage would be the best if the central bank can target only one inflation rate (e.g. for policy clarity). Furthermore, the output gap should depend on the flex-price-flex-wage level of output, and the steady-state nominal policy

control the interest rate on liquid domestic-currency bond, the central bank conducts open market operations by adjusting the level of monetary base (i.e. cash held by households and financial intermediaries) and its holding of liquid domestic-currency bond (in this model, this would be the amount of liquid domestic-currency bond issued by the central bank).[29]

Furthermore, the central bank may intervene in the FX market to influence the exchange rate. Specifically, the central bank determines the level of foreign reserves $F_{M,t}$ in the way that the path of $F_{M,t}$ is stationary (when $0 < \rho_f < 1$) according to the rule:

(2.27) $$F_{M,t} = \rho_f F_{M,t-1} + \left(1 - \rho_f\right)\left\{\bar{F}_M + u_{F,t}\right\} + \varepsilon_{F,t},$$

where $u_{F,t}$ should be specified such that FX interventions respond appropriately to economic developments while $\varepsilon_{F,t}$ captures deviations of changes in the stock of foreign reserves from the specified rule. For simplicity, let's assume that the central bank does not intervene in the FX market in a systematic manner so that $u_{F,t}$ is constant (normalized to be zero) and innovations in $\varepsilon_{F,t}$ completely influence the dynamics of foreign reserves.[30]

In order to safeguard price stability, FX interventions must be mostly sterilized. Therefore, the central bank is obligated to issue liquid (government) domestic-currency bond, which would be held by households and financial intermediaries, to fully finance purchases or sales of foreign-currency bond by the amount of:

(2.28) $$B_{M,t} - B_{M,t-1} = S_t\left(F_{M,t} - F_{M,t-1}\right) - \left(M_{M,t} - M_{M,t-1}\right).$$

Based on equation (2.28), the amount of liquid domestic-currency bond issued by the central bank may change as a result of either FX interventions or open market operations. However, the magnitude of sterilized FX interventions would actually determine the level of total government liabilities:

(2.29) $$B_{M,t} + M_{M,t} = B_{M,t-1} + M_{M,t-1} + S_t\left(F_{M,t} - F_{M,t-1}\right),$$

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interest rate should instead be the (time-varying) natural (nominal) interest rate (i.e. the interest rate that can deliver the flex-price-flex-wage outcome).

[29] For a model in which financial assets provide liquidity benefits, in the absence of interventions in the FX market, the central bank also needs to determine the level of total government liabilities (i.e. $M_{M,t} + B_{M,t}$). Then, the composition has to be adjusted endogenously to achieve the targeted policy interest rate.

[30] If FX interventions are devoted to deal with capital flows, then $u_{F,t}$ may take the form: $u_{F,t} = \theta_\varphi(\varphi_t - \bar{\varphi})$. This prescribed rule should help stabilize exchange rate movements generated by capital flows. It is noteworthy that when the central bank systematically intervenes in the FX market, households would take such actions into account in a similar way to what they would do with standard monetary policy.

which in turn affects the financial system's liquidity condition; this is called the "liquidity provision" effect in Canzoneri et al. (2008). Then, for a given level of total government liabilities, the central bank adjusts the composition of total government liabilities accordingly through open market operations in order to control the policy interest rate; a change in the composition of liquid financial assets, namely cash and liquid domestic-currency bond, generally generates the "liquidity buffering" effect.

Here, the prescription of sterilized FX interventions is slightly different from the conventional notion. While any purchase or sale of foreign-currency bond by the central bank does not initially affect the level of monetary base, the central bank's commitment to control the policy interest rate may require some adjustment of monetary base. Consequently, two useful measurements of money supply in this model (i.e. monetary base M_t and monetary aggregate in the sense of $M2$: $M_t + D_t$) would not remain constant as a result of sterilized FX interventions. It is important to realize that when financial assets provide liquidity benefits, the central bank's decision involves a variety of policy choices. In principle, there are numerous ways to characterize monetary policy. For example, the central bank could target monetary aggregate $M2$ rather than issue liquid domestic-currency bond according to equation (2.28); however, FX interventions would not be fully financed by bond issuances.

On the contrary, the central bank is not allowed to implement any policy that affects τ_t since the underlying factors for impediments on capital flows are fixed in this study (i.e. the values of $\acute{\tau}^B$ and $\acute{\tau}^L$ are constant). The incorporation of restrictions on financial flows is only for analyzing their role in supporting the effectiveness of sterilized FX interventions rather than their impact on economic developments. It is noteworthy that a temporary modification of capital controls does not affect the stationarity of the model whereas a permanent change in restrictions on financial flows may significantly alter steady-state properties of various variables.

To completely describe the central bank's action, the fiscal aspect of monetary policy needs to be specified. In particular, the central bank's operation must conform to the budget constraint:

(2.30) $$S_t F_{M,t} - B_{M,t} - M_{M,t} = (1 + r^*_{t-1} + \Psi_{t-1}) S_t F_{M,t-1} - (1 + r_{t-1}) B_{M,t-1} - M_{M,t-1} - T_t,$$

which relies on an implicit assumption that restrictions on financial flows do not generate any revenue to the central bank.[31] Since a change in $F_{M,t}$ results from an independent policy choice, a change in $M_{M,t}$ occurs in consequence of adjusting the policy interest rate,

[31] Based on Thailand's experience, restrictions on capital outflows primarily result from the aggregate limit on investment abroad, as well as the regulation that undermines the ability to mobilize funds to undertake investment abroad. Notice that such restrictions do not involve transfers of resources from households to other entities (e.g. taxes to the government or intermediation costs to financial intermediaries).

and a change in $B_{M,t}$ depends on the dynamics of both $F_{M,t}$ and $M_{M,t}$, it is plausible that the central bank's balance sheet exhibits some net worth $N_{M,t}$ such that

(2.31) $S_t F_{M,t} = B_{M,t} + M_{M,t} + N_{M,t}$.

Then, the budget constraint (2.30) can be rewritten as:

(2.32) $N_{M,t} = N_{M,t-1} + (S_t - S_{t-1})F_{M,t-1} + \left((r^*_{t-1} + \Psi_{t-1})S_t F_{M,t-1} - r_{t-1}B_{M,t-1}\right) - T_t,$

which says that a change in the central bank's net worth may arise from three sources: the valuation effect from holding foreign-currency bond due to exchange rate movements, the net income on interest payments, and the net payment of transfers to households. However, when the central bank operates based on the rule (2.28), the change in the central bank's net worth is purely driven by the valuation effect due to exchange rate movements:

(2.33) $N_{M,t} - N_{M,t-1} = (S_t - S_{t-1})F_{M,t-1}$.

In order to satisfy the budget constraint, the central bank in each period needs to initiate a transfer payment T_t to households:

(2.34) $T_t = (r^*_{t-1} + \Psi_{t-1})S_t F_{M,t-1} - r_{t-1}B_{M,t-1},$

which is equal to the net income on interest payments. However, when restrictions on financial flows take the form of taxes (e.g. the URR measure), the central bank may receive additional revenues, and thus the budget constraint (2.30) becomes:

(2.30') $S_t F_{M,t} - B_{M,t} - M_{M,t} = (1 + r^*_{t-1} + \Psi_{t-1})S_t F_{M,t-1} - (1 + r_{t-1})B_{M,t-1} - M_{M,t-1}$
$$-\tau_t(1 + r^*_{t-1} + \Psi_{t-1})S_t F_{H,t-1} - T_t.$$

These additional revenues are subsequently rebated to households so that the amount of transfer payment becomes:

(2.34') $T_t = (r^*_{t-1} + \Psi_{t-1})S_t F_{M,t-1} - r_{t-1}B_{M,t-1} + \tau_t(1 + r^*_{t-1} + \Psi_{t-1})S_t F_{H,t-1}$.

Lastly, it is important to recognize that the central bank in this model does not face any limitation on undertaking interventions in the FX market. Particularly, the central bank is allowed to run down foreign reserves and to engage in a negative net worth as long as the central bank's behavior does not generate a Ponzi scheme. Though unrealistic, these features seem typical in standard micro-founded macroeconomic models with Ricardian equivalence.[32] Based on the central bank setup prescribed above, the transversality

[32] It is a well-known fact that monetary policy and fiscal policy cannot be active at the same time. See Leeper (1991). In standard macroeconomic models with the interest rate policy rules satisfying the Taylor principle, fiscal policy must be passive in the sense of assuring that the government's budget constraint is

condition for the government's net liabilities should hold implicitly because the stock of foreign reserves $F_{M,t}$ and the exchange rate S_t are stationary. In reality, the central bank would not be able to defend a currency peg when the stock of foreign reserves is depleted (especially when preventing currency depreciation), and the change in the central bank's net worth may significantly affect the decision to intervene in the FX market (especially when mitigating currency appreciation). Therefore, extensions that consider alternative setups in which the level of foreign reserves and the amount of net worth can play some role seem worthwhile.

❖ Foreign Country

On the aspect of international finance, foreign agents only interact with the home country by borrowing or lending in the form of foreign-currency bond at the gross nominal interest rate $(1 + r_t^* + \Psi_t)$. Regarding the country risk premium term Ψ_t, the technical part $\psi(\cdot)$ essential for preserving the stationarity of the home country's foreign indebtedness takes the functional form:

(2.35) $$\psi\left(\frac{F_t}{P_t^*}\right) = \upsilon_f\left(e^{\frac{\bar{F}}{\bar{P}^*} - \frac{F_t}{P_t^*}} - 1\right).$$

Meanwhile, the part φ_t reflecting the foreign country's willingness to lend is exogenously determined by the stochastic process:

(2.36) $$\varphi_t = \rho_\varphi \varphi_{t-1} + \left(1 - \rho_\varphi\right)\bar{\varphi} + \varepsilon_{\varphi,t},$$

where $0 < \rho_\varphi < 1$. A fall in φ_t would increase the amount of net capital inflows as it becomes less costly for households to borrow from abroad or less attractive for households to hold international foreign-currency bond. In the steady state, the country risk premium is equal to $\bar{\varphi}$, which should be a positive number because financial claims issued by emerging markets are generally not considered as risk-free.

It is worth pointing out that the model does not incorporate foreign holding of domestic equity even though an influx of foreign funds in the form of direct investment and portfolio equity investment appeared as an important aspect of Thailand's experience. The main reasons are that the effectiveness of sterilized FX interventions does not fundamentally rely on foreign ownership of domestic equity and that the model would become much more complicated after embedding a portfolio allocation problem. In other words, one form of capital flows, namely debt flows generated by borrowing and lending

satisfied. On the other hand, models in the field of fiscal theory of the price level features active fiscal policy together with passive monetary policy in which the central bank simply prints money to satisfy the government's budget constraint.

in the form of international bond, is sufficient for developing a macroeconomic model to analyze sterilized FX interventions.[33]

On the aspect of international trade, the demand for the home country's exports can be specified by:

(2.37) $$C_{H,t}^{*} = \varrho^{*}\left(\frac{P_t^{H*}}{P_t^{*}}\right)^{-\eta^{*}} Y_t^{*} = \varrho^{*}\left(\frac{P_t^{H}}{S_t P_t^{*}}\right)^{-\eta^{*}} Y_t^{*},$$

where Y_t^* is foreign output. Note that a star ($*$) indicates the foreign counterparts. The demand specification (2.37) can be derived from micro-foundation together with certain appropriate limiting conditions that reflect differences between small and large economies (see Batini, Levine, and Pearlman (2007) for an example of the derivation). As η^* is the elasticity of substitution between home and foreign goods (for foreign agents), a large value of η^* implies high substitutability between home and foreign goods in the world market so that a small change in the terms of trade would induce a substantial change in the demand for exports.

In addition, the home country can import foreign goods at the price $S_t P_t^*$ as the law of one price holds. These foreign goods can be used for consumption (i.e. C_t^F as a part of the consumption bundle), investment (i.e. I_t^F as a part of the investment goods bundle), and imported inputs (i.e. X_t for production of wholesale firms).

Lastly, it is necessary to specify the dynamics of the foreign economy:

(2.38) $$log(Y_t^*) = \rho_y log(Y_{t-1}^*) + \left(1-\rho_y\right) log(\overline{Y}^*) + \varepsilon_{Y,t}^*,$$

(2.39) $$\pi_t^* = \rho_\pi \pi_{t-1}^* + \left(1-\rho_\pi\right)\overline{\pi}^* + \varepsilon_{P,t}^*,$$

(2.40) $$r_t^* = \rho_r r_{t-1}^* + \left(1-\rho_r\right)\left\{\overline{r}^* + \theta_\pi^*(\pi_t^* - \overline{\pi}^*) + \theta_y^*\left(log(Y_t^*) - log(\overline{Y}^*)\right)\right\},$$

where π_t^* is the foreign inflation rate. It is worth pointing out that in this model, changes in φ_t and r_t^* have similar effects as both affect the nominal interest rate on foreign-currency bond $r_t^* + \Psi_t$ faced by households in the home country. Nevertheless,

[33] However, foreign ownership of domestic equity might be a critical factor for generating suboptimal outcomes due to excessive capital controls on which the effectiveness of sterilized FX interventions can be founded. When international bond is the only financial instrument traded by domestic and foreign households, restrictions on financial flows may not be able to create such suboptimal outcomes. One specific example is that excessive controls on capital outflows would play no role so that the country becomes a net borrower when a fall in the country's risk premium induces massive capital inflows. On the contrary, if cross-border financial flows can be in the form of both debt and equity, an influx of foreign funds resulting from the growing desire of foreign entities to acquire more domestic equity may create a suboptimal outcome in the presence of excessive controls on capital outflows.

fluctuations of φ_t and r_t^* are really driven by different factors, and their effects could be different in a model that fully specifies the dynamics of the foreign economy.

❖ Market Clearing

Up to this point, five markets have been completely described. They are for money, liquid domestic-currency bond, illiquid domestic-currency bond, deposits, and loans. Equation (2.41) – (2.25) specify market-clearing conditions of these markets:

(2.41) $M_{H,t} + M_{B,t} = M_{M,t} = M_t,$

(2.42) $B_{H,t} + B_{B,t} = B_{M,t} = B_t,$

(2.43) $A_{H,t} = A_{B,t} = A_t,$

(2.44) $D_{H,t} = D_{B,t} = D_t,$

(2.45) $L_{B,t} = L_{F,t} = L_t,$

where $L_{F,t}$ denotes the amount of loans demanded by firms.

2.4.2 Effective Sterilized FX Interventions Based on Liquidity Benefits

In this study, the effectiveness of sterilized FX interventions in influencing exchange rate fluctuations rests on liquidity benefits from holding financial assets. The following discussion focuses on four issues: (i) the existence of liquidity benefits, (ii) the mechanism through which currency movements occur as a result of sterilized FX interventions, (iii) the difference in policy actions between altering the policy interest rate and undertaking sterilized FX interventions, and (iv) the key aspects of sterilized FX interventions based on liquidity benefits.

❖ Existence of Liquidity Benefits

At the moment, liquidity benefits from holding financial assets receive limited attention in the modern macroeconomic literature. Based on the Neo-Wicksellian framework to which standard macroeconomic models belong, financial markets and money are completely ignored as monetary policy is characterized by an interest rate rule. In these models, money essentially plays no direct role in describing the dynamics of the economy. Moreover, the stock of money can be determined independently based on the level of the policy interest rate. Hence, models in the Neo-Wicksellian tradition cannot address issues related to the financial system's liquidity condition. Nonetheless, the recent work by Canzoneri et al. (2008) illustrated how open market operations can affect such liquidity condition. Specifically, the liquidity buffering effect arises when the central bank conducts an open market purchase (or sale) in order to lower (or raise) the policy interest rate as households and financial intermediaries would hold less (or more) liquid domestic-currency bond. Then, decreased (or increased) liquidity mitigates the reduction (or rise) in the interest rate relevant for the consumption-saving decision.

In reality, several financial assets seem to provide liquidity benefits by helping facilitate transactions. For instance, holding deposits and liquid (government) bond in addition to cash may help households and businesses complete their transactions. Meanwhile, financial intermediaries may also hold cash and liquid (government) bond to manage liquidity of their operations. Based on Thailand's experience documented in section 2.3, the existence of liquidity premiums seems apparent and the decline in liquidity premiums looks consistent with the model's implication of large-scale sterilized FX interventions.[34] More generally, Canzoneri, Cumby and Diba (2007) showed that a negative correlation exists between the interest rate implied by a consumption Euler equation and the money-market interest rate targeted by the central bank in the US data. Their findings suggest that the magnitude of liquidity benefits provided by various financial assets is not negligible. From a broader perspective, the existence of these liquidity benefits may help explain the risk-free rate and equity premium puzzles.

In brief, casual and empirical evidence points to the existence of liquidity benefits from holding financial assets. Furthermore, the interest rate relevant for the consumption-saving decision, which serves as one of the key variables driving the dynamics of the economy, depends on the liquidity premium of illiquid domestic-currency bond. Hence, the effectiveness of sterilized FX interventions based on liquidity benefits seems promising as long as they can affect the prevailing liquidity condition in the financial system. The following discussion thus examines the mechanism through which currency movements occur as a result of the shift in the financial system's liquidity condition induced by sterilized FX interventions.

❖ Currency Movements Resulting from Sterilized FX Interventions

Because sterilized FX interventions can influence exchange rate fluctuations in the same way that changes in the policy interest rate affect the economy, it seems useful to review what would happen to the economy when the central bank adjusts the policy interest rate in a Neo-Wicksellian setup. Let's consider an example of a policy interest rate cut. The central bank in order to lower the policy interest rate r_t needs to conduct an open market operation by purchasing liquid domestic-currency bond with newly printed money. In the presence of price stickiness, real money balance increases. As a result, the marginal utility from holding money decreases and the policy interest rate falls. Since in the Neo-Wicksellian setup, the policy interest rate r_t is also the interest rate relevant for the

[34] Large-scale sterilized FX interventions with accumulation of foreign reserves should improve the financial system's liquidity condition. Thus, liquidity premiums should fall. However, the observed decline in liquidity premiums exists only to the extent that Treasury bill rates could represent the interest rate relevant for the consumption-saving decision.

consumption-saving decision r_t^C, the UIP-typed condition (2.13) implies that the nominal exchange rate must depreciate instantaneously in order to generate expected currency appreciation. This is the well-known Dornbusch's overshooting feature, which requires some nominal rigidity in prices. It is worth mentioning that in the new steady state (when no forces bring the economy back to the original steady state), the nominal exchange rate should be more depreciated, while the real exchange rate returns to its original value. Such a result is common in any model featuring the purchasing power parity and constant steady-state prices. As the economy reaches the new steady state, domestic prices need to rise to bring real money balance back to the original level. To restore the purchasing power parity, the nominal exchange rate must depreciate by the same magnitude of the increase in domestic prices. In sum, a reduction in the policy interest rate causes the nominal exchange rate to depreciate instantaneously in order to generate expected currency appreciation towards the new steady state in which the nominal exchange rate would become more depreciated. It is obvious that during the transition period, the real exchange rate would remain more depreciated than its steady-state value. It is important to realize that when prices are flexible, there would be no overshooting effects. The nominal exchange rate immediately arrives at its new steady-state value which is more depreciated; so do other nominal variables. Meanwhile, all real variables remain unaffected.

Now, let's turn to examine how sterilized FX interventions affect the economy by considering an example of accumulation of foreign reserves. Specifically, the central bank acquires additional foreign-currency bond with the proceeds from a new issuance of liquid domestic-currency bond. The central bank's action improves the prevailing liquidity condition as households and financial intermediaries would hold more liquid domestic-currency bond. When prices are fixed, real holding of liquid domestic-currency bond rises so that the liquidity premium of illiquid domestic-currency bond, captured by $r_t^C - r_t$, decreases due to the diminishing marginal utility from holding such bond. Since the central bank targets the policy interest rate r_t, the interest rate relevant for the consumption-saving decision r_t^C must fall. Then, the overshooting feature would exactly work as described in the Neo-Wicksellian setup. Similarly, as the economy arrives at the new steady state, all key nominal variables (the stock of foreign reserves is one obvious exception) would change by the same magnitude of the change in liquid domestic-currency bond, while all standard real variables would return to their original steady-state values. The nominal exchange rate would also become more depreciated in the new steady state. In addition, sterilized FX interventions have some real impact on the economy, as the real exchange rate would remain at a more depreciated value during the transition period. All of these results require some nominal rigidity in prices.

In sum, sterilized FX interventions can influence currency movements in the same way as policy interest rate adjustments do. This should not be much surprised since r_t^C can be decomposed into two components: the policy interest rate r_t and the liquidity premium of illiquid domestic-currency bond $r_t^C - r_t$. Based on the UIP-typed condition (2.13), it is r_t^C, not r_t, that influences the dynamics of the exchange rate. Therefore, the change in the stock of liquid domestic-currency bond as part of sterilized FX interventions would influence exchange rate movements owing to the liquidity provision effect. Since the principle mechanism that both policy actions affect the economy seems to work by inducing changes in the interest rate relevant for the consumption-saving decision, the following discussion explores whether the difference between undertaking sterilized FX interventions and adjusting the policy interest rate exists in other aspects.

❖ Difference between Policy Interest Rate Adjustments and Sterilized FX Interventions

In principle, implementing sterilized FX interventions and adjusting the policy interest rate can yield virtually identical outcomes. As mentioned earlier, such a feature primarily results from the tight link between the average return on loans r_t^L and the interest rate relevant for the consumption-saving decision r_t^C. This is still the case even in the presence of financial accelerator. The ability of financial intermediaries to borrow or lend in the form of illiquid domestic-currency bond effectively prevents differences in the liquidity premiums from translating into differences in external financing premiums as well as in real allocations. Nevertheless, there exists one situation in which sterilized FX interventions can have an edge over policy interest rate adjustments. Particularly, when the economy encounters the zero bound, sterilized FX interventions can still lower the interest rate relevant for the consumption-saving decision by providing additional liquidity to the financial system.

Hence, it seems worthwhile to examine how sterilized FX interventions might affect the economy differently in an alternative environment in which financial intermediaries can neither issue nor hold illiquid domestic-currency bond. This setup could be appropriate in the presence of considerable restrictions on financial intermediaries.[35] Specifically, banks are prohibited from both undertaking transactions with foreign entities and relying on wholesale funding.

Based on the assumption that financial intermediaries can neither issue nor hold illiquid domestic-currency bond, the original balance sheet constraint (2.21) should be replaced by:

(2.21') $L_{B,t} + B_{B,t} + M_{B,t} = D_{B,t}$,

which suggests that the amount of loans can be constrained by the amount of deposits since financial intermediaries cannot freely issue illiquid domestic-currency bond to

[35] It is obvious that such restrictions can be viewed as another form of financial frictions. However, the term "restrictions" is used in lieu of "frictions" to distinguish these distortions from other frictions (e.g. liquidity management of financial intermediaries) that are central to the effectiveness of sterilized FX interventions.

support the creation of new loans. It can be showed that the optimal conditions for financial intermediaries become:

$$(2.23')\quad r_t^L = r_t + (r_t^L - r_t^D)(1-\alpha_d)\frac{D_{B,t}}{B_{B,t}},$$

$$(2.24')\quad r_t^L = (r_t^L - r_t^D)\alpha_d\frac{D_{B,t}}{M_{B,t}},$$

which state that financial intermediaries make loans up to the point where the marginal revenue from extending loans is equal to the marginal benefit from holding liquid domestic-currency bond and cash, respectively. Similarly, condition (2.25) becomes:

$$(2.25')\quad r_t^L - r_t^D = \frac{1}{Z_D{\alpha_d}^{\alpha_d}(1-\alpha_d)^{1-\alpha_d}}(r_t^L)^{\alpha_d}(r_t^C - r_t)^{1-\alpha_d},$$

which implies that the marginal revenue from making a loan is equal to the marginal cost of funding that loan, i.e. interest payments on deposits plus costs associated with liquidity management of deposits.

In this alternative setup, sterilized FX interventions can lead to an outcome that is markedly different from what induced by policy interest rate adjustments because the link between r_t^C and r_t^L is decoupled. Using condition (2.23') and (2.24'), it can be showed that

$$(2.46)\quad r_t = r_t^L\left(1 - \frac{1-\alpha_d}{\alpha_d}\frac{M_{B,t}}{B_{B,t}}\right),$$

which suggests that the average return on loans r_t^L is driven by the policy interest rate r_t and the financial intermediary's cash-to-bond ratio $M_{B,t}/B_{B,t}$. Hence, sterilized FX interventions with accumulation (or decumulation) of foreign reserves would induce a decrease (or increase) in r_t^L. The change in r_t^L may considerably differ from the movement of r_t^C. The upshot is that the structure of the domestic financial system plays a critical role in determining how sterilized FX interventions affect the economy especially when their effectiveness primarily rests on liquidity benefits.

❖ Additional Key Aspects of Sterilized FX Interventions Based on Liquidity Benefits

First, sterilized FX interventions are effective in influencing currency movements because the model is non-Ricardian. This failure of Ricardian equivalence in some strict sense stems from the existence of liquidity benefits which prevents households from completely nullifying a change in the central bank's holding of foreign-currency bond since a change in the liquidity condition has a marginal impact on household decisions. It is important to recognize that differences in liquidity benefits also create imperfect substitution among financial assets.

Second, even though the model is non-Ricardian, Ricardian equivalence remains to hold in the fiscal aspect. Particularly, the amount of foreign-currency bond held by the central bank does not have an independent impact on the combined budget constraint faced by households, mainly due to the assumption that liquidity benefits are non-pecuniary. If liquidity benefits are modeled by transaction costs rather than utility, the choice of $F_{M,t}$ would appear in the combined budget constraint. In such cases, Ricardian equivalence would also fail in the fiscal aspect and sterilized FX interventions could affect currency movements through the additional channel underpinned by the wealth effect.

Third, the effectiveness of sterilized FX interventions based on liquidity benefits might be limited in developed economies due to the following factors. One is that some foreign-currency bond (specifically, issued by the foreign government) that can provide liquidity benefits may exist when the financial system is highly developed. An intuitive example is that global financial institutions may hold securities issued by a variety of governments for their liquidity management. Under such circumstances, sterilized FX interventions would not be effective since both (liquid) domestic-currency and foreign-currency bonds become perfectly substitutable again. The key implication is that an extremely large-scale FX intervention is required to influence exchange rate movements. The reason is sterilized FX interventions would re-gain their effectiveness when the central bank can affect the financial system's liquidity condition rather than alter the composition of bonds (in the private hand) denominated in different currencies. Furthermore, the bond elasticity of liquidity benefits (captured by ν_b) could be much smaller in developed countries even though the extent for liquidity benefits (reflected by ϕ_b) could be greater. Consequently, sizeable FX interventions are also needed. The last factor is related to the size of the financial system represented by the amount of liquid domestic-currency bond issued by the government (in this model, this is zero) because the impact of interventions on the nominal exchange rate becomes smaller as the size of the financial system gets larger.[36]

Fourth, the magnitude of currency movements induced by sterilized FX interventions depends on several factors. Regarding the size of the overshooting effect, the degree of price stickiness and the bond elasticity of liquidity benefits are the significant determinants. Meanwhile, the magnitude of FX interventions in percentage change, not in the absolute level, is an important determinant for the change in the steady-state value of the exchange rate. It is noteworthy that even if the magnitude of FX interventions matches the amount of private capital flows, the exchange rate should not be stabilized. To keep the exchange rate unchanged in response to flows of foreign funds, the central bank needs to undertake sterilized FX interventions up to the point where the change in the liquidity premium $r_t^C - r_t$ matches the change in the country risk premium φ_t.

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[36] Let x be the percentage change of F_M and y be the percentage change of S. Then, $y = x \frac{SF_M}{M+B_M+B_G}$, where B_G is the amount of government-issued liquid domestic-currency bond (in this model, $B_G \equiv 0$).

Fifth, the prescription of sterilized FX interventions exhibits some peculiar features. The dynamics of the exchange rate induced by FX interventions fundamentally depends on the change in the central bank's total liabilities $B_{M,t} + M_{M,t}$, not the change in the level of foreign reserves $F_{M,t}$ per se. However, these two variables are perfectly tied by condition (2.29). In principle, the central bank can influence currency movements by adjusting $B_{M,t}$ without changing $F_{M,t}$ (e.g. transfer the proceeds from bond issuance to households). This is essentially the "liquidity provision" effect described in Canzoneri et al. (2008).

2.4.3 Remaining Part on the Production Side

The behavior of firms is described here to complete the model. In this economy, firms produce goods for both consumption and investment. In addition, firms face a borrowing constraint due to the presence of private information together with agency costs. Thus, financial accelerator is embedded in the production side. For the sake of algebraic clarity, there are three types of firms: wholesale firms, retail firms and capital-producing firms.[37]

❖ Wholesale Firms

There is a continuum of wholesale firms of length unity. Operating in the environment of perfect competition, wholesale firms use labor, capital and imported inputs to produce intermediate goods for retail firms. The production function for wholesale firm i is given by:

$$(2.47)\quad Y_{i,t} = \omega_{i,t} Z_t \left(\frac{u_{i,t}}{\bar{u}} K_{i,t-1}\right)^{1-\alpha_h-\alpha_x} \left(H_{i,t}\right)^{\alpha_h} \left(X_{i,t}\right)^{\alpha_x},$$

where $K_{i,t-1}$ is capital, $H_{i,t}$ is labor, and $X_{i,t}$ is imported inputs, all of which are used by wholesale firm i in period t. Note that the amount of capital available in period t, denoted by $K_{i,t-1}$, is predetermined in period $t-1$. In addition, capital utilization, denoted by $u_{i,t}$, is adjustable. The effective level of capital thus depends on the physical amount of capital $K_{i,t-1}$ and the degree of capital utilization $u_{i,t}$ relative to its steady-state level $\bar{u}$. The rate of capital depreciation in turn depends on the rate of capital utilization according to the function:

$$(2.48)\quad \delta\left(u_{i,t}\right) = \alpha_u \left(u_{i,t}\right)^{1+\zeta_u},$$

which says that the rate of capital depreciation is increasing in the rate of capital utilization for $\zeta_u > 0$. Note that the parameter α_u simply serves as a technical device that

[37] The division of a firm into three separate entities is not necessary in this model as one can easily put all three types of firms into one unit.

makes the steady-state relationship satisfied. The level of economy-wide total factor productivity is given by Z_t, which follows the stochastic process:

$$(2.49)\quad log(Z_t) = \rho_z log(Z_{t-1}) + (1-\rho_z) log(\overline{Z}) + \varepsilon_{Z,t},$$

while $\omega_{i,t}$ is the firm-specific productivity shock, which is i.i.d. (across firms and time) distributed with mean equal to one, i.e. $\mathbb{E}[\omega_{i,t}] = 1$. The knowledge about $\omega_{i,t}$ is private information to firms; private information together with agency costs contributes to the existence of external financing premiums. Specifically, similar to Bernanke, Gertler and Gilchrist (1999), it is costly to verify the actual level of output when firms default on their debt.

Each wholesale firm is managed by an entrepreneurial manager who is risk-neutral.[38] The manager's objective is to maximize the firm's value. At time t, after observing $\omega_{i,t}$, the manager chooses $H_{i,t}$, $X_{i,t}$ and $u_{i,t}$ conditional on Z_t and $K_{i,t-1}$ to maximize the firm's value:

$$(2.50)\quad V_{W,i,t} = P_t^W Y_{i,t} + P_t^K K_{i,t-1}\left(1-\delta(u_{i,t})\right) - W_t H_{i,t} - S_t P_t^* X_{i,t} - \left(1 + r_{t-1}^L + \chi_{i,t-1}\right) L_{W,i,t-1}$$

subject to the production function (2.47) and the capital depreciation function (2.48), where P_t^W is the price of wholesale goods (which in turn is the nominal marginal cost faced by retail firms), P_t^K is the price of capital, and W_t is the nominal wage. The amount of loans taken by wholesale firm i is denoted by $L_{W,i,t}$. Based on equation (2.50), the firm's value depends on the sale revenue, the value of capital, the cost of labor and imported inputs, and the amount of loans from financial intermediaries. The wholesale firm's decision must conform to the following optimal conditions:

$$(2.51)\quad \alpha_h \frac{Y_{i,t}}{H_{i,t}} = \frac{W_t}{P_t^W},$$

$$(2.52)\quad \alpha_x \frac{Y_{i,t}}{X_{i,t}} = \frac{S_t P_t^*}{P_t^W},$$

$$(2.53)\quad (1-\alpha_h-\alpha_x)\frac{Y_{i,t}}{u_{i,t}} = \frac{P_t^K}{P_t^W} K_{i,t-1}\delta'(u_{i,t}) = \frac{P_t^K}{P_t^W} K_{i,t-1}(1+\zeta_u)\alpha_u (u_{i,t})^{\zeta_u}.$$

[38] In a typical model with external financing premiums, financial contracts between firms and financial intermediaries are written in the way that firms take all risks; such a setup yields an important implication that financial intermediaries would receive an average return on loans to firms at the rate of r_t^L. Therefore, firms must operate in the risk-neutral fashion. In Bernanke, Gertler and Gilchrist (1999) as well as other previous works, this is done by the assumption that firms are completely owned by entrepreneurs who are risk-neutral.

The first two conditions specify the demand for labor and imported inputs, while the last equation determines the rate of capital utilization. Using the capital depreciation function (2.48), condition (2.53) can be rewritten as:

(2.54) $$\frac{1-\alpha_h-\alpha_x}{1+\zeta_u}\frac{Y_{i,t}}{K_{i,t-1}\delta\left(u_{i,t}\right)}=\frac{P_t^K}{P_t^W}.$$

In addition, at time t, the manager chooses the level of capital to be used in the next period by maximizing the firm's expected value: $\mathbb{E}_t\left[V_{W,i,t+1}\right]$ subject to the production function (2.47) and the balance sheet constraint:

(2.55) $$P_t^K K_{i,t}=L_{W,i,t}+N_{W,i,t},$$

where $N_{W,i,t}$ is the amount of net worth, which is equal to the firm's value. Observe that wholesale firms bear risks associated with asset price movements (i.e. changes in the price of capital) since they own capital. Based on equation (2.55), wholesale firms can finance their holding of capital in two ways: equity or debt (e.g. loans from financial intermediaries). The optimal condition requires:

(2.56) $$\mathbb{E}_t\left[(1-\alpha_h-\alpha_x)P_{t+1}^W\frac{Y_{i,t+1}}{K_{i,t}}+P_{t+1}^K\left(1-\delta\left(u_{i,t+1}\right)\right)\right]=\left(1+r_t^L+\chi_{i,t}\right)P_t^K,$$

which implies that wholesale firms would acquire capital up to the point where the expected marginal return on an additional unit of capital is equal to the marginal cost of the funding that finances the capital purchase. The marginal cost is equal to the borrowing cost $r_t^L+\chi_{i,t}$ faced by wholesale firms, which consists of two components. One is the baseline interest rate on loans; another is the external financing premium. In general, the external financing premium should vary inversely with the firm's net worth since a larger amount of collateral entails a smaller loss incurred by the lender in the event that the firm goes bankrupt. The detail on external financing premiums is not presented here as it becomes standard in the literature. Based on Bernanke, Gertler and Gilchrist (1999), the external financing premium may be expressed as an increasing function of the firm's asset-to-equity ratio (equivalent to the firm's leverage ratio):

(2.57) $$1+\chi_{i,t}=\chi\left(\frac{P_t^K K_{i,t}}{N_{W,i,t}}\right),$$

where $\chi'(\cdot)>0$, $\chi(0)=0$, and $\chi(\infty)=\infty$. For simplicity, $\chi(\cdot)$ takes the functional form:

(2.58) $$1+\chi_{i,t}=\alpha_l\left(\frac{P_t^K K_{i,t}}{N_{W,i,t}}\right)^{\upsilon_l},$$

where υ_l is the elasticity of the external financing premium with respect to the asset-to-equity ratio, and α_l is the parameter that makes the steady-state relationship hold.

Up to this point, the analysis is done at the firm level; thus, all conditions hold for any given wholesale firm. Conditions for the aggregate level can be obtained by integrating individual firms' variables (i.e. $x_t = \int_0^1 x_{i,t} di$). Then, the aggregate demand for labor and imported inputs are described by:

(2.59) $\alpha_h \frac{Y_t}{H_t} = \frac{W_t}{P_t^W},$

(2.60) $\alpha_x \frac{Y_t}{X_t} = \frac{S_t P_t^*}{P_t^W},$

while the economy-wide rate of capital utilization is implicitly determined by:

(2.61) $\frac{1-\alpha_h-\alpha_x}{1+\zeta_u} \frac{Y_t}{K_{t-1}\delta(u_t)} = \frac{P_t^K}{P_t^W},$[39]

where the economy-wide rate of capital depreciation is approximately equal to (up to first-order approximation):

(2.62) $\delta(u_t) \approx \alpha_u (u_t)^{1+\zeta_u}.$[40]

Similarly, the aggregate production function takes the form:

(2.63) $Y_t = \kappa_\omega Z_t \left(\frac{u_t}{\bar{u}} K_{t-1}\right)^{1-\alpha_h-\alpha_x} (H_t)^{\alpha_h} (X_t)^{\alpha_x},$

where $\kappa_\omega = \left(\int_0^1 (\omega_{i,t})^{1-\alpha_h-\alpha_x} di\right)^{\frac{1}{1-\alpha_h-\alpha_x}}$, and the wholesale firm's balance sheet and the wholesale firm's value at the aggregate level are, respectively, expressed by:

(2.64) $P_t^K K_t = L_{W,t} + N_{W,t},$

[39] Note that $K_{t-1}\delta(u_t) = \left(\int_0^1 K_{i,t-t} di\right)\left(\int_0^1 \delta(u_{i,t}) di\right) = \int_0^1 K_{i,t-1}\delta(u_{i,t}) di - \mathbb{Cov}_i\left(K_{i,t-1}, \delta(u_{i,t})\right)$. Therefore, it is necessary to prove that $\mathbb{Cov}_i\left(K_{i,t-1}, \delta(u_{i,t})\right) = 0$. Nonetheless, since $K_{i,t-1}$ is predetermined, it suffices to show that $u_{i,t}$ is a function of $\omega_{i,t}$ and other aggregate variables for claiming that $\mathbb{Cov}_i\left(K_{i,t-1}, \delta(u_{i,t})\right) = 0$. Particularly, $u_{i,t} =$

$$(\omega_{i,t})^{\frac{1}{\zeta_u(1-\alpha_h-\alpha_x)}} (Z_t)^{\frac{1}{\zeta_u(1-\alpha_h-\alpha_x)}} \left(\frac{(1-\alpha_h-\alpha_x)}{(1+\zeta_u)\alpha_u} \frac{P_t^W}{\bar{u} P_t^K}\right)^{\frac{1}{\zeta_u}} \left(\frac{\alpha_h P_t^W}{W_t}\right)^{\frac{\alpha_h}{\zeta_u(1-\alpha_h-\alpha_x)}} \left(\frac{\alpha_x P_t^W}{S_t P_t^*}\right)^{\frac{\alpha_x}{\zeta_u(1-\alpha_h-\alpha_x)}}.$$

[40] In order that $\delta(u_t) = \alpha_u (u_t)^{1+\zeta_u}$, it is necessary to compute the economy-wide rate of capital utilization as $u_t = \left(\int_0^1 (u_{i,t})^{1+\zeta_u} di\right)^{\frac{1}{1+\zeta_u}}$. However, such aggregation would cause some difficulty to obtain other conditions for the aggregate level.

(2.65) $V_{W,t} = P_t^W Y_t + P_t^K K_{t-1}\left(1-\delta(u_t)\right) - W_t H_t - S_t P_t^* X_t - (1 + r_{t-1}^L) L_{W,t-1}$.[41]

Moreover, it can be showed that the external financing premium is the same for all wholesale firms:

(2.66) $$\mathbb{E}_t\left[\frac{(1-\alpha_h-\alpha_x)P_{t+1}^W \frac{Y_{t+1}}{K_t} + P_{t+1}^K\left(1-\delta(u_{t+1})\right)}{P_t^K}\right] = 1 + r_t^L + \chi_{i,t} = 1 + r_t^L + \chi_t.$$[42]

At the aggregate level, the expected marginal return on an additional unit of capital is equal to the marginal cost of borrowing faced by wholesale firms. In addition, based on the external financing premium's characteristics illustrated by equation (2.58), all wholesale firms would acquire capital in the way that the asset-to-equity ratio is the same for all wholesale firms. Hence, the external financing premium only depends on the aggregate asset-to-equity ratio:

(2.67) $$1 + \chi_t = \alpha_l \left(\frac{P_t^K K_t}{N_{W,t}}\right)^{v_l}.$$

Lastly, in each period, a fraction of existing firms would go out of business. This is simply a mechanic device to prevent wholesale firms from accumulating sufficient net worth to fully finance capital and overcome financial constraints since debt financing is more costly owing to the existence of external financing premiums. In particular, each wholesale firm faces the probability of ϑ_w to remain in business in the next period. When some existing wholesale firms go out of business, new wholesale firms would take over their places. At their termination, wholesale firms pay dividends in the amount of their remaining net worth. Furthermore, as a technical matter, it is imperative to ensure that all wholesale firms always have some net worth; otherwise, firms with zero net worth would hold no capital since they could not borrow funds from financial intermediaries at all. Hence, households in each period inject equity to all wholesale firms in the amount equal to a fraction ϖ_e of dividend payments.[43] In short, at the aggregate level, the level of net worth is:

(2.68) $$N_{W,t} = \vartheta_w V_{W,t} + \varpi_e (1-\vartheta_w) V_{W,t},$$

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[41] Note that at the aggregate level, the wholesale firm's interest payments amount to $r_t^L L_{W,t}$ because a fraction of wholesale firms would default while the rest repay their debt with the borrowing cost of $r_t^L + \chi_t$.

[42] This can be derived by first showing that $\frac{Y_{i,t}}{K_{i,t-1}} = u_{i,t}\left(\omega_{i,t}\right)^{\frac{1}{1-\alpha_h-\alpha_x}} \frac{1}{(\kappa_\omega)^{1-\alpha_h-\alpha_x}} \frac{Y_t}{u_t K_{t-1}}$, then substituting this expression into condition (2.56), and applying the law of iteration of expectations.

[43] In the literature, a typical way to inject equity to wholesale firms is done in the form of wage payments for entrepreneurial labor.

and the amount of transfer payment to households is:

(2.69) $\Gamma_{W,t} = (1-\varpi_e)(1-\vartheta_w)V_{W,t}.$

❖ Retail Firms

There is a continuum of retail firms of length unity. Operating in the environment of monopolistic competition, retail firms purchase immediate goods from wholesale firms, imprint their brands, and sell these differentiated products at their pre-set prices. All of differentiated goods are then bundled as home goods according to:

(2.70) $$Y_t^H = \left(\int_0^1 \left(Y_{f,t}^H\right)^{\frac{\varepsilon-1}{\varepsilon}} df\right)^{\frac{\varepsilon}{e-1}},$$

where $Y_{f,t}^H$ is the amount of differentiated product supplied by retail firm f, and ε is the elasticity of substitution among differentiated products. One can imagine that there exist competitive final goods firms that assemble all of differentiated products sold by retail firms. It can be showed that the demand for each differentiated product at a given price $P_{f,t}^H$ and the price of the home goods bundle must satisfy:

(2.71) $$Y_{f,t}^H = \left(\frac{P_{f,t}^H}{P_t^H}\right)^{-\varepsilon},$$

(2.72) $$P_t^H = \left(\int_0^1 \left(P_{f,t}^H\right)^{1-\varepsilon} df\right)^{\frac{1}{1-\varepsilon}}.$$

Following the New-Keynesian literature, nominal rigidity takes the form of staggered price setting in the Calvo fashion together with some backward-looking element proposed by Gali and Gertler (1999). Specifically, each retail firm in each period has the probability of $1-\vartheta_r$ to adjust its price $P_{f,t}^H$. However, retail firms can be categorized into two groups based on their price setting behavior. In particular, a fraction ϑ_b of retail firms act in a backward-looking manner, while the remaining firms behave in a forward-looking fashion.

For forward-looking retail firms, when an opportunity to adjust their prices comes, they choose their new prices $\tilde{P}_t^{H,f}$ in order to maximize the retail firm's value. The price $\tilde{P}_t^{H,f}$ can be determined based on the following profit maximization problem: maximize

(2.73) $$\mathbb{E}_t\left[\sum_{j=0}^{\infty}(\vartheta_r)^j \Lambda_{t,t+j}\left\{\left(\tilde{P}_t^{H,f} - P_{t+j}^W\right)Y_{f,t+j}^H\right\}\right]$$

subject to the demand specification (2.71). Note that retail firms use the nominal discount factor $\Lambda_{t,t+j}$ to appropriately discount the stream of profit. The optimal condition for price setting requires:

$$(2.74)\quad \mathbb{E}_t\left[\sum_{j=0}^{\infty}(\vartheta_r)^j\,\Lambda_{t,t+j}\left\{\tilde{P}_t^{H,f}-\frac{\varepsilon}{\varepsilon-1}P_{t+j}^{W}\right\}\right]=0.$$

On the other hand, backward-looking firms set their new prices at $\tilde{P}_t^{H,b}$ according to:

$$(2.75)\quad \tilde{P}_t^{H,b}=\tilde{P}_{t-1}^{H}(1+\pi_{t-1}^{H}),$$

where $\tilde{P}_{t-1}^{H}$ is the average of newly set price in the previous period:

$$(2.76)\quad \tilde{P}_{t-1}^{H}=\left(\tilde{P}_{t-1}^{H,b}\right)^{\vartheta_b}\left(\tilde{P}_{t-1}^{H,f}\right)^{1-\vartheta_b}.$$

Thus, backward-looking firms simply choose their new prices based on the recent pricing behavior of their competitors: using lagged inflation to adjust the base price which is the price set by other retail firms in the previous period. This price setting yields the so-called hybrid Phillips curve. It can be showed that under the assumption of zero steady-state inflation, the Calvo-fashioned staggered price setting together with some particular backward-looking element yields the hybrid (of Traditional Keynesian and New-Keynesian) Phillips curve:

$$(2.77)\quad \pi_t^H=\frac{\beta\vartheta_r}{\kappa_\pi}\mathbb{E}_t[\pi_{t+1}^H]+\frac{\vartheta_b}{\kappa_\pi}\pi_{t-1}^H+\frac{(1-\vartheta_b)(1-\vartheta_r)(1-\beta\vartheta_r)}{\kappa_\pi}log\left(\frac{\varepsilon}{\varepsilon-1}\frac{P_t^W}{P_t^H}\right),$$

where $\kappa_\pi=\vartheta_r+\vartheta_b\big(1-\vartheta_r(1-\beta)\big)$. According to the hybrid Phillips curve (2.77), inflation for the price of home goods depends on three components. The first factor is the expected inflation π_{t+1}^H, which reflects the forward-looking behavior in a typical New-Keynesian framework. The second component is the lagged inflation π_{t-1}^H, which arises due to the existence of backward-looking retail firms. The third element is the real marginal cost P_t^W/P_t^H, which is in general related to the magnitude of output gap: the deviation between actual and flex-price-flex-wage output levels. It is noteworthy that when no backward-looking retail firms exist (i.e. $\vartheta_b=0$), the hybrid Phillips curve turns into the New-Keynesian Phillips curve:

$$(2.78)\quad \pi_t^H=\beta\mathbb{E}_t[\pi_{t+1}^H]+\frac{(1-\vartheta_r)(1-\beta\vartheta_r)}{\vartheta_r}log\left(\frac{\varepsilon}{\varepsilon-1}\frac{P_t^W}{P_t^H}\right).$$

In addition, since retail firms make some profit due to their monopolistic power, the profit must be transferred to households as follows:

$$(2.79)\quad \Gamma_{R,t}=P_t^HY_t^H-P_t^WY_t.$$

❖ Capital-producing Firms

There is a continuum of capital-producing firms of length unity. Operating in the environment of perfect competition, capital-producing firms use investment goods to both repair worn-out existing capital and build new capital according to the technology:

(2.80) $$K_t = \left(1 - \delta(u_t)\right)K_{t-1} + \left\{I_t - \frac{\zeta_k}{2}\frac{(I_t - \delta(u_t)K_{t-1})^2}{K_{t-1}}\right\},$$

which signifies that the adjustment of capital stock is costly. Capital-producing firms purchase existing capital from wholesale firms, use investment goods to produce capital, and sell ready-to-use capital back to wholesale firms. A representative capital-producing firm maximizes the capital-producing firm's value. Such a decision is equivalent to maximize the period-by-period expected profit:

(2.81) $$\Gamma_{K,t} = P_t^K\left\{K_t - \left(1 - \delta(u_t)\right)K_{t-1}\right\} - P_t^I I_t,$$

subject to the technology specified by equation (2.80), where P_t^I is the price of investment goods. The optimal behavior of capital-producing firms must conform to:

(2.82) $$P_t^K\left\{1 - \zeta_k\frac{\left(I_t - \delta(u_t)K_{t-1}\right)}{K_{t-1}}\right\} = P_t^I.$$

Because the technology for producing capital is not constant return to scale, capital-producing firms make some profit $\Gamma_{K,t}$, which is subsequently transferred to households. In addition, assume that the bundle of investment goods consists of both home and foreign goods according to the technology:

(2.83) $$I = \left(\varrho_i^{\frac{1}{\eta_i}}\left(I^H\right)^{\frac{\eta_i - 1}{\eta_i}} + \left(1 - \varrho_i\right)^{\frac{1}{\eta_i}}\left(I^F\right)^{\frac{\eta_i - 1}{\eta_i}}\right)^{\frac{\eta_i}{\eta_i - 1}},$$

where the parameters ϱ_i and η_i for the bundle of investment goods capture the share of home goods and the elasticity of substitution between home and foreign goods, respectively. It can be showed that the bundle of investment goods with the least-cost expenditure must satisfy the following conditions:

(2.84) $$I_t^H = \varrho_i\left(\frac{P_t^H}{P_t^I}\right)^{-\eta_i} I_t,$$

(2.85) $$I_t^F = \left(1 - \varrho_i\right)\left(\frac{S_t P_t^*}{P_t^I}\right)^{-\eta_i} I_t,$$

and the price of investment goods is given by:

(2.86) $P_t^I = \left(\varrho_i (P_t^H)^{1-\eta_i} + \left(1-\varrho_i\right)(S_t P_t^*)^{1-\eta_i}\right)^{\frac{1}{1-\eta_i}}$.

❖ Market Clearing

In addition to the five financial markets, all other markets must clear as well. For the goods markets, the two important market-clearing conditions, for wholesale and home goods, are:

(2.87) $Y_t = \int_0^1 Y_{f,t}^H df$,

(2.88) $Y_t^H = C_t^H + I_t^H + C_t^{H*}$.

Condition (2.88) states that home goods can be used for domestic consumption, domestic investment, and exports to be consumed by the rest of the world. For the labor market, the nominal wage must adjust to assure that labor demand equals labor supply.

❖ Additional Definition

First of all, the real exchange rate is defined as the price of foreign consumption bundle relative to the price of domestic consumption bundle:

(2.89) $Q_t = \frac{S_t P_t^*}{P_t^C}$.

Hence, an increase in Q_t means real exchange rate depreciation. Furthermore, the combined budget constraint can specify the dynamics of the net foreign asset position:

(2.90) $F_t = (1 + i_t^* + \Psi_t)F_{t-1} + TB_t$,

where TB_t is the trade balance. Equation (2.90) simply states that the current account (i.e. $F_t - F_{t-1}$) is equal to net exports plus net factor payments, which only involve interest rate payments on international foreign-currency bond in this model. In turn, the trade balance is defined as:

(2.91) $TB_t = P_t^H C_t^{H*} - S_t P_t^* (C_t^F + I_t^F + X_t)$.

It is noteworthy that one market-clearing condition, namely for foreign-currency bond, can be replaced by equation (2.90). This is essentially an implication of the Walras Law.

It is also useful to characterize gross domestic product:

(2.92) $GY_t = P_t^H Y_t^H - S_t P_t^* X_t$,

which indicates that the production of domestic output requires some imported inputs. Similarly, let's count the amount of total transfer payment between firms and households:

(2.93) $\Gamma_t = \Gamma_{W,t} + \Gamma_{R,t} + \Gamma_{K,t}$.

2.5 Parameterization and Solution

This section's objective is to solve the model developed in the preceding section by using a numerical method. The discussion consists of two parts. Part 2.5.1 describes how to calibrate the values of parameters and how to specify the steady-state values of variables. The calibration aims to capture the dynamics of Thailand's economy. Part 2.5.2 explains how to solve the model numerically under the assumption of rational expectations.

2.5.1 Model Parameterization

This part discusses the values of parameters as well as the steady-state values of variables, which are pertinent to the preference description, the technology setting, the financial structure, and the monetary policy implementation. The calibration is aimed to explain the dynamics of Thailand's economy based on the quarterly frequency. Table 2.1 reports the values of all parameters and the steady-state values of key variables.

For preference, the discount factor β is set at 0.9879 to match the (annual) interest rate on illiquid domestic-currency bond of 5 percentage points. The elasticity of intertemporal substitution is equal to 0.5; thus, $\gamma = 2$. The parameter ξ, which captures the importance of labor disutility relative to consumption utility, is fixed at 0.3408. The steady-state labor supply $\bar{H}$ is set at 0.2381 so that the Frisch elasticity of labor supply is equal to $\frac{1}{1-\bar{H}} = 1.3125$. Regarding the elasticity of substitution between home and foreign goods in the consumption bundle, $\eta_c = 1$ for the home country and $\eta^* = 3$ for the foreign country. It is worth mentioning that in macroeconomic models, η^*, which is also the elasticity of the demand for exports, takes the value of 2 or less, even though a typical estimate based on micro-level data is about 5. Here, the value of η^* is relatively large to capture the common concern that a small change in the exchange rate can induce a big shift in the demand for exports.[44] Meanwhile, the degree of home bias in the consumption bundle is calibrated to match the trade balance and the ratio of domestic output to world output.[45] In particular, $\varrho_c = 0.5$ for the home country and $\varrho^* = 0.0026$ for the foreign country.

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[44] According to Bank of Thailand's Inflation Report (January 2008), a 1-percent depreciation of the Thai baht against the US dollar would induce additional 0.35 percent of economic growth. The assumption of $\eta^* = 3$ implies that a 1-percent exchange rate depreciation would generate a 3-percent increase in the demand for exports, which translates into a 1.9-percent expansion in output.

[45] The value of ϱ^* simply depends on the ratio of exports to GDP (set at 64 percent) and the ratio of domestic output to world output (set at 0.4 percent). In contrast, it is more complicated to specify the value of ϱ_c as it involves the share of consumption in GDP (set at 70 percent), the share of home goods in the

For parameters pertinent to liquidity benefits, all of parameters that govern the curvature of the utility function (i.e. ν_m, ν_d or ν_b) are taken to be equal to 2, which is in line with well-known theoretical results from the Baumol and Tobin model (ν_m = 2) as well as the Miller and Orr model (ν_m = 3) on the interest rate elasticity of the demand for money.[46] Note that a higher value of ν_m, ν_d or ν_b implies that a small adjustment of financial holding can lead to a large change in liquidity premiums or interest rates. In addition, the values of these parameters are set to be the same because their estimates are not known although they could, in principle, be different across types of liquidity benefits.[47] For parameters that reflect the relative importance of each type of liquidity benefits (i.e. ϕ_m, ϕ_d or ϕ_b), the value of of ϕ_m is set at 2.55×10^{-4} as the base (relative to consumption utility), and then the values of ϕ_d and ϕ_b are calibrated accordingly to match interest rate differentials (e.g. $\bar{r}^C - \bar{r}$ or $\bar{r}^C - \bar{r}^D$) as well as financial ratios (e.g. cash-to-deposits ratio or cash-to-bond ratio). The choice of ϕ_m is selected in the way that total liquidity benefits account for about 3 percent of total household utility in the steady state.

For technology of wholesale firms, the share of imported inputs α_x is fixed at 0.15 similar to Tanboon et al. (2009). The share of capital α_k, which is equal to $1 - \alpha_h - \alpha_x$, is calibrated to match the cost of capital (i.e. $\bar{r}^L + \chi + \delta$) and the capital-to-output ratio; as a result, α_k = 0.41 and α_h = 0.44. Based on the data from Thailand's National Economic and Social Development Board, the capital to output ratio is 2.76 and the annual rate of capital depreciation is 5.5 percent; hence, δ = 0.014. It is noteworthy that the value of δ taken by this study would be too low to generate a high ratio of investment to GDP at 30 percent. This particular inconsistency simply results from the assumption of zero population growth and no technological progress. Then, given the relationship between capital depreciation and capital utilization, the elasticity of marginal capital depreciation with respect to capital utilization, denoted by ζ_u, takes the value of 1.5455, and the rate of capital utilization is equal to 0.686 in the steady state. Accordingly, the parameter α_u must be equal to 0.0367.

For technology of retail firms, the elasticity of substitution across differentiated products is set at 6 so that the markup is 1.2 in the steady state. In addition, retail firms in each (quarterly) period have the probability of ϑ_r = 0.75 to keep their prices unchanged; this particular value of ϑ_r implies that the average duration of any price change is one year. In the baseline specification, ϑ_b = 0 as all retail firms are assumed to be forward-looking.

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consumption bundle (set at 50 percent), the share of home goods in the capital goods bundle (set at 50 percent), the share of imported inputs in the production of wholesale firms (i.e. α_x = 0.15), and the ratio of imports to GDP (set at 64 percent).

[46] Note that ν_m can be interpreted as the inverse of the interest rate elasticity of money demand.

[47] One should expect that ν_m is greater than both ν_d and ν_b because money plays the central role in facilitating transactions. Thus, the demand for money should be less sensitive to a change in interest rates.

For technology of capital-producing firms, the coefficient of capital adjustment costs, denoted by ζ_k, is fixed at 5. Meanwhile, the elasticity of substitution between home and foreign goods in the bundle of investment goods, denoted by η_i, is set at 0.5, which suggests some complementarity between home and foreign goods. The share of home goods in the bundle of investment goods is equal to 0.5.

Regarding parameters pertinent to the financial structure, the (annual) world interest rate and the country risk premium are taken to be 3.5 and 1.5 percentage points in the steady state, respectively. Since $\bar{r}^C = \bar{r}^* + \bar{\Psi}$, the (annual) interest rate on illiquid domestic-currency bond has to be equal to 5 percentage points. Based on the data on interest rates in Thailand, the liquidity premium of illiquid domestic-currency bond with respect to liquid domestic-currency bond (i.e. $\bar{r}^C - \bar{r}$) is fixed at 250 basis points, and that with respect to deposits (i.e. $\bar{r}^C - \bar{r}^D$) is fixed at 350 basis points; both on the annual basis. According to equation (2.9) and (2.10), greater values of the steady-state liquidity premiums mean that a given adjustment of household holding of financial assets can generate a larger change in liquidity premiums.

For deposit creation, the degree of liquidity requirement Z_D is 13.12, implying a reserve requirement of 7.6 percent for deposits, and the share of cash in liquidity management is about 0.31. While these two parameters are chosen to match the steady-state relationship described by equation (2.19), (2.23) and (2.24), their values appear in line with Thailand's regulation, which stipulates that the reserve requirement is 6 percent of deposits or liabilities. For financial accelerator, the steady-state external financing premium is equal to 3.5 percentage points (roughly, 150 basis points higher than that of the United States), and the elasticity of the external financing premium with respect to the asset-to-equity ratio, denoted by υ_l, is 0.02;[48] the values of these two parameters are taken from Tanboon et al. (2009). Furthermore, the asset-to-equity ratio is set at 1.85 based on the average value of listed firms in Thailand's stock market. Meanwhile, the stationarity-preserving coefficient for the net foreign asset position, denoted by υ_f, is chosen to be very small in the magnitude of the fourth decimal so that stationarity-preserving forces have no significant impact on the dynamics of the economy.

In addition, the steady-state values of financial ratios related to portfolio allocations must be specified. The ratio of cash to deposits is 0.122, the ratio of liquid domestic-currency bond to deposits is 0.356, and the ratio of loans to deposits is 0.853. Regarding the allocation of financial holding between households and financial intermediaries, the ratio of cash held by banks to total cash is 0.238, and the compatible ratio for liquid domestic-currency bond is 0.332. Lastly, the steady-state value of illiquid domestic-currency bond

[48] Note that parameters ϑ_w and ϖ_e, which denote the probability of wholesale firms remaining in business and the fraction of dividend payments used for equity injection are typically needed to pin down the elasticity parameter υ_l. However, there is no need to discuss these two parameters here since the value of υ_l is directly specified based on empirical estimates.

is fixed at zero in order to reflect the fact that financial intermediaries minimally rely on long-term wholesale funding.

On the description of monetary policy, the home country's central bank sets the policy interest rate according to the rule with the coefficients on the lagged interest rate, the inflation measure and the output measure as follows: $\rho_m = 0.8$, $\theta_\pi = 3$ and $\theta_y = 0.5$. The central bank may also undertake FX interventions with the coefficient on the existing stock of foreign reserves $\rho_f = 0.9$. On the other hand, monetary policy in the foreign economy is implemented based on the interest rate rule with the following parameters: $\rho_r = 0.85$, $\theta_\pi^* = 2$ and $\theta_y^* = 0.8$, which are estimates for the United States from Clarida, Gali and Gertler (2000).

2.5.2 Model Solution

This part discusses how to solve the model developed in the preceding section by using the conventional numerical method, which derives the model solution in the form of first-order log-linearization under the assumption of rational expectations. The procedure can be summarized in three steps: (i) the steady-state values of variables are determined; (ii) key equations are log-linearized; and (iii) the model in the log-linearized form is solved under the assumption of rational expectations. The detail of each step is presented below.

For the first step, the steady-state values of all variables must be determined. This step involves first specifying the values of parameters as well as the steady-state values of key variables, and then computing the steady-state values of remaining variables. This is necessary because log-linearization is defined as the percentage deviation from the steady-state value. Since the preceding part describes the choice of parameter values and steady-state values of key variables, most of the steady-state values of remaining variables can be determined in a straightforward fashion. However, additional discussion is required to pin down the steady-state values of certain variables that are primarily related to the design of international finance.

For an open economy, the design of international finance plays a critical role in setting up the model's steady-state properties. Its description is specified as follows. The steady-state net foreign asset position, denoted by $\bar{F}$, is assumed to be zero.[49] Since the net foreign asset position and the trade balance are perfectly tied, the trade balance must also be zero in the steady state (i.e. $\overline{TB} = 0$). Furthermore, the steady-state real exchange rate $\bar{Q}$ is assumed to be constant. This particular condition precludes a possibility of divergences on the real side between the two countries; specifically, both economies

[49] In this model, the steady-state net foreign asset position is a free parameter. Based on Thailand's external developments, it seems plausible that the net foreign asset position could be zero rather than negative (typical for developing economies) as the country's current account balance has been generally in surplus since the financial crisis of 1997.

experience no technological progress. On the nominal side, all prices are assumed to be constant in the steady state as well. Without loss of generality, let's normalize the prices of home and foreign goods to be one. As a result, $\bar{P}^H = \bar{P}^* = \bar{P}^C = \bar{P}^I = \bar{P}^K = 1$, and $\bar{P}^W = \frac{\varepsilon-1}{\varepsilon}$. The assumption that the steady-state inflation rate for the price of home goods is zero is essential for the Phillips curve to take a simplistic form. Since all prices are constant in the steady state, the nominal exchange rate must also be constant. Thus, let's normalize the nominal exchange to be one so that $\bar{S} = \bar{Q} = 1$. Furthermore, all other nominal variables such as money (e.g. $\bar{M}$, $\bar{M}_H$, $\bar{M}_B$), deposits (e.g. $\bar{D}$), liquid domestic-currency bond (e.g. $\bar{B}$, $\bar{B}_H$, $\bar{B}_B$), and loans (e.g. $\bar{L}$) must also be constant in the steady state owing to the implication of zero steady-state inflation and no technological progress.

For the second step, the model must be log-linearized with first-order approximation. It is noteworthy that first-order approximation is generally sufficient to derive the solution of macroeconomic models; however, higher-order approximation is required in models that are embedded with a portfolio allocation problem. Annex 2.8.3 presents the log-linearized form of key equations deriving from the model developed in section 2.4.

For the third step, the model in the log-linearized form must be solved under the assumption of rational expectations. Using the methodology developed by Blanchard and Kahn (1980) and Klein (2000), the solution of the model can be obtained in the form of:

(2.94) $x_t = \mathcal{A}x_{t-1} + \mathcal{B}v_t$,

where x_t is the vector of all variables (both endogenous and exogenous), and v_t is the vector of innovations. Policy analysis can be done once matrix $\mathcal{A}$ and $\mathcal{B}$ are known.

2.6 Policy Analysis on Sterilized FX Interventions

This section analyzes how sterilized FX interventions work in the modern monetary policy framework primarily founded on setting the interest rate policy to achieve macroeconomic stability. The analysis focuses on five different aspects, each of which is addressed in an individual part. Part 2.6.1 examines impulse response to policy actions to understand how sterilized FX interventions affect the economy. Part 2.6.2 studies how the specification of monetary policy influences the effectiveness of sterilized FX interventions. Part 2.6.3 assesses whether sterilized FX interventions can serve as a useful policy instrument for managing exchange rate movements driven by capital flows. Part 2.6.4 explores the sensitivity of the values of parameters central for determining the outcome of sterilized FX interventions. These important parameters are the curvature of the utility function capturing liquidity benefits and the elasticity of the demand for exports. Part 2.6.5 considers some extensions of the baseline model. The extended setup incorporates the backward-looking price setting behavior and the additional financial friction barring banks from holding and issuing illiquid domestic-currency bond.

2.6.1 Impulse Responses to Policy Actions

The goal of this part is to examine how sterilized FX interventions affect the economy by reviewing impulse responses to three different policy actions:

(i) A reduction in the policy interest rate by 25 basis points (equivalent to 1 percentage point on the annual basis),
(ii) A sterilized purchase of foreign reserves by the amount of 3 percent of GDP together with holding the policy interest rate constant,
(iii) A sterilized purchase of foreign reserves by the amount of 3 percent of GDP together with automatic adjustments of the policy interest rate.

The magnitude of sterilized FX interventions is chosen at 3 percent of GDP so that the effects induced by different policy actions are comparable. Impulse responses to these three policy actions, presented in Figure 2.3, seem generally consistent with the discussion in part 2.4.2.

A reduction in the policy interest rate r_t leads to a reduction in the interest rate on illiquid domestic-currency bond r_t^C, which is relevant for the consumption-saving decision, as well as a reduction in the effective interest rate on loans $r_t^L + \chi_t$. The decline is both r_t^C and $r_t^L + \chi_t$ induces households to consume more and firms to undertake additional investment. Furthermore, the nominal exchange rate S_t depreciates on impact and then appreciates over time; such an outcome results from a fall in the domestic interest rate, i.e. r_t^C, in the UIP-typed condition. The presence of nominal rigidity also translates nominal exchange rate depreciation to real exchange rate depreciation, which in turn raises the demand for exports. The decline in r_t^C is less than the reduction in r_t due to the liquidity buffering effect; in other words, the liquidity premium of illiquid domestic-currency bond increases as a consequence of the central bank's open market purchases.

A sterilized purchase of foreign reserves together with holding the policy interest rate constant affects the economy primarily through the decline in the liquidity premium of illiquid domestic-currency bond, which in turn causes a reduction in r_t^C. Then, the effect of sterilized FX interventions works through mechanisms similar to those triggered by a change in the policy interest rate. Few interesting points are worth being emphasized.

- Both adjusting the policy interest rate and implementing sterilized FX interventions, in principle, can induce virtually identical outcomes in which major real allocations are similar under the same path of the nominal exchange rate although portfolio allocations of financial assets are different.

- While sterilized FX interventions can be effective in influencing currency movements as well as other real macroeconomic variables, the magnitude of the central bank's purchases (or sales) of foreign-currency bond needs to be massive. Based on the simulation exercise, in order attain comparable effects to a reduction of the policy interest rate by 25 basis points, the size of FX interventions needs to be in the range of 3 percent of GDP, which looks quite large.[50] The principal reason is that households must borrow much more to offset the central bank's acquisition of foreign reserves. Specifically, the on-impact increase in the net foreign asset position is merely less than 0.1 percent of GDP after an accumulation of foreign reserves by 3 percent of GDP.
- In contrast to policy interest rate adjustments, sterilized FX interventions induce a substantial reallocation of financial assets held by both households and financial intermediaries. The volatility of financial variables under the implementation of sterilized FX interventions is at least three times as large as that under the scheme of policy interest rate changes. The upshot is that even though sterilized FX interventions could serve as a useful policy instrument, they may come with considerable welfare loss since a larger fluctuation in household holding of financial assets contributes to a lower level of utility.
- In this study, sterilized FX interventions are implemented under the arrangement that the policy interest rate rather than the supply of money is held constant. As a result, money supply rises (or falls) when the central bank engages in a sterilized purchase (or sale) of foreign-currency bond. Moreover, when monetary base increases as a consequence of accumulation of foreign reserves, cash held by households increases while financial intermediaries reduce their holding of cash.

In addition, when sterilized FX interventions are implemented as a supplementary policy instrument under the framework in which the policy interest rate is set to secure macroeconomic stability (i.e. sterilized FX interventions together with automatic adjustments of the policy interest rate), a sterilized purchase (or sale) of foreign reserves would lead to an increase (or decrease) in the policy interest rate to stabilize expansionary (or contractionary) effects generated by the FX intervention. Hence, when automatic adjustments of the policy interest rate are in place, the effect of sterilized FX interventions would be partially offset due to the stabilizing interest rate rule.[51]

[50] This seems consistent with Thailand's experience. In 2007, even though the level of foreign reserves increased by 8.2 percent of GDP, the exchange rate was appreciating steadily.

[51] Another interesting feature is that the changes in financial assets held by households and financial intermediaries look roughly identical in response to a sterilized purchase of foreign reserves regardless whether the policy interest rate is held constant. The reason is that sterilized FX interventions trigger substantial reallocation of financial asset holding while an open market operation implemented to alter the policy interest rate does not.

A key implication is that the central bank, from the effectiveness perspective, should not implement sterilized FX interventions with no accommodation from the interest rate policy. In order to attain the full effectiveness of sterilized FX interventions, the central bank should hold the policy interest rate unchanged by creating monetary shocks (i.e. unanticipated adjustments of the policy interest rate). Unsurprisingly, the BoT's policy stance of maintaining the policy interest rate at a high level to control inflation while engaging in large-scale sterilized purchases of foreign reserves prior to the introduction of capital controls in 2006 did not seem successful to mitigate exchange rate appreciation.

2.6.2 Effectiveness of Sterilized FX Interventions with Respect to Monetary Policy Specification

This part's objective is to examine how the effectiveness of sterilized FX interventions depends on the specification of monetary policy. Here, four simulation exercises are implemented to explore the outcome of sterilized FX interventions under different parameter values governing the persistence in sterilized FX interventions (by ρ_F), the monetary policy responsiveness to inflation (by θ_π), and the monetary policy responsiveness to output (captured by θ_y), as well as different targets of price stability.

Regarding the persistence in sterilized FX interventions, Figure 2.4 presents impulse responses to a sterilized purchase of foreign reserves by the initial amount of 3 percent of GDP together with holding the policy interest rate constant for different levels of intervention persistence. The main message is that an increase in the persistence in sterilized FX interventions contributes to a greater impact on the economy by both magnitude and persistence. For instance, an on-impact increase in output in response to a sterilized purchase of foreign reserves rises from 0.2 to 0.3 percent when ρ_F increases from 0.5 to 0.9. Intuitively, a higher degree of persistence means a larger scale of FX interventions over time; therefore, the impact on the economy should also be greater even though the initial amount of FX interventions is identical. Moreover, differences in sterilized FX intervention outcomes seem to be primarily driven by differences in the liquidity premium of illiquid domestic-currency bond and the external financing premium.

Regarding the monetary policy responsiveness to inflation, Figure 2.5 displays impulse responses to a similar sterilized FX intervention with different values of θ_π. A higher degree of responsiveness to inflation leads to a larger expansion in output as well as other real variables over time (though slightly smaller on impact). On the other hand, price levels become clearly higher after the first year for a larger value of θ_π. This result might seem counterintuitive because the more aggressiveness in curbing inflation should translate into more contractionary policy actions. However, it is actually the opposite in this simulation exercise because the central bank needs to create some positive monetary shocks (e.g. innovations in $\varepsilon_{M,t}$) to keep the policy interest rate constant. Hence, the policy interest rate is lower than it would have been otherwise. Moreover, a larger positive monetary shock is required for a higher value of θ_π so that the central bank's aggressiveness in controlling inflation turns to generate expansionary effects under sterilized FX interventions. In all cases, the behavior of all interest rates looks basically similar, with some small divergence in the external financing premium.

Regarding the monetary policy responsiveness to output, Figure 2.6 shows impulse responses to a similar sterilized FX intervention with different values of θ_y. When the central bank's responsiveness to output is more lenient, sterilized FX interventions induce more expansionary effects. Output and other real variables increase by a larger magnitude; price levels also follow a similar pattern. Intuitively, as the central bank's lenience on preserving output stability leads to higher inflation, a larger positive monetary shock is required to maintain the policy interest rate constant when the value of θ_y is smaller. In all cases, the pattern of all interest rates looks broadly similar, with some minimal divergence in the external financing premium.

Regarding the target of price stability, Figure 2.7 illustrates impulse responses to a similar sterilized FX intervention with different target schemes. Two other alternatives, which are inflation targeting on the price of the consumption bundle and price targeting on the price of home goods, are included in addition to the baseline arrangement of inflation targeting of the price of home goods. Figure 2.7 suggests that under a price targeting regime, the effect of sterilized FX interventions which seems smaller but more long-lasting is primarily driven by the pattern of capital accumulation. The stability of all prices also looks greater under the price targeting alternative.

In sum, the outcome of sterilized FX interventions critically depends on the specification of monetary policy. The overall scale of sterilized FX interventions largely depends on both magnitude and persistence of FX interventions being undertaken. Furthermore, a sterilized purchase (or sale) of foreign reserves generates a larger expansionary (or contractionary) under the monetary regime with more aggressive responsiveness to inflation impact. Meanwhile, under a more pro-output-stability interest rate rule, a sterilized purchase (or sale) of foreign-currency bond induces a smaller expansionary (or contractionary) effect.

2.6.3 Role of Sterilized FX Interventions in Managing Capital Flows

This part assesses whether sterilized FX interventions can be a useful policy instrument for managing exchange rate movements driven by large and volatile financial flows, which are modeled by changes in the country risk premium, i.e. φ_t, in this study.

In order to gain some insight of real-world policy implementations, several combinations of such policy actions as adjusting the policy interest rate and undertaking sterilized FX interventions are considered. Furthermore, simulation exercises explore the impact of each policy action on the economy and evaluate the welfare associated with each outcome. The principal criterion for judging the superiority of policy actions is the sum of discounted value of household utility. Specifically, the welfare function for the period between 0 and T is:

$$(2.95)\quad U_{0,T}=\sum_{t=0}^{\mathrm{T}}\beta^t\left\{u(C_t,H_t)+v\left(\frac{M_{H,t}}{P_t^C},\frac{D_{H,t}}{P_t^C},\frac{B_{H,t}}{P_t^C}\right)\right\},$$

$$U_{0,T}=\sum_{t=0}^{\mathrm{T}}\beta^t\left\{\frac{1}{1-\gamma}\left(C^{1-\xi}(1-H)^{\xi}\right)^{1-\gamma}+\frac{\phi_m}{1-\nu_m}\left(\frac{M}{P^C}\right)^{1-\nu_m}+\frac{\phi_d}{1-\nu_d}\left(\frac{D}{P^C}\right)^{1-\nu_d}+\frac{\phi_b}{1-\nu_b}\left(\frac{B}{P^C}\right)^{1-\nu_b}\right\}$$

with the same functional form that describes the household preference in section 2.4.

The main simulation exercise considers various policy actions in response to a decline in the country risk premium by 25 basis points based on the quarterly basis. They include:

(i) Hold the policy interest rate constant,
(ii) Allow the policy interest rate to adjust automatically,
(iii) Keep the nominal exchange rate constant by adjusting the policy interest rate,
(iv) Keep the nominal exchange rate constant by undertaking sterilized FX interventions together with automatic adjustments of the policy interest rate,
(v) Keep the nominal exchange rate constant by undertaking sterilized FX interventions together with holding the policy interest rate constant.[52]

Figure 2.8 shows impulse responses to these five different policy actions. Interesting observations are summarized as follows:

- Following a reduction in the country risk premium, the real exchange rate appreciates regardless of which policy actions are taken. As a result, the demand for exports falls. Even if the nominal exchange rate is kept constant, real currency appreciation still occurs on the back of rising prices.
- Both consumption and investment expand. When foreign funds become cheaper, firms have incentives to borrow more to expand their capital stock. In this

[52] All policy actions are implemented under the prescribed interest rate rule (2.26). Thus, the central bank may need to create monetary shocks in order to hold the policy interest rate or the nominal exchange rate constant.

simulation exercise, households also borrow more to increase consumption; thus, the substitution effect seems to outweigh the income effect.

- The effect on output depends on policy actions. In particular, an increase in consumption and investment could be mostly (or even completely) offset by a decrease in exports. When the nominal exchange rate is held constant, the extent of real currency appreciation is smaller so that exports fall less and output expands slightly. On the other hand, when the nominal exchange rate is allowed to appreciate, a sizeable output decline occurs primarily because exports account for a large share of output (i.e. 64 percent in the steady state).
- Price developments chiefly depend on the outcome of output and the level of the nominal exchange rate. When the central bank keeps the policy interest rate constant in the face of a reduction in the country risk premium, price levels fall as a result of a contraction in output and a decline in costs of imported inputs (due to exchange rate appreciation). In contrast, all prices increase when the central bank holds the nominal exchange rate constant owing to inflationary pressure induced by a sharp rise in the real marginal cost following a small output expansion.
- When the central bank relies on sterilized FX interventions to keep the nominal exchange rate constant, the amount of foreign-currency bond purchases needs to be massive. To stabilize the nominal exchange rate in the response to a decline in the country risk premium by 25 basis points (equivalent to 1 percentage point on the annual basis), an immediate sterilized purchase of foreign reserves by 20 and 13 percent of GDP is needed when the policy interest rate is allow to adjust automatically and is held constant, respectively.
- The policy action that uses sterilized FX interventions to moderate currency movements and concurrently adjusts the policy interest rate to control inflation does not look transparent as the paths of policy variables (i.e. $F_{M,t}$ and r_t) exhibit a hump shape. Furthermore, a possibility of the policy interest rate to move in different directions (i.e. this policy option (iv) requires an increase, while the standard policy response option (ii) demands a reduction) can generate confusion. The upshot is that better communication with the public seems necessary.

Let's now turn to evaluate the welfare associated with each policy action in response to a reduction in the country risk premium. Based on Figure 2.9 and Table 2.2, important lessons can be drawn as follows:

- In terms of welfare, policy actions that feature sterilized purchases of foreign reserves, i.e. policy options (iv) and (v), outperform other alternatives largely due to a greater extent of liquidity benefits generated by substantial household holding of liquid domestic-currency bond and deposits. This assertion is supported by the following two observations. One is that the welfare level under the policy action that uses the policy interest rate to stabilize currency movements, i.e. policy option (iii), is lower even though the paths of consumption and labor supply induced by all policy actions that hold the nominal exchange rate constant look similar. Another is that the best welfare outcome occurs under the policy option that undertakes sterilized FX interventions to maintain the nominal exchange rate constant together with automatic adjustments of the policy interest rate. The reason is that when the policy interest rate is allowed to move, the scale of sterilized purchase of foreign-reserves needs to be larger. Consequently, household holding of liquid domestic-currency bond and deposits becomes even more sizeable.

- Among policy options that do not feature sterilized FX interventions, a flexible exchange rate arrangement, i.e. policy option (ii), rather than a fixed exchange rate regime, i.e. policy option (iii), delivers a more favorable welfare outcome, which is driven by a much higher utility level from leisure under policy option (ii). A flexible exchange rate fares better even though an output contraction occurs. This result seems contradictory to some earlier works, e.g. Gertler, Gilchrist and Natalucci (2007), which showed that a flexible exchange rate arrangement is preferable when the country faces with a sudden stop of international capital flows triggered by a significant increase in the country risk premium.[53] The different conclusion seems to stem from the muted role of financial accelerator in this study.[54] Here, the elasticity of the external financing premium with respect to the asset-to-equity ratio, denoted by υ_l, takes the value of 0.02 based on empirical estimates. This value of υ_l, however, looks much smaller than a typical value used in models featuring financial accelerator.[55] Consequently, the change in the external financing premium seems secondary to the change in the average return on loans, and the dynamics of the economy is not significantly influenced by financial accelerator.
- The value of υ_l is critical to the determinacy of this model under a fixed exchange rate arrangement. In particular, the elasticity of the external financing premium with respect to the asset-to-equity ratio cannot be too big; the maximum value of υ_l to assure the determinacy is 0.038. In contrast, the determinacy is not an issue under a flexible exchange rate arrangement. Hence, in the presence of financial

[53] Due to linearity of the model, what happens as a result of an increase in the country risk premium is simply the opposite of what happens in the case that the country risk premium instead declines.

[54] According to Gertler, Gilchrist and Natalucci (2007) whose model is based on the Korean financial crisis of 1997, a fixed exchange rate regime looks highly unfavorable because the external financing premium would increase substantially when the country risk premium rises. As a result, a severe recession occurs. It seems that such a predominant role of financial accelerator requires a sufficiently large value of υ_l. When the model takes a small value of υ_l (i.e. based on empirical estimates), liability dollarization rather than financial accelerator may serve the critical force that makes a fixed exchange rate undesirable.

[55] Usually, the elasticity of the external financing premium is calibrated based on the contract design together with the assumption on firm characteristics and external financing premiums. See Bernanke, Gertler and Gilchrist (1999) for more complete details.

accelerator, policy actions that keep the nominal exchange rate constant in response to changes in the country risk premium may generate substantial instability. This occurs when the external financing premium is highly sensitive to the leverage ratio regardless of how the central bank implements a fixed exchange rate arrangement. One plausible reason is that when the nominal exchange rate is held constant, the real effective interest rate on loans may decline continually following an influx of foreign funds triggered by a reduction in the country risk premium. As a result, any attempt to stabilize the nominal exchange rate when the economy faces a country risk premium shock might be a bad policy because substantial macroeconomic instability may ensue (provided that the value of υ_l is sufficiently large).

Hence, it remains unclear whether sterilized FX interventions with the effectiveness resting on liquidity benefits can be very useful for helping manage currency movements driven by financial flows. Such FX interventions can lead to a better welfare outcome only when they induce greater liquidity benefits, which occur precisely in the case of sterilized purchases of foreign reserves. Furthermore, as discussed earlier, the central bank may simply adjust the policy interest rate to generate an outcome virtually identical to what caused by sterilized FX interventions. Nonetheless, sterilized FX interventions clearly have an edge when the economy hits the zero bound.

Before ending this part, additional simulation exercises are undertaken to gain more insight on how the central bank should implement sterilized FX interventions.

Figure 2.10 presents impulse responses to sterilized FX interventions with different paths and scales. Specifically, in this simulation exercise, the central bank engages in purchases or sales of foreign-currency bond according to the rule:

(2.27) $F_{M,t} = \rho_f F_{M,t-1} + \left(1 - \rho_f\right)\left\{\bar{F}_M + u_{F,t}\right\} + \varepsilon_{F,t},$

where $u_{F,t} = \theta_\varphi \varphi_t$. In words, the central bank increases (or reduces) its holding of foreign reserves when the country risk premium falls (or rises) to moderate currency movements. Two interesting observations emerge from this simulation exercise.

- In response to a reduction in the country risk premium, sterilized FX interventions that help stabilize the exchange rate immediately seem to be a superior option. Therefore, policymakers should opt for implementing aggressive policy actions in a timely manner (Figure 2.11 and Table 2.3).
- Sterilized FX interventions that occur with inertia by gradually accumulating foreign reserves over an extended period, i.e. policy option with $\theta_\varphi = 5$ and $\rho_f = 0.95$, do not appear as a good policy. One reason is that it fails to help stabilize currency movements in time so that a contraction in output occurs. Moreover,

such long-lasting sterilized FX interventions lead to a larger capital stock accumulation. In the presence of distortions that can create resource misallocations, such sterilized FX interventions may exacerbate rather than improve the welfare (Figure 2.11 and Table 2.3).

Figure 2.12 and Table 2.4 display the welfare outcome under various policy actions for different characteristics of the country risk premium shock (in terms of its persistence as well as its size) to understand whether the choice of appropriate policy responses depends on the characteristics of shocks. The key message is that the welfare outcome is more favorable when the central bank intervenes in the FX market to stabilize currency movements in response to a reduction in the country risk premium regardless of the degree of persistence and the magnitude of shocks. However, when the persistence of the decline in the country risk premium is not much (e.g. $\rho_f = 0.5$), sterilized purchases of foreign reserves together with holding the policy interest rate constant outperform those that allow automatic policy interest adjustments.

2.6.4 Sensitivity of Sterilized FX Interventions to Key Parameters

This part's goal is to explore how the outcome of sterilized FX interventions depends on the values of key parameters such as the curvature of the utility function capturing liquidity benefits and the elasticity of the demand for exports.

For the curvature parameters, there are three of them, i.e. ν_m, ν_d and ν_b, which govern the utility function for liquidity benefits from holding cash, deposits and liquid domestic-currency bond, respectively. Among these three parameters, the parameter ν_b is the one that significantly determines the effectiveness of sterilized FX interventions. In fact, the parameter ν_b can be interpreted as the inverse of the liquidity premium elasticity of the demand for liquid domestic-currency bond by households. Thus, a higher value of ν_b, which implies a lower elasticity, should make sterilized FX interventions more effective in influencing currency movements. In other words, for a given change in the central bank's holding of foreign-currency bond (and thus its issuance of liquid domestic-currency bond), a higher value of ν_b leads to a larger change in the liquidity premium $r_t^C - r_t$ (and thus a larger change in the interest rate relevant for the consumption-saving decision, r_t^C) so that the impact on the nominal exchange rate is greater (Figure 2.13). When the value of ν (and also ν_b) is higher, an identical sterilized purchase of foreign reserves can influence both nominal and real exchange rates to depreciate by a bigger magnitude, with a greater consequent expansionary effect being witnessed by a larger expansion in output, a more sustained capital accumulation and a sharper rise in prices.

It is noteworthy that although the knowledge of the value of ν_b which is critical for determining the effectiveness of sterilized FX interventions is limited, the choice of ν_b does not matter much. All results based on simulation exercises in the preceding part which examines the role of sterilized FX interventions in managing financial flows and currency movements are basically insensitive to the values of ν_m, ν_d and ν_b. The reason is that all relevant real variables (e.g. output, capital stock, etc.) and all prices are identical across different values of these curvature parameters. The main difference is that the scale of FX interventions needs to be larger (or smaller) for a lower (or higher) value of ν_b. Then, the holding of financial assets adjusts accordingly based on the amount of foreign reserves required to stabilize currency movements. In other words, the knowledge about the parameter value ν_b is important only for gauging the size of purchases or sales of foreign reserves needed to generate the desired exchange rate path.

For the elasticity of the demand for exports, the parameter η^* is always important for determining the dynamics of an open economy. The intuition is that the elasticity for the demand for exports (or the elasticity of substitution between home and foreign goods, in general) plays a principle role in regulating the link between currency movements and real factors (e.g. demand for home goods and thus domestic output). When the value of η^* is higher, the demand for home goods by foreign agents is more sensitive to exchange rate movements. In other words, a small change in the exchange rate can cause a large shift in the demand for exports. Figure 2.13 illustrates that when the elasticity of the demand for exports is higher, sterilized FX interventions induce a smaller change in both nominal and real exchange rates but a larger change in exports and output. More interestingly, when the policy interest rate is also held fixed, the magnitude of foreign reserves accumulated by the central bank to keep the nominal exchange constant when the country risk premium falls is the same regardless of the value of η^*. Nevertheless, the impact on real variables is different. The reason is that monetary shocks required to maintain the policy interest rate constant vary with the value of η^*.

2.6.5 Baseline Model with Additional Elements

This part considers some extensions of the baseline model. The additional elements include the backward-looking price setting behavior and the financial friction in the form of restrictions on banks to hold and issue illiquid domestic-currency bond.

For the first extension, some backward-looking element in the price setting behavior as a means to heighten the degree of price stickiness is incorporated. The key question is whether a greater extent of nominal rigidity in prices helps improve the effectiveness of sterilized FX interventions; recall that the presence of nominal rigidity is necessary for enabling monetary actions, including sterilized FX interventions, to be effective in influencing real factors in the economy.

Figure 2.14 shows that additional backward-looking element in the price setting behavior as in the hybrid Phillips curve does not affect the outcome of sterilized FX interventions for any realistic value of ϑ_b, which denotes the fraction of firms whose price setting behavior is backward-looking. In particular, impulse responses do not differ significantly from one another for the value of ϑ_b in the range between 0 and 0.5.[56] Nonetheless, a smaller magnitude of on-impact nominal exchange rate movements is observed as the degree of backward-looking element becomes greater. Meanwhile, no differences exist for the real exchange rate dynamics.

For the second extension, the financial friction in the form of restrictions on banks to hold and issue illiquid domestic-currency bond (effectively, making financial intermediaries unable to indirectly borrow from or lend to foreign entities) is incorporated. This simulation exercise examines impulse responses to policy actions that are analyzed in Figure 2.3 but instead in the alternative setup described by equation 2.21', 2.23', 2.24' and 2.25'. The key question is how considerable financial restrictions affect the outcome of sterilized FX interventions.

Figure 2.15 illustrates that while not altering the way that policy interest rate adjustments influence the dynamics of the economy, this particular financial friction significantly affects the way that sterilized FX interventions work. Specifically, following a sterilized purchase of foreign reserves, a decline in the effective interest rate on loans (30 basis points on impact) is much larger than a decline in the interest rate relevant for the consumption-saving decision (10 basis points on impact). Consequently, a substantial increase in investment takes place. This outcome is primarily driven by a sizeable fall in the average return on loans that financial intermediaries would receive.[57] Furthermore, the nominal exchange rate barely moves on impact before beginning to appreciate. Nevertheless, the real exchange rate becomes slightly more depreciated. A trade deficit also emerges on the back of an investment boom that overshadows an export expansion.

The main message is that when financial intermediaries are prohibited from issuing and holding illiquid domestic-currency bond, the effect of sterilized FX interventions can be very different from what people usually expect. Thus, it seems very important to improve the understanding on how sterilized FX interventions work especially when the financial system is underdeveloped or repressed because it is likely to be developing countries that regularly engage in FX interventions.

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[56] For the United States, an estimate for ϑ_b by Gali and Gertler (1999) is about 0.25.

[57] The principle factor seems to be a significant change in the financial intermediary's holding of financial assets. Recall that $r_t = r_t^L\left(1 - \frac{1-\alpha_d}{\alpha_d}\frac{M_{B,t}}{B_{B,t}}\right)$. When the policy interest rate is held constant, a marked decline in the ratio of cash to liquid domestic-currency bond would lead to a sizeable decline in r_t^L.

2.7 Conclusion

Motivated by the fact that policymakers in several countries have extensively implemented sterilized FX interventions to manage their exchange rates, this chapter aims to develop a micro-founded macroeconomic model in which sterilized FX interventions can be effective in influencing currency movements. The concluding remark consists of two parts. The first part summarizes what can be learned from this study, and the second part discusses what should be done in the future research.

For what can be learned, section 2.2 addresses that Ricardian equivalence is the predominant factor contributing to the ineffectiveness of sterilized FX interventions in a typical DNK model. The intuition is that when Ricardian equivalence holds, households would completely offset any change in foreign reserves adjusted by the central bank so that sterilized FX interventions simply lead to a portfolio reshuffling. Section 2.4 develops a macroeconomic model that features effective sterilized FX interventions based on liquidity benefits from holding financial assets (see Annex 2.8.2 for other factors that can contribute to the effectiveness of sterilized FX interventions). Section 2.6 examines various simulation exercises in order to understand how sterilized FX interventions work in the modern monetary framework. Key lessons can be summarized as follows.

- Sterilized FX interventions with the effectiveness founded on liquidity benefits can affect the economy through a change in the liquidity premium $r_t^c - r_t$, which in turn induces a change in the interest rate relevant for the consumption-saving decision r_t^c when the policy interest rate r_t is held constant. The mechanism through which currency movements occurs as a result of sterilized FX interventions is similar to what caused by policy interest rate adjustments. It is noteworthy that these two policy actions, in principle, can generate virtually identical outcomes.
- Sterilized FX interventions must be undertaken on a massive scale to trigger a sizeable exchange rate movement. In particular, a sterilized FX intervention with the magnitude of 3 percent GDP is roughly as effective as a change in the policy interest rate by 100 basis points on the annual basis. The reason is that non-Ricardian elements in the model, which primarily exist due to liquidity benefits, seem minimal. As a result, households nearly (or even completely) offset changes in the central bank's holding of foreign reserves.
- The outcome of sterilized FX interventions critically depends on the specification of monetary policy. The intuition is that some monetary shocks are needed when FX interventions are sterilized in the sense that the policy interest rate is held constant. Moreover, since the policy interest rate rule is stabilizing, an accommodative interest rate policy seems essential for sterilized FX interventions to be fully effective.

- In terms of welfare, the policy action that relies on sterilized purchases of foreign reserves to stabilize currency movements driven by a reduction in the country risk premium outperforms other policy alternatives. Such a higher level of welfare primarily results from a greater extent of liquidity benefits thanks to the massive amount of liquid domestic-currency bond and deposits held by households as a result of sterilized FX interventions.
- It remains unclear whether sterilized FX interventions can be very useful for helping manage currency movements driven by financial flows. The reasons are that a similar real allocation can also be attained by using the policy interest rate and that a fixed exchange rate regime can lead to substantial macroeconomic instability in the presence of financial accelerator with a high elasticity of the external financing premium with respect to the asset-to-equity ratio.

In brief, this study develops a macroeconomic model in which sterilized FX interventions can influence currency movements and real allocations, with the effectiveness of sterilized FX interventions resting on liquidity benefits from holding financial assets. The model can be used to study how sterilized FX interventions affect the economy both qualitatively and quantitatively, interact with other policy instruments (e.g. the policy interest rate), and work in certain macroeconomic situations (e.g. an influx of foreign funds).

For what should be done in the future research, the following discussion addresses some interesting works that can help improve the understanding on how sterilized FX interventions based on liquidity benefits function in the modern monetary policy framework.

- Parameters that are pertinent to liquidity benefits should be estimated. The parameters governing the curvature of the utility function for liquidity benefits are the critical determinants for the size of sterilized FX interventions. Meanwhile, the parameters specifying the relative importance of liquidity benefits are also important because the value of overall utility depends on them.
- It also seems essential to incorporate additional non-Ricardian elements so that the model becomes more realistic. Specifically, forces to counteract the central bank's actions are not usually large in a traditional framework as well as in the real world, with a change in foreign reserves largely translating into an adjustment of the current account.
- Extra works seem necessary before a firm judgment on optimal policies in response to financial flows can be made. In particular, such additional important factors as resource misallocation and real rigidity, which may make exchange rate movements more costly, need to be considered. Furthermore, it is imperative to examine the role of financial accelerator in an open economy environment since the value of the elasticity of the external financing premium with respect to the

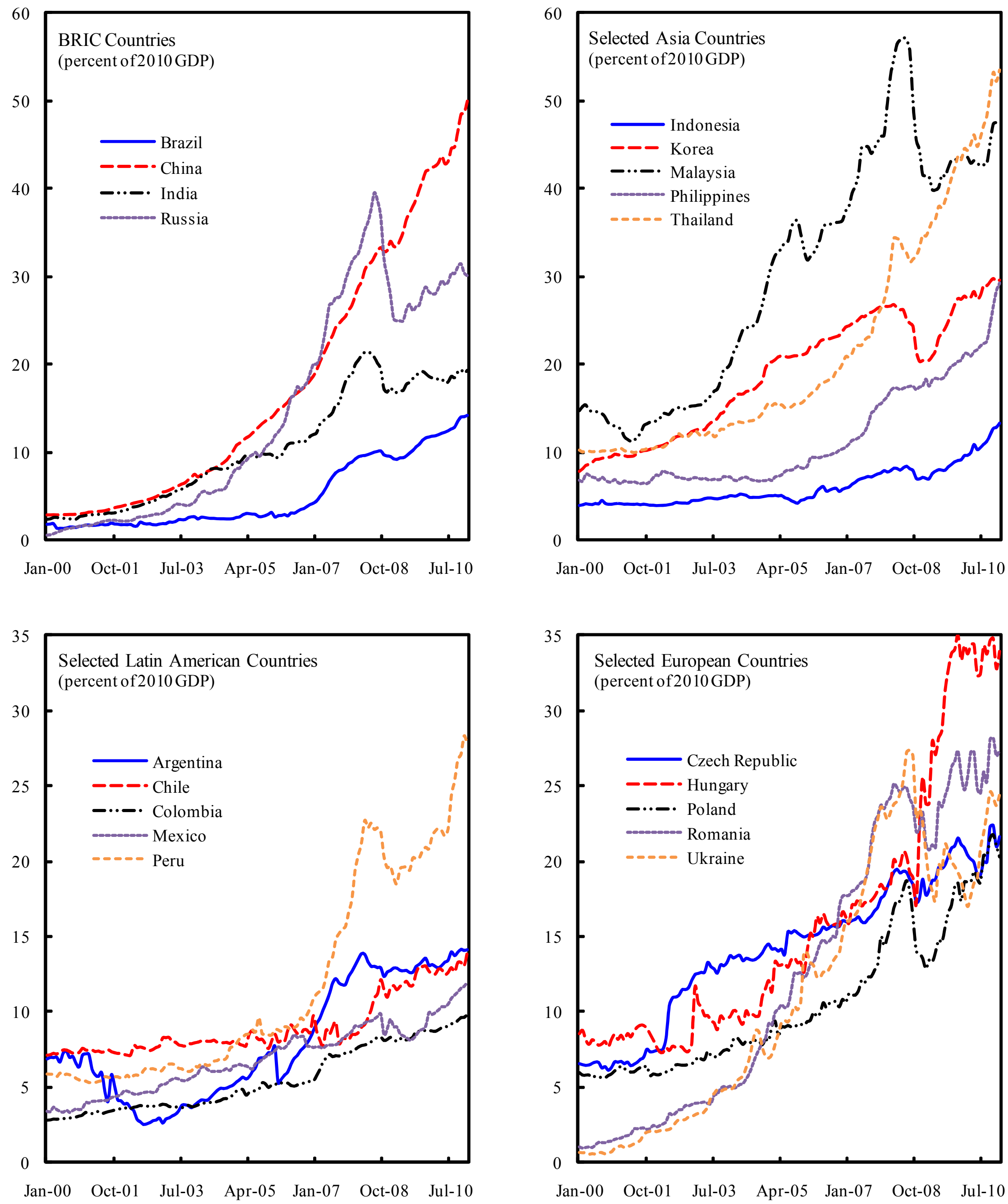
asset-to-equity ratio can significantly affect both the determinacy and the dynamics of the model.

To conclude, there remains substantial amount of works needed to be done before we can completely understand appropriate monetary responses to large and volatile capital flows especially if some part of policy actions feature sterilized FX interventions. Since these problems seem very important for many emerging markets as good or bad policy decisions can lead to benign or disastrous macroeconomic outcomes, this research topic is worth being pursued in the future.

2.8 Annex

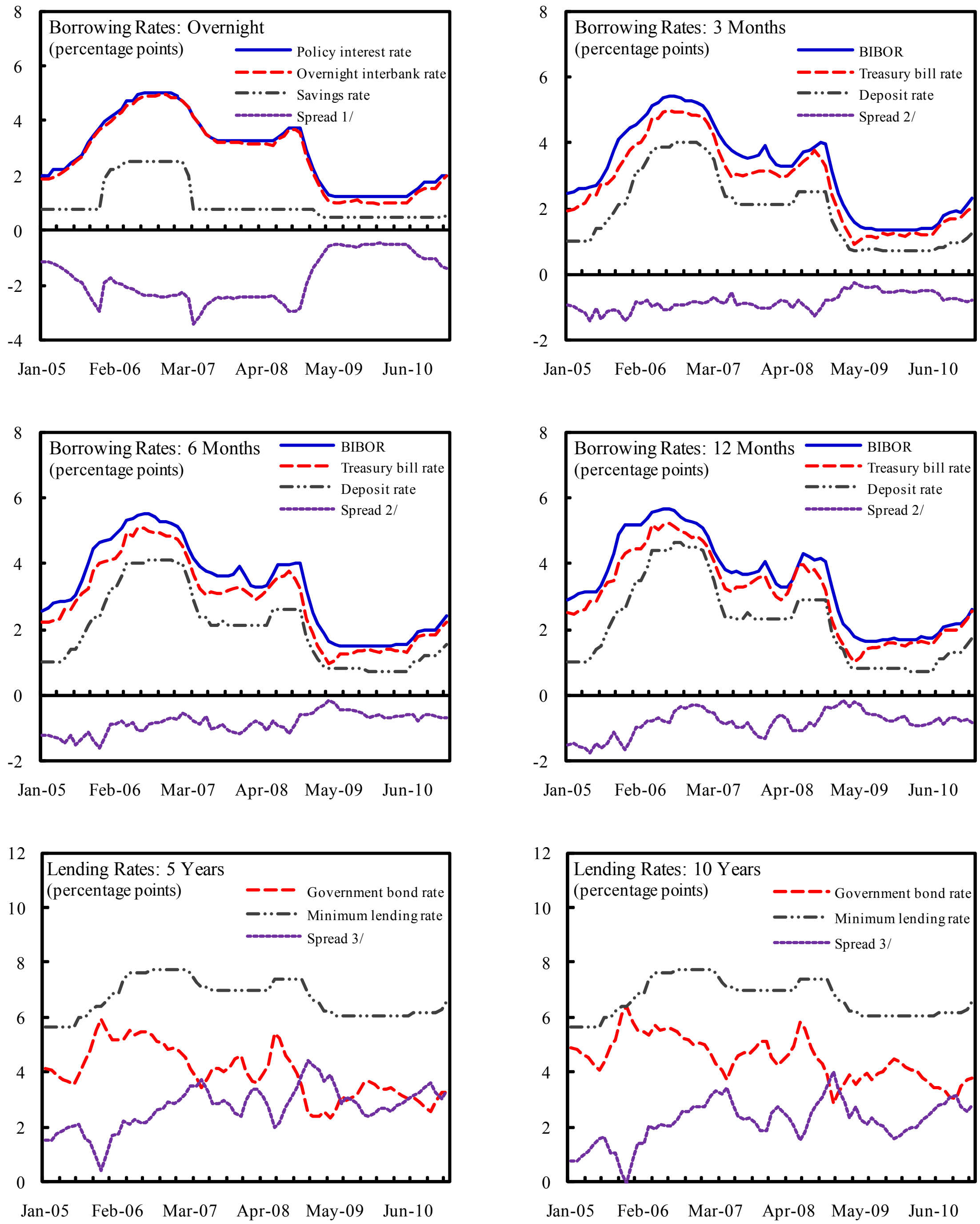
2.8.1 Figures and Tables

Figure 2.1 Emerging Markets: Accumulation of Foreign Reserves



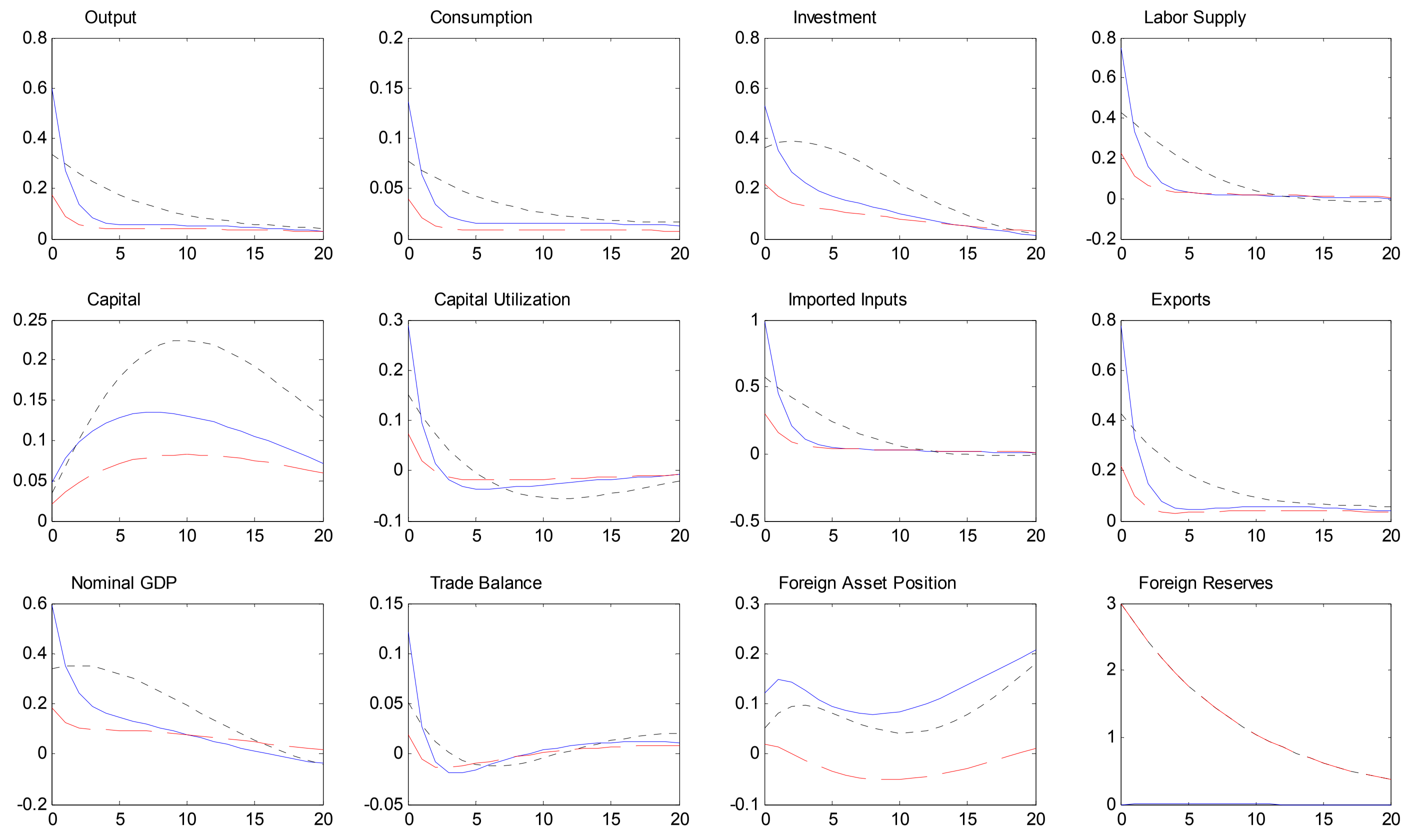
Source: International Monetary Fund, International Financial Statistics; and author's calculations.

Figure 2.2 Thailand: Interest Rates



Source: Bank of Thailand; and author's calculations.
Note:
1. Based on overnight interbank rate and savings rate.
2. Based on Treasury bill rate and deposit rate.
3. Based on government bond rate and minimum lending rate.

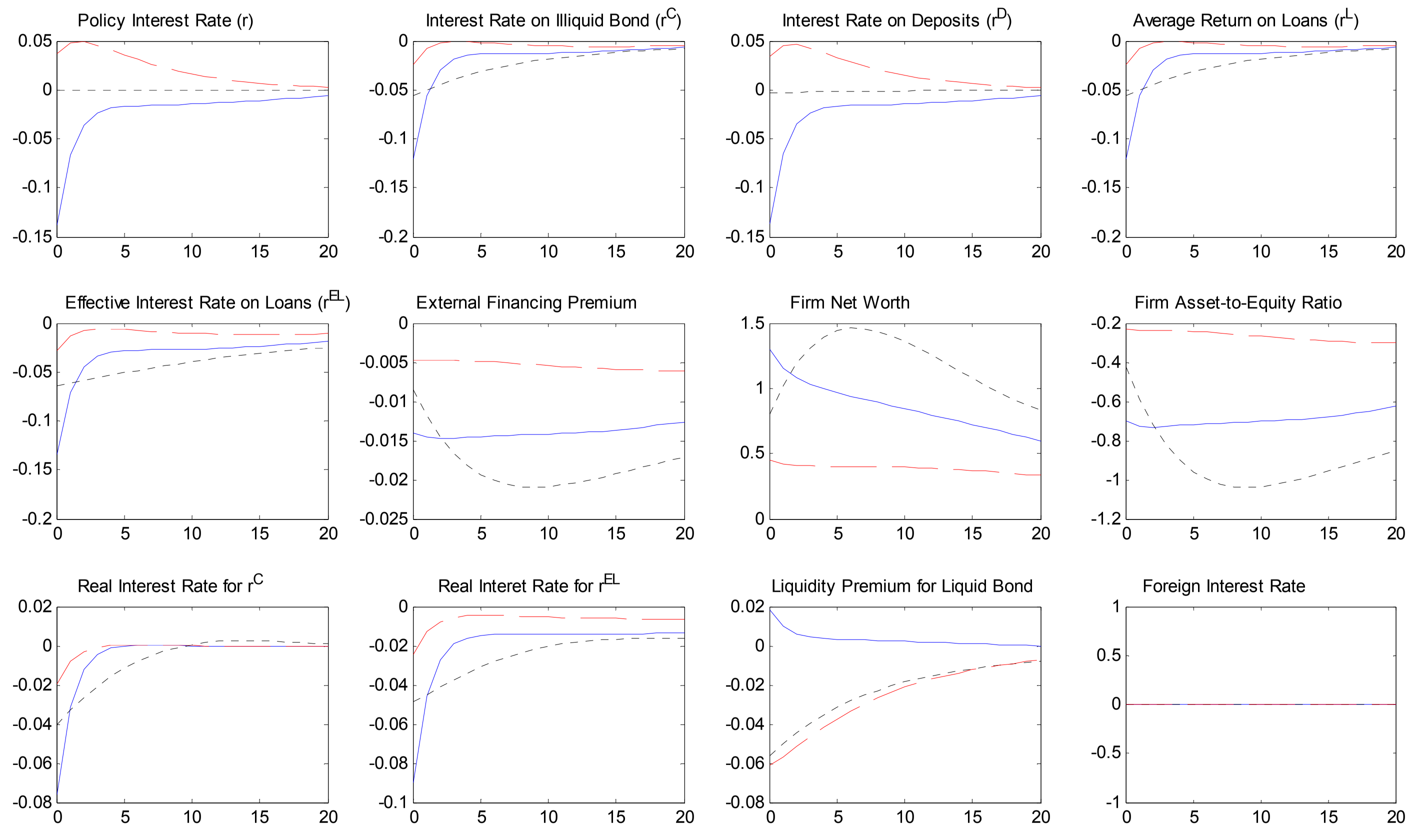
Figure 2.3 Impulse Responses to Main Policy Actions



– – "blue" = a reduction in the policy interest rate by 25 basis points

-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant

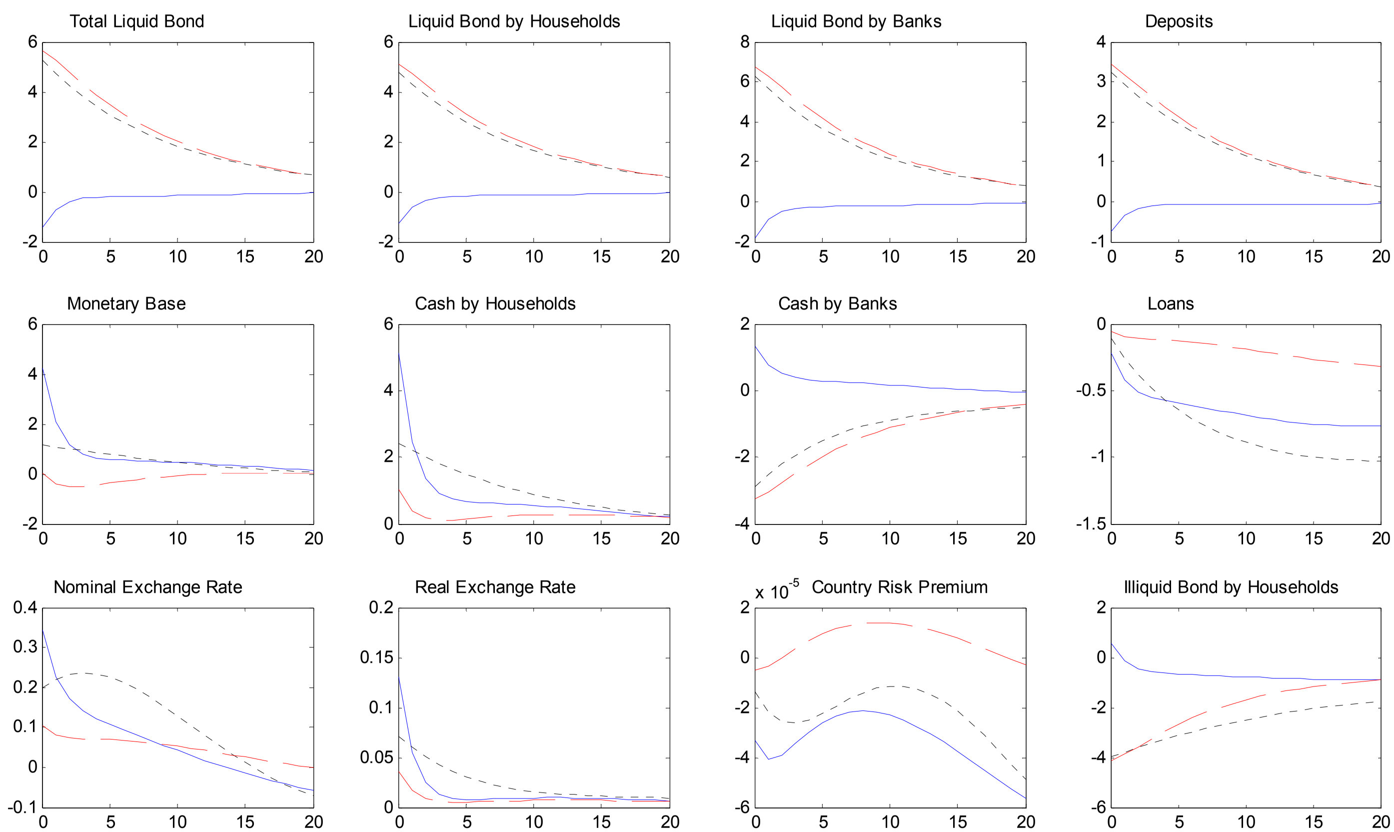
— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate



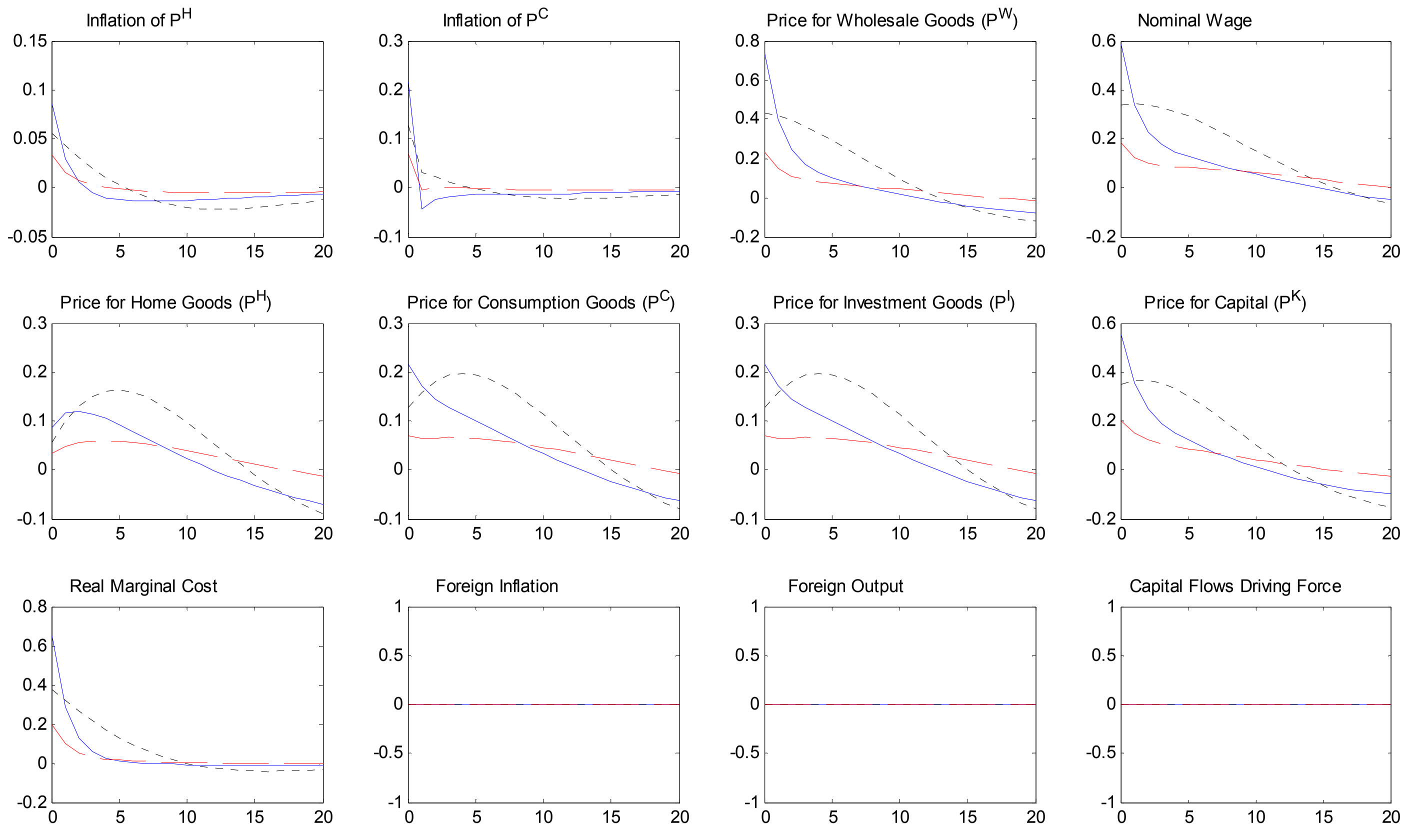
– – "blue" = a reduction in the policy interest rate by 25 basis points

-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant

— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate

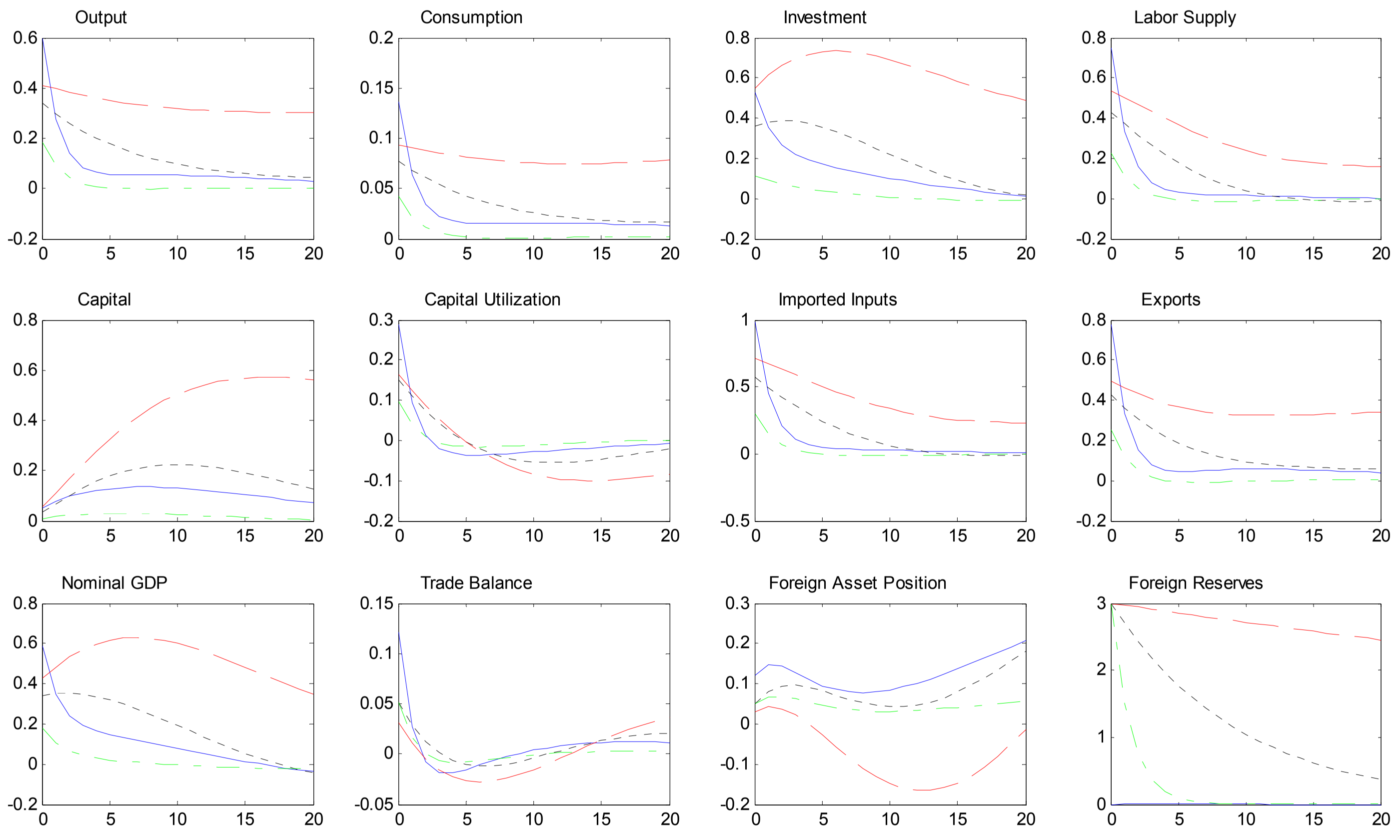


– – "blue" = a reduction in the policy interest rate by 25 basis points
-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant
— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate

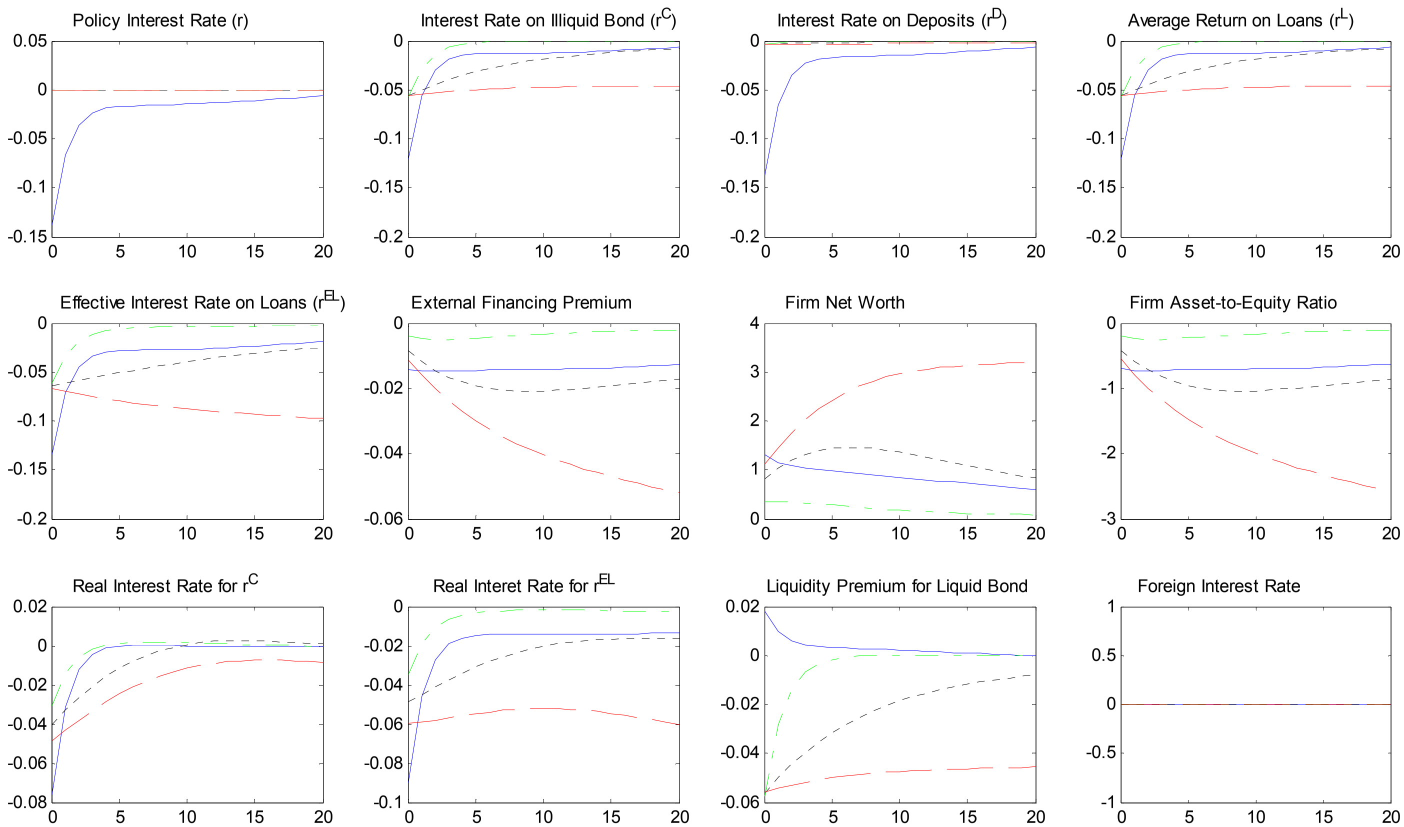


– – "blue" = a reduction in the policy interest rate by 25 basis points
-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant
— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate

Figure 2.4 Impulse Responses to Sterilized Foreign-Exchange Interventions with Different Degree of Intervention Persistence



— "blue" = a reduction in the policy interest rate by 25 basis points
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.9$ (baseline)
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.5$ (minimally persistent)
– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.99$ (nearly permanent)

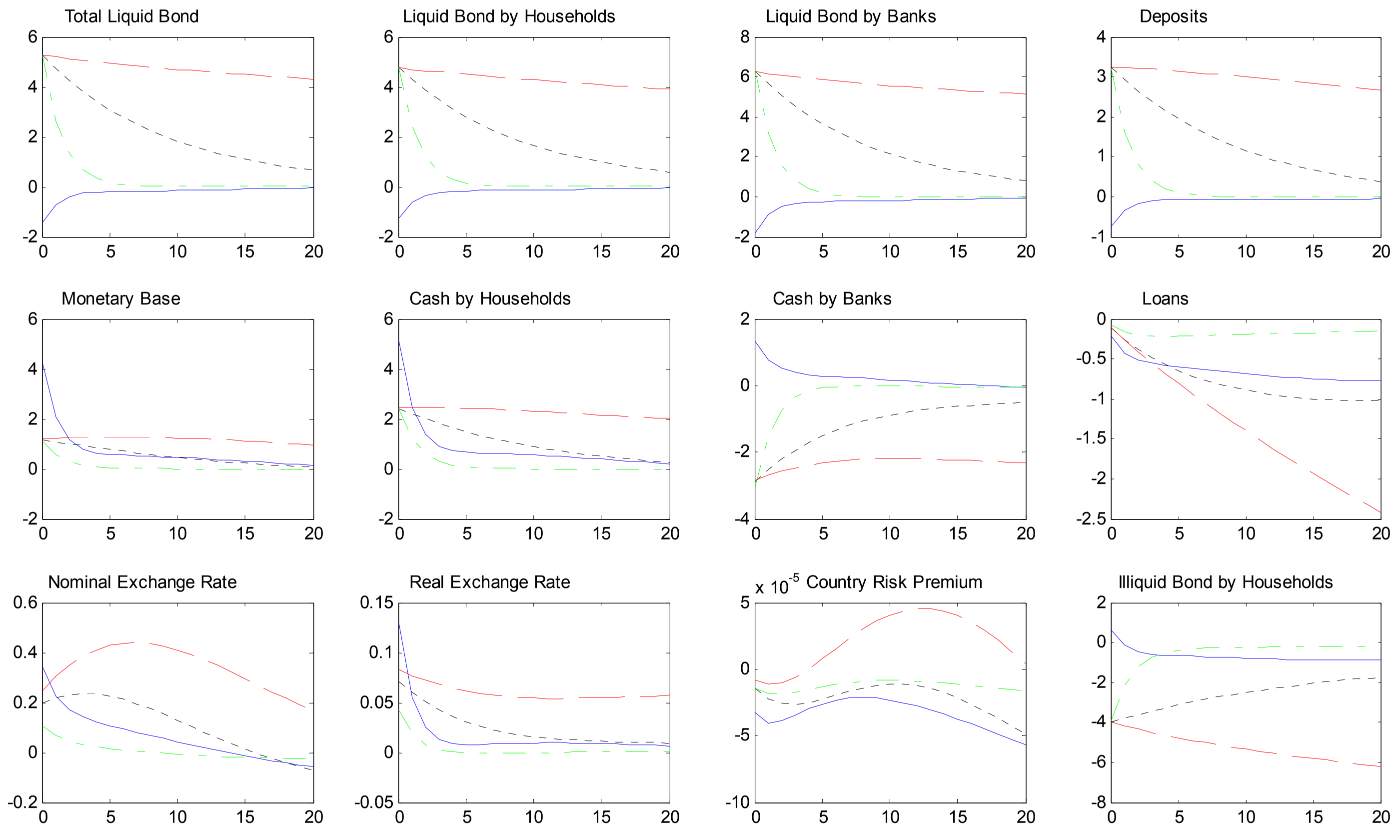


— "blue" = a reduction in the policy interest rate by 25 basis points

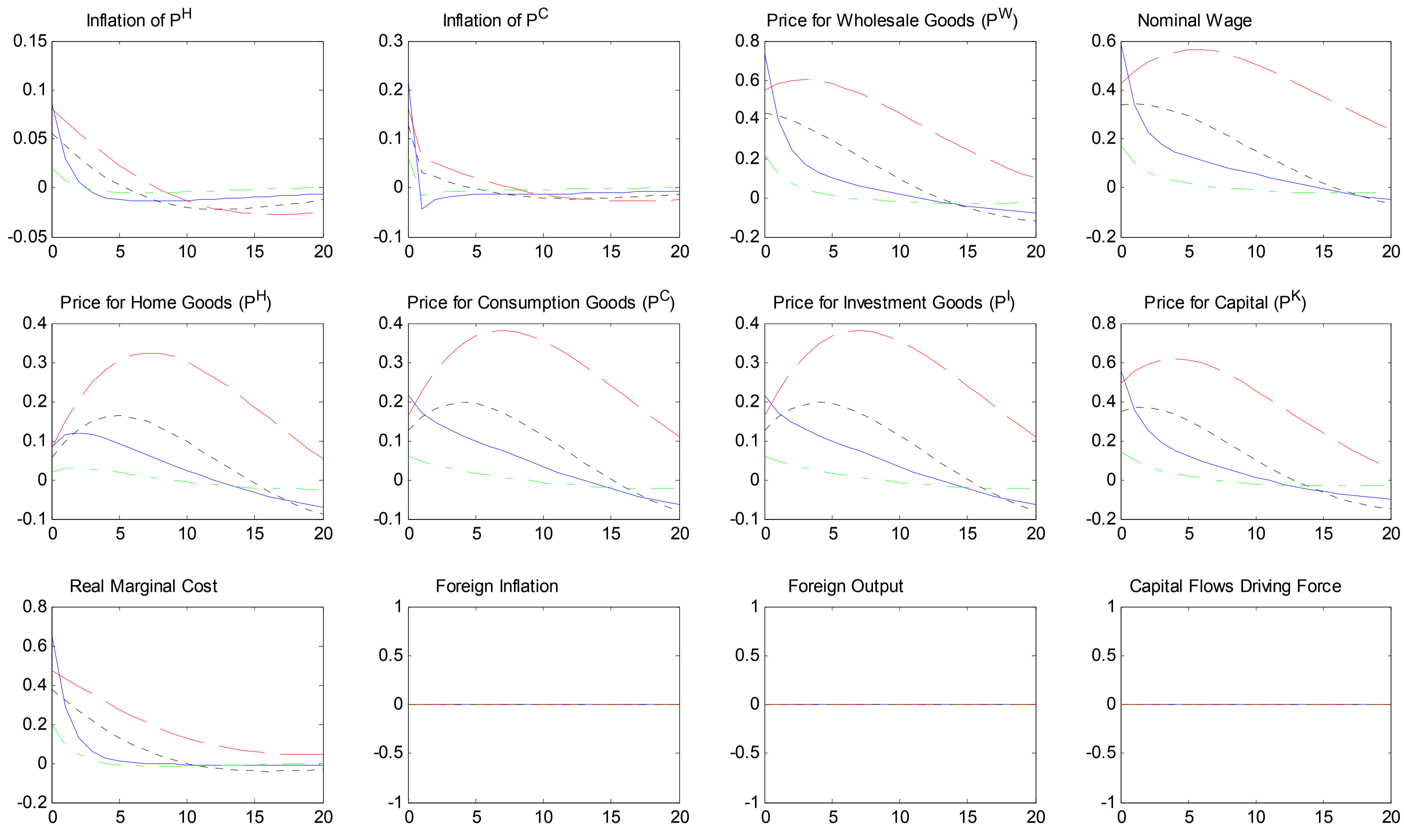
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.9$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.5$ (minimally persistent)

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.99$ (nearly permanent)



— "blue" = a reduction in the policy interest rate by 25 basis points
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.9$ (baseline)
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.5$ (minimally persistent)
– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.99$ (nearly permanent)



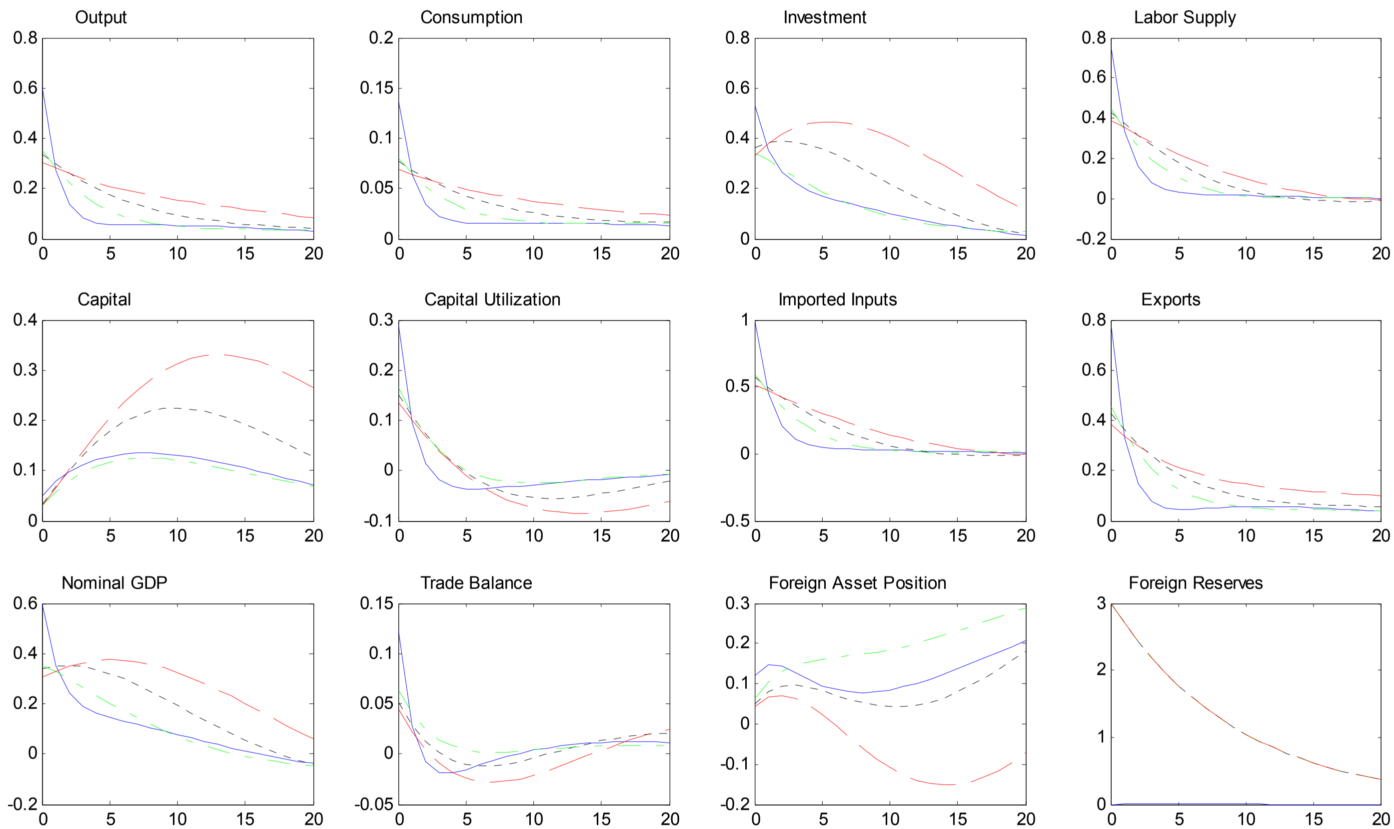
— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.9$ (baseline)

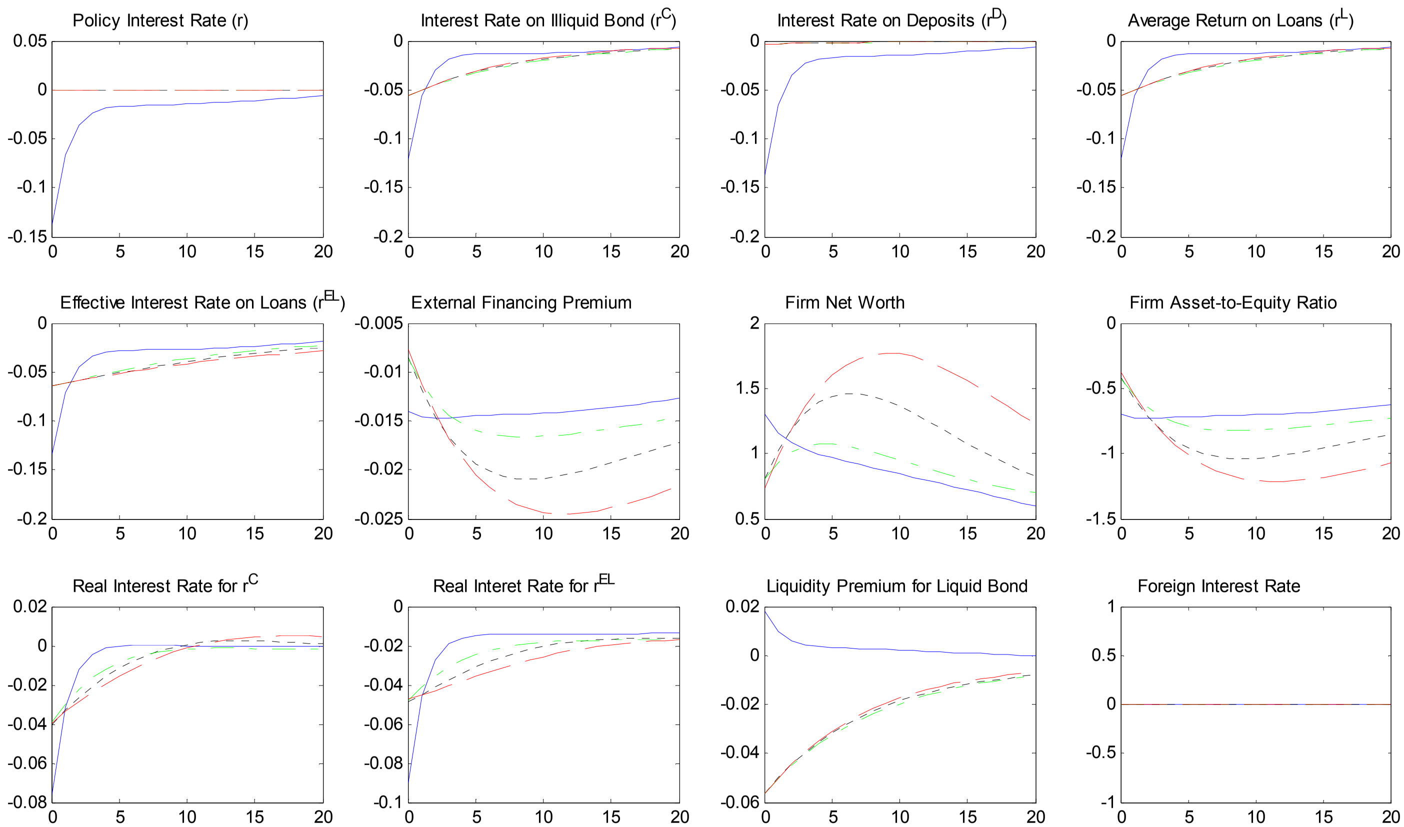
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.5$ (minimally persistent)

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\rho_F = 0.99$ (nearly permanent)

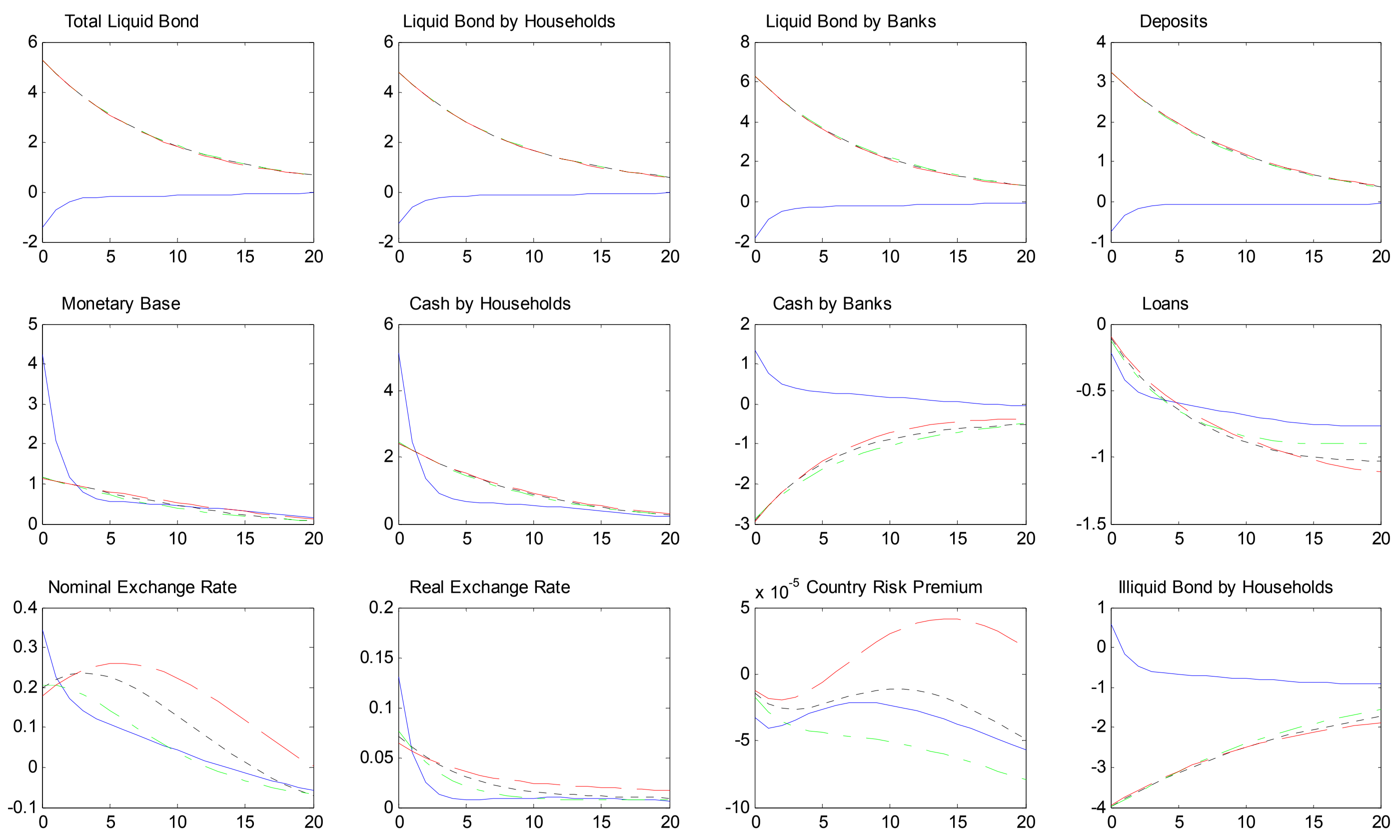
Figure 2.5 Impulse Responses to Sterilized Foreign-Exchange Interventions with Different Degree of Responsiveness to Inflation



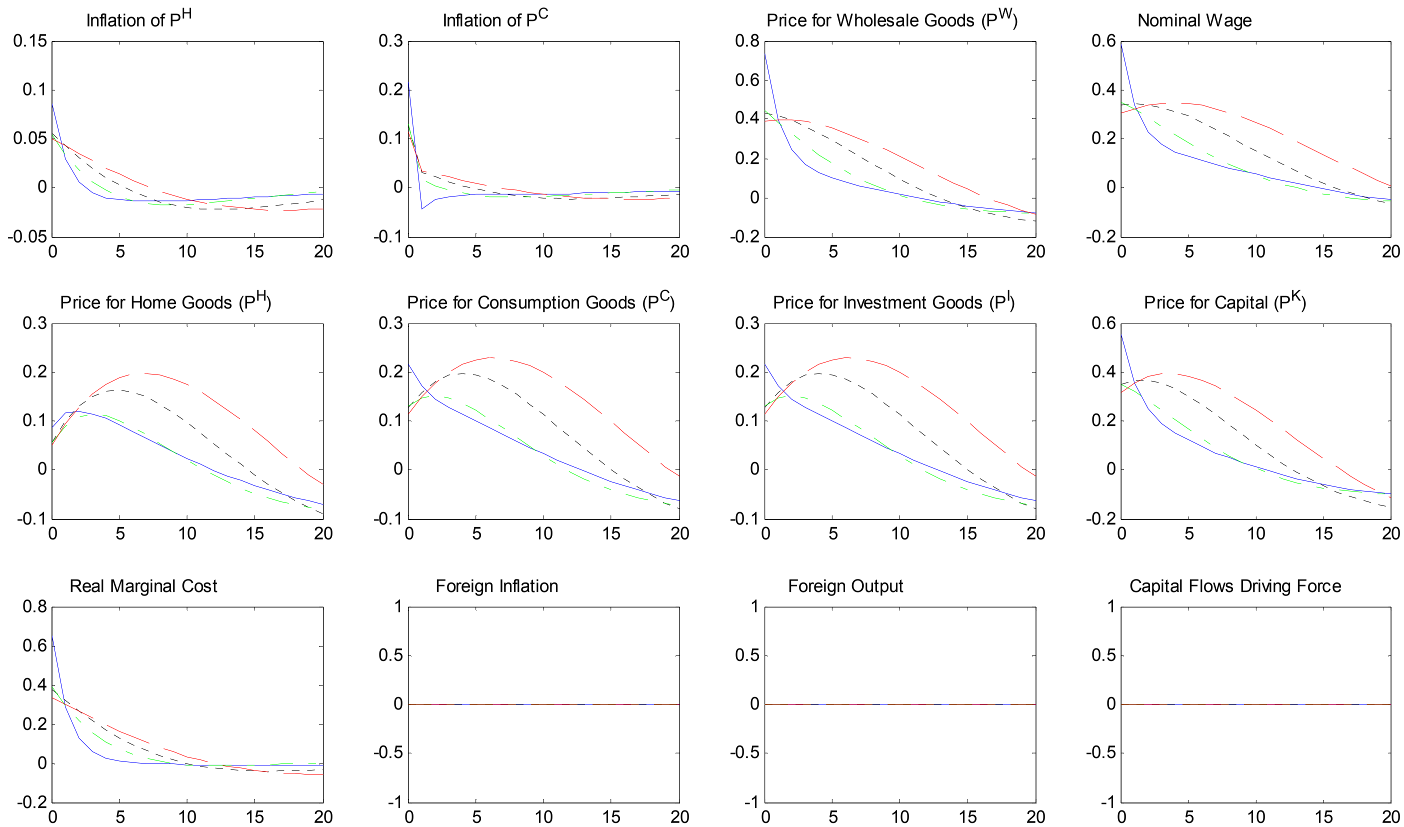
— "blue" = a reduction in the policy interest rate by 25 basis points
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 3$ (baseline)
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 1$ (lenient on inflation)
– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 5$ (aggressive against inflation)



— "blue" = a reduction in the policy interest rate by 25 basis points
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 3$ (baseline)
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 1$ (lenient on inflation)
– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 5$ (aggressive against inflation)



— "blue" = a reduction in the policy interest rate by 25 basis points
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 3$ (baseline)
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 1$ (lenient on inflation)
– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 5$ (aggressive against inflation)



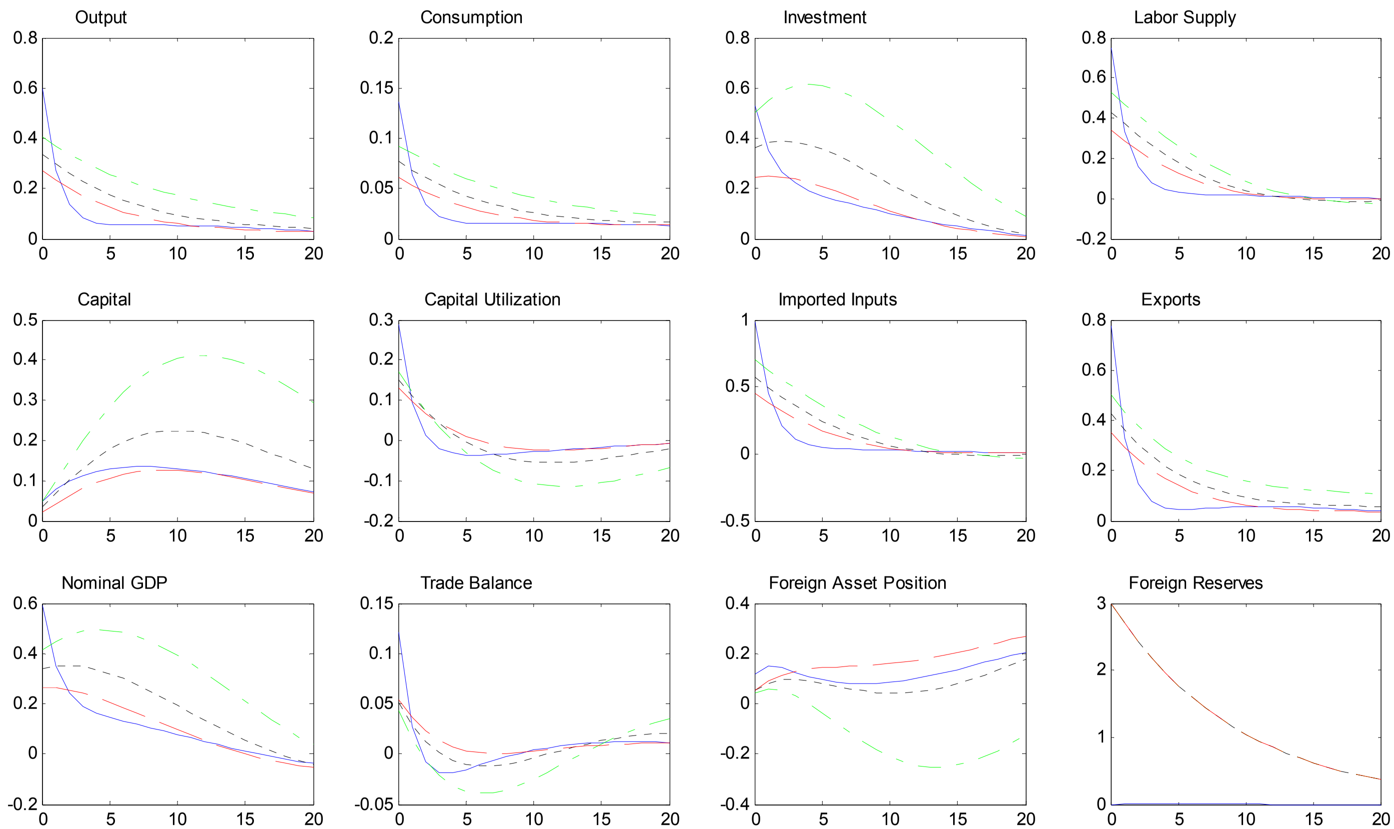
— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 3$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 1$ (lenient on inflation)

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_\pi = 5$ (aggressive against inflation)

Figure 2.6 Impulse Responses to Sterilized Foreign-Exchange Interventions with Different Degree of Responsiveness to Output

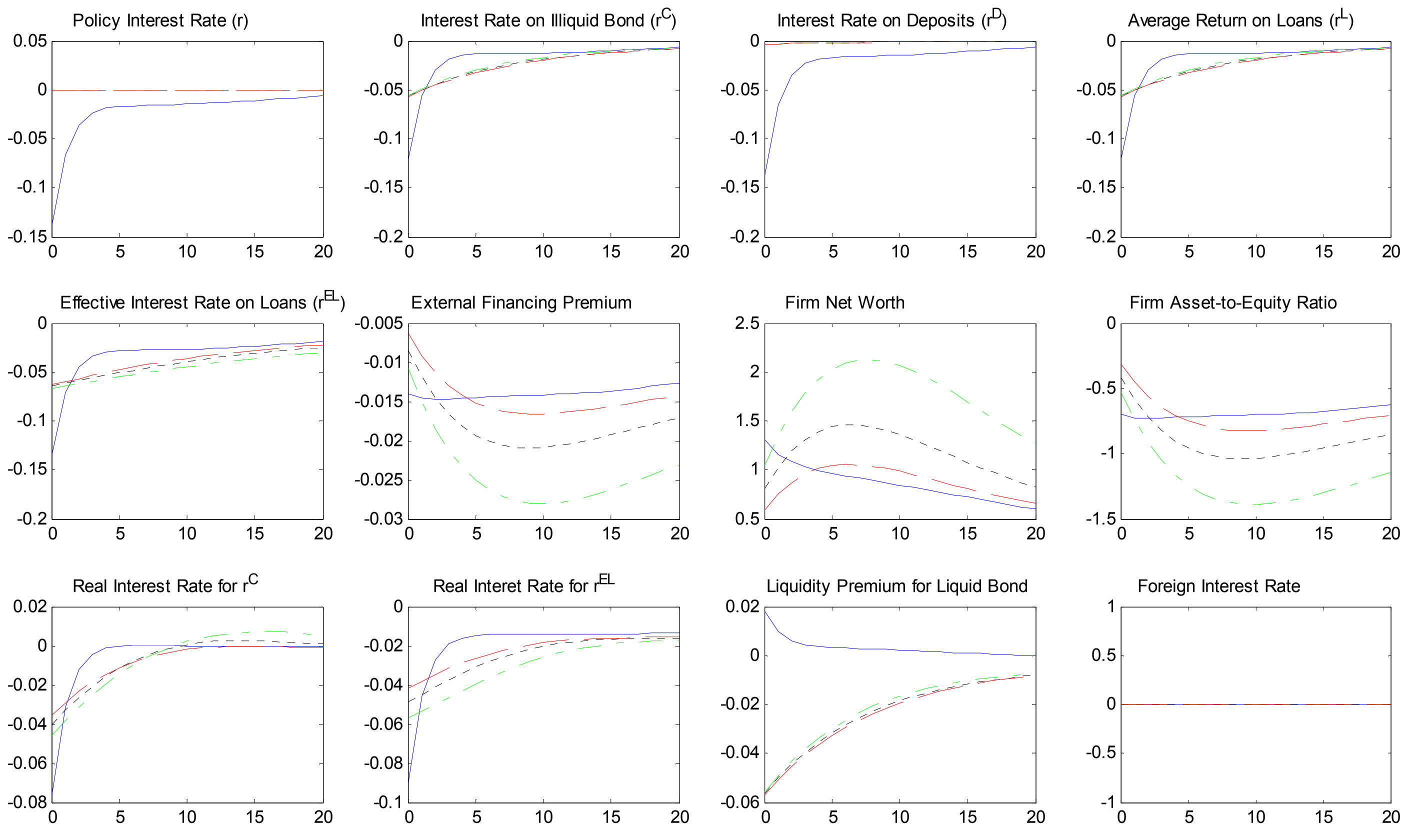


— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.5$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.25$ (pro-expansion)

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 1$ (pro-stability)

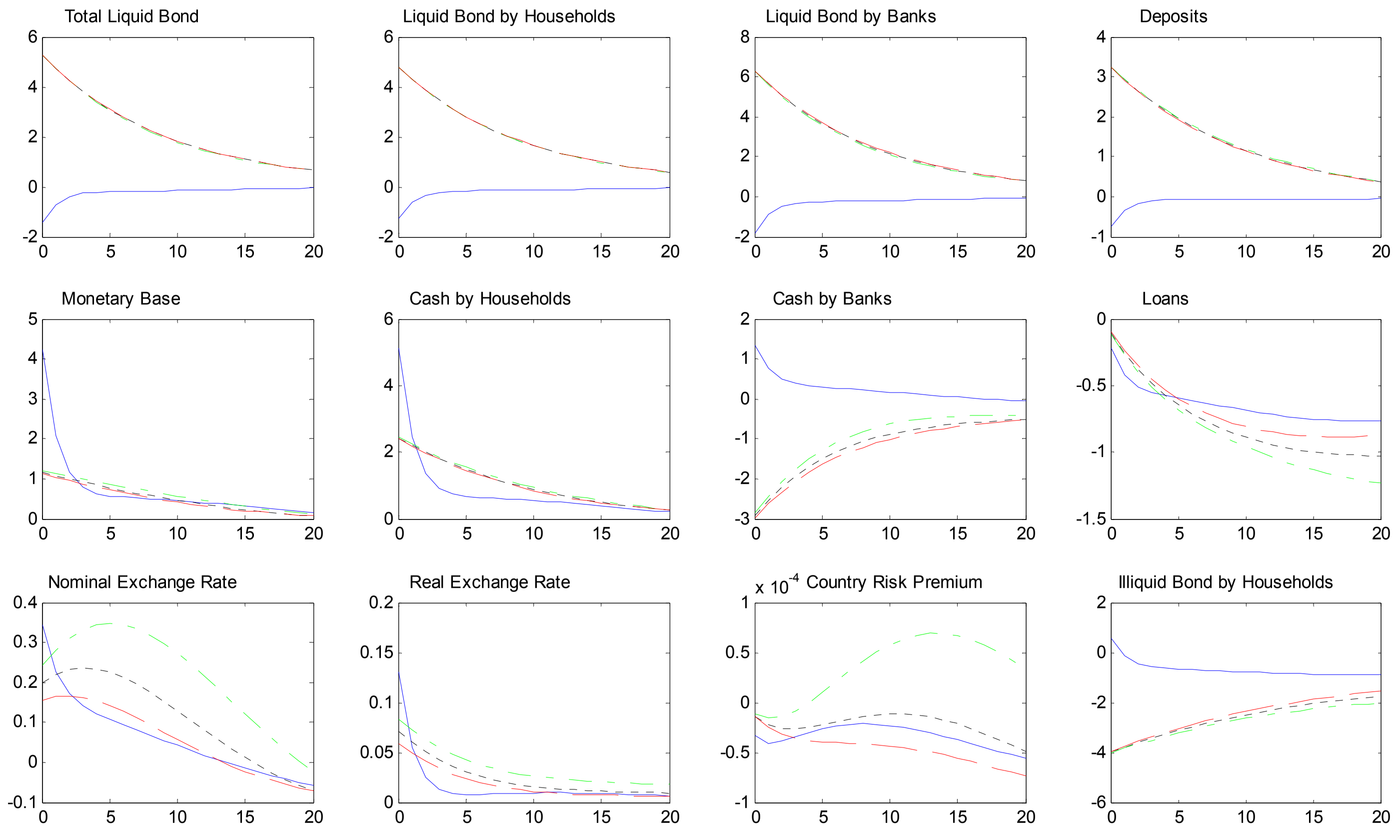


— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.5$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.25$ (pro-expansion)

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 1$ (pro-stability)

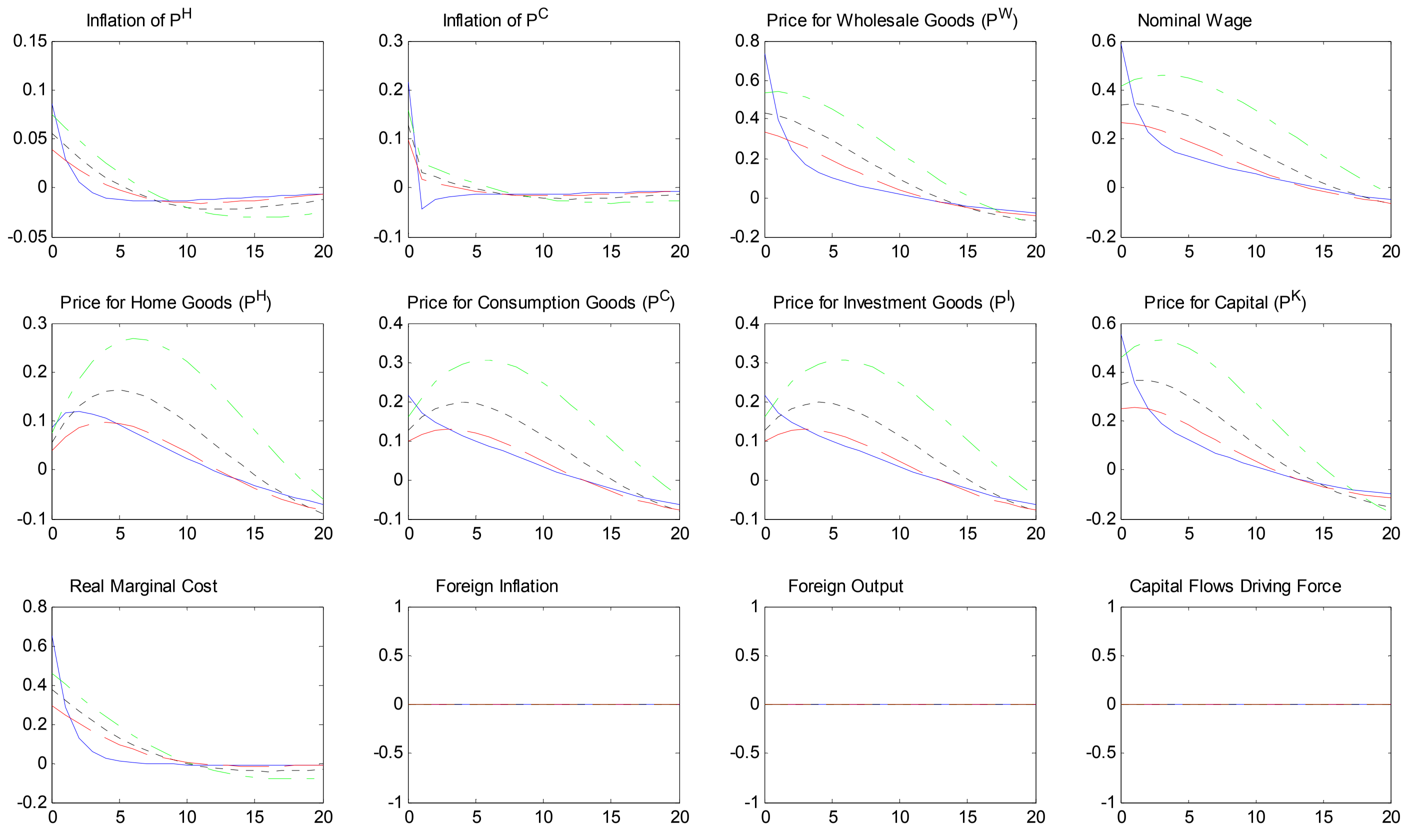


— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.5$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.25$ (pro-expansion)

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 1$ (pro-stability)



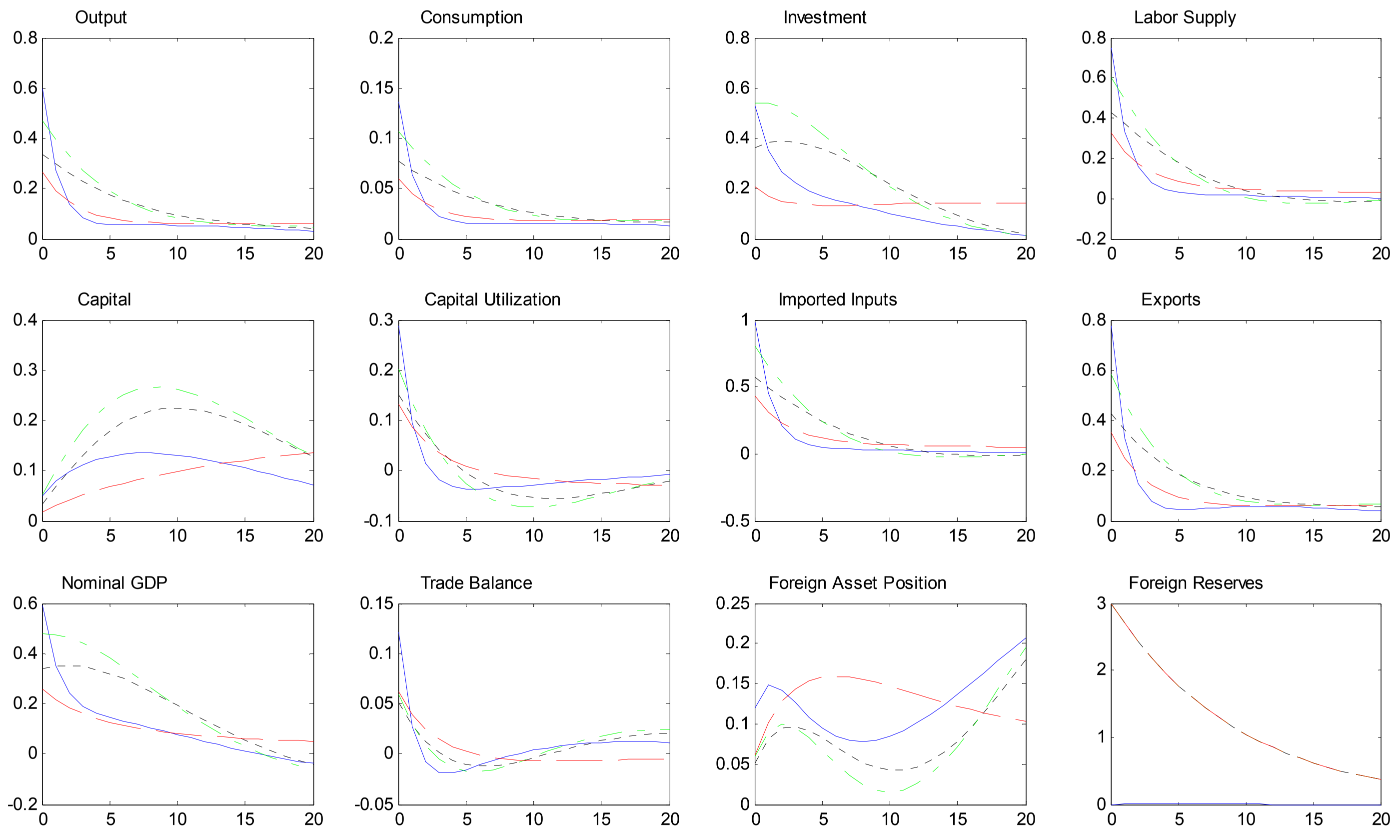
— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.5$ (baseline)

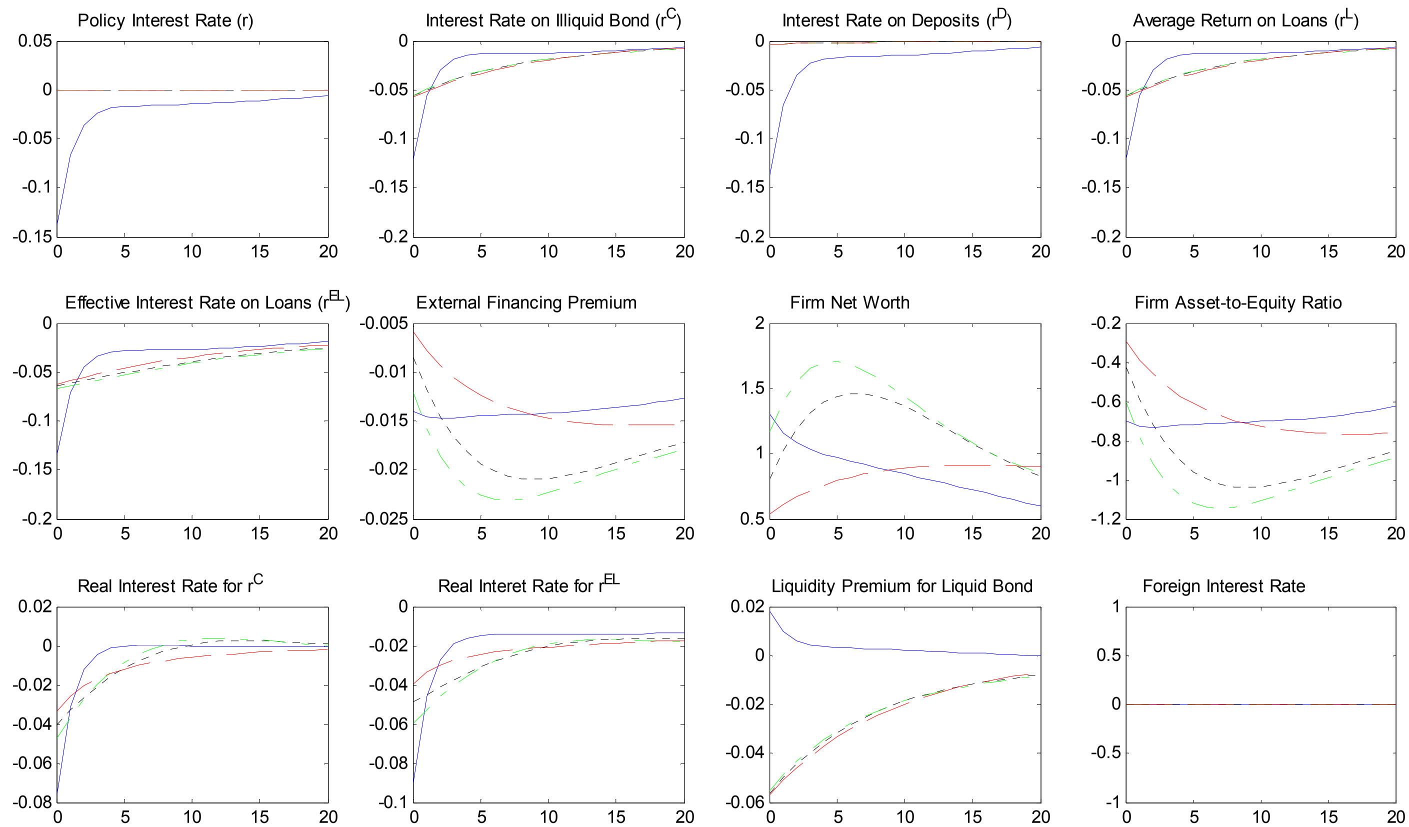
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 0.25$ (pro-expansion)

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with $\theta_y = 1$ (pro-stability)

Figure 2.7 Impulse Responses to Sterilized Foreign-Exchange Interventions with Different Target of Price Stability



— "blue" = a reduction in the policy interest rate by 25 basis points
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^{H}-targeting and $\theta_{\pi} = 3$ (baseline)
-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^{C}-targeting and $\theta_{\pi} = 3$
– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with p^{H}-targeting and $\theta_{p} = 1$

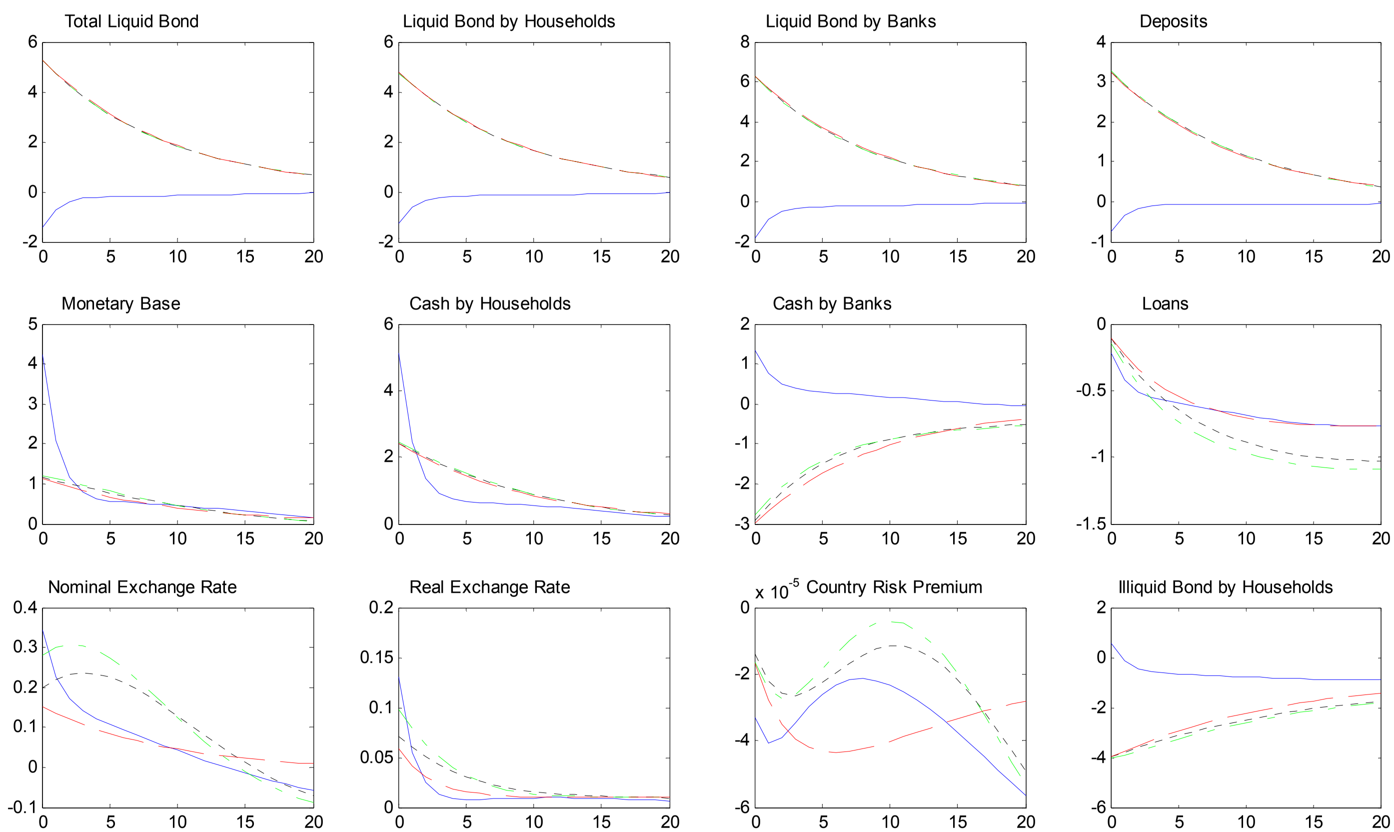


— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^H-targeting and $\theta_\pi = 3$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^C-targeting and $\theta_\pi = 3$

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with p^H-targeting and $\theta_p = 1$

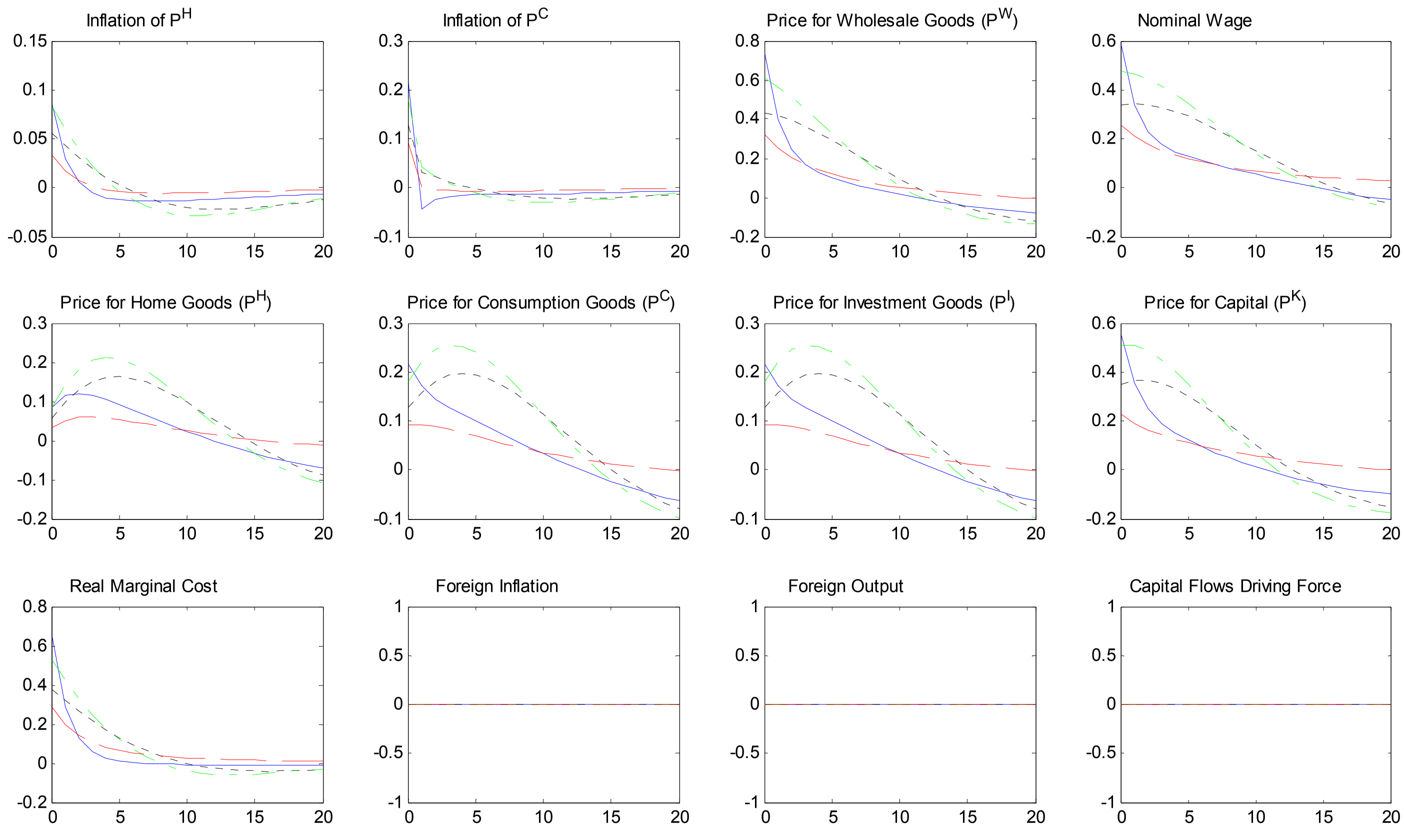


— "blue" = a reduction in the policy interest rate by 25 basis points

… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^H-targeting and $\theta_\pi = 3$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^C-targeting and $\theta_\pi = 3$

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with p^H-targeting and $\theta_p = 1$



— "blue" = a reduction in the policy interest rate by 25 basis points

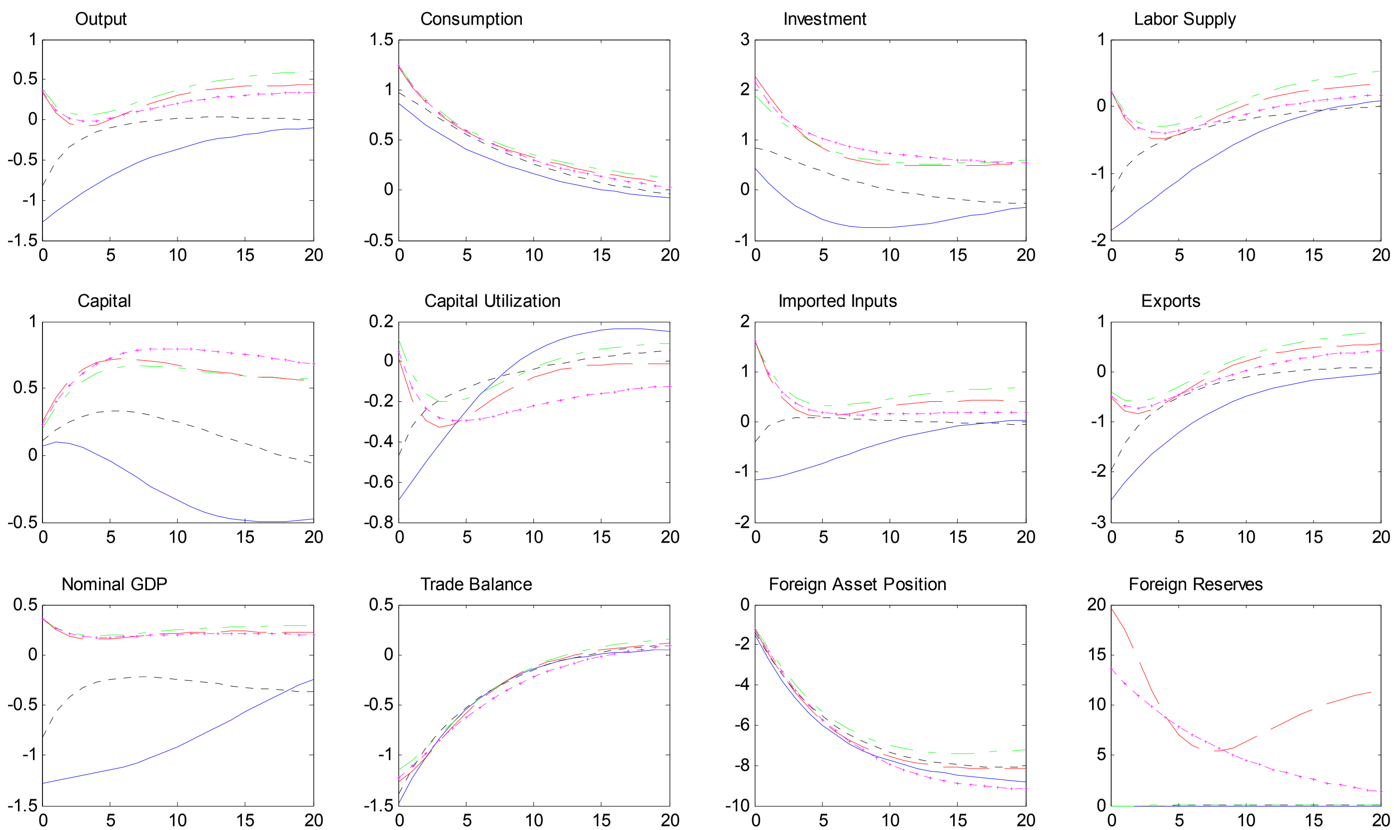
… "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^H-targeting and $\theta_\pi = 3$ (baseline)

-.-. "green" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with π^C-targeting and $\theta_\pi = 3$

– – "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP with p^H-targeting and $\theta_p = 1$

Figure 2.8 Impulse Reponses to Policy Actions for Managing Financial Flows (Set A)

Shock Description: Initial shock is a decline in the country risk premium by 25 basis points



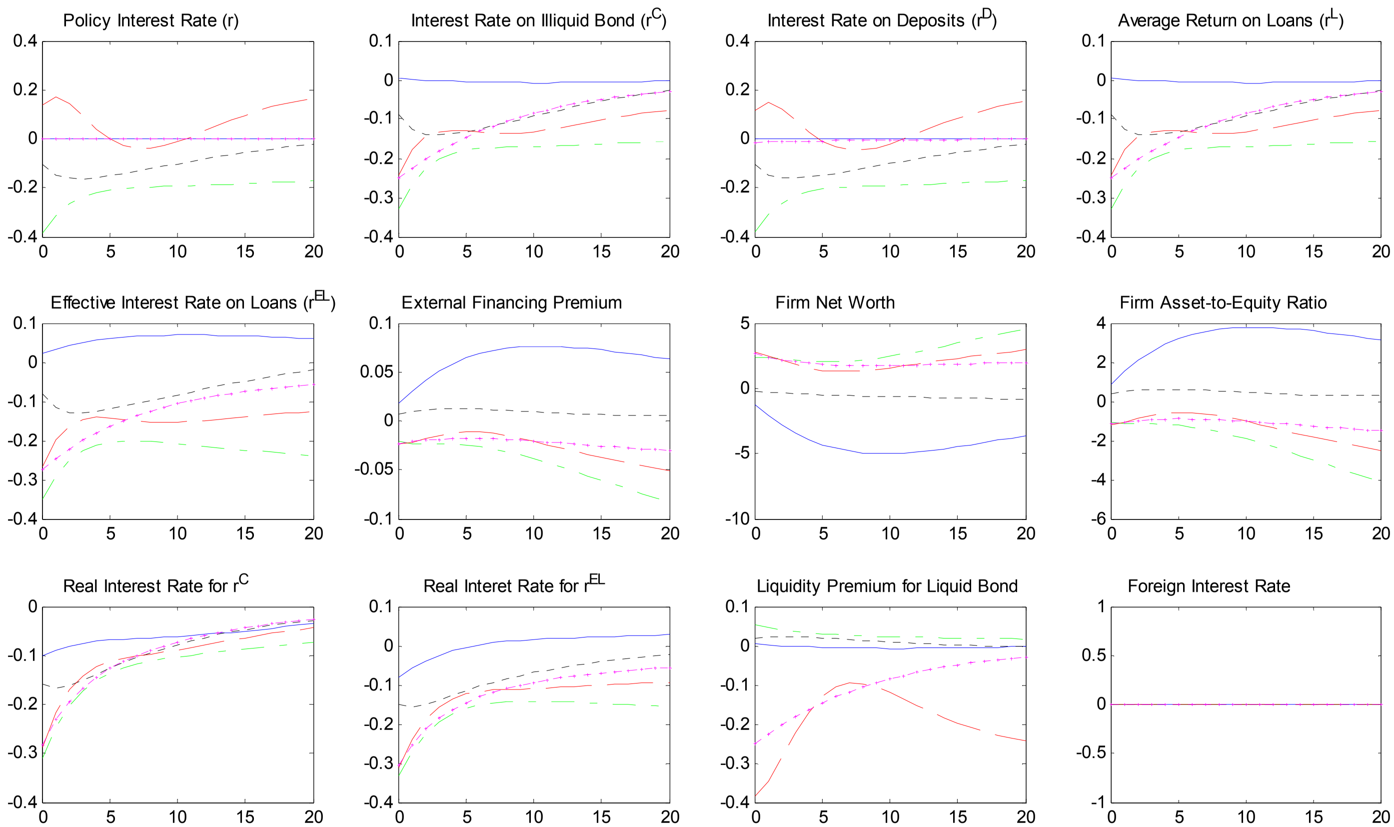
— "blue" = the policy interest rate being held constant

… "black" = the policy interest rate being automatically adjusted according to the prescribed rule

-.-. "green" = the policy interest rate being adjusted to keep the nominal exchange rate constant

– – "red" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)

..+. "magenta" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)



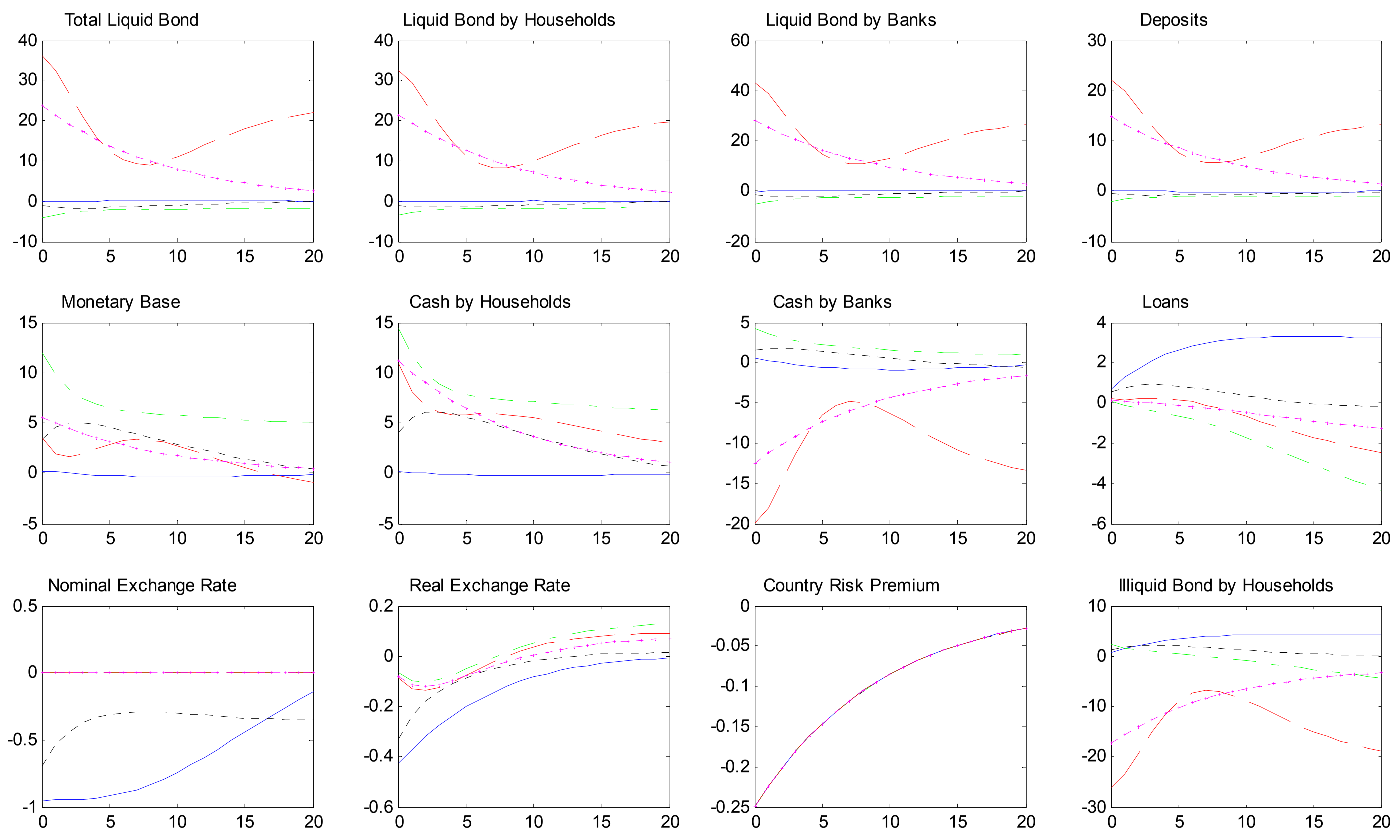
— "blue" = the policy interest rate being held constant

… "black" = the policy interest rate being automatically adjusted according to the prescribed rule

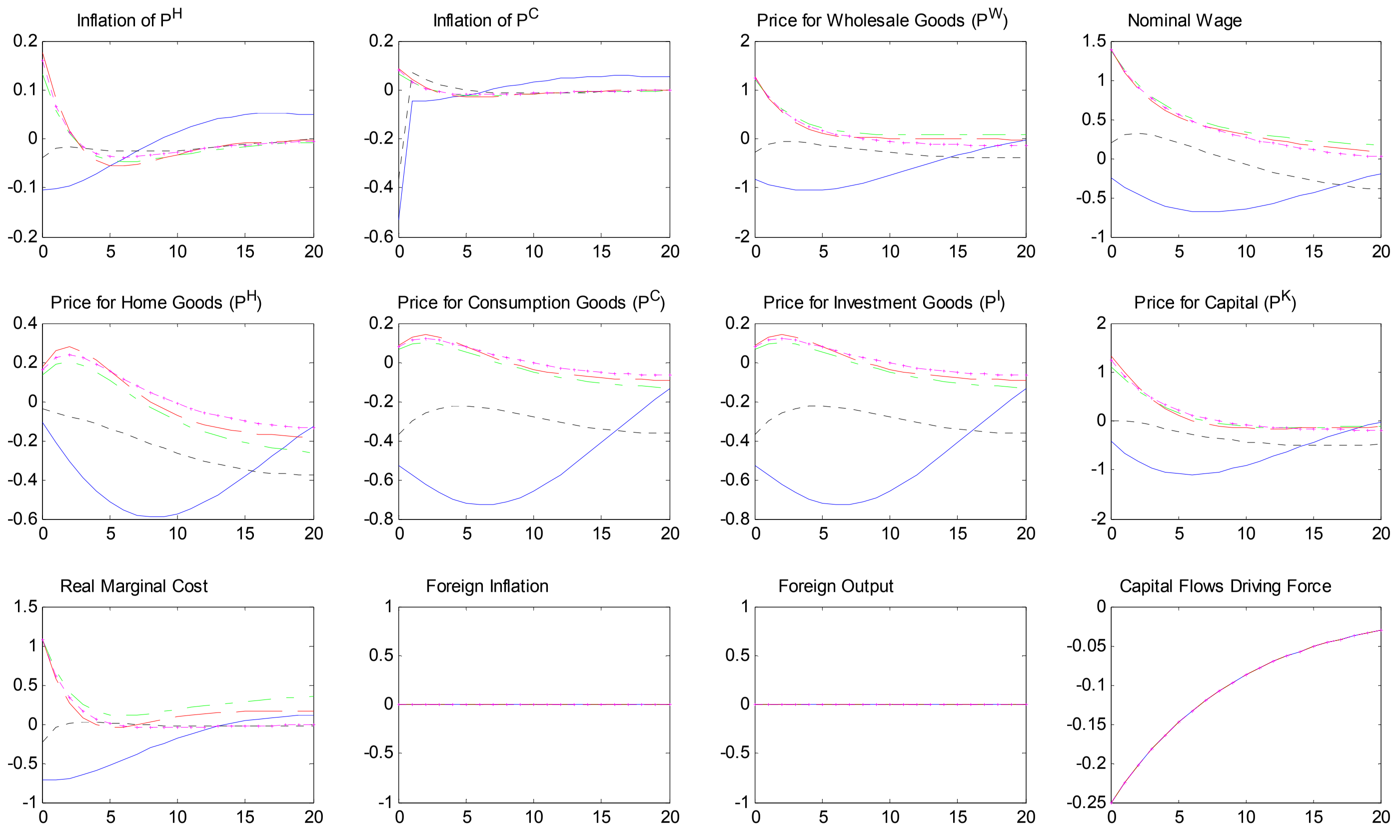
-.-. "green" = the policy interest rate being adjusted to keep the nominal exchange rate constant

– – "red" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)

..+. "magenta" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant



— "blue" = the policy interest rate being held constant
… "black" = the policy interest rate being automatically adjusted according to the prescribed rule
-.-. "green" = the policy interest rate being adjusted to keep the nominal exchange rate constant
– – "red" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)
..+.. "magenta" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)



— "blue" = the policy interest rate being held constant

… "black" = the policy interest rate being automatically adjusted according to the prescribed rule

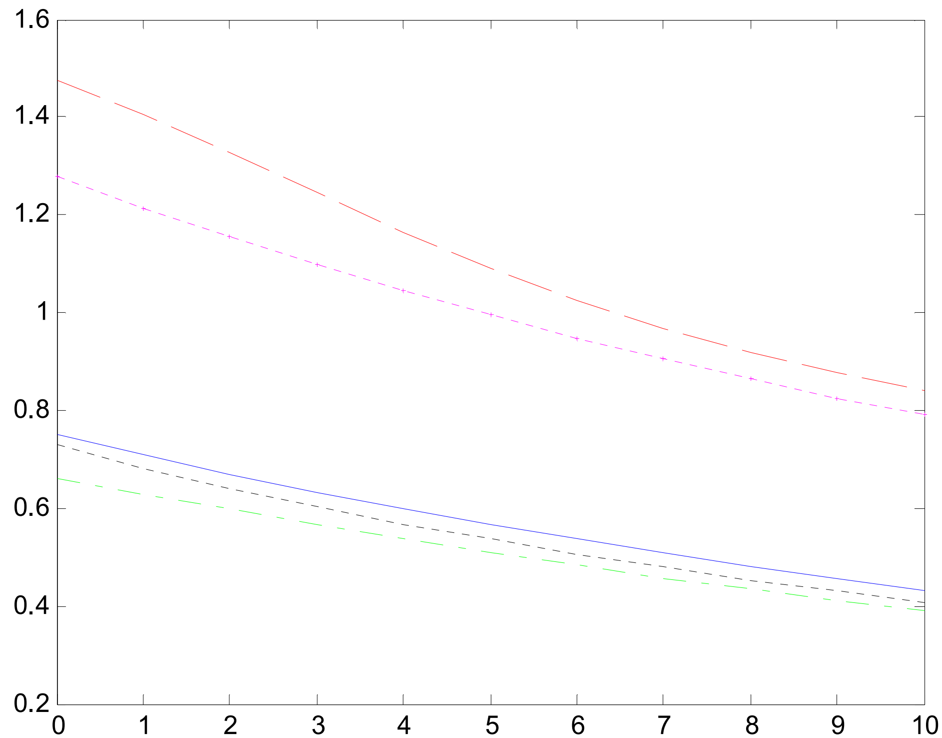
-.-. "green" = the policy interest rate being adjusted to keep the nominal exchange rate constant

– – "red" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)

..+. "magenta" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

Figure 2.9 Welfare Outcome for Different Policy Actions for Managing Financial Flows (Set A)

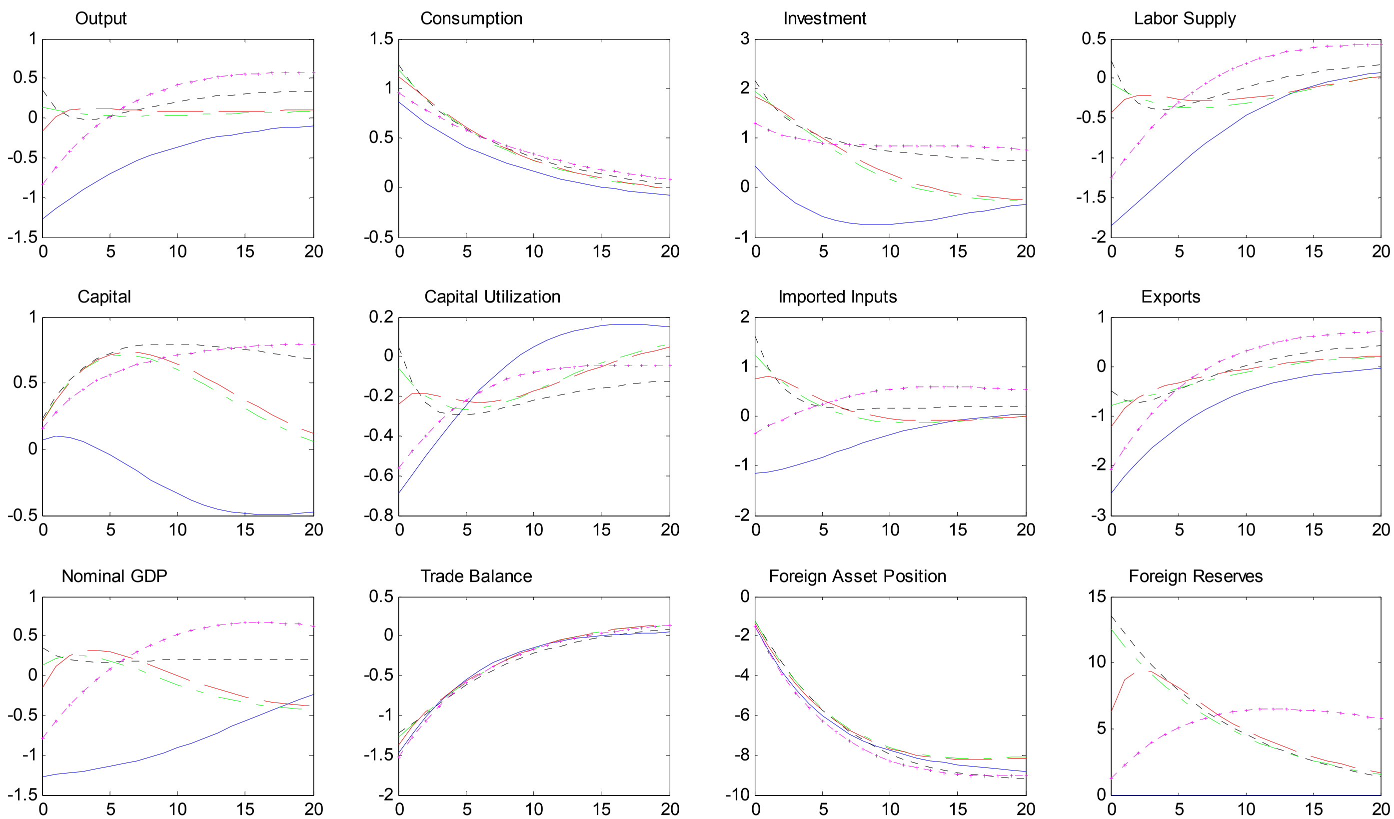
Shock Description: Initial shock is a decline in the country risk premium by 25 basis points



— "blue" = the policy interest rate being held constant
… "black" = the policy interest rate being automatically adjusted according to the prescribed rule
-.-. "green" = the policy interest rate being adjusted to keep the nominal exchange rate constant
– – "red" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)
..+.. "magenta" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

Figure 2.10 Impulse Reponses to Policy Actions for Managing Financial Flows (Set B)

Shock Description: Initial shock is a decline in the country risk premium by 25 basis points



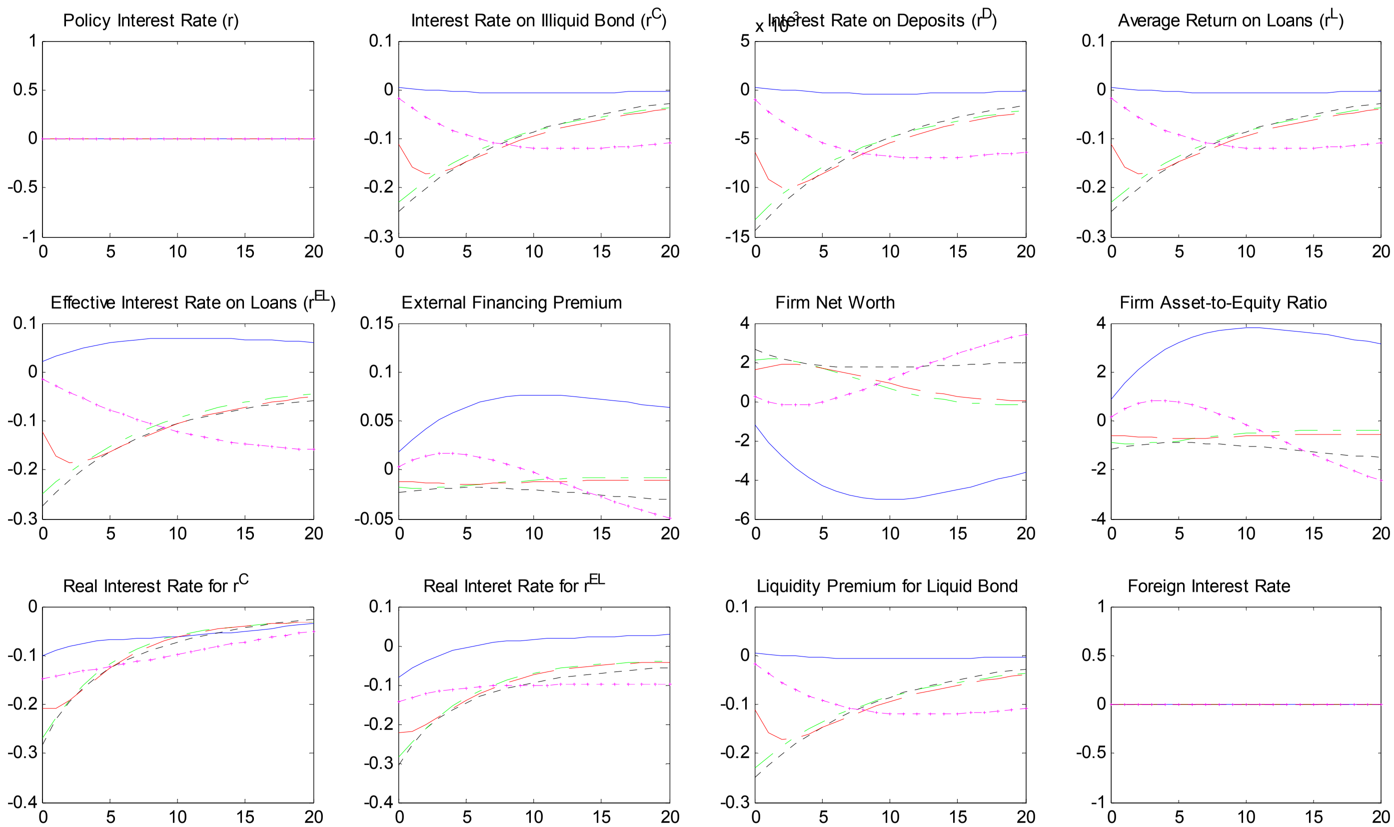
— "blue" = the policy interest rate being held constant

… "black" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

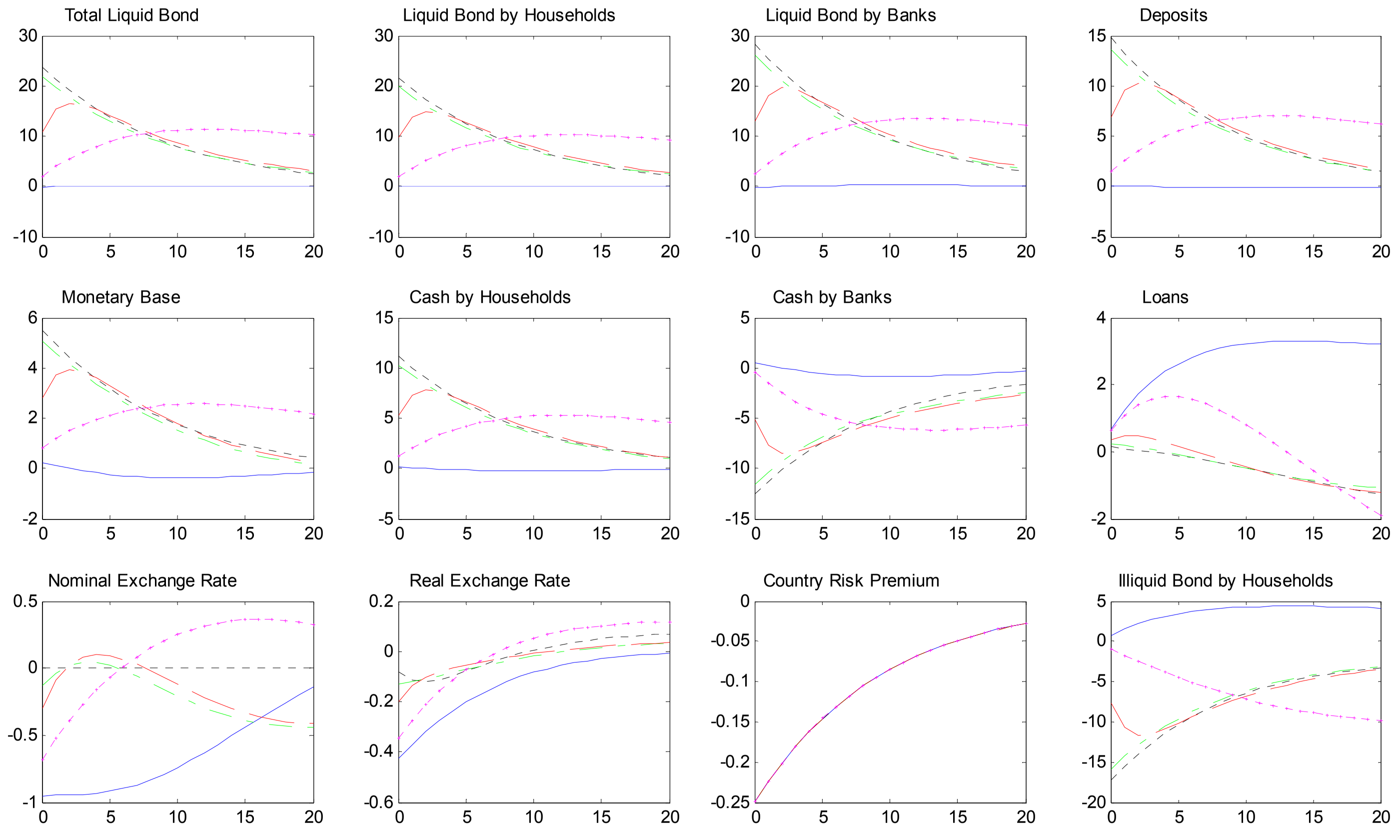
-.-. "green" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_{\varphi} = 50, \rho_f = 0$)

– – "red" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_{\varphi} = 25, \rho_f = 0.5$)

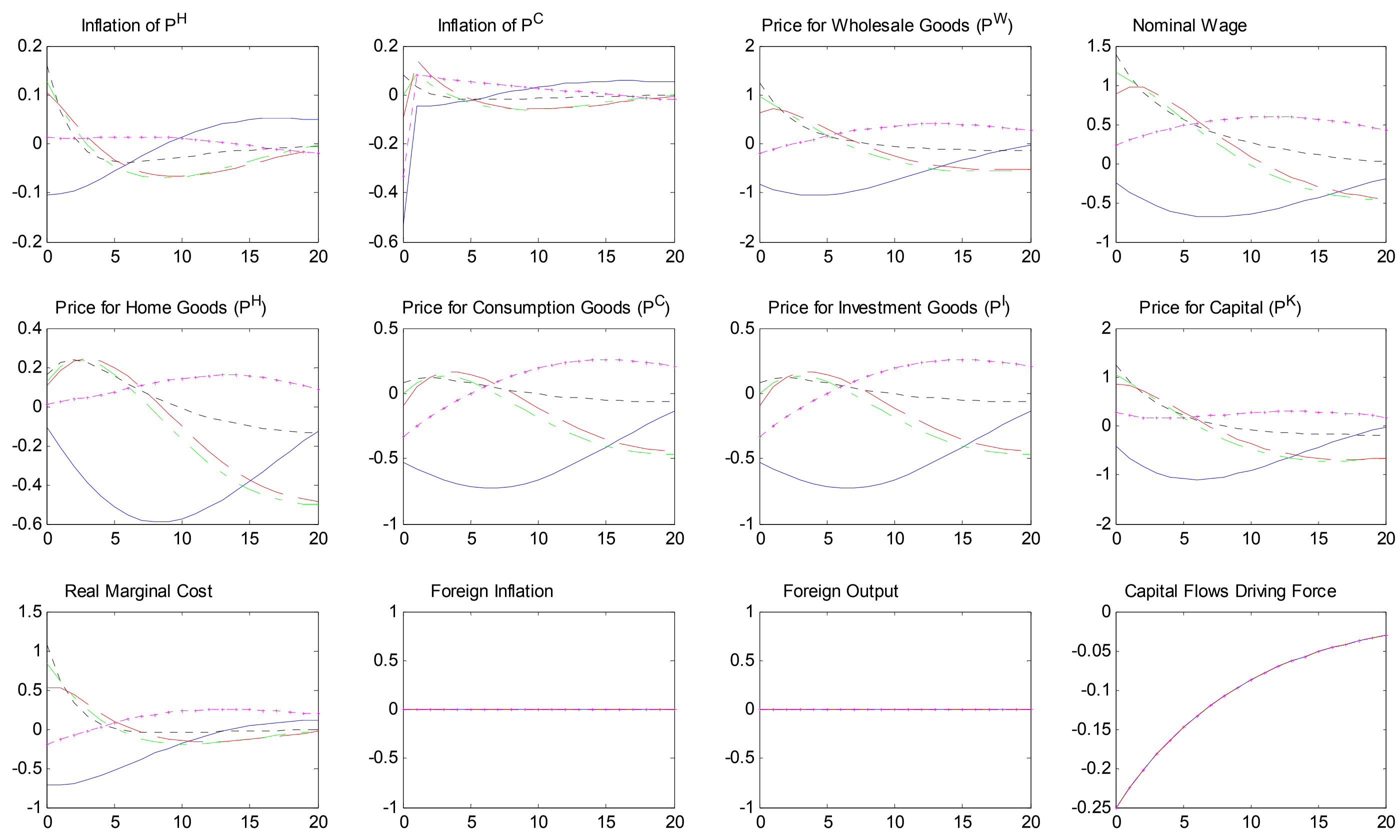
..+.. "magenta" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_{\varphi} = 5, \rho_f = 0.95$)



— "blue" = the policy interest rate being held constant
… "black" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)
-.-. "green" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 50$, $\rho_f = 0$)
– – "red" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 25$, $\rho_f = 0.5$)
..+.. "magenta" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 5$, $\rho_f = 0.95$)



— "blue" = the policy interest rate being held constant
… "black" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)
-.-. "green" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 50, \rho_f = 0$)
– – "red" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 25, \rho_f = 0.5$)
..+.. "magenta" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 5, \rho_f = 0.95$)



— "blue" = the policy interest rate being held constant

… "black" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

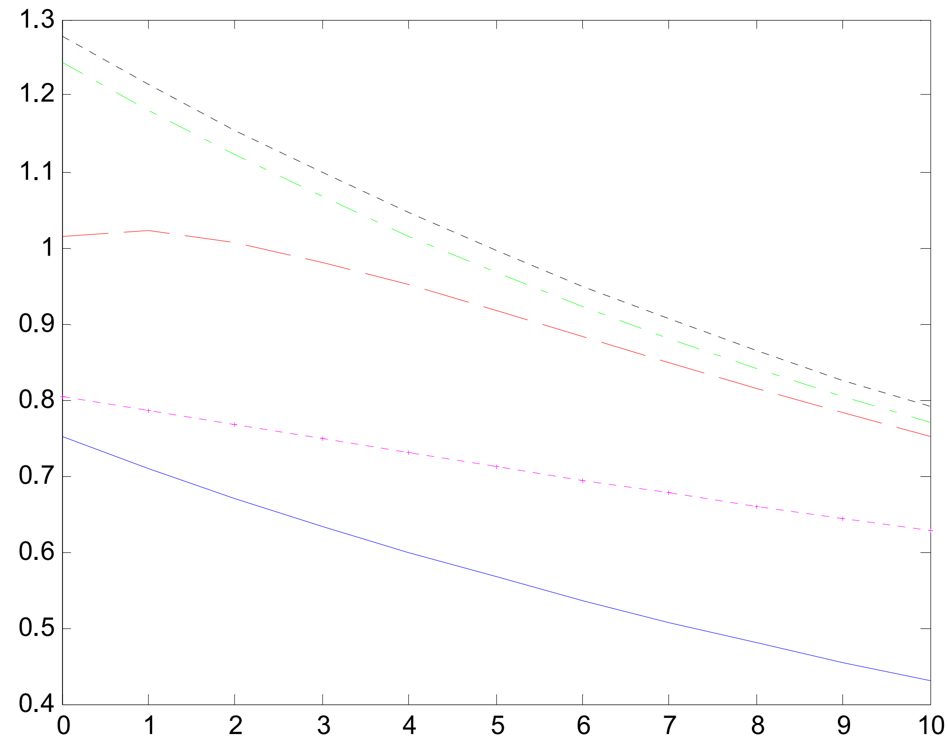
-.-. "green" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 50$, $\rho_f = 0$)

– – "red" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 25$, $\rho_f = 0.5$)

..+.. "magenta" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 5$, $\rho_f = 0.95$)

Figure 2.11 Welfare Outcome for Different Policy Actions for Managing Financial Flows (Set B)

Shock Description: Initial shock is a decline in the country risk premium by 25 basis points



— "blue" = the policy interest rate being held constant

… "black" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

-.-. "green" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 50$, $\rho_f = 0$)

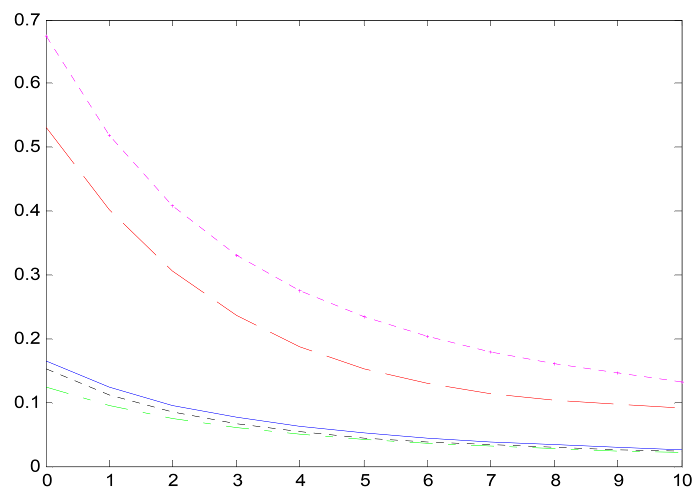
– – "red" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 25$, $\rho_f = 0.5$)

..+. "magenta" = sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 5$, $\rho_f = 0.95$)

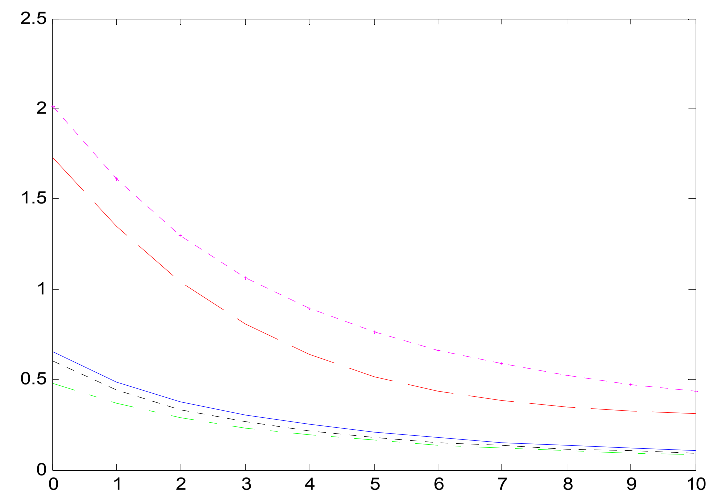
Figure 2.12 Welfare Outcome for Different Policy Actions for Managing Financial Flows (Set C)

Shock Description: Initial shock is a decline in the country risk premium by 25 basis points

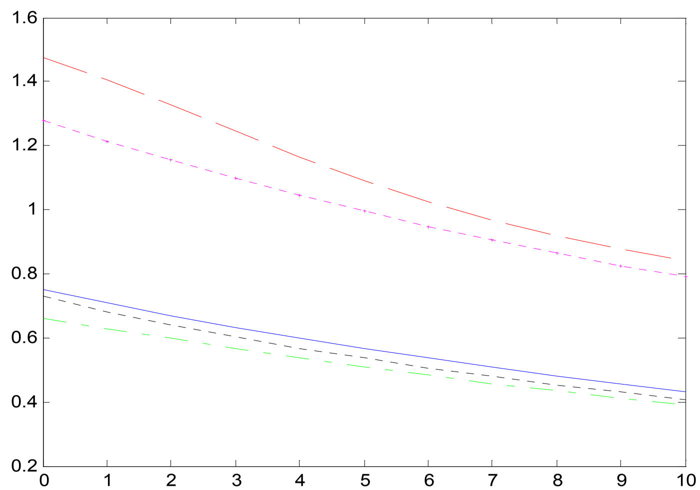
— "blue" = the policy interest rate being held constant
… "black" = the policy interest rate being automatically adjusted according to the prescribed rule
-.-. "green" = the policy interest rate being adjusted to keep the nominal exchange rate constant
– – "red" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)
..+.. "magenta" = sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)



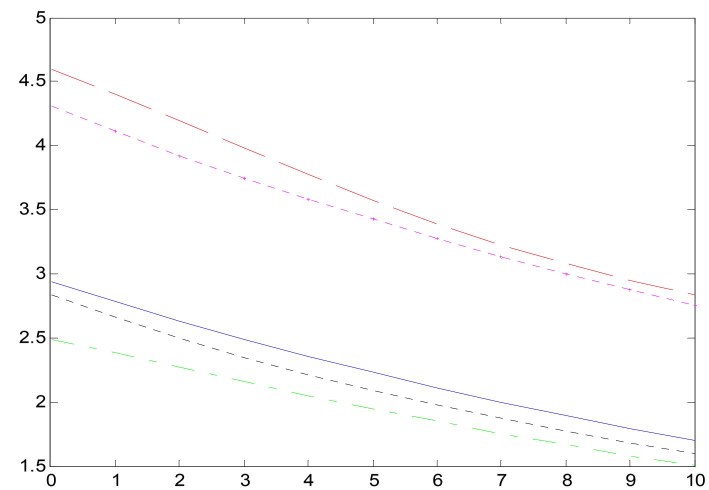
$\rho_\varphi = 0.5,\ \varepsilon_{\varphi,0} = -0.0025$



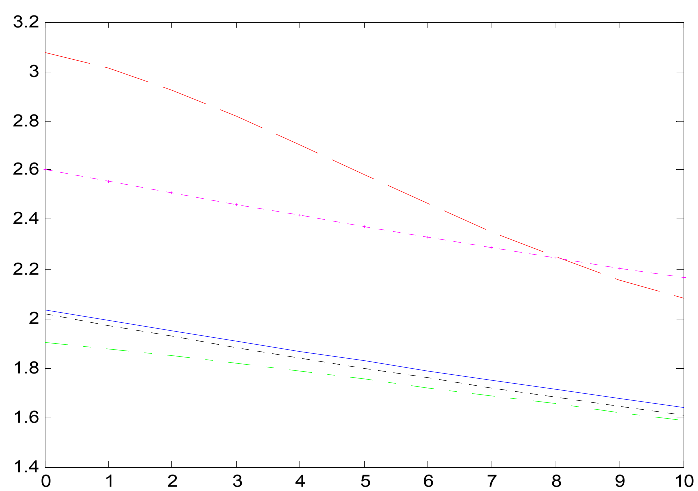
$\rho_\varphi = 0.5,\ \varepsilon_{\varphi,0} = -0.01$



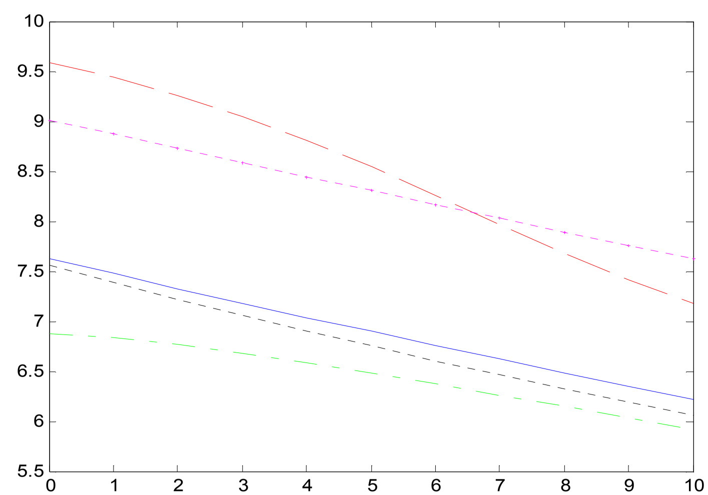
$\rho_\varphi = 0.9$, $\varepsilon_{\varphi,0} = -0.0025$ (baseline)



$\rho_\varphi = 0.9$, $\varepsilon_{\varphi,0} = -0.01$



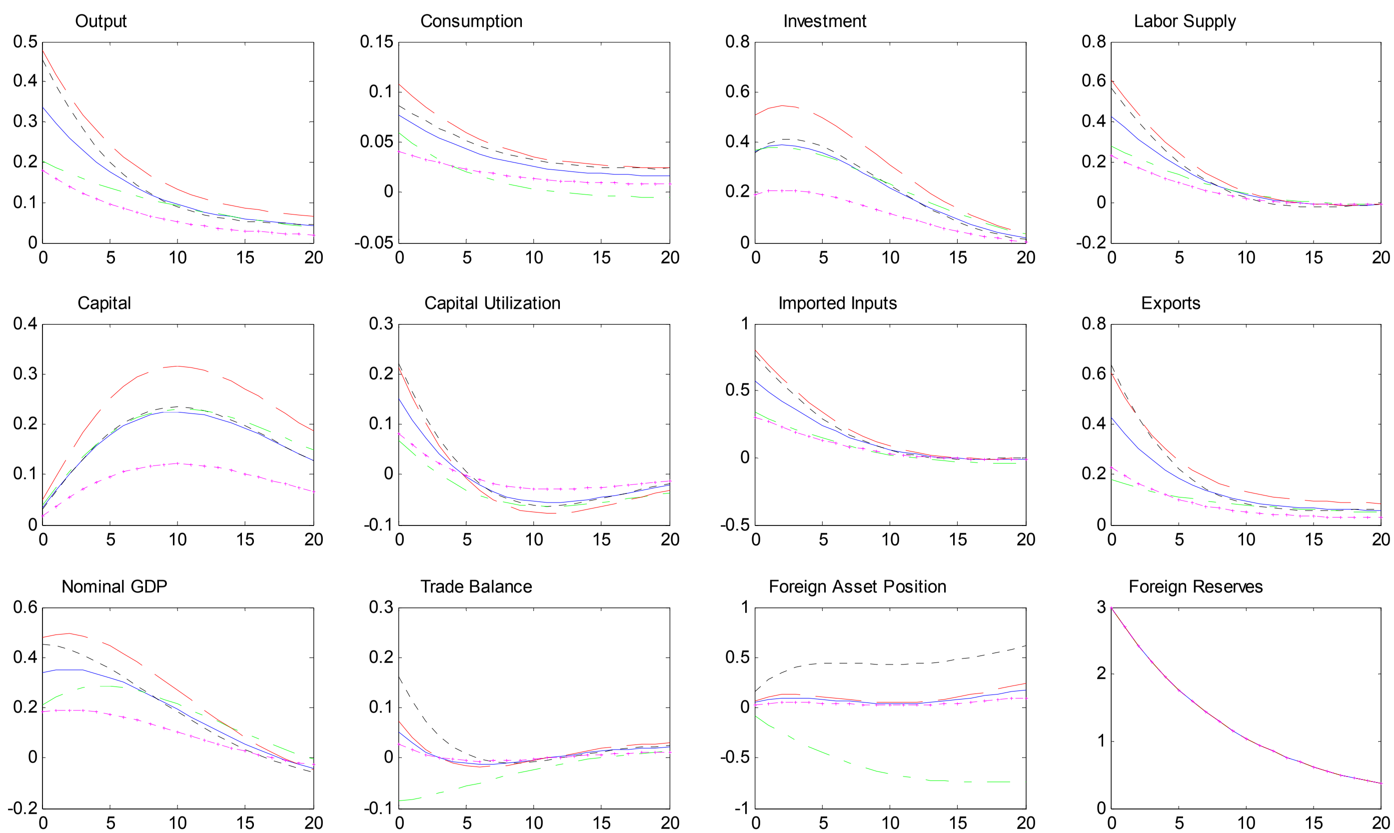
$\rho_\varphi = 0.975$, $\varepsilon_{\varphi,0} = -0.0025$



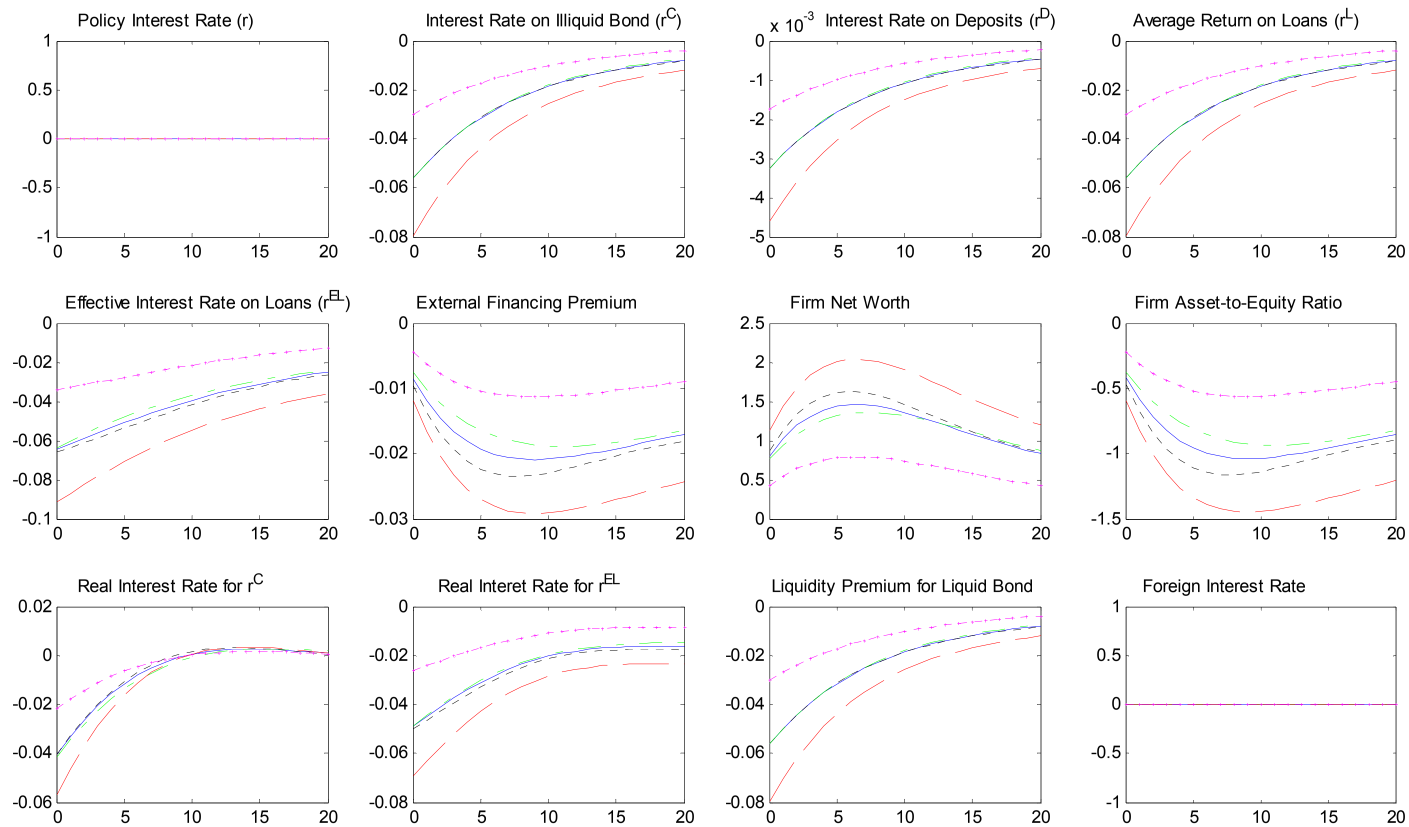
$\rho_\varphi = 0.975$, $\varepsilon_{\varphi,0} = -0.01$

Figure 2.13 Impulse Responses to Sterilized Foreign-Exchange Interventions with Different Elasticity of Export Demand and Different Curvature Parameter for Liquidity Benefits

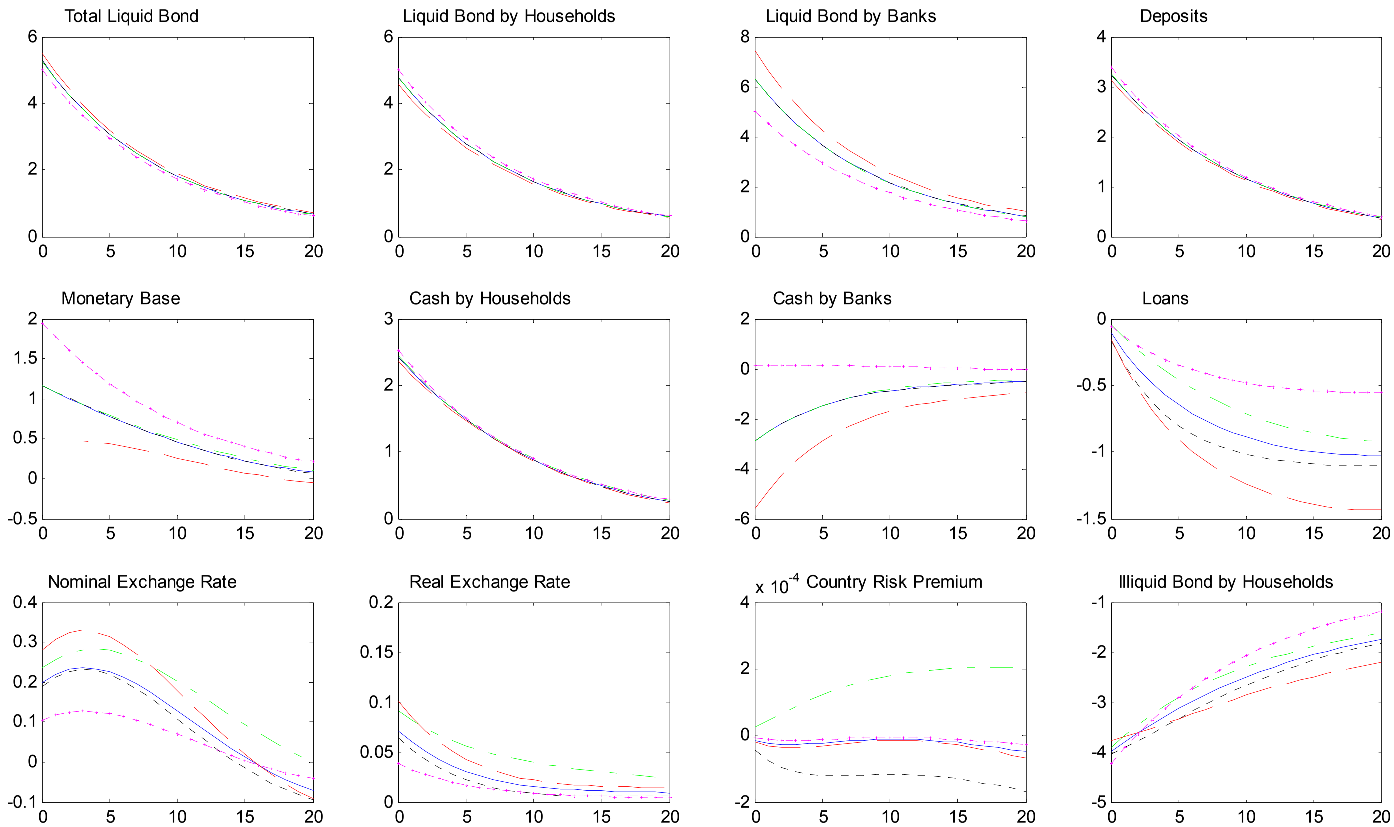
Policy Action: A sterilized purchase of foreign reserves by the amount of 3% of GDP



— "blue": $\eta^* = 3$ and $\nu = 2$ (baseline)
… "black": $\eta^* = 5$ (estimate based on microeconomic data)
-.-. "green": $\eta^* = 1$ (unitary)
– – "red": $\nu = 3$ (high elasticity)
..+. "magenta": $\nu = 1$ (low elasticity)



— "blue": $\eta^* = 3$ and $\nu = 2$ (baseline)
… "black": $\eta^* = 5$ (estimate based on microeconomic data)
-.-. "green": $\eta^* = 1$ (unitary)
– – "red": $\nu = 3$ (high elasticity)
..+.. "magenta": $\nu = 1$ (low elasticity)



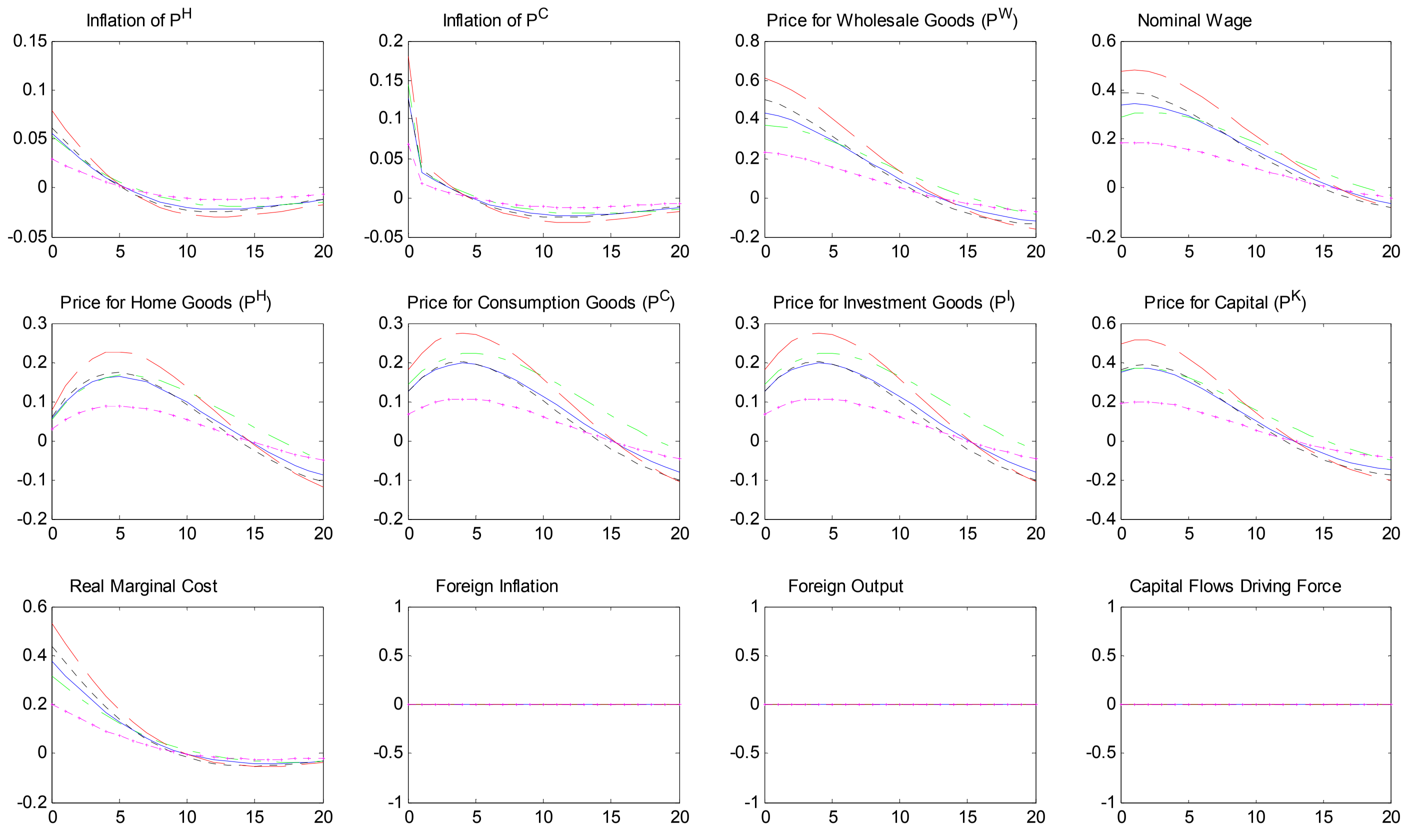
— "blue": $\eta^* = 3$ and $\nu = 2$ (baseline)

… "black": $\eta^* = 5$ (estimate based on microeconomic data)

-.-. "green": $\eta^* = 1$ (unitary)

– – "red": $\nu = 3$ (high elasticity)

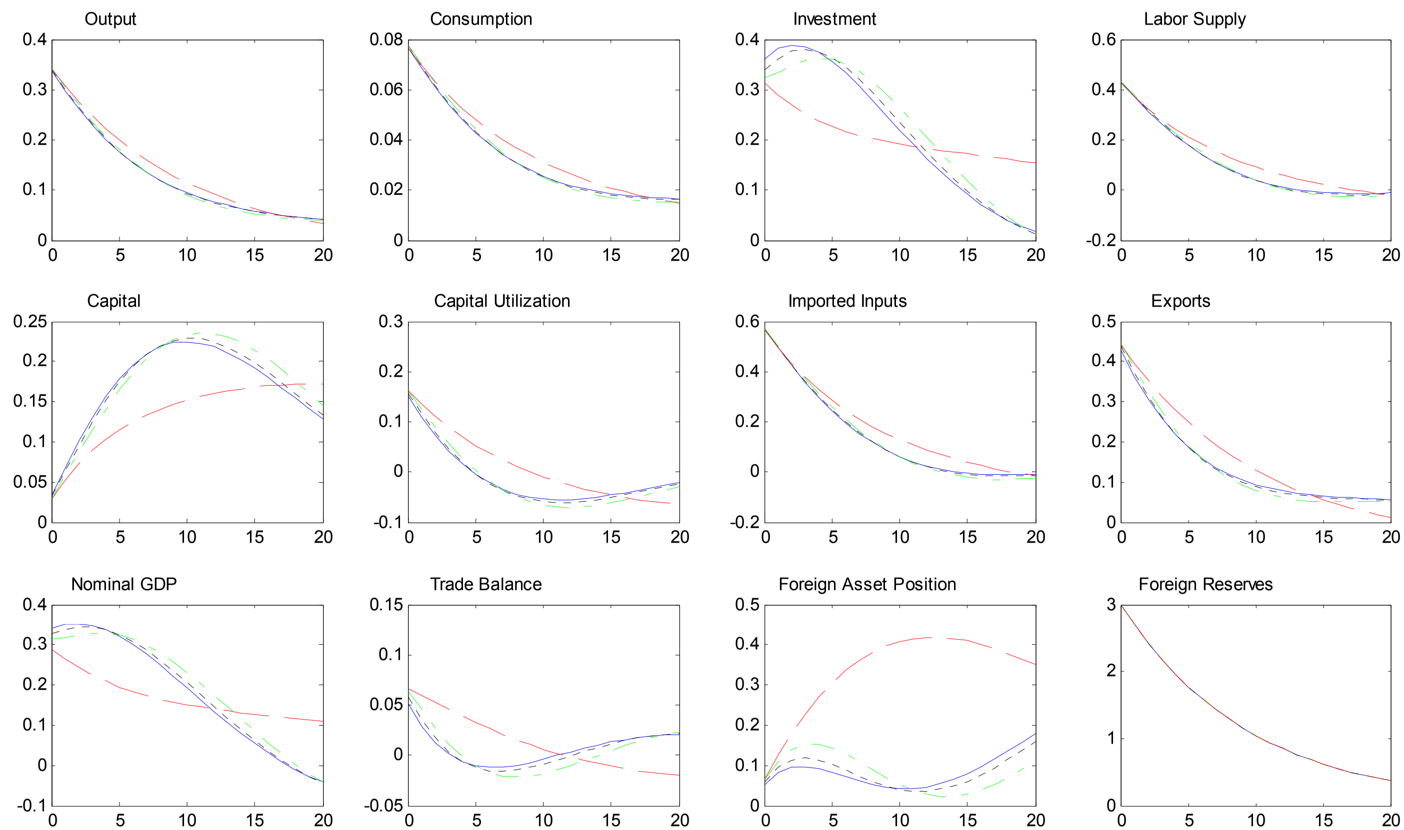
..+. "magenta": $\nu = 1$ (low elasticity)



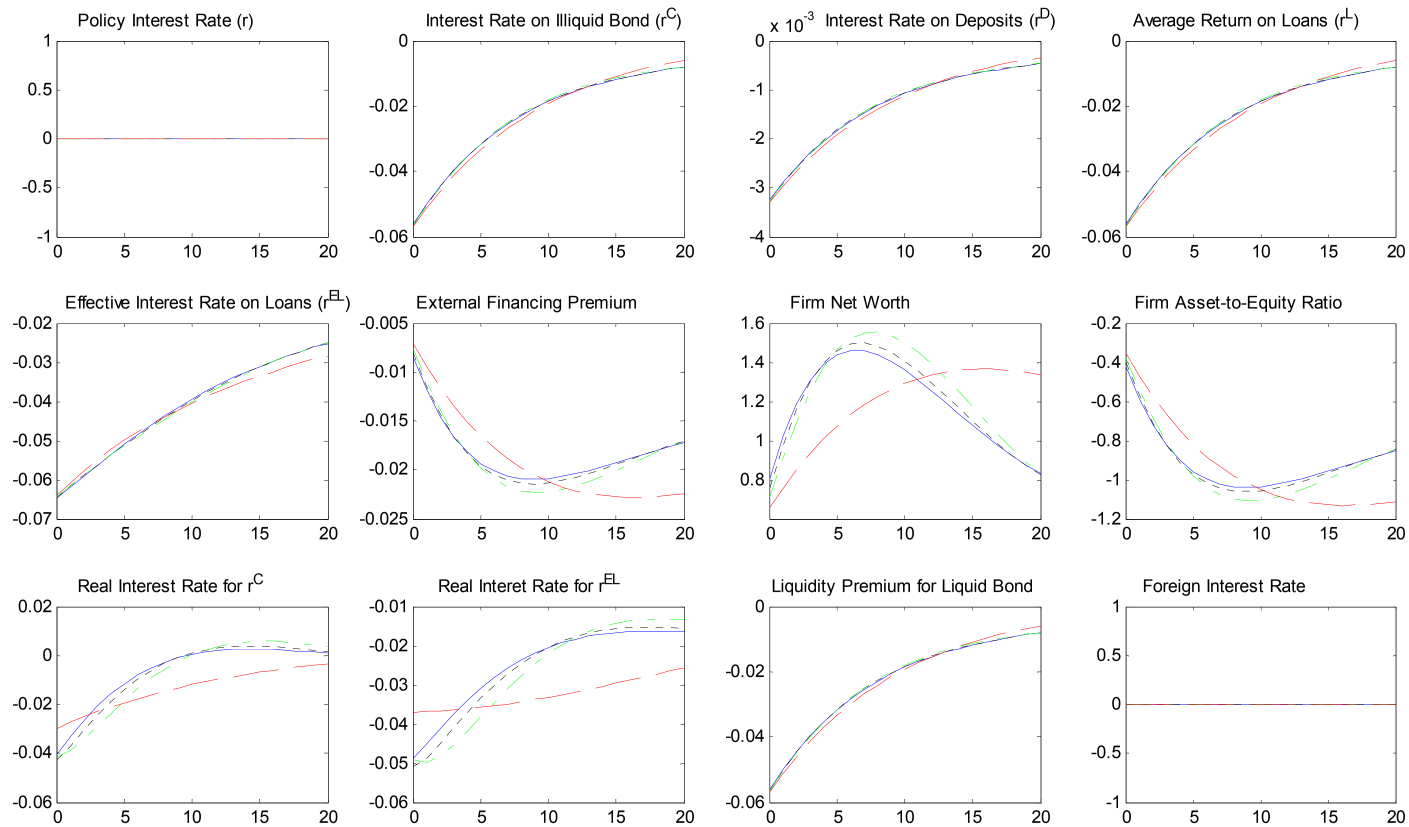
— "blue": $\eta^* = 3$ and $\nu = 2$ (baseline)
… "black": $\eta^* = 5$ (estimate based on microeconomic data)
-.-. "green": $\eta^* = 1$ (unitary)
– – "red": $\nu = 3$ (high elasticity)
..+. "magenta": $\nu = 1$ (low elasticity)

Figure 2.14 Impulse Responses to Sterilized Foreign-Exchange Interventions with Different Degree of Backward-Looking Price Setting

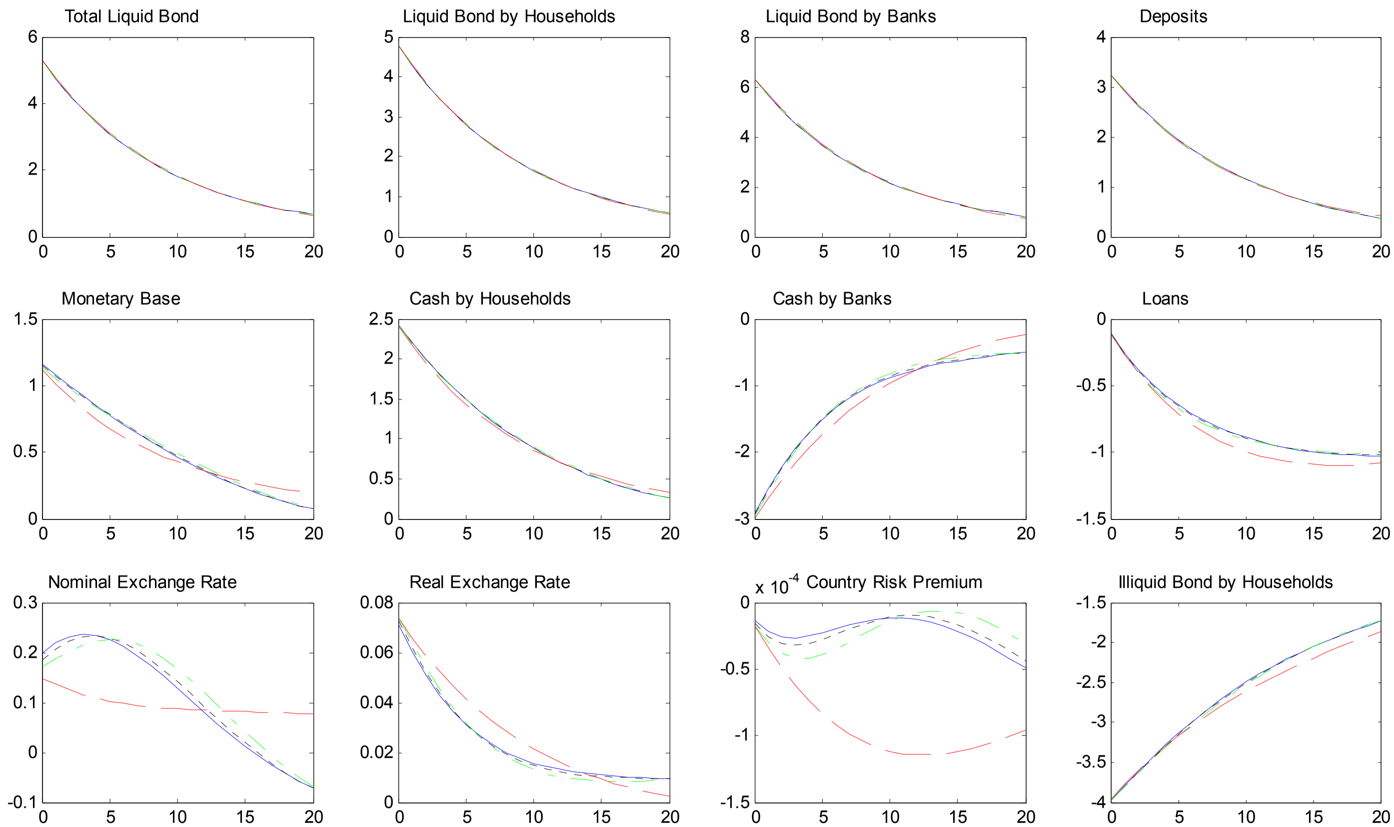
Policy Action: A sterilized purchase of foreign reserves by the amount of 3% of GDP



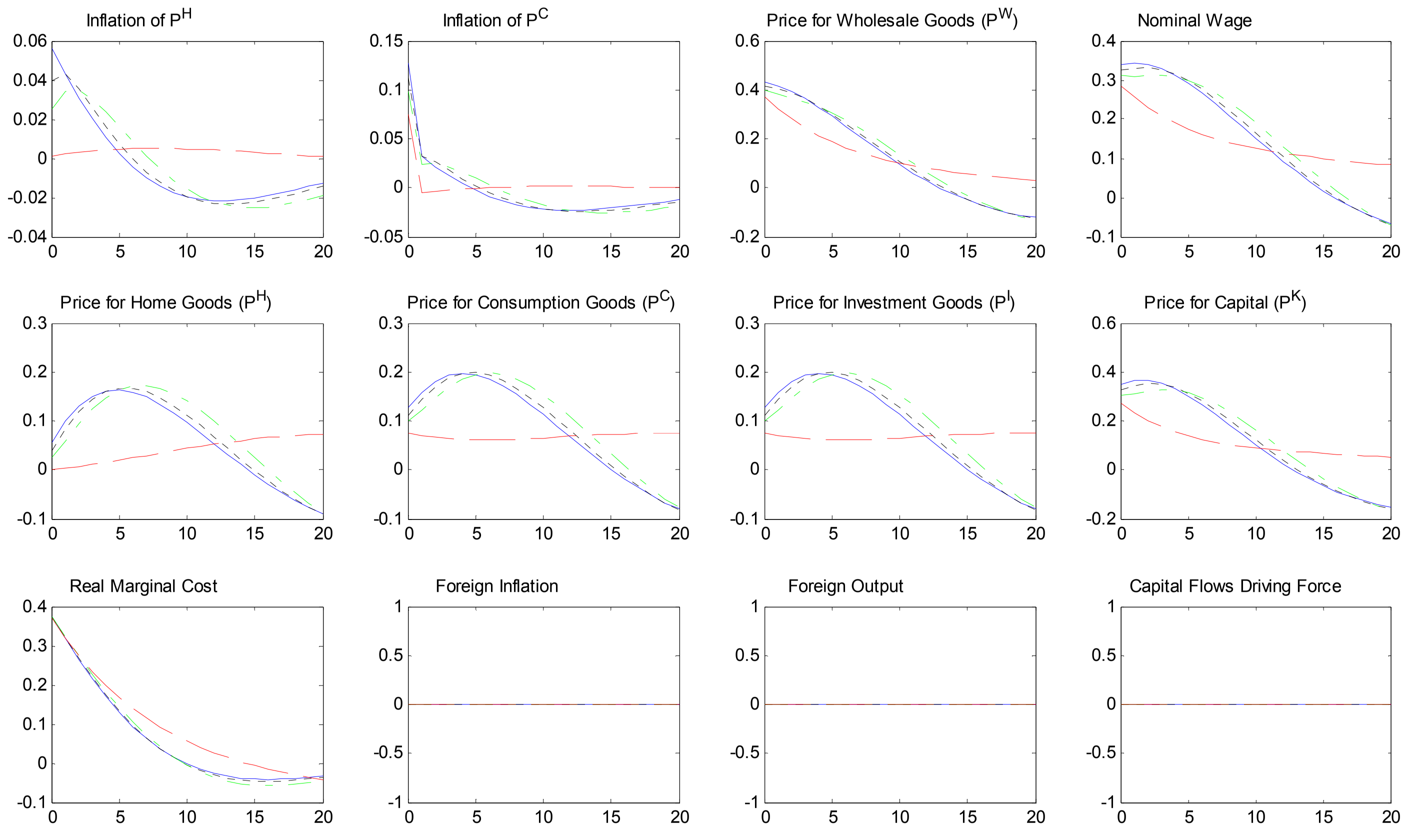
— "blue": $\vartheta_b = 0$ (baseline)
… "black": $\vartheta_b = 0.25$ (moderate backward-looking)
-.-. "green": $\vartheta_b = 0.5$ (substantial backward-looking)
– – "red": $\vartheta_b = 0.97$(maximum for attaining determinacy)



— "blue": $\vartheta_b = 0$ (baseline)
… "black": $\vartheta_b = 0.25$ (moderate backward-looking)
-.-. "green": $\vartheta_b = 0.5$ (substantial backward-looking)
– – "red": $\vartheta_b = 0.97$(maximum for attaining determinacy)



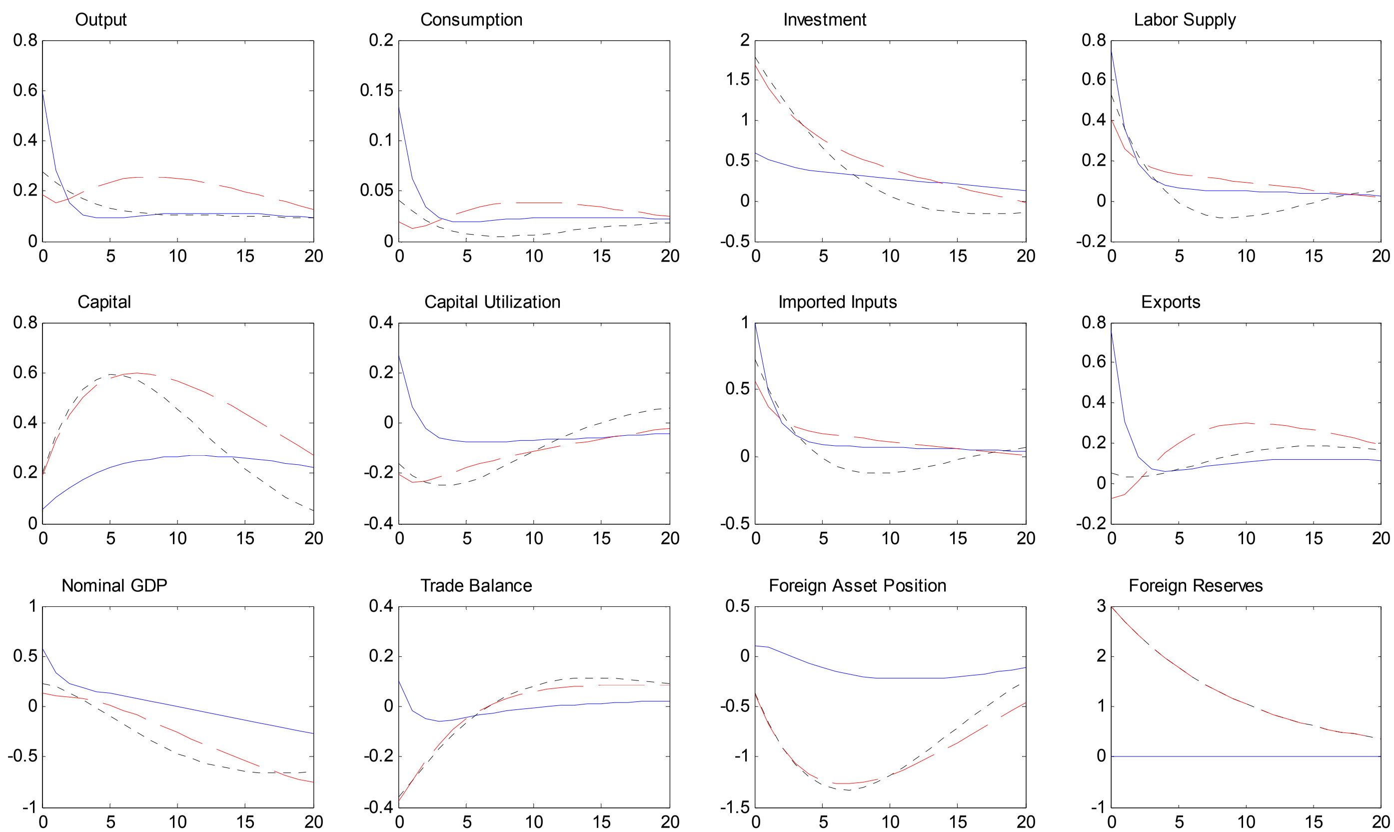
— "blue": $\vartheta_b = 0$ (baseline)
… "black": $\vartheta_b = 0.25$ (moderate backward-looking)
-.-. "green": $\vartheta_b = 0.5$ (substantial backward-looking)
— — "red": $\vartheta_b = 0.97$(maximum for attaining determinacy)



— "blue": $\vartheta_b = 0$ (baseline)
… "black": $\vartheta_b = 0.25$ (moderate backward-looking)
-.-. "green": $\vartheta_b = 0.5$ (substantial backward-looking)
– – "red": $\vartheta_b = 0.97$(maximum for attaining determinacy)

Figure 2.15 Impulse Responses to Main Policy Actions with Restrictions on Financial Intermediaries (Alternative Setup, i.e. $A_t \equiv 0$)

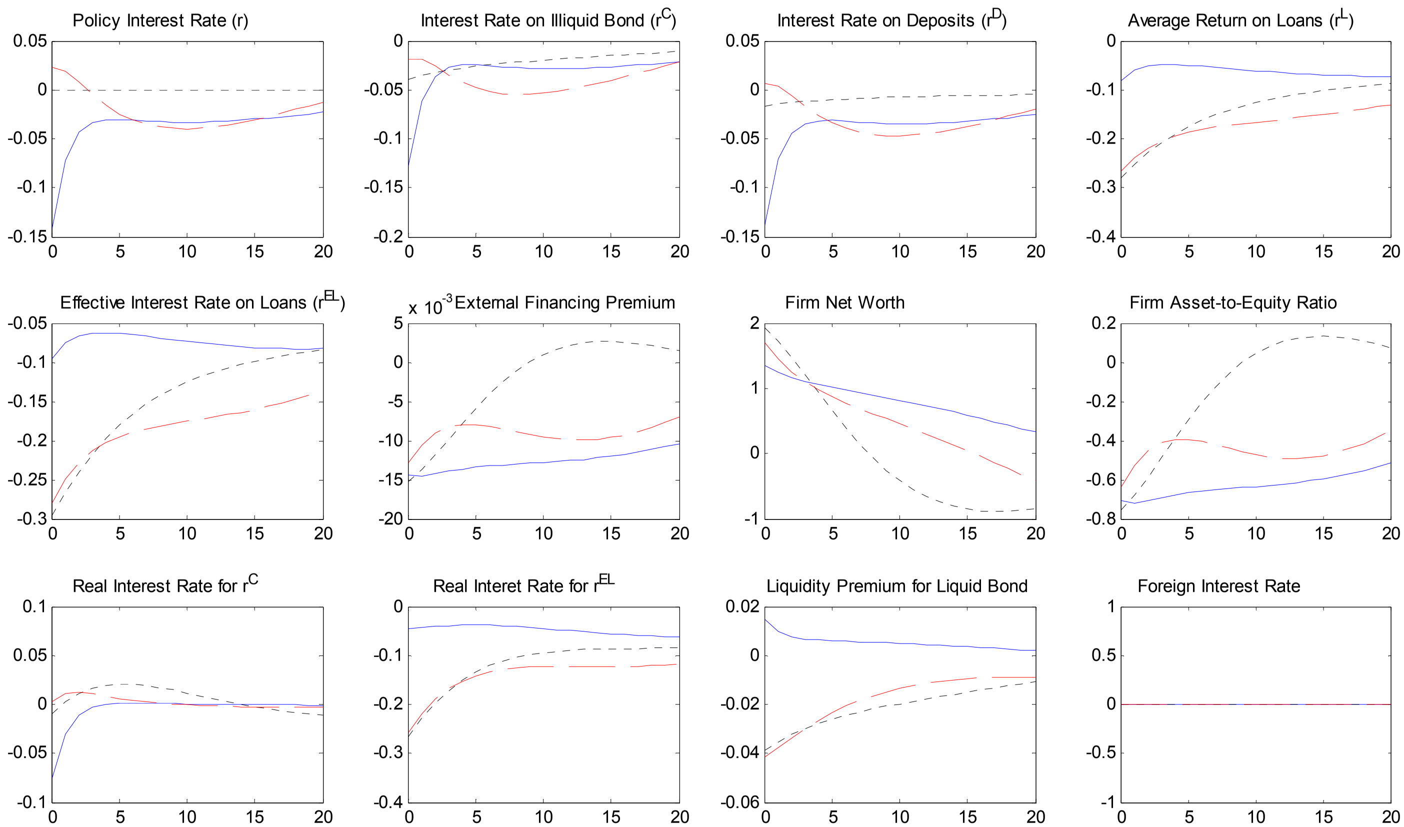
Policy Action: A sterilized purchase of foreign reserves by the amount of 3% of GDP



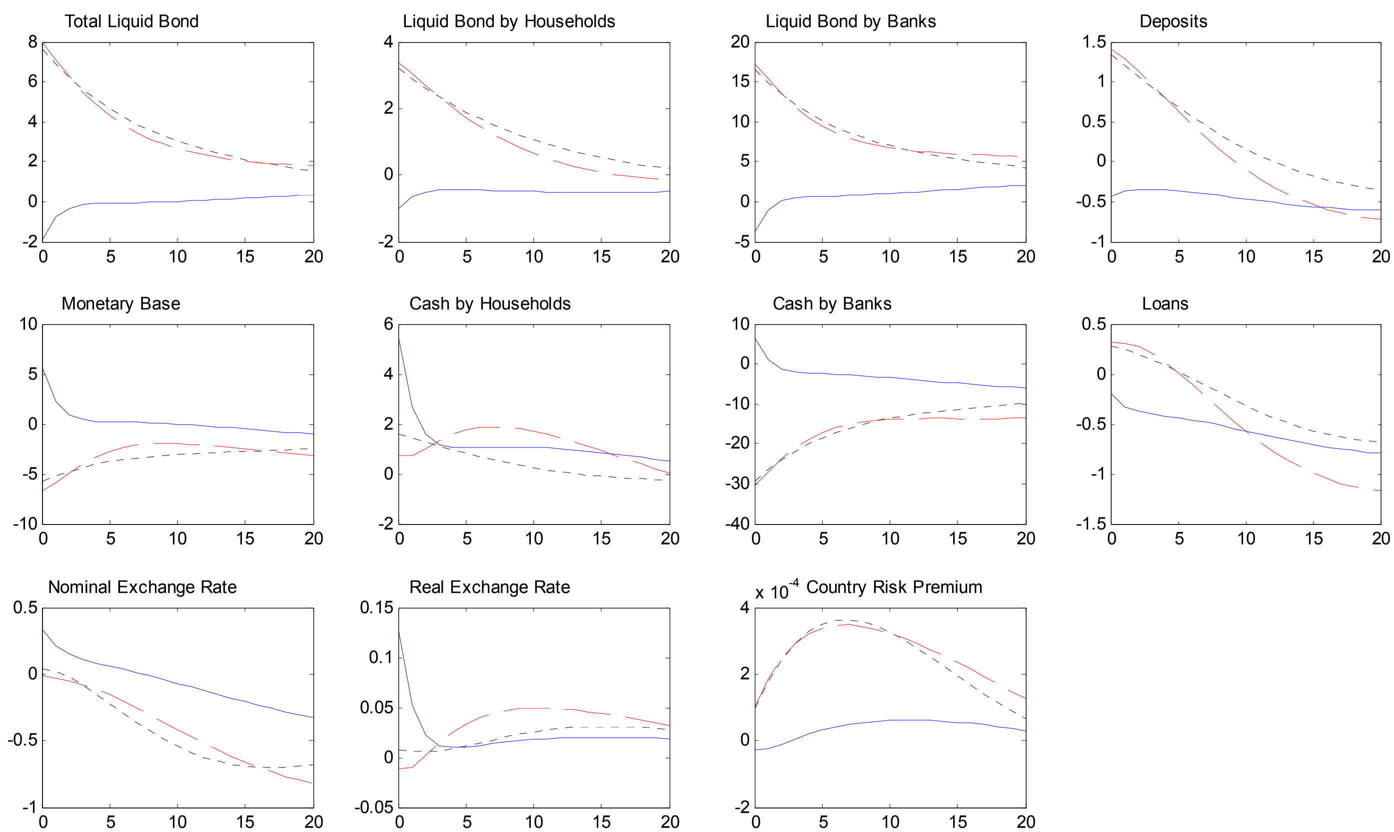
– – "blue" = a reduction in the policy interest rate by 25 basis points

-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant

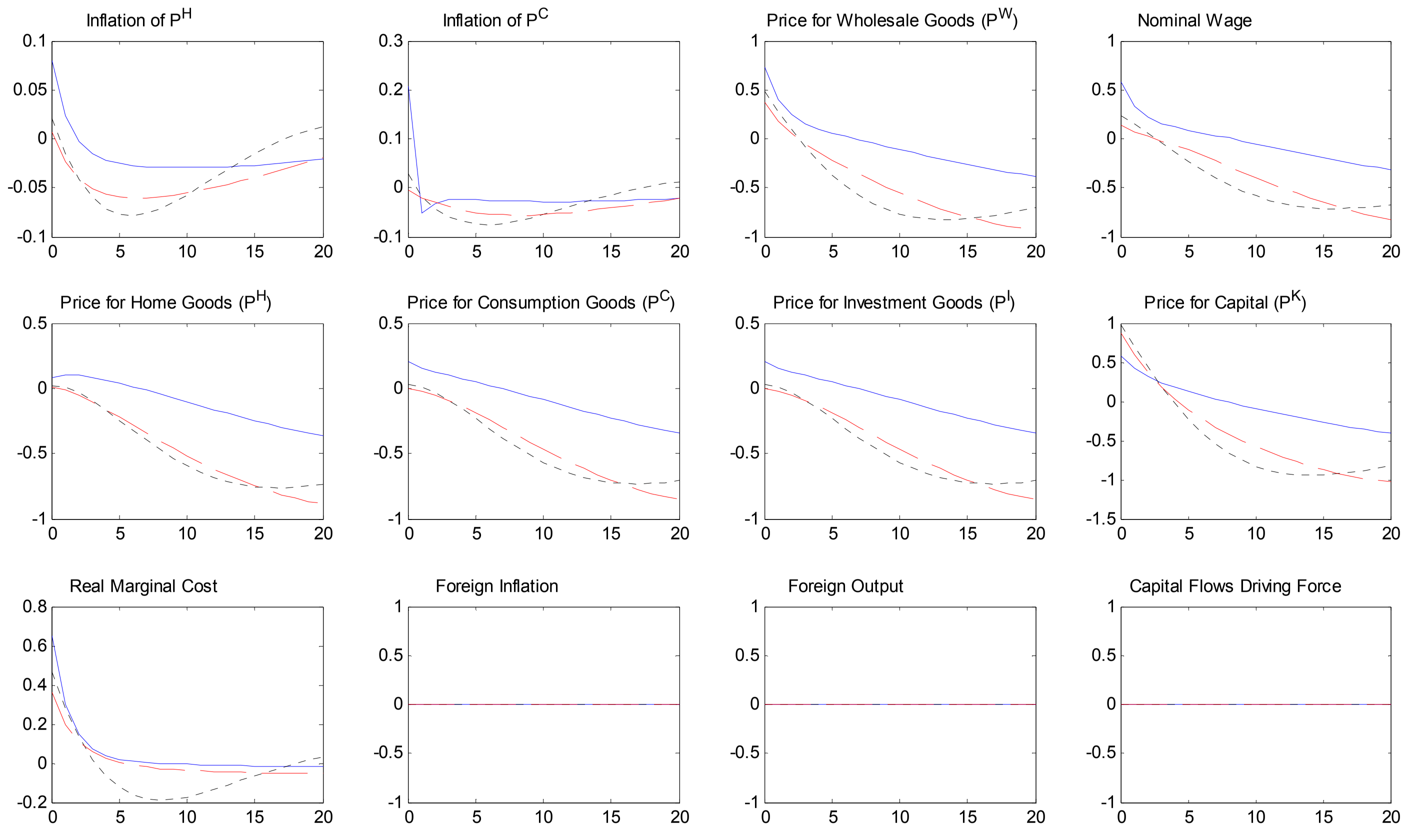
— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate



– – "blue" = a reduction in the policy interest rate by 25 basis points
-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant
— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate



– – "blue" = a reduction in the policy interest rate by 25 basis points
-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant
— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate



– – "blue" = a reduction in the policy interest rate by 25 basis points
-.-. "black" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with holding the policy interest rate constant
— "red" = a sterilized purchase of foreign reserves by the amount of 3% of GDP together with automatic adjustments of the policy interest rate

Table 2.1 Summary of the Values of All Parameters and Steady-State Values of Key Variables

Symbol	Value	Description
		Household Preference
$1/\gamma$	0.5	elasticity of intertemporal substitution
$\bar{H}$	0.2381	steady-state labor supply
ξ	0.3408	importance of labor disutility relative to consumption utility
β	0.9879	discount factor
ϕ_b	$2.55\text{x}10^{-4}$	importance of liquidity benefits of liquid domestic-currency bond
ϕ_d	0.0205	importance of liquidity benefits of deposits
ϕ_m	$8.27\text{x}10^{-4}$	importance of liquidity benefits of cash
ν_b	2	curvature of liquidity benefits for liquid domestic-currency bond
ν_d	2	curvature of liquidity benefits for deposits
ν_m	2	curvature of liquidity benefits for cash
η_c	1	elasticity of substitution b/w home and foreign goods (for home, consumption)
ϱ_c	0.5	degree of home consumption bias (for home)
		Foreign Economy
ρ_φ	0.9	autoregressive coefficient for country risk premium
ρ_y	0.9	autoregressive coefficient for foreign output
ρ_π	0.9	autoregressive coefficient for foreign inflation
ρ_r	0.85	degree of persistence in foreign policy interest rate
θ_π^*	2	coefficient of foreign monetary policy responsiveness to inflation
θ_y^*	0.8	coefficient of foreign monetary policy responsiveness to output
η^*	3	elasticity of substitution b/w home and foreign goods (for foreign)
$1-\varrho^*$	0.9974	degree of home consumption bias (for foreign)
$\bar{r}^*$	0.035	steady-state foreign interest rate
$\bar{\Psi}$	0.015	steady-state country risk premium
υ_f	10^{-4}	stationarity-preserving coefficient for net foreign asset
$\bar{F}$	0	steady-state net foreign asset
		Financial Structure
$\bar{r}^C$	0.05	steady-state illiquid domestic-currency bond
$\bar{r}^C-\bar{r}$	0.025	steady-state liquidity premium with respect to liquid domestic-currency bond
$\bar{r}^C-\bar{r}^D$	0.035	steady-state liquidity premium with respect to deposits
$\bar{\chi}$	0.035	steady-state external financing premium
$\bar{M}_B/\bar{M}$	0.24	steady-state share of cash held by banks
$\bar{B}_B/\bar{B}$	0.33	steady-state share of liquid domestic-currency bond held by banks
$\bar{M}/\bar{D}$	0.12	steady-state money to deposits ratio
$\bar{B}/\bar{D}$	0.36	steady-state liquid domestic-currency to deposits ratio
$\bar{L}/\bar{D}$	0.85	steady-state loans to deposits ratio
$\bar{A}$	0	steady-state illiquid domestic-currency bond issued by banks
Z_D	13.12	degree of liquidity requirement
α_d	0.31	share of cash in liquidity management technology

Symbol	Value	Description
		Financial Structure
$\bar{K}/\bar{N}_W$	1.85	steady-state asset-to-equity ratio
υ_l	0.02	elasticity of external financing premium with respect to asset-to-equity ratio
		Monetary Policy
ρ_m	0.8	degree of persistence in domestic policy interest rate
θ_π	3	coefficient of domestic monetary policy responsiveness to inflation
θ_y	0.5	coefficient of domestic monetary policy responsiveness to output
ρ_f	0.9	degree of persistence in of foreign reserves
		Technology of Wholesale Firms
κ_ω	1	technical constant term in wholesale production
α_k	0.41	share of capital in wholesale production
α_h	0.44	share of labor in wholesale production
α_x	0.15	share of imported inputs in wholesale production
ρ_z	0.9	autoregressive coefficient for productivity in wholesale production
ζ_u	1.5455	elasticity of marginal capital depreciation with respect to capital utilization
δ	0.014	capital depreciation rate
		Technology of Retail Firms
ε	6	elasticity of substitution across differentiated retail goods
ϑ_r	0.75	probability of retail firms to keep prices unchanged
ϑ_b	0	fraction of retail firms being backward-looking
		Technology of Capital-producing Firms
ζ_k	5	coefficients of capital adjustment costs
η_i	0.5	elasticity of substitution b/w home and foreign goods (for home, investment)
ϱ_i	0.5	degree of home investment bias (for home)
		Macroeconomic Relationship
$\overline{GY}/\bar{Y}^*$	0.004	steady-state domestic GDP to world GDP ratio
$\bar{C}^{H*}/\overline{GY}$	0.64	steady-state exports to GDP ratio
$\bar{C}/\overline{GY}$	0.7	steady-state consumption to GDP ratio
$\bar{K}/\overline{GY}$	2.76	steady-state capital to GDP ratio

Table 2.2 Welfare Outcome for Different Policy Actions for Managing Financial Flows (Set A)

Shock Description: Initial shock is a decline in the country risk premium by 25 basis points

Welfare Gain as a Percentage of Steady-State Consumption

Policy Option	(1)	(2)	(3)	(4)	(5)
Welfare (2 years)	0.796	0.753	0.721	1.514	1.418

Volatility of Output and Inflation

Policy Option	(1)	(2)	(3)	(4)	(5)
Output	1.2957	0.4625	0.3717	0.3412	0.1637
CPI Inflation	0.0159	0.0068	0.0004	0.0007	0.0005

Policy options:

(1) the policy interest rate being held constant

(2) the policy interest rate being automatically adjusted according to the prescribed rule

(3) the policy interest rate being adjusted to keep the nominal exchange rate constant

(4) sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)

(5) sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

Table 2.3 Welfare Outcome for Different Policy Actions for Managing Financial Flows (Set B)

Shock Description: Initial shock is a decline in the country risk premium by 25 basis points

Welfare Gain as a Percentage of Steady-State Consumption

Policy Option	(1)	(2)	(3)	(4)	(5)
Welfare (2 years)	0.796	1.418	1.380	1.330	1.062

Volatility of Output and Inflation

Policy Option	(1)	(2)	(3)	(4)	(5)
Output	1.2957	0.1637	0.0072	0.0372	1.8069
CPI Inflation	0.0159	0.0005	0.0013	0.0028	0.0071

Policy options:

(1) the policy interest rate being held constant

(2) sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

(3) sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 50, \rho_f = 0$)

(4) sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 25, \rho_f = 0.5$)

(5) sterilized purchases of foreign reserves together with holding the policy interest rate constant ($\theta_\varphi = 5, \rho_f = 0.95$)

Table 2.4 Welfare Outcome for Different Policy Actions for Managing Financial Flows (Set C)

Welfare Gain as a Percentage of Steady-State Consumption

Welfare (2 years)	ρ_φ	0.5	0.5	0.9	0.9	0.975	0.975
	$\varepsilon_{\varphi,0}$	0.0025	0.01	0.0025	0.01	0.0025	0.01
Policy Option	(1)	0.06	0.24	0.80	3.17	2.79	11.11
	(2)	0.05	0.21	0.75	2.99	2.74	10.93
	(3)	0.05	0.19	0.72	2.83	2.70	10.68
	(4)	0.18	0.60	1.51	5.09	3.73	13.27
	(5)	0.28	0.91	1.42	4.96	3.63	13.39

Policy options:
(1) the policy interest rate being held constant
(2) the policy interest rate being automatically adjusted according to the prescribed rule
(3) the policy interest rate being adjusted to keep the nominal exchange rate constant
(4) sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with automatic adjustments of the policy interest rate)
(5) sterilized purchases of foreign reserves to keep the nominal exchange rate constant (with holding the policy interest rate constant)

2.8.2 Additional Bases for Effective Sterilized FX Interventions

This annex explores additional grounds for sterilized FX interventions to be effective in influencing currency movements. In this study, the effectiveness could be materialized on three bases:

- Ricardian equivalence fails in some restricted sense as a change in the central bank's holding of foreign reserves has a marginal impact on household decisions owing to the existence of liquidity benefits from holding financial assets (the principal focus of this study) or frictions in the domestic financial system (see the first discussion).
- Restrictions on financial flows contribute to the effectiveness of sterilized FX interventions in the following circumstances: (i) minimal capital controls lead the central bank's holding of foreign reserves to have an independent impact on the combined budget constraint so that Ricardian equivalence fails due to the wealth effect (see the second discussion); (ii) excessive capital controls create an environment of capital immobility so that a change in the central bank's holding of foreign reserves triggers an exactly comparable adjustment of the current account balance (see the third discussion); and (iii) excessive capital controls induce suboptimal outcomes so that households have no incentives to nullify the central bank's actions that help improve such suboptimal outcomes (see the fourth discussion).
- Ricardian equivalence fails in more general sense as some households are not totally liable for potential gain or loss (due to exchange rate movements) resulting from sterilized FX interventions. In this case, imperfect substitution among financial assets on account of exchange rate risks plays an important role in generating currency movements (see the fifth discussion).

❖ Frictions in the Domestic Financial System

This discussion does not aim to examine other forms of frictions that exist in the real world such as costs to create and monitor loans and capital requirements to cushion losses potentially arising from risky investment. Instead, the discussion focuses on illustrating that liquidity management of deposits alone can provide a basis for the effectiveness of sterilized FX interventions even when financial assets do not provide liquidity benefits to households.

Let's consider a variant of the model developed in section 2.4. Specifically, households do not hold liquid domestic-currency bond; one justification could be that the bond market is under-developed so that associated transaction costs outweigh the interest rate differential $r_t - r_t^D$.[58] Moreover, financial intermediaries can neither issue nor hold illiquid domestic-currency bond (like the alternative setup embedded with considerable financial restrictions). Then, it is straightforward to show that $r_t^C = r_t^D$ as all financial assets except money do not provide liquidity benefits. In addition, the interest rate on deposits must be lower than the interest rate on liquid domestic-currency bond, i.e. $r_t^D < r_t$, since financial intermediaries face some costs associated with liquidity management of deposits.

The mechanism through which currency movements occur as a result of sterilized FX interventions is basically similar to what analyzed in the baseline model. In particular, sterilized FX interventions affect the steady-state value of the nominal exchange rate, with all key nominal variables (one obvious exception is the stock of foreign reserves) moving by the same proportion. Meanwhile, all relevant real variables remain unchanged in the new steady state. However, the interest rate on deposits r_t^D would instead rise (or decrease) when the central bank increases (or reduces) its holding of foreign-currency bond. Consequently, sterilized FX intervention with accumulation of foreign reserves may cause the nominal exchange rate to move in either direction on impact in order to be on the path consistent with expected currency depreciation, with the path being determined by a variety of factors including the degree of price stickiness, the magnitude of interventions, and the change in the interest rate on deposits. In addition, an increase in r_t^D following a sterilized purchase of foreign reserves results from the need of financial intermediaries to raise additional deposits to support their larger holding of liquid domestic-currency bond. As financial intermediaries hold more liquid financial assets, their improved liquidity position would narrow the differential between r_t and r_t^D.

❖ Minimal Restrictions on Capital Flows

This discussion illustrates how minimal capital controls lead the central bank's holding of foreign reserves to have an independent impact on the combined budget constraint so that Ricardian equivalence fails on the back of the wealth effect. The discussion assumes that the magnitude of τ_t remains minimal for households to be willing to borrow from or lend to the rest of the world. Furthermore, restrictions on financial flows must not involve any transfer from households to other entities; in particular, Ricardian equivalence would hold when such restrictions take the form of taxes.

Before exploring the role of the wealth effect in generating the effectiveness of sterilized FX interventions in the presence of minimal restrictions on capital flows, it is helpful to understand the general function of capital controls in serving as a basis for the effectiveness of sterilized FX interventions. Specifically, the following three questions should be considered:

[58] In some sense, such market imperfections in the domestic financial system can be viewed as differences in liquidity benefits across types of financial assets.

(i) Do households want to nullify the central bank's adjustments of its foreign-currency bond holding in the presence of capital controls?
(ii) If they desire to do so, are households in the presence of capital controls able to nullify the central bank's actions?
(iii) What are the consequences of household actions (in the case that households indeed nullify or that households do not nullify because they are neither able nor willing to do so)?

In the presence of minimal capital controls, Ricardian equivalence fails as a result of the wealth effect associated with households' additional borrowing or lending in the attempt to offset any change in the central bank's holding of foreign reserves. Such actions occur because it is optimal for households to do so. Moreover, households are capable of adjusting their holding of foreign-currency bond to counteract the central bank's actions as their ability to borrow from or lend to the foreign country remains in the presence of minimal capital controls.

To see the wealth effect, let's examine the combined budget constraint. Putting the budget constraint (2.2) and the balance sheet constraint (2.21) together with all market-clearing conditions and the zero-profit condition of financial intermediaries (deriving from both balance sheet constraint and optimal conditions), the combined budget constraint looks like:

$$(2.96)\quad P_t^C C_t + S_t F_t + L_t - (1 + r_{t-1}^L)L_{t-1} - \Gamma_t - W_t H_t \\ = (1 + \tau_{t-1})(1 + r_{t-1}^* + \Psi_{t-1})S_t F_{t-1} - \tau_{t-1}(1 + r_{t-1}^* + \Psi_{t-1})S_t F_{M,t-1}.$$

For notational clarity, define the nominal (gross) return for holding foreign-currency bond as $\tilde{R}_t = (1 + \tau_t)(1 + r_t^* + \Psi_t)$. Then, the combined budget constraint becomes:

$$(2.97)\quad \frac{1}{S_t \tilde{R}_{t-1}}\{P_t^C C_t + L_t - (1 + r_{t-1}^L)L_{t-1} - \Gamma_t - W_t H_t\} + \frac{\tau_{t-1}}{1 + \tau_{t-1}} F_{M,t-1} + \frac{1}{\tilde{R}_{t-1}} F_t = F_{t-1},$$

which reveals that the central bank's choice of $F_{M,t}$ affects the combined budget constraint when the wedge τ_t is non-zero. The existence of capital controls may provide a basis for the effectiveness of sterilized FX interventions because such restrictions create some impediments that prevent households from fully offsetting financial flows that occur as a result of changes in the central bank's holding of foreign reserves. In particular, households and the central bank face with different returns for holding foreign-currency bond due to minimal restrictions on financial flows. It is critical to emphasize that the term $\frac{\tau_t}{1+\tau_t} F_{M,t}$ in equation (2.97) when being positive (or negative) can be interpreted as costs (or benefits) that households need to pay (or receive) in consequence of sterilized FX interventions.[59]

The wealth effect induced by sterilized FX interventions plays the central role in generating currency movements as follows. When the term $\frac{\tau_t}{1+\tau_t} F_{M,t}$ increases, resources of households would be taken away with certainty in subsequent periods. As a result, there must be an increase in household savings. If the change in $F_{M,t}$ is permanent, the current account would not change since the increase in household savings would completely match the cost induced by interventions and capital controls. If the change in $F_{M,t}$ is temporary, the increase in household savings would be smaller, and the current account would deteriorate. These results essentially derive from the concept of the intertemporal approach to the current account: a permanent income shock would have no impact on the current account, while a temporary negative shock (which is the case here) would lead households to borrow from abroad. As the current account deteriorates, the real exchange rate must appreciate. If prices are sticky, the nominal exchange rate must also appreciate. Moreover, the real exchange would become more appreciated in the new steady state in the absence of forces preserving the stationarity. The opposite applies when the term $\frac{\tau_t}{1+\tau_t} F_{M,t}$ decreases instead.

In brief, adjustments of the central bank's holding of foreign reserves can influence currency movements based on the following four scenarios (Table 2.5):

(i) An increase in $F_{M,t}$ induces exchange rate appreciation in the presence of restrictions on foreign borrowing ($\tau_t = \tau_t^B > 0$ and $F_H < 0$);
(ii) An increase in $F_{M,t}$ induces exchange rate depreciation in the presence of restrictions on foreign lending ($\tau_t = \tau_t^L < 0$ and $F_H > 0$);
(iii) A decrease in $F_{M,t}$ induces exchange rate depreciation in the presence of restrictions on foreign borrowing ($\tau_t = \tau_t^B > 0$ and $F_H < 0$);
(iv) A decrease in $F_{M,t}$ induces exchange rate appreciation in the presence of restrictions on foreign lending ($\tau_t = \tau_t^L < 0$ and $F_H > 0$).

While scenarios (ii) and (iv) seem accustomed to the common belief that accumulation (or decumulation) of foreign reserves leads to currency depreciation (or appreciation), scenarios (i) and (iii) sound counterintuitive. However, the mechanism described above certainly generates such effects because the central bank's actions help households circumvent existing barriers to borrow from the rest of the world. The upshot is that

[59] Since capital controls effectively impose additional costs on households' borrowing or lending, one might wonder why a negative value of $\frac{\tau_t}{1+\tau_t} F_{M,t}$ could be interpreted as benefits. The following example should clarify the puzzle. Suppose that some restrictions on foreign lending exist and that households originally hold some foreign-currency bond. Then, an increase in foreign reserves that leads to a reduction in household holding of foreign-currency bond should be beneficial for households since they can now avoid restrictions on holding foreign financial assets.

restrictions on foreign borrowing worsen the effectiveness of sterilized FX interventions, while restrictions on foreign lending attribute to some improvement in the effectiveness.

To sum up, the existence of minimal capital controls may provide a basis for the effectiveness of sterilized FX interventions owing to the breakdown of Ricardian equivalence as the choice of $F_{M,t}$ has an independent impact on the combined budget constraint. Three points deserve some discussion:

- Although the model assumes that restrictions on capital flows take the form of additional costs on international borrowing and lending, major results obtained in this discussion (minimal restrictions on capital flows) and the subsequent discussion (capital immobility due to excessive capital controls) can be readily extended from restrictions on foreign borrowing to controls on financial inflows, and from restrictions on foreign lending to controls on financial outflows. Intuitively, when capital controls are also applied to repayment of existing external liabilities and repatriation of existing foreign assets, households would encounter the wealth effect (in the case of minimal restrictions on capital flows) or the inability to move funds across borders (in the case of capital immobility due to excessive capital controls) in a similar way to what they face with minimal restrictions on international borrowing and lending as analyzed here.
- The interaction between sterilized FX interventions and restrictions on capital inflows may lead the exchange rate to move in the opposite direction. The URR measure implemented by the BoT could be counter-productive for sterilized FX interventions if costs associated with the URR measure were shared by foreign agents. Nevertheless, the impact of sterilized FX interventions based on the wealth effect seems limited. Let's consider the following back-on-envelope calculation. Suppose that controls on outflows induce $\tau_t = -0.02$. Then, an increase in foreign reserves of 50 billion US dollars would augment household resources by 1 billion US dollars per year. As this amount seems tiny (only 0.5 percent of Thailand's GDP), the impact of FX interventions on the exchange rate should be minimal.
- For sterilized FX interventions to be effective in the presence of minimal capital controls, three requirements must be satisfied. First, restrictions on financial flows must be minimal so that the wealth effect exists. Second, restrictions on financial flows must be non-Ricardian: they must not involve any transfer from households to other entities.[60] Third, sterilized FX interventions must be

[60] If such restrictions take the form of taxes which generate revenues to the central bank, the amount of transfer payment between the central bank and households would include such revenues, and then equation (2.97) becomes: $\frac{1}{S_t\tilde{R}_{t-1}}\{P_t^C C_t + L_t - (1 + r_{t-1}^L)L_{t-1} - \Gamma_t - W_t H_t\} + \frac{1}{\tilde{R}_{t-1}}F_t = F_{t-1}$, where $\tilde{R}_{t-1} = (1 + r_t^* + \Psi_t)$. In short, the wealth effect due to sterilized FX interventions no longer exists.

temporary; otherwise there would be no adjustment of the current account and thus no change in the exchange rate.

❖ Capital Immobility due to Excessive Capital Controls

This discussion demonstrates how excessive capital controls create an environment of capital immobility so that a change in the central bank's holding of foreign reserves forces an exactly comparable adjustment of the current account balance. The discussion assumes that the magnitude of τ_t is excessively large so that condition (2.8) is not binding (i.e. condition (2.8') is used instead):

$$(2.8') \quad u_{C,t} \neq \beta \mathbb{E}_t \left[u_{C,t+1}(1+\tau_t)(1+r_t^*+\Psi_t)\frac{S_{t+1}}{S_t}\frac{P_t^C}{P_{t+1}^C} \right].$$

To be more specific, when restrictions on foreign lending are prohibitive ($\tau_t = \tau_t^L$),

$$(2.98) \quad \mathbb{E}_t \left[\Lambda_{t,t+1}(1+r_t^*+\Psi_t)\frac{S_{t+1}}{S_t} \right] > \mathbb{E}_t\left[\Lambda_{t,t+1}(1+r_t^C)\right] > \mathbb{E}_t \left[\Lambda_{t,t+1}(1+\tau_t)(1+r_t^*+\Psi_t)\frac{S_{t+1}}{S_t} \right],$$

and when restrictions on foreign borrowing are instead exorbitant ($\tau_t = \tau_t^B$),

$$(2.99) \quad \mathbb{E}_t \left[\Lambda_{t,t+1}(1+r_t^*+\Psi_t)\frac{S_{t+1}}{S_t} \right] < \mathbb{E}_t\left[\Lambda_{t,t+1}(1+r_t^C)\right] < \mathbb{E}_t \left[\Lambda_{t,t+1}(1+\tau_t)(1+r_t^*+\Psi_t)\frac{S_{t+1}}{S_t} \right].$$

In the environment of capital mobility, although households want to nullify any change in the central bank's holding of foreign-currency bond, excessive capital controls make it not optimal to do so (price-based controls) or impossible to do so (quantity-based controls). Consequently, a change in foreign reserves translates into a comparable adjustment of the current account balance, which in turn must be supported by some exchange rate movements.

Sterilized FX interventions may trigger currency fluctuations in the presence of capital mobility as follows. Let's consider an example of accumulation of foreign reserves. An increase in the central bank's holding of foreign-currency bond should prompt households to reduce their holding of foreign-currency bond (e.g. either undertake additional foreign borrowing or repatriate existing foreign assets) provided that households are not initially subjected to a suboptimal outcome due to excessive restrictions on international lending.[61] When excessive restrictions on foreign borrowing exist, households would not borrow more from abroad. Consequently, the increase in foreign reserves leads to a current account improvement, which must be supported by a

[61] The analysis on suboptimal outcomes is left to the subsequent discussion. Under such circumstances, households would not reduce their holding of foreign-currency bond.

more depreciated value of the real exchange rate.[62] If prices are flexible, the nominal exchange rate does not need to adjust. However, in the presence of nominal rigidity in prices, the nominal exchange must depreciate to equilibrate the balance of payments:

(2.13') $CA_t(S_t) = -FA_t - MA_t$.

It is important to emphasize that when sterilized FX interventions with accumulation of foreign reserves can influence currency movements, the domestic real interest rate would also rise to rebalance domestic investment and domestic savings (including net foreign borrowing or lending). Therefore, continual sterilized FX interventions may induce a sufficiently large increase in the domestic real interest rate, which in turn makes restrictions on international borrowing no longer excessive (i.e. the differential in real interest rates is sufficiently large to favor borrowing with punitive additional costs). Mathematically, the second inequality in equation (2.99) vanishes. Under such circumstances, the effect of sterilized FX interventions would instead be driven by minimal restrictions on financial flows.

Similarly, capital immobility due to excessive restrictions on international lending can provide a basis for sterilized FX interventions with decumulation of foreign reserve to cause the real exchange rate to appreciate.

It is noteworthy that the reliance on capital immobility to generate effective sterilized FX interventions seems limited in practice. The major reason is that excessive capital controls that apply to all categories of financial flows seem very rare; even for China, such excessive restrictions on financial flows may only exist for certain categories of funds (e.g. quota-typed limitations on non-residents to hold domestic equity). Moreover, policymakers might need to implement controls on capital inflows (or outflows) rather than restrictions on foreign borrowing (or lending) to really attain the effectiveness of sterilized FX interventions. However, such regulations might be equivalent to announce a suspension on debt repayment (e.g. restrictions on financial outflows), which would in turn triggers adverse repercussions.[63]

❖ Suboptimal Outcomes due to Excessive Capital Controls

This discussion illustrates how excessive capital controls induce suboptimal outcomes so that households have no incentives to nullify the central bank's actions that help improve such suboptimal outcomes. This discussion assumes the existence of a suboptimal outcome, which emerges from a combination of excessive capital controls as specified by equation (2.98) or (2.99) and certain economic disturbances which bring the economy

[62] Another implicit assumption is that households do not hold any foreign financial assets.

[63] Capital controls on outflows implemented by Malaysia after the Asian financial crisis of 1998 only comprised restrictions on non-residents to repatriate their investment without imposing any restriction on external debt repayment.

into a suboptimal equilibrium. For example, an increase in the discount factor β in the presence of excessive restrictions on international lending may create a suboptimal outcome in which households are unable to lend their additional savings abroad.

When a suboptimal outcome exists, households might have no incentives to nullify changes in the central bank's holding of foreign-currency bond. In particular, appropriate sterilized FX interventions that help improve the suboptimal outcome would lead to adjustments of the current account balance, which in turn must be supported by some exchange rate movements.

Sterilized FX interventions may trigger currency fluctuations in the existence of a suboptimal outcome as follows. Let's consider an example of accumulation of foreign reserves. In this case, the suboptimal outcome must emerge under the circumstance that households initially want to lend money to the rest of the world (but they cannot). Then, a sterilized purchase of foreign reserves would not prompt households to borrow additional funds from abroad to offset the increase in the central bank's holding of foreign-currency bond as they would typically do. Consequently, the increase in foreign reserves would trigger a current account improvement, which must be supported by a more depreciated level of the real exchange rate. If prices are flexible, the nominal exchange rate does not need to adjust. However, in the presence of nominal rigidity in prices, the nominal exchange must depreciate to equilibrate the balance of payments:

(2.13') $CA_t(S_t) = -FA_t - MA_t$.

While the mechanism through which currency movements under suboptimal outcomes looks identical to that based on capital immobility, it is critical to highlight that excessive restrictions on international lending rather than borrowing (as needed to generate capital immobility for this compatible case) are required to induce currency depreciation. Furthermore, since the domestic real interest would rise, sterilized FX interventions could influence the exchange rate dynamics only if the suboptimal outcome still prevails. Mathematically, the increase in the domestic real interest rate is not yet sufficient to eliminate the first inequality in equation (2.98). Once the domestic real interest rate becomes equal to the world real interest rate, the suboptimal outcome disappears as households would have incentives to borrow from abroad. At that point, additional sterilized FX interventions are ineffective.

Similarly, a preexisting suboptimal outcome emerging from excessive restrictions on international borrowing can contribute to the effectiveness of sterilized FX interventions with decumulation of foreign reserves in generating some real exchange rate appreciation.

Some interesting aspects and implications related to sterilized FX interventions with the effectiveness founded on suboptimal outcomes deserve to be discussed:

- The effectiveness of this type of sterilized FX interventions is fairly intuitive. The central bank simply acts as an intermediary to help households circumvent restrictions on international lending by raising funds from liquid domestic-currency bond issuances to invest in foreign-currency bond. Similarly, when households face substantial constraints on international borrowing, the central bank can improve such suboptimal outcomes by running down the stock of foreign reserves and expanding domestic credit.
- Although this type of sterilized FX interventions is obviously welfare-improving, it may not be the most efficient policy option. Particularly, removing restrictions on financial flows is likely to be a better policy option.
- Suboptimal outcomes require some economic shocks to hit the economy as excessive impediments on capital flows by themselves are not sufficient to generate the effectiveness of sterilized FX interventions.
- Regarding Thailand's experience, a suboptimal outcome was likely to exist during the URR regime as the BoT's measures that liberalized restrictions on domestic residents to undertake investment abroad triggered an outflow of funds by the amount of greater than 10 billion US dollars. Such a suboptimal outcome might result from an influx of foreign funds for equity investment and a decline in consumer confidence and business sentiment triggered by the political crisis.

❖ Ricardian Failure and Exchange Rate Risks

This discussion explores the effectiveness of sterilized FX interventions when Ricardian equivalence fails in more general sense. In particular, some households are not totally liable for potential gain or loss as a result of exchange rate movements driven by sterilized FX interventions. The discussion assumes the existence of some non-Ricardian elements (by allowing the existence of non-optimizing households) as well as imperfect substitution among financial assets due to exchange rate risks (by taking second-order log-linearization of the UIP-typed condition (2.8) to generate a time-varying risk premium).[64,65]

Specifically, assume that there is a continuum of households of length unity. A fraction $1-\vartheta_o$ of households are non-optimizing agents who only work and consume.[66]

[64] There are numerous ways to break down Ricardian equivalence, which is a common feature of any micro-founded macroeconomic model. For the purpose of making some households not totally liable for potential gain or loss as a result of currency movements, the setup with overlapping generations can be another alternative.

[65] Imperfect substitution between domestic-currency and foreign-currency bonds already exists in the UIP-typed condition (2.8). However, first-order log-linearization would make both bonds become perfectly substitutable.

[66] It is not necessary that non-optimizing households need to consume all disposable income in every period. A deterministic saving rate would be able to break down Ricardian equivalence as well. One may

Meanwhile, another fraction ϑ_o of households are optimizing agents whose behavior is similar to the prescription in the model developed in section 2.4. The aggregate budget constraint of non-optimizing households is:

(2.100) $(1-\vartheta_o)P_t^C C_t^N = (1-\vartheta_o)W_t H_t + (1-\vartheta_o)T_t.$[67]

Meanwhile, the aggregate budget constraint of optimizing households is:

$$\text{(2.101)}\ \vartheta_o P_t^C C_t^O + S_t F_{H,t} + A_{H,t} + B_{H,t} + D_{H,t} + M_{H,t}$$
$$= \vartheta_o W_t H_t + (1+\tau_{t-1})(1+r_{t-1}^* + \Psi_{t-1})S_t F_{H,t-1} + (1+r_{t-1}^C)A_{H,t-1}$$
$$+ (1+r_{t-1})B_{H,t-1} + (1+r_{t-1}^D)D_{H,t-1} + M_{H,t-1} + \Gamma_t + \vartheta_o T_t,$$

where C_t^N and C_t^O are consumption for non-optimizing and optimizing households, respectively. Then, it is straightforward to derive the combined aggregate budget constraint of optimizing households:

$$\text{(2.102)}\ \frac{1}{S_t\tilde{R}_{t-1}}\left\{\vartheta_o P_t^C C_t^O + L_t - (1+r_{t-1}^L)L_{t-1} - \Gamma_t - \vartheta_o W_t H_t\right\} + \frac{\tau_{t-1}}{1+\tau_{t-1}}F_{M,t-1}$$
$$+ \frac{1}{S_t\tilde{R}_{t-1}}(1-\vartheta_o)T_t + \frac{1}{\tilde{R}_{t-1}}F_t = F_{t-1},$$

which looks similar to equation (2.97). However, equation (2.102) has an additional term $(1-\vartheta_o)T_t/S_t\tilde{R}_{t-1}$ to reflect that gain or loss related to sterilized FX interventions does not totally fall on optimizing households although they would end up holding all liquid domestic-currency bond issued by the central bank. Consequently, sterilized FX interventions can affect the country's holding of financial assets, and thus the dynamics of the exchange rate. Notice that when ϑ_o converges to one, this additional term drops out. To see the impact of FX interventions, let's rewrite equation (2.102) as follows:

$$\text{(2.103)}\ \frac{1}{S_t\tilde{R}_{t-1}}\left\{\vartheta_o P_t^C C_t^O + L_t - (1+r_{t-1}^L)L_{t-1} - \Gamma_t - \vartheta_o W_t H_t - \vartheta_o T_t\right\} + \frac{\tau_{t-1}}{1+\tau_{t-1}}F_{M,t-1}$$
$$+ \frac{1}{S_t\tilde{R}_{t-1}}T_t + \frac{1}{\tilde{R}_{t-1}}F_t = F_{t-1},$$

$$\text{(2.104)}\ \frac{1}{S_t\tilde{R}_{t-1}}\left\{\vartheta_o P_t^C C_t^O + L_t - (1+r_{t-1}^L)L_{t-1} - \Gamma_t - \vartheta_o W_t H_t - \vartheta_o T_t\right\} + \frac{1}{S_t\tilde{R}_{t-1}}\left\{S_t F_{H,t} + B_t + M_t\right\}$$
$$= F_{H,t-1} + \frac{1}{S_t\tilde{R}_{t-1}}\{(1+r_{t-1})B_{t-1} + M_{t-1}\}.$$

view that non-optimizing households in this setup may indeed be rational but they lack access to saving instruments.

[67] Non-optimizing households are also not allowed to hold any money. Thus, the central bank cannot rely on money as an instrument for transferring resources between non-optimizing and optimizing households (to attain perfect risk sharing among heterogeneous households). This helps make optimizing households not entirely liable for gain or loss associated with sterilized FX interventions.

According to equation (2.104), optimizing households are entitled to all gain or loss from their investment in financial assets. It is the term $F_{H,t}$ rather than F_t that shows up in equation (2.104). Under such circumstances, when the central bank undertakes sterilized FX interventions, there must be some changes in the risk premium component in the UIP-typed equation.[68] Let's consider the case in which the central bank issues liquid domestic-currency bond to acquire additional foreign reserves. The central bank's action would induce a change in the risk premium in order to generate the expected positive return for holding domestic-currency bond relative to foreign-currency bond, which essentially requires that the nominal exchange rate is expected to appreciate. As a result, the exchange rate must depreciate instantaneously. This is the mechanism that people usually have in mind when they think about sterilized FX interventions.

In short, when some households are not totally liable for potential gain or loss (due to exchange rate movements) resulting from sterilized FX interventions, Ricardian equivalence might fail.[69] Under such circumstances, the central bank's interventions in the FX market could be effective in influencing currency movements. Nonetheless, domestic-currency and foreign-currency bonds need to be imperfectly substitutable; otherwise, households would be indifferent between holding these two financial assets. It is noteworthy that whether the impact of sterilized FX interventions would be large or small depends on various factors. They include: the size of non-optimizing households relative to optimizing households, the amount of transfer payment T_t (which depends on the prescription of FX interventions), the degree of price stickiness, and the sensitivity in the risk premium component in the UIP-typed condition (which depends on the nominal stochastic discount factor $\Lambda_{t,t+1}$).

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[68] The risk premium in the UIP-typed condition is $(1+\tau_t)(1+r_t^*+\Psi_t)\dfrac{\mathbb{Cov}_t\left[\Lambda_{t,t+1},\frac{S_{t+1}}{S_t}\right]}{\mathbb{E}_t[\Lambda_{t,t+1}]}$.

[69] The transfer payment between the central bank and households actually captures potential gains or loss resulting from sterilized FX interventions. Observe the term T_t is equation (2.103).

Table 2.5 Summary of Sterilized Foreign-Exchange Interventions with Effectiveness Resting on Restrictions on Capital Flows

	Change in Foreign Reserves	Minimal Restrictions		Excessive Restrictions	
		Initial Condition	Effect	Initial Condition	Effect
Restrictions On Foreign Borrowing	Accumulation	$F_H > 0$	No Impact [1]	$F_H > 0$	No Impact [1]
		$F_H = 0$	Appreciation Negative Wealth Effect	$F_H = 0$	Depreciation Capital Immobility [3]
		$F_H < 0$		$F_H < 0$	
	Decumulation	$F_H > 0$	No Impact	$F_H > 0$	No Impact
		$F_H = 0$	Depreciation Positive Wealth Effect	$F_H = 0$	Appreciation Suboptimal Outcome [4]
		$F_H < 0$		$F_H < 0$	
Restrictions On Foreign Lending	Accumulation	$F_H > 0$	Depreciation Positive Wealth Effect	$F_H > 0$	
		$F_H = 0$		$F_H = 0$	Depreciation Suboptimal Outcome [4]
		$F_H < 0$	No Impact	$F_H < 0$	No Impact
	Decumulation	$F_H > 0$	Appreciation Negative Wealth Effect	$F_H > 0$	
		$F_H = 0$		$F_H = 0$	Appreciation Capital Immobility [3]
		$F_H < 0$	No Impact [2]	$F_H < 0$	No Impact [2]

Note:
1. There would be some effect (similar to that of restrictions on foreign borrowing) under restrictions on capital inflows rather restrictions on foreign borrowing.
2. There would be some effect (similar to that of restrictions on foreign lending) under restrictions on capital outflows rather restrictions on foreign lending.
3. Capital immobility remains as long as the domestic interest rate is not sufficiently high (or low) under restrictions on foreign borrowing (or lending). Otherwise, the degree of capital controls becomes minimal.
4. Suboptimal outcomes require that households initially want to borrow from or lend to the foreign country but they cannot and that the central bank's actions help households overcome such existing barriers.

2.8.3 Log-Linearized Form of Key Equations

Note:

A caret denotes (^) denotes a percentage deviation from the steady state, i.e. $\hat{x} = \frac{x-\bar{x}}{\bar{x}}$; a tilde (~) denotes a deviation from the steady state, i.e. $\tilde{x} = x - \bar{x}$, a check denotes a deviation from the steady state relative to steady-state nominal GDP, i.e. $\check{x} = \frac{x-\bar{x}}{\overline{GY}}$; and a bar (–) denotes the steady state.

Households

Labor supply	$\left(1 + \frac{\bar{H}}{1-\bar{H}}\right)\hat{H}_t + \gamma\hat{C}_t = \hat{W}_t - \hat{P}_t^C$
Consumption Euler equation	$\hat{u}_{C,t} = \mathbb{E}_t\left[\hat{u}_{C,t+1} + \beta\tilde{r}_t^C - \tilde{\pi}_{t+1}\right]$
Demand for $B_{H,t}$	$\nu_b\left(\hat{P}_t^C - \hat{B}_{H,t}\right) = \hat{u}_{C,t} + \frac{1}{\bar{r}^C - \bar{r}}(\tilde{r}_t^C - \tilde{r}_t) - \beta\tilde{r}_t^C$
Demand for $D_{H,t}$	$\nu_d\left(\hat{P}_t^C - \hat{D}_t\right) = \hat{u}_{C,t} + \frac{1}{\bar{r}^C - \bar{r}^D}(\tilde{r}_t^C - \tilde{r}_t^D) - \beta\tilde{r}_t^C$
Demand for $M_{H,t}$	$\nu_m\left(\hat{P}_t^C - \hat{M}_{H,t}\right) = \hat{u}_{C,t} + \frac{\beta}{\bar{r}^C}\tilde{r}_t^C$
Marginal utility of consumption	$\hat{u}_{C,t} = \left((1-\xi)(1-\gamma) - 1\right)\hat{C}_t - \xi(1-\gamma)\left(\frac{\bar{H}}{1-\bar{H}}\right)\hat{H}_t$
UIP-typed condition	$\tilde{r}_t^C = \tilde{r}_t^* + \tilde{\Psi}_t + \frac{1}{\beta}\mathbb{E}_t\left[\Delta\hat{S}_{t+1}\right]$
Demand for C_t^H	$\hat{C}_t^H = \hat{C}_t - \eta_c\left(\hat{P}_t^H - \hat{P}_t^C\right)$
Demand for C_t^F	$\hat{C}_t^F = \hat{C}_t - \eta_c\left(\hat{S}_t + \hat{P}_t^* - \hat{P}_t^C\right)$
Price P_t^C	$\hat{P}_t^C = \varrho_c\hat{P}_t^H + (1-\varrho_c)\left(\hat{S}_t + \hat{P}_t^*\right)$

Financial Intermediaries

Balance sheet	$\frac{\bar{L}}{\bar{D}}\hat{L}_t + \frac{\bar{B}_B}{\bar{D}}\hat{B}_{B,t} + \frac{\bar{M}_B}{\bar{D}}\hat{M}_{B,t} = \hat{D}_t$
Demand for $B_{F,t}$	$\frac{1}{\bar{r}^L - \bar{r}}(\tilde{r}_t^L - \tilde{r}_t) = \frac{1}{\bar{r}^L - \bar{r}^D}(\tilde{r}_t^L - \tilde{r}_t^D) + \hat{D}_t - \hat{B}_{B,t}$
Demand for $M_{F,t}$	$\tilde{r}_t^L = \frac{1}{\bar{r}^L - \bar{r}^D}(\tilde{r}_t^L - \tilde{r}_t^D) + \hat{D}_t - \hat{M}_{B,t}$
Liquidity management for deposits	$\hat{D}_t = \alpha_d\hat{M}_{B,t} + (1-\alpha_d)\hat{B}_{B,t}$

Central Bank

Policy interest rate $\tilde{r}_t = \rho_m \tilde{r}_{t-1} + (1-\rho_m)(\theta_\pi \tilde{\pi}_t + \theta_y \hat{Y}_t) + \varepsilon_{M,t}$

Foreign reserves $\overline{GY}\check{F}_{M,t} = \rho_f \overline{GY}\check{F}_{M,t-1} + (1-\rho_f)u_{F,t} + \varepsilon_{F,t}$

Issuance of B_t $\hat{B}_t = \hat{B}_{t-1} + \frac{\overline{GY}}{\bar{B}}(\check{F}_{M,t} - \check{F}_{M,t-1}) - \frac{\bar{M}}{\bar{B}}(\hat{M}_t - \hat{M}_{t-1})$

Foreign Country

Country risk premium $\tilde{\Psi}_t = -\upsilon_f \overline{GY}\check{F}_t + \varphi_t$

Driving force of capital flows $\tilde{\varphi}_t = \rho_\varphi \tilde{\varphi}_{t-1} + \varepsilon_{\varphi,t}$

Demand for exports $\hat{C}^*_{H,t} = \hat{Y}^*_t - \eta^*(\hat{P}^H_t - \hat{S}_t - \hat{P}^*_t)$

Foreign output $\hat{Y}^*_t = \rho_y \hat{Y}^*_{t-1} + \varepsilon^*_{Y,t}$

Foreign inflation $\tilde{\pi}^*_t = \rho_\pi \tilde{\pi}^*_{t-1} + \varepsilon^*_{P,t}$

Foreign interest rate $\tilde{r}^*_t = \rho_r \tilde{r}^*_{t-1} + (1-\rho_r)(\theta^*_\pi \tilde{\pi}^*_t + \theta^*_y \hat{Y}^*_t)$

Wholesale Firms

Production function $\hat{Y}_t = \hat{Z}_t + (1-\alpha_h-\alpha_x)(\hat{u}_t + \hat{K}_{t-1}) + \alpha_h \hat{H}_t + \alpha_x \hat{X}_t$

Total factor productivity $\hat{Z}_t = \rho_z \hat{Z}_{t-1} + \varepsilon_{Z,t}$

Demand for labor $\hat{Y}_t - \hat{H}_t = \hat{W}_t - \hat{P}^W_t$

Demand for imported inputs $\hat{Y}_t - \hat{X}_t = \hat{S}_t + \hat{P}^*_t - \hat{P}^W_t$

Choice of capital utilization $\hat{Y}_t - \hat{K}_t - \hat{\delta}(u_t) = \hat{P}^K_t - \hat{P}^W_t$

Capital depreciation $\hat{\delta}(u_t) = (1+\zeta_u)\hat{u}_t$

Balance sheet $\hat{P}^K_t + \hat{K}_t = \frac{\bar{L}}{\bar{L}+\bar{N}_W}\hat{L}_t + \frac{\bar{N}_W}{\bar{L}+\bar{N}_W}\hat{N}_{W,t}$

Net worth $\bar{V}_W \hat{N}_{W,t} = (1-\alpha_h-\alpha_x)\left(\frac{\varepsilon-1}{\varepsilon}\right)\bar{Y}(\hat{P}^W_t + \hat{Y}_t)$

Choice of capital

$$\mathbb{E}_t\left[(1-\alpha_h-\alpha_x)\left(\frac{\varepsilon-1}{\varepsilon}\right)\frac{\bar{Y}}{\bar{K}}(\hat{P}^W_{t+1}+\hat{Y}_{t+1}-\hat{K}_t)\right]$$

$$+\mathbb{E}_t\left[\left(1-\bar{\delta}(u)\right)\left(\hat{P}^K_{t+1} - \frac{\bar{\delta}(u)}{1-\bar{\delta}(u)}\hat{\delta}(u_{t+1})\right)\right] = (1+\bar{r}^L+\bar{\chi})\left(\hat{P}^K_t + \frac{1}{1+\bar{r}^L+\bar{\chi}}(\tilde{r}^L_t + \tilde{\chi}_t)\right)$$

External financing premium $\frac{1}{1+\bar{\chi}}\tilde{\chi}_t = \upsilon_l(\hat{P}^K_t + \hat{K}_t - \hat{N}_{W,t})$

Retail Firms

Phillips curve $\tilde{\pi}_t^H = \beta \mathbb{E}_t[\tilde{\pi}_{t+1}^H] + \frac{(1-\vartheta_r)(1-\beta\vartheta_r)}{\vartheta_r}\left(\hat{P}_t^W - \hat{P}_t^H\right)$

Capital-producing Firms

Capital accumulation $\hat{K}_t = \left(1 - \frac{\bar{I}}{\bar{K}}\right)\left(\hat{K}_{t-1} - \frac{\bar{\delta}(u)}{1-\bar{\delta}(u)}\hat{\delta}(u_t)\right) + \frac{\bar{I}}{\bar{K}}\hat{I}_t$

Price P_t^K $\hat{P}_t^K - \zeta_k \frac{\bar{I}}{\bar{K}}\left(\hat{I}_t - \hat{K}_{t-1}\right) - \zeta_k \bar{\delta}(u)\hat{\delta}(u_t) = \hat{P}_t^I$

Demand for I_t^H $\hat{I}_t^H = \hat{I}_t - \eta_i\left(\hat{P}_t^H - \hat{P}_t^I\right)$

Demand for I_t^F $\hat{I}_t^F = \hat{I}_t - \eta_i\left(\hat{S}_t + \hat{P}_t^* - \hat{P}_t^I\right)$

Price P_t^I $\hat{P}_t^I = \varrho_i \hat{P}_t^H + (1-\varrho_i)\left(\hat{S}_t + \hat{P}_t^*\right)$

Market Clearing Conditions

Money $\frac{\bar{M}_H}{\bar{M}}\hat{M}_{H,t} + \frac{\bar{M}_B}{\bar{M}}\hat{M}_{B,t} = \hat{M}_t$

Liquid domestic-currency bond $\frac{\bar{B}_H}{\bar{B}}\hat{B}_{H,t} + \frac{\bar{B}_B}{\bar{B}}\hat{B}_{B,t} = \hat{B}_t$

Wholesale goods $\hat{Y}_t = \hat{Y}_t^H$

Home goods

$$\hat{Y}_t^H = \frac{\bar{C}^H}{\bar{Y}^H}\hat{C}_t^H + \frac{\bar{I}^H}{\bar{Y}^H}\hat{I}_t^H + \frac{\bar{C}^{H*}}{\bar{Y}^H}\hat{C}_t^{H*}$$
$$= \frac{\bar{C}^H}{\bar{Y}^H}\left(\hat{C}_t - \eta_c\left(\hat{P}_t^H - \hat{P}_t^C\right)\right) + \frac{\bar{I}^H}{\bar{Y}^H}\left(\hat{I}_t - \eta_i\left(\hat{P}_t^H - \hat{P}_t^I\right)\right)$$

Other Conditions

Foreign asset position $\check{F}_t = \frac{1}{\beta}\check{F}_{t-1} + \widetilde{TB}_t$

Trade balance

$$\widetilde{TB}_t = \frac{\bar{Y}^H}{\bar{GY}}\left(\hat{Y}_t^H + \hat{P}_t^H\right) - \frac{\bar{C}}{\bar{GY}}\left(\hat{C}_t + \hat{P}_t^C\right) - \frac{\bar{I}}{\bar{GY}}\left(\hat{I}_t + \hat{P}_t^I\right)$$
$$- \frac{\bar{X}}{\bar{GY}}\left(\hat{X}_t + \hat{S}_t + \hat{P}_t^*\right)$$

Foreign-currency bond $\check{F}_t = \check{F}_{H,t} + \check{F}_{M,t}$

Real exchange rate $\hat{Q}_t = \hat{S}_t + \hat{P}_t^* - \hat{P}_t^C$

Nominal GDP $\widehat{GY}_t = \frac{\bar{Y}}{\bar{Y}-\bar{X}}\left(\hat{P}_t^H + \hat{Y}_t^H\right) - \frac{\bar{X}}{\bar{Y}-\bar{X}}\left(\hat{S}_t + \hat{P}_t^* + \hat{X}_t\right)$

Chapter 3

Do Capital Controls on Inflows Remain a Viable Option? – Thailand's Experience of Stock Market Crash

3.1 Introduction

In response to rapid and substantial exchange rate appreciation, the Bank of Thailand (BoT) imposed controls on capital inflows in the form of unremunerated reserve requirement (URR) between December 2006 and February 2008. The Thai baht had been appreciating by 15 percent against the US dollar or by 10 percent based on real effective exchange rate movements over the pre-URR period in 2006 (Figure 1.4). As earlier policy responses, which included undertaking foreign-exchange (FX) interventions and tightening the measures to prevent currency speculation, seemed futile in stemming currency appreciation, the BoT on December 18, 2006 undertook a bold step by introducing the URR measure, which stipulated that a fraction of capital inflows must be deposited in a non-interest-bearing account at the central bank.

Thailand's experience of capital controls appears particularly interesting due to the severe stock market crash that occurred as a result of the introduction of the URR measure. From time to time, countries impose restrictions on capital flows in order to address particular components of financial flows and preserve exchange rate stability.[1] Many of capital control episodes (e.g. Brazil and Colombia) indeed embrace certain features of the URR, which has become a widely recognized form of restrictions on inflows owing to Chile's experience in the 1990s. Nevertheless, Thailand's experience deserves some special attention because it raises a challenging question to policymakers who may

[1] Recent well-known episodes of controls on inflows include Brazil 1994-1999, 2008 and 2009-present, Chile 1991-1998, Colombia 1993-2000 and 2007-2008, Malaysia 1994, and Thailand 2006-2008, whereas the most famous episode of controls on outflows belongs to Malaysia 1998. Moreover, the talk on capital controls has recently re-emerged as many emerging markets face massive financial inflows and sizeable currency appreciation.

believe in the usefulness of capital controls.[2] The critical concern is whether capital controls on inflows remain a viable policy option after the introduction of the URR measure by the BoT triggered a historical collapse of Thailand's stock market.[3] As the severe stock market crash generated panic among investors and provoked public criticism, the BoT removed the control on inflows to the stock market within one day. While such an overnight relaxation led to a strong market rebound on the next day, the Thai economy could not escape from contractionary effects due to deterioration in consumer confidence and business sentiment. In short, if a stock market collapse is unavoidable, it is unlikely that restrictions on financial flows will be kept on the menu of policy options. On the other hand, the viability of capital controls should remain if it is plausible to implement a well-designed capital control regime that can mitigate adverse consequences.

The key objective of this chapter is to illustrate that the underlying factor for the stock market crash was the punitive implied tax rate, which resulted from the interaction among the penalty on early withdrawal imposed as a part of the URR measure, certain existing institutional features owing to the measures to prevent currency speculation, and the transitory nature of portfolio equity investment. The theoretical analysis suggests that limited foreign participation, which arose when the implicit tax rate was sufficiently large to make any new foreign investment in the domestic stock market unprofitable, could trigger a sharp reduction in share prices through two major mechanisms. One was a revaluation of idiosyncratic risks, as Thai stocks would be priced by domestic, rather than world, aggregate risks; another was a decline in stocks' liquidity, as foreign investors would no longer actively trade Thai shares. These changes demanded an increase in equity premiums, or equivalently a decline in share prices. The aforementioned theoretical assertion is also supported by the empirical evidence which portrays that difference in covariances and trading frequency are the most important explanatory variables for changes in share prices across firms during the stock market collapse and recovery.

The chapter proceeds as follows. Section 3.2 reviews key aspects of the introduction of the URR measure and the incidence of the stock market crash. Section 3.3 develops a theoretical model to explain how limited participation of foreign investors in the domestic stock market as a result of the punitive tax rate induced by capital controls can cause a

[2] Several studies on the effectiveness of capital controls generally concluded that controls on capital inflows neither reduced the total amount of inflows nor mitigated exchange rate appreciation, while they could alter the composition of inflows towards long-term maturity and reduce the volatility of financial variables such as stock returns and exchange rates. See Magud and Reinhart (2007) for an overview of studies on various capital control episodes.

[3] In other countries, market responses to capital controls that affect foreign investment in local stock markets have been relatively minimal. For instance, principal stock market indices declined by 3.1 percent in Brazil on October 19, 1994, 2.1 percent in Chile on July 4, 1995, 3.7 percent in Colombia on May 23, 2007, and 2.9 percent in Brazil on October 20, 2009.

stock market crash. Section 3.4 presents some supportive empirical evidence based on Thailand's experience that the change in equity premiums played the instrumental role in driving the change in share prices during the stock market collapse and recovery. Section 3.5 concludes.

3.2 Thailand's URR Measure and Stock Market Crash

In late 2006, the development of substantial exchange rate appreciation became a major concern faced by policymakers in Thailand. A strong expansion in exports appeared necessary for the Thai economy to grow amid weak private domestic demand that was underpinned by ongoing political turmoil ranging from street protests to the failed election and the military coup (Figure 1.3).[4] However, the Thai baht had been appreciating steadily throughout 2006 as a result of massive capital inflows (Figure 1.6). By late 2006, cumulative currency appreciation seemed so large that it could significantly erode the country's competitiveness.

On December 18, 2006, the BoT introduced the URR measure in order to "safeguard the stability of the Thai baht and prevent currency speculation" after such earlier policy responses as intervening in the FX market and tightening the measures to prevent currency speculation failed to curb exchange rate appreciation. The measure required that 30 percent of all incoming foreign-currency funds were subjected to the reserve requirement. The reserve in the currency of incoming funds must be deposited in a non-interest-bearing account at the central bank for the withholding period of one year after which the reserve would be returned. If such funds stayed in the country for less than one year, only two-thirds of the reserve would be returned; thus, any early withdrawal would entail a hefty penalty equivalent to 10 percent of incoming funds.

On December 19, the day that it came in effect, the URR measure caused a stock market crash. The SET index dropped 8.9 percent at the market opening before continually tumbling to the trough of the day, with the market enduring the dramatic fall of 19.5 percent. Then, the SET index rebounded moderately towards the end of the turbulent trading day, which recorded the largest one-day loss of 14.8 percent, the worst performance in 31 years since the opening of Thailand's stock exchange. The stock market crash led to a reduction in market capitalization of 820 billion baht (10.5 percent of GDP). Furthermore, the stock market collapse coincided with gigantic sale by foreign investors. The amount of net foreign sale at the historical record of 25 billion baht could

[4] The failed election occurred because all major non-government political parties boycotted the election. An early election was called to rubber-stamp the government's legitimacy to stay in power amid several scandals arising from corruption, misconduct and power abuse.

only be matched by the magnitude of cumulative net foreign sale over the entire month in which massive foreign withdrawal from Thailand's stock market occurred (Figure 3.1).

The severe stock market crash promptly brought Thailand into a crisis mode. In the afternoon of December 19, the finance minister called an emergency meeting to assess the situation. Supposedly, the impact of capital controls on output should be expansionary.[5] The BoT aimed that imposing controls on capital inflows should induce exchange rate depreciation, which could help promote strong export growth essential for sustaining economic expansion amid sluggish private domestic demand. However, as contractionary effects caused by the stock market crash loomed large, Thai authorities in the same evening decided to lift the control on inflows to the stock market. While the stock market responded to the partial removal of capital controls with a strong rebound on the next day, with the SET index rising 11.2 percent, the Thai economy could not escape from contractionary effects. In particular, both consumer confidence and business sentiment deteriorated considerably, further depressing domestic demand that had remained weak due to ongoing political turmoil. For the worst of all, the public questioned the competence of Thai authorities in managing the economy.

The URR measure had remained in place until the entire removal on February 29, 2008,[6] although the control on inflows to the stock market was repealed overnight. During the URR regime, the BoT continued to employ a combination of several policy instruments to mitigate exchange rate appreciation; these policy actions consisted of lowering the policy interest rate, undertaking large-scale sterilized FX interventions and liberalizing domestic financial outflows. Nevertheless, the Thai baht had continually appreciated by 3.4 percent based on real effective exchange rate movements. See Chapter 1 for more complete details on macroeconomic developments and policy responses during the URR regime.

3.3 Theoretical Analysis

The stock market crash on December 19, 2006 was indisputably the most significant event associated with Thailand's recent experience of capital controls. In general, a

[5] It is noteworthy that the impact of capital controls in the form of URR on output can be either ways. The outcome critically depends on the exchange rate regime. In particular, under a fixed exchange rate regime (i.e. Chile's experience), capital controls should lead to an increase in domestic interest rates, which in turn slows down economic activity. On the other hand, if the exchange rate is flexible (i.e. Thailand's experience), capital controls should induce some currency depreciation, which in turn helps promote strong export performance.

[6] Political pressure from the newly elected government appeared as the most influential factor, although the BoT attempted to justify that economic forces underpinning exchange rate appreciation would diminish on the back of an increase in domestic demand (including imports), which should help reduce currency appreciation pressure emerging to support the process of correcting current account imbalances.

severe stock market crash by itself is undesirable due to its contractionary effects through various channels, including a reduction in wealth, a decline in consumer confidence as well as business sentiment, and a Tobin's q effect. Therefore, it is crucial to understand why the stock market collapse occurred in response to the introduction of the URR measure. The answer to the abovementioned question should be useful for providing some important policy implications concerning the viability of capital controls as a policy option and the design of capital controls that can mitigate the occurrence of stock market crashes.

This section's central goal is to illustrate how the URR measure implemented by the BoT could trigger such a severe stock market crash. One might first wonder why capital controls on new foreign funds could generate a significant impact on the stock market. To some extent, this might explain why the BoT underestimated the URR measure's effects on financial markets. The theoretical analysis, however, aims to demonstrate that a stock market collapse should indeed be expected. Part 3.3.1 argues that the implicit rate for new foreign investment in the stock market in the case of Thailand's URR measure could be excessively large. Part 3.3.2 presents a benchmark theoretical model that explains how the excessively large implied tax rate served as the underlying factor for the substantial decline in share prices, while part 3.3.3 considers supplementary issues important to the theoretical analysis. Part 3.3.4 concludes with a revisit to address policy implications. The main lesson is that policymakers in principle can implement capital controls without triggering a stock market collapse by assuring that the implicit tax rate is not excessively large. In other words, capital controls should remain a viable policy instrument.[7]

3.3.1 Excessively Large Implicit Tax Rate

This part discusses why the implied tax rate for new foreign investment in the stock market was excessively large in the case of Thailand's URR measure. In particular, such a punitive implicit tax rate arose as a result of the interaction among the penalty on early withdrawal imposed as a part of the URR measure, certain existing institutional features owing to the measures to prevent currency speculation, and the transitory nature of portfolio equity investment.

The implied tax rate induced by capital controls can be calculated based on the concept of the net-return-equivalent cost, which develops on the idea of the interest-rate-equivalent cost for measuring costs generated by the URR in the literature (see De Gregorio, Edwards and Valdes (2000) as an example). Specifically, the reserve requirement can be

[7] Policymakers should ensure that capital controls are effective in delivering desired benefits like preserving macroeconomic stability and, moreover, that such benefits outweigh associated costs, including potential micro-level distortions (see Forbes (2006) as an example).

viewed as a tax on new foreign investment in terms of the net-return-equivalent cost defined as the difference in net returns between the cases with and without capital controls.[8]

The net-return-equivalent cost for short-term investment was particularly substantial. According to Table 3.1, investment with maturity of less than one year faced a punitive tax rate as a result of the penalty on early withdrawal, which was equivalent to 10 percent of incoming funds. While being below 2 percent for investment with maturity of one year or more, the net-return-equivalent cost even exceeded 100 percent for investment with maturity of one month or less. Such an excessively large implicit tax rate for short-term investment should effectively deter most, if not all, investment whose maturity was less than the withholding period of one year. In this study, the implicit tax rate is considered "excessively large" when it can cause a negative expected return on relevant investment; an explicit threshold is not specified.

The transitory characteristic of portfolio investment in equity combined with certain restrictions owing to the measures to prevent currency speculation entailed that back-and-forth movements of foreign funds across the border were essential to accommodate frequent stock trading. Because it would be very difficult to imagine of no changes in a stock portfolio at all over the period of one month, not to mention one year, portfolio equity investment should be regarded as naturally short-term. However, the need to frequently trade stocks did not necessarily require foreign investors to move their funds across the border if they were able to temporarily keep their funds between each stock trading in Thailand's financial system. Under such circumstances, the implicit tax rate should not be excessively large as foreign investors could avoid paying the hefty penalty on early withdrawal. Unfortunately, the measures to prevent currency speculation caused several limitations.[9] First, domestic financial institutions could not borrow from non-residents in baht for maturity of less than 6 months. Moreover, borrowings in the form of bills of exchange and repurchase agreements were completely prohibited. Second, deposits in non-resident baht accounts were subjected to the end-of-day outstanding limit of 300 million baht. Third, foreign investors could purchase public debt securities only if their holding would be longer than 3 months, whereas private debt securities accounted for a small fraction of all debt securities in Thailand's fledging bond market.

To sum up, portfolio investment in equity seemed likely to be subjected to the excessively large implicit tax rate. It is noteworthy that the alternative of raising funds in Thailand in lieu of bringing in new funds from abroad was also infeasible because the

[8] See Annex 3.6.2 for the derivation of the net-return-equivalent cost based on Thailand's URR measure.

[9] One may question whether these restrictions were binding. What happened on the day that the stock market crashed might provide some clues. In that afternoon, the BoT lifted the end-of-day outstanding limit of non-resident baht accounts temporarily to accommodate massive foreign funds from equity sale.

measures to prevent currency speculation imposed restrictions on non-residents to obtain baht credit facilities and issue debt securities.

3.3.2 Benchmark Model

This part develops a theoretical model to explain that the stock market crash trigged by the URR measure primarily resulted from the excessively large implicit tax rate for new foreign investment in the stock market. The benchmark model highlights the leading roles of both limited foreign participation underlying a re-pricing of domestic equity's idiosyncratic risks and foreign sale of domestic equity necessary for triggering a stock price collapse. In particular, reduced risk sharing can induce a substantial equity price decline on the back of a sharp increase in the equity premium component of the expected return.

❖ Basic Setup

The analytical framework builds on a portfolio allocation problem. The world consists of two representative agents, namely home and foreign, as well as three financial assets, including domestic equity, international equity and international risk-free bond. This simple setup is sufficient to demonstrate the role of risk sharing embedded in the central mechanism for triggering a stock market crash.

The setup assumes that each representative agent maximizes the one-period-ahead expected utility based on wealth. In particular, the home agent maximizes $\mathbb{E}_t U(W_{t+1})$ subject to the budget constraint:

(3.1) $$W_{t+1} = R^f_{t+1} W_t + \left(V_{t+1} - R^f_{t+1} P_t\right) x_{D,t},$$

where W_t is wealth in period t, R^f_{t+1} is the (gross) risk-free rate between period t and $t+1$, V_{t+1} is the value of domestic equity in period $t+1$ (price plus dividend), P_t is the price of domestic equity in period t, and $x_{D,t}$ is the number of shares of domestic equity held by the home agent. Similarly, the foreign agent maximizes $\mathbb{E}_t U(W^*_{t+1})$ subject to the budget constraint:

(3.2) $$W^*_{t+1} = R^f_{t+1} W^*_t + \left(V^*_{t+1} - R^f_{t+1} P^*_t\right) x^*_{F,t} + \left(V_{t+1} - R^f_{t+1} P_t\right) x^*_{D,t},$$

where a star ($*$) denotes the foreign or international counterparts. The utility takes the form of $U(W_{t+1}) = -exp(-A_t W_{t+1})$, with $A_t W_t = \gamma$, where A_t is the time-varying absolute risk aversion in period t and γ is the constant relative risk aversion. The foreign agent's preference shares similar features.

According to the budget constrain (3.1), the home agent is not allowed to hold any international equity. This assumption seems appropriate for Thailand since the amount of investment in equity abroad has been minimal. Furthermore, V_{t+1} and V_{t+1}^* are assumed to be normally distributed so that the portfolio allocation problem becomes equivalent to maximize $\mathbb{E}_t(W_{t+1}) - \frac{1}{2}A_t\mathbb{Var}_t(W_{t+1})$ and $\mathbb{E}_t(W_{t+1}^*) - \frac{1}{2}A_t^*\mathbb{Var}_t(W_{t+1}^*)$ subject to the respective budget constraints. Then, the first-order condition for the home agent sets:

$$(3.3) \qquad x_{D,t} = \frac{\mathbb{E}_t(V_{t+1}) - R_{t+1}^f P_t}{A_t\mathbb{Var}_t(V_{t+1})},$$

which provides the home agent's demand for domestic equity. Similarly, the first-order conditions for the foreign agent specify:

$$(3.4) \qquad x_{D,t}^* = \frac{\mathbb{E}_t(V_{t+1}) - R_{t+1}^f P_t - A_t^*\mathbb{Cov}_t(V_{t+1}, x_{F,t}^* V_{t+1}^*)}{A_t^*\mathbb{Var}_t(V_{t+1})},$$

$$(3.5) \qquad x_{F,t}^* = \frac{\mathbb{E}_t(V_{t+1}^*) - R_{t+1}^f P_{t+1}^* - A_t^*\mathbb{Cov}_t(V_{t+1}^*, x_{D,t}^* V_{t+1})}{A_t^*\mathbb{Var}_t(V_{t+1}^*)},$$

which determine the foreign agent's demand for domestic equity and international equity, respectively. These demand specifications together with the market-clearing conditions, i.e. $\bar{x}_D \equiv 1 = x_{D,t} + x_{D,t}^*$ and $\bar{x}_F \equiv 1 = x_{F,t}^*$, determine the prices of both equity types. For instance, let's consider the market for domestic equity, with the market-clearing condition requiring:

$$(3.6) \qquad \bar{x}_D \equiv 1 = x_{D,t} + x_{D,t}^* = \frac{\mathbb{E}_t(V_{t+1}) - R_{t+1}^f P_t}{A_t\mathbb{Var}_t(V_{t+1})} + \frac{\mathbb{E}_t(V_{t+1}) - R_{t+1}^f P_t - A_t^*\mathbb{Cov}_t(V_{t+1}, x_{F,t}^* V_{t+1}^*)}{A_t^*\mathbb{Var}_t(V_{t+1})},$$

$$(3.7) \qquad P_t = \frac{\mathbb{E}_t(V_{t+1})}{R_{t+1}^f + \gamma\mathbb{Cov}_t\left(\frac{V_{t+1}}{P_t}, \frac{V_{t+1} + V_{t+1}^*}{W_t + W_t^*}\right)},$$

which describes that the price of domestic equity is equal to the present value of the expected payoff (price plus dividend) discounted by the appropriate expected return.

The expected return consists of two components: the risk-free rate and the equity premium. When the foreign agent holds domestic equity, the equity premium depends on the covariance between the return on domestic equity, denoted by $\tilde{R}_{t+1} = V_{t+1}/P_t$, and the return on total wealth, i.e. $(V_{t+1} + V_{t+1}^*)/(W_t + W_t^*)$. The latter can be approximated by the return on international equity, denoted by $\tilde{R}_{t+1}^* = V_{t+1}^*/P_t^*$, in the case that domestic equity and home wealth are negligible relative to international equity and foreign wealth, respectively. Based on this approximation, the price of domestic equity becomes:

$$(3.8) \qquad P_t \cong \frac{\mathbb{E}_t(V_{t+1})}{R_{t+1}^f + \gamma\mathbb{Cov}_t(\tilde{R}_{t+1}, \tilde{R}_{t+1}^*)},$$

which implies the existence of risk sharing. The equity premium reflects that domestic equity is priced by world (indeed, foreign) aggregate risks. Note that domestic equity would be priced by domestic aggregate risks when the foreign agent does not hold domestic equity. Similarly, the price of international equity follows:

$$(3.9) \quad P_t^* = \frac{\mathbb{E}_t(V_{t+1}^*)}{R_{t+1}^f + \gamma \mathbb{C}\mathrm{ov}_t\left(\frac{V_{t+1}^*}{P_t^*}, \frac{W_{t+1}^*}{W_t^*}\right)} \cong \frac{\mathbb{E}_t(V_{t+1}^*)}{R_{t+1}^f + \gamma \mathbb{V}\mathrm{ar}_t(\tilde{R}_{t+1}^*)},$$

which suggests that international equity is also priced by world aggregate risks.

❖ Capital Controls

In order to analyze the impact of capital controls on the price of domestic equity, let's suppose that the home country imposes capital controls, which can be thought as some tax on new foreign investment. Particularly, capital controls can affect investment decisions in two ways. The primary channel is that capital controls make it more costly for the foreign agent to invest in domestic equity so that the foreign agent's budget constraint (3.2) becomes:

$$(3.10) \quad W_{t+1}^* = R_{t+1}^f W_t^* + (V_{t+1}^* - R_{t+1}^f P_t^*) x_{F,t}^* + (V_{t+1} - R_{t+1}^f P_t) x_{D,t}^* \\ + \tau(x_{D,t}^* - x_{D,t-1}^*) P_t \mathcal{I}\{x_{D,t}^* > x_{D,t-1}^*\},$$

where τ is the tax rate for new foreign investment in domestic equity, and $\mathcal{I}\{.\}$ is the indicator function. In addition, the risk-free rate in the home country increases from R_{t+1}^f to $R_{t+1}^f(1+\hat{\tau})$ because capital controls also apply to new borrowings from abroad, where $\hat{\tau}$ is the effective tax rate for overall foreign investment in the home country.[10] The home agent's budget constraint (3.1) accordingly becomes:

$$(3.11) \quad W_{t+1} = R_{t+1}^f(1+\hat{\tau})\, W_t + (V_{t+1} - R_{t+1}^f(1+\hat{\tau})\, P_t) x_{D,t},$$

If short-selling is prohibited, there are two possible outcomes, which chiefly depend on the magnitude of the tax rate for new foreign investment in domestic equity. When τ is minimal, the first-order condition determines the foreign agent's demand for domestic equity, i.e. $x_{D,t}^* \geq 0$. On the other hand, if τ is excessively large, it is unprofitable for the foreign agent to acquire additional domestic equity; thus, $x_{D,t}^* \leq x_{D,t-1}^*$.

[10] The effective tax rate is referred to the tax rate that matters for investment decisions. For instance, let's think about a situation in which foreign residents lend money to domestic residents. Assume that the tax rate is excessively high for short-term borrowings but minimal for long-term borrowings. Then, the amount of short-term borrowings should be zero. However, short-term domestic interest rates would not increase by the same order of such an excessively large tax rate applicable to short-term borrowings. The reason is that some people to would obtain long-term foreign funds to invest in domestic short-term financial assets. These arbitrage activities would prevent short-term domestic interest rates to rise substantially. As a result, the effective tax rate should be equal to the net-return-equivalent cost for which borrowings actually occur.

In the case that τ is minimal, the foreign agent's demand for domestic equity is:

$$x_{D,t}^{*} = \frac{\mathbb{E}_t(V_{t+1}) - R_{t+1}^{f}P_t - \tau P_t \mathfrak{I}\{x_{D,t}^{*} > x_{D,t-1}^{*}\} - A_t^{*}\mathbb{Cov}_t(V_{t+1}, x_{F,t}^{*}V_{t+1}^{*})}{A_t^{*}\mathbb{Var}_t(V_{t+1})}$$

(3.12) $$x_{D,t}^{*} = \frac{\mathbb{E}_t(V_{t+1}) - R_{t+1}^{f}(1+\hat{\tau})P_t - A_t^{*}\mathbb{Cov}_t\left(V_{t+1}, x_{F,t}^{*}V_{t+1}^{*}\right)}{A_t^{*}\mathbb{Var}_t(V_{t+1})}$$

since τ and $\hat{\tau}$ should be equalized by arbitrage; recall that $\hat{\tau}$ is the effective tax rate for overall foreign investment in the home country. Then, the market-clearing condition yields the price of domestic equity:

(3.13) $$P_t \cong \frac{\mathbb{E}_t(V_{t+1})}{R_{t+1}^{f}(1+\hat{\tau}) + \gamma\mathbb{Cov}_t(\tilde{R}_{t+1}, \tilde{R}_{t+1}^{*})},$$

which suggests that domestic equity remains to be priced by the same equity premium, i.e. the covariance between the return on domestic equity and the return reflecting world aggregate risks. However, the risk-free rate is higher because it is more costly to borrow in the presence of capital controls. In the context of the URR measure, these additional costs basically arise from the financing cost of the reserve. It is important to emphasize that when τ is minimal, the foreign agent continues to participate in domestic equity investment so that risk sharing remains.

On the contrary, when τ is excessively large, it becomes unprofitable for the foreign agent to acquire additional domestic equity. Therefore, $x_{D,t}^{*}$ should be viewed as exogenous on account of limited foreign participation in domestic equity investment. The market-clearing condition then implies:

$$\bar{x}_D - x_{D,t}^{*} = x_{D,t} = \frac{\mathbb{E}_t(V_{t+1}) - R_{t+1}^{f}(1+\hat{\tau})P_t}{A_t\mathbb{Var}_t(V_{t+1})},$$

(3.14) $$P_t = \frac{\mathbb{E}_t(V_{t+1})}{R_{t+1}^{f}(1+\hat{\tau}) + \gamma\mathbb{Cov}_t\left(\tilde{R}_{t+1}, \frac{W_{t+1}}{W_t}\right)}.$$

Using the home agent's budget constraint (3.11), the equity premium can be written as:

(3.15) $$\gamma\mathbb{Cov}_t\left(\tilde{R}_{t+1}, \frac{W_{t+1}}{W_t}\right) = \gamma(1-\omega_t)\mathbb{Var}_t(\tilde{R}_{t+1}),$$

where $1-\omega_t$ is the fraction of the home agent's wealth being invested in domestic equity. Following $W_t = B_t + x_{D,t}P_t \equiv \omega_t W_t + x_{D,t}P_t$, where B_t is the home agent's holding of international risk-free bond, the relationship $W_t = \frac{1}{1-\omega_t}x_{D,t}P_t$ can be used to derive the equity premium as displayed in (3.15) so that the price of domestic equity becomes:

$$P_t = \frac{\mathbb{E}_t(V_{t+1})}{R^f_{t+1}(1+\hat{\tau}) + \gamma(1-\omega_t)\mathbb{Var}_t(\tilde{R}_{t+1})}, \quad (3.16)$$

which suggests some limitation on risk sharing. In particular, domestic equity is priced by domestic, rather than world, aggregate risks.

However, it is important to recognize that a change in the equity premium as illustrated in expression (3.16) requires the foreign agent to sell some domestic equity. Notice that the equity premium depends on both the variance of the return on domestic equity and the size of the home agent's holding of domestic equity. At the introduction of capital controls, the equity premium with no foreign sale defined as $\gamma(1-\omega_{t,0})\mathbb{Var}_t(\tilde{R}_{t+1})$ should be equal to $\gamma\mathbb{Cov}_t(\tilde{R}_{t+1}, \tilde{R}^*_{t+1})$.[11] Hence, a reduction in the foreign agent's holding of domestic equity seems necessary to generate an increase in the equity premium component of the expected return. Moreover, when a decline in ω_t occurs as a result of foreign sale, the expected return must rise to compensate the home agent for taking additional risks from holding more domestic equity.[12] The increase in the expected return in turn causes the price of domestic equity to fall. It is worth mentioning that when ω_t becomes zero, the home country equivalently turns into financial autarky in which the equity premium is equal to $\gamma\mathbb{Var}_t(\tilde{R}_{t+1})$.

In summary, a stock market collapse defined as a substantial decline in the price of domestic equity is likely to occur when capital controls are introduced with an excessively large tax rate for new foreign investment in domestic equity. Under such circumstances, foreign participation in domestic equity investment becomes limited, and domestic equity is thus priced by domestic, rather than world, aggregate risks. The re-pricing of idiosyncratic risks which reflects an increase in systematic risks serves as the triggering mechanism of a domestic equity price collapse whose magnitude critically depends on the amount of domestic equity being sold by the foreign agent.

❖ Foreign Sale

Up to this point, the analysis only illustrates that the foreign agent's sale of domestic equity must be an integral part of the stock market collapse, which is consistent with the fact that massive foreign sale occurred during Thailand's stock market crash. This part explores potential factors that might set off gigantic foreign sale. The discussion focuses on three sources: regular withdrawal, forced sale and rational panic.

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[11] This results from the implicit assumption that both agents hold domestic equity prior to capital controls, which implies: $\mathbb{Cov}_t(\tilde{R}_{t+1}, \tilde{R}^*_{t+1}) \cong \mathbb{Cov}_t\left(\tilde{R}_{t+1}, \frac{W^*_{t+1}}{W^*_t}\right) = \mathbb{Cov}_t\left(\tilde{R}_{t+1}, \frac{W_{t+1}}{W_t}\right) = (1-\omega_{t,0})\mathbb{Var}_t(\tilde{R}_{t+1})$.

[12] The change in ω depends on two offsetting effects: the portfolio rebalancing effect and the wealth effect relative to the price effect, i.e. $1 - \frac{\Delta\omega}{1-\omega} = \left(1 + \frac{\Delta x_D}{x_D}\right)\left\{\left(1 + \frac{\Delta P}{P}\right)/\left(1 + \frac{\Delta W}{W}\right)\right\}$. One can show that an increase in the home's agent holding of domestic equity must coincide with a decline in the price of domestic equity.

First of all, regular withdrawal is motivated based on a realistic assumption that both home and foreign agents in each period need to liquidate a fraction of their holding of domestic equity (and also international equity). Theoretically, this particular assumption can be justified in the context of the overlapping generation framework in which people in the old cohort have to liquidate all of their financial assets to pay for consumption in their terminal period. In reality, this assumption seems appropriate because portfolio investment in equity naturally features frequent portfolio rebalancing.

In order to see the effect of regular withdrawal, let's assume that both agents in each period need to liquidate a fraction of their holding of domestic equity.[13] In the case of no capital controls, regular withdrawal does not have any effect on the price of domestic equity. Specifically, since the optimal holding of domestic equity remains the same due to no changes in the fundamentals of financial assets, the receipt from liquidation would be entirely used to repurchase domestic equity. However, when capital controls exist, the outcome depends on the level of the tax rate for new foreign investment in domestic equity.

When τ is minimal, regular withdrawal should have no impact on the price of domestic equity for the same reason as discussed above. In contrast, when τ is sufficiently large, regular withdrawal causes liquidation to be permanent withdrawal of some foreign investment in domestic equity over the period of capital controls. Since it is unprofitable for the foreign agent to bring in new foreign funds to repurchase domestic equity, the home agent must acquire all domestic equity being liquidated by the foreign agent. Consequently, ω_t decreases as $x_{D,t}$ increases. The price of domestic equity must fall according to the pricing formula:

$$(3.16) \quad P_t = \frac{\mathbb{E}_t(V_{t+1})}{R^f_{t+1}(1+\hat{\tau}) + \gamma(1-\omega_t)\mathbb{V}\mathrm{ar}_t(\tilde{R}_{t+1})}.$$

Furthermore, when capital controls may last for several periods, the amount of immediate foreign sale could be larger than the amount of liquidation required for the current period. When different cohorts among foreign agents exist, the group of foreign agents who need to liquidate domestic equity in the subsequent periods might want to sell now. If the current price of domestic equity has not fallen sufficiently to the level that can reflect potential foreign sale arising from liquidation in the subsequent periods, someone in these cohorts should be better off by selling now rather than waiting to sell later. Nonetheless, it is not rational for everyone in these cohorts to sell now because holding domestic equity to sell later yields a higher expected return.

[13] For simplicity, regular withdrawal only applies to the holding of domestic equity. The existence of regular withdrawal for the holding for international equity would not affect the analytical results.

For the second factor, forced sale may arise when some group of foreign agents can no longer invest in domestic equity due to regulatory requirements or institutional restrictions. For example, agreements between some mutual funds and their clients may explicitly state that fund managers cannot invest in a country which imposes capital controls. Another notable example is that many index-tracking funds can only invest in investible equity. When the tax rate is excessively large, domestic equity effectively becomes non-investible as it is impossible for fund managers to replicate the return generated by domestic equity. Hence, domestic equity is removed out of their portfolios.

While forced sale may occur anyway regardless of the level of the tax rate induced by capital controls, the price of domestic equity would definitely decline by a greater magnitude in the case that the tax rate is excessively large primarily because all of forced sale must be absorbed by home agents during the period of capital controls. On the other hand, when the tax rate is minimal, it seems likely that other group of foreign agents may come in to take advantage of inexpensive domestic equity. Therefore, the amount of net foreign sale should be minimal in the sense that home wealth remains negligible relative to outstanding foreign wealth, i.e. $(1-\delta^*)W_t^*$, where δ^* represents the fraction of foreign agents who are subjected to forced sale. Based on the assumption that all agents have the same degree of relative risk aversion γ, the price of domestic equity follows:

$$(3.17)\quad P_t = \frac{\mathbb{E}_t(V_{t+1})}{R_{t+1}^f(1+\hat{\tau}) + \gamma\mathbb{Cov}_t\left(\tilde{R}_{t+1}, \dfrac{V_{t+1} + x_{F,t}^{fh*}V_{t+1}^*}{W_t + (1-\delta^*)W_t^*}\right)},$$

where $x_{F,t}^{fh*}$ denotes the holding of international equity by foreign agents who can freely hold domestic equity. Since $x_{F,t}^{fh*}$ is approximately equal to $1-\delta^*$,[14] the price of domestic equity becomes:

$$(3.18)\quad P_t \cong \frac{\mathbb{E}_t(V_{t+1})}{R_{t+1}^f(1+\hat{\tau}) + \gamma\mathbb{Cov}_t(\tilde{R}_{t+1}, \tilde{R}_{t+1}^*)},$$

which suggests that the equity premium remains unchanged. The result is driven by that the change in $x_{F,t}^{fh*}$ is negligible; thus, the return on the portfolio of the representative agent holding domestic equity is roughly equal to $\tilde{R}_{t+1}^*$.

For the third factor, rational panic, which represents panic driven by rational motive, may occur during a disastrous event as people tend to change their viewpoints radically.

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[14] The holding of international equity is equal to $x_{F,t}^{fh*} = (1-\delta^*)\kappa - \frac{\mathbb{Cov}_t\left(V_{t+1}^*, x_{D,t}^{fh*}V_{t+1}\right)}{\mathbb{Var}_t(V_{t+1}^*)}$ for foreign agents who can freely hold domestic equity, and $x_{F,t}^{fs*} = \delta^*\kappa$ for foreign agents who are subjected forced sale, respectively, where $\kappa = \frac{\mathbb{E}_t(V_{t+1}^*) - R_{t+1}^f P_{t+1}^*}{\gamma\mathbb{Var}_t(V_{t+1}^*)} W_t^*$.

Because it takes time and effort to completely understand the event, people with imperfection information may become in panic, adjust their beliefs dramatically, and react rationally based on their newly adopted views. In the event of a severe stock market crash, some agents may significantly reduce their optimal holding of domestic equity.

In order to evaluate the effect of rational panic on the price of domestic equity, let's assume that that a fraction δ of home agents and a fraction of δ^* of foreign agents become in panic and that these panicked agents sell all of their domestic equity. Like other cases, the price of domestic equity depends on the level of the tax rate τ. In particular, when τ is minimal, the price of domestic equity is:

$$(3.19) \quad P_t = \frac{\mathbb{E}_t(V_{t+1})}{R^f_{t+1}(1+\hat{\tau}) + \gamma \mathbb{Cov}_t\left(\tilde{R}_{t+1}, \frac{V_{t+1} + x^{np*}_{F,t} V^*_{t+1}}{(1-\delta)W_t + (1-\delta^*)W^*_t}\right)},$$

where $x^{np*}_{F,t}$ denotes the holding of international equity by non-panicked foreign agents. Based on a similar argument made earlier for the analysis on forced sale, the amount of net foreign sale should be minimal so that $x^{np*}_{F,t}$ is approximately equal to $1 - \delta^*$. Then, the price of domestic equity becomes:

$$(3.20) \quad P_t \cong \frac{\mathbb{E}_t(V_{t+1})}{R^f_{t+1}(1+\hat{\tau}) + \gamma \mathbb{Cov}_t\left(\tilde{R}_{t+1}, \tilde{R}^*_{t+1}\right)},$$

which exhibits that idiosyncratic risk pricing remains unchanged. On the other hand, when τ is excessively large, the price of domestic equity is:

$$(3.21) \quad P_t = \frac{\mathbb{E}_t(V_{t+1})}{R^f_{t+1}(1+\hat{\tau}) + \gamma \frac{(1-\omega_t)\mathbb{Var}_t\left(\tilde{R}_{t+1}\right)}{(1-\delta)}},$$

which reflects that the equity premium depends on the degree of panic among home agents in addition to the magnitude of domestic equity being sold by foreign agents. Since non-panicked home agents must absorb all domestic equity being sold for any motive during the stock market crash, the expected return must further increase to compensate these agents for taking additional risks. Equivalently, the price of domestic equity must fall to a sufficiently low level that investment in domestic equity appears attractive to non-panicked agents.

Several developments preceding the introduction of the URR measure could cause panic to be more concentrated among foreign agents. For instance, the widespread public antipathy towards the sale of Shin Corporation to Themasek, the advocacy for the King's "Sufficiency Economy" philosophy by the government at that time, and the ongoing investigation on illegal use of Thai nominee shareholders by foreign investors could induce a greater degree of panic among foreign agents due to the fear that Thailand might become more averse to foreign investment. Furthermore, opinions on the same event could differ markedly. Particularly, while Thai people might regard that the military coup that ousted the Thaksin administration in September could bolster political stability, foreigners might instead concern about the rise in military dictatorship.[15]

Consequently, the introduction of the URR measure could significantly fuel the anxiety of foreign agents especially if they anticipated that additional restrictions on foreign investment would likely follow. From the perspective of panicked foreign agents, the likelihood that Thai authorities would implement regulations that could adversely affect foreign investment might increase considerably, even though the BoT only intended to impose capital controls temporarily in order to mitigate currency appreciation. Such worries could arise in several forms. For example, foreign agents might fear about controls on financial outflows, taxes on foreign funds, and reductions in benefits currently provided to foreign investment. All of these concerns could lead foreign agents to significantly reduce their investment in Thailand.

It is worth mentioning that if the sale of domestic equity by foreign agents occurred primarily because of panic, the situation could be improved substantially. Better communication that properly conveyed the rationale for capital controls as well as firmly demonstrated the commitment to protect property rights and maintain favorable attitude towards foreign investment should help limit the degree of panic. In retrospect, the BoT's underestimation of the impact of capital controls on the stock market provided some explanation for why policymakers at that time paid little attention on communicating with the public.

In summary, massive foreign sale of domestic equity can arise on the basis of regular withdrawal, forced sale and rational panic. However, the level of the tax rate for new foreign investment in domestic equity is critical to determine whether a substantial decline in the price of domestic equity will occur. While all the three factors analyzed here can generate gigantic gross foreign sale, sizeable net foreign sale can occur only in the case that the tax rate is excessively large. Otherwise, other group of foreign agents will take advantage of purchasing domestic equity at a bargaining price. Hence, an excessively large tax rate for new foreign investment in domestic equity is essential to trigger a stock market crash.

[15] In retrospect, although it helped create more political stability in the short-run, the military coup became the cause of political turmoil for many years to come.

3.3.3 Supplementary Issues

This part addresses four important issues pertinent to the theoretical analysis on the stock market crash. The first issue focuses on the role of expected profitability and expected foreign sale in inducing changes in the price of domestic equity in order to complement the analysis in the previous part, which concentrates on changes in the expected return as a result of limited foreign participation. The second issue examines the importance of assumptions that are central to generate limited foreign participation in the economic environment compatible to Thailand. Specifically, a stock market crash is less likely if foreign investors can raise funds in the home country to purchase domestic equity or domestic agents can invest in international equity. The third issue analyzes the role of anticipated large capital inflows in driving the price of domestic equity. In particular, the price of domestic equity may fall to reflect the revised expectation that large capital inflows originally anticipated will not be materialized in the presence of capital controls. Lastly, the fourth issue considers the liquidity effect driven by limited foreign participation. If capital controls prevent foreign investors from trading actively in the domestic equity market, domestic equity can become much more illiquid. Consequently, a decline in the price of domestic equity occurs to compensate for the increased difficulty of liquidating domestic equity. The discussion addresses these four issues in turn.

❖ Expected Profitability and Expected Foreign Sale

A change in the price of domestic equity can also result from a change in the expected dividend payment in addition to a change in the expected return highlighted in the previous part's analysis. For simplicity, let's consider the following 3-period setup in which capital controls are introduced in period 1, are maintained in period 2, and are removed in period 3. Following the definition of the return on domestic equity between period t and $t+1$: $\tilde{R}_{t+1} = V_{t+1}/P_t = (D_{t+1} + P_{t+1})/P_t$, where D_{t+1} is the dividend payment in period $t+1$ based on profitability in period t, the Campbell-Shiller approximation yields:

$$(3.22) \quad p_t - d_t = const + \sum_{j=0}^{\infty} \rho^j \left(\Delta d_{t+j+1} - r_{t+j+1}\right),$$

where $p_t = log(P_t)$, $d_t = log(D_t)$, $r_t = log\left(\frac{D_{t+1}+P_{t+1}}{P_t}\right)$, $\rho = 1 - f'(dp_0)$, $f(dp_0) = log(1 + e^{dp_0})$, and dp_0 is the mean of $log\left(\frac{D_t}{P_t}\right)$. Then, the price of domestic equity in period 1 is:

$$(3.23) \quad p_1 = const + \mathbb{E}_1\big((1-\rho)d_2 - r_2\big) + \mathbb{E}_1\rho\big((1-\rho)d_3 - r_3\big) + \mathbb{E}_1\left(\sum_{j=4}^{\infty} \rho^{j-2}\left((1-\rho)d_j - r_j\right)\right).$$

If capital controls do not have any impact on long-term fundamentals (i.e. the last term in equation (3.23) remains constant), a change in the price of domestic equity can only occur as a result of a change in the expected dividend payment driven by profitability or the expected return during the period of capital controls (i.e. period 1 and 2). Therefore, only the price of domestic equity in period 1 and 2 are affected, while the price of domestic equity in period 3 remains unchanged.

The impact of capital controls on the expected dividend payment is ambiguous. Particularly, the expected dividend payment can be higher if capital controls induce exchange rate depreciation and thus promote strong export growth. However, the expected dividend payment can be lower if capital controls trigger a stock market crash and thus weaken consumer confidence as well as business sentiment. Hence, changes in expected profitability which critically depend on whether a stock market crash occurs are unlikely to serve as the key underlying factor for the stock market crash experienced by Thailand.

Furthermore, both immediate and expected foreign sale of domestic equity can influence the price of domestic equity on the back of changes in the expected return when the tax rate for new foreign investment in domestic equity is excessively large. For simplicity, assume no dividend payments, i.e. $D_2 = D_3 = 0$, a constant risk-free rate, i.e. $R_t^f = R^f$, and time-invariant second moments of the return of equity, i.e. $\mathbb{Var}_t(\tilde{R}_{t+1}) = \mathbb{Var}(\tilde{R})$ and $\mathbb{Cov}_t(\tilde{R}_{t+1}, \tilde{R}_{t+1}^*) = \mathbb{Cov}(\tilde{R}, \tilde{R}^*)$. Then, the price of domestic equity in period 1 without capital controls is:

$$(3.24) \quad P_1^o = \frac{\mathbb{E}_1(P_3)}{\left(R^f + \gamma \mathbb{Cov}(\tilde{R}, \tilde{R}^*)\right)^2} = \frac{\mathbb{E}_1(P_3)}{\left(R^f + \gamma(1-\omega_0)\mathbb{Var}(\tilde{R})\right)^2},$$

and the price of domestic equity in period 1 with capital controls is:

$$(3.25) \quad P_1^c = \frac{\mathbb{E}_1(P_3)}{\left(R^f(1+\hat{\tau}) + \gamma(1-\omega_1)\mathbb{Var}(\tilde{R})\right)\left(R^f(1+\hat{\tau}) + \gamma(1-\omega_2)\mathbb{Var}(\tilde{R})\right)}.$$

While immediate foreign sale affects the price through the expected return as ω_0 decreases to ω_1, expected foreign sale also affects the price via the term ω_2. Expected foreign sale means $\omega_2 < \omega_1$ so that the price in period 1 declines further due to the higher expected return in period 2. In short, the price of domestic equity depends on the effective expected return defined as the average of the expected returns over the entire period of capital controls.

❖ Importance of Assumptions

Two assumptions based on Thailand's institutional features are central to generate limited foreign participation. A stock market crash is less likely to occur when one of these two characteristics is not present. The first assumption is that the foreign agent cannot raise funds in the home country to purchase domestic equity. Then, the original budget constraint:

$$(3.10)\quad W^*_{t+1} = R^f_{t+1}W^*_t + \left(V^*_{t+1} - R^f_{t+1}P^*_t\right)x^*_{F,t} + \left(V_{t+1} - R^f_{t+1}P_t\right)x^*_{D,t} + \tau\left(x^*_{D,t} - x^*_{D,t-1}\right)P_t\mathcal{I}\left\{x^*_{D,t} > x^*_{D,t-1}\right\},$$

which illustrates that funds for foreign investment in domestic equity must come from the foreign country, becomes:

$$(3.26)\quad W^*_{t+1} = R^f_{t+1}W^*_t + \left(V^*_{t+1} - R^f_{t+1}P^*_t\right)x^*_{F,t} + \left(V_{t+1} - R^f_{t+1}(1+\hat{\tau})P_t\right)x^*_{D,t},$$

which implies that the foreign agent can raise funds in the home country to purchase domestic equity. By doing so, the foreign agent can avoid the punitive tax rate for incoming foreign funds for investment in domestic equity. Based on the new budget constraint (3.26), the price of domestic equity follows:

$$(3.27)\quad P_t \cong \frac{\mathbb{E}_t(V_{t+1})}{R^f_{t+1}(1+\hat{\tau}) + \gamma\mathbb{Cov}_t\left(\tilde{R}_{t+1}, \tilde{R}^*_{t+1}\right)},$$

which suggests that risk sharing remains regardless of the level of the tax rate for new foreign investment in domestic equity. The price of domestic equity should fall by a much smaller magnitude since the increase in the risk-free rate looks minimal compared to the tax rate applicable for equity investment.

The second assumption is that the home agent does not invest in international equity. If the home agent's portfolio consists of international equity, risk sharing would remain to some extent even if the tax rate for new foreign investment in domestic equity is excessively large. In particular, the price of domestic equity conforms to:

$$(3.28)\quad P_t = \frac{\mathbb{E}_t(V_{t+1})}{R^f_{t+1}(1+\hat{\tau}) + \gamma\left(\alpha_{D,t}\mathbb{Var}_t\left(\tilde{R}_{t+1}\right) + \alpha_{F,t}\mathbb{Cov}_t\left(\tilde{R}_{t+1}, \tilde{R}^*_{t+1}\right)\right)},$$

where $\alpha_{D,t} = \left(x_{D,t}P_t\right)/W_t$ and $\alpha_{F,t} = \left(x_{F,t}P^*_t\right)/W_t$ are the fraction of the home's agent wealth invested in domestic and international equity, respectively. If $\alpha_{F,t}$ is very large relative to $\alpha_{D,t}$, the pricing formula for all tax rates would converge; domestic equity remains to be priced by world aggregate risks. Under such circumstances, even though the foreign agent's participation may become limited, risk sharing does not vanish. Hence, a stock market crash is less likely to occur when the home agent also invests in international equity.

❖ Anticipation of Large Capital Inflows

Since restrictions on financial flows tend to be imposed in response to an anticipated influx of foreign funds, the price of domestic equity may fall to reflect the revised expectation that large capital inflows originally anticipated will not be materialized.

Here, key factors underlying capital flow developments are additional costs that the foreign agent faces when investing in domestic equity. Specifically, the original budget constraint (3.2) becomes:

(3.29) $W_{t+1}^{*} = R_{t+1}^{f} W_t^{*} + \left(V_{t+1}^{*} - R_{t+1}^{f} P_t^{*}\right) x_{F,t}^{*} + \left(V_{t+1} - R_{t+1}^{f}(1+\phi_t) P_t\right) x_{D,t}^{*},$

where ϕ_t captures such additional costs, which may include information cost (to observe what happen abroad), management cost (to satisfy additional regulatory requirements) and financing cost (for borrowing funds to finance overseas investment which is deemed more risky).

Based on Thailand's experience, an influx of foreign funds into the home country might result from a reduction in ϕ_t driven by a decline in financing cost due to the global saving glut or the global liquidity excess. Particularly, the amount of foreign investment in domestic equity increased significantly as the majority of inflows since 2004 took the form of direct investment and portfolio equity investment.

In order to see the role of anticipated capital inflows, let's examine how an expected decline in ϕ_2 affects the price of domestic equity in the 3-period framework analyzed above. Suppose that $\phi_1 = \phi_3 = \phi_H > \phi_L = \phi_2$. When the tax rate for new foreign investment in domestic equity is excessively large, the change in the price of domestic equity in period 1 as a result of capital controls follows:

$$\frac{P_1^c}{P_1^o} = \frac{\left(R^f(1+\phi_H) + \gamma \mathbb{Cov}(\tilde{R}, \tilde{R}^*)\right)\left(R^f(1+\phi_L) + \gamma \mathbb{Cov}(\tilde{R}, \tilde{R}^*)\right)}{\left(R^f(1+\hat{\tau}) + \gamma(1-\omega_1)\mathbb{Var}(\tilde{R})\right)\left(R^f(1+\hat{\tau}) + \gamma(1-\omega_2)\mathbb{Var}(\tilde{R})\right)}$$

(3.30) $$\frac{P_1^c}{P_1^o} = \left\{\frac{R^f\left(1+\phi_L\right) + \gamma \mathbb{Cov}(\tilde{R}, \tilde{R}^*)}{R^f\left(1+\phi_H\right) + \gamma \mathbb{Cov}(\tilde{R}, \tilde{R}^*)}\right\} \cdot \left\{\frac{\left(R^f + \gamma(1-\omega_0)\mathbb{Var}(\tilde{R})\right)^2}{\left(R^f(1+\hat{\tau}) + \gamma(1-\omega_1)\mathbb{Var}(\tilde{R})\right)\left(R^f(1+\hat{\tau}) + \gamma(1-\omega_2)\mathbb{Var}(\tilde{R})\right)}\right\}$$

since $R^f(1+\phi_H) + \gamma \mathbb{Cov}(\tilde{R}, \tilde{R}^*) = R^f + \gamma(1-\omega_0)\mathbb{Var}(\tilde{R})$. Thus, equation (3.30) suggests that the decline in the price comes from two sources. The former part captures the change in ϕ_t. Without capital controls, there would be a larger amount of foreign investment in period 2; P_1^o would also rise to reflect a reduction in ϕ_2. However, when capital controls exist with an excessively large tax rate, no new foreign investment would come in, and P_1^c should not be affected by the expected decline in ϕ_2. On the other hand, the latter part captures the change in the equity premium through the principal mechanism underpinned by limited risk sharing. In short, the price of domestic equity may fall on account of the revised expectation reflecting the drainage of potential large capital inflows in addition to the revaluation of idiosyncratic risks triggered by reduced risk sharing.

❖ Liquidity Effect

Limited foreign participation may cause a sharp decline in the liquidity of domestic equity if capital controls prevent foreign agents from trading actively in the domestic stock market. For Thailand, the liquidity effect could be particularly significant because the value of trading activities by foreign investors accounted for 28.3, 34.4 and 34.2 percent of all trading activities in 2005, 2006 and 2007, respectively. In order to illustrate the liquidity effect, the analysis only considers certain aspect of liquidity, which focuses on how potential temporary withdrawal of investment in equity in between periods affects the price.

Specifically, in period t, all agents invest in equity with the expectation that at the middle point between period t and $t+1$, a fraction θ of agents need to hold no equity temporarily. Consequently, the rest of agents must absorb all equity being sold. However, in period $t+1$, all agents will resume to hold equity as usual; thus, the value of equity in period $t+1$ remains unaffected. Based on this setup, the price of domestic equity becomes:

(3.31) $$P_t = \frac{\mathbb{E}_t(V_{t+1})}{\left(R^f_{t+1}+\gamma\mathbb{Cov}_t(\tilde{R}_{t+1},\tilde{R}^*_{t+1})\right)^{1/2}\left(R^f_{t+1}+\gamma\mathbb{Cov}_t(\tilde{R}_{t+1},\tilde{R}^*_{t+1})+\gamma\frac{\theta}{(1-\theta)}\frac{P_t}{(W_t+W^*_t)}\mathbb{Var}_t(\tilde{R}_{t+1})\right)^{1/2}},$$ [16]

which illustrates that the price of domestic equity in period t would be lower to compensate for potential risks attached to the need to sell equity at the time when a sizeable withdrawal of investment in equity occurs. The expected return thus becomes higher due to the existence of the equity premium component reflecting liquidity (henceforth referred to as liquidity premium), which is another part of the equity premium in addition to the component reflecting risk analyzed so far. In particular, the liquidity premium takes the form of:

(3.32) $$\gamma\frac{\theta}{(1-\theta)}\frac{P_t}{(W_t+W^*_t)}\mathbb{Var}_t(\tilde{R}_{t+1}),$$

which is proportional to the variance of the return on domestic equity. The magnitude of the liquidity premium depends on two factors. One is the size of potential temporary

[16] This pricing formulation can be derived from:

$$P_t = \frac{\mathbb{E}_t(V_{t+1})}{\left(R^f_{t+1}+\gamma\mathbb{Cov}_t(\tilde{R}_{t+1},\tilde{R}^*_{t+1})\right)^{1/2}\left(R^f_{t+1}+\gamma\mathbb{Cov}_t\left(\tilde{R}_{t+1},\frac{V_{t+1}+(1-\theta)V^*_{t+1}}{(1-\theta)(W_t+W^*_t)}\right)\right)^{1/2}},$$

which reflects that a fraction of θ of all agents temporarily do not hold domestic equity while all foreign agents still hold international equity.

withdrawal, which is captured by θ.[17] Another factor is the relative importance of domestic equity in the overall portfolio.[18] Furthermore, the liquidity premium is essentially negligible in the case that home equity is relatively small to total wealth.

In the presence of capital controls, the level of the tax rate for new foreign investment in domestic equity is the principal determinant for the liquidity effect. Particularly, the liquidity premium remains unchanged when the tax rate is minimal. However, when the tax rate is excessively large, the liquidity premium becomes:

$$(3.33)\quad \gamma\frac{\theta}{(1-\theta)}(1-\omega_{t+0.5})\mathbb{Var}_t(\tilde{R}_{t+1}) \cong \gamma\frac{\theta}{(1-\theta)}\frac{x_{D,t+0.5}P_t}{W_t}\mathbb{Var}_t(\tilde{R}_{t+1}),$$

which suggests that the increase in the liquidity premium can come occur based on two factors. First, the liquidity premium is no longer negligible due to limited foreign participation induced by the excessively large tax rate. Another arises from additional foreign sale of domestic equity, with any foreign sale on the basis of temporary withdrawal turning out to be permanent. Foreign funds that leave the home country would never return during the period of capital controls. To sum up, capital controls with an excessively large tax rate can cause the price of domestic equity to fall more as limited foreign participation leads domestic equity to become significantly illiquid.

3.3.4 Policy Implications

The theoretical analysis illustrates that capital controls with an excessively large tax rate for new foreign investment in domestic equity is likely to cause a stock market crash. The substantial decline in the price of domestic equity primarily results from reduced risk sharing that arises from a combination of limited foreign participation and massive foreign sale of domestic equity. Key policy implications can be drawn as follows.

First of all, capital controls should remain a viable policy option since a stock market crash is unlikely to occur when the tax rate for new foreign investment in domestic equity is minimal.[19] However, it is imperative that a well-designed capital control regime is implemented. In particular, the effective tax rate for overall foreign investment must be sufficiently large to preserve the efficacy of capital controls, while the implicit tax rate

[17] For stocks with regular trading, the value of θ should be relatively low since anyone who would like to sell such stocks should be able to sell at a reasonable price. On the other hand, stocks with infrequent trading should feature a higher value of θ since any sale would mean a sizeable withdrawal.

[18] In the case of financial autarky, the domestic agent's portfolio is largely overwhelmed by domestic equity so that the liquidity premium becomes: $\gamma\frac{\theta}{(1-\theta)}\mathbb{Var}_t(\tilde{R}_{t+1})$.

[19] Based on the theoretical analysis, the relationship between the probability of a stock market crash and the level of the tax rate for new foreign investment in domestic equity is likely to be an S-shape.

for new foreign investment in the stock market at the same time must be minimal to assure that a stock market crash is avoided.[20]

For Thailand, the implicit tax rate for new foreign investment in the stock market could be significantly lower if the capital control regime shares one of the following features:[21]

- Inflows to the stock market are not subjected to capital controls at all. This option was taken by the BoT after the stock market crash. The major drawback is that when portfolio investment in equity is the major component of inflows as it is the case for Thailand, capital controls might not be much effective.
- Inflows to the stock market while remaining subjected to the reserve requirement are exempted from the penalty on early withdrawal. In this case, the implicit tax rate would not be sufficiently large to cause a stock market crash.
- Inflows to the stock market are subjected to other type of restrictions. For instance, such inflows might be subjected to the full hedging obligation instead of the reserve requirement. Because full hedging effectively nullifies any potential gain from exchange rate appreciation, the investment decision would become more focused on the fundamentals underlain by firm profitability rather than speculative motives related to currency appreciation.

Regarding policy responses to a stock market crash, the priority should be to eliminate the excessively large implicit tax rate for new foreign investment in the stock market.[22,23] In addition, better communication with the public is essential for calming down panic.

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[20] Another important consideration is that benefits provided by capital controls such as enhancing macroeconomic stability should outweigh associated costs, including potential micro-level distortions as well as contractionary effects (resulting from a stock market crash).

[21] In any case, the ability to distinguish foreign funds for investment in the stock market from other types of inflows is crucial; otherwise, people can circumvent by relabeling other types of funds as portfolio investment in equity. Based on Thailand's experience, the BoT stipulated that foreign funds for investment in the stock market must be transacted through a special non-resident baht account for securities.

[22] However, the extent of relaxation should depend on the source of foreign sale. If regular withdrawal is predominant, whether the control is entirely removed is not much important. As long as the tax rate becomes minimal, any foreign investor who sold domestic equity based on regular withdrawal would soon resume purchasing domestic equity. On the other hand, if forced sale is the major source, a complete removal of the control might be necessary in the case that no other group of foreign investors would come in to take advantage of inexpensive domestic equity. Lastly, if foreign sale is mostly driven by rational panic, maintaining a minimal tax rate would be sufficient to attract foreign agents to return after panic subsides. A partial removal together better communication with the public should be able to calm down the anxiety of investors.

[23] Empirical evidence and casual observation suggest that the selling pressure from forced sale and rational panic seemed limited for two reasons. First, stocks that were initially held more by foreign investors did not experience a larger decline in share prices after controlling for changes in equity premiums. In addition, the large amount of gross foreign purchase of 11 billion baht during the stock market crash revealed that some foreign investors eager to purchase inexpensive domestic equity.

Lastly, the outcome of capital controls critically depends on existing institutional arrangements as well as initial conditions. For example, a stock market crash is more likely to occur in Thailand because foreign investors hold Thai share directly rather than through other vehicles such as American depository receipts (e.g. Brazil and Chile). Moreover, the penalty on early withdrawal might not matter considerably if foreign investors could retain funds between each stock trading in the domestic financial system.

3.4 Empirical Evidence

This section's central objective is to provide empirical evidence for supporting the theoretical analysis that the excessively large implicit tax rate for new foreign investment in domestic equity was the predominant factor that caused the stock crash. In particular, the empirical analysis examines factors that influenced changes in share prices across stocks traded on Thailand's stock market during the stock market collapse and rebound. Part 3.4.1 discusses the data and methodology used for the empirical analysis. Part 3.4.2 shows preliminary empirical results which explore potential explanatory factors for changes in share prices. Part 3.4.3 presents baseline empirical results which demonstrate that difference in covariances and trading frequency are the most influential explanatory factor for changes in share prices across firms. Hence, a revaluation of idiosyncratic risks and a change in stocks' liquidity served as the principal mechanisms that drove substantial movements of share prices. Part 3.4.4 discusses extended empirical results that address additional issues, including momentum anomaly, profitability impact and size effect. These extended results do not stand in contradiction to the baseline results. In brief, empirical evidence presented here suggests that that the stock market crash mainly resulted from the excessively large implicit tax rate.

3.4.1 Data and Methodology

The empirical analysis examines factors underlying changes in share prices across stocks traded on Thailand's stock exchange during the stock market collapse and rebound. The dataset, which is constructed based on data from SETSmart, Datastream and Thomson One Banker, covers 509 stocks that were actively traded on Thailand's stock market at the time the URR measure was introduced on December 18, 2006.

In contrast to the theoretical analysis that is essentially based on representative domestic equity, the empirical analysis aims to exploit the variation in share prices across firms and time frames to identify factors that triggered the stock market crash. Building on Chari and Henry (2004), Errunza and Losq (1985), and Hietala (1989), the methodology for the empirical analysis can be summarized as follows.

Capital controls can affect share prices through changes in either the expected dividend payment or the expected return. Based on the Campbell-Shiller approximation, the price of the stock i in the home country can be written as:

$$(3.34)\quad p_{i,t} = const + \mathbb{E}_t\Big((1-\rho)d_{i,t+1} - r_{i,t+1}\Big) + \mathbb{E}_t\left(\sum_{j=2}^{\infty}\rho^{j-1}\Big((1-\rho)d_{i,t+j} - r_{i,t+j}\Big)\right),$$

where $p_{i,t}$ is the price in period t, $d_{i,t+1}$ is the dividend payment in period $t+1$ based on profitability in period t, and $r_{i,t+1}$ is the (gross) return between period t and $t+1$. All variables are expressed on logarithmic scale. Suppose that capital controls are imposed temporarily between period t and $t+1$ and also do not have any impact on long-term fundamentals, i.e. the last term in equation (3.34) remains constant. Then, the change in $p_{i,t}$ due to capital controls only depends on the change in the expected return $\mathbb{E}_t r_{i,t+1}$ and the expected dividend payment $\mathbb{E}_t d_{i,t+1}$.

❖ Change in Expected Return

Based on the theoretical analysis, the expected return on stock i, denoted by $R_{i,t+1}$, takes the form of:

$$(3.35)\quad \mathbb{E}_t(R_{i,t+1}) = R_{f,t+1} + \eta_{i,t+1} = R_{f,t+1} + \eta_{i,+t+1}^{risk} + \eta_{i,+t+1}^{liquidity} + \eta_{i,+t+1}^{anomaly},$$

where $R_{f,t+1}$ is the risk-free rate that prevails in the home country and $\eta_{i,t+1}$ is the equity premium consisting of three components that reflect risk, liquidity and anomaly. The risk component prices idiosyncratic risks with respect to systematic risks, the liquidity component compensates for costs of liquidating illiquid financial assets, and the anomaly component captures additional characteristics such as momentum driven by the anticipation of large capital inflows. The following discussion addresses how the imposition of capital controls influences the risk-free rate as well as all the three components of the equity premium.

Let's first consider how capital controls affect the risk-free rate and the equity premium component reflecting risk. Under the assumption that agents maximize their wealth, when the home country is financially integrated with the world without capital controls, the expected return on stock i features a CAPM-typed form of:

$$(3.36)\quad \mathbb{E}_t(R_{i,t+1}) = R_{f,t+1} + \gamma\mathbb{C}\mathbb{O}\mathbb{V}_t(R_{i,t+1}, R_{W,t+1}) = R_{t+1}^{f} + \gamma\mathbb{C}\mathbb{O}\mathbb{V}_t(R_{i,t+1}, \tilde{R}_{t+1}^{*}),$$

where γ is the relative risk aversion, $R_{W,t+1}$ is the return on wealth of the representative agent holding stock i, R_{t+1}^{f} is the international risk-free rate, and $\tilde{R}_{t+1}^{*}$ is the return on international equity. Intuitively, the risk-free rate in the home country must be equalized to the international risk-free rate, and idiosyncratic risks associated with stock i should be priced by world aggregate risks. It is noteworthy that when home agents do not hold international equity, it is plausible that some stocks in the home country could be held only by either home or foreign agents. Therefore, these stocks should be priced by either the return on home wealth or the return on foreign wealth, respectively. This is Thailand's situation prior to the introduction of capital controls.

Suppose that capital controls are imposed with an excessively large implicit tax rate for new foreign investment in domestic equity. Since the excessively large tax rate leads to limited foreign participation, stocks in the home countries would be instead priced by the return on home wealth equaling to $(1-\omega_t)\tilde{R}_{t+1}$, which depends on the return on domestic equity and the holding of domestic equity by home agents captured by ω_t. Recall that foreign sale, which can be driven by various factors such as regular withdrawal, forced sale and rational panic, contributes to a decline in ω_t. The home country may equivalently turn into financial autarky if ω_t reaches zero. Let $\hat{\tau}$ be the effective tax rate for overall foreign investment. Then, the expected return on stock i as a result of capital controls becomes:

(3.37) $\mathbb{E}_t\left(R_{i,t+1}\right) = R_{f,t+1} + \gamma \mathbb{Cov}_t\left(R_{i,t+1}, R_{W,t+1}\right) = R^f_{t+1}(1+\hat{\tau}) + \gamma(1-\omega_t)\mathbb{Cov}_t\left(R_{i,t+1}, \tilde{R}_{t+1}\right).$

Up to this point, the expected return on stock i may change for two reasons. One is that the risk-free rate prevailing in the home country would rise to reflect additional costs for obtaining funds from abroad, with the increase in the risk-free rate equaling to:

(3.38) $\Delta R_{f,t+1} = R^f_{t+1}\hat{\tau} \cong \hat{\tau}.$

Another is that the equity premium component reflecting risk would also change. Because of acquiring all domestic equity being sold by foreign agents, home agents would inevitably bear greater risks. For stocks which are initially held by both home and foreign agents, the change in the equity premium component reflecting risk should be:

(3.39) $\Delta \eta^{risk}_{i,t+1} = \gamma\left(\left(1-\omega_t\right)\mathbb{Cov}_t\left(R_{i,t+1}, \tilde{R}_{t+1}\right) - \mathbb{Cov}_t\left(R_{i,t+1}, \tilde{R}^*_{t+1}\right)\right),$

which suggests that difference in covariances characterized by $\mathbb{Cov}\left(R_{i,t}, \tilde{R}_t\right) - \mathbb{Cov}\left(R_{i,t}, \tilde{R}^*_t\right)$ should be a significant factor that explains the change in share prices across firms.[24] In the baseline empirical analysis, covariances are calculated based on daily returns from the same trading date,[25] with the SET index representing the return on domestic equity and the MSCI World index representing the return on international equity.

[24] Under the assumption that second moments of all returns are time-invariant, $\mathbb{Cov}_t\left(R_{i,t+1}, \tilde{R}_{t+1}\right) - \mathbb{Cov}_t\left(R_{i,t+1}, \tilde{R}^*_{t+1}\right)$ becomes equivalent to $\mathbb{Cov}\left(R_{i,t}, \tilde{R}_t\right) - \mathbb{Cov}\left(R_{i,t}, \tilde{R}^*_t\right)$.

[25] One common issue of using daily returns from different countries is the time alignment because of differences in market business hours. It is plausible to calculate difference in covariances using different time alignments, e.g. (i) the return on international equity lagged by one day, (ii) both returns from the two

There are three important caveats. First, difference in covariances might not perfectly quantify the change in the equity premium component reflecting risk because the exact change depends on ω_t. Nonetheless, difference in covariances should serve as a good proxy that captures the revaluation of idiosyncratic risks. Second, the change in systematic risks relevant for idiosyncratic risk pricing is not limited to stocks being held by foreign agents prior to the imposition of capital controls. Stocks being completely held by home agents initially should also experience an increase in the expected return. The reason is that idiosyncratic risk pricing depends on the representative home agent's portfolio which would become more exposed to domestic equity. Third, the analysis implicitly assumes that all stocks are integrated with the market (i.e. stocks that are actively traded by a large number of shareholders). However, in reality, some stocks are held by a limited number of shareholders. These non-market stocks should not experience any re-pricing of idiosyncratic risks since they are not an integral part of the representative domestic equity.

Next, let's consider how capital controls affect the equity premium component reflecting liquidity. It is worth emphasizing that while an increase in systematic risks serves as the triggering mechanism of a stock market crash, a reduction in stocks' liquidity would have some impact on share prices only after the crash actually occurs. Specifically, some investors (both home and foreign) may become in panic and withdraw their investment in domestic equity in the aftermath of the stock market collapse so that the liquidity premium would increase. Note that stocks that are integrated with the market are more likely to experience a larger increase in the liquidity premium than non-market stocks. The reason is that shareholders of non-market stocks have taken account of illiquidity of these stocks in the first place.

Furthermore, stocks that are initially held by foreign investors should experience some additional increase in the liquidity premium. Recall that when the tax rate for inflows of foreign funds for investment in the stock market is excessively large, new foreign investment in domestic equity becomes unprofitable. A sharp reduction in trading activities by foreign investors (which account for about 30 percent of all trading activities) would certainly lead to a marked increase in the liquidity premium of stocks that are a part of foreign portfolio investment. The upshot is that trading frequency defined as the ratio of active trading days to total trading days, which can capture the degree of stocks' liquidity, should be an important factor that explains the change in share prices across firms.

Lastly, let's consider the equity premium component reflecting anomaly. Here, anomaly is limited to momentum driven by the anticipation of large capital inflows. As discussed in the theoretical analysis, the anticipation of large incoming foreign funds should lead to

adjacent trading dates, and (iii) both returns from the same trading week (thus weekly returns are used instead). Nevertheless, key empirical results are not sensitive to how covariances are calculated.

an immediate increase in share prices. In reality, share prices might instead increase steadily over time because each agent might recognize such development at a different point of time. This characteristic is consistent with the model featuring momentum traders by Hong and Stein (1999). When capital controls are imposed with an excessively large implicit tax rate for new foreign investment in domestic equity, limited foreign participation leads to the drainage of foreign funds and breaks down the momentum anomaly. As a result, share prices fall as people recognize that large capital inflows originally anticipated will not be materialized.

Since the anticipation of large capital inflows should be reflected by an increase in share prices over the period prior to the introduction of capital controls, abnormal price gain given that stocks are held by foreign investors should be an important factor that explains the change in share prices. To be specific, abnormal price gain is defined as the sum of $\varepsilon_{i,t}$ over some specified period from the following regression:

$$(3.40) \quad \frac{\Delta P_{i,t+1}}{P_{i,t}} = \alpha_i + \beta_i \tilde{R}^*_{t+1} + \varepsilon_{i,t+1},$$

where $\beta_i = \mathbb{Cov}(R_{i,t}, \tilde{R}^*_t)/\mathbb{Var}(\tilde{R}^*_t)$, i.e. the beta for stock i based on the global stock market.

In summary, the imposition of capital controls can affect share prices on account of changes in expected returns. While the risk-free rate should increase regardless, equity premiums should rise only if the implicit tax rate for new foreign investment in domestic equity is excessively large. Moreover, changes in equity premiums should be primarily driven by a re-pricing of idiosyncratic risks and a change in stocks' liquidity since the momentum story only works in the case that the expectation of large capital inflows has been in place.

❖ Change in Expected Dividend

In addition to changes in the expected return, changes in the expected dividend payment may provide another mechanism that influences share prices. In particular, the expected dividend payment of stock i depends on the firm's profitability during the period of capital controls. Profitability can be affected by capital controls for various reasons, which could be broadly classified into two categories: the nature of business and the structure of finance.

Regarding the nature of business, the impact of capital controls should be different across firms and industries. For instance, if capital controls induce some exchange rate depreciation, firms in the exporting sector should benefit while firms that intensively use imported inputs should suffer. If capital controls trigger a stock market crash, firms with business largely dependent on consumer confidence such as firms in the property development sector should encounter a sharp reduction in revenues. Furthermore, banks are likely to be adversely affected by a fall in credit expansion as well as a rise in non-performing loans in the aftermath of the stock market crash. In this context, business-type indicators should be sufficient to capture differences arising from the nature of business across industries.[26]

Regarding the structure of finance, the imposition of capital controls definitely raises costs of capital as the risk-free rate prevailing in the home country becomes higher. Therefore, firms with a high level of debt should experience a decline in profitability due to rising costs of capital. In this context, variables measuring firms' reliance on debt financing should be able to explain differences stemming from the structure of finance across firms.

It is noteworthy that the change in expected dividend payments should explain the change in share prices regardless of the level of the implicit tax rate for new foreign investment in domestic equity; the question would be whether such effects are significant.

❖ Regression

The empirical analysis can be undertaken based on the following regression:

(3.41) $\Delta p_i = \alpha + x_i^r \beta_r + x_i^d \beta_d + \varepsilon_i,$

where Δp_i is the change in share prices, x_i^r are variables capturing the change in equity premiums (e.g. difference in covariances, trading frequency, and abnormal price gain), x_i^d are variables capturing the change in profitability (e.g. business-type indicators and variables measuring firms' reliance on debt), and ε_i is the error term.

Essentially, the regression equation (3.41) reflects that the change in share prices can arise from:

(3.42) $\Delta p_{i,t} = (1-\rho)\Delta\left(\mathbb{E}_t d_{i,t+1}\right) - \Delta\left(\mathbb{E}_t r_{i,t+1}\right) = (1-\rho)\Delta\left(\mathbb{E}_t d_{i,t+1}\right) - \Delta r_{f,t+1} - \Delta\left(\mathbb{E}_t \eta_{i,t+1}\right),$

where Δ denotes the pre-control and post-control difference. Thus, the constant term α in the regression equation (3.41) should capture the change in the risk-free rate as well as the average effect of capital controls on firm profitability.

Since the principle hypothesis is whether the excessively large implicit tax rate for new foreign investment in domestic equity was the predominant factor that caused the stock market collapse, the baseline specification focuses on examining the revaluation of

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[26] Based on the categorization of firms by the Stock Exchange of Thailand, stocks can be classified into 8 industry groups and 25 (sub-industry) business types in addition to the other separated group for (small-sized enterprise) stocks listed on the Market for Alternative Investment. The sub-industry categorization provides business-type indicators used in the empirical analysis.

idiosyncratic risks and the change in stocks' liquidity.[27] As a result, $x_{i,t}^r$ only contains difference in covariances and trading frequency, while $x_{i,t}^d$ includes business-type indicators to control for differences across sectors. The OLS estimates for coefficients associated with difference in covariances and trading frequency should be consistent provided that these two variables are uncorrelated with the momentum anomaly and the expected change in firm profitability, which are left in the error term.[28] Although there is no legitimate reason for why such a correlation should exist, the extended empirical results confirm that the inclusion of additional factors does not change the baseline empirical results.[29] In some sense, Thailand's stock market crash triggered by the introduction of capital controls offered an excellent natural experiment setup to test risk-sharing and liquidity effects.

To sum up, difference in covariances and trading frequency should largely explain changes in share prices during the stock market collapse and rebound in order to support the hypothesis that the excessively large implicit tax rate was the leading factor that caused the stock market crash on the back of limited foreign participation.

❖ Data Related Issues

The dataset for the empirical analysis largely comprises data readily available from SETSmart, Datastream and Thomson One Banker; however, some variables are needed to be created. As the preceding discussion addresses the construction of other important variables used in the empirical analysis, the focus here is to explain how to construct the foreign ownership variable.

The amount of foreign ownership of stock i is, by construction, the percentage of foreign ownership in company i based on the most recent ownership record prior to December 18, 2006. The ownership record is typically available when the company pays dividends or holds a meeting to make important decisions. For most stocks, the foreign ownership variable is constructed based on the ownership record within six months prior to the introduction of capital controls. Since the sources of foreign sale (e.g. regular withdrawal, forced sale and rational panic) tend to be applicable for portfolio investment,

[27] These two channels are highlighted by the theoretical analysis. Moreover, the preliminary empirical results suggest that difference in covariances and trading frequency are the most important explanatory variables for changes in share prices.

[28] Another implicit requirement is that measurement errors associated with the computation of difference in covariances are random.

[29] The correlation between difference in covariances and change in firm profitability is not an issue in this study unlike Chari and Henry (2004). In their study, which examined the impact of financial liberalization on risk sharing, countries tend to undertake financial liberalization when economic conditions are benign. Therefore, share prices may increase because of an expected improvement in firm profitability or a reduction in equity premiums due to risk sharing. Here, there is no strong reason for why benefits from risk sharing should vary with expected changes in firm profitability. In any case, business-type indicators should capture expected changes in firm profitability to certain extent.

not direct investment, it seems more appropriate to exclude foreign ownership whose holding is larger than five percent as this type of foreign investment could be considered as direct investment. This adjusted version, referred as foreign ownership – portfolio and denoted by FO^P, is used in the baseline empirical analysis.[30]

3.4.2 Preliminary Results

The preliminary empirical analysis aims to provide a statistical summary rather than a rigorous empirical assessment of what happened during the stock market collapse and rebound. To explore potential explanatory variables for changes in share prices, this part uses bivariate regressions controlling for industry-specific factors:

(3.43) $\Delta P_i = \alpha + \beta X_i + Z_i^{'}\theta + \varepsilon_i$,

where ΔP_i is the change in share prices, X_i is the explanatory variable of interest and Z_i is the set of business-type indicators. Table 3.2 presents regression results which can be summarized as follows.

Difference in covariances and trading frequency are the most important factors that explain changes in share prices at all time frames during the stock market collapse and rebound. There two factors can account for 36 (34) and 26 (25) percent of the variation in share prices during the collapse (rebound), respectively. Moreover, all coefficients associated with these two factors are statistically significant with the appropriate sign. Hence, a re-pricing of idiosyncratic risks and a change in stocks' liquidity appeared as key mechanisms that caused changes in share prices.

Foreign ownership can explain changes in share prices to some extent. Only foreign ownership based on portfolio investment exhibits a statistically significant relationship with changes in share prices, with stocks owned more by foreign investors encountering larger share price movements. Thus, foreign sale was primarily driven by portfolio investment rather than long-term investment. In addition, foreign ownership mainly explains the variation in share prices at the market opening on the crash day (17 percent based on FO^P) as the R-square is much lower at other time frames.

Profitability measures minimally explain the variation in share prices, with the R-square ranging between 2 and 4 percent. Furthermore, the profitability impact on share prices

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[30] An alternative measurement is to use the percentage of foreign ownership consisting of minor shareholders and non-voting depository receipt (NVDR) holders; this version is denoted by FO^{MN} (foreign ownership – minority and NVDR). It is worth discussing that NVDR, which is considered as a Thai entity, enables foreign investors to undertake investment in listed companies with foreign holding exceeding the legal limit (e.g. 50 percent for a typical Thai company). Since NVDR provides all financial benefits but no voting rights, it is not possible for foreign investment in the form of NVDR to gain control of particular companies.

seemed lasting beyond the overnight removal of the control on inflows to the stock market since all profitability measures exhibit some statistically significant relationship with changes in share prices during the stock market crash only.[31] In short, changes in expected dividend payments did not seem to considerably affect share prices during the stock market collapse and rebound.

Leverage measures only explain the variation in share prices at the market opening of the crash day, with companies more reliant on debt financing experiencing a larger decline in share prices. The insensitivity of profitability to the structure of finance suggests that the imposition of capital controls would have minimal effects on the risk-free rate or that listed companies would not encounter much difficulty with borrowing funds. The latter appears consistent with Forbes (2006) which found that capital controls made it more difficult for small-sized firms in Chile to obtain funds for financing investment projects.

The momentum anomaly is not supported by regression results. In particular, stocks with some abnormal price gain actually experienced a smaller decline in share prices during the stock market crash, even though the momentum story based on the anticipation of large financial inflows implies that a greater decline in share prices of these stocks should occur. Nevertheless, the ability of abnormal price gain to explain the variation in share prices looks limited.

Among other company characteristics, firm size seems able to explain changes in share prices. Specifically, firms with a larger size faced a greater decline (or increase) in share prices during the collapse (or rebound). Moreover, firm size, similar to foreign ownership, mainly explains the variation in share prices at the market opening of the crash day (12-13 percent). The size effect existed chiefly because foreign funds for portfolio investment tended to concentrate at large firms. As a result, stocks of large firms endured more selling pressure during the stock market crash underpinned by massive foreign sale of domestic equity.

In brief, preliminary empirical results confirm the theoretical analysis that a revaluation of idiosyncratic risks and a change in stocks' liquidity served as principal mechanisms for triggering the stock market crash since difference in covariances and trading frequency appear as the most important explanatory factors for changes in share prices. The baseline empirical analysis thus focuses on these two channels.

[31] There profitability measures include net profit margin, return on asset, return on equity, net profit over asset, and net profit over equity. Here, the profitability impact on share prices existed to the extent that current profitability provided useful information about firm resilience to a disaster. In particular, explanatory variables represent current profitability rather than change in expected profitability.

3.4.3 Baseline Results

This part aims to provide supportive empirical evidence that the stock market crash primarily occurred as a result of limited foreign participation, which in turn induced an increase in systematic risks as well as a decline in stocks' liquidity. The baseline empirical analysis uses multivariate regressions based on:

(3.44) $\Delta P_i = \alpha + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + Z_i^{'}\theta + \varepsilon_i,$

where ΔP_i is the change in share prices, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, and Z_i is the set of business-type indicators. As discussed in part 3.4.1, all coefficients in the regression equation (3.44) can be estimated consistently by the OLS. Table 3.3 presents regression results explaining the change in share prices at different time frames (e.g. the market opening of the crash day, the crash day, and the rebound day).

Before examining how the re-pricing of idiosyncratic risks and the change in stocks' liquidity affected share prices at each time frame, it is important to discuss that difference in covariances cannot explain changes in share prices in some subsamples. Even though all coefficients associated with difference in covariances are statistically significant at all time frames in the whole sample, a revaluation of idiosyncratic risks did not occur for stocks that were not integrated with the market. Specifically, let's classify stocks into four categories: (i) foreign & market, (ii) foreign & non-market, (iii) local & market, and (iv) local & non-market.[32] Differences across these types of stocks are evident in Figure 3.2, which shows scatter plots between change in share prices on the crash day and difference in covariances. While no relationship exists for non-market stocks, a negative relationship looks apparent for market stocks regardless of whether these stocks are a part of foreign investors' portfolio investment. Regression results based on specification A.2 in Table 3.3 confirm similar findings illustrated by Figure 3.2. It is worth mentioning that these differences across types of stocks are robust to how foreign stocks and market stocks are defined.

In brief, the re-pricing of idiosyncratic risks with respect to systematic risks underlay substantial changes in share prices of foreign & market stocks, while its impact on non-market stocks seemed fairly limited. To streamline the subsequent discussion, foreign & non-market and local & non-market stocks are grouped as non-market stocks since

[32] Foreign stocks are stocks held by foreign investors as a part of portfolio investment while local stocks are non-foreign stocks. A stock is considered to be a foreign stock if its foreign ownership – portfolio (FO^P) is larger than 1.22 (the 25th percentile) and its foreign ownership – minority & NVDR (FO^{MN}) is also larger than 0.50 (the 25th percentile). On the other hand, market stocks are stocks that are integrated with the market (i.e. stocks that are actively traded by a large number of shareholders). A stock is considered to be a market stock if its trading frequency is higher than 0.625 (25th percentile).

statistical tests suggest that coefficients associated with difference in covariances for these two types of stocks are statistically indifferent. For local & market stocks, difference in covariances can explain changes in share prices at all time frames except the market opening of the crash day. Thus, the revaluation of idiosyncratic risks for local & market stocks became important only after the stock market crash actually occurred. Next, let's examine what happened at each time frame.

At the market opening of the crash day (based on Open19_Close18), limited foreign participation as a result of the excessively large implicit tax rate for new foreign investment in domestic equity primarily caused an increase in systematic risks for stocks in foreign investors' portfolio investment. In particular, difference in covariances can explain the change in share prices only for market stocks, although the change in idiosyncratic risk pricing seemed smaller for local & market stocks. On the other hand, coefficients associated with trading frequency are statistically insignificant. Therefore, a full-scale re-pricing of idiosyncratic risks for local & market stocks as well as a reduction in stocks' liquidity only occurred after the stock market indeed collapsed.

In addition to difference in covariances, foreign ownership (FO^P) can explain the change in share prices at the market opening of the crash day. When foreign ownership is included, the R-square increases to 23 from 14 percent. The fact that stocks owned more by foreign investors experienced a larger decline in share prices suggests that these stocks were subjected to more selling pressure chiefly triggered by foreign sale. Forced sale and rational panic might induce some foreign investors to withdraw their investment in Thailand's stock market in response to the introduction of capital controls.

During the stock market collapse (based on Close19_Close18), the change in idiosyncratic risk pricing continued to drive the decline in share prices. By the end of the crash day, local & market stocks also experienced a revaluation of idiosyncratic risks with the magnitude similar to that of foreign & market stocks. On the contrary, additional downward pressure on share prices due to foreign sale no longer existed as the coefficient associated with foreign ownership becomes statistically insignificant. Therefore, in contrast to the common belief, the role of panic seemed limited.

Furthermore, the reduction in stocks' liquidity became important. The coefficient associated with trading frequency is statistically significant, and the inclusion of trading frequency improves the R-square to 43 from 41 percent. However, the reduction in stocks' liquidity while largely concentrating among foreign & market stocks (see specification A.6) was fairly limited for other types of stocks. Such findings seem consistent with the theoretical analysis that limited foreign participation should lead to a sharp decline in stocks' liquidity for foreign & market stocks, whereas other market stocks may become more illiquid only if a large number of domestic agents withdraw their investment from the stock market.

During the stock market rebound (based on Close20_Close19), all mechanisms that led share prices to fall during the stock market collapse worked in reverse. Coefficients associated with difference in covariances for market stocks and trading frequency for foreign & market stocks are statistically significant. Hence, Thai stocks returned to be priced by world aggregate risks after the removal of the control on inflows to the stock market, and the liquidity of foreign & market stocks increased as foreign participation would no longer be limited.

Over the period of two days encompassing the stock market collapse and rebound (based on Close20_Close18), difference in covariances is the only factor that can explain the change in share prices for market stocks, although its ability to explain the variation in share prices seems much more limited. Particularly, the R-square for this time frame is only 13 percent compared to 37-40 percent for the day that the stock market collapsed or rebounded. Such findings point out that idiosyncratic risks attached to individual stocks were not completely priced by world aggregate risks after the control on inflows to the stock market was lifted.

This incomplete reversion of idiosyncratic risk pricing suggests that certain factors prevented some foreign investors from returning to hold optimal portfolios immediately. One plausible explanation is that foreign investors might want to wait until the uncertainty regarding regulatory changes became clear; indeed, net foreign sale remained as large as 3 billion baht on the rebound day. Theoretically, the incomplete reversion of idiosyncratic risk pricing sounds possible as equity should be priced by the effective expected return (i.e. the average of the expected returns over multiple periods). In particular, the expected return in the short run should remain affected in the event that foreign agents temporarily held domestic equity below the optimal (original) level, even though the expectation that foreign agents would eventually return to hold optimal portfolios should be able to anchor the expected return in the long run. Therefore, domestic equity could be influenced by a combination of home and world aggregate risks.

At the trough of the stock market crash (based on Low19_Close18), while market stocks experienced an increase in systematic risks as usual, all stocks became relatively illiquid. Coefficients associated with trading frequency are statistically significant in the whole sample rather than the subsample of foreign & market stocks. In contrast, the selling pressure driven by foreign sale did not look apparent at the time that share prices reached the bottom.

In summary, baseline empirical results show that the re-pricing of idiosyncratic risks with respect to systematic risks served as the triggering mechanism of the substantial decline in share prices at the beginning of the stock market collapse. Then, the reduction in stocks' liquidity followed once the stock market crash actually occurred. Similarly, on the rebound day, the re-pricing of idiosyncratic risks and the change in stocks' liquidity both drove up share prices. However, after the removal of the control on inflows on the stock market, domestic equity was not completely priced by world aggregate risks because a fraction of foreign investors did not immediately return to invest in Thailand's stock market. Lastly, the selling pressure driven by foreign sale only existed at the beginning of the stock market crash. Hence, the role of panic, in contrast to the common belief, should be fairly limited.

Based on Thailand's experience of the stock market crash, the average stock price change was 14.33 and 9.03 percent on the crash day and rebound day, respectively. During the stock market collapse and rebound, the average effect of the revaluation of idiosyncratic risks can account for two-fifths of the change in share prices (Table 3.4). This figure is compatible with Chari and Henry (2004).[33] Moreover, another two-fifths can be accounted by the change in stocks' liquidity. Hence, the decomposition of the average effect confirms that the re-pricing of idiosyncratic risks and the change in stocks' liquidity were the two predominant channels that underlay substantial share price movements.

3.4.4 Extended Results

This part addresses additional issues, including momentum anomaly, profitability impact and size effect, to complement the baseline empirical analysis which focuses on the two principal mechanisms that triggered the stock market crash (i.e. revaluation of idiosyncratic risks and change in stocks' liquidity). Building on baseline regressions as described by equation (3.44), the extended empirical analysis uses multivariate regressions based on:

(3.45) $\Delta P_i = \alpha + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + AE_i^{'}\pi + Z_i^{'}\theta + \varepsilon_i,$

where AE_i is the set of variables capturing additional effects of interest. They could be variables quantifying abnormal price gain, profitability and leverage measures, indicators reflecting the nature of business indicators, and variables measuring firm size such as total asset. Key findings related to momentum anomaly, profitability impact and size effect are presented in order.

The momentum anomaly based on the anticipation of large capital inflows did not appear as a significant factor driving changes in share prices. Abnormal price gains over all four relevant periods (i.e. since December 2006, since November 2006, since the military coup in September 2006, and since January 2006) cannot systematically explain the

[33] Their study examined the revaluation of stocks within the month that financial liberalization took place in emerging markets and found that the average effect of the reduction in systematic risks can account for two-fifths of the share price revaluation, with an average change of 15.1 percent.

change in share prices (Table 3.5).[34] Although some coefficients associated with abnormal price gain are statistically significant, the inclusion of abnormal price gain to the benchmark regressions (i.e. specification A.5 of baseline regressions) does not increase the R-square. These findings are also robust to alternative measurements of abnormal price gain.[35] There could be two reasons for why the momentum anomaly was not an important explanatory factor for the stock market crash. One is related to measurement errors because it is difficult to quantify abnormal price gain driven by certain factors in general. Another results from that the expectation of large capital inflows did not contribute to an increase in share prices in the first place. Based on their price to earning ratios, Thai shares had remained undervalued relative to compatible stocks in the region as a result of ongoing political turmoil.

The profitability impact on changes in share prices during the stock market collapse and rebound seemed limited. Particularly, profitability and leverage measures cannot serve as additional factors that explain the change in share prices. Business-type indicators similarly play a limited role in the benchmark regressions which account for the revaluation of idiosyncratic risks and the change in stocks' liquidity. Moreover, differences in firm profitability arising from the nature of business did not significantly influence share prices. Such findings seem consistent with Cutler (1988) which showed minimal market reactions to news of changes in corporate tax codes. The analysis on profitability impact consists of three approaches, all of which are discussed below.

The first approach considers how the augmentation of profitability and leverage measures affects the benchmark regressions in order to assess whether profitability and leverage measures can explain the change in share prices. Regression results presented in Table 3.6 suggest that the inclusion of profitability and leverage measures neither affects coefficients associated with difference in covariances and trading frequency, nor improves the ability to explain the variation in share prices. These findings remain unchanged even if other profitability and leverage measures are used in place of net profit margin and debt to asset ratio.

The second approach inspects how business-type indicators behave in the benchmark regressions. Business-type indicators by themselves can explain a great amount of the variation in share prices as reflected by a high R-square value in specification D.1 of Table 3.7. Most coefficients associated with business-type indicators become statistically

[34] The first two periods are considered because large and rapid currency appreciation became a major policy concern by that time. The third period is considered because the military coup was an important political event of the year. The last period is considered to generally reflect an influx of foreign funds throughout 2006.

[35] These abnormal price gain measures include abnormal price gain, abnormal price gain conditional on being foreign & market stocks, and indicator of some positive abnormal price gain conditional on being foreign & market stocks. The reason is that the momentum anomaly channel should be limited to foreign & market stocks that had experienced some price increases.

insignificant in the benchmark regressions.[36,37] Moreover, a smaller variation of these coefficients in the benchmark regressions reflects that differences across business types do not matter much after accounting for a re-pricing of idiosyncratic risks and a change in stocks' liquidity. Hence, business-type indicators, which should capture changes in expected profitability as a result of capital controls, are not important explanatory factors for changes in share prices.

The third approach examines whether the change in share prices depended on the nature of business, with indicators constructed based on firms' business description available from the Thomson One Banker database.[38] In particular, the analysis focuses on companies with foreign revenues and manufacturing firms since the effect of potential exchange rate depreciation induced by capital controls could be important. Based on regression results presented in Table 3.8, companies with foreign revenues experienced a smaller decline in share prices during the stock market collapse, especially at the market opening. Thus, market participants might expect that capital controls would induce some exchange rate depreciation.[39] However, the effect of potential exchange rate depreciation disappeared after the removal of the control on inflows to the stock market. Empirical evidence looks less supportive for manufacturing companies.

The size effect per se did not drive substantial changes in share prices. Although preliminary empirical results show that variables measuring firm size can explain the change in share prices, the inclusion of firm size in the benchmark regressions does not increase the R-square (Table 3.6). Moreover, coefficients associated with firm size become either statistically insignificant or statistically significant with the inappropriate sign. The reason for the size effect appearing important in bivariate regressions is that foreign investors' portfolio investment tends to consist of a greater portion of large-firm stocks as illustrated by the following regression:

(3.46) $FO^P = -25.87\ (3.16) + 4.37\ (0.42)\ Size, \quad R^2 = 0.34.$

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[36] The statistical significance of these coefficients in specification D.1 should not be surprising because they simply summarize the average of changes in share prices.

[37] Specification A.5 of Table 3.7 does not include the constant term. The change does not affect coefficients associated with other explanatory factors, but it makes more convenient to compare coefficients associated with business-type indicators between specification A.5 and specification D.1.

[38] These indicators include companies with foreign revenues (either from export sales or overseas operations), companies with agricultural manufacturing, companies with industrial manufacturing, companies in the services sector, companies in the real estate sector, financial companies with and without credit-provision business.

[39] Another interpretation is that the introduction of capital controls signaled that policymakers became seriously concerned about exchange rate appreciation. Thus, additional policy measures to stem currency appreciation were likely to follow.

As a result, the observed size effect essentially resulted from the existing correlation between firm size and difference in covariances owing to the fact that these large-firm stocks were more likely to be subjected to a revaluation of idiosyncratic risks during the stock market collapse and rebound.

In summary, the extended empirical analysis which focuses on momentum anomaly, profitability impact and size effect suggests that these additional factors did not significantly explain the change in share prices during the stock market collapse and rebound. Therefore, these extended empirical results support the baseline empirical results that the stock market crash were primarily driven by an increase in systematic risks and a reduction in stocks' liquidity.

3.5 Conclusion

This chapter takes Thailand's experience surrounding the introduction of the URR measure as a case study for examining the impact of capital controls on financial markets. Regardless of whether capital controls could deliver benefits such as preserving macroeconomic stability and inducing exchange rate depreciation, it is imperative to understand why the stock market crash occurred in response to the imposition of capital controls by the BoT. The viability of capital controls as a policy option critically depends on whether they can be implemented without causing a stock market collapse. Thus, the key objective of this study is to explain why the price of domestic equity declined substantially based on Thailand's experience.

The theoretical analysis illustrates that the excessively large implied tax rate imposed by the URR measure was the predominant factor that triggered the stock market crash. The punitive tax rate for new foreign investment in the stock market could induce limited foreign participation, which in turn caused a re-pricing of idiosyncratic risks with respect to systematic risks and reduced the liquidity of domestic equity. Furthermore, consistent with the fact that the stock market crash was accompanied by massive foreign sale, the theoretical analysis highlights the role of foreign sale in generating reduced risk sharing that led Thai shares to be priced by domestic, rather than world, aggregate risks.

The empirical analysis provides supportive evidence that the excessively large implicit tax rate was the leading factor that caused the stock market crash through the increase in systematic risks and the reduction in stocks' liquidity. In particular, the benchmark regressions show that both difference in covariances and trading frequency are the most important explanatory variables for changes in share prices during the stock market collapse and rebound. On the other hand, the ability of additional factors that capture momentum anomaly, profitability impact and size effect to explain the variation in share prices seems limited. Moreover, the role of panic reflected by the selling pressure driven by foreign sale appears insignificant at all time frames except the beginning of the stock market crash.

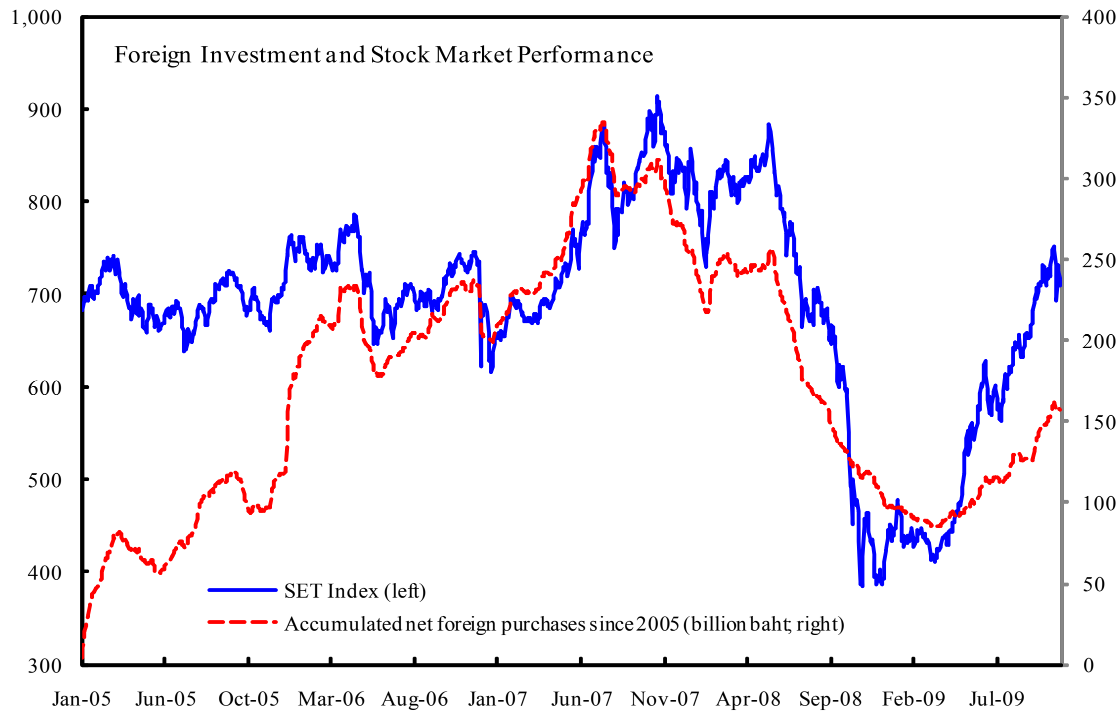
In conclusion, this chapter illustrates that Thailand's stock market crash primarily occurred as a consequence of the excessively large implicit tax rate for new foreign investment in the stock market. Hence, capital controls should remain a viable policy instrument provided that policymakers believe in the effectiveness of capital controls in delivering policy objectives. Although the implicit tax rate was indisputably excessively large owing to a combination of the punitive penalty on early withdrawal under the URR regime, the limitation on foreign investors to temporarily retain funds in the domestic financial system between each equity trading, and the frequent rebalancing of stock portfolios, the threshold of such excessively large tax rate remains to be determined.

The final remark is that capital controls could be useful to safeguard macroeconomic stability in the world of large and volatile capital flows. Nevertheless, it is imperative to implement a well-designed capital control regime which critically depends on existing institutional features. Otherwise, policymakers might become subjected to huge humiliation as illustrated by Thailand's experience.

3.6 Annex

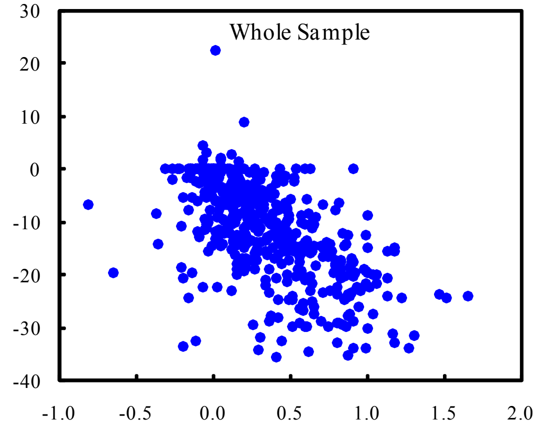
3.6.1 Figures and Tables

Figure 3.1 Thailand: Stock Market Developments



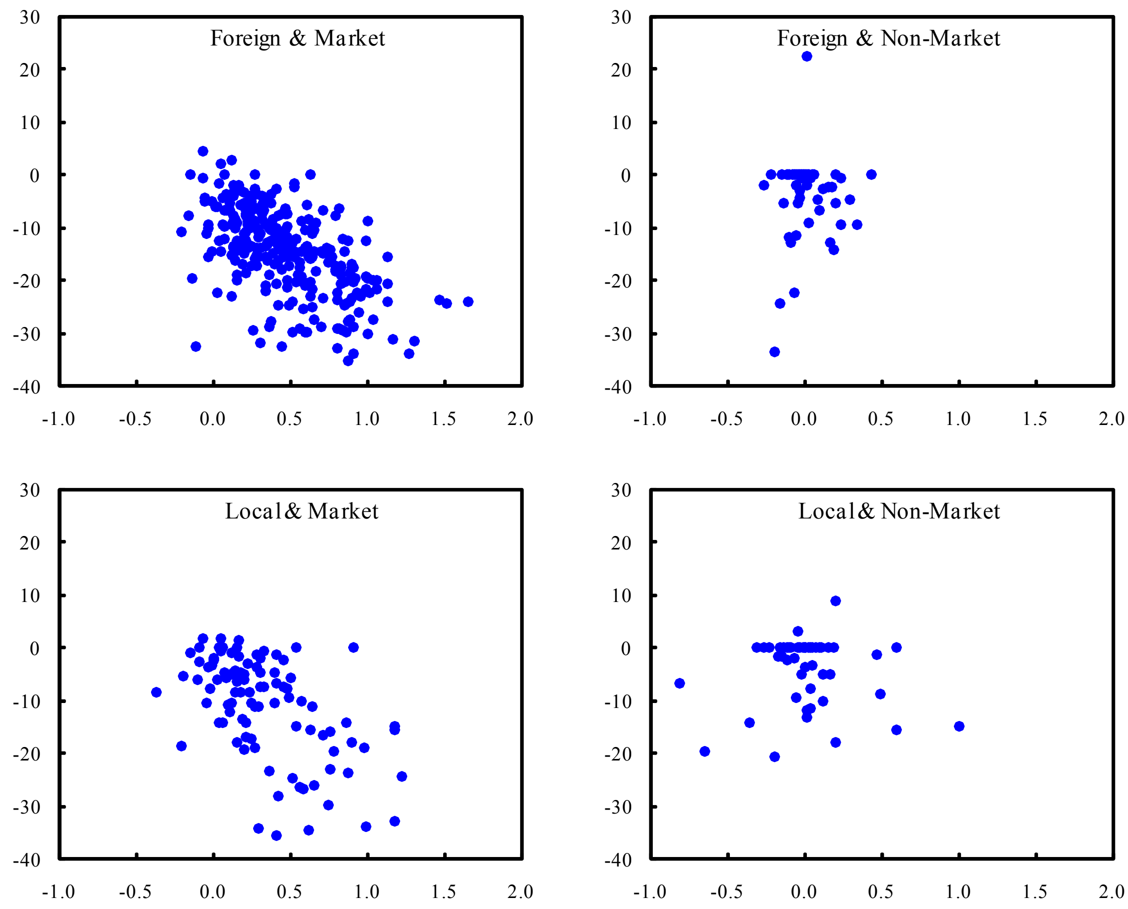
Source: CEIC; and author's calculations.

Figure 3.2 Relationship between Change in Share Prices and Difference in Covariances



Scatter plots: Change in share prices (between market openning on December 19, 2006 and market closing on December 18, 2006) on the y-axis vs. difference in covariances on the x-axis.

Definition: Foreign is defined as foreign ownership (portfolio) being greater than 1.22 (25th percentile) and foreign ownership (minority & NVDR) being greater than 0.50 (25th percentile). Market is defined as trading frequency being higher than 0.625 (25th percentile).



Source: SETSmart; and author’s calculations.

Table 3.1 Net-Return-Equivalent Costs for Different Investment Horizons

k (months)	τ_k	
1	173.571	
2	87.857	
3	59.286	
4	45.000	
5	36.429	
6	30.714	
7	26.633	
8	23.571	
9	21.190	
10	19.286	
11	17.727	
12	2.143	2.143
15	1.714	1.579
18	1.429	1.250
21	1.224	1.034
24	1.071	0.882
30	0.857	0.682
36	0.714	0.556
48	0.536	0.405
60	0.429	0.319

Note: For $k \geq 12$, the first sub-column is for the returned reserve being invested abroad, while the second sub-column is for the returned reserve being invested domestically. The calculation is based on the assumption that the international interest rate is 5 percent, the reserve requirement is 30 percent, the withholding period is 1 year, and the penalty on early withdrawal is 1/3 of the reserve.

Remark: Based on the assumption above, if there is no penalty on early withdrawal, τ_k is equal to 2.143 for $k \leq 12$.

Table 3.2 Bivariate Regressions

Regression Specification: $\Delta Price_i = \lambda + \beta X_i + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price, X_i is the explanatory variable of interest, and Z_i is the set of business-type indicators. Notation: O stands for the market opening and C stands for the market closing. For example, O19_C18 represents the change in share price between the market opening on December 19 and the market closing on December 18.

For each variable of interest, the coefficient is reported in the first row along with its standard error (in parentheses) in the second row as well as the regression R-square in the third row. Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors.

	O19_C18	C19_C18	C19_O19	O20_C19	C20_C19	C20_O20	C20_C18
Equity Premium for Risk and Liquidity							
Difference in Covariances – Same Date	**-4.342****	**-13.141****	**-8.807****	**7.001****	**9.015****	**2.018****	**-4.127****
	(0.821)	(1.157)	(1.126)	(0.711)	(0.875)	(0.605)	(0.701)
	0.100	0.363	0.165	0.248	0.342	0.030	0.110
Difference in Covariances – American Influence	**-2.960****	**-11.193****	**-8.241****	**5.934****	**7.641****	**1.709****	**-3.550****
	(0.791)	(1.157)	(1.178)	(0.699)	(0.859)	(0.538)	(0.725)
	0.075	0.346	0.179	0.235	0.322	0.027	0.109
Difference in Covariances – Adjacent Dates	**-2.094****	**-6.157****	**-4.066****	**3.083****	**4.085****	**0.999****	**-2.075****
	(0.468)	(0.563)	(0.552)	(0.407)	(0.455)	(0.301)	(0.421)
	0.095	0.321	0.140	0.207	0.292	0.026	0.108
Difference in Covariances – Trading Week	**-0.344**	**-1.621****	**-1.278****	**0.886****	**1.055****	**0.170**	**-0.567****
	(0.176)	(0.210)	(0.221)	(0.124)	(0.166)	(0.099)	(0.127)
	0.035	0.213	0.124	0.146	0.189	0.012	0.073
Trading Frequency in 2006	**-4.055****	**-14.533****	**-10.487****	**7.440****	**9.951****	**2.513****	**-4.581****
	(1.014)	(1.347)	(1.129)	(0.895)	(0.915)	(0.558)	(1.184)
	0.047	0.259	0.149	0.164	0.246	0.031	0.079
Trading Frequency in 2005	**-4.304****	**-13.270****	**-8.975****	**7.001****	**9.259****	**2.260****	**-4.010****
	(0.986)	(1.409)	(1.271)	(0.872)	(0.927)	(0.644)	(1.053)
	0.050	0.237	0.127	0.155	0.230	0.028	0.069
Foreign Ownership							
Foreign Ownership – All	**-0.043****	**-0.024**	**0.019**	**0.012**	**0.010**	**-0.003**	**-0.015**
	(0.014)	(0.016)	(0.016)	(0.012)	(0.012)	(0.008)	(0.010)
	0.031	0.004	0.004	0.004	0.002	0.000	0.004
Foreign Ownership – Exceeding 5 %	**0.009**	**0.008**	**-0.001**	**-0.008**	**-0.018**	**-0.010**	**-0.010**
	(0.014)	(0.021)	(0.017)	(0.014)	(0.015)	(0.009)	(0.012)
	0.003	0.004	0.001	0.004	0.008	0.002	0.000
Foreign Ownership – Portfolio	**-0.201****	**-0.122****	**0.080***	**0.072****	**0.091****	**0.019**	**-0.031**
	(0.034)	(0.034)	(0.035)	(0.022)	(0.025)	(0.016)	(0.018)
	0.169	0.049	0.006	0.045	0.049	0.001	0.013

	O19_C18	C19_C18	C19_O19	O20_C19	C20_C19	C20_O20	C20_C18
Foreign Ownership (… continued)							
Foreign Ownership – Minority	**-1.131****	**-0.702****	**0.427****	**0.376****	**0.501****	**0.125***	**-0.202***
	(0.153)	(0.157)	(0.149)	(0.094)	(0.110)	(0.062)	(0.088)
	0.195	0.057	0.007	0.046	0.054	0.002	0.018
Foreign Ownership – Minority & NVDR	**-0.374****	**-0.255****	**0.117**	**0.137****	**0.179****	**0.043**	**-0.077***
	(0.073)	(0.073)	(0.072)	(0.047)	(0.056)	(0.034)	(0.037)
	0.157	0.061	0.001	0.049	0.057	0.002	0.020
Profitability and Leverage Measures							
Net Profit Margin	**-0.014**	**0.070****	**0.084****	**0.011**	**-0.015**	**-0.027**	**0.055****
	(0.016)	(0.027)	(0.027)	(0.023)	(0.020)	(0.020)	(0.015)
	0.003	0.012	0.025	0.002	0.001	0.013	0.023
Return on Asset	**-0.043**	**0.070**	**0.114****	**0.017**	**0.000**	**-0.017**	**0.071****
	(0.029)	(0.042)	(0.040)	(0.035)	(0.031)	(0.028)	(0.023)
	0.000	0.013	0.016	0.000	0.001	0.002	0.026
Return on Equity	**-0.022**	**0.070****	**0.092****	**0.001**	**-0.005**	**-0.007**	**0.064****
	(0.023)	(0.022)	(0.024)	(0.019)	(0.017)	(0.014)	(0.016)
	0.003	0.015	0.028	0.000	0.000	0.001	0.039
Net Profit over Asset	**-0.104**	**0.421***	**0.526****	**0.110**	**0.059**	**-0.052**	**0.480****
	(0.138)	(0.165)	(0.162)	(0.188)	(0.133)	(0.168)	(0.100)
	0.001	0.023	0.020	0.000	0.001	0.000	0.055
Net Profit over Equity	**-0.065**	**0.213***	**0.277****	**0.032**	**0.014**	**-0.019**	**0.227****
	(0.090)	(0.102)	(0.090)	(0.081)	(0.076)	(0.066)	(0.063)
	0.000	0.018	0.024	0.000	0.001	0.001	0.043
Debt to Equity Ratio for Non-financial Companies	**-0.935***	**-0.579**	**0.354**	**-0.118**	**0.083**	**0.201**	**-0.497**
	(0.414)	(0.484)	(0.401)	(0.270)	(0.308)	(0.202)	(0.388)
	0.039	0.021	0.000	0.002	0.006	0.003	0.026
Debt to Equity Ratio For Financial Companies	**0.159**	**0.509***	**0.349**	**-0.330**	**-0.279***	**0.051**	**0.229**
	(0.250)	(0.212)	(0.343)	(0.174)	(0.125)	(0.126)	(0.142)
	0.049	0.001	0.025	0.001	0.002	0.001	0.000
Debt to Asset Ratio	**-4.682****	**-1.927**	**2.747**	**-0.056**	**1.190**	**1.246**	**-0.743**
	(1.551)	(1.983)	(1.971)	(1.293)	(1.249)	(1.043)	(1.447)
	0.067	0.029	0.000	0.012	0.019	0.003	0.017
Momentum Anomaly							
Abnormal Gain since Dec 2006	**-0.094**	**0.284****	**0.379****	**-0.186****	**-0.179****	**0.007**	**0.105**
	(0.059)	(0.077)	(0.063)	(0.044)	(0.050)	(0.031)	(0.055)
	0.000	0.083	0.098	0.072	0.069	0.000	0.033
Abnormal Gain since Nov 2006	**-0.032**	**0.089****	**0.121****	**-0.038***	**-0.040**	**-0.002**	**0.048***
	(0.020)	(0.032)	(0.027)	(0.017)	(0.022)	(0.015)	(0.021)
	0.001	0.024	0.036	0.012	0.011	0.000	0.021

	O19_C18	C19_C18	C19_O19	O20_C19	C20_C19	C20_O20	C20_C18
Momentum Anomaly (… continued)							
Abnormal Gain since the Coup	**-0.015** (0.016) 0.000	**0.046** (0.026) 0.009	**0.060**** (0.024) 0.012	**-0.018** (0.015) 0.004	**-0.017** (0.018) 0.002	**0.001** (0.011) 0.001	**0.029*** (0.014) 0.012
Abnormal Gain since Jan 2006	**0.013** (0.009) 0.002	**0.003** (0.013) 0.001	**-0.011** (0.013) 0.004	**-0.002** (0.010) 0.000	**0.005** (0.010) 0.005	**0.007** (0.007) 0.006	**0.008** (0.007) 0.001
Price Gain since Dec 2006	**-0.077** (0.056) 0.000	**0.328**** (0.078) 0.097	**0.405**** (0.066) 0.113	**-0.167**** (0.042) 0.060	**-0.168**** (0.050) 0.060	**-0.001** (0.031) 0.001	**0.160**** (0.053) 0.059
Price Gain since Nov 2006	**-0.021** (0.018) 0.000	**0.111**** (0.030) 0.036	**0.132**** (0.026) 0.049	**-0.032** (0.017) 0.009	**-0.037** (0.021) 0.009	**-0.005** (0.013) 0.000	**0.074**** (0.019) 0.046
Price Gain since the Coup	**-0.006** (0.014) 0.000	**0.065**** (0.023) 0.019	**0.071**** (0.021) 0.024	**-0.013** (0.015) 0.002	**-0.015** (0.016) 0.001	**-0.003** (0.011) 0.000	**0.050**** (0.012) 0.039
Price Gain since Jan 2006	**0.004** (0.006) 0.001	**0.037**** (0.011) 0.032	**0.033**** (0.010) 0.031	**-0.005)** (0.008 0.002	**-0.009** (0.008) 0.005	**-0.004** (0.006) 0.001	**0.028**** (0.006) 0.053
Other Characteristics							
Price to Earnings Ratio	**0.011** (0.038) 0.001	**0.038** (0.060) 0.003	**0.027** (0.050) 0.001	**-0.040** (0.039) 0.001	**-0.005** (0.045) 0.006	**0.035** (0.026) 0.008	**0.033** (0.032) 0.000
Market to Book Ratio	**-1.225**** (0.304) 0.034	**-0.401** (0.379) 0.009	**0.826** (0.428) 0.002	**0.595*** (0.265) 0.020	**0.714*** (0.282) 0.029	**0.119** (0.195) 0.003	**0.316** (0.208) 0.002
Dividend Yield	**0.182** (0.133) 0.012	**0.219** (0.163) 0.010	**0.037** (0.153) 0.000	**-0.190** (0.137) 0.007	**-0.111** (0.104) 0.009	**0.079** (0.097) 0.000	**0.107** (0.096) 0.003
Size by Asset	**-1.387**** (0.226) 0.133	**-1.072**** (0.292) 0.063	**0.313** (0.304) 0.000	**0.691**** (0.196) 0.059	**0.979**** (0.197) 0.067	**0.288** (0.150) 0.002	**-0.095** (0.165) 0.015
Market Capitalization	**-1.194**** (0.212) 0.115	**-0.972**** (0.247) 0.057	**0.220** (0.262) 0.000	**0.811**** (0.156) 0.076	**0.994**** (0.169) 0.081	**0.182** (0.115) 0.001	**0.021** (0.150) 0.005
Beta wrt. SET Index (Jan 2005 – Control)	**-3.118**** (0.708) 0.101	**-9.835**** (1.077) 0.387	**-6.716**** (0.995) 0.184	**4.870**** (0.621) 0.245	**6.197**** (0.747) 0.334	**1.328**** (0.367) 0.027	**-3.638**** (0.583) 0.149

Table 3.3 Multivariate Regressions on Changes in the Equity Premium Components Reflecting Risk and Liquidity

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market opening on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, and Z_i is the set of business-type indicators.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.3.1	Open19_Close18					
	A.1	A.2	A.3	A.4	A.5	A.6
DiffCov	**-4.342****	**-6.010****	**-4.290****	**-4.290****	**-4.732****	**-4.687****
β_1	(0.821)	(1.002)	(0.896)	(0.895)	(0.989)	(1.219)
DiffCov * Local_Market		**5.226****	**2.294***	**2.294***	**2.247***	**2.108**
β_2		(1.195)	(1.135)	(1.133)	(1.130)	(1.740)
DiffCov * Foregin_NonMarket		**6.802**	**5.206**			
β_3		(6.561)	(6.743)			
DiffCov * Local_NonMarket		**6.350****	**4.534**			
β_4		(2.467)	(2.580)			
DiffCov * NonMarket				**4.667**	**5.060***	**4.994**
β_5				(2.508)	(2.479)	(2.708)
ForeignOwnership			**-0.170****	**-0.170****	**-0.174****	**-0.173****
γ			(0.036)	(0.036)	(0.037)	(0.039)
TradingFreq					**1.462**	**1.584**
δ_1					(1.382)	(1.721)
TradingFreq * Foreign_Market						**-0.117**
δ_2						(1.231)
Constant	**-2.897****	**-2.680****	**-1.461****	**-1.460****	**-2.407***	**-2.453***
λ	(0.382)	(0.388)	(0.414)	(0.412)	(0.998)	(1.121)
R-Square	0.100	0.138	0.225	0.225	0.225	0.225
Number of Observations	489	489	487	487	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		0.459	**0.046**	**0.046**	**0.019**	**0.022**
$\beta_1 + \beta_3 = 0$		0.903	0.892			
$\beta_1 + \beta_4 = 0$		0.877	0.918			
$\beta_3 = \beta_4$		0.948	0.925			
$\beta_1 + \beta_5 = 0$				0.872	0.884	0.893
$\delta_1 + \delta_2 = 0$						0.287

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, and Z_i is the set of business-type indicators.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.3.2	Close19_Close18					
	A.1	A.2	A.3	A.4	A.5	A.6
DiffCov	**-13.141****	**-15.081****	**-14.909****	**-14.909****	**-13.207****	**-12.535****
β_1	(1.157	(1.141)	(1.152)	(1.150)	(1.204)	(1.326)
DiffCov * Local_Market		**1.610**	**0.887**	**0.887**	**1.070**	**-0.971**
β_2		(2.089)	(2.131)	(2.128)	(2.102)	(2.876)
DiffCov * Foregin_NonMarket		**18.456****	**15.786***			
β_3		(6.731)	(6.480)			
DiffCov * Local_NonMarket		**15.015***	**14.748****			
β_4		(3.820)	(3.920)			
DiffCov * NonMarket				**14.953****	**13.440****	**12.478****
β_5				(3.406)	(3.690)	(3.868)
ForeignOwnership			**-0.040**	**-0.040**	**-0.023**	**-0.012**
γ			(0.029)	(0.029)	(0.030)	(0.032)
TradingFreq					**-5.631****	**-3.831**
δ_1					(1.674)	(2.632)
TradingFreq * Foreign_Market						**-1.723**
δ_2						(1.742)
Constant	**-7.024**	**-6.512**	**-6.096**	**-6.095**	**-2.449**	**-3.119**
λ	(0.547)	(0.509)	(0.555)	(0.553)	(1.253)	(1.496)
R-Square	0.363	0.400	0.407	0.407	0.434	0.432
Number of Observations	489	489	487	487	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
$\beta_1 + \beta_3 = 0$		0.619	0.893			
$\beta_1 + \beta_4 = 0$		0.986	0.966			
$\beta_3 = \beta_4$		0.948	0.891			
$\beta_1 + \beta_5 = 0$				0.989	0.947	0.987
$\delta_1 + \delta_2 = 0$						**0.001**

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 20 and the market closing on December 19, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, and Z_i is the set of business-type indicators.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.3.3	Close20_Close19					
	A.1	A.2	A.3	A.4	A.5	A.6
DiffCov	**9.015****	**10.127****	**9.858****	**9.857****	**8.567****	**8.306****
β_1	(0.875)	(0.928)	(0.965)	(0.964)	(1.006)	(1.065)
DiffCov * Local_Market		**-0.771**	**-0.037**	**-0.036**	**-0.175**	**0.616**
β_2		(1.516)	(1.567)	(1.566)	(1.570)	(2.296)
DiffCov * Foregin_NonMarket		**-12.853****	**-10.996***			
β_3		(4.366)	(4.346)			
DiffCov * Local_NonMarket		**-8.337***	**-7.997***			
β_4		(3.371)	(3.475)			
DiffCov * NonMarket				**-8.590****	**-7.442***	**-7.069***
β_5				(3.005)	(3.081)	(3.195)
ForeignOwnership			**0.041**	**0.041**	**0.028**	**0.024**
γ			(0.024)	(0.024)	(0.024)	(0.025)
TradingFreq					**4.271****	**3.574**
δ_1					(1.180)	(1.948)
TradingFreq * Foreign_Market						**0.667**
δ_2						(1.278)
Constant	**4.103****	**3.804****	**3.427****	**3.423****	**0.657**	**0.917**
λ	(0.381)	(0.385)	(0.417)	(0.416)	(0.885)	(1.065)
R-Square	0.342	0.367	0.374	0.373	0.402	0.401
Number of Observations	489	489	487	487	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
$\beta_1 + \beta_3 = 0$		0.523	0.787			
$\beta_1 + \beta_4 = 0$		0.570	0.566			
$\beta_3 = \beta_4$		0.395	0.576			
$\beta_1 + \beta_5 = 0$				0.643	0.697	0.672
$\delta_1 + \delta_2 = 0$						**0.000**

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 20 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, and Z_i is the set of business-type indicators.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.3.4	Close20_Close18					
	A.1	A.2	A.3	A.4	A.5	A.6
DiffCov	**-4.127****	**-4.955****	**-5.050****	**-5.050****	**-4.642****	**-4.223****
β_1	(0.701)	(0.755)	(0.772)	(0.772)	(0.741)	(0.830)
DiffCov * Local_Market		**0.829**	**0.838**	**0.839**	**0.883**	**-0.389**
β_2		(1.430)	(1.501)	(1.500)	(1.492)	(2.097)
DiffCov * Foregin_NonMarket		**5.588**	**4.774**			
β_3		(6.898)	(6.953)			
DiffCov * Local_NonMarket		**6.705**	**6.775**			
β_4		(4.117)	(4.097)			
DiffCov * NonMarket				**6.380**	**6.017**	**5.417**
β_5				(3.636)	(3.569)	(3.716)
ForeignOwnership			**0.001**	**0.001**	**0.005**	**0.011**
γ			(0.018)	(0.018)	(0.018)	(0.020)
TradingFreq					**-1.351**	**-0.231**
δ_1					(1.497)	(2.055)
TradingFreq * Foreign_Market						**-1.073**
δ_2						(1.143)
Constant	**-2.923****	**-2.709****	**-2.668****	**-2.672****	**-1.796**	**-2.214**
λ	(0.349)	(0.373)	(0.417)	(0.413)	(1.212)	(1.356)
R-Square	0.110	0.132	0.133	0.133	0.139	0.139
Number of Observations	489	489	487	487	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.009**	**0.009**	**0.009**	**0.018**	**0.018**
$\beta_1 + \beta_3 = 0$		0.927	0.968			
$\beta_1 + \beta_4 = 0$		0.642	0.646			
$\beta_3 = \beta_4$		0.885	0.799			
$\beta_1 + \beta_5 = 0$				0.689	0.682	0.725
$\delta_1 + \delta_2 = 0$						0.388

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the individual lowest point on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, and Z_i is the set of business-type indicators.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.3.5	Low19_Close18					
	A.1	A.2	A.3	A.4	A.5	A.6
DiffCov	**-18.090****	**-20.588****	**-20.203****	**-20.203****	**-16.291****	**-15.805****
β_1	(1.548)	(1.587)	(1.616)	(1.614)	(1.621)	(1.752)
DiffCov * Local_Market		**2.943**	**1.540**	**1.537**	**1.959**	**0.481**
β_2		(2.395)	(2.472)	(2.471)	(2.372)	(3.486)
DiffCov * Foregin_NonMarket		**25.911****	**21.173****			
β_3		(8.321)	(7.669)			
DiffCov * Local_NonMarket		**16.666***	**16.112***			
β_4		(7.189)	(7.368)			
DiffCov * NonMarket				**17.112****	**13.633***	**12.937**
β_5				(6.219)	(6.639)	(6.782)
ForeignOwnership			**-0.077**	**-0.077**	**-0.038**	**-0.030**
γ			(0.041)	(0.041)	(0.040)	(0.041)
TradingFreq					**-12.943****	**-11.641****
δ_1					(2.023)	(3.234)
TradingFreq * Foreign_Market						**-1.247**
δ_2						(2.148)
Constant	**-11.986****	**-11.385****	**-10.603****	**-10.595****	**-2.214**	**-2.699**
λ	(0.730)	(0.695)	(0.736)	(0.733)	(1.538)	(1.829)
R-Square	0.406	0.440	0.451	0.450	0.518	0.517
Number of Observations	489	489	487	487	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
$\beta_1 + \beta_3 = 0$		0.528	0.899			
$\beta_1 + \beta_4 = 0$		0.572	0.566			
$\beta_3 = \beta_4$		0.400	0.632			
$\beta_1 + \beta_5 = 0$				0.604	0.679	0.657
$\delta_1 + \delta_2 = 0$						**0.000**

Table 3.4 Average Stock Price Changes by the Revaluation of Idiosyncratic Risks and the Change in Stocks' Liquidity

Estimated coefficients are based on specification A.5. The calculation is based on foreign & market stocks. Notation: O stands for the market opening and C stands for the market closing. For example, O19_C18 represents the change in share price between the market opening on December 19 and the market closing on December 18.

	O19_C18	**C19_C18**	**C20_C19**	**C20_C18**	**L19_C18**
Average Price Change	-5.87	-14.33	9.03	-5.31	-22.56
Average DiffCov	0.46				
Coefficient	-4.69	-12.54	8.31	-4.22	-15.81
Average Price Change by DiffCov	-2.17	-5.81	3.85	-1.96	-7.33
(percentage)	(37.01)	(40.57)	(42.68)	(36.91)	(32.49)
Average TradingFreq	0.90				
Coefficient	1.46	-5.63	4.27	-1.35	-12.94
Average Price Change by TradingFreq	1.32	-5.09	3.86	-1.22	-11.70
(percentage)	(-22.50)	(35.51)	(42.76)	(23.01)	(51.85)
Average Price Change by Both	-0.85	-10.90	7.71	-3.18	-19.03
(percentage)	(14.51)	(76.08)	(85.44)	(59.91)	(84.35)

Table 3.5 Multivariate Regressions on Changes in the Equity Premium Components Reflecting Risk, Liquidity and Anomaly

Regression Specification: $\Delta Price_i = \lambda + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + AG_i^{'}\pi + Z_i^{'}\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, AG_i is the set of variables quantifying abnormal price gain, and Z_i is the set of business-type indicators. Notation: $\mathcal{I}\{.\}$ is the indicator function.

The regression specification is based on the specification A.5 with the addition of AG_i. Only the estimate of π is reported, as other estimates of λ, β, γ, and δ remain similar to those in the specification A.5.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Open19_Close18		Since Dec 2006			Since Nov 2006		
		B.1(a)	B.2(a)	B.3(a)	B.1(b)	B.2(b)	B.3(b)
Abnormal		**-0.146***	**-0.133**		**-0.031**	**-0.025**	
π_1		(0.058)	(0.099)		(0.019)	(0.025)	
Abnormal * Foreign_Market			**-0.021**			**-0.012**	
π_2			(0.121)			(0.035)	
$\mathcal{I}$\{Abnormal>0\} * Foreign_Market				**-1.682***			**-0.577**
π_3				(0.799)			(0.816)
R-square	0.225	0.235	0.235	0.231	0.228	0.228	0.226
No. of Observations	487	483	483	487	487	487	487
Test							
$\pi_1 + \pi_2 = 0$			0.029			0.140	

Open19_Close18		Since the Coup			Since Jan 2006		
		B.1(c)	B.2(c)	B.3(c)	B.1(d)	B.2(d)	B.3(d)
Abnormal		**-0.024**	**-0.025**		**-0.002**	**-0.011**	
π_1		(0.015)	(0.017)		(0.008)	(0.008)	
Abnormal * Foreign_Market			**0.002**			**0.016**	
π_2			(0.029)			(0.015)	
$\mathcal{I}$\{Abnormal>0\} * Foreign_Market				**-0.665**			**0.303**
π_3				(0.788)			(0.816)
R-square	0.225	0.228	0.226	0.226	0.228	0.226	0.226
No. of Observations	487	486	487	484	484	487	487
Test							
$\pi_1 + \pi_2 = 0$			0.339			0.689	

Close19_Close18		Since Dec 2006			Since Nov 2006		
		B.1(a)	B.2(a)	B.3(a)	B.1(b)	B.2(b)	B.3(b)
Abnormal		**0.087**	**-0.023**		**0.077****	**0.102***	
π_1		(0.069)	(0.120)		(0.029)	(0.042)	
Abnormal * Foreign_Market			**0.174**			**-0.051**	
π_2			(0.145)			(0.049)	
$\mathcal{I}${Abnormal>0} * Foreign_Market				**1.246**			**1.121**
π_3				(0.808)			(0.833)
R-square	0.434	0.443	0.438	0.448	0.449	0.438	0.226
No. of Observations	487	483	487	487	487	487	487
Test							
$\pi_1 + \pi_2 = 0$			0.064			0.102	

Close19_Close18		Since the Coup			Since Jan 2006		
		B.1(c)	B.2(c)	B.3(c)	B.1(d)	B.2(d)	B.3(d)
Abnormal		**0.029**	**0.040**		**-0.014**	**-0.011**	
π_1		(0.025)	(0.041)		(0.011)	(0.019)	
Abnormal * Foreign_Market			**-0.022**			**-0.006**	
π_2			(0.044)			(0.023)	
$\mathcal{I}${Abnormal>0} * Foreign_Market				**-0.519**			**-0.347**
π_3				(0.870)			(0.816)
R-square	0.434	0.442	0.433	0.443	0.442	0.434	0.226
No. of Observations	487	486	487	484	484	487	487
Test							
$\pi_1 + \pi_2 = 0$			0.466			0.215	

Close20_Close19		Since Dec 2006			Since Nov 2006		
		B.1(a)	B.2(a)	B.3(a)	B.1(b)	B.2(b)	B.3(b)
Abnormal		**-0.041**	**-0.046**		**-0.032**	**-0.046**	
π_1		(0.043)	(0.074)		(0.021)	(0.031)	
Abnormal * Foreign_Market			**0.007**			**0.029**	
π_2			(0.091)			(0.036)	
$\mathcal{I}${Abnormal>0} * Foreign_Market				**-0.588**			**-0.551**
π_3				(0.574)			(0.597)
R-square	0.402	0.410	0.410	0.404	0.406	0.408	0.404
No. of Observations	487	483	483	487	487	487	487
Test							
$\pi_1 + \pi_2 = 0$			0.461			0.448	

Close20_Close19		Since the Coup			Since Jan 2006		
		B.1(c)	B.2(c)	B.3(c)	B.1(d)	B.2(d)	B.3(d)
Abnormal		**-0.004**	**-0.011**		**0.018***	**0.018**	
π_1		(0.018)	(0.028)		(0.008)	(0.011)	
Abnormal * Foreign_Market			**0.012**			**0.000**	
π_2			(0.030)			(0.015)	
$\mathcal{J}\{\text{Abnormal}>0\}$ * Foreign_Market				**0.264**			**0.123**
π_3				(0.636)			(0.615)
R-square	0.402	0.407	0.408	0.402	0.416	0.416	0.402
No. of Observations	487	486	486	487	484	484	487
Test							
$\pi_1 + \pi_2 = 0$			0.916			0.115	

Close20_Close18		Since Dec 2006			Since Nov 2006		
		B.1(a)	B.2(a)	B.3(a)	B.1(b)	B.2(b)	B.3(b)
Abnormal		**0.046**	**-0.069**		**0.044***	**0.055**	
π_1		(0.057)	(0.118)		(0.021)	(0.031)	
Abnormal * Foreign_Market			**0.181**			**-0.022**	
π_2			(0.128)			(0.036)	
$\mathcal{J}\{\text{Abnormal}>0\}$ * Foreign_Market				**0.654**			**0.563**
π_3				(0.514)			(0.537)
R-square	0.139	0.139	0.147	0.142	0.154	0.155	0.142
No. of Observations	487	483	483	487	487	487	487
Test							
$\pi_1 + \pi_2 = 0$			0.031			0.151	

Close20_Close18		Since the Coup			Since Jan 2006		
		B.1(c)	B.2(c)	B.3(c)	B.1(d)	B.2(d)	B.3(d)
Abnormal		**0.024**	**0.029**		**0.004**	**0.008**	
π_1		(0.014)	(0.022)		(0.007)	(0.011)	
Abnormal * Foreign_Market			**-0.010**			**-0.007**	
π_2			(0.026)			(0.014)	
$\mathcal{J}\{\text{Abnormal}>0\}$ * Foreign_Market				**-0.260**			**-0.237**
π_3				(0.536)			(0.523)
R-square	0.139	0.148	0.148	0.139	0.140	0.141	0.139
No. of Observations	487	486	486	487	484	484	487
Test							
$\pi_1 + \pi_2 = 0$			0.228			0.901	

Table 3.6 Multivariate Regressions on Changes in the Equity Premium Components Reflecting Risk and Liquidity, Profitability and Leverage Measures, and Size

Regression Specification: $\Delta Price_i = \lambda + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + PL_i^{'}\rho + \phi S_i + Z_i^{'}\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market opening on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, PL_i is the set of variables quantifying profitability and leverage measures, S_i is the variable measuring firm size, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of PL_i and S_i. PL_i consists of net profit margin and debt to asset ratio, and S_i uses total asset. All are Q3-2006 numbers.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.6.1	Open19_Close18					
			A.5	C.1	C.2	C.3
DiffCov			-4.732**	-4.879	-4.575**	-4.323**
β_1			(0.989)	1.046	(1.020)	(0.985)
DiffCov * Local_Market			2.247*	2.778	3.104*	2.452*
β_2			(1.130)	1.168	(1.262)	(1.182)
DiffCov * NonMarket			5.060*	5.393	6.453*	4.591
β_5			(2.479)	2.435	(3.040)	(2.578)
ForeignOwnership – $F.O.^P$			-0.174**		-0.170**	-0.147**
γ			(0.037)		(0.036)	(0.039)
ForeignOwnership – $F.O.^{MN}$				-0.294		
γ				0.078		
TradingFreq			1.462	1.230	1.387	2.026
δ_1			(1.382)	1.407	(1.385)	(1.413)
NetProfitMargin	-0.035*				-0.020	
ρ_1	(0.017)				(0.015)	
DebtToAssetRatio	-5.506**				-5.126**	
ρ_2	(1.668)				(1.630)	
TotalAsset		-1.387**				-0.571**
ϕ		(0.226)				(0.239)
Constant	-1.660*	6.937**	-2.407*	-2.649	-0.028	1.402
λ	(0.716)	(1.797)	(0.998)	0.999	(1.130)	(1.884)
R-Square	0.079	0.133	0.225	0.205	0.261	0.234
Number of Observations	481	490	487	487	474	482
Test (p-value)						
$\beta_1 + \beta_2 = 0$			0.019	0.056	0.226	0.109
$\beta_1 + \beta_5 = 0$			0.884	0.814	0.508	0.909

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + PL_i'\rho + \phi S_i + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, PL_i is the set of variables quantifying profitability and leverage measures, S_i is the variable measuring firm size, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of PL_i and S_i. PL_i consists of net profit margin and debt to asset ratio, and S_i uses total asset. All are Q3-2006 numbers.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.6.2	Close19_Close18					
			A.5	C.1	C.2	C.3
DiffCov			**-13.207****	**-13.336****	**-12.833****	**-13.178****
β_1			(1.204)	(1.200)	(1.215)	(1.231)
DiffCov * Local_Market			**1.070**	**1.384**	**2.246**	**2.298**
β_2			(2.102)	(2.086)	(2.374)	(2.349)
DiffCov * NonMarket			**13.440****	**13.587****	**14.768****	**13.230****
β_5			(3.690)	(3.658)	(3.730)	(3.567)
ForeignOwnership – $F.O.^P$			**-0.023**		**-0.040**	**-0.035**
γ			(0.030)		(0.030)	(0.031)
ForeignOwnership – $F.O.^{MN}$				**-0.009**		
γ				(0.060)		
TradingFreq			**-5.631****	**-5.790****	**-5.840****	**-6.111****
δ_1			1.674)	(1.694)	(1.677)	(1.711)
NetProfitMargin	**0.062***				**0.054***	
ρ_1	(0.028)				(0.022)	
DebtToAssetRatio	**-0.522**				**0.445**	
ρ_2	(1.998)				(1.743)	
TotalAsset		**-1.072****				**0.305**
ϕ		(0.292)				(0.253)
Constant	**-11.389****	**-2.616**	**-2.449**	**-2.478***	**-2.767**	**-4.472***
λ	(1.038)	(2.485)	(1.253)	(1.252)	(1.413)	(2.158)
R-Square	0.013	0.063	0.434	0.434	0.437	0.427
Number of Observations	481	490	487	487	474	482
Test (p-value)						
$\beta_1 + \beta_2 = 0$			**0.000**	**0.000**	**0.000**	**0.000**
$\beta_1 + \beta_5 = 0$			0.947	0.943	0.588	0.988

Regression Specification: $\Delta Price_i = \lambda + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + PL_i^{'}\rho + \phi S_i + Z_i^{'}\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 20 and the market closing on December 19, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, PL_i is the set of variables quantifying profitability and leverage measures, S_i is the variable measuring firm size, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of PL_i and S_i. PL_i consists of net profit margin and debt to asset ratio, and S_i uses total asset. All are Q3-2006 numbers.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.6.3	Close20_Close19					
			A.5	C.1	C.2	C.3
DiffCov			**8.567****	**8.698****	**8.215****	**8.091****
β_1			(1.006)	(1.002)	(1.018)	(1.002)
DiffCov * Local_Market			**-0.175**	**-0.501**	**-1.906**	**-1.617**
β_2			(1.570)	(1.566)	(1.625)	(1.618)
DiffCov * NonMarket			**-7.442***	**-7.598***	**-7.923***	**-6.824***
β_5			(3.081)	(3.057)	(3.598)	(3.054)
ForeignOwnership – $F.O.^P$			**0.028**		**0.026**	**0.021**
γ			(0.024)		(0.024)	(0.026)
ForeignOwnership – $F.O.^{MN}$				**0.019**		
γ				(0.050)		
TradingFreq			**4.271****	**4.436****	**4.641****	**4.516****
δ_1			(1.180)	(1.184)	(1.200)	(1.203)
NetProfitMargin	**-0.005**				**-0.002**	
ρ_1	(0.021)				(0.016)	
DebtToAssetRatio	**1.219**				**0.530**	
ρ_2	(1.345)				(1.108)	
TotalAsset		**0.979****				**0.101**
ϕ		(0.197)				(0.187)
Constant	**6.464****	**-0.925**	**0.657**	**0.694**	**0.306**	**-0.097**
λ	(0.704)	(1.641)	(0.885)	(0.883)	(1.046)	(1.499)
R-Square	0.020	0.067	0.402	0.401	0.395	0.392
Number of Observations	481	490	487	487	474	482
Test (p-value)						
$\beta_1 + \beta_2 = 0$			**0.000**	**0.000**	**0.000**	**0.000**
$\beta_1 + \beta_5 = 0$			0.697	0.701	0.931	0.656

Regression Specification: $\Delta Price_i = \lambda + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + PL_i^{'}\rho + \phi S_i + Z_i^{'}\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 20 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, PL_i is the set of variables quantifying profitability and leverage measures, S_i is the variable measuring firm size, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of PL_i and S_i. PL_i consists of net profit margin and debt to asset ratio, and S_i uses total asset. All are Q3-2006 numbers.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.6.4	Close20_Close18					
			A.5	C.1	C.2	C.3
DiffCov			**-4.642****	**-4.638****	**-4.618****	**-5.086****
β_1			(0.741)	(0.735)	(0.748)	(0.747)
DiffCov * Local_Market			**0.883**	**0.868**	**0.328**	**0.668**
β_2			(1.492)	(1.485)	(1.527)	(1.549)
DiffCov * NonMarket			**6.017**	**6.007**	**6.845**	**6.424**
β_5			(3.569)	(3.561)	(4.194)	(3.509)
ForeignOwnership – $F.O.^P$			**0.005**		**-0.014**	**-0.014**
γ			(0.018)		(0.018)	(0.020)
ForeignOwnership – $F.O.^{MN}$				**0.009**		
γ				(0.038)		
TradingFreq			**-1.351**	**-1.345**	**-1.193**	**-1.584**
δ_1			(1.497)	(1.515)	(1.505)	(1.532)
NetProfitMargin	**0.056****				**0.052****	
ρ_1	(0.016)				(0.016)	
DebtToAssetRatio	**0.689**				**0.968**	
ρ_2	(1.405)				(1.452)	
TotalAsset		**-0.095**				**0.402***
ϕ		(0.165)				(0.180)
Constant	**-4.924****	**-3.520***	**-1.796**	**-1.789**	**-2.462***	**-4.551****
λ	(0.687)	(1.443)	(1.212)	(1.213)	(1.247)	(1.631)
R-Square	0.016	0.015	0.139	0.139	0.158	0.136
Number of Observations	481	490	487	487	474	482
Test (p-value)						
$\beta_1 + \beta_2 = 0$			**0.018**	**0.018**	**0.008**	**0.007**
$\beta_1 + \beta_5 = 0$			0.682	0.683	0.576	0.683

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + PL_i'\rho + \phi S_i + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the individual lowest point on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, PL_i is the set of variables quantifying profitability and leverage measures, S_i is the variable measuring firm size, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of PL_i and S_i. PL_i consists of net profit margin and debt to asset ratio, and S_i uses total asset. All are Q3-2006 numbers.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.6.5	Low19_Close18					
			A.5	C.1	C.2	C.3
DiffCov			**-16.291****	**-16.340****	**-15.600****	**-16.352****
β_1			(1.621)	(1.611)	(1.613)	(1.657)
DiffCov * Local_Market			**1.959**	**2.111**	**3.029**	**3.617**
β_2			(2.372)	(2.340)	(2.731)	(2.686)
DiffCov * NonMarket			**13.633***	**13.721***	**18.085****	**13.456***
β_5			(6.639)	(6.603)	(5.929)	(6.301)
ForeignOwnership – $F.O.^P$			**-0.038**		**-0.060**	**-0.072**
γ			(0.040)		(0.040)	(0.042)
ForeignOwnership – $F.O.^{MN}$				**-0.060**		
γ				(0.077)		
TradingFreq			**-12.943****	**-13.013****	**-13.269****	**-14.070****
δ_1			(2.023)	(2.042)	(2.021)	(2.049)
NetProfitMargin	**0.054**				**0.048**	
ρ_1	(0.036)				(0.030)	
DebtToAssetRatio	**-2.713**				**-1.317**	
ρ_2	(2.602)				(2.156)	
TotalAsset		**-1.419****				**0.796***
ϕ		(0.410)				(0.363)
Constant	**-16.763****	**-6.359**	**-2.214**	**-2.266**	**-1.523**	**-7.489***
λ	(1.369)	(3.494)	(1.538)	(1.535)	(1.778)	(3.004)
R-Square	0.025	0.061	0.518	0.518	0.525	0.516
Number of Observations	481	490	487	487	474	482
Test (p-value)						
$\beta_1 + \beta_2 = 0$			**0.000**	**0.000**	**0.000**	**0.000**
$\beta_1 + \beta_5 = 0$			0.679	0.682	0.662	0.634

Table 3.7 Multivariate Regressions on Changes in the Equity Premium Components Reflecting Risk and Liquidity with Details of Business-Type Effects

Regression Specification: $\Delta Price_i = \lambda + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + Z_i^{'}\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, and Z_i is the set of business-type indicators.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.7.1	Open19_Close18			Close19_Close18		
	D.1	D.2	A.5	D.1	D.2	A.5
DiffCov		**-5.289****	**-4.732****		**-13.722****	**-13.207****
β_1		(0.950)	(0.989)		(1.120)	(1.204)
DiffCov * Local_Market		**1.921**	**2.247***		**0.999**	**1.070**
β_2		(1.088)	(1.130)		(2.110)	(2.102)
DiffCov * NonMarket		**5.749***	**5.060***		**14.182****	**13.440****
β_5		(2.483)	(2.479)		(3.842)	(3.690)
ForeignOwnership		**-0.178****	**-0.174****		**-0.014**	**-0.023**
γ		(0.033)	(0.037)		(0.025)	(0.030)
TradingFreq		**1.009**	**1.462**		**-7.858****	**-5.631****
δ_1		(1.315)	(1.382)		(1.517)	(1.674)
Constant		**-1.808**			**-0.607**	
λ		(0.962)			(1.071)	
R-Square	0.394	0.227	0.495	0.696	0.435	0.797
Number of Observations	497	487	487	497	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.002**	**0.019**		**0.000**	**0.000**
$\beta_1 + \beta_5 = 0$		0.847	0.884		0.903	0.947
Inclusion of:						
Business-type Indicators	Yes	No	Yes	Yes	No	Yes
θ						
Agribusiness	**-2.590***		**-1.268**	**-6.195****		**-0.412**
Food and Beverage	**-4.242***		**-3.070**	**-8.821****		**-2.855**
Fashion	**-2.263***		**-1.900**	**-3.396****		**-0.392**
Home and Office Products	**-4.364**		**-3.501**	**-10.155****		**-3.867**
P. Products and Pharmaceuticals	**-2.350****		**-1.602**	**-6.600****		**-0.807**
Banking	**-13.136****		**-5.248**	**-17.371****		**-3.846**
Finance and Securities	**-6.386****		**-4.106**	**-16.937****		**-3.888**
Insurance	**-2.928***		**-2.724**	**-3.544****		**-0.161**
Automotive	**-3.805***		**-2.703**	**-9.567****		**-1.458**
Ind. Materials and Machinery	**-2.709****		**-1.846**	**-11.827****		**-3.823**
Paper and Printing Materials	**-2.133****		**-0.665**	**-9.500**		**-4.273**

Table 3.7.1 (… continued)	Open19_Close18			Close19_Close18		
	D.1	D.2	A.5	D.1	D.2	A.5
θ						
Petrochemicals and Chemicals	-3.469*		-2.131	-7.162**		0.174
Packaging	-0.246		0.934	-5.015**		1.841
Construction Materials	-5.081**		-3.456*	-15.316**		-4.477*
Property Development	-7.356**		-3.169*	-16.337**		-2.654
Energy and Utilities	-4.600**		-1.341	-14.332**		-3.331
Mining	-2.900		1.387	-4.450		5.115
Commerce	-3.080**		-0.237	-11.253**		-2.195
Health Care Services	-3.177**		-2.575*	-6.177**		0.628
Media and Publishing	-3.515**		-1.889	-12.985**		-3.915*
Professional Services	-3.750**		-0.594	-13.350**		1.684
Tourism and Leisure	-2.881**		-2.538*	-8.638**		-3.704
Transportation and Logistics	-4.013**		-0.993	-11.387**		-1.505
Electronic Components	-1.336**		1.435	-8.055**		1.200
Info. and Com. Technology	-5.919**		-3.629*	-16.723**		-5.304**
Small Enterprises (mai)	-2.879**		-2.565	-11.026**		-3.155

Table 3.7.2	Close20_Close19			Close20_Close18		
	D.1	D.2	A.5	D.1	D.2	A.5
DiffCov		8.864**	8.567**		-4.857**	-4.642**
β_1		(0.876)	(1.006)		(0.729)	(0.741)
DiffCov * Local_Market		0.129	-0.175		1.112	0.883
β_2		(1.558)	(1.570)		(1.562)	(1.492)
DiffCov * NonMarket		-7.293*	-7.442*		6.910*	6.017
β_5		(3.045)	(3.081)		(3.211)	(3.569)
ForeignOwnership		0.019	0.028		0.004	0.005
γ		(0.022)	(0.024)		(0.016)	(0.018)
TradingFreq		5.698**	4.271**		-2.150	-1.351
δ_1		(0.993)	(1.180)		(1.334)	(1.497)
Constant		-0.494			-1.108	
λ		(0.653)			(1.051)	
R-Square	0.644	0.404	0.750	0.468	0.140	0.518
Number of Observations	497	487	487	497	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		0.000	0.000		0.020	0.018
$\beta_1 + \beta_5 = 0$		0.601	0.697		0.522	0.682
Inclusion of:						
Business-type Indicators	Yes	No	Yes	Yes	No	Yes
θ						
Agribusiness	2.660**		-1.621	-3.540**		-2.041
Food and Beverage	4.617**		0.149	-4.204**		-2.710
Fashion	2.029**		-0.321	-1.367		-0.717
Home and Office Products	5.045**		0.415	-5.109		-3.456
P. Products and Pharmaceuticals	4.217**		-0.018	-2.433		-0.877

Table 3.7.2 (… continued)	Close20_Close19			Close20_Close18		
	D.1	D.2	A.5	D.1	D.2	A.5
Banking	**9.979****		**-0.004**	**-7.393****		**-3.849***
Finance and Securities	**10.240****		**1.067**	**-6.711****		**-2.839**
Insurance	**0.711**		**-1.829**	**-2.833***		**-1.992**
Automotive	**5.119****		**-0.811**	**-4.452****		**-2.277**
Ind. Materials and Machinery	**7.018****		**1.129**	**-4.818****		**-2.707**
Paper and Printing Materials	**7.500**		**3.347**	**-2.000**		**-0.929**
Petrochemicals and Chemicals	**4.946****		**-0.440**	**-2.192****		**-0.247**
Packaging	**4.238****		**-0.702**	**-0.792**		**1.121**
Construction Materials	**9.465****		**1.722**	**-5.852****		**-2.759**
Property Development	**11.171****		**1.481**	**-5.158****		**-1.168**
Energy and Utilities	**8.932****		**1.050**	**-5.400****		**-2.285**
Mining	**2.400**		**-4.263**	**-2.050**		**0.852**
Commerce	**8.680****		**1.978**	**-2.567***		**-0.215**
Health Care Services	**4.923****		**-0.058**	**-1.246**		**0.575**
Media and Publishing	**9.035****		**2.560**	**-3.950****		**-1.357**
Professional Services	**9.300****		**-1.109**	**-4.050**		**0.569**
Tourism and Leisure	**5.463****		**1.752**	**-3.188***		**-1.969**
Transportation and Logistics	**6.267****		**-0.758**	**-5.127****		**-2.272**
Electronic Components	**5.945****		**-0.785**	**-2.100**		**0.421**
Info. and Com. Technology	**9.642****		**1.520**	**-7.077****		**-3.784***
Small Enterprises (mai)	**7.429****		**1.672**	**-3.602****		**-1.491**

Table 3.8 Multivariate Regressions on Changes in the Equity Premium Components Reflecting Risk and Liquidity, and Nature of Business

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + NB_i'\rho + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market opening on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, NB_i is the set of variables reflecting the nature of business, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of NB_i, including indicators of firms with foreign revenues, firms with agricultural manufacturing and firms with industrial manufacturing.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.8.1	Open19_Close18					
	E.1	E.2	E.3	E.4	E.5	E.6
DiffCov		**-4.667****	**-4.960****		**-4.680****	**-4.984****
β_1		(0.987)	(0.947)		(0.998)	(0.959)
DiffCov * Local_Market		**2.177**	**1.895**		**2.229***	**2.028**
β_2		(1.129)	(1.090)		(1.133)	(1.069)
DiffCov * NonMarket		**5.092***	**5.593***		**5.041***	**5.436***
β_5		(2.506)	(2.474)		(2.479)	(2.454)
ForeignOwnership		**-0.177****	**-0.180****		**-0.171****	**-0.176****
γ		(0.036)	(0.033)		(0.036)	(0.033)
TradingFreq		**1.642**	**1.191**		**1.555**	**0.938**
δ_1		(1.348)	(1.275)		(1.389)	(1.324)
ForeignRevenue	**1.898***	**1.937****	**1.866****			
ρ_1	(0.779)	(0.745)	(0.671)			
AgriculturalManufacturing				**7.502**	**5.561**	**1.085**
ρ_2				(5.253)	(5.085)	(0.895)
IndustrialManufacturing				**-0.366**	**-0.143**	**0.925**
ρ_3				(0.714)	(0.685)	(0.555)
Constant	**-4.693****	**-2.846****	**-2.336****	**-4.908****	**-2.956****	**-2.301***
λ	(0.318)	(0.955)	(0.908)	(0.586)	(1.134)	(0.995)
R-Square	0.023	0.236	0.237	0.004	0.189	0.232
Number of Observations	489	487	487	489	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.019**	**0.005**		**0.022**	**0.004**
$\beta_1 + \beta_5 = 0$		0.852	0.788		0.872	0.846
Inclusion of:						
Business-type Indicators	Yes	Yes	No	Yes	Yes	No

Regression Specification: $\Delta Price_i = \lambda + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + NB_i^{'}\rho + Z_i^{'}\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 19 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, NB_i is the set of variables reflecting the nature of business, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of NB_i, including indicators of firms with foreign revenues, firms with agricultural manufacturing and firms with industrial manufacturing.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.8.2	Close19_Close18					
	E.1	E.2	E.3	E.4	E.5	E.6
DiffCov		**-13.145****	**-13.398****		**-13.146****	**-13.401****
β_1		(1.210)	(1.120)		(1.211)	(1.127)
DiffCov * Local_Market		**1.005**	**0.973**		**1.074**	**1.111**
β_2		(2.111)	(2.120)		(2.106)	(2.105)
DiffCov * NonMarket		**13.471****	**14.028****		**13.358****	**13.849****
β_5		(3.702)	(3.769)		(3.696)	(3.722)
ForeignOwnership		**-0.025**	**-0.016**		**-0.022**	**-0.013**
γ		(0.029)	(0.025)		(0.030)	(0.025)
TradingFreq		**-5.460****	**-7.679****		**-5.663****	**-7.937****
δ_1		(1.650)	(1.490)		(1.680)	(1.520)
ForeignRevenue	**2.565***	**1.839**	**1.838***			
ρ_1	(1.184)	(0.955)	(0.859)			
AgriculturalManufacturing				**4.875**	**1.887**	**1.115**
ρ_2				(3.068)	(2.841)	(1.075)
IndustrialManufacturing				**0.753**	**0.660**	**0.987**
ρ_3				(1.494)	(1.331)	(0.692)
Constant	**-11.958****	**-2.865***	**-1.127**	**-12.242****	**-2.845***	**-1.125**
λ	(0.403)	(1.233)	(1.056)	(0.652)	(1.361)	(1.137)
R-Square	0.040	0.439	0.441	0.029	0.436	0.438
Number of Observations	489	487	487	489	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.000**	**0.000**		**0.000**	**0.000**
$\beta_1 + \beta_5 = 0$		0.926	0.864		0.952	0.902
Inclusion of:						
Business-type Indicators	Yes	Yes	No	Yes	Yes	No

Regression Specification: $\Delta Price_i = \lambda + DC_i^{'}\beta + \gamma FO_i + TF_i^{'}\delta + NB_i^{'}\rho + Z_i^{'}\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 20 and the market closing on December 19, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, NB_i is the set of variables reflecting the nature of business, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of NB_i, including indicators of firms with foreign revenues, firms with agricultural manufacturing and firms with industrial manufacturing.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.8.3	Close20_Close19					
	E.1	E.2	E.3	E.4	E.5	E.6
DiffCov		**8.546****	**8.682****		**8.452****	**8.463****
β_1		(1.011)	(0.884)		(1.007)	(0.886)
DiffCov * Local_Market		**-0.153**	**0.144**		**-0.194**	**-0.008**
β_2		(1.571)	(1.564)		(1.543)	(1.561)
DiffCov * NonMarket		**-7.452***	**-7.207***		**-7.254***	**-6.919***
β_5		(3.088)	(3.011)		(3.085)	(2.931)
ForeignOwnership		**0.029**	**0.020**		**0.029**	**0.017**
γ		(0.024)	(0.022)		(0.024)	(0.022)
TradingFreq		**4.214****	**5.597****		**4.410****	**5.730****
δ_1		(1.189)	(1.004)		(1.178)	(0.981)
ForeignRevenue	**-1.118**	**-0.619**	**-1.035**			
ρ_1	(0.772)	(0.641)	(0.623)			
AgriculturalManufacturing				**-3.189**	**-1.051**	**-1.783****
ρ_2				(2.351)	(1.898)	(0.683)
IndustrialManufacturing				**-1.697**	**-1.699**	**-1.041***
ρ_3				(1.098)	(0.989)	(0.500)
Constant	**7.386****	**0.797**	**-0.201**	**8.092****	**1.274**	**0.166**
λ	(0.289)	(0.908)	(0.701)	(0.481)	(0.954)	(0.743)
R-Square	0.033	0.405	0.407	0.056	0.406	0.413
Number of Observations	489	487	487	489	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.000**	**0.000**		**0.000**	**0.000**
$\beta_1 + \beta_5 = 0$		0.705	0.619		0.678	0.590
Inclusion of:						
Business-type Indicators	Yes	Yes	No	Yes	Yes	No

Regression Specification: $\Delta Price_i = \lambda + DC_i'\beta + \gamma FO_i + TF_i'\delta + NB_i'\rho + Z_i'\theta + \varepsilon_i$

$\Delta Price_i$ is the change in share price between the market closing on December 20 and the market closing on December 18, DC_i is the set of variables capturing difference in covariances, FO_i is the variable measuring foreign ownership, TF_i is the set of variables characterizing trading frequency, NB_i is the set of variables reflecting the nature of business, and Z_i is the set of business-type indicators.

The regression specification is based on the specification A.5 with the addition of NB_i, including indicators of firms with foreign revenues, firms with agricultural manufacturing and firms with industrial manufacturing.

All coefficients are reported along with their standard errors (in parentheses). Standard errors are Eicker-White robust standard errors. ** denotes 1% significance and * denotes 5% significance. The regression R-square excludes the explanatory power of business-type specific factors. Regarding statistical tests, the p-value associated with each test is reported; a p-value of less than 0.05 means a rejection of the null hypothesis.

Table 3.8.4	Close20_Close18					
	E.1	E.2	E.3	E.4	E.5	E.6
DiffCov		**-4.601****	**-4.717****		**-4.696****	**-4.939****
β_1		(0.739)	(0.727)		(0.746)	(0.727)
DiffCov * Local_Market		**0.839**	**1.101**		**0.867**	**1.087**
β_2		(1.506)	(1.565)		(1.494)	(1.572)
DiffCov * NonMarket		**6.037**	**6.844***		**6.124**	**6.954***
β_5		(3.570)	(3.213)		(3.587)	(3.262)
ForeignOwnership		**0.003**	**0.003**		**0.007**	**0.004**
γ		(0.019)	(0.016)		(0.018)	(0.016)
TradingFreq		**-1.239**	**-2.072**		**-1.245**	**-2.197**
δ_1		(1.473)	(1.317)		(1.508)	(1.355)
ForeignRevenue	**1.441***	**1.214**	**0.795**			
ρ_1	(0.731)	(0.683)	(0.640)			
AgriculturalManufacturing				**1.664**	**0.814**	**-0.674**
ρ_2				(1.763)	(1.889)	(0.744)
IndustrialManufacturing				**-0.949**	**-1.045**	**-0.058**
ρ_3				(0.829)	(0.821)	(0.492)
Constant	**-4.572****	**-2.071**	**-1.333**	**-4.149****	**-1.572**	**-0.964**
λ	(0.248)	(1.185)	(1.034)	(0.375)	(1.234)	(1.101)
R-Square	0.016	0.141	0.143	0.000	0.121	0.141
Number of Observations	489	487	487	489	487	487
Test (p-value)						
$\beta_1 + \beta_2 = 0$		**0.020**	**0.025**		**0.017**	**0.018**
$\beta_1 + \beta_5 = 0$		0.668	0.505		0.671	0.534
Inclusion of:						
Business-type Indicators	Yes	Yes	No	Yes	Yes	No

3.6.2 Net-Return-Equivalent Costs

The concept of net-return-equivalent costs, building on the idea of interest-rate-equivalent costs, is developed for inferring the implicit tax rate imposed by the URR. Specifically, the reserve requirement can be viewed as a tax on new foreign investment in terms of the net-return-equivalent cost defined as the difference in net returns between the cases with and without capital controls. In comparison to the conventional approach based on the idea of interest-rate-equivalent costs (see De Gregorio, Edwards and Valdes (2000) as an example), the new approach of calculating costs induced by capital controls from the perspective of the difference in net returns is more convenient and illustrative. In particular, the concept of interest-rate-equivalent costs implicitly assumes the uncovered interest rate parity in order that the necessary increase in domestic interest rates to compensate for costs resulting from the reserve requirement can be measured. Moreover, the concept of net-return-equivalent costs can be easily extended to deal with complicated issues arising in the world of multiple currencies.

The following discussion first presents the derivation of net-return-equivalent costs in a simple setup based on Thailand's URR measure, then addresses various issues arising in the world of multiple currencies, and lastly shows how to derive return-equivalent costs in an optimization framework.

❖ Derivation of Net-Return-Equivalent Costs

To present the key intuition, the derivation assumes that the funding source is only in US dollar with the (annual) international interest rate i^*. Investment in the domestic economy with maturity of k month yields the (annual) domestic interest rate i_k. For simplicity, all interests are constant. Suppose that the central bank imposes the reserve requirement with a fraction μ of financial inflows, the withholding period of h months, and the penalty on early withdrawal amounting to a fraction $1-x$ of the reserve. Based on this static setup, the net-return-equivalent cost can be derived in a straightforward manner as presented below.

Let's first consider the case in which the investment maturity is equal to the withholding period $(k = h)$ under two different scenarios. The first setup is to borrow from abroad 1 dollar at the international interest rate i^* to invest at the rate of return i_k in Thailand:

At time $t = 0$, the investor has the remaining funds of $1-\mu$ to invest at the rate of return $i_k - \Delta e$ (positive Δe means that the domestic currency depreciates), which comes from domestic interest payment i_k and from potential domestic currency appreciation $-\Delta e$. Then, at time $t = h$, the investment is terminated. The investor receives the return $i_k - \Delta e$ on the investment funds of $1-\mu$, and the return of zero on the reserve of μ. The borrowing agreement is also settled.

The net return under capital controls is $nr_{control} = \frac{k}{12}\left((1-\mu)(i_k - \Delta e) - i^*\right)$, while the net return under no capital controls is $nr_{no\ control} = \frac{k}{12}(i_k - \Delta e - i^*)$. Therefore, the net-return-equivalent cost is: $\tau_k = \frac{12}{k}(nr_{no\ control} - nr_{control}) = \mu(i_k - \Delta e)$. When the UIP-typed condition holds, i.e., $i_k = i^* + \Delta e + \tau_k + \rho$, where ρ is the risk premium and Δe is the expected exchange rate depreciation, the net-return-equivalent cost becomes $\tau_k = \frac{\mu}{1-\mu}(i^* + \rho)$. This result can also be obtained from a portfolio allocation problem under the optimization framework.

Another scenario, which yields the result that can be obtained from a financing decision problem under the optimization framework, is to borrow from abroad the necessary amount of funds at the international interest rate i^* to invest an equivalent amount of 1 dollar at the rate of return i_k in Thailand:

At time $t = 0$, the investor needs to borrow $1 + \frac{\mu}{1-\mu}$ dollar to invest 1 dollar at the rate of return $i_k - \Delta e$, and to make the required deposit of $\mu\left(1 + \frac{\mu}{1-\mu}\right) = \frac{\mu}{1-\mu}$ dollar. Then, at time $t = h$, the investment is terminated. The investor receives the return $i_k - \Delta e$ on the investment funds of 1, and the return of zero on the reserve of $\frac{\mu}{1-\mu}$. The borrowing agreement is also settled.

The net return under capital controls is $nr_{control} = \frac{k}{12}\left(i_k - \Delta e - \left(1 + \frac{\mu}{1-\mu}\right) i^*\right)$, while the net return under no capital controls is $nr_{no\ control} = \frac{k}{12}(i_k - \Delta e - i^*)$. Hence, the net-return-equivalent cost is: $\tau_k = \frac{12}{k}(nr_{no\ control} - nr_{control}) = \frac{\mu}{1-\mu} i^*$.

Next, let's focus on short-term investment ($k < h$). Borrowing the necessary amount of funds at the international interest rate i^* to invest an equivalent amount of 1 dollar at the rate of return i_k in Thailand for k months would have the following scenario:

At time $t = 0$, the investor needs to borrow $1 + \frac{\mu}{1-\mu}$ dollar to invest 1 dollar at the rate of return $i_k - \Delta e$, and to make the required deposit of $\frac{\mu}{1-\mu}$ dollar. Then, at time $t = k$, the investment is terminated. The investor receives the return $i_k - \Delta e$ on the investment funds of 1. The reserve with zero return is given back by $x\frac{\mu}{1-\mu}$ due to the penalty on early withdrawal. The borrowing agreement is also settled.

The net return under capital controls is $nr_{control} = \frac{k}{12}(i_k - \Delta e) - \frac{k}{12}\left(1 + \frac{\mu}{1-\mu}\right) i^* - (1-x)\frac{\mu}{1-\mu}$, while the net return under no capital controls is $nr_{no\ control} = \frac{k}{12}(i_k - \Delta e - i^*)$. Therefore, the net-return-equivalent cost is: $\tau_k = \frac{12}{k}(nr_{no\ control} - nr_{control}) = \frac{\mu}{1-\mu} i^* + \frac{\mu}{1-\mu}\frac{12}{k}(1-x)$.

Similarly, the net-return-equivalent cost for borrowing from abroad 1 dollar at the international interest rate i^* to invest at the rate of return i_k in Thailand for k months is:

$\tau_k = \mu(i - \Delta e) + \mu\frac{12}{k}(1-x)$, which becomes: $\tau_k = \frac{\mu}{1-\mu}(i^* + \rho) + \frac{\mu}{1-\mu}\frac{12}{k}(1-x)$ when the UIP-typed condition holds.

For long-term investment $(k \geq h)$, a similar calculation applies. However, at the end of the withholding period, the investor has to make an additional decision on what to do with the deposited reserve being returned from the central bank.

In the case of repaying some part of the principal, borrowing the necessary amount of funds at the international interest rate i^* to invest an equivalent amount of 1 dollar at the rate of return i_k in Thailand for k months would have the following scenario:

At time $t = 0$, the investor needs to borrow $1 + \frac{\mu}{1-\mu}$ dollar to invest 1 dollar at the rate of return $i_k - \Delta e$, and to make the required deposit of $\frac{\mu}{1-\mu}$ dollar. Then, at time $t = h$, the investor receives the reserve with zero return back by $\frac{\mu}{1-\mu}$, which will be repaid for some part of the principal. When time $t = k$ arrives, the investment is terminated. The investor receives the return $i_k - \Delta e$ on the investment funds of 1. The borrowing agreement is also settled.

The net return under capital controls is $nr_{control} = \frac{k}{12}(i_k - \Delta e) - \frac{k}{12}i^* - \frac{h}{12}\frac{\mu}{1-\mu}i^*$, while the net return under no capital controls is $nr_{no\ control} = \frac{k}{12}(i_k - \Delta e - i^*)$. Thus, the net-return-equivalent cost is: $\tau_k = \frac{12}{k}(nr_{no\ control} - nr_{control}) = \frac{\mu}{1-\mu}\frac{h}{k}i^*$ in the case of repaying some part of the principal. On the other hand, the net-return-equivalent cost is: $\tau_k = \frac{\mu h}{k-\mu h}i^*$ in the case of investing the returned reserve in the domestic economy.

Similarly, for borrowing from abroad 1 dollar at the international interest rate i^* to invest at the rate of return i_k in Thailand for k months under the UIP-typed condition, the net-return-equivalent cost is $\tau_k = \frac{\mu}{1-\mu}\frac{h}{k}i^* + \frac{\mu}{1-\mu}\rho$ for repaying some part of the principal, and $\tau_k = \frac{\mu h}{k-\mu h}(i^* + \rho)$ for investing the returned reserve domestically.

The formula of τ_k under different scenarios analyzed above is summarized in Table 3.9.

The following discussion addresses some interesting issues related to net-return-equivalent costs and interest-rate-equivalent costs.

- The standard interest-rate-equivalent cost in the literature taking the form of $\frac{\mu}{1-\mu}\frac{h}{k}i^*$ has a nice interpretation. The component $\frac{\mu}{1-\mu}$ captures the amount of additional funds that investors need to bring in the country for the reserve requirement. The borrowing cost of such additional funds depends on the international interest rate i^* and the investment horizon reflected by the term $\frac{h}{k}$.

Table 3.9 Formula of Net-Return-Equivalent Costs

Scenario	Net-Return-Equivalent Cost		
	Portfolio Allocation	Portfolio Allocation under the UIP-typed Condition	Financing Decision
$k < h$	$\mu(i - \Delta e) + \mu \frac{12}{k}(1 - x)$	$\frac{\mu}{1-\mu}(i^* + \rho) + \frac{\mu}{1-\mu}\frac{12}{k}(1 - x)$	$\frac{\mu}{1-\mu} i^* + \frac{\mu}{1-\mu}\frac{12}{k}(1 - x)$
$k \geq h$, with using reserve to repay part of principal	$\mu(i - \Delta e) - \mu\left(1 - \frac{h}{k}\right) i^*$	$\frac{\mu}{1-\mu}\frac{h}{k} i^* + \frac{\mu}{1-\mu}\rho$	$\frac{\mu}{1-\mu}\frac{h}{k} i^*$
$k \geq h$, with investing reserve domestically	$\mu \frac{h}{k}(i - \Delta e)$	$\frac{\mu h}{k - \mu h}(i^* + \rho)$	$\frac{\mu h}{k - \mu h} i^*$

- The two different setups, i.e. portfolio allocation and financing decision, yield the same net-return-equivalent cost when the risk premium does not exist. However, the UIP-typed condition is required for the former scenario so that the net-return-equivalent cost is a function of the international, rather than domestic, interest rate. Typically, the derivation of interest-rate-equivalent costs implicitly assumes the UIP-typed condition.
- The wedge of net returns between the cases with and without capital controls captures the additional borrowing cost to cover the reserve and the penalty on early withdrawal. Therefore, the financing problem setup may seem more appropriate to capture costs induced by capital controls as net-return-equivalent costs measure additional costs for engaging in exactly the same domestic investment opportunities.
- It is important that the reserve is withheld in foreign currency. If the reserve can be withheld in domestic currency, investors may receive benefits from potential currency appreciation. The net-return-equivalent cost becomes $\tau_k = \frac{\mu}{1-\mu}\frac{h}{k}(i^* + \Delta e)$, which can be negative if the exchange rate appreciates considerably.
- In the dynamic setup, the calculation of net-return-equivalent can be much more complicated due to various issues such as the option value to maintain investment in the domestic financial system owing to costs induced by capital controls, the interaction between interest rates and exchange rate, and the effect of capital controls on the expectation of exchange rate movements.

❖ Multiple Foreign Currencies

The URR measure implemented by the BoT stipulated that the reserve would be withheld in the currency of incoming foreign-currency funds. Therefore, investors had freedom to choose the source of funds and the currency that they brought into Thailand. No specification on the currency of the reserve may have some implications on the pattern of financial flows. The analysis consists of two parts: arbitrage based on the UIP condition and attainment of lower costs under the CIP condition. For simplicity, the setup assumes two funding sources: US dollar and Japanese yen, with yen representing the currency with low interest rates.

Let's first look at arbitrage based on the UIP condition. Consider the case of long-term investment ($k \geq h$) in which the investor borrows from abroad the necessary amount of funds to invest an equivalent amount of 1 dollar in Thailand, and uses the returned reserve to repay some part of the principal.[40] The world consists of three currencies: US dollar, Japanese yen and Thai baht with respective interest rates: i_D, i_Y and i, with $i_Y < i_D$. The net-return-equivalent costs are: $\tau_D = \frac{\mu}{1-\mu}\frac{h}{k}i_D$ for borrowing in dollar, and $\tau_Y = \frac{\mu}{1-\mu}\frac{h}{k}i_Y$ for borrowing in yen.[41]

Suppose that the investor borrows in dollar to invest in baht with expected exchange rate depreciation $\Delta e_{B/D}$ (positive means that the Thai baht depreciates against the US dollar). The net return of such investment strategy is $nr_D = (i - \Delta e_{B/D}) - i_D - \tau_D$. Borrowing in yen to invest in baht would create the net return of $nr_Y = (i - \Delta e_{B/Y}) - i_Y - \tau_Y$. Assume that the UIP condition holds between the US dollar and the Japanese yen: $i_D = i_Y + \Delta e_{D/Y}$, and that people are risk-neutral. Substituting i_D from the UIP-typed condition to the net return nr_D, the net return becomes:

$$nr_D = (i - \Delta e_{B/D}) - i_D - \tau_D = (i - \Delta e_{B/D}) - (i_Y + \Delta e_{D/Y}) - \tau_D$$

$$nr_D = \left(i - \Delta e_{B/Y} - i_Y\right) - \tau_D = nr_Y + (\tau_Y - \tau_D) < nr_Y.$$

The net return nr_Y should be zero; otherwise, arbitrage opportunities would exist. Since borrowing in yen is cheaper, $\tau_Y < \tau_D$. Then, the net return nr_D must become negative, implying that people should not borrow in dollar to invest in baht. It would be better to borrow in yen to invest in baht because the net-return-equivalent cost induced by the URR measure is lower when funding is in yen.

The result might seem counterintuitive at first glance. The key reason is that the reserve requirement takes away benefits (which could be derived from the reserve) in the form of interest payment and potential currency movement. Without capital controls, the difference in benefits from potential currency movement should be compensated by the interest rate differential; thus, the source of funding is irrelevant. However, when capital controls exist, the difference in benefits from expected appreciation of the Japanese yen

[40] The analysis can be easily extended to other setups. For simplicity, this setup ignores the penalty on early withdrawal and the possibility to invest the returned reserve domestically.

[41] Based on interest rates prevailing during the URR regime, the difference between τ_D and τ_Y is within the neighborhood of 200 basis points.

against the US dollar is taken away, while the interest rate for borrowing remains higher in dollar than in yen. Consequently, yen provides a more favorable source of funding.

The existence of the risk premium consistent with the optimal portfolio allocation does not change the result. When the UIP-typed condition holds between the US dollar and the Japanese yen: $i_D = i_Y + \Delta e_{D/Y} + \rho_{D,Y}$, where $\rho_{D,Y}$ is the risk premium of holding dollar relative to yen, and $\rho_{D,Y} = \rho_{D,B} + \rho_{B,Y}$, a similar derivation leads to:

$$nr_D = (i - \Delta e_{B/D}) - i_D - \tau_D = (i - \Delta e_{B/D}) - (i_Y + \Delta e_{D/Y} + \rho_{D,Y}) - \tau_D$$

$$nr_D = (i - \Delta e_{B/Y} - i_Y) - (\rho_{D,B} + \rho_{B,Y}) - \tau_D = (nr_Y - \rho_{B,Y}) + (\tau_Y - \tau_D) + \rho_{B,D} < \rho_{B,D}.$$

Since the net return nr_Y should be equal to $\rho_{B,Y}$ in equilibrium, the net return nr_D must become smaller than $\rho_{B,D}$. People should not borrow in dollar to invest in baht as the net return nr_D is not sufficiently large to compensate for risks associated with holding baht relative to dollar.

Hence, the analysis predicts that money should come in yen under the URR regime because of no specification on the currency of the reserve. There should be a shift in the currency composition of financial inflows towards the Japanese yen. If money continued to come in US dollar, the UIP-typed condition (between US dollar and Japanese yen) might not hold along the line with its general empirical failure. One plausible explanation could be the existence of an extra component of the risk premium in addition to the part that is consistent with the optimal portfolio allocation (which is generally proportional to the variance of exchange rate movements). Particularly, assume the UIP-typed condition: $i_D = i_Y + \Delta e_{D/Y} + \rho_{D,Y} + \nu_{D,Y}$, where $\nu_{D,Y}$ represents the additional risk premium described above. For instance, ν may compensate for currency crashes and rare disasters as in Brunnermeier, Nagel and Pedersen (2009). Then, the relationship between the net returns becomes:

$$nr_D = (nr_Y - \rho_{B,Y}) + (\tau_Y - \tau_D - \nu_{D,Y}) + \rho_{B,D}.$$

When $\nu_{D,Y} < 0$, it is possible that the net return nr_D is equal to $\rho_{B,D}$, while the net return nr_Y is smaller than $\rho_{B,Y}$.[42] In words, when the US dollar is expected to depreciate relative to the Japanese yen due to additional risks, the favored funding source could be dollar, although the net-return-equivalent cost is lower for borrowing in yen.

Next, let's examine the attainment of lower costs under the CIP condition. The setup of the world with three currencies remains unchanged; however, assume that the CIP condition between the US dollar and the Japanese yen holds: $f^{y/d} - e^{y/d} = i_Y - i_D$, where

[42] The risk premium component $\nu_{D,Y}$ should be viewed relatively to the counterpart $\nu_{D,B}$, which is normalized to zero. In other words, when $\nu_{D,Y} < 0$ in this setup, the Japanese yen is expected to strengthen against both currencies.

$e^{y/d}$ is the spot exchange rate and $f^{y/d}$ is the forward exchange rate in terms of Japanese yen per one US dollar; both are expressed on logarithmic scale. The following investment strategy of borrowing in dollar can yield the net-return-equivalent cost equal to τ_Y.

At time $t = 0$, the investor borrows $1 + \frac{\mu}{1-\mu}$ dollar and converts dollar into yen at the rate of $e^{y/d}$ so that the money comes in Thailand in yen, and the reserve is withheld in yen. At the same time, the investor buys h-month forward of $\frac{\mu}{1-\mu}$ dollar at a rate of $f^{y/d}$ to cover the reserve only. When the money arrives in Thailand, a fraction 1 dollar ($e^{y/d}$ yen) is converted into baht to invest at the rate of return $i - \Delta e$. Then, at time $t = h$, the investor receives the deposited reserve back in yen. Due to the forward contract, the investor would receive $\frac{\mu}{1-\mu}\left(e^{y/d} - f^{y/d}\right)$ dollar after repaying some part of the principal. When time $t = k$ arrives, the investment is terminated. The investor receives the return $i_k - \Delta e$ on the investment fund of 1, and then settles the borrowing agreement.

Based on such investment strategy, the net return under capital controls is $nr_{control} = \frac{k}{12}(i - \Delta e) - \frac{k}{12} i_D - \frac{h}{12}\frac{\mu}{1-\mu} i_D + \frac{\mu}{1-\mu}\left(e^{y/d} - f^{y/d}\right)$, while the net return under no capital controls is $nr_{no\ control} = \frac{k}{12}(i - \Delta e - i_D)$. Consequently, the net-return-equivalent cost is: $\tilde{\tau}_D = \frac{12}{k}(nr_{no\ control} - nr_{control}) = \frac{\mu}{1-\mu}\left(\frac{h}{k} i_D - \frac{12}{k}\left(e^{y/d} - f^{y/d}\right)\right) = \frac{\mu}{1-\mu}\frac{h}{k} i_Y = \tau_Y$.

The analysis illustrates that people can always attain the net-return-equivalent cost induced by the currency with the lowest interest rate (i.e., yen in this setup). Because of no specification of the currency of the reserve, money should come in yen under the URR regime. The source of funding does not matter since people can use the investment strategy outlined above to attain smaller costs in the presence of the reserve requirement.

The key implication is that there should be a shift in the currency composition of financial inflows towards the Japanese yen. If money keeps coming in dollar, there should be significant frictions in the FX market. For instance, costs of undertaking FX transactions or purchasing forward contracts could be substantial. In order to attain the lowest possible net-return-equivalent cost equaling to τ_Y, there are several transactions involved. Money must be first exchanged from dollar to yen, and then from yen to baht. If no direct FX market between yen and baht exists, such a transaction may involve large costs, which in turn make this particular investment strategy unattractive.

In summary, the analysis suggests that because of no specification on the currency of the reserve, capital controls would induce a shift in the currency composition towards the Japanese yen (i.e., the currency with the lowest interest rate). The conclusion can be decomposed into two steps. First, the currency of incoming funds should be the one with the lowest interest rate. This should be true regardless the source of funding; the analysis is based on the CIP condition. Additionally, the source of funding should be the currency that features expected exchange rate depreciation induced by additional risks, not interest rate differentials; the analysis is based on the UIP-typed condition. However, casual evidence suggests that the majority of incoming funds under the URR regime came in dollar. Hence, the US dollar should be subjected to additional risks that induced expected depreciation relative to other currencies. Furthermore, substantial frictions must exist in the FX market so that incentives to bring money in yen as a means to attain lower costs were eliminated.

❖ Optimization Framework

The following presentation shows how to derive net-return-equivalent costs in an optimization framework.

Let's first look at the portfolio allocation problem. The (foreign) investor makes the portfolio allocation decision between domestic and foreign risk-free financial assets. Suppose that W_t is wealth in period t, R_{t+1} and R^*_{t+1} are the (gross) domestic and foreign risk-free rates between period t and $t+1$, respectively, and S_t is the exchange rate (an increase means domestic currency depreciation). Then, the investor maximizes $\mathbb{E}_t U(W_{t+1})$ subject to $W_{t+1} = \left((1-\alpha_t)R^*_{t+1} + \alpha_t\left(\frac{R_{t+1}S_t}{S_{t+1}}\right)\right)W_t$, with $U(W) = \frac{W^{1-\gamma}}{1-\gamma}$.

Define the portfolio return $R_{p,t+1} = (1-\alpha_t)R^*_{t+1} + \alpha_t\left(\frac{R_{t+1}S_t}{S_{t+1}}\right)$ and denote $x = log(X)$. If Δs_{t+1} is normally distributed with the variance $\sigma^2_{\Delta s,t+1}$, the optimization problem above is equivalent to maximize: $\mathbb{E}_t r_{p,t+1} + \frac{1}{2}(1-\gamma)\mathbb{Var}_t(r_{p,t+1})$. With some approximation, the portfolio return becomes: $r_{p,t+1} = r^*_{t+1} + \alpha_t(r_{t+1} - \Delta s_{t+1} - r^*_{t+1}) + \frac{1}{2}\alpha_t(1-\alpha_t)\sigma^2_{\Delta s,t+1}$. The first-order condition provides:

$$(3.47)\quad \alpha_t = \frac{\mathbb{E}_t(r_{t+1} - \Delta s_{t+1} - r^*_{t+1}) + \frac{1}{2}\sigma^2_{\Delta s,t+1}}{\gamma\sigma^2_{\Delta s,t+1}},$$

which describes the optimal portfolio allocation in the case without capital controls. Moreover, the first-order condition also yields the UIP-typed condition:

$$(3.48)\quad r_{t+1} = r^*_{t+1} + \mathbb{E}_t\Delta s_{t+1} + \rho_{t+1}.$$

Now, suppose that the central bank imposes the reserve requirement with a fraction μ of funds that are invested in domestic financial assets. Then, the portfolio return is: $R_{p,t+1} = (1-\alpha_t)R^*_{t+1} + \alpha_t(1-\mu)\left(\frac{R_{t+1}S_t}{S_{t+1}}\right) + \alpha_t\mu$, or $r_{p,t+1} = r^*_{t+1} + \alpha_t(1-\mu)(r_{t+1} - \Delta s_{t+1} - r^*_{t+1}) + \alpha_t\mu(-r^*_{t+1})$ after first-order approximation.

The net-return-equivalent cost defined as the difference of the expected portfolio return (relevant for domestic investment) between the cases with and without capital controls is:

(3.49) $\tau_{t+1} = \mu(r_{t+1} - \mathbb{E}_t\Delta s_{t+1} - r^*_{t+1}) + \mu r^*_{t+1} = \mu(r_{t+1} - \mathbb{E}_t\Delta s_{t+1})$.

Together with the UIP-typed condition (3.48), the return-equivalent cost becomes: $\tau_{t+1} = \frac{\mu}{1-\mu}(r^*_{t+1} + \rho_{t+1})$, which is identical to the one derived in the static setup (Table 3.9). When one wants to think about how the reserve requirement induces additional costs for investing 1 dollar either abroad or domestically, the portfolio allocation problem can provide an analytical framework.

Next, let's consider the financing decision problem. The (domestic) investor makes the financing decision between borrowing from abroad and borrowing domestically. Suppose that V_t is the amount of funds needed for the investment project in period t, and the project has the (gross) return $\tilde{R}_{t+1}$. The (gross) interest rates between period t and $t+1$ are R_{t+1} and R^*_{t+1} for borrowing domestically and from abroad, respectively, and S_t is the exchange rate (an increase means domestic currency depreciation). Then, the investor maximizes $\mathbb{E}_t U(V_{t+1})$ where $V_{t+1} = \frac{\tilde{R}_{t+1}}{(1-\alpha_t)R_{t+1} + \alpha_t\left(\frac{R^*_{t+1}S_{t+1}}{S_t}\right)} V_t = \frac{\tilde{R}_{t+1}}{R_{f,t+1}} V_t$, with $U(V) = \frac{V^{1-\gamma}}{1-\gamma}$.

Define the total financing cost $R_{f,t+1} = (1-\alpha_t)R_{t+1} + \alpha_t\left(\frac{R^*_{t+1}S_{t+1}}{S_t}\right)$. If Δs_{t+1} is normally distributed with the variance $\sigma^2_{\Delta s,t+1}$, the optimization problem above is equivalent to minimize: $\mathbb{E}_t r_{f,t+1} + \frac{1}{2}(\gamma - 1)\mathbb{V}\mathrm{ar}_t(r_{f,t+1})$. With some approximation, the total financing cost becomes: $r_{f,t+1} = r_{t+1} - \alpha_t(r^*_{t+1} + \Delta s_{t+1} - r_{t+1}) - \frac{1}{2}\alpha_t(1+\alpha_t)\sigma^2_{\Delta s,t+1}$. The first-order condition yields the UIP-typed condition similar to (3.48) and also provides:

$$(3.50) \quad \alpha_t = \frac{\mathbb{E}_t(r^*_{t+1} + \Delta s_{t+1} - r_{t+1}) + \frac{1}{2}\sigma^2_{\Delta s,t+1}}{(\gamma - 2)\sigma^2_{\Delta s,t+1}},$$

which specifies the optimal level of borrowings from abroad.

Now, suppose that the central bank imposes the reserve requirement with a fraction μ of funds being borrowed from abroad. Then, the total financing cost is equal to $R_{f,t+1} = (1-\alpha_t)R_{t+1} + \alpha_t\left(\frac{R^*_{t+1}S_{t+1}}{S_t}\right) + \alpha_t\frac{\mu}{1-\mu}R^*_{t+1}$. With first-order approximation, it becomes: $r_{f,t+1} = \alpha_t\left(1 - \alpha_t + \frac{\alpha_t}{1-\mu}\right)\left(r^*_{t+1} - \Delta s_{t+1} + \frac{\mu}{1-\mu}r^*_{t+1}\right) + \left(1 - \alpha_t\left(1 - \alpha_t + \frac{\alpha_t}{1-\mu}\right)\right)r_{t+1} + K_t$, where $K_t = log\left(1 - \alpha_t + \frac{\alpha_t}{1-\mu}\right)$.

Consequently, the net-return-equivalent cost is: $\tau_{t+1} = \frac{\mu}{1-\mu}r^*_{t+1}$, which is similar to the one derived in the static setup (Table 3.9). When one wants to think about how the reserve requirement induces additional costs for borrowing the necessary amount of funds to undertake a domestic investment project worth 1 dollar, the financing decision problem can provide an analytical framework.

Chapter 4

Capital Flows and Exchange Rate Movements

4.1 Introduction

One of leading concerns faced by policymakers in emerging markets is related to exchange rate movements. Such issues could involve unwarranted appreciation or depreciation with no support of macroeconomic fundamentals, excessive currency fluctuations, and misalignments from the equilibrium value. In particular, the dynamics of the exchange rate tends to be significantly influenced by capital flows that are primarily driven by international financial markets' liquidity condition as well as foreign investors' risk appetite. Based on common justifications that external forces induce their currencies to move in a way that appears inappropriate for domestic developments, many monetary authorities regularly employ various policy instruments to assure that their exchange rates remain on a desired path. However, the task of determining whether the prevailing exchange rate value is consistent with macroeconomic fundamentals does not seem simplistic. Therefore, the development of analytical tools that can provide some guideline on expected exchange rate movements in response to changes in underlying economic factors should be useful by helping enhance effective policymaking.

This chapter's main objective is to illustrate how to apply the methodology developed by Obstfeld and Rogoff (2005) and (2007) to estimate the magnitude of exchange rate adjustments required for absorbing changes in financial flows in addition to facilitating adjustments of the current account towards its medium-term position. While Obstfeld and Rogoff used a static large open-economy model to calculate the size of exchange rate adjustments needed for eliminating global current account imbalances, this chapter focuses on a slightly different aspect which aims to answer the question: what would the behavior of the exchange rate be as a result of necessary current account adjustments triggered by changes in capital flows?[1] Specifically, the analysis focuses on examining Thailand's exchange rate movements during the two major episodes of fundamental

[1] Existing methodologies for exchange rate assessments (e.g. IMF's Consultative Group on Exchange Rate Issues) do not take into account of the impact of capital flows on exchange rate movements.

changes in the pattern of financial flows. One is the sudden stop of capital inflows associated with the financial crisis of 1997; another is the revival of massive foreign funds since 2005, with a temporary slowdown during the global financial crisis.

Based on simulation exercises, the Thai baht has been significantly influenced by the development of capital flows that are primarily induced by foreign investors. In addition, the impact of large fluctuations in the price of oil on the exchange rate dynamics can be considerable. Simulation results also suggest that the Thai baht seemed relatively weak during 1999-2001, consistent with the export-led growth model supported by a competitive exchange rate value, whereas its value appeared justifiably too strong in 2006 when the Bank of Thailand (BoT) seriously concerned about large and rapid currency appreciation driven by an influx of foreign funds in the form of direct investment and portfolio equity investment. Nevertheless, the Thai currency has recently become more aligned with underlying factors that drive exchange rate movements.

The rest of the chapter is organized as follows. Section 4.2 reviews Thailand's key macroeconomic developments related to capital flows and exchange rate fluctuations. Section 4.3 introduces the analytical framework which features a small open-economy setup extended to incorporate the role of commodity prices in order to properly capture important characteristics of the Thai economy. Section 4.4 assesses the behavior of the exchange rate during the two of Thailand's leading experiences associated with capital flows based on simulation exercises. Lastly, section 4.5 concludes.

4.2 Thailand's Experiences of Capital Flows and Exchange Rate Movements

The movement of the exchange rate has been closely linked to the development of the balance of payments especially at the time when significant changes in the pattern of capital flows take place. This section discusses two major episodes. One is the sudden stop of capital inflows in the aftermath of the financial crisis of 1997; another is the renewal of massive foreign funds since 2005, with a temporary slowdown during the global financial crisis.

The first episode centered around the financial crisis of 1997 in which Thailand experienced sizable exchange rate depreciation, insolvency problems at various financial institutions, and a sudden stop of capital inflows. The crisis set off on July 2, 1997 when the BoT abandoned the fixed exchange rate arrangement after a series of ruthless speculative attacks on the peg. The Thai baht soon depreciated considerably from the pre-crisis benchmark about 25 baht per US dollar to the weakest level at 56 baht per US dollar, and eventually stabilized around the post-crisis reference point of 40 baht per US dollar (Figure 1.4). The underlying factor for such gigantic currency depreciation was the sudden stop of capital inflows, which started in the second quarter of 1997.[2] At the outbreak of the crisis, the BoT's stock of net foreign reserves was literally depleted and the country also ran a huge current account deficit. With the limited supply of foreign funds from the two aforementioned sources, the fate of the Thai baht was completely in the hand of financial flow developments.

The drainage of foreign funds effectively forced the current account to adjust significantly from a deficit of 7 percent of GDP in the second quarter of 1997 to a surplus of 13 percent of GDP in 1998. Such a dramatic current account improvement was accompanied by a sharp decline in imports at the onset of the crisis, but was later supported by a robust expansion in exports. The more depreciated value of the post-crisis real effective exchange rate by about 20 percent contributed to markedly reduced prices of goods and services produced in Thailand, and thereby propelled the export-led recovery. While the development of sizable exchange rate depreciation together with the substantial current account improvement appeared theoretically consistent, the magnitude of the current account improvement appeared much larger than what a necessary adjustment for reaching the new medium-term position required.[3] In short, the sudden stop of capital inflows played an important role in influencing the dynamics of both exchange rate and current account during the financial crisis.

The second episode revolved around the revival of massive foreign funds, which began in 2005 after the period of 2001-2004 during which developments in the external sector had been broadly stable. Over that period, fluctuations in both real and nominal effective exchange rates had been relatively small around the trend. In addition, the current account balance registered a moderate surplus with the magnitude of 3.3 percent of GDP on average, while the repayment of external debt accumulated prior to the financial crisis appeared as the principal factor underpinning capital flows. Such stability might suggest that the real exchange rate as well as the current account had been in the neighborhood of its equilibrium value and its medium-term norm, respectively.

The situation changed dramatically in 2005. A large bill of imported petroleum products driven by high energy prices together with government subsidy programs caused the current account balance to post a huge deficit of 9 percent of GDP in the first half of

[2] What actually happened was that foreign creditors stoped rolling over short-term debt which became due. As a result, a reversal of capital flows occurred. Nevertheless, the amount of direct investment and portfolio equity investment increased during the crisis because foreign investors took advantage of good investment opportunities at fire-sale prices (Figure 1.6).

[3] Theory suggests that relative prices, which are represented by the real exchange rate in this context, must adjust sufficiently in order to assure that all goods markets are cleared. Due to the decline in decent investment opportunities as well as the process of deleveraging, the new medium-term position of the post-crisis current account balance should settle at a relatively smaller deficit.

2005.[4] At the same time, the country started experiencing an influx of foreign funds primarily triggered by international financial markets' excess liquidity as well as foreign investors' risk appetite, while the repayment of external debt came to an end (Figure 1.6). Effects of these changes on the balance of payments seemed to cancel out each other, with the net impact keeping exchange rate stability intact. It is noteworthy that the recent surge in capital inflows mainly consisted of direct investment and portfolio equity investment, in contrast to the pre-crisis experience which was chiefly dominated by lending and investment in debt securities.

In 2006, massive capital inflows started placing significant pressure on the exchange rate, as the current account balance no longer exhibited a huge deficit. By the end of the year, outsized exchange rate appreciation became the predominant concern after the real effective exchange rate appreciated by about 10 percent. Such alarming developments, underlined by substantial currency appreciation together with weak private domestic demand owing to ongoing political turmoil, induced the BoT to implement various policy measures to moderate exchange rate appreciation. These policy responses featured undertaking large-scale sterilized foreign-exchange (FX) interventions, imposing capital controls in the form of unremunerated reserve requirement (URR), tightening the measures to prevent currency speculation, lowering the policy interest rate, and liberalizing restrictions on domestic financial outflows. Nevertheless, these policy actions did not appear much effective, as the Thai baht continued to appreciate until March 2008, which marked the beginning of strained developments in international financial markets.[5] Regarding macroeconomic performance, policymakers successfully secured an expansion in exports as the engine for economic growth, although the decline in imports acted as the main contributor to the improvement of the current account during 2006-2007 (Figure 1.3 and 1.5).

The robust trend of strengthening Thai baht found a temporary break during the global financial crisis. The nominal effective exchange rate initially depreciated around 4 percent between March and December 2008, and then remained broadly unchanged throughout 2009. The path of the exchange rate seemed consistent with the development of the balance of payments, which was highlighted by a slowdown in massive inflows of foreign funds together with a sizable surplus of the current account. However, pressure on the Thai currency to appreciate soon resumed in 2010 thanks to the normalization of conditions in international financial markets. In the third quarter of 2010, the momentum of exchange rate appreciation became much stronger after the violent political incidence

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[4] The government originally viewed that the increase in energy prices was temporary, and thus implemented subsidy programs. As the funding of programs looked unsustainable and the increase in energy prices seemed permanent, the government eventually abandoned such subsidies. The marked decline in energy consumption led to a sharp current account improvement after subsidy programs were eliminated.

[5] The key event in March 2008 was the collapse of Bear Sterns.

at the heart of the capital city was resolved in May. Furthermore, additional pressure on the exchange rate to appreciate is likely to emerge from the ongoing current account surplus, which needs to shrink in the process of restoring the medium-term position.

Lastly, the liberalization efforts to encourage domestic entities to undertake investment in foreign countries since 2006 have significantly increased the amount of outward domestic funds in form of direct investment as well as portfolio investment in recent years. These policy measures should help offset exchange rate appreciation to a certain degree.

4.3 Analytical Framework

This section presents the analytical framework for explaining the dynamics of the exchange rate based on major factors such as adjustments of the current account as well as changes in capital flows. Building on the work of Obstfeld and Rogoff (2005) and (2007), the model while maintaining the same underlying mechanism of exchange rate adjustments instead features a small open-economy setup extended to incorporate the role of commodity prices. Furthermore, the analysis highlights the role of currency movements required for absorbing changes in financial flows in addition to supporting adjustments of the current account towards its medium-term norm, the leading characteristics of Thailand's experiences.

This section is divided into three parts. Part 4.3.1 describes the core model, which can be summarized by four market-clearing conditions for home traded goods, home nontraded goods, foreign nontraded goods, and commodity goods. These four equations are central to the calculation of the equilibrium exchange rate path. Part 4.3.2 discusses how to derive the equilibrium exchange rate, with a focus on illustrating how its adjustments must occur as the economy absorbs changes in capital flows as well as accommodates adjustments of the current account towards its medium-term position. Part 4.3.3 addresses technical details, including the derivation of the nominal exchange rate and the effect of currency valuation.

4.3.1 Core Model

The model is developed based on a two-country framework. The home country is assumed to be a small economy that characterizes Thailand, while the foreign country represents the rest of the world. There are five types of goods: three categories of traded goods (home, foreign and commodity), and two categories of nontraded goods (home and foreign). Commodity goods are included in the model for analyzing the impact of changes in the price of oil on the dynamics of the exchange rate. Particularly, commodity goods (i.e. oil) are assumed to be solely produced in the foreign country in order to reflect Thailand's heavy dependence on imported petroleum products.

Furthermore, the model assumes that endowments for various types of outputs are given exogenously. Therefore, production inputs such as capital and labor are not mobile between sectors, and endogenous changes in the mix of goods produced are not operative. Such implicit assumptions seem appropriate for analyzing adjustments that would take place over a relatively short period, which is the case for exchange rate movements driven by changes in financial flows. It is noteworthy that factor mobility as well as firm relocation across sectors, which are likely to occur over a longer period, can mitigate the impact of current account adjustments on relative price changes.

The analytical framework is static, with a focus on the intratemporal relative price consequences of changes in the pattern of consumption driven by adjustments of the current account. Specifically, the utility-maximizing representative home agent allocates consumption expenditures among different types of goods according to the following preference:

$$(4.1) \quad C = \left(\gamma^{\frac{1}{\theta}} C_T^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_{NT}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}},$$

$$(4.2) \quad C_T = \left(\mu^{\frac{1}{\varphi}} C_{NO}^{\frac{\varphi-1}{\varphi}} + (1-\mu)^{\frac{1}{\varphi}} C_O^{\frac{\varphi-1}{\varphi}}\right)^{\frac{\varphi}{\varphi-1}},$$

$$(4.3) \quad C_{NO} = \left(w^{\frac{1}{\eta}} C_H^{\frac{\eta-1}{\eta}} + (1-w)^{\frac{1}{\eta}} C_F^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}},$$

where C is total consumption, which consists of consumption of traded and nontraded goods, denoted by C_T and C_{NT}, respectively. Note that all quantities are expressed in the amount of per capita, not national total. The basket of traded goods is composed of oil products ('O') as well as non-oil goods ('NO'). While all oil products are assumed to be produced in the foreign country, non-oil goods can be produced in either the home country (H; henceforth, home traded goods) or the foreign country (F; henceforth, foreign traded goods).

The incorporation of oil is for examining the impact of changes in the price of key commodity goods, which are petroleum products in the case of Thailand, on the exchange rate dynamics. For the home agent's preference, the parameters γ, μ and w specify the relative importance of traded goods in total consumption, non-oil goods in consumption of traded goods, and home traded goods in consumption of non-oil goods, respectively. Consistent with well-documented facts, the model also allows for a home consumption bias in (traded) non-oil goods. Such substantial relative preference for non-oil goods produced domestically gives a rise to the so-called transfer effect. In particular, an increase in relative national expenditure improves a country's terms of trade (i.e. the price of exports relative to the price of imports).

In addition, the parameters θ, φ and η specify the elasticity of substitution between traded and nontraded goods, between non-oil and oil goods, and between home and foreign traded goods, respectively. The values of these elasticity parameters are critical for the analysis because they govern the magnitude of price responses to quantity adjustments in the way that lower substitution elasticity signifies a greater movements of prices required for accommodating a given change in quantities consumed. Hence, the impact of changes in capital flows or adjustments of the current account on exchange rate movements is more pronounced especially when the elasticity of substitution between traded and nontraded goods is lower in the presence of a relatively sizeable nontraded sector, or when the elasticity of substitution between home and foreign traded goods is lower in the presence of a relatively large share of exports and imports.

Similarly, the foreign agent's preference can be described as follows:

(4.4) $$C^* = \left(\gamma^{*\frac{1}{\theta}} C_T^{*\frac{\theta-1}{\theta}} + (1-\gamma^*)^{\frac{1}{\theta}} C_{NT}^{*\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}},$$

(4.5) $$C_T^* = \left(\mu^{*\frac{1}{\varphi}} C_{NO}^{*\frac{\varphi-1}{\varphi}} + (1-\mu^*)^{\frac{1}{\varphi}} C_O^{*\frac{\varphi-1}{\varphi}}\right)^{\frac{\varphi}{\varphi-1}},$$

(4.6) $$C_{NO}^* = \left((1-w^*)^{\frac{1}{\eta}} C_H^{*\frac{\eta-1}{\eta}} + w^{*\frac{1}{\eta}} C_F^{*\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}},$$

where a star ($*$) denotes the foreign counterparts. Note that while the values of elasticity parameters (i.e. θ, φ and η) are assumed to be the same for both home and foreign agents, the values of parameters indicating the relative importance of goods in consumption baskets are varied to reflect differences between Thailand's economic structure and that of the rest of the world.

Based on the prescribed preference, the consumption-based price indices can be derived from optimal conditions for allocating consumption expenditures among different types of goods. The corresponding overall consumer price index in the home country, in domestic currency, is:

(4.7) $$P = \left(\gamma {P_T}^{1-\theta} + (1-\gamma){P_{NT}}^{1-\theta}\right)^{\frac{1}{1-\theta}},$$

which can be fully determined based on the consumer price indices for traded goods and for non-oil goods:

(4.8) $$P_T = \left(\mu {P_{NO}}^{1-\varphi} + (1-\mu){P_O}^{1-\varphi}\right)^{\frac{1}{1-\varphi}},$$

(4.9) $P_{NO} = \left(wP_H{}^{1-\eta} + (1-w)P_F{}^{1-\eta}\right)^{\frac{1}{1-\eta}}.$

The corresponding price indices in the foreign country, in foreign currency, can be specified as follows:

(4.10) $P^* = \left(\gamma^* P_T^{*1-\theta} + (1-\gamma^*)P_{NT}^{*}{}^{1-\theta}\right)^{\frac{1}{1-\theta}},$

(4.11) $P_T^* = \left(\mu^* P_{NO}^{*}{}^{1-\varphi} + (1-\mu^*)P_O^{*}{}^{1-\varphi}\right)^{\frac{1}{1-\varphi}},$

(4.12) $P_{NO}^* = \left((1-w^*)P_H^{*}{}^{1-\eta} + w^* P_F^{*}{}^{1-\eta}\right)^{\frac{1}{1-\eta}}.$

It is noteworthy that the price indices for traded goods can differ between the two countries (i.e. $P_T \neq \mathcal{E}P_T^*$), even though the model assumes that the law of one price holds for individual traded goods (e.g. $P_H = \mathcal{E}P_H^*$). Note that $\mathcal{E}$ denotes the nominal exchange rate defined as the price of domestic currency per unit of foreign currency; thus, an increase in $\mathcal{E}$ means that the home country's nominal exchange rate depreciates. The divergence in the price indices for traded goods has a root in the asymmetric preference for individual goods in consumption baskets of traded goods, typically owing to the home consumption bias in non-oil goods. As a result, changes in the relative price between home and foreign traded goods usually affect the real exchange rate.

With these price indices, key relative prices central to the analysis can be defined as follows. The real exchange, denoted by Q, is the price of foreign consumption basket relative to the price of domestic consumption basket:

(4.13) $Q = \frac{\mathcal{E}P^*}{P}.$

Thus, an increase in Q implies that the home country's real exchange rate depreciates. For (traded) non-oil goods, the relative price between goods produced in the home and foreign countries is:

(4.14) $\tau = \frac{P_F}{P_H} = \frac{P_F^*}{P_H^*},$

which can represent the foreign country's terms of trade in the absence of commodity goods (i.e. $\mu = \mu^* = 1$). For instance, an increase in τ, equivalent to a rise in the price of foreign traded goods in terms of home traded goods, means a deterioration in the home country's terms of trade of non-oil goods. The relative price between traded and nontraded goods produced in the home country is:

(4.15) $x = \frac{P_N}{P_T},$

and the counterpart in the foreign country is:

$$(4.16)\quad x^* = \frac{P_N^*}{P_T^*}.$$

Lastly, the price of oil should be quoted in terms of some foreign price for the sake of being consistent with the reality. Here, it turns out to be quite convenient to define the price of oil in terms of the price of foreign traded goods:

$$(4.17)\quad \rho = \frac{P_O^*}{P_F^*} = \frac{P_O}{P_F}.$$

The dynamics of the real exchange rate critically relies on the behavior of these key relative prices. In particular, the real exchange rate in equation (4.13) can be rewritten as:

$$(4.18)\quad Q = \frac{\left(\mu^*\left((1-w^*)\tau^{\eta-1}+w^*\right)^{\frac{1-\varphi}{1-\eta}} + (1-\mu^*)\rho^{1-\varphi}\right)^{\frac{1}{1-\varphi}}}{\left(\mu\left(w\tau^{\eta-1}+(1-w)\right)^{\frac{1-\varphi}{1-\eta}} + (1-\mu)\rho^{1-\varphi}\right)^{\frac{1}{1-\varphi}}} \frac{\left(\gamma^* + (1-\gamma^*)x^{*1-\theta}\right)^{\frac{1}{1-\theta}}}{\left(\gamma + (1-\gamma)x^{1-\theta}\right)^{\frac{1}{1-\theta}}},$$

which can be logarithmically approximated by:

$$(4.19)\quad \hat{Q} = \left((1-\gamma^*)\hat{x}^* - (1-\gamma)\hat{x}\right) + \left(\mu w - \mu^*(1-w^*)\right)\hat{\tau} + (\mu-\mu^*)\hat{\rho},$$

where a caret (^) denotes a percentage change. It is evident from equation (4.19) that an increase in the home country's price of nontraded goods in terms of traded goods leads the home country's real exchange rate to appreciate, holding other things else constant. Similarly, a rise in the price of foreign traded goods in terms of home traded goods, which can be conceived as a deterioration in the home country's terms of trade in the absence of commodity goods, is likely to trigger the home country's real exchange rate to depreciate provided that the home consumption bias in non-oil goods is sufficiently substantial.

However, it is more complicated to assess the impact of a change in the price of oil on the home country's real exchange rate. On the one hand, the direct effect purely based on equation (4.19) points out that an increase in the price of oil causes the home country's real exchange rate to appreciate in the case that $\mu^* > \mu$, which requires the home country to have a larger share of oil in the consumption basket of traded goods. For Thailand where the condition $\mu^* > \mu$ holds, the real exchange rate is supposed to appreciate when the price of oil rises. On the other hand, the indirect effect driven by changes in other relative prices resulting from a change in the price of oil is likely to induce the home country's real exchange rate to depreciate when the price of oil rises. In particular, the oil trade balance is likely to worsen because oil products are complements to non-oil goods (i.e. $0 < \varphi < 1$) and all consumption of oil products is imported from the foreign country. Then, for a given level of the current account balance, the non-oil trade balance must improve, and the terms of trade of non-oil goods must also deteriorate. The upshot is that the home country's real exchange rate is likely to depreciate when the price of oil rises under the circumstance that the home country fundamentally relies on imported oil products. The direct effect can be readily outweighed by the indirect effect because the share of oil in the consumption basket tends not to differ considerably across countries.

Up to this point, the discussion has described both preference and technology of the model. Recall that the technology part is trivial as the model features an endowment economy, i.e. endowments for different types of outputs are given exogenously. Hence, the model would be complete once market-clearing conditions are specified. In this model, there are five markets (i.e. one for each type of goods). Since all quantities are expressed in the amount of per capita, the relative size of economies is necessary for pinning down the amount of national total. Specifically, let's v denote the share of the home country's population, and normalize the world's population to be one.

For home traded goods, the market-clearing condition requires:

(4.20) $$vY_H = vC_H + (1-v)C_H^*,$$

where Y_H is output of home traded goods. Using the optimal conditions that describe the demand for home traded goods by both home and foreign countries, equation (4.20) can be rewritten in terms of quantities as:

(4.21) $$Y_H = \mu w \left(\frac{P_H}{P_{NO}}\right)^{-\eta} \left(\frac{P_{NO}}{P_T}\right)^{-\varphi} C_T + \frac{1-v}{v}\mu^* (1-w^*) \left(\frac{P_H^*}{P_{NO}^*}\right)^{-\eta} \left(\frac{P_{NO}^*}{P_T^*}\right)^{-\varphi} C_T^*,$$

or equivalently in terms of value as:

(4.22) $$P_H Y_H = \mu w \left(\frac{P_H}{P_{NO}}\right)^{1-\eta} \left(\frac{P_{NO}}{P_T}\right)^{1-\varphi} P_T C_T + \frac{1-v}{v}\mu^*(1-w^*) \left(\frac{P_H^*}{P_{NO}^*}\right)^{1-\eta} \left(\frac{P_{NO}^*}{P_T^*}\right)^{1-\varphi} \mathcal{E} P_T^* C_T^*.$$

Since the analysis focuses on the behavior of the exchange rate influenced by adjustments of the current account or changes in capital flows, it seems useful to rewrite equation (4.22) in terms of the current account. In particular, equation (4.22) is equivalent to:

(4.23) $$\begin{aligned} P_H Y_H = {} & \mu w \left(\frac{P_H}{P_{NO}}\right)^{1-\eta} \left(\frac{P_{NO}}{P_T}\right)^{1-\varphi} (P_H Y_H + iF - CA) \\ & + \frac{1-v}{v}\mu^*(1-w^*) \left(\frac{P_H^*}{P_{NO}^*}\right)^{1-\eta} \left(\frac{P_{NO}^*}{P_T^*}\right)^{1-\varphi} \left(\mathcal{E} P_F^* Y_F + \mathcal{E} P_O^* Y_O - \frac{v}{1-v} iF + \frac{v}{1-v} CA\right) \end{aligned}$$

after using the identity of the current account balance, which is the sum of net exports and net factors payments:

$$(4.24)\quad CA = P_H Y_H - P_T C_T + iF = \frac{1-v}{v}\left(\mathcal{E}P_T^* C_T^* - \mathcal{E}P_F^* Y_F - \mathcal{E}P_O^* Y_O\right) + iF,$$

where CA is the current account, F is the net foreign asset position, i is the world interest rate, Y_F is output of foreign traded goods, and Y_O is output of oil. Here, net factor payments consist of only net capital income in the form of net interest rate payments.

Other market-clearing conditions can be similarly derived as follows. The market-clearing condition for foreign traded goods is:

$$(4.25)\quad (1-v)Y_F = vC_F + (1-v)C_F^*,$$

which is equivalent to:

$$(4.26)\quad P_F Y_F = \frac{v}{1-v}\mu(1-w)\left(\frac{P_F}{P_{NO}}\right)^{1-\eta}\left(\frac{P_{NO}}{P_T}\right)^{1-\varphi}\left(P_H Y_H + iF - CA\right)$$
$$+ \mu^* w^* \left(\frac{P_F^*}{P_{NO}^*}\right)^{1-\eta}\left(\frac{P_{NO}^*}{P_T^*}\right)^{1-\varphi}\left(\mathcal{E}P_F^* Y_F + \mathcal{E}P_O^* Y_O - \frac{v}{1-v}iF + \frac{v}{1-v}CA\right).$$

For oil products, the market-clearing condition requires:

$$(4.27)\quad (1-v)Y_O = vC_O + (1-v)C_O^*,$$

which is equivalent to:

$$(4.28)\quad P_O Y_O = \frac{v}{1-v}(1-\mu)\left(\frac{P_O}{P_T}\right)^{1-\varphi}\left(P_H Y_H + iF - CA\right)$$
$$+ (1-\mu^*)\left(\frac{P_O^*}{P_T^*}\right)^{1-\varphi}\left(\mathcal{E}P_F^* Y_F + \mathcal{E}P_O^* Y_O - \frac{v}{1-v}iF + \frac{v}{1-v}CA\right).$$

The markets for nontraded goods are cleared when $Y_N = C_N$ and $Y_N^* = C_N^*$, where Y_N and Y_N^* are output of home and foreign nontraded goods, respectively. These two market-clearing conditions are equivalent to:

$$(4.29)\quad P_N Y_N = \frac{1-\gamma}{\gamma}\left(\frac{P_N}{P_T}\right)^{1-\theta}\left(P_H Y_H + iF - CA\right),$$

$$(4.30)\quad \mathcal{E}P_N^* Y_N^* = \frac{1-\gamma^*}{\gamma^*}\left(\frac{P_N^*}{P_T^*}\right)^{1-\theta}\left(\mathcal{E}P_F^* Y_F + \mathcal{E}P_O^* Y_O - \frac{v}{1-v}iF + \frac{v}{1-v}CA\right).$$

With these five market-clearing conditions, the model is complete. In fact, according to the Walras law, only four market-clearing conditions are sufficient. The analysis thus employs four equations, namely equation (4.23), (4.28), (4.29) and (4.30) for simulation exercises which calculate the path of the exchange rate required for accompanying adjustments of the current account or changes in financial flows. Furthermore, it appears useful to rewrite these four conditions in terms of relative prices as well as relative output endowments. Particularly, let's define:

(4.31) $$\sigma_T = \frac{vY_H}{(1-v)Y_F};$$

(4.32) $$\sigma_N = \frac{Y_N}{Y_H};$$

(4.33) $$\sigma_N^* = \frac{Y_N^*}{Y_F};$$

(4.34) $$\sigma_O = \frac{Y_O}{Y_F};$$

(4.35) $$f = \frac{F}{P_H Y_H};$$

(4.36) $$ca = \frac{CA}{P_H Y_H}.$$

Then, the four market-clearing conditions, which form the core model, can be rewritten as follows:

(4.37) $$1 = \frac{\mu w}{\left(w+(1-w)\tau^{1-\eta}\right)\left(\mu+(1-\mu)\dfrac{\rho^{1-\varphi}}{\left(w\tau^{\eta-1}+(1-w)\right)^{\frac{1-\varphi}{1-\eta}}}\right)}(1+if-ca) + \frac{\mu^*(1-w^*)}{\left((1-w^*)+w^*\tau^{1-\eta}\right)\left(\mu^*+(1-\mu^*)\dfrac{\rho^{1-\varphi}}{\left((1-w^*)\tau^{\eta-1}+w^*\right)^{\frac{1-\varphi}{1-\eta}}}\right)}\left(\frac{1}{\sigma_T}\tau(1+\sigma_O\rho)-if+ca\right);$$

(4.38) $$\frac{\sigma_O}{\sigma_T}\rho\tau = \frac{(1-\mu)\rho^{1-\varphi}}{\left(\mu\left(w\tau^{\eta-1}+(1-w)\right)^{\frac{1-\varphi}{1-\eta}}+(1-\mu)\rho^{1-\varphi}\right)}(1+if-ca) + \frac{(1-\mu^*)\rho^{1-\varphi}}{\left(\mu^*\left((1-w^*)\tau^{\eta-1}+w^*\right)^{\frac{1-\varphi}{1-\eta}}+(1-\mu^*)\rho^{1-\varphi}\right)}\left(\frac{1}{\sigma_T}\tau(1+\sigma_O\rho)-if+ca\right);$$

(4.39) $$\sigma_N = \frac{1-\gamma}{\gamma}x^{-\theta}\left(\mu\left(w+(1-w)\tau^{1-\eta}\right)^{\frac{1-\varphi}{1-\eta}}+(1-\mu)(\rho\tau)^{1-\varphi}\right)^{\frac{-1}{1-\varphi}}(1+if-ca);$$

(4.40) $$\sigma_N^* = \frac{1-\gamma^*}{\gamma^*}x^{*-\theta}\left(\mu^*\left((1-w^*)\tau^{\eta-1}+w^*\right)^{\frac{1-\varphi}{1-\eta}}+(1-\mu^*)\rho^{1-\varphi}\right)^{\frac{-1}{1-\varphi}}\left(1+\sigma_O\rho-\sigma_T\frac{if}{\tau}+\sigma_T\frac{ca}{\tau}\right).$$

Up to this point, the model specification still features some flavor of a large economy setup. In particular, equation (4.40) portrays that some economic developments in the home country may affect the rest of the world (e.g. a change in τ could trigger a change in x^*). A comparable set of conditions for a small economy setup can be obtained by applying appropriate limits to equation (4.37) – (4.40). Particularly, one needs $w^* \to 1$ and $v \to 0$. The former limiting condition implies that the share of home traded goods in the foreign country's consumption basket is miniscule, while the latter limiting condition implies that the home country's population is relatively infinitesimal in comparison with the world's population. Both aspects simply reflect that the home country's economy has a much smaller size. In brief, equation (4.41) – (4.44) characterize the set of conditions for a small economy setup corresponding equation (4.37) – (4.40), which are relevant for a large economy setup, as follows:

(4.41) $$1 = \frac{\mu w \tau^{\eta-1}\left(w\tau^{\eta-1} + (1-w)\right)^{\frac{\eta-\varphi}{1-\eta}}}{\left(\mu\left(w\tau^{\eta-1} + (1-w)\right)^{\frac{1-\varphi}{1-\eta}} + (1-\mu)\rho^{1-\varphi}\right)}(1 + if - ca) + \frac{\mu^*(1+\sigma_O\rho)\tau^{\eta}}{(\mu^* + (1-\mu^*)\rho^{1-\varphi})};$$

(4.42) $$\sigma_O\rho = \frac{(1-\mu^*)(1+\sigma_O\rho)\rho^{1-\varphi}}{(\mu^* + (1-\mu^*)\rho^{1-\varphi})};$$

(4.43) $$\sigma_N = \frac{1-\gamma}{\gamma}x^{-\theta}\left(\mu(w + (1-w)\tau^{1-\eta})^{\frac{1-\varphi}{1-\eta}} + (1-\mu)(\rho\tau)^{1-\varphi}\right)^{\frac{-1}{1-\varphi}}(1 + if - ca);$$

(4.44) $$\sigma_N^* = \frac{1-\gamma^*}{\gamma^*}x^{*-\theta}(\mu^* + (1-\mu^*)\rho^{1-\varphi})^{\frac{-1}{1-\varphi}}(1+\sigma_O\rho).$$

According to equation (4.44), the foreign country's relative price between traded and nontraded goods (i.e. x^*) is now independent of economic variables associated with the home country. Nevertheless, the value of x^* depends on the price of oil rather than remains constant.

4.3.2 Equilibrium Exchange Rate

The equilibrium exchange rate refers to the value of the real exchange rate deriving from the solution of the core model. The dynamics of the equilibrium exchange rate critically depends on the values of such key relative prices as τ, ρ, x and x^*, which essentially characterize the solution of the core model and at the same time completely determine the value of the real exchange rate as illustrated by equation (4.18):

$$(4.18)\quad Q = \frac{\left(\mu^*\left((1-w^*)\tau^{\eta-1}+w^*\right)^{\frac{1-\varphi}{1-\eta}}+(1-\mu^*)\rho^{1-\varphi}\right)^{\frac{1}{1-\varphi}}}{\left(\mu\left(w\tau^{\eta-1}+(1-w)\right)^{\frac{1-\varphi}{1-\eta}}+(1-\mu)\rho^{1-\varphi}\right)^{\frac{1}{1-\varphi}}}\frac{(\gamma^*+(1-\gamma^*)x^{*1-\theta})^{\frac{1}{1-\theta}}}{(\gamma+(1-\gamma)x^{1-\theta})^{\frac{1}{1-\theta}}}.$$

Therefore, the path of the real exchange rate can be readily simulated after the core model is solved and the values of key relative prices are known.[6] Moreover, within the system of equations underlying the core model, the variable ca (current account balance) appears as the most significant factor that determines the values of key relative prices. Based on equation (4.41) – (4.44), a change in the current account balance is likely to generate the largest impact on key relative prices among comparable changes of other exogenous variables. Particularly, the effect induced by a change in the net foreign asset position (in fact, a predetermined variable) is attenuated by the multiple of the world interest rate as illustrated by the term if appearing in the core model, and a movement of the world interest rate can generate a significant change in key relative prices only when the net foreign asset position is quite large.[7] Furthermore, the effect created by a change in the price of commodity goods (i.e. oil in this study) critically depends on the elasticity parameter φ. A sizable impact on the real exchange rate is warranted only in the case that the value of φ is very small (i.e. commodity goods are complements to non-commodity goods; oil is a perfect example of commodity goods belonging to this category). In addition, a change in relative output endowments resulting from a change in relative productivity between sectors is unlikely to occur with a large magnitude in the short run.

Hence, the analysis focuses on the exchange rate dynamics that is chiefly related to the development of the current account. In this study, two principal motives for current account adjustments are considered. One reflects the current account's self-correcting mechanism for attaining its medium-term norm. Another stems from changes in the pattern of financial flows. The former motive indeed seems consistent with the common idea that the exchange rate is pressed to appreciate (or depreciate) when the country runs a huge current account surplus (or deficit) because of the growing (or declining) demand as well as the falling (or increasing) supply for the domestic currency in the FX market. The upward (or downward) pressure on the exchange leads the current account to deteriorate (or improve). Such development helps facilitate adjustments of the current account towards its medium-term position. For the latter motive, changes in the current

[6] In this study, the set of endogenous variables, which will be solved from equation (4.41) – (4.44), consists of τ, x, x^* and σ_O rather than τ, ρ, x and x^*. Although the analytical framework is based on an endowment economy, it seems wise to take ρ as an exogenous variable because the price of oil can be directly observed while it is more difficult to estimate the relative output ratio σ_O.

[7] For example, the net foreign asset position must be in the magnitude of 100 percent of GDP in order that a change in the world interest rate by 1 percentage point can cause movements of key relative prices identical to those generated by an adjustment of the current account by 1 percent of GDP.

account balance are driven by changes in capital flows that do not occur as an endogenous process determined by the consumption-saving decision of domestic agents. Great examples of such exogenous changes include the sudden stop of capital inflows in the aftermath of financial crisis in 1997 as well as the influx of foreign funds in the form of portfolio equity investment for the post-2005 episode. Regardless of underlying factors for these capital flow developments, the current account must undergo necessary adjustments in order that the economy can absorb occurring changes in financial flows.

In addition to the main exogenous variable ca, the variable f (net foreign asset position) deserves some discussion as being the key predetermined variable. Its current value depends on its own past value as well as the ongoing development of the balance of payments. Specifically, in the absence of the exchange rate valuation effect, the net foreign asset position evolves primarily based on the current account dynamics:

(4.45) $F^{'} = F + CA^{'}$,

where a prime ($'$) denotes the variable's new value as opposed to its original value. While the value of (original) CA typically takes the actual value of the current account balance, the value of (new) $CA^{'}$ can be any figure of interest. For instance, it could be zero as in Obstfeld and Rogoff (2005) and (2007) which studied the unwinding of global current account imbalances. It could also be the value of the current account's medium-term norm. Otherwise, it could be the value of the current account that reflects some absorption of a change in capital flows, denoted by ΔCF. Based on the last example, the value of $CA^{'}$ corresponds to:

(4.46) $CA^{'} = CA + \Delta CF$.

To sum up, the path of the equilibrium exchange rate can be derived in accordance to the following procedure:

(i) Prescribe the simulation scenario: adjustments of the current account towards its medium-term norm or changes in the pattern of financial flows;
(ii) Solve the core model based on the economy's original position.
(iii) Calculate the original value of the real exchange rate, which is a function of such key relative prices as τ, ρ, x and x^{*} obtained instep (ii).
(iv) Determine the new values of such exogenous variables as ca and f.
(v) Solve the core model based on the economy's new position.
(vi) Calculate the new value of the real exchange rate with the new values of key relative prices obtained in step (v).[8]

[8] Reiterations are required if the values of ca and f, or the ratios of CA and F relative to GDP are kept constant.

4.3.3 Technical Details

This part provides technical details on the two topics which include the derivation of the nominal exchange rate and the feature of currency valuation.[9]

The preceding part discusses the essence of the procedure to calculate the equilibrium exchange rate, which chiefly involves generating the path of the real exchange rate deriving from the core model. The behavior of the nominal exchange rate, which unarguably receives more attention in day-to-day discussions, has not been addressed. It is worth emphasizing that certain assumption on nominal rigidities in prices is required in order to pin down the path of the nominal exchange rate, which in turn critically depends on such an assumption. Here, the discussion considers two simple options.

The first arrangement assumes that monetary authorities in both countries maintain their respective overall consumer price indices constant. The key implication is that both real and nominal exchange rates follow exactly the same dynamics.

The second arrangement instead assumes that monetary authorities target the weighted average of price indices for nontraded goods and traded non-commodity goods produced in their own countries. The price of commodity goods is excluded because monetary authorities, in general, have no (direct) controlling power over commodity prices. The derivation of the nominal exchange rate, which becomes much more complicated, can be done as follows. Without loss of generality, let's assume that

(4.47) $${P_H}^{\gamma}{P_N}^{1-\gamma} = 1$$

for the home country, and that

(4.48) $$P_F^{*\frac{\gamma^*\mu^*}{1-\gamma^*(1-\mu^*)}} P_N^{*\frac{1-\gamma^*}{1-\gamma^*(1-\mu^*)}} = 1$$

for the foreign country. Then, the nominal exchange rate is equal to:

$$\mathcal{E} = \frac{QP}{P^*}$$

(4.49) $$\mathcal{E} = \frac{QP_H}{P_F^*} \frac{\left(\gamma\left(\mu\left(w + (1-w)\tau^{1-\tau}\right)^{\frac{1-\varphi}{1-\eta}} + (1-\mu)(\rho\tau)^{1-\varphi}\right)^{\frac{1-\theta}{1-\varphi}} + (1-\gamma){P_H}^{\frac{1-\theta}{\gamma-1}}\right)^{\frac{1}{1-\theta}}}{\left(\gamma^*\left(\mu^*\left((1-w^*)\tau^{\eta-1} + w^*\right)^{\frac{1-\varphi}{1-\eta}} + (1-\mu^*)\rho^{1-\varphi}\right)^{\frac{1-\theta}{1-\varphi}} + (1-\gamma^*)P_F^{*\frac{(1-\theta)(1-\gamma^*(1-\mu^*))}{\gamma^*-1}}\right)^{\frac{1}{1-\theta}}}.$$

[9] The discussion on how to derive the nominal exchange rate is for illustration only. The assessment of the exchange rate behavior undertaken in section 4.4 is primarily based on the real exchange rate.

Based on expression (4.49), the values of P_H and P_F^* must be known in addition to the values of the real exchange rate along with key relative prices. It turns out that the value of P_H can be derived from assumption (4.47):

$$(4.50)\quad P_H = x^{\gamma-1}\left(\mu\left(w+(1-w)\tau^{1-\eta}\right)^{\frac{1-\varphi}{1-\eta}} + (1-\mu)(\rho\tau)^{1-\varepsilon}\right)^{\frac{\gamma-1}{1-\varphi}},$$

and the value of P_F^* can also be derived from assumption (4.48):

$$(4.51)\quad P_F^* = x^{*\frac{\gamma^*-1}{1-\gamma^*(1-\mu^*)}}\left(\mu^*\left((1-w^*)\tau^{\eta-1}+w^*\right)^{\frac{1-\varphi}{1-\eta}} + (1-\mu^*)\rho^{1-\varphi}\right)^{\frac{\gamma^*-1}{(1-\varphi)(1-\gamma^*(1-\mu^*))}}.$$

It is worth discussing that the magnitude of exchange rate movements generated by simulation exercises in this study could be much smaller than what might be observed in reality. Particularly, the presence of imperfect pass-through from exchange rates to prices can significantly amplify the size of currency adjustments for a given change in the current account balance. Obstfeld and Rogoff (2007) suggested that if pass-through from exchange rates to prices is about 50 percent, the requisite change in the nominal exchange rate could be roughly doubled.

Next, the discussion turns to examine the impact of currency valuation on the dynamics of the exchange rate. The effect of exchange rate valuation can be important especially when currency mismatch between foreign assets and foreign liabilities exists. The net foreign asset position would be affected by nominal exchange rate movements according to:

$$(4.52)\quad F' = F + CA' + \left(\frac{\mathcal{E}' - \mathcal{E}}{\mathcal{E}}\right)(\alpha A - \lambda L),$$

where A is the foreign asset position, L is the foreign liability position, α is the share of foreign assets in foreign currency, and λ is the share of foreign liabilities in foreign currency. In short, the evolution of the net foreign asset position in the presence of the exchange rate valuation effect is described by equation (4.52) rather than (4.45).

Regarding the procedure to derive the equilibrium exchange rate, it is straightforward to incorporate the currency valuation effect by simply reiterating the values of $\mathcal{E}'$ and F' until both are stabilized. Specifically, after the value of the nominal exchange rate is calculated based on the method prescribed in the preceding discussion, the new net foreign asset position adjusted for the exchange rate valuation effect can be computed. Then, the procedure is repeated to obtain the value of the nominal exchange rate with the new net foreign asset position. The process continues until a convergence is achieved.

It is noteworthy that the exchange rate valuation effect should be an important aspect of the two episodes of Thailand's experiences discussed earlier. During the financial crisis of 1997, many firms that were heavily loaded with foreign-currency debt faced difficulties of honoring their debt obligations. After the Thai baht depreciated substantially, the value of debt in terms of domestic currency or relative to the ability to generate revenues suddenly skyrocketed. Bankruptcy then became a critical concern owing to the currency valuation effect. In contrast, the renewal of foreign funds, which contributed to considerable exchange rate appreciation since 2005, raised a problem related to wealth transfer from Thailand to the rest of the world. In the post-crisis period, foreign assets, which chiefly comprise the central bank's foreign reserves, are mainly denominated in foreign currency, while foreign liabilities, largely in the form of equity investment, are mostly denominated in domestic currency. As a result, any appreciation of the Thai baht would cause Thailand's net foreign asset position to deteriorate.

Although the currency valuation effect could be quite important in reality, it turns out that its impact on the exchange rate dynamics based on simulation exercises seems fairly minimal. This, however, should not be a big surprise. The effect of currency valuation affects the behavior of the exchange rate through changes in the net foreign asset position as illustrated by equation (4.52). Unless its magnitude is enormous, a nominal exchange rate movement is unlikely to trigger a sizable change in key relative prices because its effect, primarily driven by a change in the net foreign asset position, is attenuated by the multiple of the world interest rate. Even though its impact on the exchange rate path due to changes in the net foreign asset position might be limited, the currency valuation effect could trigger a sudden stop of capital flows in the presence of substantial currency mismatch. Therefore, the role of exchange rate valuation in influencing the behavior of the currency could be significant, even though simulation exercises in this study cannot capture such effects.

4.4. Simulation

This section's principal objective is to conduct simulation exercises based on the analytical framework described in the previous section. The section first discusses the implementation of simulation exercises as well as the choice of parameter values, and then assesses the behavior of the Thai baht during the two of Thailand's leading experiences associated with capital flows based on simulation exercises.

4.4.1 Simulation Description

This study considers two types of simulation exercises. The first set consists of historical exercises, which simulate a real exchange rate path based on the actual development of the current account. Such exercises, similarly done by Obstfeld and Rogoff (2007), aim to assess whether the exchange rate dynamics has been driven by the model's central mechanism, which relies on relative price adjustments to assure goods market clearing posited by current account developments. Specifically, historical exercises calculate a path of the equilibrium exchange rate abstracting from all other than the current account balance (CA), the net foreign asset position (F), relative output of home nontraded goods to home traded goods (σ_N), and the price of oil (ρ), all of which are the four exogenous forcing variables in the core model.

These historical simulation exercises can be implemented by solving the core model, characterized by equation (4.41) – (4.44), with all exogenous forcing variables taking their actually observed values. It is noteworthy that while the exogenous forcing variables σ_N and ρ always take their actually observed values, the values of CA and F vary across different types of simulation exercises. Thus, the following discussion focuses on these two exogenous forcing variables.

Historical Simulation Exercises

Exogenous forcing variables for calculating key relative prices		
round	variables	description
original	current account	actually observed value of CA
	net foreign asset	actually observed value of F
new	current account	actually observed value of CA'
	net foreign asset	actually observed value of F'

The other type comprises hypothetical exercises, which simulate an equilibrium exchange rate path under the assumption that adjustments of the current account may occur on the basis of two important motives. The first motive reflects the current account's self-correcting mechanism for attaining its medium-term position. The other stems from the necessity of the current account to adjust in order to absorb changes in the pattern of financial flows. These hypothetical exercises can be implemented by solving the core model with such exogenous forcing variables as CA and F taking their actually observed values in the original round and the implied values in the new round. In particular, the implied value of the net foreign asset position essentially depends on the implied value of the current account balance, which is specified based on the underlying motive of current account adjustments as follows:

(i) For the former motive, the current account's medium-term norm, which sets the implied value of the current account balance and thus determines the simulated dynamics of the exchange rate, may take the value of zero, the 5-year historical moving average current account (HMA-CA), or the current account balance that stabilizes net foreign assets (sNFA-CA).[10]

(ii) For the latter motive, the implied value of the current account balance is determined by the amount of realized capital flows that are not endogenously driven by the consumption-saving decision of domestic agents. This study focuses on the two major episodes of Thailand's experiences associated with capital flows, i.e. the sudden stop of capital inflows following the financial crisis of 1997 and the revival of massive foreign funds since 2005.[11]

Hypothetical Simulation Exercises

Current Account Adjustments towards Medium-Term Position

Exogenous forcing variables for calculating key relative prices		
	variables	Description
original	current account	actually observed value of CA
	net foreign asset	actually observed value of F
new	current account	$CA' = CA\_norm$
	net foreign asset	$F' = F + CA'$

Hypothetical Simulation Exercises

Current Account Adjustments Driven by Capital Flows

Exogenous forcing variables for calculating key relative prices		
	variables	description
original	current account	actually observed value of CA
	net foreign asset	actually observed value of F
new	current account	$CA' = CA + \Delta CF$
	net foreign asset	$F' = F + CA'$

To sum up, simulation exercises first obtain key relative prices (i.e. τ, ρ, x and x^*) by solving the core model with the values of exogenous forcing variables (i.e. ca, f, σ_N and ρ) for the original round and the new round, and then calculate the value of the real

[10] The HMA-CA is simply the average of the current account balance over the five previous years. The sNFA-CA is the current account balance that stabilizes the ratio of net foreign assets to GDP. See Table 4.2 for details on how to compute the sNFA-CA.

[11] For the sudden stop, the non-endogenous component of capital flows consists of private funds in the form of currency and deposits, and loans (i.e. other investment flows to banks and other sectors, excluding trade credits; liabilities). For the influx of massive foreign funds, the non-endogenous component of capital flows is characterized by foreign investment in Thailand's stock market (i.e. portfolio equity investment; liabilities) or foreign investment in equity (i.e. both direct investment and portfolio equity investment; liabilities). Furthermore, other types of non-endogenous financial flows are considered: domestic outflows triggered by liberalization policies (i.e. direct investment and portfolio investment; assets) and FX interventions (i.e. changes in reserve assets).

exchange rate for each round using these relative prices according to equation (4.18), and finally construct a path of the equilibrium exchange rate based on changes in the real exchange rate (i.e. difference between original and new values of the real exchange rate).

4.4.2 Parameter Values

The first set of key parameters for simulation exercises consists of the three elasticity parameters because they govern the magnitude of price responses to quantity adjustments. Following the baseline case of Obstfeld and Rogoff (2005) and (2007), this study sets $\theta = 1$ (elasticity of substitution between traded and nontraded goods) and $\eta = 2$ (elasticity of substitution between home and foreign traded goods). The chosen values of θ and η seem appropriate as simulations exercises generate a real exchange rate path based on changes in relative prices over the period of one year.[12] Furthermore, the value of φ (elasticity of substitution between oil and non-oil goods) is taken to be 0.1 to reflect that oil products are complements to non-oil goods and to capture that a small change in the supply of petroleum products leads to a large swing in their prices.

Another important set includes parameters that specify the relative importance of goods in consumption baskets. For the home country, these parameters (i.e. γ, μ and w) are allowed to be time-varying to reflect changes in the economic structure over time. As the Thai economy has become more integrated with the world economy, the share of traded goods produced and the level of imported goods consumed have been steadily rising. Against this background, (for the setup with commodity goods) this study sets $\gamma \in [0.35,0.45]$ (relative importance of traded goods in total consumption), $\mu = 0.84$ (relative importance of non-oil goods in consumption of traded goods), and $w \in [0.10,0.27]$ (relative importance of home traded goods in consumption of non-oil goods).[13] The complete specification of parameter values is presented in Table 4.1. On the contrary, the parameter values for the foreign country are time-invariant by taking $\gamma^* = 0.25$ (relative importance of traded goods in total consumption) and $\mu^* = 0.87$ (relative importance of non-oil goods in consumption of traded goods). Furthermore, the value of w^* can be calculated according to:

$$(4.53) \quad w^* = 1 - \frac{\left(\mu^*(1-w) - (1-\mu)\right)}{\mu^*}\sigma_T,$$

[12] Obstfeld and Rogoff (2005) provided a detailed discussion on the choice of parameters θ and η. They took the view the values of θ and η depend on the pace of the global rebalancing. In particular, they set $\theta = 1$, $\eta = 2$ for the moderate pace over 1-2 years, $\theta = 2$, $\eta = 4$ for the gradual pace over 5-7 years, and $\theta = 4$, $\eta = 8$ for the very gradual pace over 10-12 years.

[13] Although certain parameters are allowed to be time-varying, their values are restricted to be constant over the period of 1997-2002 and 2005-2010 in order to limit any effect from structural changes in the analysis.

which is the condition that assures balanced trade between the home and foreign countries.

In addition to the parameters mentioned above, it is essential to obtain the values of exogenous forcing variables such as the current account balance, the foreign asset and foreign liability position together with the detailed breakdown, the output level of different goods, and the price of oil. The breakdown of foreign assets and foreign liabilities into investment in equity and debt instruments is also necessary for tracking the evolution of foreign assets and foreign liabilities given the development of capital flows. Similarly, the breakdown into investment denominated in domestic and foreign currencies is essential for analyzing the effect of exchange rate valuation.

4.4.3 Simulation Results

This part assesses the behavior of the Thai baht during (i) the sudden stop of capital inflows in the aftermath of the financial crisis of 1997 and (ii) the revival of massive foreign funds since 2005, with a temporary slowdown during the global financial crisis. The assessment of the exchange rate dynamics is primarily based on simulation exercises prescribed in this study. In particular, the presentation of simulation results starts from analyzing historical exercises, which aim to check whether currency movements are chiefly driven by relative price adjustments necessary to accommodate current account developments. Then, the discussion turns to examine hypothetical exercises, the main focus in this study, whose baseline scenario is founded on the assumption that the current account needs to adjust towards its medium-term norm of zero within one year. Supplementary hypothetical exercises address some relevant interesting questions as well as explore alternative assumptions on the current account's medium-term value.

❖ Historical Exercises

The dynamics of the US dollar to a considerable extent appears to be influenced by relative price changes that occur to clear goods markets following current account adjustments. The top panel of Figure 4.1 presents simulation results of historical exercises that replicate the analysis on the US dollar dynamics done by Obstfeld and Rogoff (2007). The figure illustrates that the simulated path of the real exchange rate looks consistent, at least qualitatively, with the actual behavior of the US dollar over the period 1980-2002, notwithstanding a sizeable divergence in the past decade.

On the contrary, the analytical framework that calculates the equilibrium exchange rate purely based on current account developments might not perform well for countries like Thailand and some other emerging markets, which are exposed to fluctuations in capital flows with the magnitude deemed to be outsized relative to their economies. Based on the bottom panel of Figure 4.1, there have been a number of occasions on which the behavior of the Thai baht appeared markedly divergent from the simulated path of the real exchange rate. Such an observation provides the motivation for implementing hypothetical exercises which examine the behavior of the exchange rate in the presence of significant changes in financial flows, especially those that are not endogenously determined by the consumption-saving decision of domestic agents.

❖ Baseline Hypothetical Exercises – Sudden Stop of Capital Inflows

The first set of baseline hypothetical exercises examines the behavior of the Thai baht during the 1997-1998 sudden stop of capital inflows and subsequent deleveraging over the period ending in 2003, with the pattern of capital flows characterized by private funds in the form of currency and deposits, and loans (i.e. other investment flows to banks and other sectors, excluding trade credits; liabilities).

Figure 4.2 suggests that the sharp current account adjustment by itself could not trigger sizeable exchange rate depreciation by the scale being observed at the time of crisis. In fact, such substantial currency depreciation was primarily underpinned by the sudden stop of capital inflows. Although the Thai baht actually depreciated considerably by almost 30 percent from the pre-crisis level, the model predicts that the magnitude of exchange rate depreciation should even be greater by about 5-15 percent. In contrast, the Thai baht had remained more depreciated than the equilibrium exchange rate predicted by the model during 1999-2001. This illustration seems consistent with the view that policymakers adopted an export-led growth model by maintaining the exchange rate at a competitive level.

As part of robustness checks, Figure 4.3 shows that during the sudden stop episode, the role of commodity prices seemed somewhat limited thanks to the stability of the price of oil. Moreover, the impact of currency valuation on the dynamics of the exchange rate looked negligible despite its instrumental role in causing across-the-board bankruptcy and inducing the sudden stop in the presence of substantial currency mismatch. As discussed above, the underestimation mainly results from the design of simulation exercises in which the currency valuation effect is not taken as a triggering factor for the drainage of foreign funds, which can emerge when foreign investors become in panic due to the expectation of sharp exchange rate depreciation.

❖ Baseline Hypothetical Exercises – Renewal of Massive Foreign Funds

The second set of baseline hypothetical exercises assesses the behavior of Thailand's exchange rate during the renewal of massive foreign funds beginning in 2005, with the pattern of capital flows characterized by foreign investment in Thailand's stock market (i.e. portfolio equity investment; liabilities). Furthermore, the analysis covers the period of 2005-2010 for evaluating the effect induced by a temporary slowdown in capital inflows during the global financial crisis, and examines other types of non-endogenous financial flows such as domestic outflows triggered by liberalization policies (i.e. direct investment and portfolio investment; assets).

Figure 4.4 illustrates that the stability of the Thai baht in 2005 was achieved despite in the presence of substantial capital inflows because some exchange rate depreciation was required to accommodate the correction of the current account deficit. However, the Thai baht, which started appreciating sharply in 2006, became much more appreciated than the model's equilibrium exchange rate by around 10 percent. Such findings help justify the BoT's serious concern about large and rapid exchange rate appreciation, which led the BoT to undertake several policy actions, including imposing capital controls in the form of URR and liberalizing domestic financial outflows. Simulation results also suggest that the liberalization policies, which triggered sizeable domestic outflows, alone could induce the Thai baht to depreciate by about 10 percent in 2007.

The Thai baht became relatively stable in 2008-2009, even though the equilibrium exchange rate determined by the model continues to strengthen largely due to the gigantic current account surplus that faced considerable pressure to narrow towards a more sustainable level in early 2009. In reality, strained conditions in international financial markets, which caused excess liquidity to disappear and risk appetite to diminish, seemed to be the most important factor that helped put a break on the influx of foreign funds. However, simulation results reveal that the reversal of portfolio equity investment inflows marginally induced currency depreciation. Consequently, the Thai baht became significantly more depreciated than the model's equilibrium exchange rate during 2008-2009. Nonetheless, as the size of the current account surplus diminished (thus reducing pressure on currency appreciation) and the amount of domestic outflows prompted by liberalization measures increased (thereby forcing the current account to deteriorate), the Thai baht has recently become more aligned with the equilibrium exchange rate.

Furthermore, as part of robustness checks, Figure 4.5 highlights that the dynamics of the Thai baht critically depends on the price of oil. For Thailand, an increase (or decrease) in the price of oil contributes to a stronger (or weaker) value of the model's equilibrium exchange rate. Simulation results reveal that the indirect effect owing to the fact that Thailand is a petroleum importing country outweighs the direct effect borne by a larger share of oil products in the consumption basket of traded goods. Moreover, changes in the price of oil could induce currency movements as large as 9 percent, reflected by the difference in equilibrium exchange rate values that holds the price of oil constant and that embraces actual changes in the price of oil. These findings allude that any study on the behavior of the exchange rate should take into account of movements of key commodity prices relevant to the economy.

❖ Supplementary Hypothetical Exercises

Various supplementary hypothetical exercises address some relevant interesting questions as well as explore alternative assumptions on the current account's medium-term norm.

First of all, when the influx of foreign funds is characterized by foreign investment in equity (i.e. both direct investment and portfolio equity investment; liabilities) rather than just foreign investment in the stock market, the path of the model's equilibrium exchange rate looks more comparable to the actual behavior of the Thai baht during 2005-2006 (Figure 4.6). Therefore, substantial exchange rate appreciation in 2006 was likely to be driven by a combination of portfolio equity investment and greater-than-average direct investment inflows, in contrast to the common belief that fluctuations in financial inflows to the stock market serve as the key factor underpinning the exchange rate dynamics.

FX interventions also appeared as one of major policy actions that sought to limit currency appreciation induced by massive financial inflows. Figure 4.6 shows that the largest scale of interventions in the FX market was undertaken in 2007 when the Thai baht continued to appreciate during the URR regime. Based on simulation results, the BoT's FX interventions featuring a substantial increase in foreign reserves could induce currency depreciation by about 5 percent. These simulation exercises are implemented under the assumption that FX interventions can generate some non-endogenous financial flows (i.e. Ricardian equivalence does not hold) with the effective impact of 25 percent on the exchange rate dynamics (i.e. households offset a change in foreign reserves by about 75 percent so that the remaining 25 percent of the change would trigger currency movements).[14]

Lastly, alternative options of the current account's medium-term norm are considered. Baseline hypothetical exercises take the current account's medium-term position to be zero for clarity and simplicity. The reference point of zero also seems realistic as a current account deficit (or surplus) tends to generate currency depreciation (or appreciation) pressure for supporting the process of eliminating current account imbalances. However, it is worth implementing simulation exercises using other choices of the current account's medium-term position. In particular, two options are considered here. One is the HMA-CA, which seems reasonable since the trend of current account developments should not change dramatically over a short period of time. Another is the sNFA-CA, which shares the spirit of the intertemporal approach to the current account in the aspect that external borrowing and lending as a result of risk sharing should be netted out over time. Differences in simulation results across the three alternatives are discussed below.

[14] When Ricardian equivalence fails, it seems appropriate to view that FX interventions can induce non-endogenous financial flows because domestic entities do not completely offset changes in foreign assets initiated by the central bank.

For the sudden stop episode, the equilibrium exchange rate path based on the medium-term norm deriving from the HMA-CA, relative to the baseline alternative, appears to be less depreciated during the financial crisis but more depreciated afterwards. These simulation results presented in Figure 4.7 emerge from the fact that the current account's medium-term position (based on the HMA-CA) turned from a deficit to a surplus in 1999, as the Thai economy had run a persistent current deficit prior to the financial crisis of 1997 and then has managed to maintain a current account surplus most of the time since then. In any case, the main messages from baseline hypothetical exercises remain unchanged. Particularly, the sudden stop of capital inflows served as the predominant factor driving substantial exchange rate depreciation. Moreover, the Thai baht had remained more depreciated than the model's equilibrium exchange rate during 1999-2001, with such a competitive currency value helping facilitate the reallocation of resources from nontraded to traded sectors as well as support export-led growth.

For the episode featuring the influx of foreign funds, the path of the equilibrium exchange rate appears to be qualitatively similar regardless of the choice of the current account's medium-term position (Figure 4.8), although certain noticeable quantitative differences exist. Relative to the baseline alternative, the equilibrium exchange rate calculated based on the HMA-CA is more depreciated while the equilibrium exchange rate generated by taking the sNFA-CA as the medium-term norm is more appreciated. These simulation results stem from the characteristics that the HMA-CA always exhibits a surplus whereas the sNFA-CA displays a sustained deficit (Table 4.2), with the implication that the magnitude of current account adjustments needed for attaining the medium-term position dictated by the HMA-CA (or sNFA-CA) is smaller (or larger). As a result, the model's equilibrium exchange rate is required to appreciate relatively less under the HMA-CA alternative.

4.5 Conclusion

This chapter employs the methodology developed by Obstfeld and Rogoff (2005) and (2007) to estimate the magnitude of exchange rate adjustments required for absorbing changes in capital flows as well as supporting adjustments of the current account towards its medium-term norm. The chapter particularly focuses on analyzing the behavior of the Thai baht when the economy experiences major changes in the pattern of financial flows. Two important episodes, the sudden stop of capital flows associated with the financial crisis of 1997 and the revival of massive foreign funds since 2005, are examined. Key findings can be summarized as follows.

First, the dynamics of the Thai baht has been significantly influenced by the development of capital flows. In particular, the drainage of foreign funds was the predominant factor underpinning sharp exchange rate depreciation during the financial crisis of 1997. The role of capital flows in determining exchange rate movements has also been evident over the period starting from 2005 when the renewal of substantial foreign funds began. The pressure on the Thai baht to appreciate during 2006 primarily came from a combination of sizeable portfolio equity investment and greater-than-average direct investment inflows, although policy measures that liberalized domestic outflows to a considerable extent also helped mitigate the magnitude of currency appreciation in 2007.

Second, the impact of large fluctuations in the price of oil on the exchange rate dynamics can be very significant. In the case of Thailand which is a petroleum importing country, the exchange rate depreciates (or appreciates) when the price of oil rises (or falls). Moreover, based on simulation exercises using actual changes in the price of oil, the equilibrium exchange rate could fluctuate considerably up to 9 percent. Therefore, any study on the behavior of the exchange rate should incorporate movements of key commodity prices important to the economy.

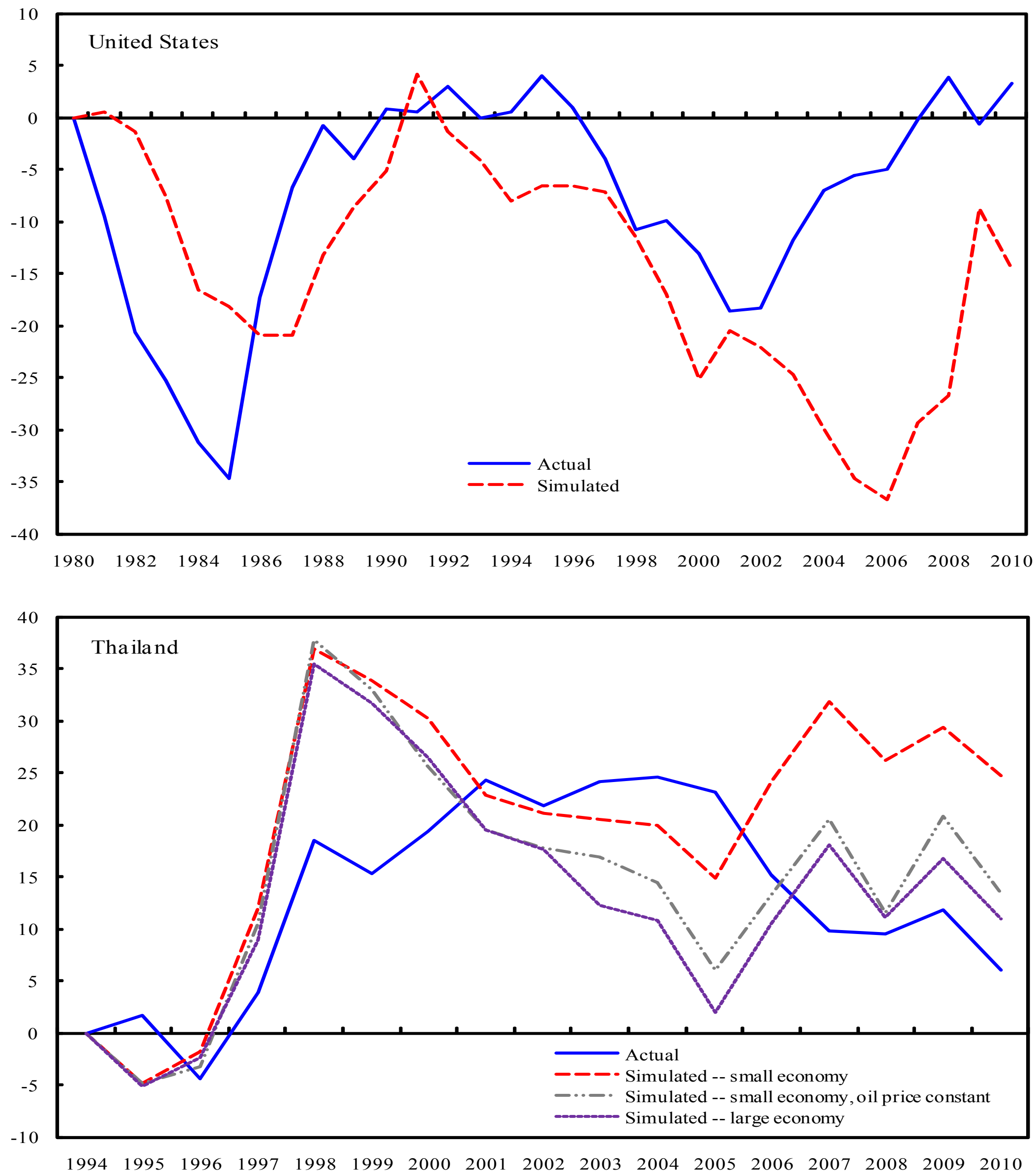
Third, some signs on exchange rate misalignments can be drawn from simulation exercises by gauging differences between the actually observed exchange rate and the model's equilibrium exchange rate. Based on simulation exercises, the Thai baht looked relatively weak during 1999-2001, consistent with the view that policymakers at that time adopted an export-led growth model founded on a competitive exchange rate value. Furthermore, the concern about large and rapid exchange rate depreciation in 2006 could be warranted by the observation that the actual exchange rate dynamics markedly diverged from the equilibrium exchange rate path. Nonetheless, the behavior of the Thai baht over the last year has become more aligned with underlying factors that generate currency movements in the model. Therefore, evidence for major exchange rate misalignments seems limited at present.

In conclusion, the simulation-based framework developed in this study can serve as a useful tool for analyzing the exchange rate dynamics and assessing whether the currency value is consistent with macroeconomic fundamentals. Here, the central mechanism driving exchange rate fluctuations is founded on the necessity of exchange rate movements resulting from relative price changes to accommodate exogenous developments of capital flows as well as adjustments of the current account towards its medium-term position.

4.6 Annex

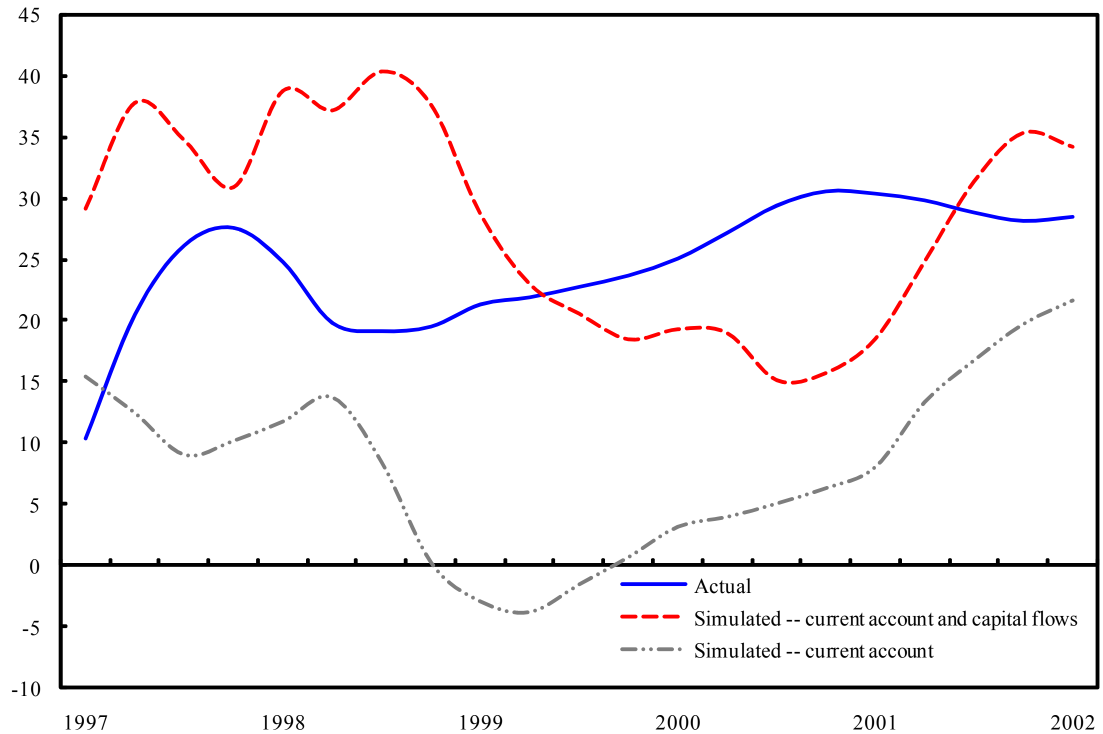
4.6.1 Figures and Tables

Figure 4.1 Historical Exercises: Actual and Simulated Real Effective Exchange Rates



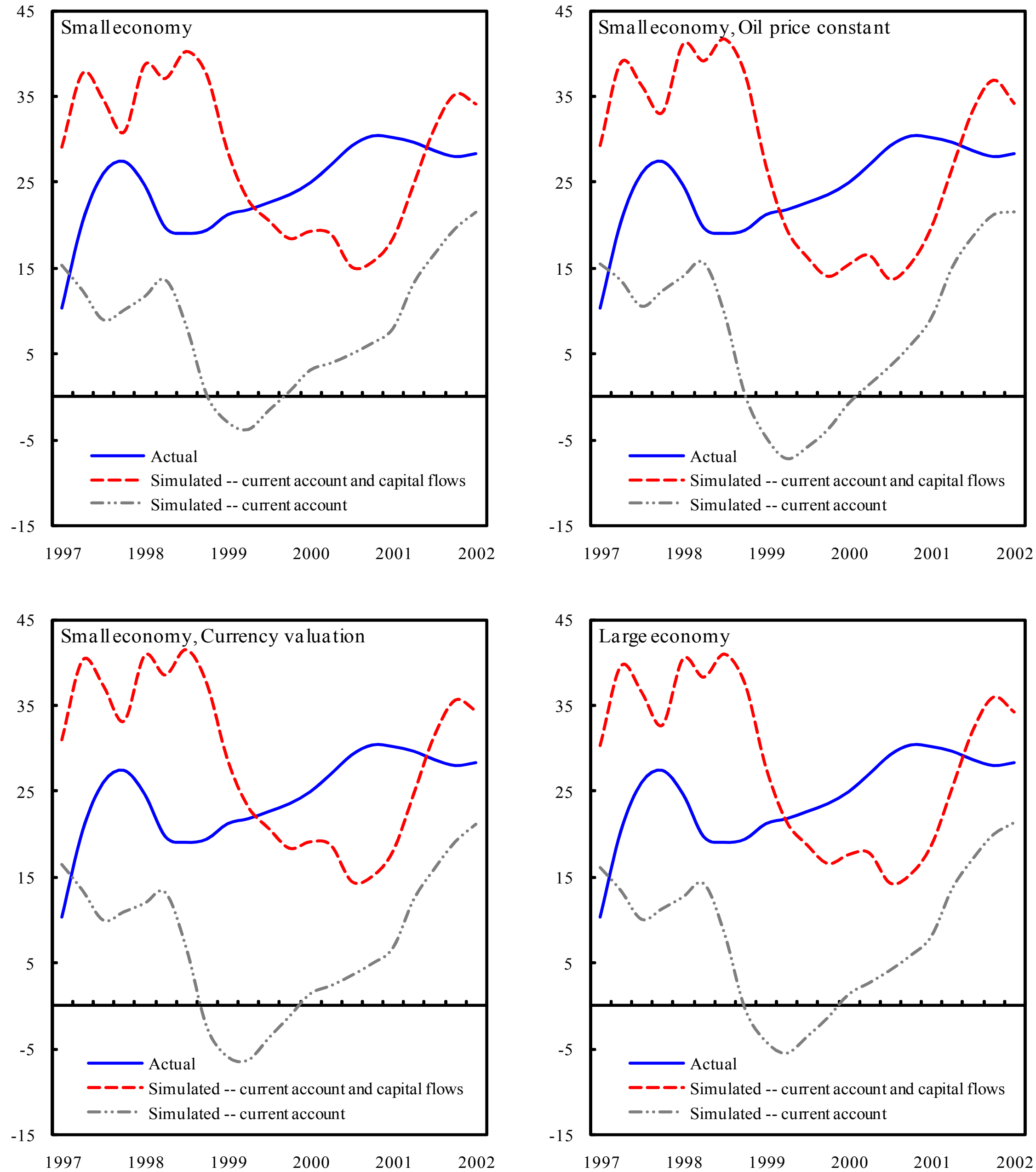
Sources: Bank of Thailand; International Monetary Fund; and author's simulations.
Note:
1. On logarithmic scale, in percent. For the United States, normalize to zero in 1980; for Thailand, normalize to zero in 1994.
2. An increase means depreciation.
3. Historical exercises simulate a real exchange rate path based on the actual current account developments.
4. For the United States, this replicates Figure 8 in Obstfeld and Rogoff (2007), with the period being extended to 2010.

Figure 4.2 Hypothetical Exercises on Thailand's Sudden Stop and Subsequent Deleveraging (1997-2003): Actual and Simulated Real Effective Exchange Rates – Baseline



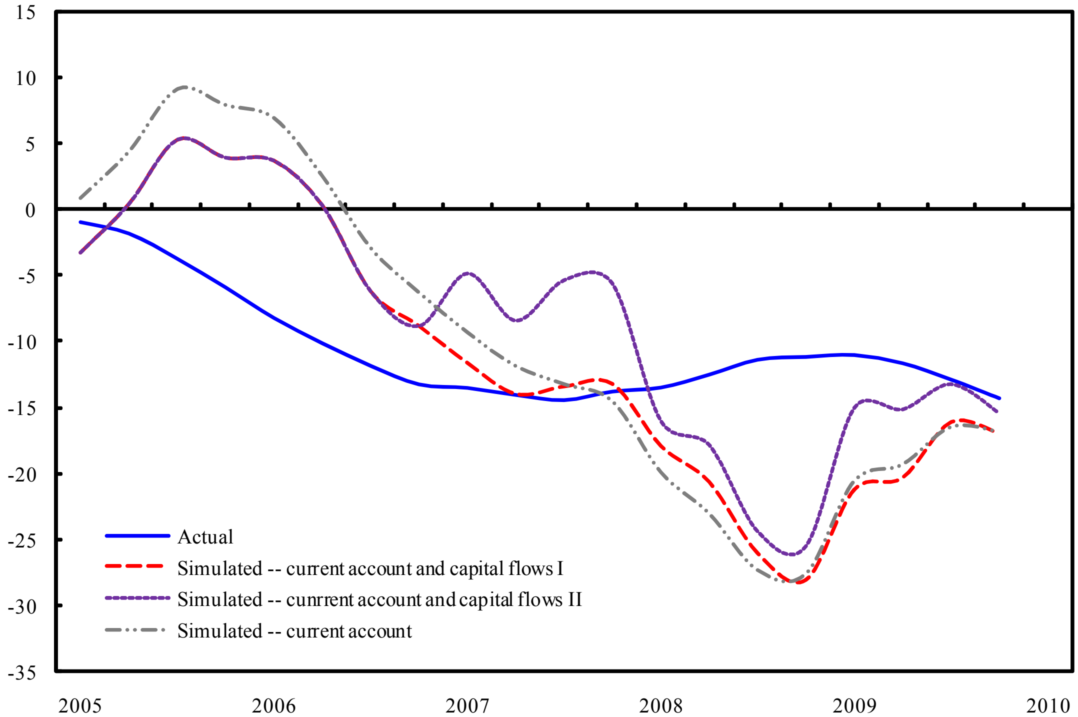
Sources: Bank of Thailand; and author's simulations.
Note:
1. On logarithmic scale, in percent. Normalize to zero in 1996.
2. An increase means depreciation.
3. Hypothetical exercises simulate a real exchange rate path under the assumption that the current account's dynamics is influenced by (i) an adjustment towards its medium-term norm of zero within one year, and (ii) an adjustment needed to absorb changes in capital flows in the event of the 1997-1998 sudden stop and subsequent deleveraging over the period ending in 2003. The pattern of capital flows is characterized by private funds in the form of currency and deposits, and loans (i.e. other investment flows to banks and other sectors, excluding trade credits; liabilities).

Figure 4.3 Hypothetical Exercises on Thailand's Sudden Stop and Subsequent Deleveraging (1997-2003): Actual and Simulated Real Effective Exchange Rates – Robustness Checks



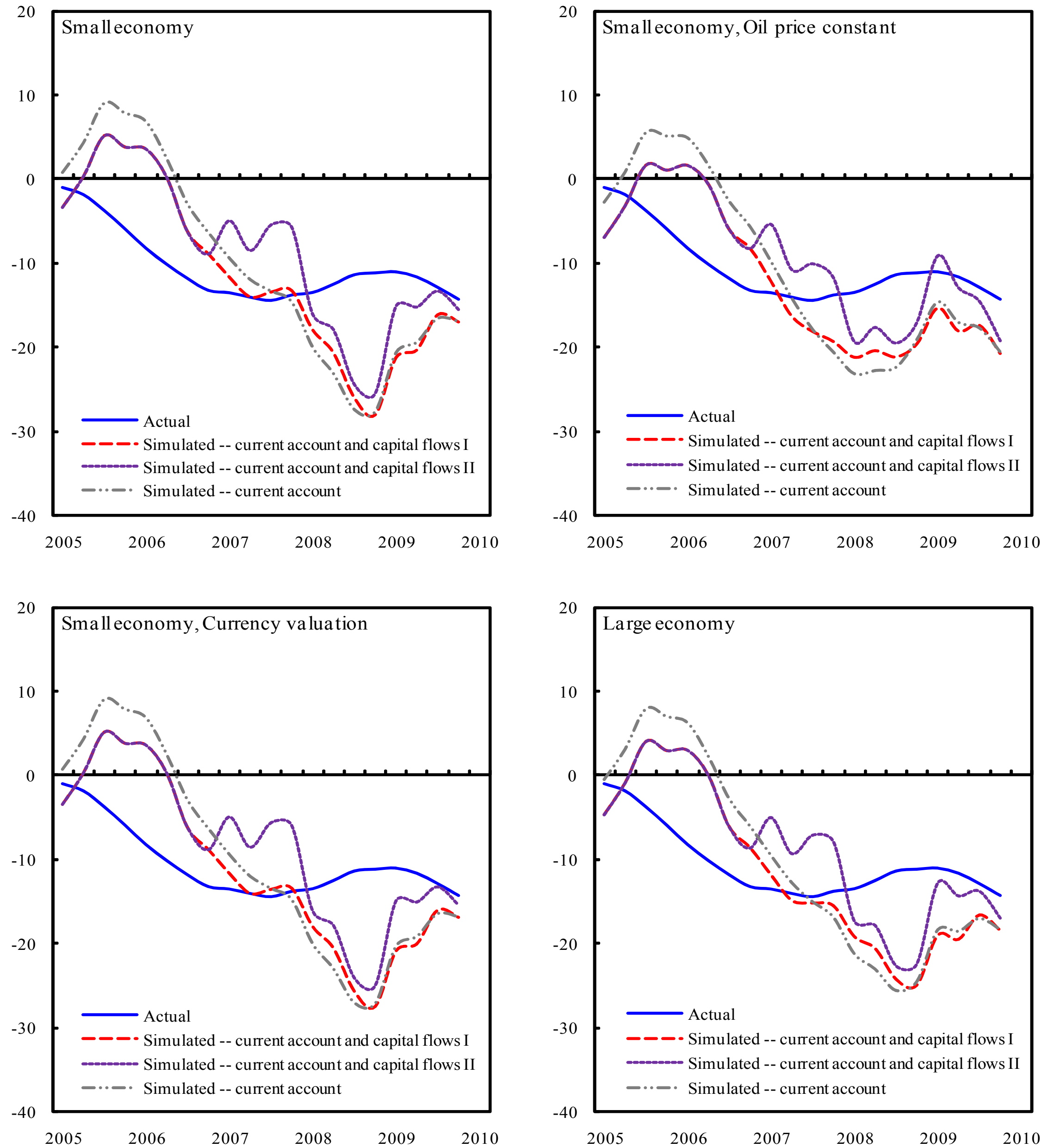
Sources: Bank of Thailand; and author's simulations.
Note:
1. On logarithmic scale, in percent. Normalize to zero in 1996.
2. An increase means depreciation.
3. Hypothetical exercises simulate a real exchange rate path under the assumption that the current account's dynamics is influenced by (i) an adjustment towards its medium-term norm of zero within one year, and (ii) an adjustment needed to absorb changes in capital flows in the event of the 1997-1998 sudden stop and subsequent deleveraging over the period ending in 2003. The pattern of capital flows is characterized by private funds in the form of currency and deposits, and loans (i.e. other investment flows to banks and other sectors, excluding trade credits; liabilities).

Figure 4.4 Hypothetical Exercises on Thailand's Influx of Foreign Funds (2005-2010): Actual and Simulated Real Effective Exchange Rates – Baseline



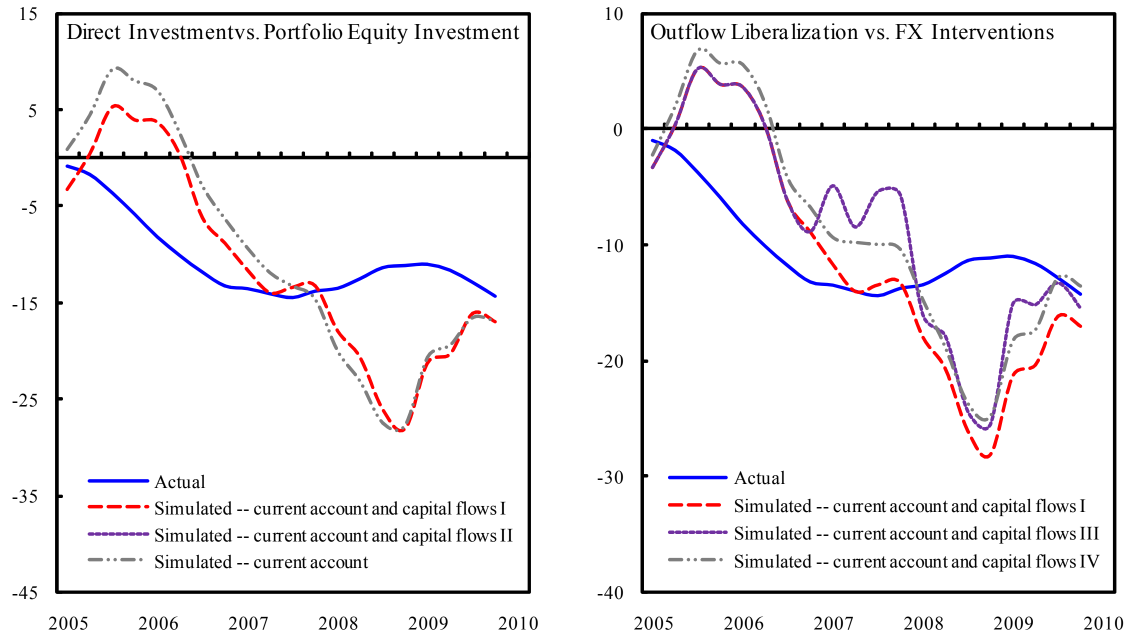
Sources: Bank of Thailand; and author's simulations.
Note:
1. On logarithmic scale, in percent. Normalize to zero in 2004.
2. An increase means depreciation.
3. Hypothetical exercises simulate a real exchange rate path under the assumption that the current account's dynamics is influenced by (i) an adjustment towards its medium-term norm of zero within one year, and (ii) an adjustment needed to absorb changes in capital flows in the event of the revival of massive foreign funds since 2005. The pattern of capital flows is characterized by foreign investment in Thailand's stock market (i.e. portfolio equity investment; liabilities) and domestic outflows triggered by liberalization policies (i.e. direct investment and portfolio investment; assets). Scenario I includes only the former component, while scenario II includes both.

Figure 4.5 Hypothetical Exercises on Thailand's Influx of Foreign Funds (2005-2010): Actual and Simulated Real Effective Exchange Rates – Robustness Checks



Sources: Bank of Thailand; and author's simulations.
Note:
1. On logarithmic scale, in percent. Normalize to zero in 2004.
2. An increase means depreciation.
3. Hypothetical exercises simulate a real exchange rate path under the assumption that the current account's dynamics is influenced by (i) an adjustment towards its medium-term norm of zero within one year, and (ii) an adjustment needed to absorb changes in capital flows in the event of the revival of massive foreign funds since 2005. The pattern of capital flows is characterized by foreign investment in Thailand's stock market (i.e. portfolio equity investment; liabilities) and domestic outflows triggered by liberalization policies (i.e. direct investment and portfolio investment; assets). Scenario I includes only the former component, while scenario II includes both.

Figure 4.6 Hypothetical Exercises on Thailand's Influx of Foreign Funds (2005-2010): Actual and Simulated Real Effective Exchange Rates – Additional Investigations

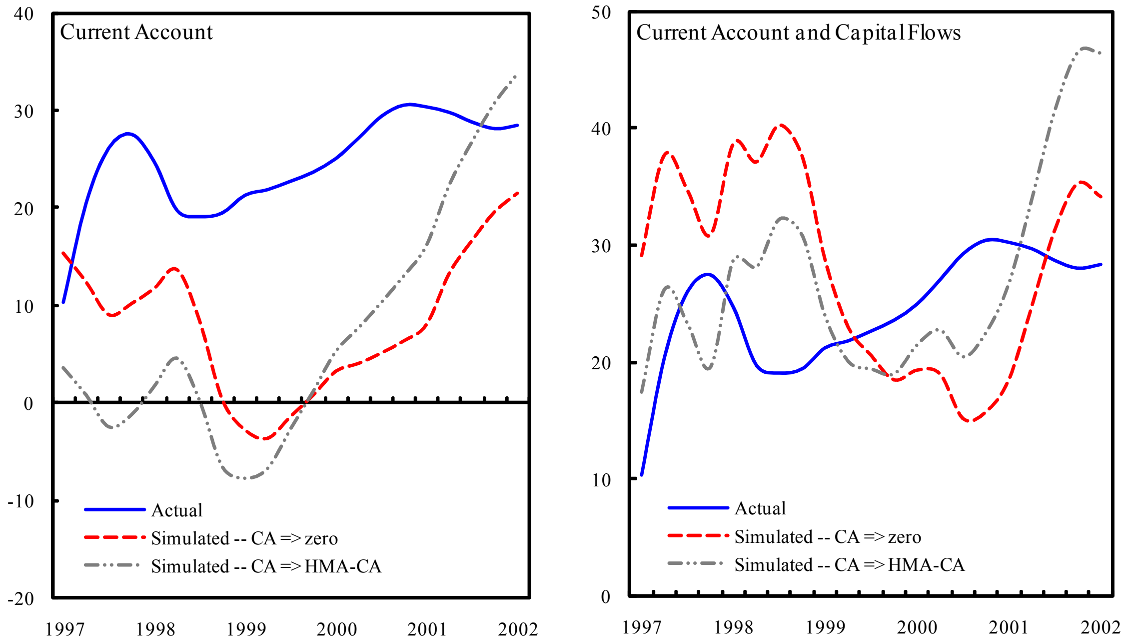


Sources: Bank of Thailand; and author's simulations.

Note:

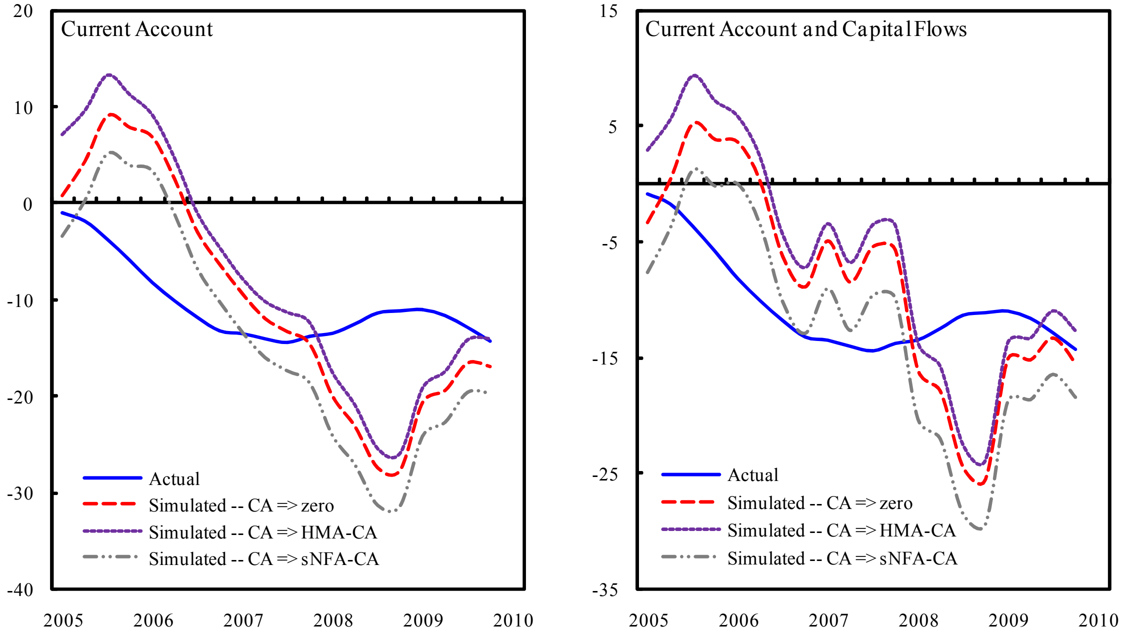
1. On logarithmic scale, in percent. Normalize to zero in 2004.
2. An increase means depreciation.
3. Hypothetical exercises simulate a real exchange rate path under the assumption that the current account's dynamics is influenced by (i) an adjustment towards its medium-term norm of zero within one year, and (ii) an adjustment needed to absorb changes in capital flows in the event of the revival of massive foreign funds since 2005. The pattern of capital flows is characterized by (A) foreign investment in Thailand's stock market (i.e. portfolio equity investment; liabilities), (B) foreign direct investment (i.e. direct investment; liabilities), (C) domestic outflows triggered by liberalization policies (i.e. direct investment and portfolio investment; assets), and (D) FX interventions (i.e. changes in reserve assets; the effective impact of FX interventions on the exchange rate is assumed to be 25 percent). Scenario I includes only (A), scenario II includes (A) and (B), scenario III includes (A) and (C), and scenario IV includes (A) and (D).

Figure 4.7 Hypothetical Exercises on Thailand's Sudden Stop and Subsequent Deleveraging (1997-2003): Actual and Simulated Real Effective Exchange Rates – Alternative Current Account's Medium-Term Norm



Sources: Bank of Thailand; and author's simulations.
Note:
1. On logarithmic scale, in percent. Normalize to zero in 1996.
2. An increase means depreciation.
3. Hypothetical exercises simulate a real exchange rate path under the assumption that the current account's dynamics is influenced by (i) an adjustment towards its medium-term norm within one year, and (ii) an adjustment needed to absorb changes in capital flows in the event of the 1997-1998 sudden stop and subsequent deleveraging over the period ending in 2003. The pattern of capital flows is characterized by private funds in the form of currency and deposits, and loans (i.e. other investment flows excluding trade credits to banks and other sectors; liabilities). The current account's medium-term norm is either zero or the 5-year historical moving average current account (HMA-CA).

Figure 4.8 Hypothetical Exercises on Thailand's Influx of Foreign Funds (2005-2010): Actual and Simulated Real Effective Exchange Rates – Alternative Current Account's Medium-Term Norm



Sources: Bank of Thailand; and author's simulations.
Note:
1. On logarithmic scale, in percent. Normalize to zero in 2004.
2. An increase means depreciation.
3. Hypothetical exercises simulate a real exchange rate path under the assumption that the current account's dynamics is influenced by (i) an adjustment towards its medium-term norm of zero within one year, and (ii) an adjustment needed to absorb changes in capital flows in the event of the revival of massive foreign funds since 2005. The pattern of capital flows is characterized by foreign investment in Thailand's stock market (i.e. portfolio equity investment; liabilities) and domestic outflows triggered by liberalization policies (i.e. direct investment and portfolio investment; assets). The current account's medium-term norm is zero, the 5-year historical moving average current account (HMA-CA), or the current account balance that stabilizes net foreign assets (sNFA-CA).

Table 4.1 Summary of Key Parameter Values

Symbol	Value		Description
	United States	Thailand	
σ_T	0.293	0.012-0.015	relative output of home goods to foreign goods
γ	0.25	0.35-0.43	relative importance of traded goods in total home consumption
μ	1.00	0.84	relative importance of non-oil goods in home consumption of traded goods
w	0.70	0.10-0.27	relative importance of home goods in home consumption of non-oil goods
γ^*	0.25	0.25	relative importance of traded goods in total foreign consumption
μ^*	1.00	0.87	relative importance of non-oil goods in foreign consumption of traded goods
θ	1	1	elasticity of substitution between traded and nontraded goods
ε	…	0.1	elasticity of substitution between oil and non-oil goods
η	2	2	elasticity of substitution between home and foreign traded goods
i	0.05	0.05	world interest rate

Table 4.2 Summary of Current Account's Medium-Term Norm Values

Year	Stabilizing Net Foreign Asset Current Account	5-year Historical Moving Average Current Account
1993	…	-5.96
1994	…	-6.35
1995	…	-6.26
1996	…	-6.34
1997	…	-5.65
1998	…	-2.09
1999	…	1.02
2000	-1.49	4.12
2001	-1.04	6.58
2002	-1.44	7.73
2003	-2.33	5.85
2004	-2.80	4.16
2005	-2.86	1.77
2006	-3.02	1.11
2007	-2.88	1.64
2008	-2.68	1.09
2009	-1.79	2.28

Note:
1. The stabilizing net foreign asset current account (sNFA-CA) is the current account balance that stabilizes the ratio of net foreign assets to GDP. Let the ratio be denoted by ca^*. Then, the value of ca^* can be derived from the relationship: $ca^* = nx^* + rf^*$, where r is the real return on net foreign assets, f^* is the desired net foreign asset position (as a ratio of GDP), and nx^* is the net export level that stabilize net foreign assets. The value of nx^* must satisfy: $nx^* = -\frac{(r-g)}{1+g}f^*$, where g is the real output growth rate. In this study, the desired net foreign asset position is the average of the net foreign asset position over the five preceding years.
2. The 5-year historical moving average current account (HMA-CA) is simply the average of the current account balance over the five previous years.

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