PEERING THROUGH THE MONETARY MIST: MACROECONOMIC EFFECTS OF MONETARY POLICY UNDER BORDERLESS WORLD OF FINANCIAL AND LABOR MARKET

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Suchanan Chunanantatham

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ABSTRACT

In recent years, global economic integration has accelerated on a multitude of fronts. The world has witnessed the greater openness of national economies and a move toward more integrated world financial and labor market. This seems to be the case of Thailand. It is commonly believed that Thai financial markets are more connected to the world now that they were in 1960s and 1970s. Apparently, a number of steps have been taken during the past decades to increase the degree of capital mobility. After the comprehensive reform policies to deregulate domestic financial system and liberalize the capital account have been implemented in the late 1980s and early 1990s, there has been a relatively higher correlation between onshore and offshore interest rates, a pour of the private capital inflows and an increase dependence in foreign capital. All these, together with other solid evidences from many other countries, signified convincingly overtime the higher tendency to become unity of various financial markets across the world. In addition, the migration of people from and to other countries in search of employment is by no means a new phenomenon. The employment opportunities and higher wages in Gulf region and other oversea countries were the main pull factors that lead the enormous numbers of Thai workers to seek jobs oversea. At the same time, the differences in social and economic conditions between Thailand and neighboring countries also create strong pressures that make Thailand a powerful magnet for labor immigration. In this context, it would, consequently, be a very intriguing topic for research how these market integrations affect the domestic economy and alter macroeconomic volatilities in the face of a change in monetary policy. Therefore, in order to make the contribution in such direction, this thesis deliberately intends to investigate how the economy behaves in response to change in monetary policy under different degree of capital mobility, plus the role played by international labor relocation, and thus the country size, on this sensitivity of policy-induced change in macroeconomic volatilities to the openness in financial market overtime.

In recent year, because of its ability to address the most important issues in international finance without sacrificing the rigor of explicit dynamic and welfare analysis, resorting to the class of model, so called New Open Economy

Macroeconomic models, in tradition of the model developed by Obstfeld and Rogoff (1995), has become a popular way of analyzing the effect of macroeconomic policies in an open economy setting. This thesis makes use of this intertemporal two-country general equilibrium model with flexible prices, flexile exchange rate, and monopolistic competition to take in hand the above questions. The model takes into account three kinds of international economic integration, namely goods, financial, and labor market while allowing for various degrees of market integration in the latter two. The increasing degree of capital mobility is modeled by elimination of trading friction between financial markets in different countries and the less segmented in worldwide labor markets is reflected by the change in distribution of agents resided in each countries.

In the nutshell, the simulated results carried out at different degrees of financial and labor market integration ultimately indicate that the way macroeconomic variables response, after a monetary shock hits economy, obviously differs between economy where economic agents have a free access to make a capital movement across national boundary and the one where agents are subject to cost to transfer funds. Financial market integration robustly creates lower volatility of interest rate, consumption, and higher volatility of price and exchange rate when the effect of monetary shock on the volatility is observed. Accordingly, although the approach taken here differs radically from that of traditional Mundell-Fleming model in that it allows policy issues to be analyzed by mean of a full-fledged micro-founded dynamic model, the two approaches share some implications as both models appear to predict that the nominal exchange rate effect of monetary policy tends to increase in the world where capital mobility is far above the ground. At the same time, the flexile-price NOEM model developed in this paper and the quantity theorist also are not extremely far apart in terms of output implication of monetary policy. That is, both deemphasize the role of monetary and aggregate demand shock as a driving force of the fluctuation in economy in the long-run and agree to the fact that none of the real variables, such as real output and employment, will change as a result of a change in money stock since immediately-adjusted prices and wages would bring about the classical neutrality of monetary policy.

Additionally, the simulation results suggest unquestionably that quite the same pattern still applies even after the possibility of shift in labor location is incorporated. In other word, for wide ranges of parameter choices, whether business cycle volatility increases or decreases due to the increasing financial market integration is fairly independent from the nature of integration in the world's labor market. As a consequence, regardless of the condition in terms of linkage in labor market between nations, the international financial market integration does show a consistent and dependable effect toward the behavior of economy in the upshot of shock in money supply.

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CHAPTER 1

INTRODUCTION

1.1 Statement of Problem

“Several of these approaches [international macroeconomic models developed over the years] were presented by their creators as representing a conflict with the preceding approaches, which have indeed been derived by some an erroneous orthodoxy. Our view is that such exclusiveness is unmerited: that any adequate understanding of the macroeconomics of an open economy demands an integration of all the various approaches within context of a general equilibrium model.”

John Williamson and Chris Milner 1991

The world is still a closed economy, but its regions and countries are becoming increasingly open. While trade liberalization, which has been ongoing for a longer period, has continued, more dramatic changes have occurred in the financial sphere. During the last fifty years, the globalization of financial markets has become one key manifestation of the increasing worldwide economic integration. This process of integration has been fostered by the abolition of legal restrictions on cross–border capital movements and by technological advances that have lowered information and communication costs considerably. These technology-based developments have so expanded the breadth and depth of markets that governments, even reluctant ones, increasingly have felt they have had little alternative but to deregulate and free up internal credit and financial markets. As a result, over the past decades, international financial markets have grown radically as a growing number of firms now operate across national borders and savers are investing more than ever before in far-flung places. Like many others, Thailand could also convey a perfect example for this integration process. The process of financial liberalization started in early 1980s and became intense in 1990s. The domestic financial market deregulation, together with the policy to ease up capital control, helped facilitating the international exchange, trade, and capital flow transactions and, hence, led to the financial tie-up that has gain an enormous and firm momentum. Fundamentally, although it may be premature to talk about a single global capital market, but, from the excellent evidences, both statistically and regulatory (without taking the period of financial crisis into consideration), it is not too early to say that Thai capital, as well as numerous others, undoubtedly becoming steadily more integrated at the pace that is truly remarkable. As a consequence, given that the trend toward globalization is clear and also that an environment conducive to stable product prices and to sustainable economic growth is a prime responsibility of governments and, of course, central banks, it is of great importance to ask whether this integration process strengthens or weakens the ability of policymakers to stabilize the economy using macroeconomic policies.

To the extent that financial market integration is a result of policy choice, investigating the effect of presence of financial market integration could lead to interesting results in terms of its effect on volatilities of the economy in response to a change in monetary policy. However, the existing economic theory does not give a clear answer to this question.

Since 1960, the real and nominal effects of monetary (and fiscal) policy have been analyzed within the framework of a by-now classic workhorse model developed by Fleming (1962) and Mundell (1963). By merging Keynesian pricing assumption and international market segmentation within the simple, yet illuminating, groundwork, Mundell-Fleming model exemplifies the most successful interaction of method for analyzing monetary and fiscal policy issues in an open economy setting. The model apparently exhibits that capital mobility enhances the effectiveness of monetary policy, measured by its impact on output, in an open economy with flexible exchange rate. To be exact, in a system of floating exchange rates, a monetary expansion brings about a depreciation of the exchange-rate which, in turn, stimulates aggregate demand through export. A central result of the model is that this effect tends to be stronger; the higher is the degree of international capital mobility. For that reason, the model predicts that the effect of monetary policy on exchange rate, and hence, output is an increasing function of the extent of financial attachment between countries. Along with this, the extension of static Mundell-Fleming model was presented by Dornbusch in 1976. In agreement with Mundell-Fleming, Dornbusch's model of exchange rate dynamics appears to support also the view that sticky output price in a model with free capital mobility could give rise to exchange rate overshooting in short-run. Finally, many variants of Mundell-Fleming-Dornbusch model does, in general, show that the effectiveness of macroeconomic policies depends crucially on whether economy is operated under fixed or flexible exchange rate and, more notably, on the degree of capital mobility.

Nevertheless, in spite of the undeniable time-tested appeal of the above Mundell-Fleming-Dornbusch models, their lack of micro foundation presents problems at many levels. They do not take into account the intertemporal budget constraints that are central to the analysis of current account and exchange rate dynamics. More fundamentally, there are arguments that such ad hoc models do not fully take the role of financial market into consideration. That is, they do not allow for the opportunity that the economic agents can substitute consumption and leisure intertemporally and share risk. Hence, financial market integration doesn't permit agents to deal with a random shock effectively. Last but not least, these models fail to give any meaningful welfare criteria by which to evaluate the effectiveness of alternative macroeconomic policies. Altogether, these factors have limited the traditional model's relevance in policy-oriented discussion in open economy surroundings.

Currently, a major advance in open economy macroeconomic theory overcoming these drawbacks has been made by recent models concentrating on the intertemporal approach to current account with market imperfections. Amongst the most significant contributions in this field is Obstfeld and Rogoff (1995). They have built up the two-country general equilibrium model of international policy transmission under flexible exchange rate system that embodied the main element of intertemporal approach along with short-run nominal price rigidities and monopolistic competition. This class of model, so called new open macroeconomics model (NOEM), essentially forms a new paradigm in international macroeconomic theory, which is better equipped to explain the effects of macroeconomic policies on output, exchange rates, and current account without sacrificing the rigor of explicit dynamic and welfare analysis. This thesis, thus, develops a model based on Obstfeld and

Rogoff as a framework for considering the issues concerning the macroeconomic effect of monetary policy at different degrees of capital mobility further.

To be more specific, in order to determine how the enduring integration of financial markets changes the way national economies respond to shock, this paper uses the approach advanced by Sutherland (1996) to add into the model various degrees of capital market integration. In their only bond economy, imperfect mobility of financial capital is modeled by assuming that a domestic agent can deal costlessly in the domestic financial market but is subject to convex cost of adjustment in foreign financial market. The process of financial integration is seen as a result of reduction in this friction cost in cross-border financial transactions. In the end, the simulation results from the paper indicate that the macroeconomic effect of fiscal and monetary policy changes significantly depending on the presence of incompletely integrated market. While interest rate and consumption volatilities are reduced, international capital mobility tends to strengthen the power of monetary policy to affect exchange rate and output at business-cycle frequencies, as analogous to Mundell-Fleming-Dornbusch model.

Furthermore, with the above things being mentioned, it must be emphasized before moving on that the properties of the alternative international monetary arrangements and policy designs have been studied extensively in the economic literatures. Surprisingly, most of this latter works collectively assume no migration of labor across countries. Though this assumption alleviates the theoretical analysis of the propagation of shocks, it is clearly at variance with empirical evidences available from labor market around the world. Evidently, in this era of world with blur national boundary, not only goods, services and capitals are mobile among countries but labors, too, become, to an increasing extent, the internationally mobile factor of production. Thus, in recent years, we have thoroughly observed large flows of labors among all the economies world-wide. Thailand per se also has a long history of exporting and importing labors. The pattern of emigrant workers initially started in the 1970s when the labor markets in the Middle East began to recruit a large number of semi-skills and high skilled workers in construction and manufacturing sectors. More recently, the major labor flows from Thailand have been re-directed to the East Asian countries of Japan, Taiwan, Singapore, and Malaysia. At present, according to ministry of labor, the existing Thai workers overseas are reported at 148,595 in 2004. On the incoming side, since the early 1990s, Thailand has, on the whole, turned into a receiving country for workers from less developed neighboring countries such as Myanmar, Cambodia, and Laos as well. Consequently, in an attempt to fully appreciate the role of financial market integration for the propagation of monetary shock, extending the model to include international labor flow consideration would seem to be an obvious and promising direction for further research. This additional distinguish feature would certainly render the model to be more practical while allow for more a detailed study of financial market integration.

Explicitly, the integration in labor market between countries is modeled with a simplifying assumption that the agents cannot choose the amount of working effort they want to supply. Rather, it is fixed exogenously from the beginning period. The degree of labor market integration or the amount of migration will, then, be represented by varying this level of fixed labors located in each country. Essentially speaking, in the course of making the above extension, we make a new contribution in that the analysis of financial market is transferred into the case where we have, indeed, the two countries with unequal size. At the same time, the inelastic nature of labor supply does also imply the shift toward the main alternative approaches of New Keynesian theory, the monetarism. In particular, as a result of fixed choice of labor supply in each country and free entry and exit of firm in monopolistic competitive market, positive (or negative) profit cannot sustain. This zero-profit condition, then, produces the flexibility of price in adjusting to equate wage. As a result, the model is constructed on the basis of flexible good prices and perfect functioning good and labor market, and hence, reflecting, in essence, a synthesis between the flexible-price Monetarist model and the open-economy New Keynesian approach with intertemporal structure.

In short, with profound empirical and theoretical supports, this thesis carries the Mundell-Fleming model forward to the modified version of NOEM, i.e. the two-country monopolistic competition model with fixed labor supply decision and flexible-prices feature, and look into the insight of policy conclusion by numerically investigating whether financial market integration raises or lowers macroeconomic volatility in the face of a change in monetary policy. Moreover, while most studies make the assumption of no cross-border movement of labors, this thesis incorporates the possibility of international labor migration into a model of an open economy with a competitive labor market and explores its consequences on the effect that financial market integration has on the adjustment of the economy to unanticipated changes in money supply.

1.2 Objective of the Study

- To understand the implications of different degrees of capital mobility, from the micro-founded two-country general equilibrium flexible exchange rate model with flexible price and monopolistic competition, on the macroeconomic impact of monetary policy, measured by business-cycle volatility.
- To study the roles played by international labor migration on the sensitivity of macroeconomic impact of monetary policy with respect to different degrees of financial market integration.

1.3 Scope of the Study

- The model composes of two countries, home and foreign, with three economic agents; consumers, firms, and government.
- Capital stock is fixed in this model. The only production factor used by firms in a particular country, with identical technology and price, is labors, which are allowed to move between nations.
- So as to avoid problem of finding inaccurate parameters for Thailand, the parameters used to calibrate the model are taken from Sutherland (1996), which are estimated from US data. This calibration of the model is fairly standard in NOEM and it also makes sure that the results can be compared with those reported in the literatures.
- In investigating the effect of varying the degree of market integration, the model is subjected to only one form of shock, permanent asymmetric money supply shock.
- Volatility is measured by the effect of shock on macroeconomic variables: general price index, exchange rate, wage, interest rate, consumption index, individual

consumption of differentiated goods, amount of fund transferred, and domestic and foreign asset accumulation

1.4 Organization of the Study

The remaining of this paper is organized as follows. Following this first chapter, chapter two offers a general idea of the increasing trend of globalization by reporting the stylized facts about the international development of Thai financial and labor market in chapter two. After that, chapter three devotes to theoretical framework, which consists of the review of two important frameworks concerning respectively the static and dynamic diffused effects of macroeconomic policy, i.e., Mundell-Fleming and New open economy macroeconomic model. Next, chapter four is a summary of a number of related literatures that seek to understand the financial and labor market integration and their implications on stabilization policies. Then, the specification of the model and the solution of the optimization process would be presented in chapter five while the detail and the procedure for solving for the implications of the model are in chapter six. In chapter seven, I analyze the numerical simulation results of the model through impulse response functions, with the confirmed sensitivity studies described in chapter eight. Finally, after all items are being considered, chapter eight concludes, puts across some policy implications, and recommends for further study.

CHAPTER 2

OVERVIEW: EVIDENCES FOR MARKET INTEGRATION

This chapter gives a descriptive analysis on how Thai financial and labor market have been developed over the years, focusing mainly on the economic linkages between countries. Stylized facts, emerged from the below statistical measures and regulatory evidences, appear to support unambiguously the view that, bearing a resemblance to other countries, Thailand has moved toward more integration with the world market, both in terms of capital and labor flows.

2.1 Financial Market Integration: Financial System Deregulation and Capital Control Relaxation

The higher degree of capital mobility in Thailand has resulted largely by two main factors: the domestic financial market deregulation and the increased openness of capital account in late 1980s and early 1990s. The key policy measures in these two areas are demonstrated below.

2.1.1 Liberalization of domestic financial system

Although the process of Thai financial liberalization started in the early 1980s, it was not until the beginning of 1990s that Thai government accelerated the liberalization process in earnest. In 1990, the financial reform policy became intense when Thai government promulgated two three-year comprehensive financial reform plans with the stated objectives to enhance the efficiency, flexibility, and stability of financial system and to increase competitiveness of financial institution. The first Three-Year Financial System Development plan (1990-1992) has four major components:

- Deregulate and liberalize interest rates, foreign exchange transactions, and the scope of financial institutions' businesses.
- Develop new financial instruments, facilities, and services
- Improve supervision and examination of financial institutions,
- Develop payment system.

The major financial reform measures for the domestic sector in Thailand during 1989-1997 are summarized in Appendix A1. Corresponding to the plan, the core policy deregulation measures include

1) Dismantling of interest rate controls

Among the most important actions, taken in the reform program, was the abolishment of various domestic interest rate controls over the period 1989 to 1992. Ceilings on commercial bank deposit rates (time and saving deposit) were lifted during 1989–92. In June 1992, ceilings on finance and credit foncier companies borrowing, deposit and lending rates, together with commercial banks' lending rates were removed. However, in October 1993, given the interest rates spreads between prime and non-prime borrowers, commercial banks were required to declare their minimum lending rate (MLR)—the rate on term credits to large customers, its minimum retail rate (MRR)—the rate on small prime customers, and the widest margins charged above these rates. These margins will be added to MRR as reference rate for customers other than those eligible for MLR. Thus, the domestic interest rate structure is liberalized to fluctuate according to market mechanism since 1992.

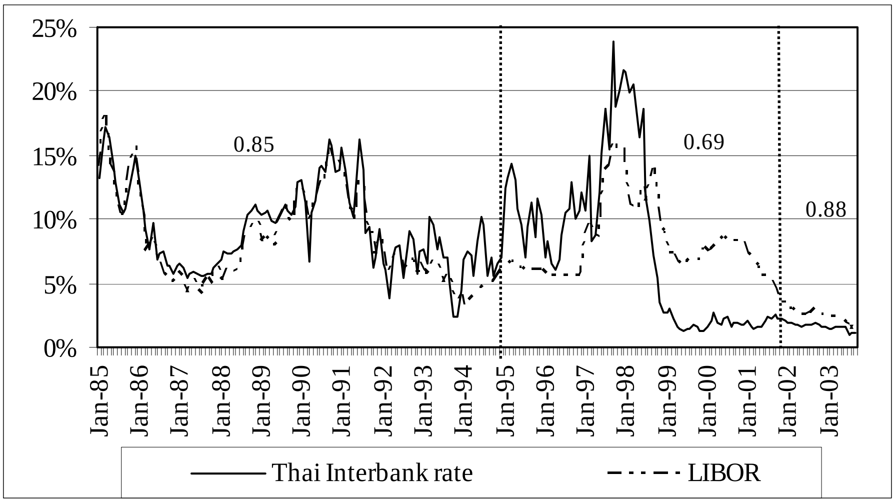
2) Relaxation of portfolio restrictions and expanding the scope of activities of financial institutions: Also important in the reform program were those measures that eliminated restrictions on the scope of activity and portfolio of financial institutions. By 1992, prior requirements on portfolio composition of commercial banks were relaxed. (by expanding the definition of agricultural credits, in which commercial banks are expected to lend). At the end of 1991, to bolster the competitive position of domestic financial institutions, finance companies were authorized to conduct leasing business. In March 1992, finance companies were approved to act as selling agents for government bonds, to provide economic, financial, and investment information services, and to advise companies seeking listing on the SET and by June 1992, monetary authority permitted commercial banks to expand their areas of operation to include issuance, underwriting, and distribution of debt securities, to act as supervisors as well as selling agents for mutual funds, and to become securities registrars. Finally, in 1994, commercial banks were allowed to invest in any business of not more than 10 percent of the total share sale.

3) Financial supervisory and prudential regulations: Reform programs, for the most part, included adoption of the BIS standard for commercial bank or Bank for International Settlements capital adequacy ratios (CARs) in January 1993. Under this regulation, commercial banks were required to maintain 7% of capital to risk ratio and foreign bank branches were required to maintain 6% of tier 1 capital to risk ratio. Also, in 1995, BOT required banks to submit detailed information on risk control measures on trading in foreign exchange and derivatives. In June 1997, 16 (and further 35 in August) of the 91 finance companies were suspended and forced to merge with new domestic or foreign partners or liquidate after the due diligence process has been completed.

As a result of above domestic financial reform policies and the liberalization of international capital movements to be analyzed below, Thai and the world financial market became more integrated. This higher degree of financial market integration is largely reflected in the closer gap between domestic and foreign interest rate overtime.

Figure 2.1

Movement of Thai interbank lending rates and LIBOR, 1985-2003



Source: Bank of Thailand

As apparent from Figure 2.1, prior to the interest rate liberalization in 1989, Thai interbank lending rate adjusted in accordance with world interest rate, as represented by one-month Eurodollar interbank rate (LIBOR) and still continued to move closely together following the removal of the ceilings. During that period (1985-1995), the correlation coefficient between the two rates was as high as 0.85.

However, owing to the financial crisis during 1997, policies to increase the convertibility of capital have been interrupted. That is why we can witness the wider space between the two rates, with the value of the correlation coefficient down to 0.69 from 1996 to 2001. Currently, an increase in the correlation coefficient to 0.88 (2002-2003) suggests that the domestic interest has become again more sensitive to movements in the world interest rates, adjusting quickly to the change in LIBOR.

2.1.2 Liberalization of capital account

Prior financial crisis: during 1989-1996

In addition to above domestic financial system deregulation in the late 1980s and early 1990s, Thai government also embarked on a program to open the capital account and liberalize foreign exchange markets. The authorities began to liberalize international capital flows in 1980s with the relaxation of foreign direct investment restrictions. They, then, focused on liberalizing portfolio investment in the stock market and bank loans. Later on, liberalization of portfolio and banking flows were accompanied lastly by the lessening of foreign exchange control.

Following the first-three year plan, the second Three-Year Financial System Development plan (1993-1995) was launched in 1993, aiming at

- Enhance financial market efficiency
- Mobilize domestic savings through pension systems and other means
- Transform Bangkok into a regional financial center by establishing an offshore banking center.

The major milestones in the liberalization process between 1990 and 1996 encompass (See appendix A2 for the summary of key measures)

1) Current account transactions: IMF article VIII obligations were assumed in May 1990. By this compulsion, Thailand has agreed to remove foreign exchange restrictions in current-account-related transactions, which means importantly that the payments for the current account transactions cannot be restricted by the BOT.

2) Foreign direct investment: In 1991, other than amendments in the Investment Promotion Act to promote more foreign investment, the government

authorized 100 percent foreign ownership of firms that export all their outputs. In 1992, the criteria for granting tax incentives were designed to promote investment in special sectors. Also, direct investment by Thai residents overseas was gradually liberalized in 1991 and 1996.

3) Portfolio investment: During 1986, the authorities reduced tax impediments to portfolio inflows, in particular for purchasing Thai mutual funds. This was followed in 1990 by creation of three mutual funds to attract foreign investment. In 1991, repatriation of investment funds, interest and loan repayments by foreign investors was fully liberalized and in 1992, to draw foreign investment in That stock market, there were cutbacks in the tax treatment of dividends, royalty payments, capital gains, and interest payments on foreign debentures. Last but not least, the authorities subjected nonresident Baht accounts at domestic commercial banks to the lower reserve requirements in 1995.

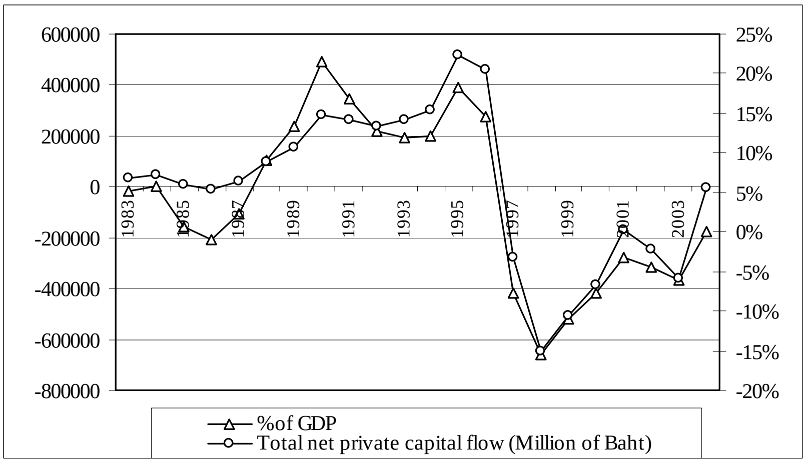
4) Foreign exchange system: The most important change was the establishment in 1993 of the Bangkok International Banking Facility (BIBF), an offshore financial market which enjoyed tax and regulatory advantages aimed at fostering the development of Bangkok as a regional financial center. The main operations of BIBF banks on the liability side are deposits or borrowings in foreign exchange from abroad, mainly through foreign inter-bank transactions and inter-office borrowings. On the asset side, their foremost activities are lending in foreign currency to Thai residents (out-in) and non-residents (out-out). As of the third quarter of 1996, 49 banks had been granted BIBF licenses, including Thai commercial banks and foreign banks with and without local branches in Thailand. Other liberalization measures adopted during the 1990–1995 period included a gradual elimination of the restrictions on the purchases of foreign exchange by residents and abolishment of constraints on transfers of Baht overseas.

Without a doubt, on account of above international liberalized policy program, financial market becomes more loosen up. The most obvious evidences suggesting such increasing openness in Thai financial market are faultlessly the surge in the private capital inflows and increase reliance on foreign capital.

In the first haft of 1990s, as Thailand embraced the ideology of free capital market, we can see growing inflows of foreign capital. As obvious from Figure 2.2, private capital flows to Thailand soared in 1988. Between 1987 and 1990, inflow increased to around 260 billion baht, where they stabilized until 1993. In 1994 and especially 1995, inflows climbed up once again, passing 518 billion baht in 1995, but declined sharply in 1996. As ratio of GDP, the story is somewhat the same. Again, the data seems to suggest a structural break in 1988, after which flows increased rapidly until 1990 to about 21.4 percent of GDP, a local maximum. After stabilizing at about 11-12 percent of GDP in 1992–94, there was a second local maximum in 1995 when flows surpassed 18.3 percent of GDP.

Figure 2.2

Total net private capital flows and their percentage shares in GDP, 1983-2004



Source: Bank of Thailand

As said by Table 2.1, disaggregating net private capital flows provides us two salient facts regarding the components and trends of capital inflows to Thailand. First, banks played an increasing role during the full inflow periods. The banks' share of net private capital was 4.6 percent in 1983-1986 but raised to 40.7 percent in 1995-1996, more than eight time increase. This occurred in principal as a result of the establishment of BIBF in 1993. Thai firms, who could not directly access oversea capital markets, were able to borrow from BIBF Thai bank. Second, while the nonbank inflows were mainly in the form of foreign direct investment till the early 1990s, they later shifted to short-term inflows, which include portfolio investment, nonresident baht account, and loans from foreign financial institutions. As appeared in the table, during 1987-1990, FDI accounted for much larger proportion (25.1 percent) of nonbank capital inflows than during 1995-1996 (6.8 percent). In contrast, the percentage shares of portfolio investment happen to be higher to 17.7 percent during 1995-1996. As such, despite the falling down in its share overtime (from 24.3 percent to 17.7 percent during the same period), the relative importance of portfolio investment was substantial. In effect, we can witness this fact also by observing, from Figure 2.3, the rising in ratio of portfolio investment to GDP, both inflow and outflow, ahead of the economic crisis in 1997.

Table 2.1

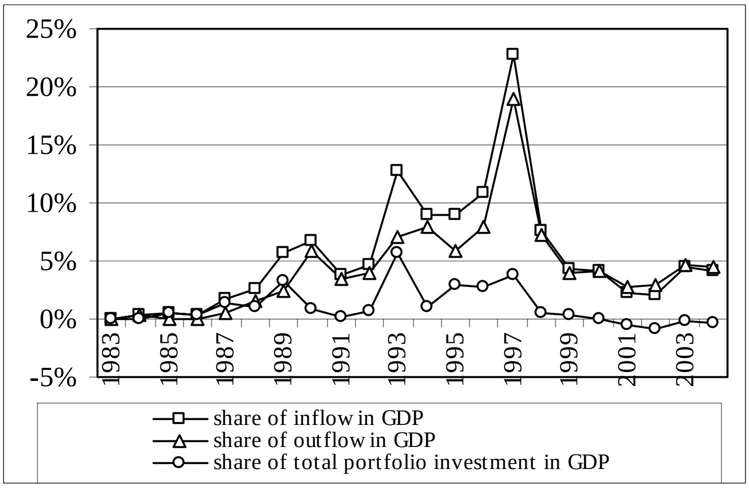
Compositions of net private capital flows (Percentage shares in total flows)

Main Components	1983-1986	1987-1990	1991-1994	1995-1996	1997-2000	2001-2003
Bank	**4.602**	**14.612**	**42.236**	**40.740**	**77.449**	**16.634**
Nonbank	**95.398**	**85.388**	**57.764**	**59.260**	**22.551**	**83.366**
Direct investment	13.633	25.169	15.150	6.801	-30.738	-43.034
Other loans	35.729	1.378	2.979	18.659	37.978	42.544
Portfolio investment	11.452	24.304	15.880	17.782	-14.087	13.175
Non-resident baht account	33.281	25.167	20.427	16.127	26.897	62.866
Trade credit	0.030	8.258	4.886	-0.040	3.250	1.949

Source: Bank of Thailand

Figure 2.3

Shares of portfolio investment in GDP, 1983-2004



Source: Bank of Thailand

Along with above verifications, the heavy dependence of Thai banks on foreign funds, prior to the crisis, also speak for the consequences of the relaxation of capital control, i.e., greater unitization of Thai capital market and the world.

Table 2.2

Funding structures of Thai commercial banks (Percentage shares in total liabilities)

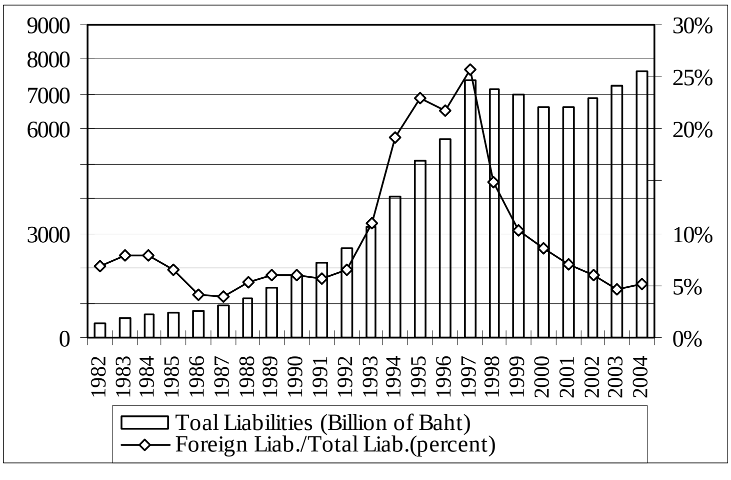
Main components	1983-1986	1987-1990	1991-1994	1995-96	1997-2000	2001-2004
Liability from comercial bank and other financial institutions	2.281	2.304	2.237	3.944	3.913	4.681
Total deposit of business and household	74.119	76.040	71.421	57.384	59.733	68.522
Borrowing from government	2.587	2.311	2.949	3.441	3.623	4.570
Foreign liability	6.575	5.345	10.600	22.414	14.833	5.696
Capital account	5.602	6.012	7.308	9.900	12.916	12.345

Source: Bank of Thailand

According to Table 2.2, domestic deposits explained 76 percent of commercial bank liabilities in 1987-1990, but only 57.3 percent in 1995-1996 while the commercial banks' share of foreign debts to total debts, went up from 5.3 percent to 22.4 percent between the same periods. Given this, Figure 2.4 plots the shares of foreign borrowing in total commercial bank liabilities which, as well, indicate a positive movement toward the end of 1996. The easy access to foreign funds seems to have reduced the incentives for banks to mobilize funds from domestic to foreign sources.

Figure 2.4

Shares of foreign liabilities and total liabilities of Thai commercial banks, 1982-2004



Source: Bank of Thailand

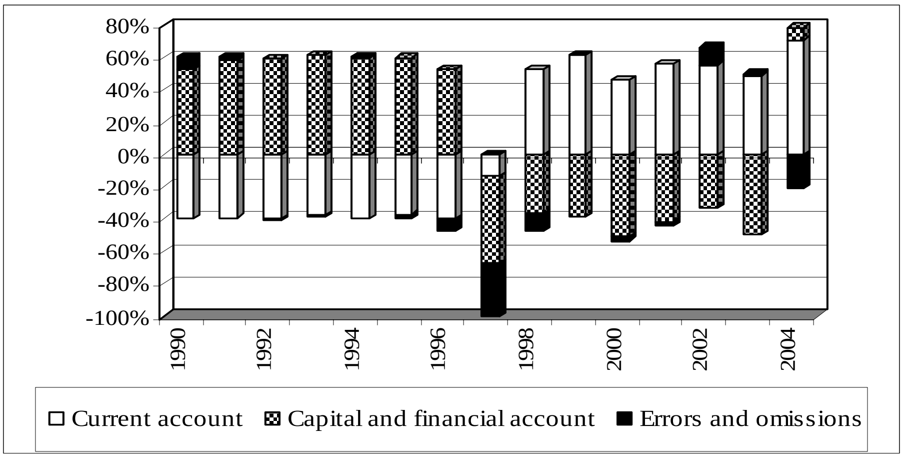
Following the financial crisis: from 1997 onward

After the financial liberalization in 1990s, the vulnerability of Thai economy rose dramatically. Huge short-term capital inflows, brought about by capital control relaxation in the early 1990s, along with an expansion in asset markets, created the lending boom that fueled the asset price bubble. This over-lending behavior of Thai financial institution, together with a mismatching in currency and maturity enhanced the instability to Thai economy, at least in short-run. Moreover, such fragility was further weakening by overvaluation of exchange rate as a result of rising inflation. Faced of an appreciating real exchange rate, growth and investment levels deteriorated and export declined sharply, as revealed in Figure 2.5. The large current account deficit, high interest rate, and increasing inflation, therefore, left the country more vulnerable to external shock and a shift in market sentiment. All these indicated the high vulnerable exposure and were a sign of the financial distresses that will come when investors changed their perception about the country's risks. Panicky investors became distrustful and a withdrawal of funds from Thailand suddenly became stampede. Speculative investors speculated in foreign exchange market resulting in capital flight. Depositors also made withdrawal from Thai financial institutions and later there was a bank run and panic. In July 1997, to muddle through a run on currency, banking crisis, and large foreign exchange losses, the authorities floated the baht and adopted a managed floating exchange rate regime.

In response to the financial crisis, restrictive control policies on exchange rate arrangement and international capital movement have been brought back in an attempt to lower down speculative attacks and subdue capital flights. In May 1997, The Thai monetary authorities requested (and followed it up in August by legal measures or order) financial institutions in Thailand not to enter into financial dealing with those non-residents without basic proof of underlying trade and investment purpose. Later on next month, the forward outright transactions in baht with nonresidents and the other kind of selling transactions of baht against foreign currencies to nonresidents were temporarily restricted. Then, in January 1998, banks became subject to 50 million baht limit on transaction that does not originate from trade or investment purpose. Notwithstanding such controls, however, capital outflows and the selling the currencies, in general, were not put off. This pattern definitely comes out from a quite look in Figure 2.5 and 2.6. Starting from financial crisis in 1997, regardless of a substantially rise in foreign direct investment and current accounts in the aftermath of massive currency depreciation, short-term capital flows plunged sharply and continued to do so thereafter.

Figure 2.5

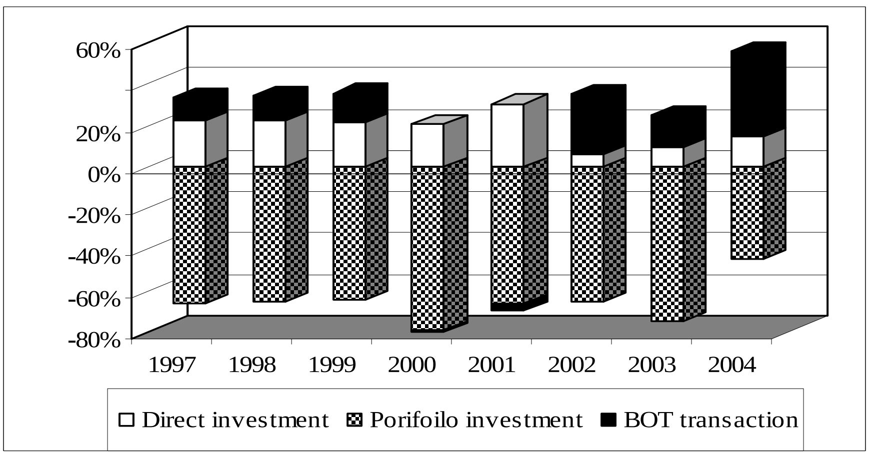
Balance of payments, 1990-2004



Source: Bank of Thailand

Figure 2.6

Financial and capital accounts, 1997-2004



Source: Bank of Thailand

At present, although some capital control policies and policies concerning exchange rate arrangements are still being implemented to prevent the speculative movement of funds, they are relatively less strict, thank to a large improvement in the macroeconomic and the balance of payments situation. In spite of the fact that BOT is still imposing, in 2004, the constraints on transfers of Baht overseas (not to exceed 50,000 baht each time with the exception of 500,000 baht in the case of the border trade), they have continued to put no limit on the capital outflows that have a validation of the underlying trade and investment transaction (such as the repatriation of investment fund, interest rate, and loan repayment) and lower the limit on outward transactions relating to other investments (such as an real estate acquisition). Plus, on the incoming move of currencies into Thai economy, the liberalization measures could as well be seen from the prolonging relaxation of restrictions concerning the bringing in of foreign exchange or baht since before the crisis. As a consequence, with this eased controls on capital flows and foreign exchange transactions, as well as the relatively liberal measures to encourage the export and import of goods and services, we can still notice the relatively high degree of capital mobility in Thai financial market at the present time.

To further support this view, the primary indication of this openness is, as mentioned in the first part, the higher value of interest rate correlation coefficients or smaller distance between domestic and foreign interest rate in Figure 2.1. Moreover, apparently in Figure 2.2, there is an increasing trend of total private capital inflows, both in the level and as a percentage of GDP. After the dropping down in share of inflows in GDP to about 15 percent in 1998, Thailand has gradually regained the strength in terms of capital inflows, as showing by lowering negative value to nearly balance in 2004. Next, according to Figure 2.5, financial and capital account has turned to be positive after reported deficit since the economic crisis in 1997. Finally, the recent data on portfolio investment (Figure 2.6) show that there were fewer deficits, especially in 2004. Specifically, with respect to total inflow and outflow, Figure 2.3 illustrates the percentage share of portfolio investment relative to GDP that was rising since 2002 as well. Therefore, all of the above indicators point out ultimately that there exist lower barriers in doing financial transactions between Thailand and foreign countries up until present time.

Altogether, for the reasons mentioned above, we can, thus, conclude that starting from the midst of 1980s, Thailand has, in a great deal, a higher association in doing financial businesses with the world economy, as compared to the earlier periods. Ignoring the exceptionally substantial instability phase during the deep economic crisis in 1997-1998, the evidences overwhelmingly show that Thai economy has remained relatively open and, jointly with experiences from other countries, imply a worldwide trend of reasonably intense process of financial integration, the end result that leads us to the starting point of in this thesis here.

2.2 Labor Market Integration: Trend in International Labor Migration and Labor Migration Policies

2.2.1 Development in labor migration

The situation of international labor movement in Thailand can be drawn in two areas: oversea Thai workers and foreign workers in Thailand.

- Emigrations: Out-going Thai workers oversea

1) Destination and volume

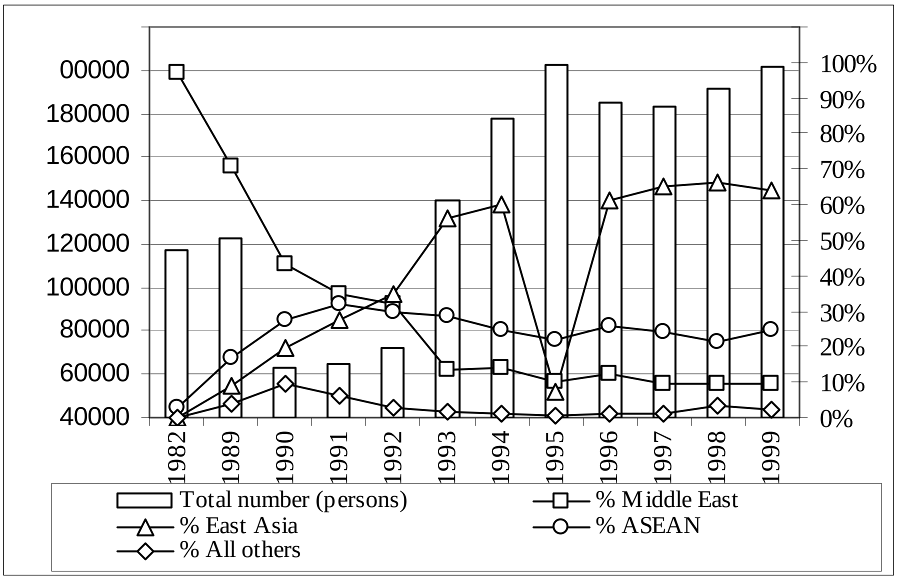
Thailand has a long history of exporting labor. Because job opportunities were limited and wage levels were low in the pasts, many Thais lived in poverty. The high poverty rates in 1960s and 1970s, especially in rural, created strong pressures for young adults to search for overseas jobs promising a higher pay. In addition, lack of educational opportunities in rural areas and labor segmentation in urban areas cause urban-rural income difference to increase and, thus, are the push factors which have driven some of the most able-bodied labors to work oversea.

During the past 10 years, more than a million Thai workers have gone to work in many countries and earned foreign currency to help the country's current account deficit. In the early years, most Thai workers, who began to move oversea for employment in 1970s, headed for oil-rich countries of Middle East, especially to Saudi Arabia. According to the register at the Thai Ministry of Labor and Social Welfare, a sizable number of Thai labors moved oversea. From Figure 2.7, there were 117,341, 139747, and 202,056 Thais went to work oversea in 1982, 1993, and 1999 consecutively. The great majority of them, 97.2 percent in 1982, landed in the Middle East and North Africa at the earlier stage of movement. However, due to the fall in demand for labor in the early 1990s in the oil-producing countries as a result of a drop in oil prices and several incidents involving Thais (theft and murder), its share in the total volume of Thai workers abroad declined significantly to about 13.46 and 9.35 percent in 1993, and 1999, respectively. On the contrary, the share of Thai workers going to ASEAN countries and East Asia increased substantially, from about 3 percent to 84.86 and 88.65 percent during the same period. This is because, during the 1980s, East Asia experienced a rapid economic growth and structural transformation. This fact created labor shortage and an increase in the flow of workers from Thailand.

Figure 2.7

Registered numbers of Thai emigrants

and the shares for selected host regions,1982-1999



Source: Ching-lung Tsay (2002)

In recent times, despite many emigration policies from government that are designed to promote the oversea employment, the number of Thai emigrant workers has constantly dropped from 177,709 in 2000 to 160,807 in 2002 and 148,595 in 2004 (Table 2.3). The three most reductions came form Taiwan, Singapore, and Israel, due mainly to high competition from emerging low cost countries, high unemployment rates, as well as, a political instability of receiving countries. The unsolved excessive high cost of recruitment agencies has also turned off a pool of the new migrants.

Table 2.3

Leading destinations of out-going Thai workers oversea

Destination	2000	2001	2002	2003	2004
Taiwan	110,753	94,126	79,589	75,849	69,982
Singapore	21,273	20,411	15,354	12,480	11,338
Isarael	8,764	12,163	12,952	6,327	10,611
Brunei	8,607	8,607	7,155	6,118	5,680
Japan	5,207	5,246	4,701	5,037	5,857
Malaysia	1,579	2,197	14,619	7,479	5,853
Hong Kong	5,121	5,488	4,962	4,143	4,126
South Korea	2,089	1,180	2,428	8,631	10,647
UAE	1,902	1,743	2,171	1,835	1,842
USA	1,520	1,897	1,955	2,331	2,743
Total number of Thai migrant abroad	**177,709**	**165,047**	**160,807**	**147,769**	**148,595**

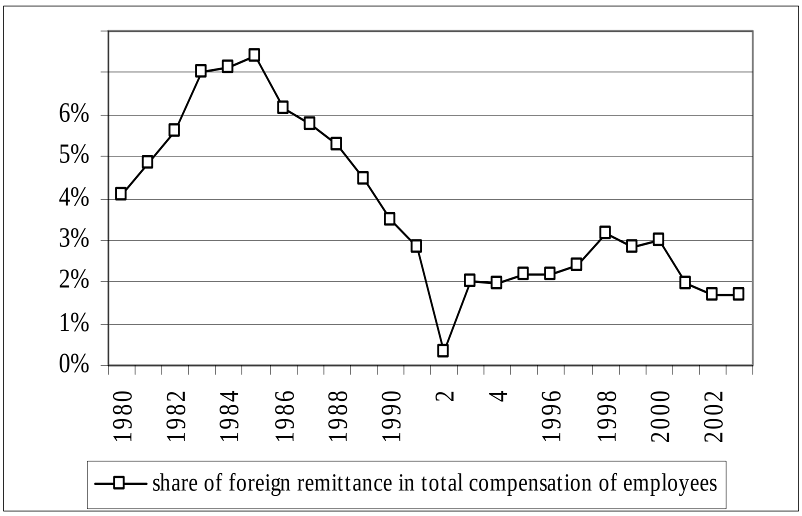
Source: Oversea employment administration office, Department of employment, Ministry of Labor

2) Trends in remittances

The tendency of remittances from oversea workers has somewhat fluctuated but, recently, on the rising trend. Figure 2.8 illustrates the percentage share of repatriated incomes from the rest of the world in total compensation of employees. The trend is corresponded with actual condition in labor market.

Figure 2.8

Trends of remittances of Thai oversea employees, 1980-2003



Source: National Economics and Social Development Board (NESDB)

During a decade of economic boom, there was high demand for labors, which could be reflected in smaller number of total workers migrated oversea and higher revenue obtained from labors hired domestically. As a result, the remittance from aboard slowly plunged until 1992 when number of Thai emigrant started to rise again. At the moment, the amount of proceeds received from the rest of the world was 31,571 and 29,614 million baht in 2001 and 2003, which contributed for about 2 percent of total compensation of employees in Thailand.

- Immigrations: In-coming foreign worker in Thailand

Since the early 1990s, due to the exceptional economic performance, Thailand, ceased to be only a labor-exporting society, became one that both sends workers abroad and receives foreign labor. The Thai government clarified the alien workers in Thailand as persons who do not have Thai nationality working in Thailand and classified estimated alien workers into four main categories.

1) Legal Alien

In accordance with the alien workers control policy, the Ministry of Labor has been dealing with the in-coming foreign workers in four major legal channels: Alien Act of 1978, temporally workers under Alien Employment Act of 1978, Investment Promotion Act of 1977, and Article 12 of Immigration Act of 1995. Table 2.4 presents the number of foreign workers who are granted permanent residence under each main channel. Total number of legal aliens in Thailand reached 316,174 in 1996, a sizable increase from 180,022 in 1994. This represents an increase of 37.81 percent per annum. In fact, the number of permanent permits has not changed. Only temporary work permits increased, especially those granted under Article 12 of Immigration Law. This resulted from cabinet resolution in mid-1996 which allowed employers to bring their illegal workers to apply for stay and work permits. As regards to BOI immigrants, the number of aliens who received work permits raised 10.7 percent. They are largely skilled and highly-skilled workers in the areas of medium-high technology manufacturing. This reflects the economic development and structural change that took placed in Thailand in the 1980s and 1990s. Intense international competition from lower cost countries and the boom-induced increase in wage rates have increasingly priced out the country from further expansion in labor-intensive industrialization. Thai industry has indeed been slowly shifting to higher value added production. This gave rise to general tightening in labor market and labor shortage, especially in medium- and high- educated workers during late 1980s and early 1990s.

Table 2.4

Cumulative numbers and percentages of

the remaining legal aliens in Thailand, 1994 and 1996

	Total		Permanent		Temporary		BOI		Article 12	
	Persons	Percent	Persons	Percent	Persons	Percent	Persons	Percent	Persons	Percent
1994										
Bangkok	121,740	**100**	84,492	**69.4036**	28,343	**23.2816**	8,692	**7.14**	213	**0.17**
Others	58,282	**100**	37,721	**64.7215**	6,463	**11.0892**	6,631	**11.38**	7,467	**12.81**
Total	**180,022**	**100**	**122,213**	**67.8878**	**34,806**	**19.3343**	**15,323**	**8.51**	**7,680**	**4.27**
1996										
Bangkok	131,015	**100**	84,482	**64.4827**	35,089	**26.7824**	10,712	**8.18**	732	**0.56**
Others	185,159	**100**	37,039	**20.0039**	9,909	**5.35162**	7,897	**4.26**	130,314	**70.38**
Total	**316,174**	**100**	**121,521**	**38.4348**	**44,998**	**14.232**	**18,609**	**5.89**	**131,046**	**41.45**
Growth										
Bangkok	3.80935		-0.00592		11.9006		11.6199		121.831	
Others	108.848		-0.90401		26.6594		9.54607		822.599	
Total	**37.8154**		**-0.28311**		**14.6412**		**10.7224**		**803.164**	

Source: Yongyuth Chalamwong (1998)

Currently, the report from Ministry of Labor and Social Welfare (Table 2.5) indicates that the total of 2,225,142 alien workers registered to work in Thailand in 2003. Among this number, legal alien is approximated at around 502,680 persons, which composed of 93,422 skilled foreign workers who are permitted to work and estimated 409,258 over stay alien.

Table2.5

Classifications of Aliens working in Thailand, 2003

Classification	2003
Legal Aliens	**502,680**
with work permit	93,422
over stay	409,258
Refugees from War	**119,258**
Hill Tribes and Minorities	**514,424**
illegal Migrants (Myanmar, Laos PDRs, and Cambodia)	**1,088,780**
with work permit	288,780
without work permit(estimated)	800,000
Total	**2,225,142**

Source: Sakdina Sontisakyothin (2004)

2) Refugees from war reports at 119,258 persons in 2003

3) Hill tribes and minorities: 2003 figure indicates 514,424 persons

4) Illegal migrant workers

Cross-border migration is a well-known phenomenon in Thai history. Economic development and structural change in Thailand also attracted not only legal, but a huge number of illegal immigrants from neighboring countries, mainly from Myanmar, Cambodia, and Laos. Regardless of the fact that cabinet agreed to allow illegal immigrant to register for work in Thailand under Immigration Act in 1995 and the firm enforcement at all check points along the border, the influx of the illegal migrants without work permits has continued. By survey of department of employment, in Table 2.6, the ratio of unregistered illegal immigrants in total of 943,745 undocumented workers was still as high as 71.4 percent in 1997.

Table2.6

Survey of undocumented migrants in Thailand, October 1997

Area	**Undocumented**		**Registered Migrants**		**Unregistered Migrants**	
	Persons	**Percent**	**Persons**	**Percent**	**Persons**	**Percent**
Border	256146	**27.14**	79195	**29.34**	176951	**26.26**
Coastal	313896	**33.26**	117549	**43.55**	196347	**29.14**
Bangkok	223288	**23.66**	38412	**14.23**	184876	**27.44**
Non-Bangkok	150415	**15.94**	34792	**12.89**	115623	**17.16**
Total	**943745**	**100**	**269948**	**100**	**673797**	**100**
Percent	**100**		**28.60**		**71.40**	

Source: Yongyuth Chalamwong (1998)

Table 2.7

Cross-border illegal migrants working in Thailand, 2003

Nationalities	**Persons**
With work permit	**288,780**
Myanmar	247,791
Lao PDRs	21,314
Cambodia	19,675
Without work permit	**800,000**
Total	**1,088,780**

Source: Sakdina Sontisakyothin (2004)

Today, total population of undocumented foreign workers is believed to be quite large. From Table 2.7, total cross-border illegal workers in 2003 are estimated at 1,088,780 persons, which only 288,780 of them have registered and granted a temporary stay and work in Thailand. The other estimated 800,000 are still working behind the factory and living in the dark.

There are several factors contributing to an ever increasing number of illegal migrants in Thailand. First, socio-economic conditions of Thai's neighboring countries have been slowly improved. The examples of how those countries are far behind Thailand in their development include enormous wage differences, lack of work opportunity in their own countries, economic sanctions from western countries, and instability of political conditions. So, economically and socially speaking, they all reveal a high potential for labor out-migration. Second, the strong pressures for illegal labors migration is also originated from the becoming reluctant of Thai workers to accept menial and lower paid work as more jobs open in the industrial and service sectors. Finally, informally organized networks of private placement agencies help speed up the influx of illegal immigrants.

2.2.2 Labor exportation and importation policy

The ministry now has reshaped its labor migration based on two pillars of management, namely

- Emigration policy

There was no government policy to promote Thai citizens going oversea for employment until about ten years after the outflow of workers began. In accordance with the promotion in the 5th National Economic and Social Plan (1982-1986), the Labor Recruitment and Protection Act was introduced in 1985 to regulate the placement of Thais in oversea jobs. The legislation covers such matters as the qualification of recruitment agencies and the protection of job seekers against exploitations by recruitment agents oversea;

Besides, to alleviate the problem of workers having to pay high sum of money to be able to work oversea and of workers being deceived by illegal placement agencies, The Labor Recruitment Office was established to assist Thai workers in obtaining legal employment aboard. The office also initiated the "Fund to Assist

Workers in Foreign Country" that is now managed by the Oversea Employment Administration Office. This fund has three basic functions

-Assist Thai workers who find themselves unable to return to Thailand

-Help Thai migrant workers in trouble oversea

-Select and test the skill of workers leaving to work oversea.

The money in fund came mainly from Thais who obtain employment oversea legally (Each worker has to contribute 500 baht).

In the latest emigration policy, government has continued to maintain the existing markets, while encouraging placement agencies and workers to find new markets aboard. This was driven primarily by a desire to decrease unemployment and poverty and the appreciation of benefits from remittances. Along with these measures, the current government in line with the 9th National Economic and Social Development Plan (2000-2006) has initiated recently the following policy changes to support Thais to seek employment oversea:

-Training programs to develop basic skills. This has included short courses in Thai message and home care.

-Thai Labor Offices are located in main destination countries to help Thai workers who work there and to coordinate with workers and employers about labor supply matter.

-The Small and Medium Enterprise (SME) Bank provide loans (without collateral) to cover the costs of Thais going oversea to work.

-Automated labor database under the control of the Oversea Employment Administration Office.

- Immigration policy

-Legal foreign workers policy

The policy aims to facilitate on issuance of work permit for investors or skill foreign workers, given the soaring demand for labors with high experienced and high expertise on modern technology.

-Illegal migrant workers policy

In the early 1990s, the government began to realize that there were many people in Thailand, who had entered illegally and obtained employment. Due to the fear of inability to control this movement of people, in 1992 the cabinet for the first time introduced a series of measures to manage people from Burma already in Thailand. Accordingly, people from Burma, who registered for work permits, were allowed to work temporarily in 27 jobs in some of the border provinces.

Then, second cabinet resolutions, governing foreign labor, were issued in 1996, allowing foreign laborers from Burma, Laos, and Cambodia to work in 24 jobs in 43 provinces. Later on in 1998, the number increased to 47 jobs in 53 provinces. This policy granting temporary amnesty and the issuing of work permits have provided many migrant workers with improved protection and go some way to acknowledging the contribution of migrant workers to the Thai economy (a labor shortage due to a boom in the industry).

In 2001 and 2002, the cabinet resolution centered on the three broad policies of documentation, monitoring and protection of alien workers. For 2001 resolutions, the key elements consist of:

- The obtaining of better estimates of the number of aliens in the country was mechanism to assist with the implementation to achieve goals of control, manage, and limit the number of illegal alien workers in Thailand. Therefore, the resolution in 2001 was to allow for unrestricted registration of alien workers, so we could have a better idea of how many foreigners were in the country.

-The establishment of a committee that would design policies governing alien workers, which led to the establishment of the Alien Labor Policy Committee.

-The Ministry of Labor kicked off the bilateral negotiations with the governments of Laos, Burma and Cambodia to regulate the flow of workers between their countries and Thailand. The Memorandum of Understanding (MOU) involves procedures for documentation of migrant workers and measures to return workers to their home country when their contracts of employment have expired.

-The discussions surrounding the resolutions aimed at working out long term policy solutions. For example, The National Security Agency was requested to collaborate with the Thai Development Research Institute to study the structure of demand for alien workers, a project that had been discussed for many years.

In addition, the 2002 resolutions encompass mainly

- The policy of allowing unlimited registration across all provinces in 2001 was continued into 2002. The motivation was again to improve the estimate of the number of foreign resident in the country so that the government could improve policy design.

- An urgent priority was to move forward with bilateral negotiations on the MOUs governing alien workers.

- There was a resolution to establish a database of employers and employees through the use of information technology.

Finally, as of 2004, the Thai government will grant a final opening for the entire illegal migrants who still working behind the factories to show up and register with the local administrative agencies. Additionally, apart from what have been done in the past, Thai government is now undertaking a new long-term policy and measures on systematizing migrant workers in Thailand by introducing *The Economic Cooperation Strategy between Cambodia, Lao PDR, Myanmar, and Thailand* or ECS. The ECS is a tool or method primarily aim to strengthen a cooperation among Asian' members and reduce a gap between Thailand and neighboring countries. The mechanism of ECS is expected to lessen a new inflow of illegal migrants from neighboring countries to Thailand while the process of systematizing and legalizing the entire illegal migrant workers is undergone.

In conclusion, as barriers between domestic and world labor market is leaved out, we can naturally observe a higher number of workers flow in and out of countries. As confirmed by both migration statistics and policy rationales, international migration of workers has taken place throughout the years, not only in the world economy, but also for Thailand. At last, as stated in the second objective, these facts definitely come into play when we pursue a study of the relationship between macroeconomic effect of monetary policy and the degree of openness in financial market overtime.

CHAPTER 3

THEORETICAL FRAMEWORK

In order to endow ourselves with theoretical background, the main papers concerning the international monetary transmission mechanism are examined before the review of associated literatures to our specific topic in next chapter. Provided that we are going to draw some policy implications in comparison to Mundell-Fleming model and since the model presenting in this paper accommodates such type of model as NOEM, the following two sections outline the key concepts underlying those two major approaches.

3.1 Mundell-Fleming: the Classic Workhorse Model[1]

In a half-century ago, the monetary approach to balance of payment is developed by 1999-Nobel-prize laureate Robert A. Mundell. By merging Keynesian pricing assumptions and international market segmentation within a simple, yet enlightening model, Mundell makes available the basic template for much subsequent researches in both theory and policy. Like small counties model developed by Keynesian, Mundell assumes that the speed of adjustment of goods prices is so slow that it can be ignored in short run, so a change in demand are entirely reflected as change in output. Moreover, agreed with Keynesian model, the balances of trade are assumed to vary inversely with domestic expenditure and directly with domestic currency value of foreign exchange rate, the capital account varies directly with the rate of return that various countries are offering on all assets, and demand for money depends only on income and interest rate. Nevertheless, in line with the evolution of world financial markets since Meade's book, Mundell puts international capital flows at the center stage in his analysis. In effect, his model has extended the traditional Keynesian model and IS-LM model of closed economy by explicitly inserted

[1] This section is an abbreviation from Fleming, J. Marcus (1962). The graphical clarifications used in this analysis can be founded in Cave, Frankel, and Jones (1999).

international capital flows into the model that is used to determine national income. This changes the model radically, particularly regarding the effect of macroeconomic policies.

Since the publication of Mundell’s work, it has been generally acknowledged in the international macroeconomics and finance literatures that international capital mobility has important theoretical and practical implications in operation of macroeconomic policy. In one of his most celebrated contributions, Mundell, as well as J. Marcus, Fleming, who work in parallel framework, question the short-run effect of monetary and fiscal policy under different exchange rate regimes. They demonstrated that this effect of sterilization policy hinges on the international mobility of financial asset. Their analysis, the so-called Mundell-Fleming model, has apparently been relevant in the policy-oriented discussion of exchange rate system, mobility of capital, and macroeconomic policies and it will be clearly discussed below.

3.1.1 Effect of an increase in stock of money under fixed exchange rate

Figure 3.1 (a) and (b) illustrate the effect of money expansion progressively from low to high capital mobility. From the initial equilibrium at point E, a monetary expansion shifts LM curve to the right. Under fixed exchange rate regime, an increase in stock of money has similar effect on interest rate and income in each case. An increase in money stock causes a decline in the velocity of circulation and leads to a reduction in rate of interest. Through Keynesian multipliers, lower interest rate stimulates private spending (consumption and investment) and, hence, raises income and output. The higher import and resulting trade deficit that are caused by an increase in income and output will, in turn, deteriorate balance of payments on current account. In addition, the fact that interest rate has fallen below foreign rate will result in the outflow of capital and deficit in capital account. As a consequence, due to the negative sign in both accounts, the overall balance of payments is weakened, as read off graghically by looking at the new IS-LM intersection, point A. It locates to the right and below the BP curve, which indicates that import is too high and capital inflow is too low. Therefore, in contrast with the case of increase in public expenditure, deterioration in balance of payments as a whole is bound to occur in all circumstances.

Apparently, the presence of international capital mobility plays a key role in determining how large of overall balance deficit is in the above mechanism. Because the lower interest rate causes larger capital outflows at higher degree of capital mobility, balance of payment must deteriorate by more in case of highly (3.1b) than less integrated financial market (3.1a). In other word, the overall balance of payments would likely to be more deficit; the more sensitive are capital movements to change in rate of interest.

If a country is running balance of payments deficit, as in figure 3.1 (a) and (b), it is basically losing foreign exchange reserve overtime. If central bank tries to maintain both its exchange rate target and its new money supply target, it will rapidly exhaust its entire stock of foreign exchange reserve. Under fixed exchange rate system, central bank will be forced to give up its money supply target and allow the outflow of reserves through capital account to reduce money supply (the nonsterilization assumption in monetary approach to balance of payment). This will result in leftward shift of LM curve to original position. The decline in money supply and increase in interest rate will push the economy back to the original point where it started (point E), leaving no permanent effect on income.

. What difference does the higher degree of capital mobility make in this case? Because balance of payments deficit is greater in case of highly mobile capital, figure 3.1b, relative to less mobile capital, figure 3.1a, the rate at which money supply decreases over time (speed of offset) is greater, and therefore, the economy returns to its starting point more rapidly.

To push things to the extreme, the case of perfect capital mobility is obviously a limit progression. Central bank could not sterilize the outflows even if it wants to. Hence, the expansion of output does not actually occur even in short run. Thus, it follows from the above results that among the three objectives; exchange rate stability, perfect capital mobility, and monetary autonomy, policymakers can choose to have only two attributes, but it cannot choose all three. This incompatibility among these three goals is known as Mundell’s “impossible trinity”.

In sum, under monetary approach to balance of payments, when central bank decides to give up the attempt to sterilize the outflow, any increase in money supply eventually flows out through balance of payments and leaves no long run effect on income, with the speed precedes more rapidly, the more integrated world financial market. Logically, in the polar case of perfect capital mobility, monetary policy loss all its effectiveness under a regime of fixed exchange rate.

3.1.2 Effect of increase in money stock under floating exchange rate system

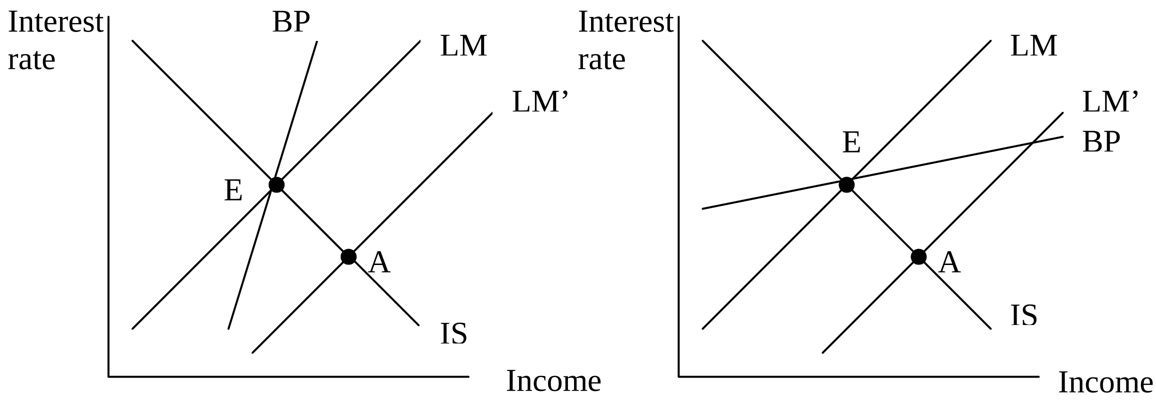
We will now consider the effect of monetary expansion under floating exchange rate regime and how it changes as a result of increasing capital mobility. The case of low and high capital mobility is depicted in figure 3.2 (a) and (b), respectively. It will be apparent below that monetary expansion will always have a more powerful effect on exchange rate and output when a country adopts floating exchange rate than peg exchange rate system.

As we already seen above that, given fixed exchange rate, increase in money stock will be associated by the deficit in overall balance of payments. Now, when the experiment is translated to the case of floating rate, the tendency toward an adverse shift in the balance of payments will cause a depreciation of exchange rate to the extent that is necessary to keep total balance in equilibrium. The favorable effect of depreciation on export and trade balance must come to outweigh the deterioration in the whole balance. This implies a rightward shift in the BP and IS until all three curves intersect at the same point, which is at point B in the figures. The stimulus on current account will also act as stimulus to income, raising it above the level that would prevail in fixed exchange rate system. Therefore, the monetary expansion raises income by more under floating exchange rate than under fixed exchange rate (compare A to B).

Furthermore, the expansive effect of an increase in money stock will be larger, the higher degree of capital mobility. When capital is relatively mobile, deficit in balance of payments would be large. The overall balance of payment deteriorates more at point A in figure 3.1 (b) than (a). This implies that the depreciation of currency must be greater in case of high capital mobility than low capital mobility if it is to equilibrate the balance of payments. Thus, stimulus to export, and hence income, is greater. Accordingly, through the greater exchange rate depreciation, capital mobility enhances the effectiveness of monetary policy at changing output under floating exchange rate. In the excessive case, monetary policy reaches its peak effectiveness when capital is mobile.

Figure 3.1

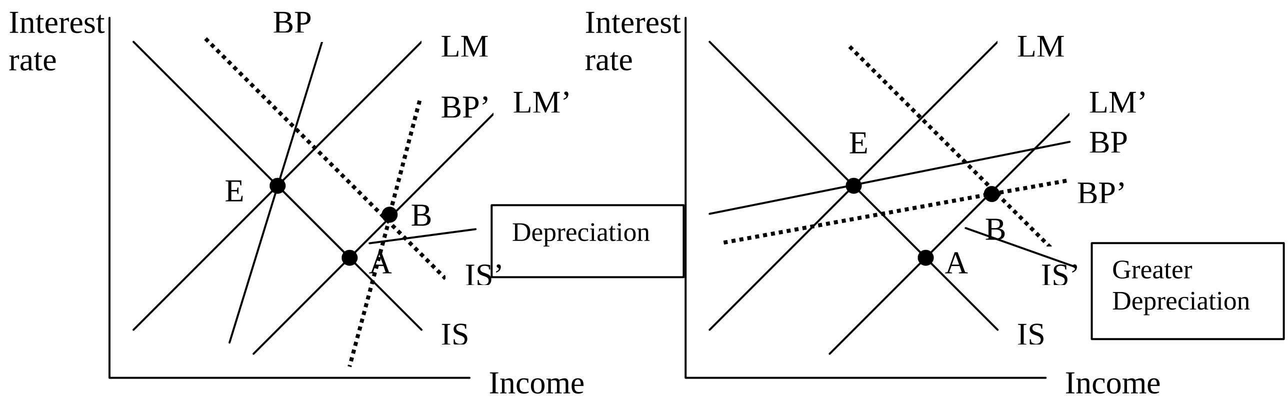
Monetary expansions under fixed exchange rate in Mundell-Fleming model



(a) Low capital mobility (b) high capital mobility

Figure 3.2

Monetary expansions under floating exchange rate in Mundell-Fleming model



(a) Low capital mobility (b) High capital mobility

To summarize, we have derived, from above paragraphs, just two opposite results obtained from monetary approach to balance of payment under fixed and flexible exchange rate regime (compare point E and B)[2]. When government chooses to maintain exchange rate fixed, high capital mobility means that any given expansion in domestic credit simply flows out through balance of payments much faster. Therefore, capital mobility diminishes the effectiveness of monetary policy. However,

[2]Also, the above results also contrast with the results for fiscal policy expansion. The key to these divergences is the response to interest rate.

when country chooses to keep money supply fixed and instead let exchange rate adjust, high capital mobility implies that any given expansion has extra expenditure-switching effect via depreciation. Consequently, expansionary effect of a given increase in money supply will be greater, the more openness of country's financial market.

3.2 New Open Economy Macroeconomic: the Prototype Model

Exchange rate dynamics redux by Obstfeld and Rogoff (1995) is commonly recognized as the contribution that launches the new wave of research that led to new open economy macroeconomics. By combining three mains factors (namely, intertemporal decisions, monopolistic competition, and presence of nominal rigidity), NOEM model gives a new foundation for thinking about some of the fundamental problems in international finance. Comparing to traditional static Keynesian models, this framework is more complete to offer a satisfactory analysis on exchange, output, and current account.

3.2.1 Characterization of preference, market structure, and technology

The Redux analyzes a perfect foresight setting and then introduces a one-time unforeseen policy shock. In the model, the world is assumed to inhabit by continuum of yeoman-framers (consumers-producers), each of whom produces a single differentiated product. [(1,n) live in home and (n,1) live in foreign country]. Individuals across the world are assumed to have identical preference. The representative consumers in each country maximize a utility function, which is defined over consumption index, real money balances, and efforts spent in production. Home resident maximizes intertemporal utility function of the form

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} \left[\log C_s + \frac{\chi}{1-\varepsilon} \left(\frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{\kappa}{2} y_s(z)^2 \right] \tag{3.1}$$

The consumption index, on which utility depends, is defined over all goods and given by constant-elasticity-of-substitution (CES) function.

$$C = \left[\int_0^1 c(z)^{\theta-1/\theta} dz \right]^{\theta/\theta-1} \quad \theta > 1 \tag{3.2}$$

where c(z) is home individual's consumption of product z. Again, foreign resident has the same demand function.

In this paper, output market is assumed to be perfectly integrated. There is no barrier to trade such that law of one price holds for each good. This assumption, coupled with the identical preference, implies that purchasing power parity holds and consumption-base real exchange rate is constant.

The paper assumes also that there is an integrated world capital market in which both countries can borrow and lend and the only asset traded in this market is real bonds denominated in term of composite consumption good. Individual budget for representative individual, therefore, is given by

$$P_t F_t + M_t = P_t (1 + r_{t-1}) F_{t-1} + M_{t-1} + p_t(z) y_t(z) - P_t C_t - P_t T_t \qquad (3.3)$$

where Ft and Mt refer to stock of bonds and domestic money held by home residents entering period t+1, rt is real interest earned on bonds between date t and t+1 , y(z) denotes individual's output, and T is real tax paid to domestic government.

In terms of government, home and foreign government purchases of consumption goods do not directly affect private utility. Per capita real government consumption expenditure is modeled as a composite of government consumptions of individual goods, g(z), in the same manner as private consumption. Since Ricardian equivalence holds in this model, nothing is lost by assuming that both home and foreign government spending are financed by taxes and seigniorage.

$$G_t = T_t + \frac{M_t - M_{t-1}}{P_t} \qquad (3.4)$$

Finally, each individual producer has a degree of monopoly power so that, in aggregate, a country faces a downward-sloping demand curve for its output. Let C_t^w and G_t^w correspond to world private consumption demand and world government demand, respectively. It follows from (3.2) that producer of good z faces a constant-elasticity demand curve, which is determined by aggregate world consumption,

$$y_t^d(z) = \left[\frac{p_t(z)}{P_t} \right]^{-\theta} (C_t^w + G_t^w) \qquad (3.5)$$

3.2.2 Individual decisions and equilibrium of the model

Each agent must decide his optimal choices of consumption, money holding, and labor supply and set his or her optimal output price. Taking world demand as given, six first-order conditions can be drawn from maximizing lifetime utility (3.1) subject to budget constraint (3.3) of home and foreign individual with respect to C, M, and y(z). Prices are assumed to be set one period in advance, but can be adjusted fully after one period. This feature of preset nominal price is used to introduce nominal rigidity in this model since no underlying source of price stickiness is explicitly assumed here.

Equilibrium of the model is a set of variables that enables market clearing in goods, labor, and money market. These include those that satisfy all optimal evolutions of intertemporal consumption and money holding, labor market clearing, optimal prices setting, as well as intertemporal budget constraints.

3.2.3 The solution technique

Because of monopoly pricing and endogenous output, the model here does not yield simple closed-form solutions. One could analyze the effect of exogenous shock through numerical simulation. To understand the intuition of the model, however, this paper first solves for steady state of the model. Then, the log-linear approximation of the model and its equilibrium conditions around the initial steady state with no foreign asset holding and government spending are adopted to study the dynamics effect of money shock. By log-linearizing the model around symmetric steady state, one can go further and allow for asymmetries in policies and current accounts.

3.2.4 Flexible price vs. sticky price model

Since the model is developed base on the assumption of sticky nominal goods price for one period, the solution is distinguished between the first-period effect of shock and its long run steady-state effect. The short run and long run behavior of exchange rate, current account, and other key variables, nontheless, can be established with the same ground. In fact, only some changes are needed to characterize equilibrium conditions for the two schemes. In particular, because nominal producer prices p(z) and $p^*(z)$ are preset in short run, output becomes demand determined and the log-linearized version of world demand, equation (3.5), must be used to determine output in contradiction of labor supply equations, which equate marginal revenue and marginal cost in flexible-price model.

To highlight these differences, in short run, the model is expressed in terms of short run deviation from the symmetric steady-state path (all t-subscripted variables is replaced with hated variables without time subscript), whereas percentage change in steady state value is used when we consider the economy in the long run (all t+1-subscripted variables is swooped to steady-state change).

3.2.5 Solution of the model: Money shock

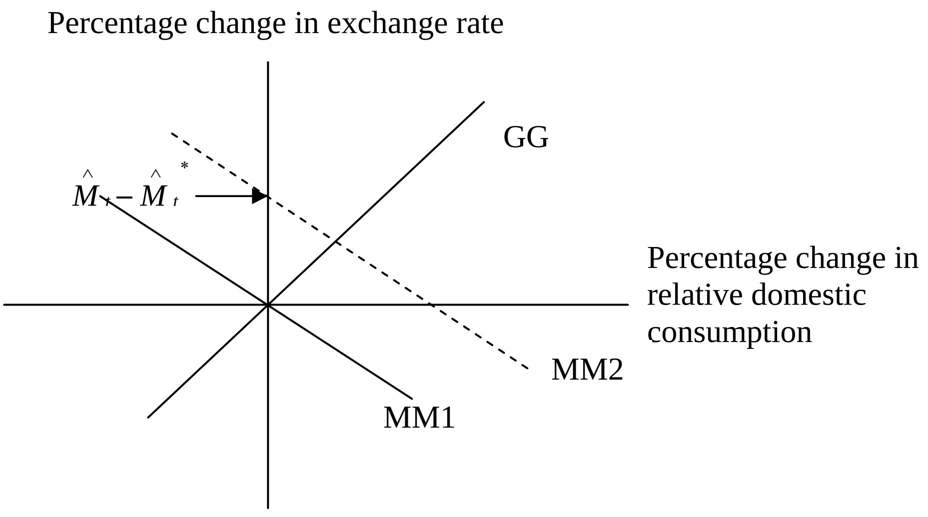
Thought direct solution is possible from solving set of log-linear equations, the paper employs the intuitive approach that exploits the model's symmetry.

- First-period and long run steady state effect of money shock

A positive unanticipated monetary shock to the home country[3] will have some of the same effects found in the standard Mundell-Fleming model: the shock will lead domestic households to increase their aggregate consumption demand and a depreciation of the exchange rate in short run.

Figure 3.3

A graphical illustration of exchange rate dynamics in Obstfeld and Rogoff (1995)



[3]More details on the algebraically solution for exchange rate change, relative consumption change, and other variables are in the original paper by Obstfeld and Rogoff (1995)

Figure 3.3 illustrates this impact effect of permanent money shock. A rise in money stock causes a rightward shift in MM schedule, from MM1 to MM2. The intersection of MM2 and GG is the new short run equilibrium. The domestic currency depreciates, but by amount proportionally smaller than the increase in the relative home money supply because of an increase in relative consumption.

Plus, a home monetary expansion also brings down the world interest rate, and thus, raises global demand in short run. This, coupled with the nominal exchange rate depreciation, translate into a shift into home product at the foreign producers' expense. Accordingly, home output rises relatively more in short run.

Moreover, the short run effect of monetary shock on domestic claim on foreigners is resulted from the short-run rise in relative domestic income. As income increases, home residents save part of extra income via purchasing foreign assets. By running a current-account surplus, they smooth the increase in their relative consumption over the future.

As for ratio of home price to foreign, with fixed nominal prices, the depreciation in exchange rate will cause a home term of trade to deteriorate in short run. However, a positive home money shock generates improvement in term of trade in long-run. To see this, let look at the wealth effect of positive net foreign assets position that is arisen from monetary shock. As a result of a money expansion, home has increase in domestic net foreign assets and surplus in current account. The resulting interest rate income leads to increase in wealth. With higher long run wealth, home residents choose to enjoy more leisure, thereby creating a fall in long-run domestic output and rise in relative home output price. A permanent improvement in term of trade will, thus, result.

- Neutrality of money

The possibility that money shock may have long-lasting consumption and term of trade effect can be seen from the model. As long as there exist any type of short run nominal rigidities, unanticipated money shocks are likely to lead to international capital flows. The resulting transfers will cause a permanent increase in consumption and the improvement in home's term of trade. In this manner, the real effects of shock are extended beyond the initial sticky-price time horizon. Hence, money is not neutral in long run.

- Exchange rate volatility due to money shock

Another interesting result is that exchange rate overshooting is not possible in this model. To see this, it is useful to present equations describing the exchange rate dynamic

$$\hat{E} = \left(\hat{M} - \hat{M}^*\right) - \frac{1}{\varepsilon}\left(\hat{C} - \hat{C}^*\right)$$

$$\hat{\bar{E}} = \left(\hat{\bar{M}} - \hat{\bar{M}}^*\right) - \frac{1}{\varepsilon}\left(\hat{\bar{C}} - \hat{\bar{C}}^*\right)$$

Because relative consumption immediately jumps to its new level and, by definition, a permanent money shock will induce the relative money supply to jump to its new level straight away, it follows that the exchange rate will also immediately jump to the new equilibrium levels despite the inability of prices to adjust in short run or, algebraically,

$$\left(\hat{C} - \hat{C}^*\right) = \left(\hat{\bar{C}} - \hat{\bar{C}}^*\right)$$

$$\left(\hat{M} - \hat{M}^*\right) = \left(\hat{\bar{M}} - \hat{\bar{M}}^*\right)$$

$$\hat{E} = \hat{\bar{E}}$$

Besides, the fact that inflating country experiences an improvement in its long run term of trade tempers the need for initial depreciation. Therefore, comparing to the world of flexible price, the preset price actually reduces exchange rate volatility in the Dornbusch's exercise of the unanticipated money shock of this present model.

- Welfare analysis of international monetary transmission

Finally, the monetary shock's impact of home and foreign welfare can be calculated. In evaluating welfare, the disparate effect on short-run and long-run consumption, real balance, and leisure must be aggregated according to weight implied by utility function. Remarkably, it turns out that while allowing for many Keynesian effects (expenditure switch effects), this Redux model offers the welfare implication that differ from Keynesian conclusion (beggar-thy-neighbor effects that a country inflicts on trading partners when it depreciates its currency).

To be more specific, this model puts less emphasis on the expenditure-switching effects of exchange rate depreciation. The crux of the matter is that starting in the initial equilibrium, where marginal revenue and cost of working are equal, the fact that home agents produce more from lowering price due to exchange rate depreciation does not necessarily raise there relative utility. Indeed, the extra revenue is exactly cancelled out by an increase in work effort. Therefore, the expenditure-switching effect and current account effects that accompany the unilateral monetary change are only of second-order importance here. On the other hand, while the importance of expenditure-swishing effect is demoted, the initial general increase in world demand is prominently the first order effect of monetary shock instead. The intuition for this is that, since the imperfect competition distortion means that the initial level of output is too low, a demand-driven increase in world output raises welfare to the equal benefit of both countries. As a result, diverse from Mundell-Fleming-Dornbusch model, home and foreign welfare are raised by the same amount, despite the asymmetric output and consumption effect of change in money supply. This analysis, in the end, suggests that "even in the cases, in which the conventional Mundell-Fleming-Dornbusch paradigm yields empirical sensible results, its ostensible welfare implications can be quite misleading."[4]

[4] Maurice Obstfeld and Kenneth Rogoff (1995)

CHAPTER 4

REVIEW OF RELATED LITERATURES

This chapter offers a summary of several literatures that are related to the topic at hand. It is divided into two parts. The first-half of this chapter discusses a few of the many numerical literatures under NOEM approach, that put one's mind on analyzing policy transmission under different stages of international financial integration, and surveys empirical literatures, that emphasis on the independence of monetary policy and varied degrees of international capital mobility, using econometric procedures. Then, paper relating to the labor market integration is examined in the last section.

4.1 Model for Financial Market Integration

4.1.1 Theoretical analysis: Development in NOEM literature based on trading friction in financial market.

The exchange rate dynamics redux marked the beginning of a surge in work on a new class of open-economy macroeconomic models. Outstandingly, over the past decades, many of the assumptions are modified in subsequent works. One of the main extensions that have been made to the Redux model focuses exclusively on analysis of trading friction in international financial market. Those papers are reviewed below.

Importantly, before passing by, note that, given the complexity of the model, attempts to extend the NOEM would become much easier if one is willing to settle for numerical results rather than analytical ones. For many purposes, including the one we have below, resorting to numerical methods is necessary compromise. Therefore, in the following paragraphs, with no close-form solution gain from the model, the authors faithfully use numerical simulations to analyze the properties of the calibrated log-linearized version of the model. (Since we make use of US parameters, all the studies reviewed here are made for US economy as well.)

Alan Sutherland (1996) is the first to introduce trading frictions in a flexible exchange rate intertemporal general equilibrium setting based on the Redux framework. By bringing in the adjustment cost incurred when transferring funds across border, this paper investigates the effect of financial market integration on volatility of macroeconomic variables when economy faces economic shocks that is originated from three sources, i.e., money supply, government purchases, and labor supply.

- The Model

The model setup is similar to that of Obstfeld and Rogoff. Nevertheless, to allow for more detail studies in financial market integration and richer price dynamics, two modifications are made to the model.

First, financial capital is made less than perfectly mobile across international boundaries. The crucial assumption of the model is that financial market integration is not perfectly integrated with the adjustment cost formulated as

$$Z_t = \frac{1}{2}\psi I_t^2$$

where I_t is the level of funds transferred from the domestic to foreign bond market in periods t. The process of financial integration is represented by reduction in trading frictions between different countries or dropping the parameter ψ .

Second, multiperiod nominal contracts are explicitly introduced as underlying source of price stickiness. Sutherland uses the discrete-time version of sticky price adjustment mechanism, described by Calvo (1983), which assumes that firms change their prices after time interval of random length. According to this pricing structure, there is probability γ that an individual firm will leave their prices at the previous level, whereas the remaining 1- γ is probability that individual firm will revise prices to new optimum level (termed in Calvo as probability of receiving price-change signal). With the likelihood γ, firms, which are forced to announce prices in nominal terms, will find it prohibitively costly to change prices at every point in time.

Since price set in this period might have an impact on profit in the future, each firm has to bear in mind when engage in profit maximization problem that there is positive chance γ that it cannot alter its price setting decision made in period s > t. As a result, firms, which do set price in period t, will maximize discounted value of current and future profits with each future period weighted by the probability that current price will still be in force in that period. Hence, firm z's maximand is

$$V_t(z) = \sum_{s=t}^{\infty} \gamma^{s-t} R_{t,s} \frac{\Pi_s(z)}{P_s}$$

where $R_{t,s}$ is discount factor between time t and s and π_t denotes period t firm profit. The result from above profit maximization is individual pricing rule that can be used to derive index of prices for domestically produced goods and aggregate output of each country.

- Simulation result

To add in monetary shock, money supply is set to increase by 1 percent in home while the foreign money supply is reduced by 1 percent. The deterministic dynamic solution paths are presented for different degrees of financial market integration and price inertia. Two cases are examined, i.e., in the former investigation between ψ =0 (perfect capital mobility) and ψ =5 (imperfect capital mobility) and in the latter case, between γ=0.5 (sticky price adjustment) and γ=0.25 (flexible price adjustment).

With *perfectly integrated financial market integration*, the responses of various economic variables are the same as in Obstfeld and Rogoff. That is, when capital is perfectly mobile, internationally traded risk-free bonds are perfectly substituted so that there is only one interest rate. A perfect asymmetric shock implies that the quantity of funds domestic agents want to lend (or borrow) is always identical to the quantity of funds foreign agents want to borrow (or lend). As a consequence, the asymmetric money shock does not change interest rate. Along with unchanged interest rate, the reaction of domestic consumption to change in money supply must be a once and for all step increase to a new long run level.

To see the exchange rate dynamics, money market condition of the two countries derived from the model and PPP relationship can be used.

$$\hat{E}_t = \hat{M}_t - \hat{M}_t^* - \frac{1}{\sigma\varepsilon}[\hat{C}_t - \hat{C}_t^*] + \frac{\beta}{\varepsilon}[\hat{i}_t - \hat{i}_t^*]$$

where hat denotes a log deviation from steady state. Due to the flat increase in relative consumption and a zero interest rate differential, the above expression suggests that the effect of once-and-for-all step change in money supply on exchange rate is once-and-for-all-step increase (The exchange rate increases less than the relative domestic money supply because the domestic relative consumption rises). The fact that the nominal exchange rate depreciates while nominal prices are sticky, in turn, means that the relative prices of domestically produced goods or terms of trade decline in short run. As a result, the rise in demand-determined domestic output will be followed. Now, to go further, as nominal contracts are renewed, relative prices will adjust and output will move back toward the original level. Domestic agents have high income in short run while maintain a flat consumption. Saving will, therefore, rise as home consumers are accumulating bonds.

Turn now to the case of *imperfect financial integration*. In the economy with imperfect capital mobility, domestic and foreign bond become distinguishable and, thus, pay different interest rates. The fact that domestic agents attempt to accumulate assets drives down the domestic interest rate (negative yield differential). This creates the incentive for domestic consumers to bring consumption forward in time, hence, causing the consumption to rise sharply before the effect dies down thereafter. Consequently, as a result of negative interest rate differential and more strongly positive consumption differential, exchange rate depreciates but by the amount less than in perfect capital mobility case. Ultimately, this implies that domestic output rises by less as well.

In sum, if volatility is measured by effect of shock, then increasing financial market integration reduces volatility of interest rate and consumption, but increases velocity of nominal exchange rate. For that reason, given that price is fixed in short-run, the output is more volatile with integrated market. Ultimately, in spite of the difference, NOEM model and Mundell-Fleming model share some implications in case of monetary shock, i.e., a higher degree of international capital mobility enhances the expenditure switching effect of exchange rate change and extends short-run effectiveness of monetary policy in open economies, as measured by change in national income.

The last part of the paper demonstrates how *the speed of price adjustment* affects the importance of shock and the implications of financial market integration. The result turns out that, as the degree of price inertia decreases, impacts of shock on real variables decline (as agreed by classical dichotomy), so do the differences between perfect and imperfect capital mobility. This is most pronounced for monetary shock. Thus, the spread of monetary shock and the noteworthy of financial market integration become more obvious when prices are sticky.

Christian Pierdzioch (2002) also uses the dynamic general equilibrium model developed by Ofstfeld and Rogoff to evaluate the consequences of international capital mobility for the effectiveness of monetary policy in open economies, measured by output volatility. Using the model similar to that of Sutherland (1996), this paper makes an extension by distinguishing between the elasticity of substitution among goods produced in different countries and among goods produced in the same country. Because the degree of substitution of goods produced in different countries is equal to sum of the elasticity of export and import, making this assumption frees up the opportunity to check the results under two alternative conditions, i.e. when Marshell-Lerner condition does and does not hold.

- The model

The model employed in this paper is analogous to Sutherland's model. Other than the difference in the elasticity of substitution and the role played by the substitutability of goods produced in different countries, the main differences in the feature of the model are namely:

First, the model is developed in stochastic setting, in which households form rational expectation and maximize their expected lifetime utility. In particular, home and foreign households in this model are seeking to maximize the discounted value of their expected lifetime utility, defined as

$$U_t = E_t \sum_{s=t}^{\infty} \beta^{s-t} u_s$$

The period-utility function, U_t, is of the form similar to the one used in Sutherland (with parameter κ equal to 1). However, it is aggregate consumption index, which is a CES aggregate of an index of Home consumption goods and of foreign consumption goods, that enters the utility function, instead of a country consumption index. Let $\rho > 0$ stands for the elasticity of substitution between the home and foreign consumption index. The aggregate consumption index is given by

$$C_t = \left[n^{\frac{1}{\rho}} (C_t^h)^{\frac{(\rho-1)}{\rho}} + (1-n)^{\frac{1}{\rho}} (C_t^f)^{\frac{(\rho-1)}{\rho}} \right]^{\frac{\rho}{(\rho-1)}}$$

Like Tille (2001), the index C_t^h (C_t^f) is defined as a CES aggregate over a continuum of differentiated, perishable home (Foreign) consumption goods.

$$C_t^h = \left[n^{-\frac{1}{\theta}} \int_0^n \left\{ c_t^h(z) \right\}^{\frac{(\theta-1)}{\theta}} dz \right]^{\frac{\theta}{(\theta-1)}}, C_t^h = \left[(1-n)^{-\frac{1}{\theta}} \int_n^1 \left\{ c_t^f(z) \right\}^{\frac{(\theta-1)}{\theta}} dz \right]^{\frac{\theta}{(\theta-1)}}$$

where $\theta > 0$ denotes the elasticity of substitution between consumption goods produced within the same country. The fact that in general $\theta \neq \rho$ means that the elasticity of substitution between goods produced in different countries and goods produced in the same country are distinct. Tille (2001) proves that the elasticity of substitution between goods produced in different countries, ρ, is equal to the sum of the absolute export and import elasticity with respect to the terms of trade. This implies that the Marshall-Lerner condition holds if $\rho > 1$ and is violated if $\rho < 1$.

Second, firms set prices according to a variant of the price setting mechanism advanced by Fuhrer and Moore (1995), which assures a reasonable degree of inflation persistence and, third, as suggested by Taylor (1993), monetary policy is targeted at the short-term interest rate rather than the money supply.

- Simulation result

This paper performs three experiments to verify Mundell-Fleming prediction regarding the effectiveness of monetary policy; the first two concern Marshall-Lerner condition and the last one deals with monetary policy rule. The results of all numerical simulations support the policy conclusion of Mundell-Fleming model and point out that higher degree of capital mobility enhances the effectiveness of monetary policy only if the elasticity of substitution between goods produced in different countries exceeds unity (Marshall-Lerner condition holds).

In the paper, the degree of *financial market integration* matters because when capital mobility is less perfect, the impact of the asymmetric monetary policy shock on the dynamics of the foreign asset position is directly reflected in the following version of uncovered interest rate parity.

$$\left(1-\beta\right)\left(\hat{i}_t-\hat{i}_t^*\right)=E_t\left(\hat{S}_{t+1}-\hat{S}_t\right)+\psi E_t\left(\hat{I}_{t+1}-\hat{I}_t\right) \tag{4.1}$$

Unlike in the world of low barrier in international financial market, there is direct effect of change in foreign asset position on international nominal yield differential. Specifically, for any given interest rate differential, a positive expected change in cross-border flow of funds, that is occurred when Marshall-Lerner condition holds, would translate into smaller expected depreciation. Then, it follows that, the initial appreciation of domestic currency is lower (the undershooting is less pronounced) when international financial markets are segmented. Therefore, the output effect of monetary policy is lower in case of low capital mobility than high.

Now, owing to the fact that the monetary policy-induced real appreciation of home currency does not lead to normal reaction of the trade balance and foreign asset position for a model in which the elasticity of substitution between goods produced in different countries is less than unity, the impulse response functions for the case, in which *Marshall-Lerner condition* is not satisfied, reveal the opposite results. That is, it indicates that the output effect and, thus, the effectiveness of monetary policy would be larger, the lower is the degree of international capital mobility. This, thus, implies that, paralleling to Mundell-Fleming approach, the Marshall-Lerner condition turns out to be an important determinant of the implications of international financial market integration for the effectiveness of monetary policy in open economies.

To check the robustness of this result, the model is simulated using four alternative *specifications of monetary policy rule*. In the end, the author finds out that the above conclusions of model can be realized for the diverse choices of parameterization of monetary policy.

Ozge Senay (1998) pulls off the study using the exact same model as Sutherland model, but adjusts the assumption underlying international goods market. By introducing the imperfect good market integration through discrimination by firms across export markets, i.e. pricing-to-market (PTM) framework, this paper determines the macroeconomic effects of international integration of goods and financial market in response to several economic disturbances.

- The model

Every detail of Senay's model duplicates that of Sutherland, except in part of firms' price setting. To be more specific, two types of firms exist in an imperfectly competitive setting where all firms are price setters; PTM and non-PTM. Fraction s of firms do price discrimination across market destinations and set prices independently for the home and foreign country. These are called PTM firms. The model assumes that each PTM good is sold exclusively by an individual firm so that the possibility of individuals engaging in trade and arbitraging away price differentials between the two countries is ruled out. The remaining 1-s firms produce non-PTM goods, which are traded freely by consumers in both countries. Price differences in non-PTM goods, then, are arbitraged away so that firms set a single international price.

Given these characterizations, the number of non-PTM firms in the economy is taken to represent the degree of goods market integration achieved by the two countries. Complete PTM (s=1) characterizes the case where each nation's goods markets are kept totally apart whereas goods markets are completely integrated (PPP holds) when no goods are PTM (s = 0).

With the specific nature of nominal rigidities, described by Calvo (1983), coupled with imperfect goods market integration, represented by the presence of PTM, price setting mechanism and thus aggregate output determination can be divided into that of PTM firms, which separately choose optimal pricing rule for the home and foreign market, and that of non-PTM firms, which set a single international optimal price.

- Simulation result

From the numerical simulations of the model in its calibrated and log-linearized form, the paper considers how volatile macro variables are in response to asymmetric shock under following four cases

Case 1: Complete good and financial market integration

Case 2: Incomplete GMI, Complete FMI

Case 3: Complete GMI, Incomplete FMI

Case 4: Incomplete GMI, Incomplete FMI

To provide a benchmark, consider first case 1. Complete GMI results in the presence of full PPP (so the nominal exchange rate, domestic, and foreign price levels will adjust to maintain purchasing power parity across countries), while complete FMI ensures that uncovered interest rate arbitrage (UIP) or the equality of expected returns holds. Given this, the combination of PPP and UIP, thus, implies equality of real interest rates in the two countries. Under these conditions, an asymmetric money supply shock would generate no change in the general level of real interest rate, and the reaction of domestic consumption, exchange rate, term of trade, output, and foreign bond accumulation would, in turn, be identical to the case of perfect integrated world in Sutherland (1996).

In case 2, where incomplete GMI is introduced, all firms are PTM so the PPP condition breaks down. This has two direct impacts on the effects of a money shock. First, real interest rates can diverge. As there is demand for holding assets, domestic real interest rate falls. This causes a rise in consumption and overshooting of nominal exchange rate in short-run. Second, the extent that the exchange rate depreciation, induced by the asymmetric monetary expansion, leads to an increase in demand for domestic goods depends on the degree to which it is passed onto the relative prices of domestic goods. If producers engage in PTM (i.e. goods are priced in the currency of the buyers) and prices are fixed by contracts, change in nominal exchange rate does not reflect in change in relative goods price. This absent in pass-through effect means that the nominal exchange rate depreciation produces smaller increase in output. The output effect of monetary policy, as a result, significantly diminishes when goods markets in each country are separated.

In case 3, where incomplete FMI is introduced, UPI fails. The main direct impact of this is to allow yield (nominal interest rate less the expected depreciation) on domestic and foreign bonds to diverge. The tendency for the money supply shock to induce an asset accumulation in domestic economy implies that domestic yields fall. This downward pressure on domestic yield leads to a fall in real interest rate and causes agents to consume now rather than in the future. So, an increase in consumption is apparent. Like Sutherland (1996), when households cannot adjust the international flow of funds without incurring some costs, given higher positive consumption and negative interest rate differential, the impact effect of monetary shock on the exchange rate must necessarily be smaller. The comparatively small depreciation in case of perfect capital mobility, then, pushes relative prices of domestic goods to go down less and, thus, output increases by less when capital mobility is near to the ground. As for holding of foreign bonds, despite the increase in foreign interest rate, the amount of domestic claim on foreigner is reduced, compared to case 1, due to the presence of adjustment cost of moving funds across the border.

Finally, consider case 4 where there are both incomplete GMI and FMI. The fact that UIP no longer holds puts a certain additional effect on real interest rates as compared to case 2 where money shock does not lead to any yield differential. However, since foreign bonds holding is not significantly large in case 2, introducing imperfect capital mobility does not place too much pressure on yield differential and the domestic real interest rate. Therefore, they do not fall to a great extent relative to case 2. Accordingly, the presence of imperfect capital mobility does not extensively alter the volatility of any of the macroeconomic variables as compared to case 2.

Lastly, Table 4.1 is the recap of the effects of GMI and FMI on macroeconomic variables.

Table 4.1

Summary of the impact effects of monetary shock on various macroeconomic variables by Senay (1998)

Cases	Consumption	Output	Real interest rate	Nominal exchange rate	Foreign bond holding
Financial market integration					
Incompletely integrated goods market: from case 4 to 2	-	-	-	+	-
Complete integrated goods market: from case 3 to 1	-	+	-	+	+
Goods market integration					
Incompletely integrated financial market: from case 4 to 3	-	+	-	-	+
Completely integrated financial market: from case 2 to 1	-	+	-	-	+

Overall, the results have shown that the effects of monetary policy on the movement of economic variables change significantly depending on the presence of incompletely integrated goods and/or financial markets with integration in one market independent of the other. In terms of output movement, both goods and financial market integration enhance the effectiveness of monetary policy with the effect of both works through the greater role of expenditure switching effect of exchange rate. Therefore, regarding the effects of financial market integration, the results in this paper are consistent with policy conclusions suggested by the traditional Mundell-Fleming framework.

Christain Pierdzioch (2003) suggests that the conclusion about policy effectiveness has to be qualified if one relaxes the assumption that households have identical references across countries, an assumption on which most models developed in the international finance literature are built. By loosing up this assumption, one allows for the home bias in international trade to enter the model. This means that the model is extended to include a specific form of incomplete goods market integration. As revealed by the paper, a result complementary to that of Senay (1998) can be obtained upon carrying out a minor modification of Sutherlands' model. In fact, extending Sutherland's model to incorporate a home bias in international trade requires adding just one additional parameter to households' preference.

- The model

Like the other papers inspected here, the model used in this paper is an extension of Sutherland (1996). The unique aspect of this model is that home-product bias in household preferences is building into the model by forming aggregate consumption index, C_t, as a CES aggregate defined over consumption goods produced in the home economy and in the foreign economy as follows:

$$C_t = \left[\int_0^{1/2} \alpha^{\frac{1}{\theta}} (c_t^h(z))^{\frac{\theta-1}{\theta}} dz + \int_{1/2}^{1} (2-\alpha)^{\frac{1}{\theta}} (c_t^f(z))^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}$$

θ denotes the intratemporal elasticity of substitution between consumption goods. As in Warnock (2000), $\alpha \in (0,2)$ captures the home-product bias in preference. If $\alpha \in (1,2)$, then households have a bias for domestically produced goods. In contrast, if $\alpha \in (0,1)$, then, for a given vector of relative prices, households prefer goods produced abroad over goods produced in their home country. Finally, if $\alpha = 1$, there is no home-product bias in preferences at all. The development in degree of integration in goods market is signified by changing value of α.

- Simulation result

The paper gives the result of two simulated experiments, with and without home-product bias in preferences. When there is *no home product bias in preference (good market are perfectly integrated)*, the dynamic impact of monetary shock collapses to the one developed by Senay (moving from case 3 to case 1), in which the short-run output effect of the asymmetric monetary policy shock is comparatively smaller in a regime of low capital mobility than in a regime of high capital mobility. The explanation here is that, according to uncovered interest rate parity with the adjustment cost, equation (4.1), because of current account surplus and negative expected rate of change in trading of foreign bonds, the expected rate of depreciation in case of high transaction cost is positive. Hence, the nominal exchange rate will undershoot its post-shock steady state value, thereby, producing a relatively weak expenditure-switching effect toward home products when domestic and foreign agents have constraint to engage in financial transaction in each other country.

However, things are different if households have a *home-product bias in preferences (imperfect integration in good market)*. With a home-bias in preferences, a nominal and a real interest rate differential can arise not only in a world of low, but also in world high capital mobility. This has vital implications for the difference in the magnitude of the short-run output effect of a monetary policy shock in either regime. To see this, note that the fall in the home real interest rate in a world of high capital mobility, made possible by the home-bias in preferences, results in a relatively sharp short-run increase of home households consumption. This increase in consumption spending, thus, implies that the current account imbalance, caused by the monetary policy shock when capital is relatively mobile, comes relatively closer to that caused when in a world has low capital mobility. That is, the size of current account surplus becomes smaller. In consequence, resembling the results found by Senay (moving from the case 4 to 2), the difference in the short-run effect on output from monetary policy under high and under low capital mobility tends to decline as the home-product bias in preferences increases. To put it differently, the relative importance of transaction costs for undertaking positions in international bond market for the short run effectiveness of monetary policy is worsen when the parameter capturing household's home-product bias in preference approaches its upper limit.

Taken together, this paper indicates that, corresponding to what Senay (1998) found, if one assumes a home-bias in international trade and, so, relaxes the assumption of perfect good market integration, the links between the degree of international capital mobility and the short-run output effect of monetary policy become weaker than in the basic Mundell-Fleming model. Depending on the degree of households' home-bias in preferences and hence goods market integration, the empirically observed ongoing integration of international financial markets can but need not result in significant changes in the way monetary policy shocks propagate through the economy.

4.1.2 Empirical analysis: Evidences on Mundell-Fleming framework

After a long search, there have been only a relatively small number of empirical studies on how the capital mobility affects the macroeconomic of monetary policy under flexible exchange rate for Thailand, probably because it requires a broadest span of data set. Yet, to make this concept regarded by the policymakers, its empirical foundations deserve greater attention. Therefore, following few paragraphs are devoted to a summary of the observed evidences concerning several aspects of Mundell-Fleming model under the monetary approach to balance of payment (reviewed in chapter 3). The first paper looks at the impact of capital control policies on the independence of monetary policy for the case of Thailand while the other two, on the other hand, get to the bottom of the Mundell's "impossible trinity". The results founded from those analyses could be used as guideline of the interaction between the effectiveness of monetary policy and degree of financial market integration that occurs within short-run.

Prisadee Jindahra (1995) carries out a study concerning implication of the capital mobility on the effectiveness of Thai monetary policy during the period of fixed exchange rate regime. By applying the concept of offsetting capital flow in the context of the Monetary approach to balance of payment; this paper investigates the extent to which monetary policy is offset by capital flows by estimating the reduced form of capital flow equation (under the less than perfect capital mobility).

Additionally, to entirely understand the independence of monetary policy, the analysis of how bank of Thailand sterilizes the balance of payment effect on money supply is presented via Bank of Thailand reaction function.

In order to achieve above objectives, this paper observes the results from 1980 to 1993. This data set is divided into two subcategories: before and after the financial liberalization 1990 so as to see the differences the capital mobility makes.

From the test of offsetting capital flow hypothesis, what we are paying attention is the offset coefficient, the value that represents the fraction of the private sector's capital flows which offset any change in money supply (domestic credits) done by the central bank in the opposite direction. The OLS estimates of offsetting coefficients show that the change in net domestic assets provides no influence over total capital flows in the two separated periods. However, looking at a particular item of total capital flows indicates that for the case of private long-term capital flows and the central government capital flows in period 1980-1993, the offsetting coefficient takes a significantly negative sign. Hence, this result implies that the offsetting power is quite strong in the long-run, but not subperiods before and after financial liberalization.

Sterilization coefficient from bank of Thailand reaction function gives us the degree to which monetary authority may vary domestic credits to counteract the effect from offsetting capital flows, thus, maintain the effectiveness of monetary policy. In this paper, for the whole study periods, there is no significant evidence of sterilization behavior. In subperiod, however, capital inflows induce Bank of Thailand to reduce net domestic assets in 1880-1990, thus implying the sterilization action from Bank of Thailand in the period prior to financial liberalization.

In conclusion, the empirical results of Thailand support the hypothesis of offsetting capital flows, and therefore Mundell-Fleming framework, during 1980 to 1993. Yet, it is shown that the offsetting power is not so strong in short-run. Moreover, with respect to the sterilization reaction, Bank of Thailand has not sterilized a change in capital flows by net domestic assets after the financial liberalization in 1990, while it uses to implement such policy in the former periods.

Maurice Obstfeld, Jay C. Shambaugh, and Alan M. Taylor (2003), unlike the above paper, assess monetary approach to balance of payment by proposing the empirical analysis to resolve the policy arguments concerning the Mundell-Fleming's trade off between exchange rate stability, monetary divergence, and capital mobility; The classical trilemma. This paper extends very few literatures on this question both temporally (using long historical data: Gold Standard 1870-1913, Bretton Wood period 1959-73, post-Bretton Wood era 1974-2003.) and methodologically (via appropriate econometric techniques) and tests the degree to which a local country's interest rate follows a base interest rate (the extent of monetary independence), in conjunction with an examination of capital mobility and exchange rate regime. On the whole, this paper finds strong evidences in support of trilemma.

A number of specifications to test the monetary autonomy are addressed in this paper. The estimated regressions are run for both panel and individual country model. Since the time series properties are ambiguous, the analyses under different assumptions about the stationary of variables are also pursued.

Specification 1: Panel data

Non-stationary data: $\Delta R_{it} = \alpha + \beta \Delta R_{bit} + u_{it}$, Stationary: $R_{it} = \alpha_i + \beta R_{bit} + u_{it}$

With perfect capital mobility and an exchange rate permanently and credibly pegged within a band that is literally of zero width, we would expect to find $\beta = 1$: pegging country's monetary independence would not at all exist.

Specification 2: Individual country data (PSS test)

$$\Delta R_{it} = \alpha + \beta \Delta R_{bit} + \theta(c + R_{i,t-1} - \gamma R_{bi,t-1}) + u_{it}$$

where γ and θ are cointegrating coefficient and adjustment speed, respectively. These two parameters determine whether there is a long-run relationship and their low values indicate that monetary policies are independent.

The overall lesson from this study is that, going along with Mudell-Fleming model, trilemma makes sense as a guiding policy framework. By looking at the values of β and R^2 from panel regression and γ and θ from individual regression for a within era information, the exchange rate regime does influence the extent to which a country follows the base, with countries that peg do indeed have less monetary freedom than the floaters. In particular, for both Gold Standard and modern era, while the peg shows sign of little independence (most striking under Gold Standard), there are floating episodes that demonstrate substantial independences (even though the comparison with Gold Standard suggests that floating of today does appear to have more of a connection to base rate than in the past, during period before 1914). In addition, the capital controls appear to be important in this study. For Bretton Wood period, low R^2 and negative level relationship show that the capital controls of the era seem to have essentially shut down the mechanism by which local countries are forced to follow the base country. As a final check, evidences from pooling all the data sets from every period also validate both legs of trilemma, i.e. exchange rate regime and capital control. Float with open markets and peg with close seem to have some autonomy and, as expected, pegs with open markets have the lease of all.

Finally, therefore, despite recent challenges to the trilemma as a concept, this paper exhibits that its lesson borne out over a broad range of historical experiences.

Andrew K. Rose (1994), in the same way as the preceding paper, quantifies empirically the specific case of Mundell-Fleming model under the monetary approach to balance of payment, The Holy Trinity. This paper exploits a panel of data for twenty-two countries around the world with monthly observation from 1967 through 1992. In this econometric work, this paper answers whether exchange rate volatility tightly linked to monetary divergence and whether this link depends on the degree of capital mobility. Nevertheless, unlike the above paper, the answers turn out affirmative, but perhaps surprisingly weak.

The framework for the empirical analysis used by this paper is a monetary model of exchange rate. The model is examined in two different variants: one with flexible good prices and one with short-run sticky prices (The two differ with the specification of FUND and disturbance terms). To investigate the incompatibility among the three components of the holy trinity, the estimating equation resulted from this model is given by

$$\begin{aligned}\sigma(\Delta e)_{it} &= \sum\nolimits_i D_i + \sum\nolimits_t E_t + \beta_j \left[\sigma(\Delta FUND^j)\right]_{it} + \delta_1 KMOB_{it} \\ &\quad + \delta_{2j}\left[KMOB_{it}(\sigma(\Delta FUND^j)_{it})\right] + \phi BAND_{it} + u_{ijt}\end{aligned} \tag{4.1}$$

Where subscript "i" denotes the relationship between country "i" and home country, j=F,S for the flexible and sticky-price versions of fundamentals respectively, D is set of county-specific fixed effect dummy variables. E is set of time-specific dummies, FUND denotes the measure of monetary fundamentals or monetary independence which in this paper defined as the divergence of home macroeconomic variables from foreign, KMOB is a measure of capital mobility, and BAND is officially declared bandwidth for the exchange rate. Due to the problem of measurement error, the above equation is estimated with instrumental variable technique, so as to deliver consistent coefficient.

Regarding the focus of this paper, the coefficient δ_2 is of special interest because a positive value suggests that the higher the degree of capital mobility, the stronger the effect of a given amount of fundamental volatility on exchange rate instability. In addition, the contrived testable hypotheses suggested by the incompatibility of impossible trinity can be written as $H_0 : \beta, \delta_1, \delta_2 = 0, H_0 : \delta_1, \delta_2 = 0$,and $H_0 : \beta, \delta_1 = 0$. The first hypothesis states that neither fundamental volatility nor capital mobility affects exchange rate instability while the second and third center on just fundamentals and capital mobility, correspondingly.

With the moderate precision of model fitting, the estimation results and the hypothesis tests reveal that there are evidences that fundamental macroeconomic volatility and the degree of capital mobility affect exchange rate volatility. However, these evidences depend on the exact measure of monetary fundamentals, and are not of overwhelming statistical importance. From the regression results of above equation, fundamental volatility has the expected effect on exchange rate volatility with moderately significant (β is always estimated to be positive with full sample) while effect of capital mobility is never significantly positive (δ_1 are negative for four of six of measure of monetary fundamental). The latter effect is complemented by the interaction between capital mobility and fundamental, i.e., being negative and significant when the capital mobility coefficient is positive and significant. From the confident level of various hypothesis tests, the fundamental volatility affects exchange rate volatility significantly only for sticky-price and augmented measures of fundamentals, whereas capital mobility is important only when traditional measures of fundamentals are used. Therefore, this paper concludes, without definitive judgment, that no strong support for the mutual incompatibility of the three parts of Mundell's impossible trinity is found.

To cut a long story short, I make a brief digest of the above literatures conclusions and assess them with regard to Mundell-Fleming model in table 4.2. Some of this information may be useful in chapter 7, where the implication of financial and labor market integration on macroeconomic variables is scrutinized in comparison with Mundell-Fleming model and Sutherland's paper.

Table 4.2
Review of the conclusions proposed from the studies of financial market integration

Literatures	Results compared to Mundell-Fleming model	Explanations
Theoretical analysis		
Alan Sutherland (1996)	Consistent	A higher degree of international capital mobility enhances the expenditure switching effect of exchange rate change and extends short-run effectiveness of monetary policy in open economies, as measured by change in national income.
Christian Pierdzioch (2002)	Consistent	The output effect and, thus, the effectiveness of monetary policy would be larger; the lower is the degree of international capital mobility. Plus, the Marshall-Lerner condition turns out to be an important determinant of the implications of international financial market integration for the effectiveness of monetary policy in open economies.

Literatures	Results compared to Mundell-Fleming model	Explanations
Ozge Senay (1998)	Consistent	In term of output volatility, both goods and financial market integration enhance the effectiveness of monetary policy with the effect of both works through the greater role of expenditure switching effect of exchange rate.
Christian Pierdzioch (2003)	The link between the degree of international capital mobility and the short-run output effect of monetary policy becomes weaker than in the basic Mundell-Fleming model.	Depending on the degree of households' home-bias in preferences and hence goods market integration, the empirically observed ongoing integration of international financial markets can but need not result in significant changes in the way monetary policy shocks propagate through the economy.
	Empirical analysis	
Prisadee Jindahra (1995)	The evidences supporting the hypothesis of offsetting capital flows, hence, Mundell-Fleming model are not so strong in short-run.	The offsetting power is quite strong in the long-run, but not subperiods before and after financial liberalization.
Maurice Obstfeld, Jay C. Shambaugh, and Alan M. Taylor (2003)	The overall lesson from this study is that trilemma makes sense as a guiding policy framework	The exchange rate regime and capital control does influence the extent to which a country follows the base. It is found that float with open markets and peg with close seem to have some autonomy and, as expected, pegs with open markets have the lease of all.

Literatures	Results compared to Mundell-Fleming model	Explanations
Andrew K. Rose (1994)	No strong support for the mutual incompatibility of the three parts of Mundell's impossible trinity is found in this paper.	The estimation results and the hypothesis tests suggest that there are evidences that fundamental macroeconomic volatility and the degree of capital mobility affect exchange rate volatility. However, these evidences depend on the exact measure of monetary fundamentals, and are not of overwhelming statistical importance.

4.2 Model for Labor Market Integration

Fujita M., P. Krugman, and A.J. Venables (1999) propose an analysis about spatial economic structures. To cope with the question of economic geography, this paper develops a spatial version of the Dixit-Stiglitz model of monopolistic competition. As opposed to the traditional urban models, this approach handles with the problem of market structure, which is posed in model with increasing return, by letting alone any direct assumption of external economies. Thus, the model somehow allows for an imperfect competitive market structure. In addition, the spatial version implies that we are dealing with the economy with multiple locations and transport cost. Ultimately, the purpose of this chapter is to give some ideas about how interactions among increasing returns at level of firm, transportation costs, and factor mobility can cause spatial economic structures to emerge and change.

- The building block: spatial version of Dixit-Stiglitz Model of Monopolistic Competition

The economy consists of two sectors; agriculture and manufacturing with the former is assumed to be perfectly competitive and produces single homogeneous goods and the latter provides a large variety of differentiated goods.

Consumer behavior

Each consumer shares the same tastes, which is specified to be Cobb-Douglas form in two types of goods

$$U = M^{\mu} A^{1-\mu} \tag{4.2}$$

where A is the consumption of agricultural good, μ is expenditure share of manufactured goods, and M is composite index of consumption of manufactured good, which is CES subutility function defined over the continuum of varieties of manufacturing goods, m(i), ranging from 0 to n.

$$M = \left[\int_0^n m(i)^{\rho} di \right]^{\frac{1}{\rho}} \quad 0 < \rho < 1 \tag{4.3}$$

The parameter ρ symbolizes the intensity of preference for varieties in manufacturing goods and $\sigma = 1/(1-\rho)$ denotes the elasticity of substitution between any two varieties.

The consumer problem can be divided into two steps

First, regardless of the value of the manufacturing composite, M, each m(i) need to be chosen so as to minimize cost of attaining M.

From the calculation, the manufacturing price index and the demand for m(i) can be written compactly as

$$G = \left[\int_0^n p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \text{ and } m(i) = \left[\frac{p(i)}{G} \right]^{-\sigma} M \text{ , respectively.} \tag{4.4}$$

Second, to divide the total income between agricultural and manufacturing good, individual chooses A and M so that the utility of consuming both goods is maximized, given the budget constraint

$$p^A A + \int_0^n p(i) m(i) di = Y \text{ ,}$$

Since the range of manufactures on offer is endogenous in Dixit-Stiglitz model, understanding the consequence of a number of varieties on behavior of consumer is essential. The implications of the above derived results are that increase in range of varieties will reduce the manufactures' price index and thus the cost of attaining a given level of utility. Furthermore, as a result of decline in price index, the demand curve will shift downward and thereby affecting the equilibrium number of variety produced by reducing the sales.

Multiple locations and transportation costs

The model employed in this chapter assumes the economy with a finite set of R discrete locations. Each variety is produced in only one location and all varieties produced in a particular location are symmetric (same technology and price).

The transport cost incurred from shipment between locations is in form of iceberg cost where the constant T_{rs} represents the amount of goods dispatched from r per a unit received by s. Because of the iceberg cost, together with the symmetry between all varieties produced in a particular location; the price index can be written as

$$G = \left[\sum_{r=1}^{R} n_r \left(p_r^M T_{rs}^M \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

Producer behavior

Next, we turn to production side of the economy. Under perfect competitive agriculture sector, goods are produced using constant-return technology. On the other hand, as mentioned, the economies of scale arise at the level of variety in manufactured firms. The technology used to produce manufacturing goods in all varieties and locations is assumed identical. Specifically, the production of quantity q^M of any variety at any given location requires labor input l^M given by

$$l^M = F + c^M q^M \tag{4.5}$$

Let q^M denotes the demand function given from consumer problem, all manufacturing firms in location r, facing a given wage and price index, engage in profit maximization $\pi_r = p_r^M q_r^M - w_r^M (F + c^M q_r^M)$ by choosing mill price p^M.

Moreover, free entry and exit condition is assumed in this model. Hence, the equilibrium output of any active firm can be written as $q^* = F(\sigma - 1)/c^M$ and associated equilibrium labor input is $l^* = F + c^M q^* = F\sigma$

With l^* that is a common constant to every active firm, the number of the varieties produced at r, n_r, amount to

$$n_r = L_r^M / l^* = L_r^M / F\sigma \tag{4.6}$$

These results suggest that with constant-elasticity demand function and nonstrategic behavior, the size of market affects neither the markup of price over marginal cost nor the scale at which individual goods are produced. Instead, the Dixit-Stiglitz model says that all market-size effects work through change in variety of good available.

Wage equation

As a result of the free entry-exit condition, total sale of single location q^M, and first order condition from firm price decision, the wage equation can be derived as

$$w_r^M = \left(\frac{\sigma - 1}{\sigma c^M}\right)\left[\frac{\mu}{q^*}\sum_{s=1}^{\infty} Y_s (T_{rs}^M)^{1-\sigma} G_s^{\sigma-1}\right]^{\frac{1}{\sigma}}$$

This is the manufacturing wage, at which the firm in each location breaks even.

- The model of economic geography: Core and Periphery

Additional assumption

The structure of the model is the same as an economy set out above. However, to facilitate the clearer and simpler illustration of spatial pattern, extra assumptions are made to the usual Dixit-Stiglitz model.

1) The world has fixed supply of labors. Total world labors are divided between $L^M=\mu$, manufacturing worker, and $L^A=1- \mu$, farmer. While each region is endowed with exogenous share of agricultural worker, denoted Φ_r, the manufacturing labor force is mobile over time, with λ_r as a share at any point in time.

2) Unlike manufacturing industry, the agricultural sector is not subject to the iceberg transport cost. Therefore, the agricultural has the same wage in all regions provided that technology is constant return.

3) What determine how workers move between regions is relative wage? The model assume the ad hoc dynamics as follows

$$\dot{\lambda}_r = \gamma(\omega_r - \overline{\omega})\lambda_r$$

The above statement simply means that labors will move toward the region that offers higher real wage than the average. Consequently, the extent that real wage varies across regions determines the allocation of manufacturing activities. However, regional wages themselves are also affected by the distribution of manufacturing across region. We can see these relationships by exploring the equilibrium relationship of the model.

Instantaneous equilibrium

The model's equilibrium can be characterized as four simultaneous equations; namely, income equation, equation for price indices, wage equation, and the real wage equation. With some normalizations ($p_r^M = w_r^M, q^* = l^*$) and the above assumptions, the price index and wage equation can now be expressed in more convenient form as.

$$G_r = \left[\sum_s \lambda_s (w_s T_{sr})^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$
$$w_r^M = \left[\sum_s Y_s T_{rs}^{\ 1-\sigma} G_s^{\sigma-1} \right]^{\frac{1}{\sigma}} \qquad (4.7)$$

The price index equation exhibits the price index effect. This means that the price index in r would tend to be lower if share of manufacturing in the region with low transports cost is high (Forward linkage).

Moreover, the nominal wage equation states that the nominal wage rate in region r would tend to be higher; the higher is income in other region with low transports cost to r (backward linkage).

Hence, location with higher manufacturing employment tends to offer higher real wage to manufacturing workers. The above two equations, therefore, make available a sign of manufacturing agglomeration. To gain further insights of these geography structures, the model is used in their specific form, i.e. the core periphery model.

The Core-periphery model and spatial economic structures

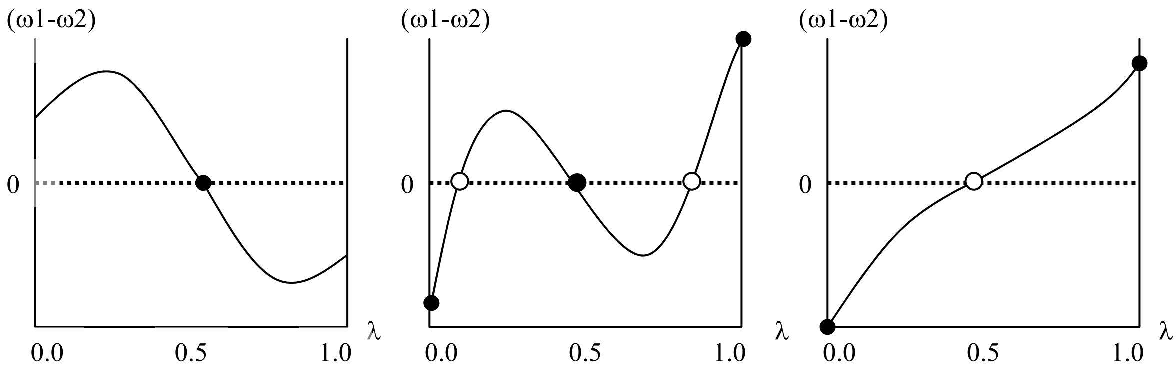
In core-periphery model, there are only two regions with agricultural sector are being divided evenly (Φ_r is ½ in each region.). The obvious question is whether manufacturing is equally divided between regions or concentrated in one region: that is whether the economy becomes divided between manufacturing core and agricultural periphery.

Let's denote λ as a region 1's share of manufacturing. Because the simultaneous equilibrium of each region consists of nonlinear equations, this paper finds the answers to the above question, or the economic geography implication of model, by analytical clarification below[1].

Figures (4.1a), (4.1b), (4.1c) are used to demonstrate how spatial structures depend upon the transportation cost. The vertical axis represents difference between two regions' real wage and the horizontal axis plots region 1's share of manufacturing. All three diagrams are drawn with different degrees of transport cost incurred between regions.

Figure 4.1

Relative wage and share of manufacturing sector by in Fujita M., P. Krugman, and A.J. Venables (1999)



(a) high transport cost (b) moderate transport cost (c) low transport cost

In case of high transport cost, wage differential is negatively correlated with share of manufacturing. That is, if the region has more than half the manufacturing labor force, its real wage is relatively lower and it is less attractive to work there. Accordingly, the economy converges to symmetric equilibrium with evenly divided manufacturing sector in long run.

The situation is opposite when we have low transport cost. The curve slopes strictly upward, which means that the higher is the share of manufacturing in either region, the more attractive that region will be. This positive relationship can be

[1]Clear algebraic results can be obtained from the model's equilibrium relationships. The condition under which the core-periphery pattern is possible (sustainable point) and condition under which it is necessary (break up point) can be calculated. The full explanations for that are in Chapter 5 Core and Periphery.

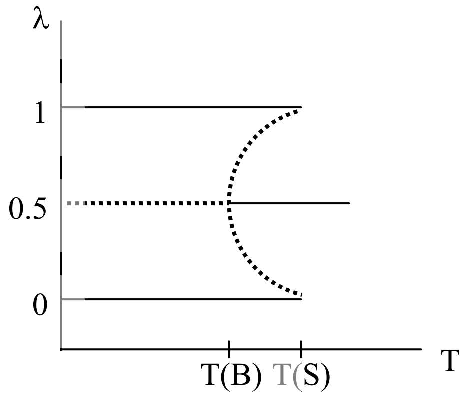
explained by the forward and backward linkage, put across in the last section. (The economy has increasing real wage as manufacturing sector becomes larger). Therefore, the equal-divided manufacturing equilibrium turns out to be unstable; the regions that have larger manufacturing sector will grow overtime at the same time as the other regions shrink, leading eventually to a core-periphery pattern with all manufacturing concentrating in one location.

Finally, for an intermediate transport cost case, there are 5 equilibriums determined from the model; three stable equilibriums (the symmetric equilibrium and the one where manufacturing concentrated in either region) and two unstable (symmetric equilibrium).

In total, the geographic structure of economy can be summarized as in figure 4.2, which plots connection between the share of manufacturing in region 1 and different levels of transport cost. At sufficiently high transportation cost, the unique stable equilibrium is symmetric equilibrium. Yet, as transport cost falls below some critical level (sustain point T(S)), new stable equilibrium with core-periphery pattern emerges. Finally, the symmetric equilibrium becomes unstable when transport cost falls further below some critical level (break-up point T(B)).

Figure 4.2

How types of equilibrium vary with transportation costs in Fujita M., P. Krugman, and A.J. Venables (1999)



CHAPTER 5

THE MODEL: THE SPECIFICATION AND PROBLEM SOLVING

The model exploited in this thesis is an extension of the NOEM model advanced by Sutherland (1996). With the same basic building block as the prototype NOEM model developed by Obstfeld and Rogoff (1995), Sutherland analyzes the effect of financial integration on the macroeconomic effect of economic policy with separated labor markets. In this paper, in stead, the model is built on the distinguishing assumption that labors are internationally mobile so that domestic firms can hire labors from foreign country and vise versa. By adding one more market integration into the model, thus allowing for the change in countries' size, the monetary shock could give rise to different patterns of macroeconomic volatilities and hence the implications of financial market integration on stabilization power of monetary policy could diverge.

Despite the above extension, the structure of the model in all other respects is rather standard to NOEM literatures. The world consists of two countries, home and foreign. Each country is populated by a continuum of infinitely-lived identical households. Households consume a group of differentiated goods produced in the world, demand money, and supply labor, which is the only factor of production. They have perfect foresight about the future and maximize lifetime utility intertemporally. Plus, households in each country own the respective identical firms. Firms in particular country are identical in the sense that they have the same technology and price. However, because of the consumers' preference for varieties and the unlimited number of potential varieties of goods, no firm would choose to produce the same variety supplied by another firms (This implies that a number of firms is equals number of product varieties). So, each firm sells a single differentiated product, indexed with z on the unity interval, in monopolistic competitive goods market and hires labors, supplied by consumers, in a perfect competitive integrated labor market with N^i denotes labors who reside within country i.

5.1 International Migration: The Simplifying Assumptions

Before going to show the specification of utility and constraint functions, it is valuable to note one point in passing here that the ability of consumers (or workers) to move across regions does have a major influence toward the way economic agents maximize their utility and the results of the model. Thus, to avoid complicating the model, a number of simplifying assumptions concerning labor migration are made in the following fashion:

First, let's assume that labors are homogeneous so that there is only one-way movement of labors. Without loss of generality, only the case of out migration of home residents into foreign is considered in this thesis. Still, as Thailand shows a migration transition by mid-1980s in that it has become both labor sending and receiving country-thank to a fast growth, this model can also be carried forward to the case of immigration from foreign. This could be well thought of as one of the possible extensions of the model.

Second, the decision to move is assumed irreversible. This certainly means that workers are allowed to migrate only once at some point in time $0<T<\infty$. To put it differently, the move is permanent so that the amount of effort labors want to supply will no longer change after period T. The basis for this is simply that there are noneconomic barriers blocking residents from moving across regions anytime but time T.

Third, to simplify further, it is assumed that T, time of migration, is fixed. Due to the deterministic nature of the model (our analysis has not allowed for uncertainty except for one-time monetary shocks), the agents have perfect foresight into the future. This implies that the pattern of monetary process is known for all agents in the model. Hence, contrasting to the model with uncertainty, T could be fixed at any point in time. Without loss of generality, let's assume that T be the first period in infinite time horizon.

Finally, so as to make the model less complicated, we make one last assumption that there is no optimal migration decision involved when labors consider resettling between the two nations. This unequivocally means that in our model labors can move between countries, but, the move is not going to be determined by the model. In particular, the number of population resided in each country are fixed at

$\bar{N}^H$ and $\bar{N}^F$ throughout all periods by the condition determined outside the model. The migration is, then, introduced by altering these exogenous amount of labor supplies in each nation at the initial equilibrium, i.e., increase in $\bar{N}^H = N_T^H$ and decrease in $\bar{N}^F = N_T^F$ in case of home labor emigration.

Accordingly, taken together, we have characterized the international labor migration as home labors moving to foreign country once by amount exogenously fixed at the beginning period, period T.

5.2 Consumers

5.2.1 Preferences

Individual consumers in both countries have the same preference defined over CES basket of goods, real money balances, and labor supply (number of labor, not the time spent on working). Each country's resident maximizes their country's aggregate[1] utility by deciding on the optimum amount of their own individual choice variables overtime.

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[1]The fact that individual maximizes a country's aggregate utility, in stead of his or her own individual utility may seem a little bit weird in a usual optimization exercise. However, the aggregate utility is essentially used here in order to allow for the impacts of total number of labor supply $\bar{N}^H$ on various economic variables through utility maximization. This is reflected by the last term in aggregate utility function. A change in a number of labors in each country will affect utility level and, thus, the various economic variables derived from its maximization. (Because each consumer supplies one unit of labor, no $\bar{N}^H$ do appear in case of individual utility). Therefore, we can set individual consumers problem as $\bar{N}^H Max U_t^H$ subject to a aggregate budget constraint $\bar{N}^H(spending) \leq \bar{N}^H(income)$.

Specifically, for domestic country, the aggregate lifetime[2] utility function is defined as

$$\text{Max} \sum_{i=1}^{\bar{N}^H} U_t^H = \bar{N}^H U_t^H = \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} \bar{N}^H \left(C_s^H\right)^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \bar{N}^H \left(\frac{M_s^H}{P_s}\right)^{1-\varepsilon} - \frac{\kappa}{\mu} \bar{N}^H \right]^{3} \quad (5.1)$$

where $0<\beta<1$, $\mu>1$, σ, $\varepsilon>0$. In the above equation, β is a fixed preference parameter, called the subjective discount factor, which measures the individual impatience to consume. High β means that consumers have preference toward future consumption (greater patience). Next, σ represents intertemporal elasticity of substitution, which denotes the sensitivity of intertemporal consumption allocation toward a change in interest rate. The higher is the value of σ, the more sensitive is the relative demand for consumption on different dates in response to change in rate of interest. Lastly, ε denotes an elasticity of substitution between consumption index and real balances, which could be interpreted as an inverse of elasticity of utility with respect to real balances and χ is preference parameter on real money balances or, simply, a weight of money demand in utility function.

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[2]The infinite horizon problem entails one methodological drawback that has to do with the convergence of the objective functional. The convergence problem takes place because the objective functional is improper integral, which may or may not have a finite value. In the case where the integral diverges, there may exist more than one path that yields an infinite value of the objective functional and it would be difficult to find which among these paths is optimal. The condition that is sufficient for the convergence of improper functional is that the integrand takes the form of $G(t,y,y')e^{-\rho t}$, where ρ is positive discount rate and the G is bounded. In the consumers decision-making problem described below, with discount factor and the assumption that utility is positive and has an upper bound, this transverality condition is satisfied and, thus, it follows that the infinite objective functional would definitely converge.

[3]This home aggregate intertemporal utility function is derived from sum of the utility of all domestic consumers of total $\bar{N}^H$.

With identical consumers, $\sum_{i=1}^{\bar{N}^H} U_t^H = \bar{N}^H U_t^H$

Since individual utility is given by

$$U_t^H = \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} \left(C_s^H\right)^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \left(\frac{M_s^H}{P_s}\right)^{1-\varepsilon} - \frac{\kappa}{\mu} (1)^{\mu} \right],$$

we have that

$$\sum_{i=1}^{\bar{N}^H} U_t^H = \bar{N}^H U_t^H = \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} \bar{N}^H \left(C_s^H\right)^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \bar{N}^H \left(\frac{M_s^H}{P_s}\right)^{1-\varepsilon} - \frac{\kappa}{\mu} \bar{N}^H \right]$$

The above period utility function involves three main decision variables. Each will be discussed in turn below.

The variable C is real consumption index of individual consumers. Much like most of the (open economy) Dixit-Stiglitz model, it is defined as CES aggregate over a continuum of differentiated, perishable domestic (h) and foreign goods (f) of total measure unity.

$$C^H = \left[\int_0^{\bar{n}} c^H(h)^{\frac{\theta-1}{\theta}} dh + \int_{\bar{n}}^1 c^H(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}} \tag{5.2}$$

where $\theta > 1$ denotes the elasticity of substitution between each individual goods and $c^H(z)$ is the consumption of goods z, z = h,f.

Consumption-base price index (price deflator for nominal money balance) is defined as the minimum aggregate[4] expenditures required in buying one unit of the aggregate consumption index, $\bar{N}^H C^H$. Given CES consumption index; consumption-base price index for home could be derived as

$$P^H = \left[\int_0^{\bar{n}} p^H(h)^{1-\theta} dh + \int_{\bar{n}}^1 \left[p^H(f) \right]^{1-\theta} df \right]^{\frac{1}{1-\theta}} \tag{5.3}$$

with the goods index between 0 and n are domestically produced (the rest are produced abroad), $p^H(h)$ is home currency price of goods h and $p^H(f)$ is home currency price of goods f. The mathematical procedures to calculate for this price index are in appendix B. Given that a total number of varieties on offer are one of the endogenous variables, it is important to understand the effects on consumers of change in n. The above price deflator formula gives a negatively correlated relationship between the P and n, simply because a larger proportion of a country's varieties would create a downward pressure on the price index. This, thus, makes that country a more attractive place for labors to stay. In addition, according to the above expression, home currency price of goods z and price index move in the same way, i.e. increase in $p^H(z)$ will lead to increase in P^H.

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[4]For the same reasons as in case of overall utility maximization problem (5.1), we employ the subutility maximization problem to find price index and individual demand for good z in aggregate level as well.

Next, people hold money in this model because real balance is an argument of utility function. The agents gain utility from both consumption and leisure. Real money balance enters utility function indirectly because it allows agent to save time in conducting their transactions; hence, enlarges the time for leisure. So, the above utility function could generally be considered as a derived utility function that includes real balances as they cut back the time agents spent transacting.

Note that households hold only the money issued by central bank of the country in which they reside. This fact clearly implies that currency substitution is not permitted in this model. The most realistic elaborated explanation for this no-currency-substitution is that the government imposes severe legal restrictions on the use of other type of currency, foreign or private. Without such restriction, government might have difficulty collecting seignorage revenue or controlling domestic price level[5].

Last but not least, with $\bar{N}^H$ stands for the number of workers who live in home and the total amount of labor supply, the final term in the period utility function captures the disutility home individual, as a whole, experiences from having to produce more output.

A foreign utility function is completely analogous to that of home and general pricing index for foreign can be derived accordingly.

5.2.2 The structure of goods market: pricing structure

To find a linkage between P^H and P^F, the model assumes no impediment to trade[6] so that law of one price holds for each individual goods. Given that E is nominal exchange rate termed as amount of domestic currency required to buy one unit of foreign currency, we have

[5]Our analysis does not require the ban on foreign currency use to be absolute. One can think of the domestic agents as being allowed to swap domestic currency for foreign currency within a period as needed to purchase instantly foreign goods or bonds. Similarly, foreign residents can acquire domestic currency to buy instantly domestic goods and bonds as well.

[6]Even though this model does not define the pattern of comparative advantage, the presence of imperfect competition (monopolistic competitive market) provides another type of distortion that creates a gain from trade, namely a procompetitive gain from trade and increased product varieties. The larger market made possible by international trade can support a larger number of firms and result in greater level of competition and product varieties.

$p^H(z) = Ep^F(z)$ where z = h,f (5.4)

Using the above relationship and provided that prices set by each firm in a country are identical, the price index (5.3) for domestic consumers is rewritten as

$$P_t^H = \left[\bar{n}p_t^H(h)^{1-\theta} + \left(1-\bar{n}\right)\left[E_t p_t^F(f)\right]^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

Similarly, foreign price index P^F is given by (5.5)

$$P_t^F = \left[\bar{n}\left[\frac{p^H(h)}{E_t}\right]^{1-\theta} + \left(1-\bar{n}\right)p^F(f)^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

In comparing P^H and P^F, we can see that home and foreign price index are related by purchasing power parity, given that home and foreign preference are identical (same θ).

$P^H = EP^F$ (5.6)

Thus, with identical preference across countries and law-of-one-price for each differentiated goods, PPP holds for aggregate price index of both countries.

5.2.3 The structure of financial market: international movement of funds

In addition to real balances, individuals hold domestic and foreign risk-free nominal bonds traded in financial market. The formation of international financial market is the same as in Sutherland (1996). The world financial market is not perfectly integrated. Such imperfection is signified by adjustment cost incurring when individual initiated capital movement across border. Whereas home households can adjust the holding of domestic bonds with no the transact cost, cross-border assets holdings are subject to the cost of adjustment. Likewise, foreign consumers get free access to foreign capital market while they incur intermediation cost when undertaking positions in international bond market. When deriving the optimal allocation of wealth between different kinds of assets, households need to take into account this imperfect harmonization in international bond market. Easing this cost of adjustment will speak for the process of increasing financial market integration.

There are many types of cost involved in trading in foreign financial market. Different costs will lead to different forms of adjustment cost function and, hence, different optimum dynamic behaviors of assets holding. Convex adjustment cost will tend to encourage consumers to spread the adjustment of asset stocks over a period of time with the optimal amount of adjustment related to the differential between yields on domestic and foreign bonds. Non-convexity, on the other hand, tends to cause a discontinuous adjustment with the end result of fewer movements in yield differential outside the range defined by trigger level. For the purposes of this paper, however, these differences in the form of cost have more or less the same implication because when the adjustment cost is large, the yield differential between domestic and foreign bonds will fluctuate over wide range and will not induce strong flow of funds between countries.

Followed Sutherland (1996), the adjustment cost is, therefore, assumed to be convex[7]. Let I_t^H depicts the level of funds transferred by home consumers from domestic to foreign bond market in period t. The intermediation costs, Z, of transacting in international asset market can be expressed as

$$\bar{N}^H Z_t^H = \frac{1}{2}\psi\left(\bar{N}^H I_t^H\right)^2 \tag{5.7}$$

where Z is in terms of composite goods and $\psi > 0$ mark a parameter that captures the degree of international capital mobility. The process of financial integration is represented by reducing the parameter ψ. By the same token, foreign transaction cost is, uniformly, assumed to be similar to that of home.

5.2.4 Budget constraint

As a closing stage to specification of consumers' problem, the individual budget constraint is presented. The only internationally traded asset is a riskless consumption-goods-denominated bond. This bond-only structure of the model is specified, not only for analytical convenience, but also because it is natural if one wants to provide microfoundations for Mundell-Fleming-Dornbusch setup. Under this assumption, the period budget constraint for domestic country is detailed, in aggregate, as,

[7]See Christiano and Eichenbaum (1992) for an example of a real business-cycle model, modified by introducing the convex cost of adjustment in consumption sector (cost involved in changing the purchasing of consumption goods) and see Jean-Olivier Hairault and Franck Portier (1993) for using a quadratic menu cost of adjustment in prices of goods in New-Keynesian model.

$$\bar{N}^H D_t^H = (1+i_{t-1}^H)\bar{N}^H D_{t-1}^H + \bar{N}^H M_{t-1}^H - \bar{N}^H M_t^H + w_t^H \bar{N}^H \\ - P_t^H \bar{N}^H C_t^H - P_t^H \bar{N}^H I_t^H - P_t^H \bar{N}^H Z_t^H + \bar{N}^H \Pi_t^H - P_t^H \bar{N}^H T_t^H \tag{5.8}$$

where D^H is the holding of domestic bonds, which pay nominal interest rate i^H, w is nominal wage, π is consumers' share of profit in domestic firms, and T is real tax paid to the domestic government (it is denominated in term of consumption aggregate, C^H, and could be negative in the event of money transfer). Similar expressions can be formed for foreign.

Indeed, the above intertemporal budget constraint gives us a country's current account, which is the change in value of its net claims on the rest of the world[8]. The current account is said to be in surplus if positive, so that economy as a whole is lending, and deficit if negative, so that the economy is borrowing.

Alternatively, a very useful way to interpret the preceding current account identity is to label it as national saving

$$\begin{aligned} CA_t^H &= \frac{P_t^H \bar{N}^H}{P_t^F}\left(F_t^H - F_{t-1}^H\right) \\ &= w_t^H \bar{N}^H + i_{t-1}^H \bar{N}^H D_{t-1}^H + \frac{P_t^H i_{t-1}^F \bar{N}^H}{P_t^F} F_{t-1}^H + \bar{N}^H \Pi_t^H \\ &- P_t^H \bar{N}^H C_t^H - \bar{N}^H\left(D_t^H - D_{t-1}^H\right) - \bar{N}^H\left(M_t^H - M_{t-1}^H\right) - P_t^H \bar{N}^H Z_t^H - P_t^H \bar{N}^H T_t^H = S_t^H \end{aligned}$$

Then, above equation states that in an economy without investment, national saving simply flows into net foreign asset accumulation.

Finally, the home consumers' foreign bond holding evolve according to

$$\bar{N}^H F_t^H = (1+i_{t-1}^F)\bar{N}^H F_{t-1}^H + P_t^F \bar{N}^H I_t^H \tag{5.9}$$

[8]This definition of a country's current account balance as the increase in its net claims on foreigners may seem puzzle if we think of current account as a country's net exports. However, remember that balance of payment statistics records a country's *sales* of asset to foreigners under its capital account. Because a payment is received from foreigners for any goods a country exports, every positive item in its net export is associated with an equal negative item in its capital account. As a pure matter of accounting, the net export surplus and the capital account surplus sum identically to zero. As such, the capital account surplus preceded by a minus sign-the net increase in foreign asset holding- equals the surplus in current account balance.

5.2.5 Utility maximization problem and first-order conditions

Not surprisingly, from the preference described above, the procedure to find an answer for dynamic optimality of macroeconomic variables is unlike Sutherland model where the labor market is not combined across regions. In Sutherland (1996), the model has unlimited or variable labor supply, not fixed by amount left not migrating. The individuals, resided in each country, thus, maximize the present value of their lifetime utility, with labor supply as one of the choice variables.

Here, in contrast, the number of domestic workers who stay and supply their labor in each country from beginning period and subsequent periods ($\bar{N}^H$ for home and $\bar{N}^F$ for foreign) are set, for the sake of simplicity, as discrete choice of some particular value. Thus, from first period onward, the underlying amount of labors supply in each country is no longer a decision variable in our analysis. With possibility that residents can relocate internationally, the maximization problem exercised by home households is, then,

$$\underset{\{C^H,D^H,M^H,F^H\}_{s=t}^{\infty}}{Max} \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} \bar{N}^H \left(C_s^H\right)^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \bar{N}^H \left(\frac{M_s^H}{P_s^H}\right)^{1-\varepsilon} - \frac{\kappa}{\mu} \bar{N}^H \right]$$

Subject to $\bar{N}^H D_t^H = (1+i_{t-1}^H)\bar{N}^H D_{t-1}^H + \bar{N}^H M_{t-1}^H - \bar{N}^H M_t^H + w_t^H \bar{N}^H$

$$- P_t^H \bar{N}^H C_t^H - P_t^H \bar{N}^H I_t^H - P_t^H \bar{N}^H Z_t^H + \bar{N}^H \Pi_t^H - P_t^H \bar{N}^H T_t^H \quad (5.10)$$

where $\bar{N}^H Z_t^H = \frac{1}{2}\psi\left(\bar{N}^H I_t^H\right)^2 \qquad t = t,.....,\infty$

$$\bar{N}^H F_t^H = (1+i_{t-1}^F)\bar{N}^H F_{t-1}^H + P_t^F \bar{N}^H I_t^H$$

$\bar{N}^H$ is given.

To find Euler equations corresponding to this consumer problem, the Lagrange function can be written as

$$L^H = \sum_{s=t}^{\infty} \beta^{s-t} \Bigg\{ \Bigg[\frac{\sigma}{\sigma-1} \bar{N}^H \left(C_s^H\right)^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \bar{N}^H \left(\frac{M_s^H}{P_s^H}\right)^{1-\varepsilon} - \frac{\kappa}{\mu} \bar{N}^H \Bigg]$$

$$+ \lambda_s^H \Big[(1+i_{s-1}^H) \bar{N}^H D_{s-1}^H - \bar{N}^H D_s^H + \bar{N}^H M_{s-1}^H - \bar{N}^H M_s^H + w_s^H \bar{N}^H - P_t^H \bar{N}^H C_s{}^H$$

$$- P_s^H \left(\frac{\bar{N}^H F_s^H}{P_s^F} - \frac{(1+i_{s-1}^F)\bar{N}^H F_{s-1}{}^H}{P_s^F} \right) - P_s^H \frac{1}{2} \psi \left(\frac{\bar{N}^H F_s^H}{P_s^F} - \frac{(1+i_{s-1}^F)\bar{N}^H F_{s-1}{}^H}{P_s^F} \right)^2$$

$$+ \bar{N}^H \Pi_s^H - P_t^H \bar{N}^H T_s^H \Big] \Bigg\}$$

The resulting first-order conditions with respect to $C_t^H, D_t^H, M_t^H, F_t^H$ are as follows;

$$C_{t+1}^H = C_t^H \left[\frac{P_t^H}{P_{t+1}^H} \beta (1+i_t^H) \right]^{\sigma} \qquad \text{where } t = t, ..., \infty \tag{5.11}$$

$$\frac{\chi \left(\frac{M_t^H}{P_t^H} \right)^{-\varepsilon}}{\left(C_t^H\right)^{-\frac{1}{\sigma}}} = \frac{i_t^H}{1+i_t^H} \tag{5.12}$$

$$\left(1+i_t^H\right)\left(1+\psi \bar{N}^H I_t^H\right) = \frac{E_{t+1}}{E_t}\left(1+i_t^F\right)\left(1+\psi \bar{N}^H I_{t+1}^H\right) \tag{5.13}$$

Appendix C contains the full description of steps in finding these equations.

Equation (5.11) is, of course, the standard consumption Euler equation. It has a simple interpretation: at utility maximum, the consumers cannot gain from feasible shifts of consumption between periods. In particular, one unit of reduction in consumption in first period lowers utility by $u'(C_t)$. The consumption unit thus saved can be converted into (1+r) units of next-period consumption that raise utility by $(1+r)\beta u'(C_{t+1})$.

In subutility maximization level, summarized in appendix B, given the CES consumption index, home consumers' individual demand for differentiated goods of each type can be derived compactly as

$$c_t^H(z) = \left[\frac{p_t^H(z)}{P_t^H} \right]^{-\theta} C_t^H, \qquad \text{where z=h,f} \tag{5.14}$$

Next, the optimal money demand schedule for home consumers is described in equation (5.12). It equates the marginal rate of substitution of composite consumption for real money balance (left-hand side) to the opportunity cost of holding real balances (right-hand side). Specifically, the right-hand side of equation (5.12) gives the user or rental cost, in term of consumption goods, of holding an extra unit of real balances for one period. To see this, think about the net consumption cost of buying one unit of real balance on date t and selling it on period t+1. By giving up a unit of consumption in period t, households acquire the Pt unit of currency equal to 1 unit of real balances. A unit of real balances carried over into period t+1 is devalued to only P_t / P_{t+1} unit by inflation and the present value of the remaining P_t / P_{t+1} unit of real balances is $\left(P_t / P_{t+1}\right)/\left(1+r_t\right)$. Consequently, on date t, the net cost of holding an extra unit of real balances of a period is $1-\left(P_t / P_{t+1}\right)/\left(1+r_t\right)$. This expression can be shown to be equal to $i_t / \left(1+i_t\right)$ by Fisher parity condition

$$1+i_{t+1}=(1+r_{t+1})\frac{P_{t+1}}{P_t} \tag{5.15}$$

Finally, equation (5.13) outlines the optimality condition representing the allocation of wealth between domestic and foreign bonds. In effect, it equates the real return on domestic and foreign bonds after adjusting for the cost of transferring funds between markets. To put it differently, the above condition asserts that when allowing for imperfect financial market integration, the no-arbitrage condition of uncovered interest rate parity includes the term accounting for the adjustment cost incurred when trading funds between markets. So, by this explanation, setting $\psi = 0$, when financial market are perfectly integrated, would reduce (5.13) to the standard uncovered interest parity condition.

$$1+i_t^H=\frac{E_{t+1}}{E_t}(1+i_t^F) \tag{5.16}$$

Analogously, for foreign country, the consumer’s decision-making problem and the set of first order condition can be obtained likewise.

5.3 Government Sector

Money is introduced into the economy by government. Assuming zero government consumption (This model abstracts from government purchase of consumption goods because the concentration of this study is devoted to monetary disturbance as macroeconomic policy effecting economic variables); the revenue earned (lost) from money creation (reduction) is returned in form of transfer (tax). The period-budget constraint for government can, then, be expressed as

$$T_t = \frac{(M_{t-1} - M_t)}{P_t}$$

In accordance with above equality, a money supply shock will lead to a corresponding change in T_t. Similar idea is also true for foreign.

5.4 Firms

5.4.1 Demand curve faced by monopolistic competitive firms and firms' profit

Let now turn to production side of economy. In monopolistic competitive market, firms, having some degree of monopoly power, are the price-setter and face a downward-sloping demand curve for their outputs. By integrating demand for goods z across all identical agents, total world demand for good z of an individual foreign firm takes constant-elasticity form[9]

$$y_t^F = \left[\frac{p_t^F}{P_t^F}\right]^{-\theta} Q_t, \qquad \text{where } t = t,...,\infty \tag{5.17}$$

where $Q_t = \bar{N}^H\left(C_t^H + Z_t^H\right) + \bar{N}^F\left(C_t^F + Z_t^F\right)$ is a aggregate world consumption. Two features in the above equality are worth mentioned. First, the analysis is shown only in term of foreign firms in order to match with the problem of consumers, who are the migrants to foreign. Similar investigation can be equivalently formulated for home firms. Second, equation (5.17) is obtained from the summation of home and foreign demand for good produced aboard after making use of (5.4) and (5.6), which imply that the real price of good z is the same at home and foreign, i.e.

$$y^F(f) = \left[\frac{p^H(f)}{P^H}\right]^{-\theta} \bar{N}^H\left(C^H + Z^H\right) + \left[\frac{p^F(f)}{P^F}\right]^{-\theta} \bar{N}^F\left(C^F + Z^F\right)$$

$$= \left[\frac{p^H(f)}{EP^F}\right]^{-\theta} \bar{N}^H\left(C^H + Z^H\right) + \left[\frac{p^F(f)}{P^F}\right]^{-\theta} \bar{N}^F\left(C^F + Z^F\right)$$

---

[9]Holding price index constant, the price elasticity of demand for every available varieties is constant and equal to θ.

$$= \left[\frac{p^F(f)}{P^F} \right]^{-\theta} \bar{N}^H \left(C^H + Z^H \right) + \left[\frac{p^F(f)}{P^F} \right]^{-\theta} \bar{N}^F \left(C^F + Z^F \right)$$

$$= \left[\frac{p^F(f)}{P^F} \right]^{-\theta} \left(\bar{N}^H \left(C^H + Z^H \right) + \bar{N}^F \left(C^F + Z^F \right) \right)$$

Note that because of the assumption that all firms in one region set the same price, the notation (z), which indicates the individual firm, is omitted.

For simplicity, all firms hire labors to produce differentiated products according to the same linear production technology. Hence, if we let $\bar{y}^F$ be outputs of each individual firm, $\bar{N}^F$ is total labor supply, and $\left(1-\bar{n}\right)$ is a number of varieties of firms in one location[10],

$$\bar{y}^F = \frac{\bar{N}^F}{(1-\bar{n})} \qquad \text{where } t = t, ..., \infty \tag{5.18}$$

Formally, firms produce its products with labors that are purchased competitively at a market clearing-flexible wage. The right hand side of above equation is total labor input for production of an individual good, which, in the economy with identical firms (having the same price, hence, output), is correspond to the total number of all workers in the region divided by total number of firms. As such, the above equality explicitly suggests that because all firms are identical, the quantities of output produced by each firm are equal to ratio of fixed aggregate labor supply to number of entire varieties.

Substituting for y_t^F give us

$$\left[\frac{p_t^F}{P_t^F} \right]^{-\theta} Q_t = \frac{\bar{N}^F}{(1-\bar{n})} \tag{5.19}$$

The above equation, in line with equation (5.3), puts into the picture how a number of varieties foreign produced $\left(1-\bar{n}\right)$ is correlated with price level (P_t^F). Apparently, from a quick look at the equation, price index would tend to be lower, the more diversification is the production sector. Therefore, given other thing being equal, a shift of production into one of the region, either home or foreign, would tend to

[10] Notice that, the number of varieties a country offers and output per firm, n and y, take only one value from the beginning and throughout the whole period.

increase the number of brands and lower the price index in that region, thus reflecting the negative relationship between the two variables.

Now, given all thing considered, period t profit of foreign firm is, therefore, given by

$$\begin{aligned}\frac{\pi_t^F}{P_t^F} &= \frac{p_t^F}{P_t^F} y_t^F - \frac{w_t^F}{P_t^F}\frac{\bar{N}^F}{(1-n_T)} \\ &= \frac{p_t^F}{P_t^F}\left[\frac{p_t^F}{P_t^F}\right]^{-\theta} Q_t - \frac{w_t^F}{P_t^F}\left[\frac{p_t^F}{P_t^F}\right]^{-\theta} Q_t\end{aligned} \qquad (5.19)$$

Demand for good offered by home and profit function of domestic firms can be formed in the same manner.

5.4.2 Aggregate output of domestic firms

Given individual firm's output (5.18), we can derive the aggregate output produced abroad, thus, aggregate labor demand as

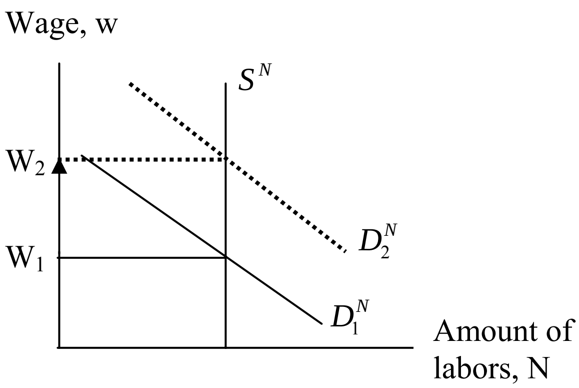
$$\bar{Y}^F = \left(1-\bar{n}\right)\bar{y}^F = \bar{N}^F \qquad \text{where } t = t, \ldots\ldots, \infty \qquad (5.20)$$

5.4.3 Price adjustment mechanism

This section explains how the individual firms in each country behave when they price their products. What is added into the model that makes the problem differs from that of Sutherland is, again, the international labor market integration. When making decision on how to price their products, home and foreign firms need to bear in mind the inelasticity in labor market occurred as amount of migration is initially determined. Not surprising, therefore, paralleling to the consumers case, the ability to move across border creates some changes, from Sutherland (1996), in the way to find pricing rule for firms in different countries.

To see this, let's take a look first at the basic natures that exemplify monopolistic competitive market. It appears that, as with monopoly, monopolistically competitive firms face downward sloping demand curves and, therefore, have, one way or another, the monopoly power. Still, this does not mean that these firms are likely to earn large chunks of profit. Plainly, monopolistic competition market is also similar to perfect competitive market by some certain means. To be more precise, there is free entry and exist, so that the potential to earn or loss profit will attract or discourage new firms with competing brands, and, as a result, drive a profit down to zero. Therefore, beside the specialization of each firms in a single differentiated product and monopoly power, the other key characteristic of monopolistic competitive market is, basically, free entry and free exit in response to profits and losses and, thus, the zero-profit of all firms in the market.

Additionally, for this existing model, the zero-profit-nature of monopolistic competitive firms seem to be even more obvious when economy has the inelastic labor supply curve, the feature that is emerged from the assumption of fixed labor supply. This is so because, in such situation, any price incentives to increase production will always be followed by corresponding rise in wage rate, which, in turn, drives down the profit to zero. As explained below diagram, owing to the exogenous fixed supply of labor, increase in consumers' demand of goods and price, hence, the firms' demand for labors would create an upward pressure in wage rate. Accordingly, as wage moves in accordance with price level, the sequential result is inevitably a reduction of firms' profit, until reaching zero level.



Therefore, along the lines of free entry and exit, the fixed choices of initial labor supply in each country essentially give rise to the adjustment mechanism with the prices and wages that would adjust freely until all firms have lifetime profit equal to zero.

5.4.4 Algebraic representation of pricing rule

From the functional form of firms' profit, together with specific structure of price adjustment mechanism explained above, foreign firms' problem definitely is

$$V_t^F = \sum_{s=t}^{\infty} R_{t,s} \left[\frac{p_T^F}{P_s^F} \left(\frac{p_T^F}{P_s^F} \right)^{-\theta} Q_s - \frac{w_s^F}{P_s^F} \left(\frac{p_T^F}{P_s^F} \right)^{-\theta} Q_s \right] = 0$$

where $R_{T,s}$ is discount factor between period t and s. Choosing p_t^F to correspond to the preceding equation gives us the following optimal condition for foreign firms:

$$p_s^F = w_s^F, \qquad where\ s = t, ..., \infty$$

As such, it is evident from the above expression that prices are flexibly adjust to equate wages level.

Notably, this fact that firms can change prices of their products continuously according to the wage rate they needed to pay implies positively the non-sticky price structure of the model. In effect, this pricing rule formation is in conflict to majority of the standard NOEM literatures, which assume sluggish price structure. In Obstfeld and Rogoff (1995), the nominal rigidity is introduced by preset nominal price. For Sutherland (1996), the underlying source of price stickiness is described by the discrete-time version of sticky price adjustment process, developed by Calvo (1983). In accordance with this process, the fact that firms can change prices of their products but only after time interval of random length does speak for the sluggish price structure of the model. However, in our case, providing that labor supply is inelastic, the attempt by firms to set price according to sticky price structure in long-run would ultimately create zero profit nevertheless. (This basically results from the firms' inability to increase price when wage is rising in response to excess of labor demand desired by firms over fixed supply. Under this situation, firms will eventually choose not to increase demand for labor, leaving the economy at the original zero-profit equilibrium in the long-run.) As a result, in term of firm's profit in long-run monopolistic competitive market with free entry, as long as the rigidity of labor supply arises, it does not really matter whether fixed and flexible price model is used. To make thing simpler, then, flexible-price arrangement is chosen in order to find implication of market integration on shock-induced volatility of macroeconomic variables from the model.

For home, firms' problem, again, resembles that of foreign.

$$V_t^H = \sum_{s=t}^{\infty} R_{t,s} \left[\frac{p_T^H}{P_s^H} \left(\frac{p_T^H}{P_s^H} \right)^{-\theta} Q_s - \frac{w_s^H}{P_s^H} \left(\frac{p_T^H}{P_s^H} \right)^{-\theta} Q_s \right] = 0$$

So, an equivalent expression can be drawn from the above equality for price charged by the individual domestic firms as

$$p_s^H = w_s^H, \qquad \text{where } s = t, ..., \infty$$

5.5 Equilibrium conditions

We may characterize the equilibrium of this two-country model as follows.

The equilibrium is defined here as a sequences of hme consumption index, consumption of individual differentiated products, price index, wage rate (individual price of each differentiated goods), exchange rate, interest rate, domestic and foreign bonds holdings, and amount of funds transferred, and all of their foreign counterparts that follow stochastic process such that:

(i) Given price index and initial labor supply, the stochastic process for $\left\{C_t^H,\ C_t^F, D_t^H, D_t^F,\ M_t^H,\ M_t^F, F_t^H,\ F_t^F\right\}_{t=t}^{\infty}$ solves the home and foreign aggregate consumers utility maximization problem. Therefore, the optimality conditions for consumption, domestic bonds holdings, money balances, and international funds transferred are satisfied.

(ii) The dynamic of consumption of an individual goods z, or $\left\{c_t^H(z),\ \mathrm{c}_t^F(z)\right\}_{t=t}^{\infty}$, where z = h and f, satisfies the home and foreign consumers' aggregate expenditure minimization problem subject to aggregate consumption index.

(iii) Given zero-profit condition, the optimality conditions for choice of price level $\left\{p_t^H \ and\ p_t^F\right\}_{t=t}^{\infty}$, set by domestic and foreign firms, are fulfilled at each time period.

(iv) The market for goods, bond, labor, and currency for both home and foreign country each clear each period[11].

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[11]Good market clearing condition is taken into account here by setting aggregate demand of good z, given by equation (5.17), equal to good z's aggregate supply, given by equation (5.18). In fact, we have seen this condition in equation (5.19). In addition, the market clearing condition for bond market is reflected in the consumer budget constraint, equation (5.8), which equates the aggregate demand for bonds to their aggregate supply represented by saving.

(v) Finally, both home and foreign consumers' and government's budget constraints, as well as the balance of payments equilibrium condition, must be realized.

5.6 Summary of the relationships from the model

In the last five sections, we described assumption underlying labor migration, drafted the first-order conditions for both consumers' and firms' problem, illustrated the governmental policy, and characterized the equilibrium conditions in the model with barrier in financial market and the possibility of labor relocations. These results and other important relationships from the model will be used as a crucial input in numerical simulation process. Therefore, to make discussion more comprehensible, all equations set out above for home and foreign are collected in Table 5.1 and 5.2 below.

As a final point, I go over again by summing up all relationships of various variables in the model in the flow chart 5.1. Left and right-hand-side diagram are drawn for the home residents (both consumers and firms) and foreign, respectively. The two countries are linked by the three international markets integration; output, bond, (as in Sutherland) and labor market. In the following diagrams, the connection in product market between the two countries is made palpable by the fact that change in current account in one country is going to translate into an opposite movement of current account recorded in the other. Moreover, the mobility in global capital market can be detected by the relationship between each country's asset returns, which consist of the interest rate differential minus expected change in exchange rate. As for labor market, the flow of labors between countries is shown by the ties between the labors supplied in each country (in this case, from home to foreign) and its influences via total number of varieties (hence, price) and via the amount of transactions in international bond market (thus, exchange rate). The integration in these markets, as will become known later on in the succeeding chapter, is expected to play roles in changing the volatility of all economic variables in response to monetary shock of both countries.

Table 5.1

Summary of model's optimum conditions

Equations		**Home**	**Foreign**
Consumer	Consumption	$C_{t+1}^H = C_t^H \left[\frac{P_t^H}{P_{t+1}^H} \beta (1+i_t^H) \right]^{\sigma}$ (5.1.1)	$C_{t+1}^F = C_t^F \left[\frac{P_t^F}{P_{t+1}^F} \beta \left(1+i_t^F\right) \right]^{\sigma}$ (5.1.2)
	Money balances	$\chi \left(\frac{M_t^{dH}}{P_t^H} \right)^{-\varepsilon} = \frac{i_t^H}{1+i_t^H} (C_t^H)^{-\frac{1}{\sigma}}$ (5.1.3)	$\chi \left(\frac{M_t^{dF}}{P_t^F} \right)^{-\varepsilon} = \frac{i_t^F}{1+i_t^F} (C_t^F)^{-\frac{1}{\sigma}}$ (5.1.4)
	Foreign assets	$\left(1+i_t^H\right)\left(1+\psi \bar{N}^H I_t^H\right) = \frac{E_{t+1}}{E_t}\left(1+i_t^F\right)\left(1+\psi \bar{N}^H I_{t+1}^H\right)$ (5.1.5)	$\left(1+i_t^F\right)\left(1+\psi \bar{N}^F I_t^F\right) = \frac{E_t}{E_{t+1}}\left(1+i_t^H\right)\left(1+\psi \bar{N}^F I_{t+1}^F\right)$ (5.1.6)
Firm	Pricing rule	$p_t^H = w_t^H$ (5.1.7)	$p_t^F = w_t^F$ (5.1.8)

Table 5.2

Summary of other related relationships from the model

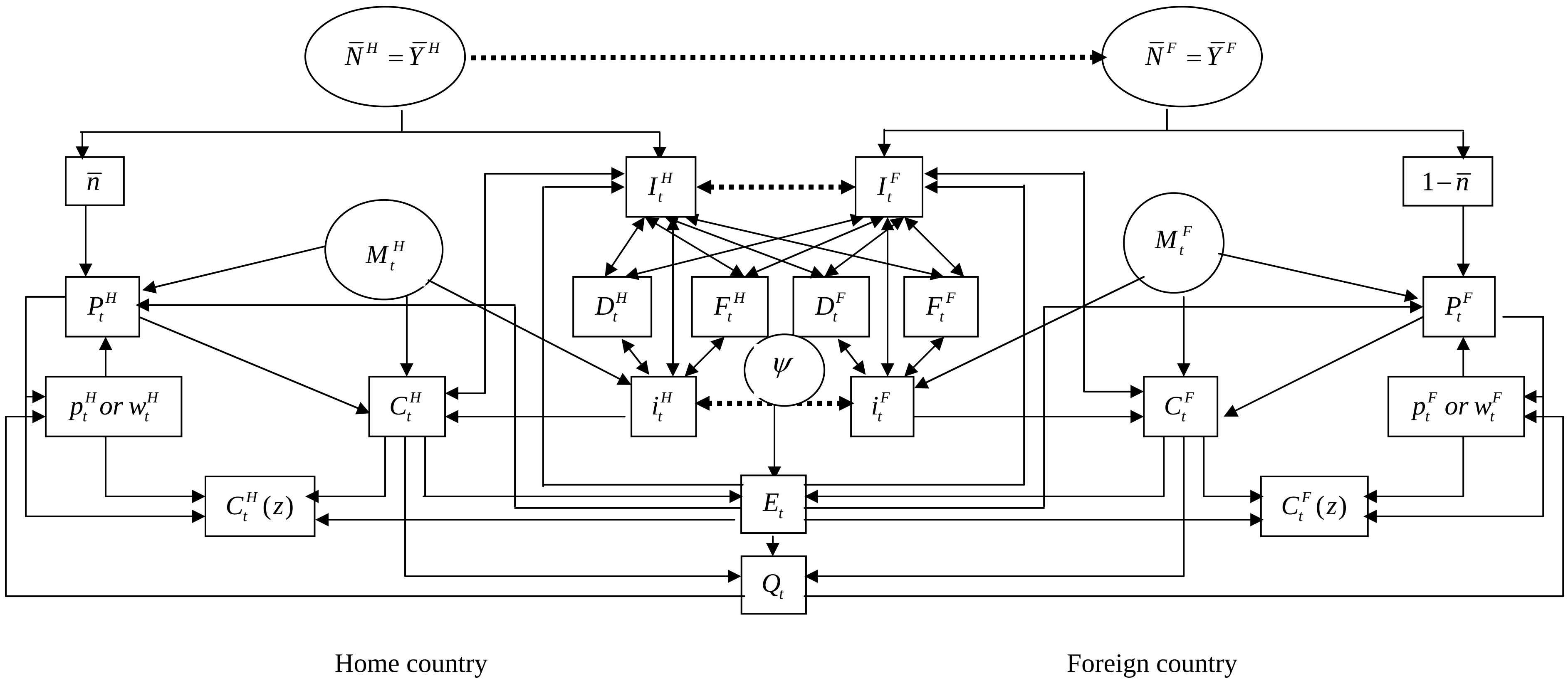
Equations	Home	Foreign
Budget constraint	$\bar{N}^H D_t^H = (1+i_{t-1}^H)\bar{N}^H D_{t-1}^H + \bar{N}^H M_{t-1}^H - \bar{N}^H M_t^H + w_t^H \bar{N}^H - P_t^H \bar{N}^H C_t^H - P_t^H \bar{N}^H I_t^H - P_t^H \bar{N}^H Z_t^H + \bar{N}^H \Pi_t^H - P_t^H \bar{N}^H T_t^H$ (5.2.1)	$\bar{N}^F F_t^F = (1+i_{t-1}^F)\bar{N}^F F_{t-1}^F + \bar{N}^F M_{t-1}^F - \bar{N}^F M_t^F + w_t^F \bar{N}^F - P_t^F \bar{N}^F C_t^F - P_t^F \bar{N}^F I_t^F - P_t^F \bar{N}^F Z_t^F + \bar{N}^F \Pi_t^F - P_t^F \bar{N}^F T_t^F$ (5.2.2)
Government budget constraint	$0 = P_t^H T_t^H + M_t^H - M_{t-1}^H$ (5.2.3)	$0 = P_t^F T_t^F + M_t^F - M_{t-1}^F$ (5.2.4)
Evolution of foreign bond holding	$\bar{N}^H F_t^H = (1+i_{t-1}^F)\bar{N}^H F_{t-1}^H + P_t^F \bar{N}^H I_t^H$ (5.2.5)	$\bar{N}^F D_t^F = (1+i_{t-1}^H)\bar{N}^F D_{t-1}^F + P_t^H \bar{N}^F I_t^F$ (5.2.6)
Adjustment cost	$\bar{N}^H Z_t^H = \frac{1}{2}\psi\left(\bar{N}^H I_t^H\right)^2$ (5.2.7)	$\bar{N}^F Z_t^F = \frac{1}{2}\psi\left(\bar{N}^F I_t^F\right)^2$ (5.2.8)
General price index	$P_t^H = \left[\bar{n} p_t^H(h)^{1-\theta} + (1-\bar{n})[E_t p_t^F(f)]^{1-\theta}\right]^{\frac{1}{1-\theta}}$ (5.2.9)	$P_t^F = \left[\bar{n}\left[\frac{p_t^H(h)}{E}\right]^{1-\theta} + (1-\bar{n}) p_t^F(f)^{1-\theta}\right]^{\frac{1}{1-\theta}}$ (5.2.10)
Current account identity	$\bar{N}^H I_t^H + \bar{N}^H I_t^F = 0$ (5.2.11)	
Individual demand for good z	$c_t^H(z) = \left[\frac{p_t^H(z)}{P_t^H}\right]^{-\theta} C_t^H$, (5.2.12, 5.2.13) where $z = h, f$ and $p_t^H(f) = E_t p_t^F(f)$	$c_t^F(z) = \left[\frac{p_t^F(z)}{P_t^F}\right]^{-\theta} C_t^F$ (5.2.14, 5.2.15) where $z = h, f$ and $p_t^F(h) = p_t^H(h)/E_t$

Table 5.2 (Continued)

World demand for goods z	$y_t^{dH} = \left[\frac{p_t^H(h)}{P_t^H}\right]^{-\theta} Q_t$ where (5.2.16) $Q_t = \bar{N}^H\left(C_t^H + Z_t^H\right) + \bar{N}^F\left(C_t^F + Z_t^F\right)$	$y_t^{dF} = \left[\frac{p_t^F(f)}{P_t^F}\right]^{-\theta} Q_t$ (5.2.17)
Labor market equilibrium condition	$\bar{y}^H = \frac{\bar{N}^H}{\bar{n}}$ or $\bar{Y}^H = (1-\bar{n})\bar{y}^H = \bar{N}^H$ (5.2.18)	$\bar{y}^F = \frac{\bar{N}^F}{(1-\bar{n})}$ or $\bar{Y}^F = (1-\bar{n})\bar{y}^F = \bar{N}^F$ (5.2.19)
Output market equilibrium condition	$y_t^{dH} = \bar{y}^H$ (5.2.20)	$y_t^{dF} = \bar{y}^F$ (5.2.21)
Money market equilibrium condition	$M_t^{dH} = M_t^{sH} = M_t^H$ (5.2.22)	$M_t^{dF} = M_t^{sF} = M_t^F$ (5.2.23)

Figure 5.1

Summary of the relationships of all home and foreign variables from the model



Note: - The three dash lines indicate three kinds of linkage between nations, namely inter-country migration of labor, international trade in goods, and global financial transaction in term of bonds.

- The circles signify the exogeniety of those variables they enclose.

CHAPTER 6

METHODOLOGY

Equipped with the mathematical model from last chapter, we are now ready to find the implications of the model according to our well-stated objectives. First, it must be emphasized that all models are, by nature, stylized and abstract. The usefulness of any theoretical model is in its application as a measuring device, much like a thermometer is in the physical sciences. By this definition, computational experiment is a useful tool since it is used to derive the quantitative implication of the economic theory. In what follows, quantitative properties based on the previous chapter's qualitative framework are investigated. It contains the step-by-step procedures in solving the nonlinear model in general (6.1), an explanation of different mix of experiments done for each market integration (6.2), description of shock (6.3), and how the proposed solution strategy is computationally conducted to find the dynamics of macroeconomic variables in our model (6.4).

6.1 Numerical Solution Method

With no closed-form solution scored from our nonlinear model, the dynamics of the model are investigated by simulating a calibrated version of the log-linear system numerically. In depth, to check out the implications of varying degrees of international capital and labor mobility, the idea is to replace the true nonlinear optimal conditions and other equations characterizing equilibrium with their loglinear approximations. The model then becomes a system of loglinear deterministic difference equations, which can be solved for linear rules that govern the vectors of endogeneous variables of interest. The solution algorithm used to calculate these linear solutions and simulate the calibrated log-linear model in this thesis is the method of undetermined coefficients, enlightened primarily by MaCallum (1983), John Y. Campbell (1994), and King, Plosser, and Rebelo (1987).

In fact, there are two main strands that have been developed for solving a nonlinear dynamic equilibrium model. On one side, followers of Kydland and

Prescott (1982) have extended the method to solve the model in its nonlinearity[1] while, on the other side, the linear approximation of the model is highlighted. Although numerical solution methods for solving nonlinear model have been studied widely in the literatures, the unpleasantly nonlinear system of difference equations is computational costly to deal with. As mentioned in Campbell (1994), the methods often seem to bear little relation to familiar techniques for solving economic dynamic model. For that reasons, an even larger number of literatures have used methods based on solving linear difference equations extensively. The key techniques here are the undetermined coefficient approach and the approach developed by Blanchard and Kahn (1995). Subject to applicability, all models relying on a log-linear approximation to the steady state have in common that they will find the same recursive equilibrium law of motion. But while Blanchard and Khan (1980) solves linear systems by searching for the unstable manifold and deriving the linear restrictions on vector of state variables for the entire system of equilibrium equations, the undetermined coefficient method, by contrast, solves directly for the desired equilibrium recursive law of motion. Because the stability condition is imposed at the point where a certain matrix quadratic equation is solved, the undetermined coefficient method, therefore, is considered natural. In addition, whereas Blanchard-Kahn approach seems clearer when the sunspot and self-fulfilling prophecies is introduced (the indeterminacy or multiple equilibrium model where there is no unstable root), undetermined coefficient method can easily accommodate the class of models which has the saddle-point steady state, hence, unique equilibrium path that leads economy back to the steady state (the number of greater-than-unity roots are equal to number of endogenous state variables). As studied by Farmer (1999), increasing returns to scale is a crucial assumption for indeterminacy equilibrium path converging to steady state. However, the model constructed in this thesis clearly does not establish this type of condition, i.e. firms have constant return to scale technology. Therefore, using undetermined coefficient method to solve for solution seems to be more straightforward.

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[1]The examples of other literatures which solve nonlinear dynamic model are Judd (1991), Hansen and Prescott (1995), and Danthine and Donaldson (1995)

To sum up, the general procedure to solve and analyze nonlinear dynamic model takes the following five steps

1) After deriving (nonlinear) first order conditions and other equations describing equilibrium, next step is to pick parameters.
2) Find steady states.
3) Log-linearize the necessary equations characterizing the equilibrium of the system to make the equations approximately linear in the log-deviations from the steady state.
4) Solve for recursive law of motion via the method of undetermined coefficients
5) Interpret the solution (the recursive law of motion) by using an impulse-response analysis or second-moment statistics.

Before going to explicitly apply the above steps to explore the properties of our calibrated log-linear approximated model, the broad discussion of the solution strategy in computing the linear decision rules in the fourth step is worth presented.

To begin with, it is convenient to first express log-linearized equilibrium relationships of all variables derived from step three in standard form. Let x_t be an endogenous state vector of size m×1, y_t is n×1 vector of other endogenous variables (control variables), and z_t is exogenous state vector, size k×1. The log-linearized equilibrium relationships are

$$\begin{aligned} 0 &= Ax_t + Bx_{t-1} + Cy_t + Dz_t & l\times 1 \\ 0 &= E[Fx_{t+1} + Gx_t + Hx_{t-1} + Jy_{t+1} + Ky_t + Lz_{t+1} + Mz_t] & p\times 1 \\ z_{t+1} &= Nz_t + \varepsilon_{t+1}; \qquad E\left(\varepsilon_{t+1}\right) = 0 & k\times 1 \end{aligned} \tag{6.1}$$

where x_t, y_t, z_t are denoted in terms of log-deviation from steady state of variables in period t and it is assumed that C is of size l×n and of rank n, F is of size p×n, p=(m+n-l), and N has only stable eigenvalue.

The above linear system of necessary conditions we staring at must be first-order conditions of some linear quadratic problem. Thus, it is a pretty good guess that the solution function will express current period endogenous variables as a linear function of the set of state variables of the model. What we are looking for is, then, the recursive equilibrium law of motion

$$x_t = Px_{t-1} + Qz_t$$
$$y_t = Rx_{t-1} + Sz_t \tag{6.2}$$

Since x, y, z are in forms of log-deviation, the entries in P, Q, R, and S can be interpreted as elasticities. The above two linear decision rules are characterized by two matrices. These two matrices can be understood by dividing up current period state variables into two sets. The first set, the endogenous state variables, includes variables which are predetermined at the beginning of current period, but are determined by model in some previous period. The second set, the exogenous state variables, comprises variables that are generated outside the model by some process. The first matrices considered in the solution strategy, feedback part P and R, are, then, the one that characterizes the impact of the lagged endogenous state variables on the current period endogenous variables and the second matrices, feedforward part Q and S, characterize the impact of the current period exogenous variables on current period endogenous variables. Our task is to find undetermined matrices P, R and Q, S such that the equilibrium described by these linear rules is consistent with log-linearized necessary conditions (6.1) and is stable.

Below, I entirely review a set of equations needed for the undetermined matrix P, Q, R, S to be satisfied. Plainly, the feedback matrices are derived from the zero of a particular matrix polynomial. Then, conditional on the feedback part, the feedforward part is the solution to a linear system of equations. After presenting these equations, I describe a strategy for solving them.

Theorem 6.1: Let C^0 be an (l-n)×l matrix, whose rows form a basis of the null space of C'[2] and C^+ be the pseudo-inverse of C[3].

If there is a recursive equilibrium law of motion (6.2) solving equations (6.1) , then the coefficient matrices can be found as follows.

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[2]C^0 can be found via the singular value decomposition of C' and $C^0C = 0$.

[3]The pseudo-inverse of a matrix C is the $n \times l$ matrix C^+ satisfying $C^+CC^+ = C^+$ and $CC^+C = C$. When matrix is not square or singular, pseudo-inverse has some, but not all, properties of normal inverse. Since it is assumed that $rank(C) \geq n$, one can get $C^+ = (C'C)^{-1}C'$.

1) P satisfies the (matrix) quadratic equations

$$0 = C^0 AP + C^0 B$$
$$0 = \left(F - JC^{+}A\right)P^2 - \left(JC^{+}B - G + KC^{+}A\right)P - KC^{+}B + H \qquad (6.3)$$

The equilibrium described by the equilibrium recursive law of motion is stable iff all eigenvalues of P are smaller than unity in absolute value.

2) R is given by

$$R = -C^{+}\left(AP + B\right) \qquad (6.4)$$

3) Given P and R, let V be the matrix

$$V = \begin{bmatrix} I_k \otimes A & I_k \otimes C \\ N' \otimes F + I_k \otimes \left(FP + JR + G\right) & N' \otimes J + I_k \otimes K \end{bmatrix}$$

Then, with vec(•) denotes columnwise vectorization.

$$V \begin{bmatrix} vec(Q) \\ vec(S) \end{bmatrix} = -\begin{bmatrix} vec(D) \\ vec(LN + M) \end{bmatrix} \qquad (6.5)$$

Obviously, if matrix V in this theorem is invertible, then multiplication of equation (6.5) with V^{-1} yields the unique solution for Q and S.

The approach explained here follows directly from Harald Uhlig (1997). Basically, the above conditions for finding the undetermined coefficients are derived from plugging equations (6.2) into equations (6.1) until only state variables remain and comparing the coefficients. The exact proof of above theorem can be found in page 35 of Uhlig (1997).

To solve for P that satisfies equations (6.3), here again, I make use of an algorithm formulated by Uhlig (1997). That is, we write equation (6.3) generally in the form of matrix-quadratic equation that can be solved by turning it into a generalized eigenvalue and eigenvector problem, for which most mathematical packages have preprogrammed routines. Recall that a generalized eigenvalue λ and eigenvector s of matrix Ξ with respect to matrix Δ are defined to be a vector and a value such that $\lambda \Delta s = \Xi s$. More commonly, the generalized eigenvector problem can be reduced to a standard one, if Δ is invertible, by calculating standard eigenvalues and eigenvectors for $\Delta^{-1}\Xi$.

Theorem 6.2: To solve the matrix-quadratic equation

$$\Psi P^2 - \Gamma P - \Theta = 0 \tag{6.6}$$

for the m×m matrix P, given m×m matrix Ψ, Γ, and Θ.

where $\Psi = \begin{bmatrix} 0_{l-n,m} \\ F - JC^{+}A \end{bmatrix}, \Gamma = \begin{bmatrix} C^{+}A \\ JC^{+}B - G + KC^{+}A \end{bmatrix}, \text{and } \Theta = \begin{bmatrix} C^{0}B \\ KC^{+}B - H \end{bmatrix}$

Define the 2m×2m matrices Ξ and Δ via

$$\Xi = \begin{bmatrix} \Gamma & \Theta \\ I_m & 0_{m,m} \end{bmatrix} \text{and } \Delta = \begin{bmatrix} \Psi & 0_{m,m} \\ 0_{m,m} & I_m \end{bmatrix}$$

If there are m generalized eigenvalues $\lambda_1,....,\lambda_m$ together with generalized eigenvectors $s_1,....s_m$ of Ξ with respect to Δ, written as $s_i = \begin{bmatrix} \lambda_i x_i' \\ x_i' \end{bmatrix}$ for some $x_i \in R^M$, and if $(x_1,....,x_m)$ is linearly independent, then

$$P = \Omega \Lambda \Omega^{-1}$$

is a solution to the matrix quadratic equation (6.6), where $\Omega = [x_1, \ldots, x_m]$ and $\Lambda =$ diagonal matrix with $\lambda_1, \ldots, \lambda_m$ as diagonal element. Proof: page 39 in Uhlig (1997).

The solution P is stable if $|\lambda_i| < 1, \forall i = 1,....,m$. (Note that only m λ and x is used to find m×m matrix P. They are chosen from 2m×2m diagonal matrix Λ and Ω after sorting its columns in ascending order.)

With matrix P in hand, it is possible to find R, Q, and S according to procedure clarified in theorem 5.1.

The preceding few paragraphs discussed the calculation of linear solution to a system of difference equations, step four. In practice, as mentioned in step five, the solution is used for two purposes, the computation of impulse response functions and the second moment properties[4] of the model. I briefly clarify these two issues in turn below.

[4]The second moment statistics could also be employed to make assessment of the model. In particular, we can make a comparison between the simulated moment statistics and the ones calculated from the actual data to determine goodness-of-fit of the model.

The results obtained, i.e. the recursive equilibrium law of motion

$$x_t = Px_{t-1} + Qz_t$$
$$y_t = Rx_{t-1} + Sz_t \qquad (6.7)$$
$$z_t = Nz_{t-1} + \varepsilon_t$$

can be used to examine model implications.

Impulse response function represents the response overtime of the elements of x_t, y_t and z_t to a pulse in one of the elements in ε_t. That is, let one element in ε_t be nonzero and the rest are zero. Suppose $\varepsilon_1 = 1$. The impulse response function to a particular shock ε1 can be calculated by setting $x_0 = 0, y_0 = 0, z_0 = 0$, as well as $\varepsilon_t = 0$ for $t \geq 2$ and recursively calculating z_t and then x_t and y_t, given $z_{t-1}, x_{t-1}, y_{t-1}$ and ε_t for $t = 1,....,T$ with the recursive equilibrium law of motion derived in (6.7).

There are two ways to compute the second moment. One works in time domain and the other works in frequency domain. Because of the properties of a small sample distribution, the time domain approach seems to be more preferable. The time domain approach is a modification on the method described above for computing the impulse response function. After drawing the sequences of ε_t, $t = 0,....,T$ from a random number generator, sequences z_t, x_t, and y_t for $t = 0,....,T$ can be computed using the law of motion in (6.7). Then, the second moment properties of interest could be computed from these sequences after the Hodrick-Prescott filter is applied. If T is very large, then the resulting second moments correspond to the population second moments implied by the model. Nevertheless, one might be, instead, interested in the small sample second moments and choose smaller value of T, say value that corresponds to the sample length available in a data set. In this case, the second moment described will exhibit Monete Carlo sampling variation. The standard way of dealing with this is to repeat the calculation many times with Monte Carlo draws of the ε_t and report the average of the second moment statistics across different Monte Carlo draws.

6.2 Combination of Experiments

The effects of exogenous shock to money supply on volatility of macroeconomic variables, namely consumption index, individual consumption of differentiated goods, general price index, wage, exchange rate, interest rate, amount of funds transferred, and domestic and foreign assets accumulation, are probed under four different combinations of financial and labor market integration. The analysis seeks to understand how different degrees of integration in financial and labor markets affect the behavior of these variables in propagation of shock and thus the stabilization power of a monetary policy.

Table 6.1

Combination of experiments conducted in this thesis

Combination of cases studied	Labor market integration	Financial market integration
Case1: Economy before labor migration with relatively high international mobility of capital	$N_T^H = N_T^F = 1$	$\psi = 2$
Case2: Economy before labor migration relatively low international mobility of capital		$\psi = 0.2$
Case3: Economy after labor migration with relatively high international mobility of capital	$N_T^H = 0.94$ $N_T^F = 1.06$	$\psi = 2$
Case4: Economy after labor migration with relatively low international mobility of capital		$\psi = 0.2$

Note: Chapter eight contains the results drawn from sensitivity analysis conducted for other values of ψ and $\overline{N}$.

In what follows, the effects of financial market integration are examined by looking at the different levels of barrier in making asset transactions across the border, i.e. by changing value of Ψ in the function described intermediary cost of transferring funds between the two countries. In standard case, the world with low degree of capital mobility is illustrated by Ψ = 2 and high by Ψ = 0.2. Along with this, the effects of labor market integration are inspected by changing the steady state value of fixed labor supply in each country. Since only the case of home emigration is considered, $\bar{N}^H$ falls from 1 to 0.94 and $\bar{N}^F$ rises from 1 to 1.06. This changing in value of N as domestic labors can move to work in offshore market represents the change in country sizes and interconnection between countries in terms of labor market integration. Overall, the four cases looked over in this thesis are shown in Table 6.1.

6.3 Shock

The simulating experiments are subjected to a shock in money supply. To learn about the dynamic behavior of endogenous variables of the model, money supply in both home and foreign country evolves according to the following stochastic process.

$$\hat{M}_t = \phi \hat{M}_{t-1} + \varepsilon_{m,t} \tag{6.8}$$

This paper resembles Sutherland (1996) and assumes the first-order autoregressive process from the beginning of period t to ∞. Hat over variable represents the deviations from initial steady state value. The coefficient ϕ gives the persistence of money supply process with the value ranging between 0 and 1 and $\varepsilon_{m,t}$ denotes a shock to money that is a serially uncorrelated stochastic disturbance term with mean zero and variance σ_m^2, $\varepsilon_{m,t} \sim iid\,(0, \sigma_m^2)$.

Following Sutherland (1996), the shock considered in this thesis is permanent and asymmetric. In the case of permanent shock, parameter ϕ is set at unity so the subsequent influences of shock still remain beyond the beginning period where the monetary shock hits economy. As pointed out in Sutherland (1996), the simulation experiments with temporary shock show only few qualitative differences when compared to permanent one. As such, only permanent shock is considered when simulating the model. Moreover, with respect to cross-country correlation of shock, asymmetric shock is assumed. The shock is asymmetric in that the domestic and foreign country are both affected by the same shocks but in the opposing way. In other words, the innovation terms in home and foreign money supply processes are negatively correlated, i.e., $\varepsilon_{1t} = 1$ and $\varepsilon_{2t} = -1$ for period $t = 1$. This assumption is made simply because a symmetric shock does not give rise to an international flow (at least in our model), hence, financial market integration would has no significant effect on the response to symmetric shock of economic variable from the model. Altogether therefore, monetary shock, used in finding the simulation results from our model, affect domestic variables through a 1 percent permanent increase while their foreign counterparts, simultaneously, undergo a permanent 1 percent decrease in money supply.

6.4 Computational Experiment: an Application of Undetermined Coefficient Method to Our Model

Now, let us return to the problem of solving for the dynamics in our variant NOEM model. This section addresses the solution-solving tasks of our model by method reviewed above. As stated in section 6.1, one needs to do five things:

6.4.1 Parameterization of the model

The first step is to calibrate the model to the stylized facts so that the abstract model mimics the real economy. These stylized facts are used to establish a correspondence between the real world and the model economy we intend to use as a measuring device. The calibrated parameters are given in Table 6.2. To make comparison with other papers in NOEM literatures, we conform as much as possible to the parameter choices made in this study. Actually, the parameter values used here are taken directly from Sutherland (1996), which are drawn for US economy.

Table 6.2

The calibrated parameters

Parameter	Description	Value
Beta β	Time preference parameter	1/1.05
Epsilon ε	Inverse of interest elasticity of real money demand	9.0
Sigma σ	Intertemporal elasticity of substitution	0.75
Theta θ	Intratemporal elasticity of substitution between differentiated product	6.0
Chi χ	Weight of real balances in the utility function	1.0

Most of these parameter values in Sutherland (1996) follow that of Hairault and Portier (1993), which has the same perfect information structure and models money demand in approximately the same way. In the case of money demand, as from Koenig (1990), the interest elasticity of real money balance is small but significantly different from zero on the US data. Therefore, ε or inverse of interest elasticity of real money demand is chosen to yield the same nominal interest rate elasticity of demand as in Hairault and Portier (1993), which is at the value of 1/9. (This value can also be interpreted as the elasticity of substitution between consumption index and real balance.)

Besides, Eichenbaum et al. (1988) showed that the intertemporal elasticity of substitution, σ, is between 1/3 and 2. Sutherland (1996) pursued the same value as of Hairault and Portier (1993) by setting it at 3/4.

Finally, for each differentiated product, θ is chosen be consistent to a steady state mark-up parameter (γ) as in Hairault and Portier (1993), i.e., $\theta=(1+\gamma)/\gamma$. Relying on Morrison (1989), this mark-up is given to be 0.197. Hence, θ is equal to 6.

6.4.2 Computation for steady state

In order to linearize the system, we need to find a well-defined steady state around which to approximate. This is the state, in which all variables grow at a constant common rate. The most convenient one, which is sufficient to establish the main points, corresponds to the case where all variables are constant.

This balanced growth path of the model or stationary state of economy can be found by imposing restrictions on every variable in the non-stochastic version of the model to have an unchanged value for all periods and solving for that value in terms of the specified parameters. Specifically, we derived from last chapter the dynamic properties of the model. As summarized in Table 5.1 and 5.2, it consists of the first order conditions and other related relationships that characterize dynamic equilibrium relationship. Dropping the time subscripts from all these equations, expressing them in terms of the model parameters, and assigned the value of the parameters set out in Table 6.2 will give us the value of variables at the steady state.

In general, there is no simple closed-form solution for the steady state, but one does exist when initial asset stocks are zero. Therefore, what we are looking for is the initial steady state where $\bar{D}^H, \bar{D}^F, \bar{F}^H, \bar{F}^F = 0$. After dropping the time subscribes from the equilibrium conditions in Table 5.1 and 5.2 and rearranging, the equations governing the steady state relationship of the model are as follows.

$$\bar{D}^H, \bar{D}^F, \bar{F}^H, \bar{F}^F, \bar{I}^H, \bar{I}^F, \bar{Z}^H, \bar{Z}^F, \bar{T}^H, \bar{T}^F = 0$$

$$\bar{i}^H = \bar{i}^F = \bar{r}^H = \bar{r}^F = \frac{(1-\beta)}{\beta}$$

$$\frac{\bar{M}^H}{\bar{P}^H} = \left(\frac{1-\beta}{\chi}\right)^{-\frac{1}{\varepsilon}} \left(\bar{C}^H\right)^{\frac{1}{\sigma\varepsilon}} \tag{6.9.1}$$

$$\frac{\bar{M}^F}{\bar{P}^F} = \left(\frac{1-\beta}{\chi}\right)^{-\frac{1}{\varepsilon}} \left(\bar{C}^F\right)^{\frac{1}{\sigma\varepsilon}} \tag{6.9.2}$$

$$\bar{p}^H = \bar{w}^H \tag{6.9.3}$$

$$\bar{p}^F = \bar{w}^F \tag{6.9.4}$$

$$\frac{\bar{w}^H}{\bar{P}^H} = \frac{\bar{C}^H}{\bar{N}^H} \tag{6.9.5}$$

$$\frac{\overline{w}^F}{\overline{P}^F} = \frac{\overline{C}^F}{\overline{N}^F} \tag{6.9.6}$$

$$\overline{P}^H = \left[\overline{n}\overline{p}^H(h)^{1-\theta} + (1-\overline{n})\left(\overline{E}\overline{p}^F(f)\right)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{6.9.7}$$

$$\overline{P}^F = \left[\overline{n}\left(\frac{\overline{p}^H(h)}{\overline{E}}\right)^{1-\theta} + (1-\overline{n})\left(\overline{p}^F(f)\right)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{6.9.8}$$

$$\overline{N}^H\overline{I}^H + \overline{N}^F\overline{I}^F = 0 \tag{6.9.9}$$

$$\overline{y}^H = \left[\frac{\overline{p}^H}{\overline{P}^H}\right]^{-\theta}\left(\overline{N}^H\overline{C}^H + \overline{N}^F\overline{C}^F\right) \tag{6.9.10}$$

$$\overline{y}^F = \left[\frac{\overline{p}^F}{\overline{P}^F}\right]^{-\theta}\left(\overline{N}^H\overline{C}^H + \overline{N}^F\overline{C}^F\right) \tag{6.9.11}$$

$$\overline{y}^H = \frac{\overline{N}^H}{\overline{n}} \text{ or } \overline{Y}^H = \overline{n}\overline{y}^H = \overline{N}^H \tag{6.9.12}$$

$$\overline{y}^F = \frac{\overline{N}^F}{(1-\overline{n})} \text{ or } \overline{Y}^F = (1-\overline{n})\overline{y}^F = \overline{N}^F \tag{6.9.13}$$

where $\overline{x}$ denotes the steady state value of variable x. The exact calculation is precisely discussed in Appendix D.

Now, to find value of the variables at their balanced growth path, we need to solve above the system of equations. The calculation of steady state is separated into two sets in order to see the effect of different degrees of openness in international labor market. One is the case where labors still reside in their native countries and the other is when they are allowed to migrate. Steady state number of each country labor supply captures the extent of international labor migration.

Case 1: Economy before international labor migration

To find the steady state relationship for this case, I assume that $\overline{N}^H = \overline{N}^F = 1$, which means that the proportion of labors resided in each country is equal at one. In this special case, the equilibrium is symmetric across the two countries implying that

$\overline{n} = 0.5$ and $\overline{p}^H(z)/\overline{P}^H = \overline{p}^F(z)/\overline{P}^F = 1$

The latter is true because the two countries have the same level of wealth. Given the above equalities, one could solve the system of equations underlining balanced growth path relationship in (6.9) by hand. In particular, substitute $\bar{N}$ and $\bar{n}$ into (6.9.12) and (6.9.13), one obtains the output per firm at steady state as

$$\bar{y}^H = \frac{\bar{N}^H}{\bar{n}} = \frac{1}{0.5} = 2$$

$$\bar{y}^F = \frac{\bar{N}^F}{(1-\bar{n})} = \frac{1}{0.5} = 2$$

Then, from the unity of real price at steady state, equation (6.9.3), (6.9.4), (6.9.5), and (6.9.6), we get that

$$\frac{\bar{w}^H}{\bar{P}^H} = \frac{\bar{C}^H}{\bar{N}^H} \rightarrow \frac{\bar{C}^H}{\bar{N}^H} = 1 \rightarrow \bar{C}^H = \bar{N}^H = 1$$

$$\frac{\bar{w}^F}{\bar{P}^F} = \frac{\bar{C}^F}{\bar{N}^F} \rightarrow \frac{\bar{C}^F}{\bar{N}^F} = 1 \rightarrow \bar{C}^F = \bar{N}^F = 1$$

Steady level of consumption of an individual in each country is equal to one. In fact, this result is also confirmed by (6.9.10) and (6.9.11).

Making use of equation (6.9.1) and (6.9.2), one can also solve for steady-state real balance as

$$\frac{\bar{M}^H}{\bar{P}^H} = \left(\frac{1-\beta}{\chi}\right)^{-\frac{1}{\varepsilon}} \left(\bar{C}^H\right)^{\frac{1}{\sigma\varepsilon}} = \left(\frac{1-(1/1.05)}{1}\right)^{-\frac{1}{\varepsilon}} = 1.402$$

$$\frac{\bar{M}^F}{\bar{P}^F} = \left(\frac{1-\beta}{\chi}\right)^{-\frac{1}{\varepsilon}} \left(\bar{C}^F\right)^{\frac{1}{\sigma\varepsilon}} = \left(\frac{1-(1/1.05)}{1}\right)^{-\frac{1}{\varepsilon}} = 1.402$$

Like labor supply, money supply is another exogenous variable that is determined outside the model. Here, the value is set to be equal to 1.402 in each country so that the resulting steady state value of price index in each country is equal to one.

Finally, from price index equation (6.9.7) or (6.9.8)

$$\bar{P}^H = \left[0.5\bar{p}^H(h)^{1-\theta} + 0.5\left(\bar{E}\bar{p}^F(f)\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

Since, at steady state, $\bar{p}^H(z)/\bar{P}^H = 1$,

$\bar{p}^H(h) = \bar{E}\bar{p}^F(f)$.

Thus, the steady state value of exchange rate is $\bar{E} = 1$.

In summary, the balance growth path of the economy before the international labor relocation satisfies

$\bar{N}^H = \bar{N}^F = 1$, $\bar{M}^H = \bar{M}^F = 1.402$

$\bar{n} = 0.5$, $\bar{y}^H = \bar{y}^F = 2$, $\bar{C}^H = \bar{C}^F = 1$,

$\bar{P}^H = \bar{P}^F = 1, \bar{p}^H = \bar{p}^F = 1, \bar{w}^H = \bar{w}^F = 1$, and $\bar{E} = 1$

Not surprisingly, in the economy where countries are symmetric, all consumers consume equally and all producers set the same price, wage, and output in equilibrium.

Case 2: Economy after international labor migration

To complete steady state computation task, we are now turning to the case where home agents emigrate. In this particular case, home labor supply is reduced to 0.94, making home a smaller country while foreign labor supply is raised to 1.06, making it a bigger country. Since the size of both countries is unequal, the initial steady state is no longer symmetric. Thus,

$\bar{n} \neq 0.5$ and $\bar{p}^H(z)/\bar{P}^H \neq \bar{p}^F(z)/\bar{P}^F \neq 1$.

These facts leave us with the difficulty in solving the above system of nonlinear equations (6.9) by hand. As a result, resorting to the command "fsolve" in MATLAB is necessary and doing so give us the following results:

$\bar{N}^H = N_T^H = 0.94, \bar{N}^F = N_T^F = 1.06, \bar{M}^H = 1, \bar{M}^F = 2$

$\bar{n} = n_T = 0.0151, \bar{y}^H = y_T^H = 62.0474, \bar{y}^F = y_T^F = 1.0687$

$\bar{C}^H = 0.5119, \bar{C}^F = 1.1397$,

$\bar{p}^H = 0.4217, \bar{p}^F = 1.4773, \bar{w}^H = 0.4185, \bar{w}^F = 1.4760$

$\bar{P}^H = 0.7689, \bar{P}^F = 1.3743$, and $\bar{E} = 0.5395$

The command lines can be found in Appendix E at the back of this thesis.

Obviously, the balance growth path of the economy does alter after the cross-border barriers in labor market are abandoned. To understand the reasons behind the above change in the steady state values, first take a look at the effect on n and y of shift in labor site. After the fall in home labor supply following the migration, the number of varieties domestic country produces, as you would expect, decline. (The opposite is true for foreign economy.) This changing range of varieties on offer, in turn, is very crucial when we come to determine the equilibrium number of output a firm produces. From equation (6.9.12) and (6.9.13), it says that as we increase the number of varieties, product market competition intensifies, shifting the demand curves for the existing product downward, and reducing the sales of these varieties. This why there are a corresponding rise and fall in a production of each domestic and foreign firm, respectively. From the above results, it becomes clear that the size of the market affects less on the markup of price over marginal cost and scale at which individual goods are produced. Normally, one would think that larger market implies that producers can take advantage by increase price over average cost or producing at larger scale. This class of Dixit-Stiglitz model says, however, that most of the scale effect works through changes in the varieties of goods available.

To understand how the balanced growth path of consumption changes, recall that the classic quantity theory of money holds in our flexible price and wage model. Therefore, as a result of downward (upward) movement in steady state output, money supply in home (foreign) country should be lower (higher). This pattern of change in money supply puts across two main results. First, it implies, from equation (6.9.1) and (6.9.2), that domestic consumption should be lower at steady state as well. To see this, note that the consumption opportunity cost of holding real balances does not change with N. As required by the optimal money demand schedule, marginal rate of substitution of composite consumption for real balances must, then, unchanged. Thus, in order to make this happen, a decrease in M must be compensated by a corresponding decrease in C for home. (Vice versa for foreign.) In addition, another important effect that the decrease in money supply in domestic economy as well as the increase in that of foreign have is that they also lead to a home (foreign) currency appreciation (depreciation), as witnessed by a lower value of steady state exchange rate.

Now consider the effect of change in $\bar{N}$ on nominal wage. Nominal wage tends to be higher if the demand for the product is high. In other word, firms can afford to pay higher wages if they have good access to a larger market. Consequently, given a lower (higher) consumption demand in home (foreign), a nominal wage falls in home country and rises in foreign country. Finally, the appreciation in the value of home currency will reduce home price index while drive foreign price index up, as seen in equation (6.9.7) and (6.9.8).

6.4.3 Log-linearization of necessary conditions charactering equilibrium around steady state

Outside the steady state, the model is a system of nonlinear equations. As mentioned in section 6.1, owing to the nonlinear cumbersome, the strategy is, instead, to look for an approximate solution by transforming the model into a system of log-linear difference equations. These resulting equations, both for home and foreign economy, would certainly form a system of equations which can be solved to yield the dynamic solution paths for all the variables of the model.

In this section, I develop the linear versions of all of the model's equilibrium conditions, summarized in Table 5.1 and 5.2. The linearization approach follows Campbell (1994), which applies the Taylor series approximation around the steady state to all the equations charactering equilibrium. By this way, the nonlinear equations are replaced by the system of linear functions with the variables that have a zero mean deviation from the steady state growth path.

Let $\hat{x}_t$ represents the time t log-deviation of variable x from the initial steady-state. The log-linearized calculation, summed up in Appendix F, gives the following equations in Table 6.3.[5] All the equations are categorized into expectation and deterministic equations to make it convenient to express the system in standard form (6.1) and, hence, to apply the computational experiment in the next section.

---

[5]Note that since we log linearize around the steady state, in which the home and foreign assets positions are zero, the log deviation of D_t, F_t, I_t is not defined. To correct this problem, therefore, I replace them by $\hat{D}_t$, $\hat{F}_t$, $\hat{I}_t$, defined as $\hat{D}_t = dD_t / d\overline{C}$, $\hat{F}_t = dF_t / d\overline{C}$, and $\hat{I}_t = dI_t / d\overline{C}$.

6.4.4 Calculation of the linear-approximated solutions by method of undetermined coefficient

Here, we process through step four of the computational experiment. Given all the equilibrium equations written as a set of first-order difference equations in state-space form, the model is ready to be solved. What we are searching for truthfully is the equilibrium recursive laws of motion that satisfies all these equations in Table (6.3). Let

$$x_t = \left[\hat{D}_t^H \; \hat{D}_t^F \; \hat{F}_t^H \; \hat{F}_t^F \; \hat{p}_t^H \; \hat{p}_t^F \right]$$

$$y_t = \left[\hat{C}_t^H \; \hat{C}_t^F \; \hat{P}_t^H \; \hat{P}_t^F \; \hat{I}_t^H \; \hat{I}_t^F \; \hat{i}_t^H \; \hat{i}_t^F \; \hat{E}_t^F \; \hat{w}_t^H \; \hat{w}_t^F \; \hat{c}_t^H(h) \hat{c}_t^F(f) \hat{c}_t^H(f) \hat{c}_t^F(h) \right]$$

$$z_t = \left[\hat{M}_t^H \; \hat{M}_t^F \right]$$

be vector of endogenous state variables, control variables (other endogenous variables), and exogenous variables (in terms of log-deviation) at time t, respectively.

Table 6.3

Collection of the Log-linearized equilibrium relationships

Expectation equation	Home	Foreign
Consumption Euler equation	$\hat{C}^{HH}_{t+1} - \hat{C}^{HH}_{t} - \sigma\hat{P}^{H}_{t} + \sigma\hat{P}^{H}_{t+1} - \sigma(1-\beta)\hat{i}^{H}_{t} \approx 0$ (6.10.1)	$\hat{C}^{F}_{t+1} - \hat{C}^{F}_{t} - \sigma\hat{P}^{F}_{t} + \sigma\hat{P}^{F}_{t+1} - \sigma(1-\beta)\hat{i}^{F}_{t} \approx 0$ (6.10.2)
Euler equation with respect to Foreign bond holding	$(1-\beta)\hat{i}^{H}_{t} + \psi\bar{N}^{H}\bar{C}^{H}\hat{I}^{H}_{t} - \hat{E}_{t+1} + \hat{E}_{t} - (1-\beta)\hat{i}^{F}_{t} - \psi\bar{N}^{H}\bar{C}^{H}\hat{I}^{H}_{t+1} \approx 0$ (6.10.3)	$(1-\beta)\hat{i}^{F}_{t} + \psi\bar{N}^{F}\bar{C}^{F}\hat{I}^{F}_{t} - \hat{E}_{t} + \hat{E}_{t+1} - (1-\beta)\hat{i}^{H}_{t} - \psi\bar{N}^{F}\bar{C}^{F}\hat{I}^{F}_{t+1} \approx 0$ (6.10.4)
Deterministic equation	Home	Foreign
Money market equilibrium condition	$\hat{P}^{H}_{t} - \hat{M}^{H}_{t} - \frac{\beta}{\varepsilon}\hat{i}^{H}_{t} + \frac{1}{\sigma\varepsilon}\hat{C}^{H}_{t} \approx 0$ (6.11.1)	$\hat{P}^{F}_{t} - \hat{M}^{F}_{t} - \frac{\beta}{\varepsilon}\hat{i}^{F}_{t} + \frac{1}{\sigma\varepsilon}\hat{C}^{F}_{t} \approx 0$ (6.11.2)
Pricing rule	$\hat{p}^{H}_{t} - \hat{w}^{H}_{t} \approx 0$ (6.11.3)	$\hat{p}^{F}_{t} - \hat{w}^{F}_{t} \approx 0$ (6.11.4)
Budget constraint	$\frac{\hat{D}^{H}_{t}}{\bar{P}^{H}} - \frac{1}{\bar{P}^{H}\beta}\hat{D}^{H}_{t-1} - \hat{w}^{H}_{t} + \hat{C}^{H}_{t} + \hat{I}^{H}_{t} + \hat{P}^{H}_{t} \approx 0$ (6.11.5)	$\frac{\hat{F}^{F}_{t}}{\bar{P}^{F}} - \frac{1}{\bar{P}^{F}\beta}\hat{F}^{F}_{t-1} - \hat{w}^{F}_{t} + \hat{C}^{F}_{t} + \hat{I}^{F}_{t} + \hat{P}^{F}_{t} \approx 0$ (6.11.6)
Evolution of foreign bond holding	$\hat{F}^{H}_{t} - \frac{1}{\beta}\hat{F}^{H}_{t-1} - \bar{P}^{F}\hat{I}^{H}_{t} \approx 0$ (6.11.7)	$\hat{D}^{F}_{t} - \frac{1}{\beta}\hat{D}^{F}_{t-1} - \bar{P}^{H}\hat{I}^{F}_{t} \approx 0$ (6.11.8)

Table 6.3 (Continued)

Purchasing power parity	$\hat{P}_t^H - \omega_1^H \hat{p}_t^H(h) - \omega_2^H \left[\hat{E}_t + \hat{p}_t^F(f)\right] \approx 0$ (6.11.9) where $\omega_1^H = \frac{\bar{n}\left(\bar{p}^H(h)\right)^{1-\theta}}{\left(\bar{P}^H\right)^{1-\theta}}$ and $\omega_2^H = \frac{(1-\bar{n})\left(\bar{E}\bar{p}^F(f)\right)^{1-\theta}}{\left(\bar{P}^H\right)^{1-\theta}}$	$\hat{P}_t^F - \omega_1^F \left[\hat{p}_t^H(h) - \hat{E}_t\right] - \omega_2^F \hat{p}_t^F(f) \approx 0$ (6.11.10) where $\omega_1^F = \frac{\bar{n}\left(\bar{p}^H(h)/\bar{E}\right)^{1-\theta}}{\left(\bar{P}^F\right)^{1-\theta}}$ and $\omega_2^F = \frac{(1-\bar{n})\left(\bar{p}^F(f)\right)^{1-\theta}}{\left(\bar{P}^F\right)^{1-\theta}}$
Current account identity	$\bar{N}^H \bar{C}^H \hat{I}_t^H + \bar{N}^F \bar{C}^F \hat{I}_t^F \approx 0$ (6.11.11)	
Individual demand for good z	$\hat{c}_t^H(h) + \theta \hat{p}_t^H(h) - \theta \hat{P}_t^H - \hat{C}_t^H \approx 0$ (6.11.12) $\hat{c}_t^H(f) + \theta\left(\hat{E}_t + \hat{p}_t^F(f)\right) - \theta \hat{P}_t^H - \hat{C}_t^H \approx 0$ (6.11.13)	$\hat{c}_t^F(h) + \theta\left(\hat{p}_t^H(h) - \hat{E}_t\right) - \theta \hat{P}_t^F - \hat{C}_t^F \approx 0$ (6.11.14) $\hat{c}_t^F(f) + \theta \hat{p}_t^F(f) - \theta \hat{P}_t^F - \hat{C}_t^F \approx 0$ (6.11.15)
World demand for goods z	$\hat{y}_t^{dH} + \theta \hat{p}_t^H - \theta \hat{P}_t^H - \frac{\bar{N}^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H\right) - \frac{\bar{N}^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F\right) \approx 0$ (6.11.16)	$y_t^F + \theta \hat{p}_t^F - \theta \hat{P}_t^F - \frac{\bar{N}^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H\right) - \frac{\bar{N}^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F\right) \approx 0$ (6.11.17)
Labor market equilibrium condition	$\hat{y}_t^H \approx 0$ or $\hat{Y}_t^H \approx 0$ (6.11.18)	$y_t^F \approx 0$ or $\hat{Y}_t^F \approx 0$ (6.11.19)
Output market equilibrium condition	$\theta \hat{p}_t^H - \theta \hat{P}_t^H - \frac{\bar{N}^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H\right) - \frac{\bar{N}^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F\right) \approx 0$ (6.11.20)	$\theta \hat{p}_t^F - \theta \hat{P}_t^F - \frac{\bar{N}^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H\right) - \frac{\bar{N}^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F\right) \approx 0$ (6.11.21)

Postulate the hypothesized decision rules, which explain all the current period endogenous variables to a set of all state variables, as

$$
\begin{aligned}
x_t &= Px_{t-1} + Qz_t \\
y_t &= Rx_{t-1} + Sz_t \\
z_t &= Nz_{t-1} + \varepsilon_t
\end{aligned}
\qquad (6.12)
$$

$$
\begin{bmatrix} \hat{D}_t^H \\ \hat{D}_t^F \\ \hat{F}_t^H \\ \hat{F}_t^F \\ \hat{p}_t^H \\ \hat{p}_t^F \end{bmatrix}
=
\begin{bmatrix}
\eta_{D1}^H & \eta_{D2}^H & \eta_{D3}^H & \eta_{D4}^H & \eta_{D5}^H & \eta_{D6}^H \\
\eta_{D1}^F & \eta_{D2}^F & \eta_{D3}^F & \eta_{D4}^F & \eta_{D5}^F & \eta_{D6}^F \\
\eta_{F1}^H & \eta_{F2}^H & \eta_{F3}^H & \eta_{F4}^H & \eta_{F5}^H & \eta_{F6}^H \\
\eta_{F1}^F & \eta_{F2}^F & \eta_{F3}^F & \eta_{F4}^F & \eta_{F5}^F & \eta_{F6}^F \\
\eta_{p1}^H & \eta_{p2}^H & \eta_{p3}^H & \eta_{p4}^H & \eta_{p5}^H & \eta_{p6}^H \\
\eta_{p1}^F & \eta_{p2}^F & \eta_{p3}^F & \eta_{p4}^F & \eta_{p5}^F & \eta_{p6}^F
\end{bmatrix}
\begin{bmatrix} \hat{D}_{t-1}^H \\ \hat{D}_{t-1}^F \\ \hat{F}_{t-1}^H \\ \hat{F}_{t-1}^F \\ \hat{p}_{t-1}^H \\ \hat{p}_{t-1}^F \end{bmatrix}
+
\begin{bmatrix}
\rho_{D1}^H & \rho_{D2}^H \\
\rho_{D1}^F & \rho_{D2}^F \\
\rho_{F1}^H & \rho_{F2}^H \\
\rho_{F1}^F & \rho_{F2}^F \\
\rho_{p1}^H & \rho_{p2}^H \\
\rho_{p1}^F & \rho_{p2}^F
\end{bmatrix}
\begin{bmatrix} \hat{M}_t^H \\ \hat{M}_t^F \end{bmatrix}
$$

$$
\begin{bmatrix} \hat{C}_t^H \\ \hat{C}_t^F \\ \hat{P}_t^H \\ \hat{P}_t^F \\ \hat{I}_t^H \\ \hat{I}_t^F \\ \hat{i}_t^H \\ \hat{i}_t^F \\ \hat{E}_t \\ \hat{w}_t^H \\ \hat{w}_t^F \\ \hat{c}_t^H(h) \\ \hat{c}_t^F(f) \\ \hat{c}_t^H(f) \\ \hat{c}_t^F(h) \end{bmatrix}
=
\begin{bmatrix}
\eta_{C1}^H & \eta_{C2}^H & \eta_{C3}^H & \eta_{C4}^H & \eta_{C5}^H & \eta_{C6}^H \\
\eta_{C1}^F & \eta_{C2}^F & \eta_{C3}^F & \eta_{C4}^F & \eta_{C5}^F & \eta_{C6}^F \\
\eta_{P1}^H & \eta_{P2}^H & \eta_{P3}^H & \eta_{P4}^H & \eta_{P5}^H & \eta_{P6}^H \\
\eta_{P1}^F & \eta_{P2}^F & \eta_{P3}^F & \eta_{P4}^F & \eta_{P5}^F & \eta_{P6}^F \\
\eta_{I1}^H & \eta_{I2}^H & \eta_{I3}^H & \eta_{I4}^H & \eta_{I5}^H & \eta_{I6}^H \\
\eta_{I1}^F & \eta_{I2}^F & \eta_{I3}^F & \eta_{I4}^F & \eta_{I5}^F & \eta_{I6}^F \\
\eta_{i1}^H & \eta_{i2}^H & \eta_{i3}^H & \eta_{i4}^H & \eta_{i5}^H & \eta_{i6}^H \\
\eta_{i1}^F & \eta_{i2}^F & \eta_{i3}^F & \eta_{i4}^F & \eta_{i5}^F & \eta_{i6}^F \\
\eta_{E1} & \eta_{E2} & \eta_{E3} & \eta_{E4} & \eta_{E5} & \eta_{E6} \\
\eta_{w1}^H & \eta_{w2}^H & \eta_{w3}^H & \eta_{w4}^H & \eta_{w5}^H & \eta_{w6}^H \\
\eta_{w1}^F & \eta_{w2}^F & \eta_{w3}^F & \eta_{w4}^F & \eta_{w5}^F & \eta_{w6}^F \\
\eta_{ch1}^H & \eta_{ch2}^H & \eta_{ch3}^H & \eta_{ch4}^H & \eta_{ch5}^H & \eta_{ch6}^H \\
\eta_{cf2}^F & \eta_{cf2}^F & \eta_{cf3}^F & \eta_{cf4}^F & \eta_{cf5}^F & \eta_{cf6}^F \\
\eta_{cf2}^H & \eta_{cf2}^H & \eta_{cf3}^H & \eta_{cf4}^H & \eta_{cf5}^H & \eta_{cf6}^H \\
\eta_{ch2}^F & \eta_{ch2}^F & \eta_{ch3}^F & \eta_{ch4}^F & \eta_{ch5}^F & \eta_{ch6}^F
\end{bmatrix}
\begin{bmatrix} \hat{C}_{t-1}^H \\ \hat{C}_{t-1}^F \\ \hat{P}_{t-1}^H \\ \hat{P}_{t-1}^F \\ \hat{I}_{t-1}^H \\ \hat{I}_{t-1}^F \\ \hat{i}_{t-1}^H \\ \hat{i}_{t-1}^F \\ \hat{E}_{t-1} \\ \hat{w}_{t-1}^H \\ \hat{w}_{t-1}^F \\ \hat{c}_{t-1}^H(h) \\ \hat{c}_{t-1}^F(f) \\ \hat{c}_{t-1}^H(f) \\ \hat{c}_{t-1}^F(h) \end{bmatrix}
+
\begin{bmatrix}
\rho_{C1}^H & \rho_{C2}^H \\
\rho_{C1}^F & \rho_{C2}^F \\
\rho_{P1}^H & \rho_{P2}^H \\
\rho_{P1}^F & \rho_{P2}^F \\
\rho_{I1}^H & \rho_{I2}^H \\
\rho_{I1}^F & \rho_{I2}^F \\
\rho_{i1}^H & \rho_{i2}^H \\
\rho_{i1}^F & \rho_{i2}^F \\
\rho_{E1} & \rho_{E2} \\
\rho_{w1}^H & \rho_{w2}^H \\
\rho_{w1}^F & \rho_{w2}^F \\
\rho_{ch1}^H & \rho_{ch2}^H \\
\rho_{cf1}^F & \rho_{cf1}^F \\
\rho_{cf1}^H & \rho_{cf1}^H \\
\rho_{ch1}^F & \rho_{ch1}^F
\end{bmatrix}
\begin{bmatrix} \hat{M}_t^H \\ \hat{M}_t^F \end{bmatrix}
$$

$$
\begin{bmatrix} \hat{M}_t^H \\ \hat{M}_t^F \end{bmatrix}
=
\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}
\begin{bmatrix} \hat{M}_{t-1}^H \\ \hat{M}_{t-1}^F \end{bmatrix}
+
\begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}
$$

The crux of the matter in the solution method undertaken in this thesis is, as the name tells, to solve for all the undetermined coefficients, η. To learn all about the underlying dynamics of the model, all the unknown coefficients in above coefficient matrix, P, Q, R, and S, are yet to be solved. Formally, one needs to substitute the postulated law of motion into the log-linerized equations until only x_{t-1} and z_t remain and compare coefficients. Without delaying the time to evaluate the answer, nonetheless, the results can be found directly by employing the formulas in Theorem 6.1. Specifically, equations (6.3) are first solved to obtain matrix P. According to theorem (6.2), this coefficient-finding problem is reduced to one of solving a matrix-quadratic equation charactering solution by generalized eigenvalue problem. The numerical values of the eigenvalues and eigenvectors of the transition matrix are calculated and the solution is shaped by writing the set of stable eigenvalues and eigenvector in a diagonalized form. Then, given matrix P, matrix R is obtained by substituting matrix P into formula (6.4) and matrix Q and S are, later, generated from formula (6.5).

Yet, as stated in Uhlig (1997), *"In looking back, we can also see that finding the necessary conditions, finding the steady state, as well as log-linearizing these conditions and constraints was comparatively easy. Painful, however, was to have to solve for v_{kk} and other coefficients [the undetermined coefficients]. For larger model or, worse, for model with multiple endogenous state variables, solving for everything by hand looks quite unattractive."* Therefore, in the course of deriving all the solutions, I basically make use of the computer program written by Harald Uhlig. On the whole, I employ the MATLAB program to carry out all the calculations for matrix P, Q, R, and S. To find out all the coefficients, the coefficient matrixes in the system of log-linearized equilibrium conditions are spelled out and all the formulas are written down in accordance with what are stated in theorem 6.1 and theorem 6.2. The below paragraph is the detailed summary of such corresponding commanding lines described in solve.m of Uhlig's toolkit file.

```
% VERSION 4.0, November 2002, COPYRIGHT H. UHLIG.(SOLVE.M)

% This M-file solves for the linear decision rules that satisfy the system
% of equilibrium conditions, which is assumed to be of the form
% 0 = AA x(t) + BB x(t-1) + CC y(t) + DD z(t)
% 0 = E_t [FF x(t+1)+GG x(t)+HH x(t-1)+JJ y(t+1)+KK y(t)+LL z(t+1)+MM z(t)]
% z(t+1) = NN z(t) + epsilon(t+1) with E_t [ epsilon(t+1) ] = 0,
% where x(t) is the endogenous state vector,
%       y(t) the vector of other endogenous variables and
%       z(t) the exogenous state vector.

% The program solves for the equilibrium law of motion
% x(t) = PP x(t-1) + QQ z(t)
% y(t) = RR x(t-1) + SS z(t).
% To use this program, we first have to define the matrices AA, BB, .., NN.
% then this M-file will calculates PP, RR, QQ, and SS.


%-------------------------------------- The matrix-quadratic equations ------------------------------------%
%                      (derived from substituting recursive law of motions                %
%                 into the linearized equations and comparing the coefficients)           %

l_equ = 17;             % Number of deterministic equations
m_state = 7;            % Number of endogenous state variables
n_endo = 17;            % Number of other endogenous variables
k_exo = 2;              % Number of exogenous variables
CC_plus = pinv(CC);  % Pseudo inverse of matrix C
CC_0 = (null(CC'))';    % Matrix, whose row form a basis of the null space of C'

Psi_matrix      = [      zeros(l_equ-n_endo,m_state)
                              FF - JJ*CC_plus*AA              ];
Gamma_matrix  = [                  CC_0 * AA
                   JJ*CC_plus*BB - GG + KK*CC_plus*AA  ];
Theta_matrix     = [                  CC_0 * BB
                              KK*CC_plus*BB - HH           ];

%---------------------------- Finding for P: Solve the matrix-quadratic equations ---------------------%
%                     by reducing it to a generalized eigenvalue problem                  %

Xi_matrix     = [    Gamma_matrix, Theta_matrix
                       eye(m_state), zeros(m_state)     ];
Delta_matrix = [          Psi_matrix, zeros(m_state)
                    zeros(m_state), eye(m_state)       ];

[Xi_eigenvec, Xi_eigenval] = eig(Xi_matrix,Delta_matrix);
%Produce 2mx2m diagonal matrix Xi_eigenval of generalized eigenvalue and
%Matrix Xi_eigenvec whose columns are the corresponding eigenvector so
%that lamda*Delta_matrix*s=Xi_matrix*s

[Xi_sortabs, Xi_sortindex] = sort(abs(diag(Xi_eigenval)));
%Give 2mx1 Xi_sortindex vector of numbers between 1 to 2m (permutation vector)
%and 2mx1 vector of abs of eigenvalues in assending order
%Xi_sortabs=abs(diag(Xi_eigenval))(Xi_sortindex)

Xi_sortvec = Xi_eigenvec(1:2*m_state,Xi_sortindex);
%Matrix 2mx2m of Xi_eigenvec with columns order according to Xi_sortindex
```

```
Xi_sortval = diag(Xi_eigenval(Xi_sortindex, Xi_sortindex));
%Vector 2mx1 of eigenvalues from Xi_eigenval
%with each element order according to Xi_sortindex
%(what we get is eigenvalues in assending order or Xi_sortabs)

Xi_select = 1:m_state;   %Vector 1 to m

Omega_matrix = [Xi_sortvec((m_state+1):(2*m_state),Xi_select)];
%mxm matrix of eigenvectors
%(formed by row m+1 to last row of first m columns of Xi_sortvec)

Lambda_matrix = diag(Xi_sortval(Xi_select));
%mxm diagonal matrix of eigenvalues
%(with diagonal as the first m row of Xi_sortval---from smallest numbers)

PP = Omega_matrix*Lambda_matrix*inv(Omega_matrix)
%Diagonalized solution of the matrix-quadratic equation

% VERSION 4.0, November 2002, COPYRIGHT H. UHLIG.(CALC_QRS.M)

%------------------------------------------------------ Finding for R ---------------------------------------------%

RR = -CC_plus*((AA*PP)+BB)

%-------------------------------------------------- Finding for Q and S ----------------------------------------%

VV = [                                    kron(eye(k_exo),AA),   kron(eye(k_exo),CC)
   kron(NN',FF)+kron(eye(k_exo),(FF*PP)+(JJ*RR)+GG),   kron(NN',JJ)+kron(eye(k_exo),KK)
];
%(lk+pk)x(km+kn)matrix

LLNN_plus_MM = (LL*NN)+MM;

TT = [ DD(:); LLNN_plus_MM(:) ];
%(lk+pk)x1 vector of all elements of DD and LLNN+MM written as a single column

QQSS_vec = -inv(VV) * TT;
%(km+kn)x(lk+pk) matrix multiply (lk+pk)x1 vector = vector(km+kn)x1

QQ = reshape(QQSS_vec(1:(m_state*k_exo)),m_state,k_exo)
% mxk matrix QQ whose elements are taken columnwise
% from vector QQSS_vec (element 1 to mk)

SS = reshape(QQSS_vec(((m_state*k_exo)+1):((m_state+n_endo)*k_exo)),n_endo,k_exo)
% nxk matrix SS whose elements are taken columnwise
% from vector QQSS_vec (element mk+1 to mk+nk)
```

What we get from the above procedures is the value to all undetermined coefficients in the linear-approximated law of motion as needed.[6] Here is the description of all of the results

Table 6.4

The assigned value of the undetermined coefficients in linear-approximated solution

Case 1: Economy before international labor migration

Degree of capital mobility: High ($\psi = 0.2$)	Degree of capital mobility: Low ($\psi = 2$)
PP: Recursive equilibrium law of motion for x(t) on x(t-1)	

[6]There are two very important points behind the results reported in table 6.4, which are needed to be clarified here. First, upon achieving the above results, matrix V is not invertible and pseudo inverse is used instead. Given the idea that the log-linear system we are looking at is only an approximation, the fact that pseudo inverse of matrix V is exploited in the current version of the model is of no great concern, however. As we shall see in the next chapter, there are substantial evidences that the dynamics of variables all approximately hold true as stated in the linearized equilibrium relationships, table 6.3. Second, the results in table (6.4) are derived with the roots of some state variables greater than one. In an attempt to search the way out of this problem, a discount factor is set to be fairly high. Although this still cause dynamic adjustment paths of some variables, such as the domestic and foreign bond holding, to be *initially* quite diverge from a neighborhood of the steady state, there is nothing intrinsic in the approach that prevents us from studying the cases. As asserted in the second footnote of chapter 6, the convergence of the variables is ensured with bounded lifetime utility function and with positive discount factor. In particular, provided that interest rate are not in a massive rise, relatively high positive discount factor (0.95) would imply that a country will not everlasting allow the others their lending because postponing of a little more of consumption in the future would certainly mean a very high cut down in its present value. Thus, looking further, the rise in demand for bond holding of bond would definitely not go on till the end. Besides, as long as all the results derived in this thesis clearly obey the dynamic of the equations derived from the model, it is not really the first priority here to have all values of root smaller than one. In the end, although we should better not trust the long simulation, the goal of analyzing the effect of monetary policy on macroeconomic variables can still be achieved with the above results.

2.1299	2.9387	-0.6242	3.5879	0	0	-0.0932	2.0602	-0.0702	0.4620	0.0139	-0.0139
0.7450	3.0774	-0.4306	2.4753	0	0	-0.7057	-0.3011	-2.5185	0.1830	0.0079	-0.0079
-0.7450	-2.0274	1.4806	-2.4753	0	0	0.8938	1.3162	3.5336	0.0051	-0.0079	0.0079
-1.0799	-2.9387	0.6242	-2.5379	0	0	0.1280	-1.8720	0.2584	-0.4272	-0.0139	0.0139
0.0496	0.1350	-0.0287	0.1648	0	0	0.4936	4.3585	3.6740	0.9953	0.0059	-0.0059
-0.0496	-0.1350	0.0287	-0.1648	0	0	-0.4936	-4.3585	-3.6740	-0.9953	-0.0059	0.0059

QQ: Recursive equilibrium law of motion for x(t) on z(t)

-0.0484	0.0484	-0.0830	0.0830
-0.0341	0.0341	-0.0474	0.0474
0.0341	-0.0341	0.0474	-0.0474
0.0484	-0.0484	0.0830	-0.0830
0.9979	0.0021	0.9700	0.0300
0.0021	0.9979	0.0300	0.9700

RR: Recursive equilibrium law of motion for y(t) on x(t-1)

-0.3349	-0.9113	0.1936	-1.1126	0	0	0.3569	-3.3963	-2.4333	-0.3596	-0.0059	0.0059
0.3349	0.9113	-0.1936	1.1126	0	0	0.6852	3.2032	2.2402	1.4017	0.0059	-0.0059
0.0496	0.1350	-0.0287	0.1648	0	0	0.4096	4.3741	3.6896	0.9113	0.0059	-0.0059
-0.0496	-0.1350	0.0287	-0.1648	0	0	-0.5777	-4.3429	-3.6585	-1.0793	-0.0059	0.0059
-0.7450	-2.0274	0.4306	-2.4753	0	0	0.8367	1.3268	2.4942	-0.0520	-0.0079	0.0079
0.7450	2.0274	-0.4306	2.4753	0	0	-0.7628	-1.3405	-2.5079	0.1259	0.0079	-0.0079
-0.0000	-0.0000	-0.0000	-0.0000	0	0	4.3703	36.5802	31.4602	8.1078	0.0473	-0.0473
-0.0000	-0.0000	0.0000	-0.0000	0	0	-4.4997	-36.5562	-31.4362	-8.2373	-0.0473	0.0473
0.0992	0.2700	-0.0574	0.3297	0	0	0.9872	8.7170	7.3481	1.9906	0.0118	-0.0118
0.0496	0.1350	-0.0287	0.1648	0	0	0.4768	4.3616	3.6772	0.9785	0.0059	-0.0059
-0.0496	-0.1350	0.0287	-0.1648	0	0	-0.5104	-4.3554	-3.6709	-1.0121	-0.0059	0.0059
-0.3349	-0.9113	0.1936	-1.1126	0	0	-0.1473	-3.3029	-2.3399	-0.8638	-0.0059	0.0059
0.3349	0.9113	-0.1936	1.1126	0	0	0.1809	3.2966	2.3336	0.8975	0.0059	-0.0059
-0.3349	-0.9113	0.1936	-1.1126	0	0	-0.1473	-3.3029	-2.3399	-0.8638	-0.0059	0.0059
0.3349	0.9113	-0.1936	1.1126	0	0	0.1809	3.2966	2.3336	0.8975	0.0059	-0.0059

SS: Recursive equilibrium law of motion for y(t) on z(t)	
$\begin{bmatrix} 0.0143 & -0.0143 \\ -0.0143 & 0.0143 \\ 0.9979 & 0.0021 \\ 0.0021 & 0.9979 \\ 0.0341 & -0.0341 \\ -0.0341 & 0.0341 \\ 0.0000 & -0.0000 \\ -0.0000 & -0.0000 \\ 0.9958 & -0.9958 \\ 0.9979 & 0.0021 \\ 0.0021 & 0.9979 \\ 0.0143 & -0.0143 \\ -0.0143 & 0.0143 \\ 0.0143 & -0.0143 \\ -0.0143 & 0.0143 \end{bmatrix}$	$\begin{bmatrix} 0.0356 & -0.0356 \\ -0.0356 & 0.0356 \\ 0.9700 & 0.0300 \\ 0.0300 & 0.9700 \\ 0.0474 & -0.0474 \\ -0.0474 & 0.0474 \\ -0.2340 & 0.2340 \\ 0.2340 & -0.2340 \\ 0.9399 & -0.9399 \\ 0.9700 & 0.0300 \\ 0.0300 & 0.9700 \\ 0.0356 & -0.0356 \\ -0.0356 & 0.0356 \\ 0.0356 & -0.0356 \\ -0.0356 & 0.0356 \end{bmatrix}$

Table 6.4 (Continued)

Case 2: Economy after international labor migration

Degree of capital mobility: High($\psi = 0.2$)	Degree of capital mobility: Low($\psi = 2$)
PP: Recursive equilibrium law of motion for x(t) on x(t-1)	
$\begin{bmatrix} 1.1666 & -1.7744 & -0.2691 & 0.5065 & 0 & 0 \\ -0.1100 & 0.5859 & -0.0331 & -0.0884 & 0 & 0 \\ 0.4935 & 2.0828 & 1.1985 & 0.3968 & 0 & 0 \\ -0.0512 & 1.1883 & 0.1731 & 0.7530 & 0 & 0 \\ 0.0667 & -0.1738 & -0.0410 & 0.1365 & 0 & 0 \\ -0.0285 & 0.0561 & 0.0151 & -0.0550 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 1.1206 & -3.5822 & -0.7517 & 1.0629 & 0 & 0 \\ 0.0075 & 0.2684 & -0.1505 & 0.2166 & 0 & 0 \\ -0.0336 & 3.5073 & 1.7252 & -0.9718 & 0 & 0 \\ -0.0384 & 2.0043 & 0.4187 & 0.4574 & 0 & 0 \\ 0.0304 & -1.4467 & -0.3069 & 0.4330 & 0 & 0 \\ -0.0070 & 0.2916 & 0.0633 & -0.0889 & 0 & 0 \end{bmatrix}$
QQ: Recursive equilibrium law of motion for x(t) on z(t)	
$\begin{bmatrix} 2.8701 & -4.4230 \\ -0.4768 & 0.7185 \\ 2.1395 & -3.2243 \\ -1.4084 & 2.1765 \\ 1.7393 & -1.1334 \\ -0.3020 & 1.4627 \end{bmatrix}$	$\begin{bmatrix} 0.3615 & -0.6610 \\ -0.1011 & 0.1293 \\ 0.4536 & -0.5804 \\ 0.0525 & -0.0206 \\ 1.0260 & -0.0856 \\ -0.0315 & 1.0571 \end{bmatrix}$

RR: Recursive equilibrium law of motion for y(t) on x(t-1)

$$\begin{bmatrix} -0.5141 & 0.7999 & 0.2438 & -0.9540 & 0 & 0 \\ 0.1770 & -0.2532 & -0.0810 & 0.3244 & 0 & 0 \\ 0.0700 & -0.1815 & -0.0429 & 0.1431 & 0 & 0 \\ -0.0252 & 0.0483 & 0.0132 & -0.0484 & 0 & 0 \\ 0.3591 & 1.5155 & 0.1081 & 0.2887 & 0 & 0 \\ -0.1430 & -0.6037 & -0.0430 & -0.1150 & 0 & 0 \\ -0.0584 & -0.5957 & -0.0644 & 0.0166 & 0 & 0 \\ 0.0100 & 0.1020 & 0.0110 & -0.0028 & 0 & 0 \\ 0.0888 & -0.2124 & -0.0521 & 0.1784 & 0 & 0 \\ 0.0667 & -0.1738 & -0.0410 & 0.1365 & 0 & 0 \\ -0.0285 & 0.0561 & 0.0151 & -0.0550 & 0 & 0 \\ -0.4942 & 0.7532 & 0.2323 & -0.9143 & 0 & 0 \\ 0.1968 & -0.3000 & -0.0925 & 0.3642 & 0 & 0 \\ -0.4564 & 0.6486 & 0.2082 & -0.8359 & 0 & 0 \\ 0.1591 & -0.1955 & -0.0685 & 0.2857 & 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} -0.0686 & 2.1636 & 0.4984 & -0.6923 & 0 & 0 \\ 0.0170 & -0.3851 & -0.0969 & 0.1324 & 0 & 0 \\ 0.0317 & -1.5035 & -0.3190 & 0.4501 & 0 & 0 \\ -0.0057 & 0.2348 & 0.0512 & -0.0718 & 0 & 0 \\ -0.0245 & 2.5520 & 0.4913 & -0.7071 & 0 & 0 \\ 0.0097 & -1.0165 & -0.1957 & 0.2817 & 0 & 0 \\ 0.2034 & -11.1792 & -2.3168 & 3.2841 & 0 & 0 \\ -0.0306 & 1.6797 & 0.3481 & -0.4934 & 0 & 0 \\ 0.0342 & -1.5834 & -0.3374 & 0.4757 & 0 & 0 \\ 0.0304 & -1.4467 & -0.3069 & 0.4330 & 0 & 0 \\ -0.0070 & 0.2916 & 0.0633 & -0.0889 & 0 & 0 \\ -0.0612 & 1.8227 & 0.4257 & -0.5898 & 0 & 0 \\ 0.0244 & -0.7260 & -0.1696 & 0.2349 & 0 & 0 \\ -0.0419 & 0.8935 & 0.2291 & -0.3122 & 0 & 0 \\ 0.0051 & 0.2032 & 0.0271 & -0.0427 & 0 & 0 \end{bmatrix}$$

SS: Recursive equilibrium law of motion for y(t) on z(t)

$$\begin{bmatrix} -5.3556 & 8.1998 \\ 1.5788 & -2.4170 \\ 1.8054 & -1.2346 \\ -0.2360 & 1.3615 \\ 1.5568 & -2.3462 \\ -0.6201 & 0.9345 \\ 0.1133 & -0.1875 \\ -0.0194 & 0.0321 \\ 1.8525 & -2.5436 \\ 1.7393 & -1.1334 \\ -0.3020 & 1.4627 \\ -4.9592 & 7.5926 \\ 1.9753 & -3.0242 \\ -3.8257 & 7.2778 \\ 0.8418 & -2.7094 \end{bmatrix}$$

$$\begin{bmatrix} -0.8324 & 1.3331 \\ 0.0611 & -0.1021 \\ 1.0583 & -0.1367 \\ 0.0007 & 1.0060 \\ 0.3301 & -0.4223 \\ -0.1315 & 0.1682 \\ -0.6149 & 0.5742 \\ 0.0924 & -0.0863 \\ 0.9379 & -1.1916 \\ 1.0260 & -0.0856 \\ -0.0315 & 1.0571 \\ -0.6390 & 1.0264 \\ 0.2545 & -0.4088 \\ 0.0788 & 1.3196 \\ -0.4632 & -0.7020 \end{bmatrix}$$

6.4.5 Interpretation of the results

After accomplishing the linear-approximated equilibrium solutions in table 6.4, we are all set to uncover the policy implications from the model.[7] Only the dynamic response functions are checked out in this thesis. The dynamic adjustment paths of macroeconomic variables for several cases of financial and labor market integration are computed by making the simulation experiments of one percent simultaneous change in each country's money supply to the equilibrium linear decision rules derived in the last section. In particular, given the linear-approximated equilibrium solutions in (6.12) with all coefficients identified, we specify $\varepsilon_{1t} = 1$ and $\varepsilon_{2t} = -1$, where $t = 1$, and find out how each variable reacts by setting $x_0 = 0,\ y_0 = 0,\ z_0 = 0$, as well as $\varepsilon_t = 0$ for $t \geq 2$ and recursively calculating z_t and then x_t and y_t, given $z_{t-1}, x_{t-1}, y_{t-1}$ and ε_t for $t = 1,....,T$. To make the picture more clear-cut, the corresponding responses of each variable to the asymmetric pulse in money shock are, then, being plotted in an impulse response panel, which will be presented in the next chapter.

To complete the steps explained in above paragraph, algorithm used to calculate and show the impulse response functions, is again taken from Uhlig's toolkit file. The MATLAB program is written, briefly, as follows

```
% VERSION 4.0, November 2002, COPYRIGHT H. UHLIG.(IMPRESP.M)

% This M-file calculates and plots impulse responses to shocks one percent
% in size to first exogenous variables in vector z(t) and minus one percent
% in size to the other exogenous variables in vector z(t)-->Asymmetric shock

% It is assumed that M-file for solving for the undetermined coefficients
% has been executed before, so that the matrices
% NN, PP, QQ, RR and SS are available, describing the law of motion
%   x(t) = PP x(t-1) + QQ z(t)
%   y(t) = RR x(t-1) + SS z(t)
%   z(t) = NN z(t-1) + epsilon(t)

% The program calculates and plots the response of all variables x(t), y(t), z(t) to each shock.
% Response is of size (m_states+n_endog+k_exog)*HORIZON.
```

[7] The actual MATLAB programs used to perform the calculation of our model in the last two sections, both solving for the laws of motion and calculating the impulse response functions are provided in Appendix G.

```
 %------------------------------------------------- Declare matrices --------------------------------------------%

for shock_counter = SELECT_SHOCKS,    % 1 : k_exog
Response = zeros(m_states+n_endog+k_exog,HORIZON);
%  Declare matrix response which contains
%  the series of variables on each row and horizon on each column.

Response(m_states+n_endog+shock_counter,1) = 1;
% In our case, we have asymmetric shock. so,
% Response(m_states+n_endog+1,1) = 1;
% Response(m_states+n_endog+2,1) = -1;
% The element in the first column on of matrix response on m+n+1 row will be one
% and on the next row (last row since k=2) will be minus one.
% This represents one-percentage asymmetric shock in money supply.

II_lag = [        PP,  zeros(m_states,n_endog),   zeros(m_states,k_exog)
                  RR, zeros(n_endog, n_endog),   zeros(n_endog, k_exog)
           zeros(k_exog,(m_states+n_endog)),   NN                              ];
% Define matrix that represents the effect of last-period state variables
% (endogenous state + exogenous variables) on all endogenous variables

II_contemp = eye(m_states+n_endog+k_exog) + ...
        [    zeros(m_states,(m_states+n_endog)),   QQ
             zeros(n_endog, (m_states+n_endog)),   SS
             zeros(k_exog,  (m_states+n_endog)),    zeros(k_exog,k_exog)    ];
% Define matrix that represents the effect of
% current-period exogenous state variables on all endogenous variables


%------------------------- Describing the response of all variables to each shock  -------------------%
%                     via the equilibrium recursive law of motion derived from last step.           %
%          Revised response matrix [x(t)',y(t)',z(t)']' = II_contemp*II_lag*[x(t-1)',y(t-1)',z(t-1)']'   %

     Response(:,1) = II_contemp*Response(:,1);
     for time_counter = 2 : HORIZON,
       Response(:,time_counter) = II_contemp*II_lag*Response(:,time_counter-1);
     end;

     Resp_mat = [ Resp_mat
                       Response ];
     % Since Response is overwritten, each time a new shock is analyzed,
     % the results are collected in
     % Resp_mat = [  Response to first shock
     %                        Response to second shock
     %                                    ...                        ]

     init_zero_response = zeros(m_states+n_endog+k_exog,INIT_DATE);
     % The initial path (periods prior to shock) of impluse response is zero.



%----------------------------------------------------- Single plot ----------------------------------------------%

for step = 1:length(IMP_SUB_SELECT),
   %IMP_SUB_SELECT= 1:(m_states+n_endog+k_exog)
   %a vector containing the indices of the variables to be plotted
```

```
   hndl = plot(Time_axis,0*Time_axis, ...
              Time_axis,[init_zero_response(IMP_SUB_SELECT(1,step),:),…
              Response(IMP_SUB_SELECT(1,step),:)]);
   %call the elementary plotting function to plot each response in a single graph

axis([-INIT_DATE/PERIOD,HORIZON/PERIOD,...
    min(0,min(min(Response(IMP_SUB_SELECT(1,step),:)))),...
    max(1,max(max(Response(IMP_SUB_SELECT(1,step),:))))]);
% Set axis limit

set(hndl(2:max(size(hndl))),'LineWidth',2);
grid;
% Select line and marker characteristic and set the grid lines

title(['Response to a one percent deviation in ',
VARNAMES(m_states+n_endog+shock_counter,:)]);
xlabel('Years after shock');
ylabel('Percent deviation from steady state');
% Annotate the graph with axis labels and title

end; % for single plot
end; % for shock_counter
```

CHAPTER 7

ANALYSIS OF DYNAMIC SOLUTION PATHS

A quantitative model is considered useful if it provides a concrete answer to an interesting well-posed question of a narrow class. Having the linear-approximated decision rules computed, we are able to perform the simulation procedure to our calibrated model with an aim to trace out what happen to all economic variables after a permanent unit asymmetric shock in money supply shock. Below, the simulation results are presented through an impulse response analysis, which consists of three parts. The first section concentrates on the implications that the financial market integration has on macroeconomic responses to the shock in the economy with the disconnected labor market (the first objective). Next, exploration is conducted to evaluate how things stand apart after the controls on oversea employment are removed. To that end, how the presence of international labor market integration alters the effects of increasing degree of capital mobility on the volatility of macro economy will be clarified (The second objective). This chapter is, then, closed with the discussion of the central implications of the studies

7.1 Capital Mobility, Monetary Policy, and Macroeconomic Volatilities: Prior to Labor Market Integration

The manifest question in this section is how the degree of international financial market integration matters for the dynamics of the model in the aftermath of monetary shock with the labor market separated between nations. The dynamic adjustment paths to a one percent permanent increase in home money supply and one percent permanent decrease in foreign money supply of domestic and foreign macroeconomic variables under high and low degree of capital mobility are shown in Figure 7.1. In each panel, the plots marked with circle correspond to the case of a perfect capital mobility (Ψ=0.2) and the plots marked with crosses embody the case of an imperfect capital mobility (Ψ=2).

7.1.1 High degree of capital mobility with incomplete labor market integration ($\bar{N}^H = \bar{N}^F = 1$ and $\psi = 0.2$)

To provide a benchmark, I will begin with the case of a highly integrated financial market (plots with circle). In the world in which authorities put almost no bar on the abilities in making international flows of funds, there is effectively only one interest rate. An asymmetric shock implies that amount of funds home households want to lend (due to a surplus in current account) is always in balance with the funds foreign households want to borrow. Therefore, the interest rates, shown in panel 7.1e and 7.1f, are leaved unaffected by monetary shock from each country.

The prices effect of monetary shock is illustrated in panel 7.1g and 7.1h. In our flexible-price model, home (foreign) price index increases (decreases) by somewhat the same amount as a change in a relative money supply. Furthermore, given the symmetry of both countries, linearized output market equilibrium conditions (6.11.20) and (6.11.21) tell us that individual prices of goods in each country (either own-produced or imported) behave like its general price index. So, apparently from panel 7.1i and 7.1j, individual prices in home (foreign) rise (fall) by one percent as well. Now, to go further, in our model where flexible price guarantees a zero-profit, the individual prices would adjust to equate wages. This has an implication that real wage remains unchanged at the level that generates steady state full employment, i.e., we have zero a deviation of outputs from the initial steady state. Obviously, where full employment is assured by wage and price flexibility, monetary policy has an impact that would be predicted from the basic quantity theory of money. That is, it is only price level in an economy, not real economic variables, such as output and employment, that is affected by the quantity of money. Contradict to Sutherland (1996) where there is nominal price-rigidity, the general level of price will change in proportion to the change in money stock, leaving the real side of the economy unchanged, as confirmed by linearized labor market equilibrium conditions (6.11.18) and (6.11.19).

As for consumer spending, the domestic consumption reacts to the expansionary monetary shock by increasing in a once-and-for-all step from its initial value to a new long-run steady state level. The main reason consumers have such flat consumption is due to the fact that the real interest has not changed so there is no incentive to reallocate consumption overtime, as reflected in equation (6.10.1),

$$\hat{C}_{t+1}^{H} - \hat{C}_{t}^{H} = \sigma\left[\left(1-\beta\right)\hat{i}_{t}^{H} - E_{t}\left(\hat{P}_{t+1}^{H} - \hat{P}_{t}^{H}\right)\right]$$

with the right hand side being zero. Plus, in reference with consumption Euler equation (the first equations in table 5.1), a country will wish to smooth consumption in the situation where a subjective discount factor is equal to the market discount factor or $\beta = 1/1+r$. Not surprisingly, therefore, in presence of the efficient ways of accumulating financial wealth, countries gain more opportunities for consumption-smoothing. See panel 7.1m and n.

Moreover, it is easy to observe from equation (6.11.12) and (6.11.13) that the behavior of consumption of each differentiated product of domestic agents (either produced domestically or imported from aboard) will be identical to the consumption index of that country. This, again, is attributed to the symmetric nature between the two countries in the model. As the amount of consumption spending is less, consumption of individual differentiated products of home consumers decline. For foreign economy, the above relationships are also true with the movement in an opposite way. Explicitly, looking at equation (6.10.2), (6.11.14), and (6.11.15), there is a one-time step decrease in time path of consumption index and consumption of individual goods in response to a contraction in foreign money supply.

Next variable is exchange rate. The exchange rate implication of a permanent rise in money supply is, by far, similar to the consumption response. The exact effects of money supply shock on the exchange rate can be determined by considering the money market equilibrium conditions in the two countries, equation (6.11.1) and (6.11.2). Combining these equations with the PPP relationship yields

$$\hat{E}_{t} = \left(\hat{M}_{t}^{H} - \hat{M}_{t}^{F}\right) - \frac{1}{\sigma\varepsilon}\left(\hat{C}_{t}^{H} - \hat{C}_{t}^{F}\right) + \frac{\beta}{\varepsilon}\left(\hat{i}_{t}^{H} - \hat{i}_{t}^{F}\right) \qquad (7.1)$$

The relative money supply is once-and-for-all step change (a permanent one), as is the change in relative consumption level. Therefore, with no change in the nominal interest rate, the equation (7.1) demonstrates that the exchange rate must also jumps immediately to its long-run level. Indeed, home currency depreciates (foreign currency appreciates) to about 2 percent, as revealed in panel 7.1s.

The idea of no-exchange-rate-overshooting property of the model, explained above, is, in fact, a usual result given the flexile price assumption of the model. To see this, note that the equation (7.1) is virtually identical to the central equation of the flexible-price monetary model of exchange rates[1]. In the monetarist model, where prices are flexible, using money market equilibrium condition and PPP, nominal exchange rate (s) is proved to be equal to

$$s = \left(m - m^*\right) - \left(y - y^*\right) + \mu\left(i - i^*\right)$$

where a small letter means a variable is in a log term, star denotes foreign country, and μ is interest elasticity of real money demand. After substituting uncovered interest rate arbitrage condition, $\left(i - i^*\right) = \Delta s_t^e$, we have

$$s = \left(m - m^*\right) - \left(y - y^*\right) + \mu \Delta s_t^e$$

According to above equation, once domestic currency is expected to depreciate over the coming period, the today demand for domestic currency will fall, causing an increase in exchange rate immediately. Consequently, for both Monetarist and our presenting model, Dornbusch-type exchange rate overshooting does not essentially occur.

Finally, it can effortlessly be seen from panel 7.1t that domestic agents are accumulating foreign bonds (increase in net claim on the rest of the world) as the depreciation in domestic currency gives rise to national current account surplus[2]. In accordance with this, the agents' wealth stock is increased, which enables them to smooth the increase in their consumption over the future. Conversely, paralleling to the domestic economy, by running a current account deficit, the domestic bonds

---

[1]The only essential difference between the flexible-price monetary model of exchange rate and our flexible-price NOEM model in the above exchange rate dynamics is that in equation (7.1) the exchange rate depends on consumption difference, not on output difference as the monetary model supposes. However, this prediction that exchange rate depends on consumption, rather than output, is common, to many intertemporal monetary models because the decision to hold money involves an opportunity cost that depends on the marginal utility to consume.

[2]Although this surplus in home current account does not come from an increase in time profile of output (constant at full employment level due to the perfectly flexible price and wage assumption) over consumption as it does in Sutherland (1996), it does result from a lower down of demand for holding domestic bond on account of lower in value of domestic currency.

holding of foreign agents, as depicted in panel 7.1u, diminishes and, hence, there is a smooth decline in foreign consumption over time.

7.1.2 Low degree of capital mobility with incomplete labor market integration ($\bar{N}^H = \bar{N}^F = 1$ and $\psi = 2$)

How does international capital mobility affect the dynamics of the model? To answer this question, let look at equation (6.10.3). The impact of expected change in foreign asset position on international nominal yield differential is directly reflected in the following version of uncovered interest rate parity.

$$(1-\beta)\hat{i}_t^H - (1-\beta)\hat{i}_t^F - E_t\left(\hat{E}_{t+1} - \hat{E}_t\right) = \psi N^H \bar{C}^H E_t\left(\hat{I}_{t+1}^H - \hat{I}_t^H\right) \tag{7.2}$$

Equation (7.2) asserts that the yield differential between domestic and foreign bond, i.e., the nominal interest differential less the expected depreciation of the nominal exchange rate, is proportional to expected rate of change of the cross-border flow of funds. In effect, the above equation exhibits that the households optimally allocate their wealth between domestic and foreign bonds by taking the cost related to transferring wealth from one financial market to the other into consideration.

Intuitively speaking, the central implication of imperfect capital mobility is that domestic and foreign bonds become differentiated and can, therefore, pay different rate of return. With low capital mobility, the tendency for a permanent change in money supply to induce higher assets accumulation in domestic economy (resulted from high adjustment cost to make international trade in financial assets) implies that there will be relatively higher downward pressure on relative yield of domestic assets. This greater magnitude of a domestic yield fall definitely marks two direct impacts on effects of a monetary shock. First, the nominal interest rate of each country becomes more diverge, i.e., the nominal interest rate substantially fall in home while it rises in foreign, as highlighted by the lines with mark in panel 7.1e and f. Second, since one component of domestic yield is capital gain arising from an expected change in exchange rate; the larger fall in domestic yield implies that the expected depreciation is relatively higher. As a consequence, given that people expect exchange rate to continue depreciating further into the future, the initial monetary-led increase in exchange rate is less pronounced when capital mobility is near to the ground. This is evident by the lines with mark in panel 7.1s, which shows that the domestic currency depreciates (foreign currency appreciates) by somewhat less in the economy where households cannot adjust their holdings of foreign bonds without putting on any cost.

Algebraically, with higher value of Ψ, a negative expected rate of change in cross-border flow of funds translates into a larger negative in international nominal interest rate differential and a bigger expected increase in value of home currency[3]. As such, it is self-evident from the former effect that domestic and foreign consumers are expected to move funds into foreign market (See panel 7.1a, b, c, and d) and from the latter effect that the initial impact on exchange rate of monetary expansion, when international financial market are segmented, would be smaller.

In fact, the insight of above explanation is that, at any point in time, utility-maximizing consumers compare the asset return from two different places when deciding to hold bonds. A home monetary expansion lower domestic interest rate while contraction in foreign money supply raises interest rate in foreign. This causes capital outflow from home to foreign in period t, as witnessed from an increase in the level of funds transferred in panel 7.1t and 7.1u. Under a flexible exchange rate regime, exchange rate will adjust automatically to ensure that balance of payments is in equilibrium. So, the domestic currency will instantly depreciate to some certain degree necessary to eliminate the gap of deficit in BOP, thus leading to a current account surplus. Resembling the Mundell-Fleming model, the presence of international capital mobility has an important implication for balance of payments deficit. With international bond market being highly integrated, the balance of payments would deteriorate by more. Thus, we can essentially recognize the higher depreciation of domestic currency if it is to restore the equilibrium.

Alternatively, the behavior of exchange rate can, again, be explained with regards to equation (7.1). In contradiction with previous case, the consumption differential, which will be seen later, is much more strongly positive, while the

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[3]Because consumers expect the exchange rate to continue depreciating at a high rate due to a permanent change in money supply, they would be interested to relocate their assets back to home to enjoy higher profit from an expected capital gain. The right-hand side of equation (7.2), or the expected rate of change in cross-border transfer of fund from home to foreign, is, therefore, negative.

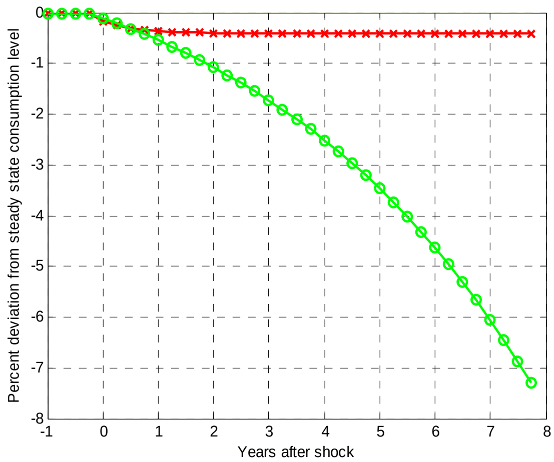
interest differential becomes negative when the financial capital is relatively immobile. These two effects simply mean that the exchange rate should not depreciate as much as in the case where consumers get a free access to trade their assets overseas, case 7.1.1.

Furthermore, the impact effect of a money shock on prices is straightforwardly outlined by movement of the exchange rate. In keeping parity of purchasing power among the countries, home general price index (and individual prices of home product) rises and foreign general price index (and individual prices of foreign product) falls by less in economy with borderless financial market due to the marginally increase in exchange rate, E.

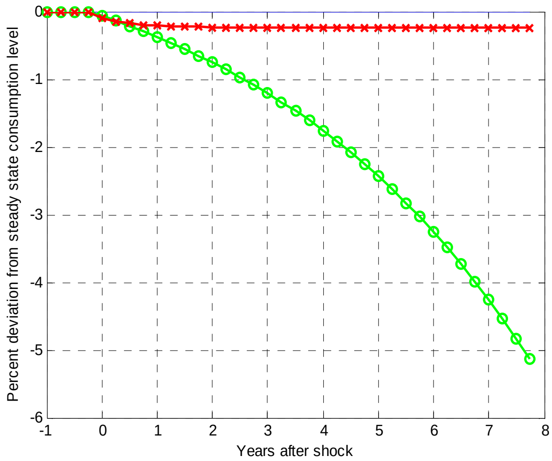
Finally, a fall in real interest rate in home, when the offshore financial transactions are prohibited, creates incentive for domestic consumers to bring consumption forward in time (nominal and real interest rates move correspondingly in our model since growth rate of money supply is zero after the first period, so does inflation). According to the marked lines in panel 7.1m, home consumption index (and individual consumption of home and imported products) rises sharply and then declines afterward. This is clear from the consumption Euler equation (5.1.1) in Table 5.1. When market interest rate differs from time-preference rate, the motivation to smooth consumption is modified by an incentive to tilt the consumption path. In our case, the capital market offers the country a rate of return that more than compensates it for the postponement of a little more consumption. Therefore, individual in the economy will maximize utility by arranging for consumption to rise between today and next period (starting from period zero until period one). Also, another reason behind a sharply rise in consumption is partly because a lower increase in price level ensures that the demand for that product doesn’t fall too much. Now, for foreign country, with the equivalent explanation, consumption sharply declines before the effect of a negative money supply shock dies down.

Figure 7.1

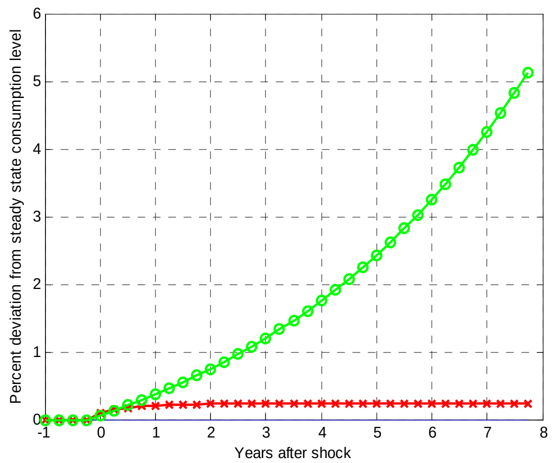
International capital mobility and the dynamic macroeconomic effects of a unit asymmetric money shock: Prior to labor market integration



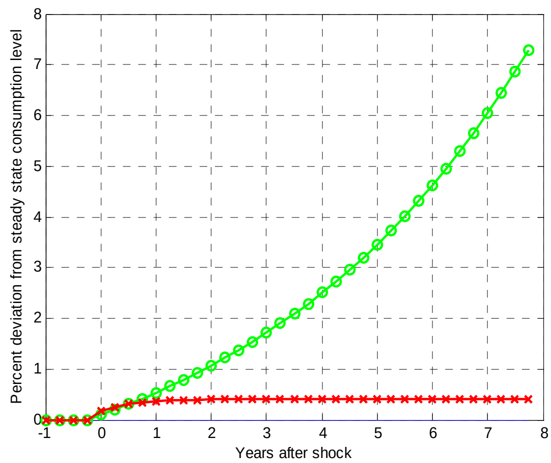
(a) Domestic bond holding by home agents



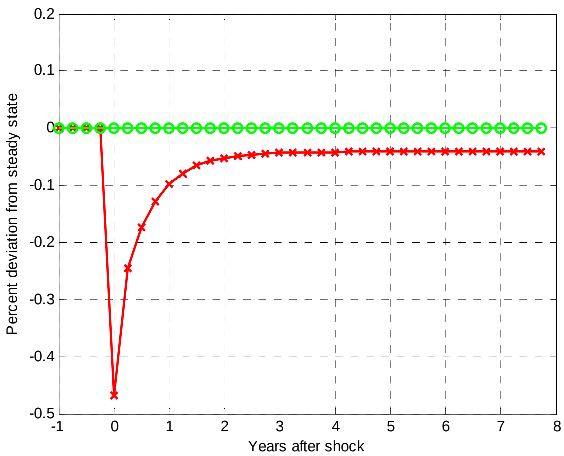
(b) Domestic bond holding by foreign agents



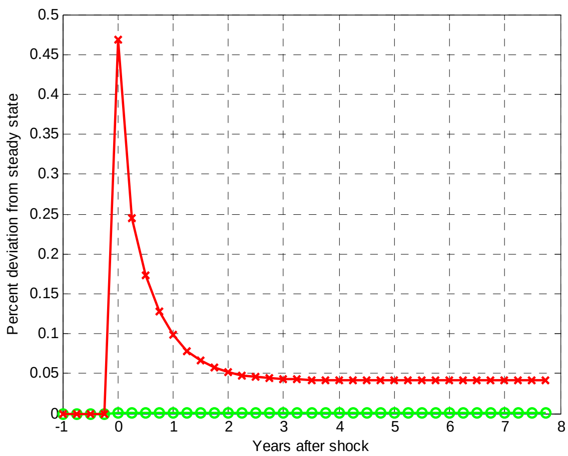
(c) Foreign bond holding by home agents



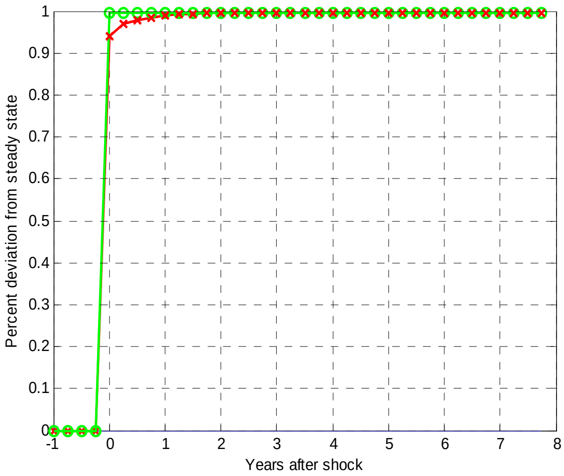
(d) Foreign bond holding by foreign agents



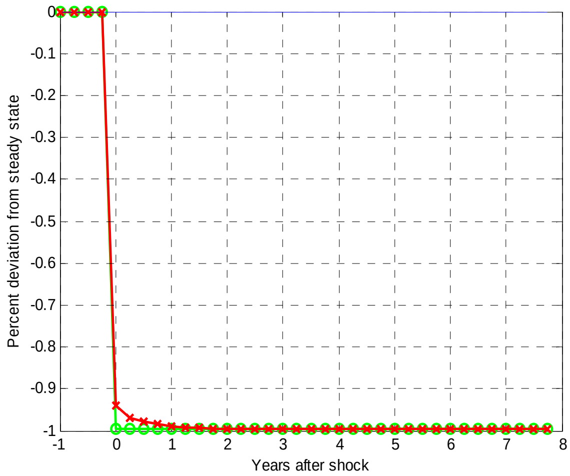
(e) Home nominal interest rate



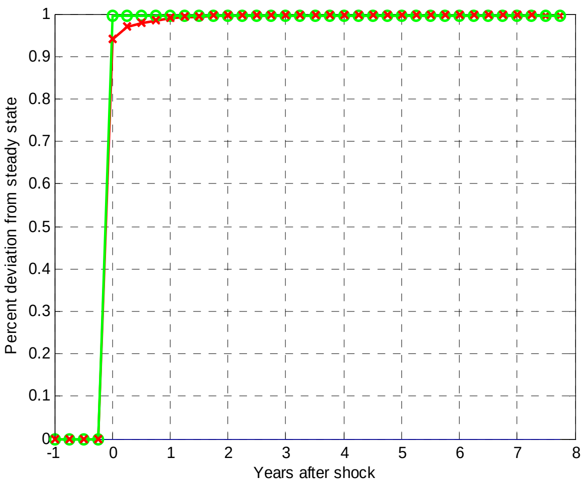
(f) Foreign nominal interest rate



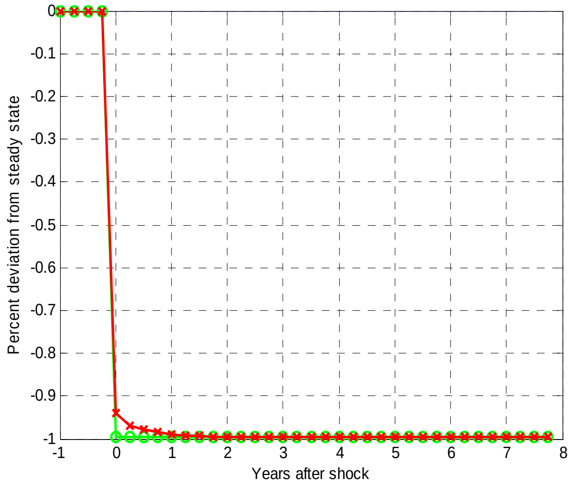
(g) Home general price index



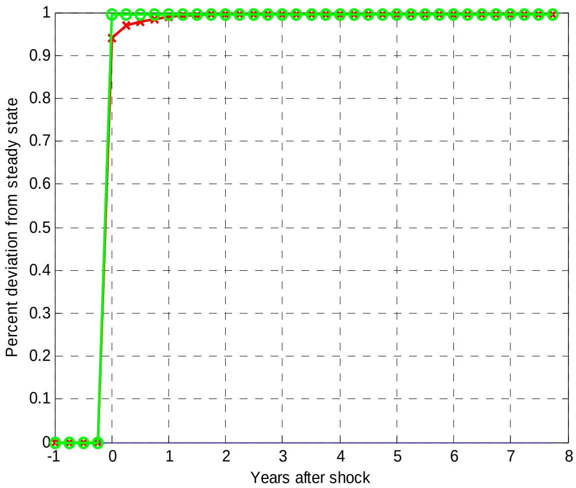
(h) Foreign general price index



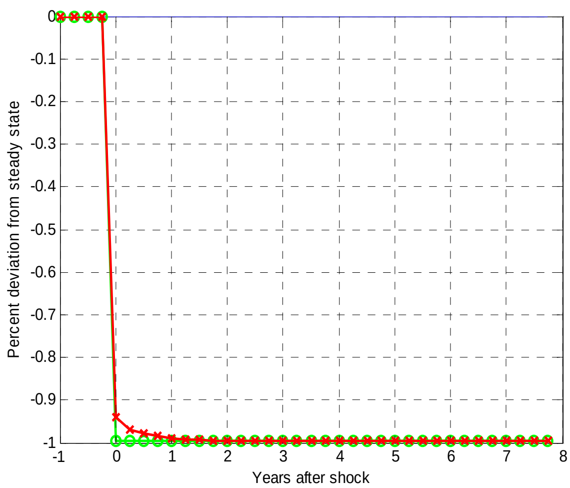
(i) Price of individual home-produced goods



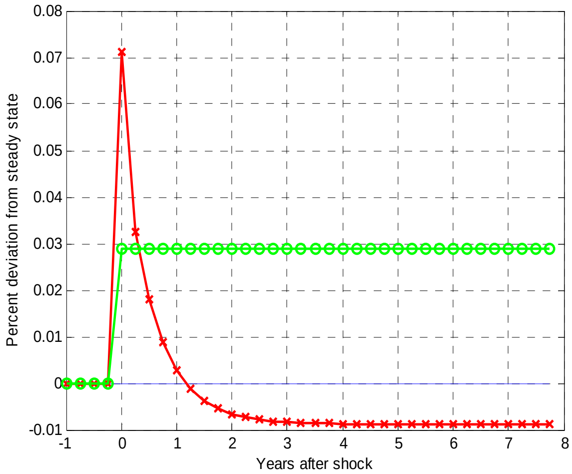
(j) Price of individual foreign- produced goods



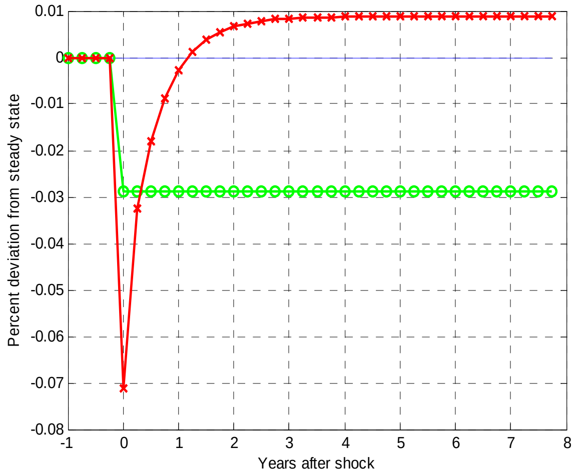
(k) Home nominal wage



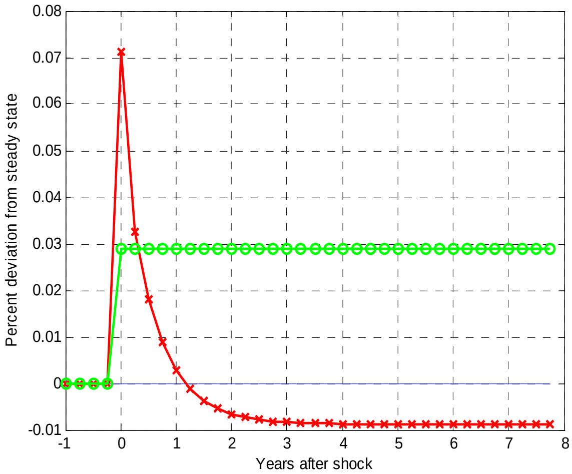
(l) Foreign nominal wage



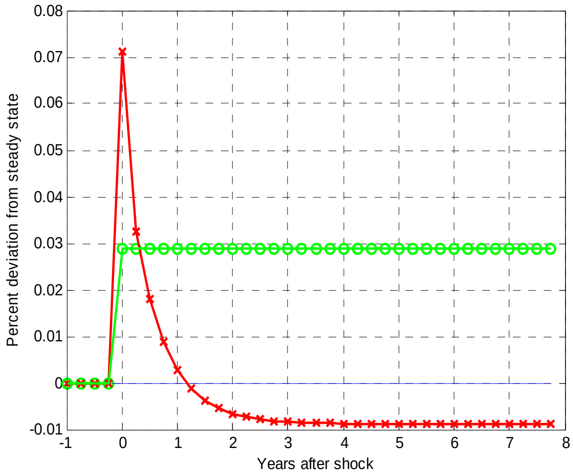
(m) Home consumption index



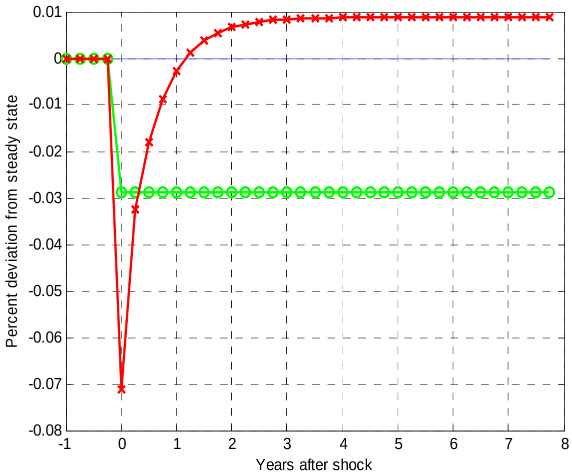
(n) Foreign consumption index



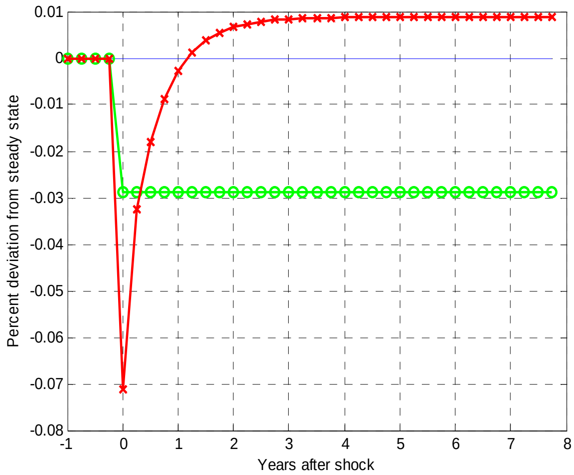
(o) Home demand for domestically produced good



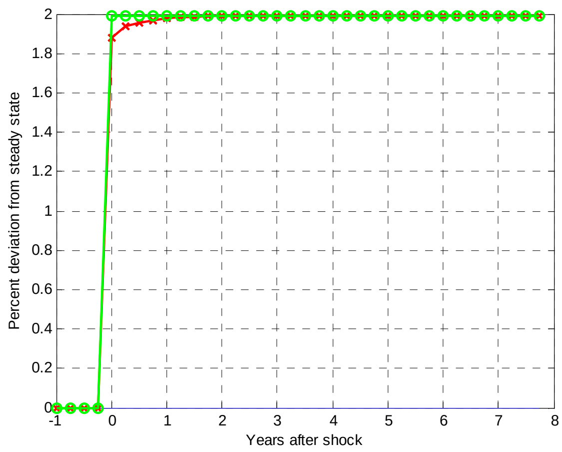
(p) Home demand for foreign produced good



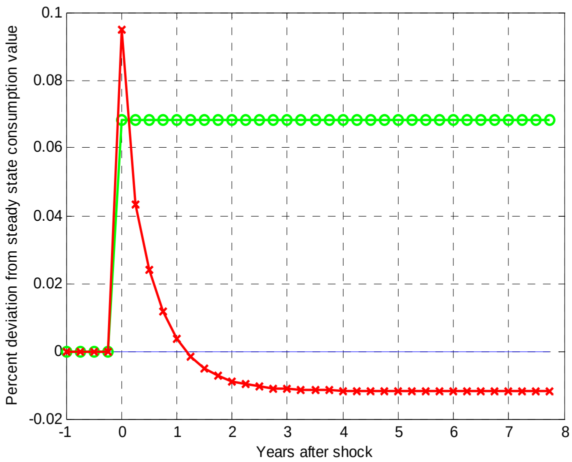
(q) Foreign demand for domestically produced good



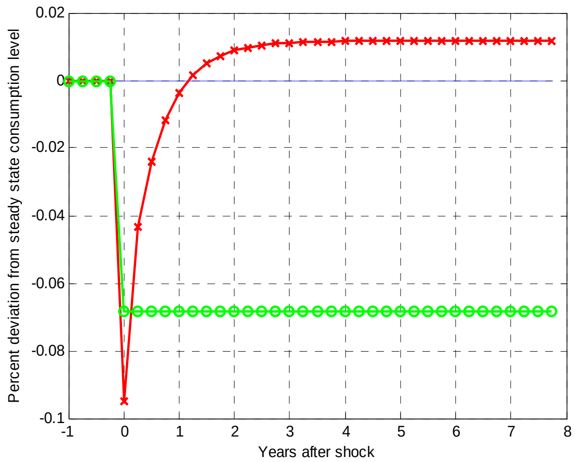
(r) Foreign demand for foreign produced good



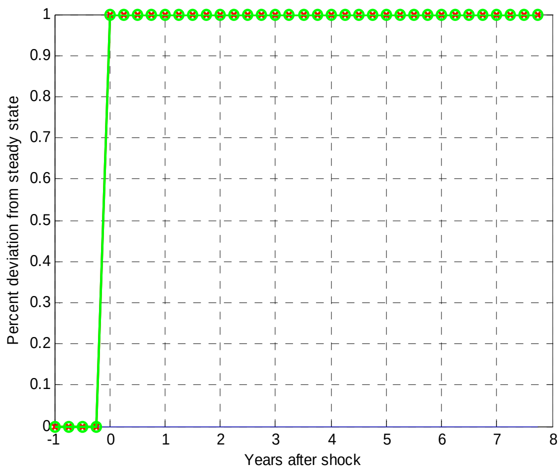
(s) Exchange rate



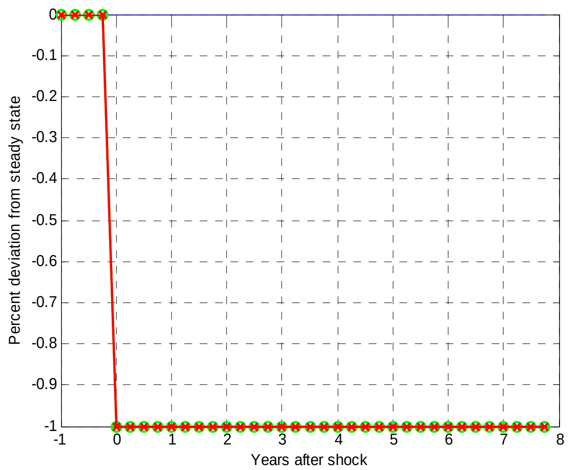
(t) Quantity of funds home agents transfers to foreign



(u) Quantity of funds foreign agents transfers to home



(v) Home money supply



(w) Foreign money supply

O Degree of capital mobility: High × Degree of capital mobility: Low

Unit of measurement:

Consumptions, prices, wages, nominal exchange rate, money supply– Percentage deviation from the initial equilibrium.

Bond holdings and flow of funds – Deviation as a percentage of the initial consumption level.

Interest rates – Percentage point deviation from initial equilibrium.

Upon comparing the differences between the two cases (moving from lines with mark to lines with circle), the message conveyed by the figures is that, as with Sutherland (1996), if the volatility is measured by the impact effects of shock, then, in summary, an increasing financial market integration reduces the volatility of interest rates and consumptions, but increases the volatility of nominal exchange rate. Thus, it follows from the last effect that the insight from the Mundell-Fleming model still applies since the nominal exchange rate effect of a monetary shock is larger, the higher is the degree of capital mobility. However, at the same time that the exchange rate change is larger, a financial market integration also raises volatility of wages and prices as both variables are perfectly flexible, thus, causing a monetary policy to lose all its effectiveness in stimulating output and other real economic variables, as revealed by equation (6.11.18) and (6.11.19) of Table 6.3, $\hat{Y}_t^H \approx 0$ and $\hat{Y}_t^F \approx 0$.

7.2 Capital mobility, Monetary Policy, and Macroeconomic Volatilities: Subsequent to Labor Market Integration.

This section provides the evidences on how things change in the presence of global linkages in labor market. The impulse response functions depicted in Figure 7.2 visualize the impact of having a particular amount of labors migrates from home to foreign country in the responses to a unit permanent asymmetric monetary shock with low and high capital mobility. First, we want to see, one by one, the effect of labor market integration against the background of high and low capital mobility. After that, I will sketch out whether implications of international capital mobility for the effects of monetary policy are sensitive to the degree of international labor market integration in the latter half of the section.

7.2.1 High degree of capital mobility with complete labor market integration ($\bar{N}^H = 0.94, \bar{N}^F = 1.06$ and $\psi = 0.2$)

Again, consider first the case of perfect capital mobility. In what follows, with the aim to reach out the conclusion about the effect of labor market integration, we compare the situation, concerning the monetary effect on macroeconomic variables, under imperfectly mobile labors (lines with circle in Figure 7.1) and the case where an economy has a highly integrated labor market (lines with circle in

Figure 7.2). At the outset, panel 7.2c and 7.2d symbolize the reaction of prices level to a relative money supply change. By spotting the line with circle in these two panels, we can see the direct effect of a change in the location of production on the price index of a country under the regime of highly deregulated financial market. Specifically, after a given amount of home labors move to foreign country, steady state value of home total outputs, as well as the number of varieties home produces, decline at the same time as an increase in that of foreign. This decrease in home outputs and varieties on offer will undoubtedly raises positive effect of expansionary monetary policy on home price whereas the counterpart increase will cause foreign price to go down by more in response to a decline in foreign money supply. In other words, there exists a “price index effect”, named in Fujita M., P. Krugman, and A.J. Venables (1999), which says that the location with a larger production sector (in this case, foreign country) has a lower price index for consumption goods. Price index in a particular region would tend to be lower, the higher is the share of production sector in that region. Accordingly, as compared to the circumstances before labor market integration, section 7.1.1, we can notice a larger rise and fall in home and foreign price index, respectively.

Now, we turn to the response of exchange rate to a monetary shock in panel 7.2e. For relatively transportable capital economy, we concentrate on the line with circle. The nominal exchange rate increases by more from an asymmetric shock in a relative money supply, as compared to the case previous to migration in panel 7.1s. To see that this is the case, let step back to equation (7.2). It appears from the equation that the relative difference between returns from holding assets of home and foreign country becomes smaller after labors relocate from home to foreign. This is true by the fact that, as the number of populations resided in home is lower, an aggregate amount of funds transferred abroad from home reduces, thus making the right hand side of the equation in smaller negative. (Also, this smaller negative does result in part from the fall in the amount of funds transferred by each individual home agent after domestic labors moved. This is so because the wealth is transferred out of the country as the migrated labors move away with all the assets they own.) The smaller yield differential, then, implies that the expected domestic currency depreciation happens to be less significant in the world where the constraints on migration are ignored. So, with lower depreciation expected, it is necessary for the impact effect of monetary change on exchange rate to be larger, i.e., home (foreign) currency is observed to have a higher depreciation (appreciation) if labors are allowed to migrate.

In fact, the higher increase in the exchange rate is actually another evidence in support of a higher increase in home price and greater decline in price of foreign. In particular, a higher depreciation in domestic currency will result in a higher rise in prices of products home import. Hence, given that imports have higher a weight in the country price index after home emigration, the greater increase in the imported price (and also the price of goods home produced as will be explained in the next paragraph) would certainly create the higher increase in the general price level domestically, as detected from price index equation (6.11.9). At the same time, the higher exchange rate would make the home exports to be cheaper. Therefore, it is obvious that the prices of differentiated products foreign import (plus, the foreign-produced goods as will be explained in the next paragraph) and, hence, the foreign price index must decline even greater in the case of highly integrated labor market.

In addition, the more substantial increase in exchange rate also has another crucial effect, i.e., it alters the extent that wages react to a shock in money supply (and, hence, the prices of individual products due to the zero-profit condition). Because a higher depreciation in home currency creates a higher demand for home products at the expense of foreign products, moving of home labors to foreign country would appear to raise home wages up higher and foreign wages down lower after the disturbance hits. As labeled by Fujita M., P. Krugman, and A.J. Venables (1999), this widespread idea of “home-market effect” does especially happen when labor supply is perfectly inelastic, as it does in our model. That is, with the vertical labor supply curve, the producers in location with larger demand for its product (in this case, home country) would have to pay a higher nominal wage. Therefore, an asymmetric change in monetary policy would cause a higher rise (fall) in home (foreign) wage rate if labor is mobile across regions. See line with circle in panel 7.2h (weigh against the same line in panel 7.1k) and 7.2i (compare with panel 7.1l).

Before passing by, it is also very valuable to note here that in our model, the distribution of labor across regions is given at any point time and does not evolve to the extent that real wages differ across regions. Regional wages, however, themselves depend on the distribution of labor inhabitation. To see this, we need to compare home market effect and the price index effect. Clearly, because the exchange rate increase is abundant, the decrease in $\bar{N}^H$ raises the nominal wage in home whereas the increase in $\bar{N}^F$ reduces that of foreign. Nevertheless, at the same time, the decline and increase in home and foreign employment also lowers and raises a output and number of varieties produced, thus driving up and down the price index of home and foreign products, respectively. In our model, this latter effect (price-index effect) can conceivably outweigh the former (home-market effect), so that the decrease (increase) number of workers in home (foreign) would actually lower (raise) their real wages. To put it differently, a shift of labors into one region would tend to lower the price and raise real wages in that region and thus making the region a more attractive place for worker to be. This implies that our model is dealing with economy in which the force toward agglomeration always prevails.

Next, think about how interest rates move. Given that agents base their decisions on the perfect foresight of the future, they would expect higher inflation in domestic economy because of greater monetary- led exchange rate depreciation in the case where home labors can switch place to stay. (Indeed, a highly integrated financial market has the highest depreciation among all four cases). This, consequently, leads the borrowers and lenders to add an inflation premium to the interest rate. So, quite a reverse from circled line in panel 7.1e, an expansion in money supply in home will ultimately raise interest rate when labor market integration is complete, as confirmed by similar line in panel 7.2j. In the same way, when money supply declines abroad, there would be a greater expectation in foreign country about deflation as a consequence of higher appreciation of exchange rate. Thus, a falling down in interest rate would be resulted from a contraction in foreign money supply following the removal of the barriers to migrate between countries. Remarkably, although the conventional wisdom that an expansionary (contractionary) monetary policy would generate a persistent decrease (increase) in interest rates, or the so call “liquidity effect”, is missing in this case, the view that a monetary shock affects interest rates exclusively through an anticipated inflation (deflation), which is known as “expected inflation effect”, is rationalized in our model. As mentioned in Christiano and Eichenbaum (1991), there is common notion among economists that this latter effect tends to dominate the former in the typical RBC model where money is introduced simply by imposing a cash-in-advance constraint or by incorporating transaction demand for money, like in our model.

To see the dynamics of the consumptions, consider equation (6.11.1) and (6.11.2). Expansionary monetary policy in home gives rise to a fall in consumption, instead of raising it as it does in the case ahead of home emigration in section 7.1.1. This is so because it generates a much higher rise in price level, which implies a lower purchasing power and thus the incentive to spending. Plus, the fact the home interest rate rises as a result of money supply increase in this case means that agents will wish to consume relatively more in the future, rather than now. So, from the line with circle in panel 7.2l, as the disturbance strikes, home consumption declines when labors are not kept inside their own countries. As for foreign country, the results come out from panel 7.2m would show the opposite movement in consumption once again for the paralleling reason.

Furthermore, from a quick look at equations (6.11.12)-(6.11.15), a stronger effect of money shock on individual prices, made possible by labor market integration, also, like in consumption index, produces the higher negative and positive pressure toward movement of home and foreign demand for an individual differentiated product (either own-produced or imported), respectively. In addition to the effect from the prices, this outcome certainly has to do with the change in consumption spending of the households in each country as well. Since home households take with them the bonds they own when they migrate, total wealth in home country declines while foreign country’s wealth increases. Hence, at variance with what is found in section 7.1.1, home consumers will unquestionably give up a less spending and place totally less demand for all individual differentiated goods and vice versa for foreign. This observation can be visibly seen in panel 7.2n, o, p, q by considering the circled lines.

Finally, the effect of this huge falling down in home consumption, coupled with a flat income profile, implies that the domestic economy runs an extended amount of current account surplus and, thereby, puts a higher increases its net claim on the rest of the world, as shown in panel 7.2r. Equivalently, the opposite is true for foreign.

7.2.2 Low degree of capital mobility with complete labor market integration ($\bar{N}^{H} = 0.94, \bar{N}^{F} = 1.06$ and $\psi = 2$)

Now consider the case where there are both complete labor market integration and incomplete financial market integration. Comparing between incomplete and complete labor market integration (lines with mark in Figure 7.1 and 7.2), it go without saying that the presence of imperfect capital mobility does not significantly alter the way any of macro variables response to shock from what is analyzed in the last section. To be more precise, like the case of highly mobile capital 7.2.1, by reducing $\bar{N}^{H}$ and thus aggregate domestic funds transferred, the labor market integration still ensures that an increase in the exchange rate level for the period subsequent to the shock is yet more than the case when home labors cannot migrate to foreign. Furthermore, given this enormous exchange rate increase following home labors emigration, the effect of an expansion in domestic money supply and a contraction in foreign money supply on general price index, individual price of differentiated products (wages), consumption index, consumption of individual differentiated products, and current account follow the same scenario as the case in section 7.2.1. That is, as apparent from price index equation (6.11.9) and (6.11.10), home (foreign) general price level rises (falls) by more in the case where a country labor market has less boundary because of the higher increase in exchange rate. Again, this is also attributed to the price index effect of a shift in labor employment. Next, not only this effect on general level of price, the individual prices of home and foreign products (nominal wage) unquestionably exhibit home market effect too, i.e., home differentiated products are more expensive whereas foreign products are cheaper after labor reallocation. Then, as price in both countries changes massively, domestic and foreign interest rate marginally falls and rises, respectively, due to the expected inflation effect. Finally, given the fact that the domestic (foreign) price increases (declines) higher and that the domestic (foreign) interest falls (rises) by less once home labors leave, home (foreign) consumption (both consumption index and consumption of individual goods) goes down (climbs up), thus leading to a current account surplus (deficit) when the two labor markets are highly integrated.

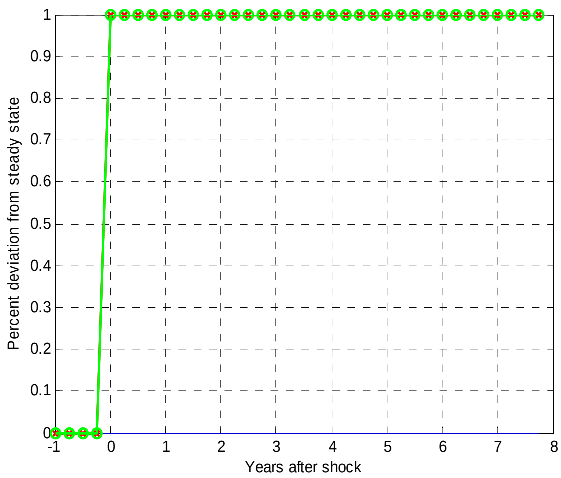
Now check out the effect of financial market integration by making comparison between the lines with circle and mark within each simulated panel in

Figure 7.2. As before international labors migration, the implications of lowering in trading friction in international financial transaction on monetary policy effects work through the interaction of relative asset return and exchange rate. After the higher impediments to cross-country capital flows are introduced, the fall in relative yield from holding assets in different countries is bigger. As such, the deviation of interest differential between domestic and foreign bond becomes wider, so does the magnitude of an increase in exchange rate depreciation expectation. This, simultaneously, means two things. First, in conflict to the case where the control on inflow and outflow of capital investment is ruled out, asymmetric shock in money supply causes home interest rate to be lower and foreign interest rate to be higher. In fact, domestic interest rate does not only being lower, but it also show an opposite response to change in money supply. This movement is true in essence because, in the imperfect capital mobility case, inflation does not raise that much, so that the liquidity effect of expansionary monetary policy overcomes expected inflation effect. Consequently, quite a opposite, we can observe a fall (rise) in home (foreign) nominal interest rate in contrast to the case where the limit on the ability of the households to close financial deal in bond market abroad is low. Second, higher expected depreciation also generates lower a monetary-induced increase in exchange rate as compared to economy with authorized offshore-financial transaction. Hence, although labor market integration stimulates higher increase in exchange rate, introducing imperfect capital mobility in combination with complete labor market integration places additional pressure on yield differential, and thus, lowering the effect toward exchange rate from change in monetary policy.

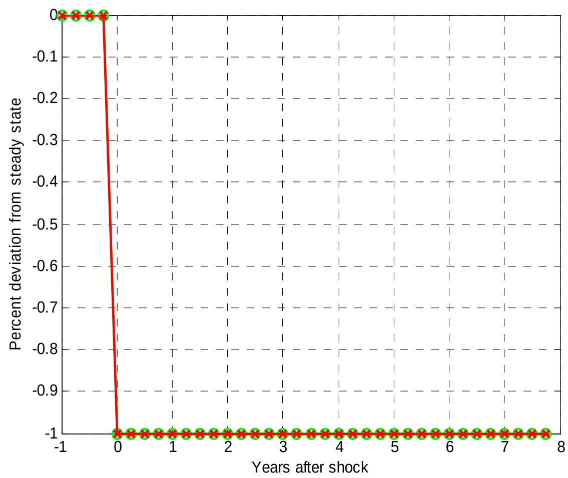
Armed with the dynamics of exchange rate, we can determine the effect of monetary policy change on other macro variables. If we compare to the case of highly mobile capital, a smaller depreciation produces a smaller change in prices, wages, consumptions, and current accounts. In other words, when the nation's capital markets are more isolated, an asymmetric shock in money supply causes price (both general price index and price of individual goods) to rise by less in home and fall by less in foreign. This, together with the decline (increase) in home (foreign) real interest rate, in turn, implies that domestic (foreign) consumption (both consumption index and consumption of individual goods) would fall (rise) by less as compared to the case of a more open financial market. Accordingly, the amount of a current account surplus (deficit) that home (foreign) is having in aftermath of monetary policy shock declines in the world in which households are subject to transaction costs in seeking positions in the international bond market.

Figure 7.2

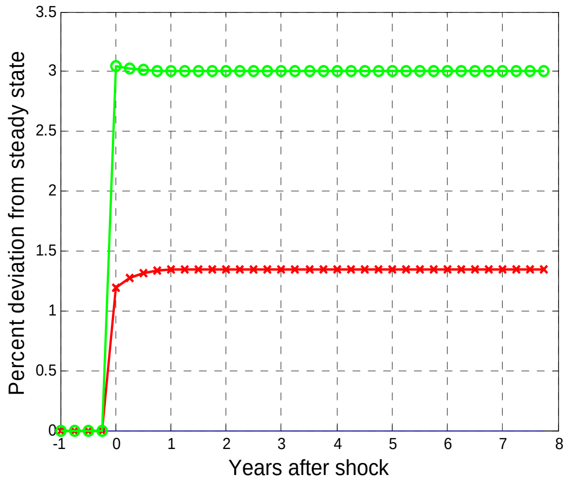
International capital mobility and the dynamic macroeconomic effects of a unit asymmetric money shock: Subsequent to labor market integration



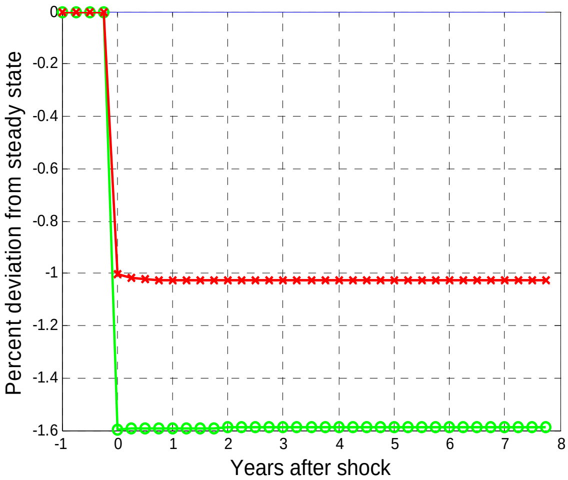
(a) Home money supply



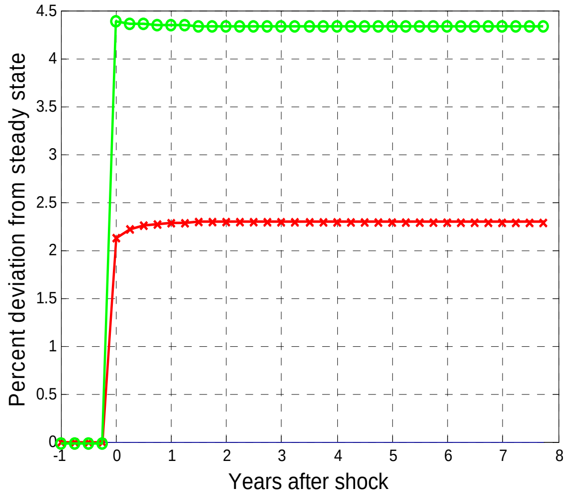
(b) Foreign money supply



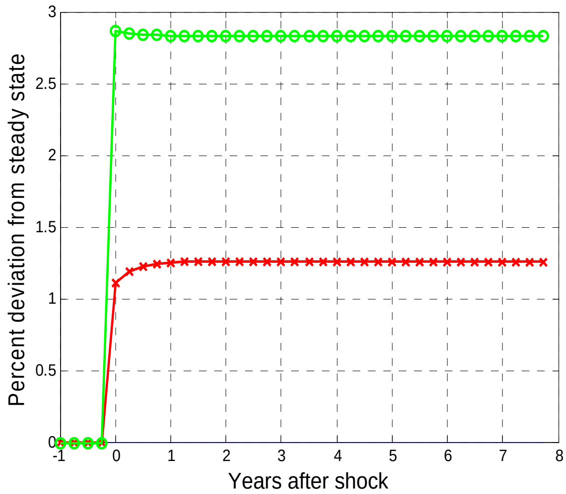
(c) Home general price index

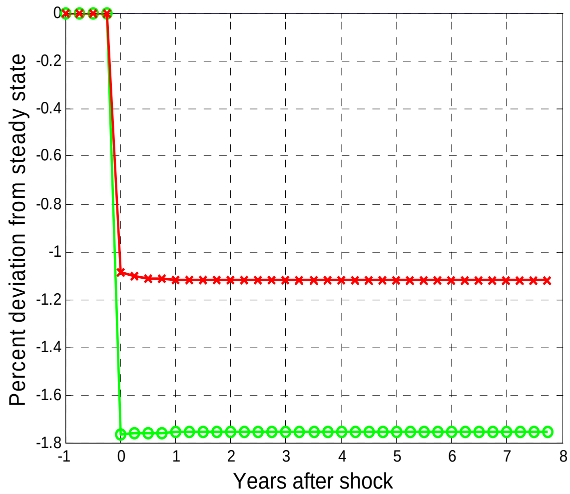


(d) Foreign general price index

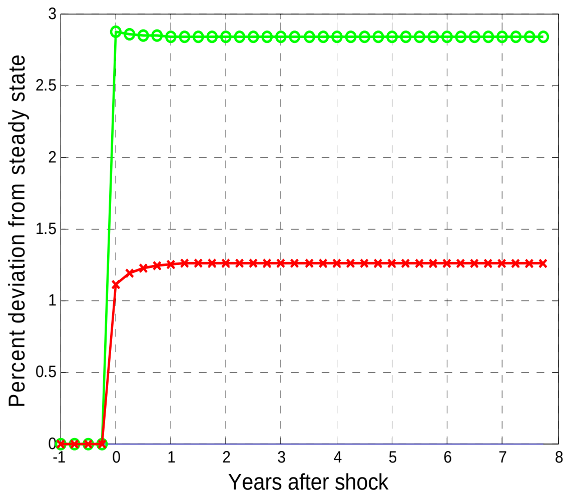


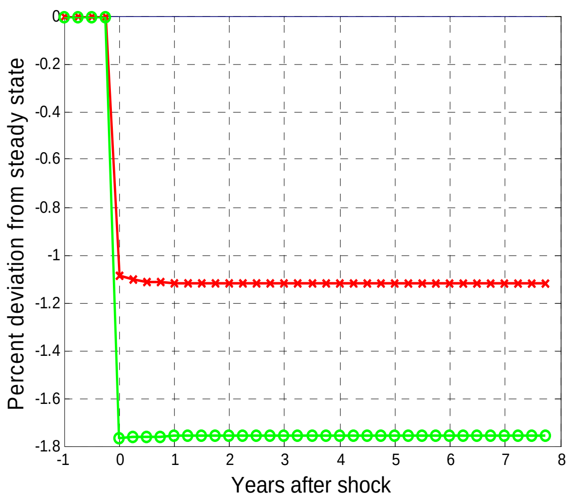
(e) Exchange rate



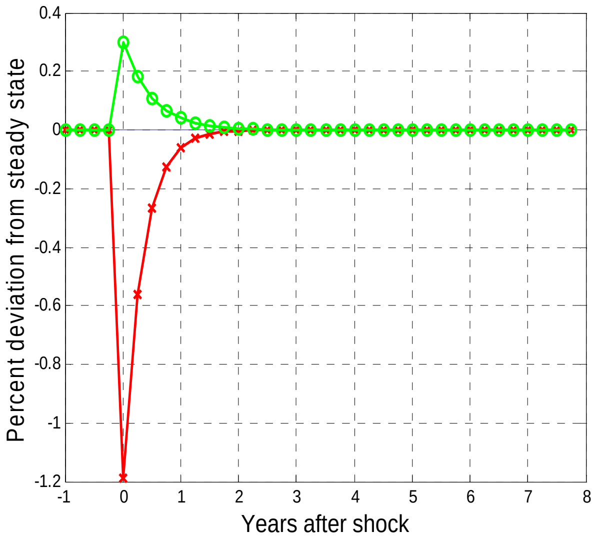


(f) Price of individual home-produced goods (g) Price of individual foreign- produced goods

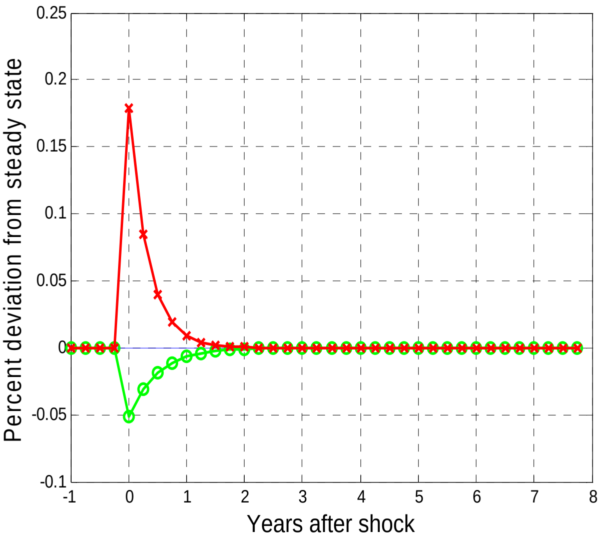




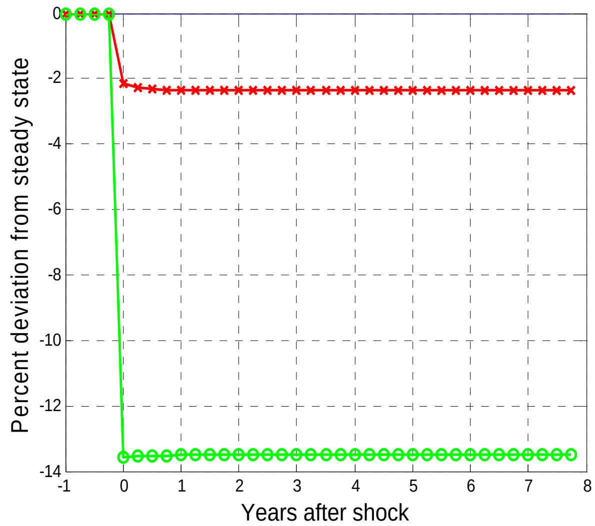
(h) Home nominal wage (i) Foreign nominal wage



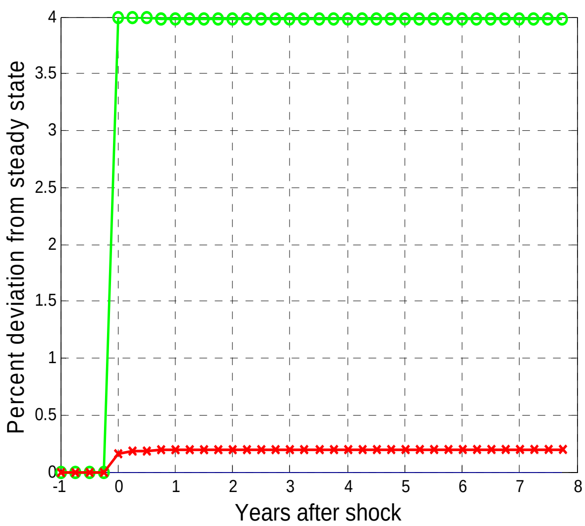
(j) Home nominal interest rate



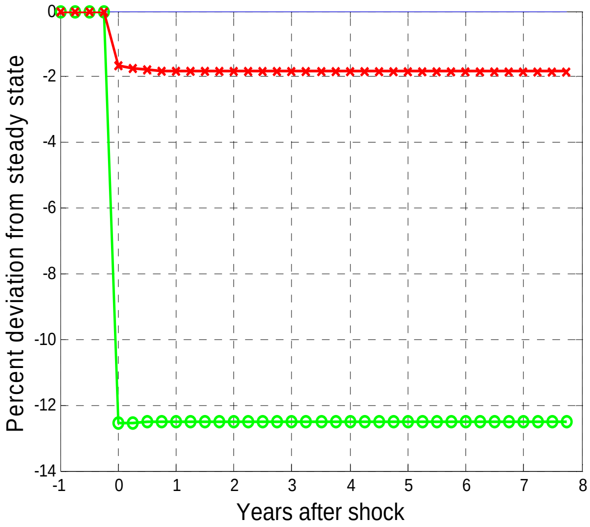
(k) Foreign nominal interest rate

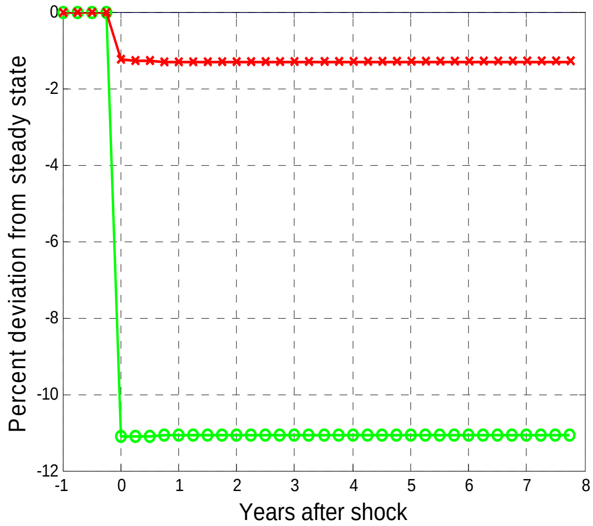


(l) Home consumption index

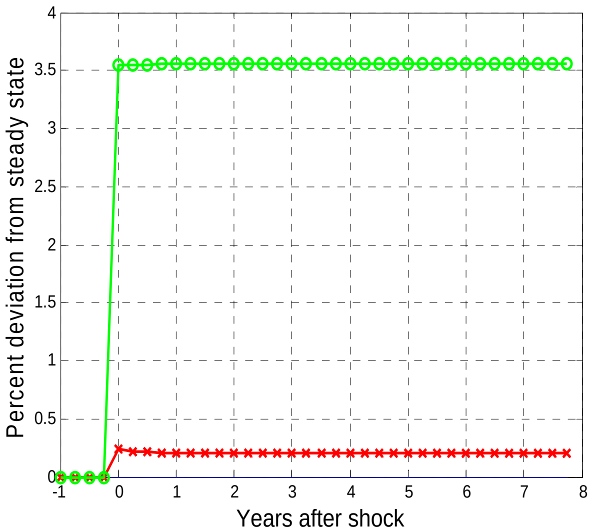


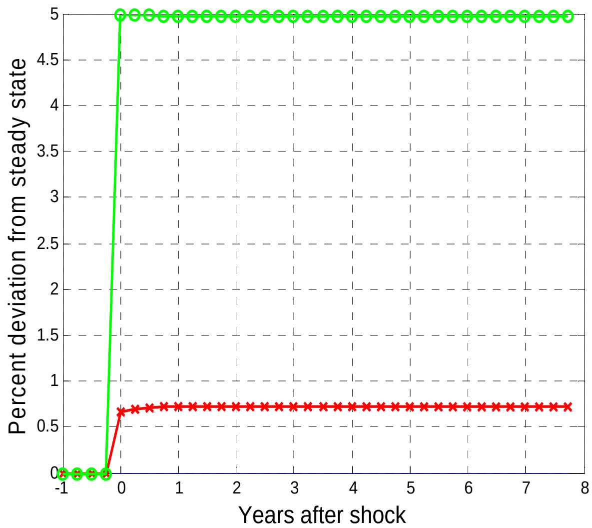
(m) Foreign consumption index



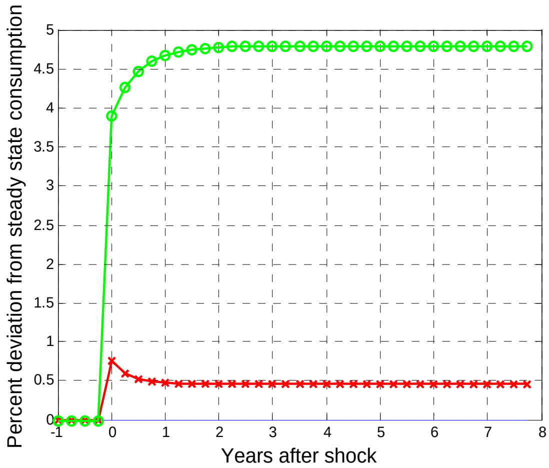


(n) Home demand for domestically produced good (o) Home demand for foreign produced good

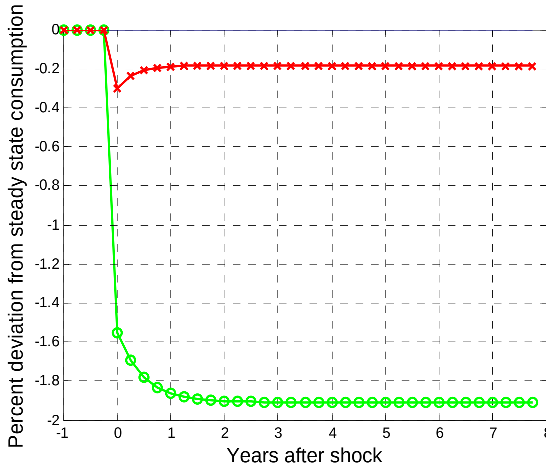




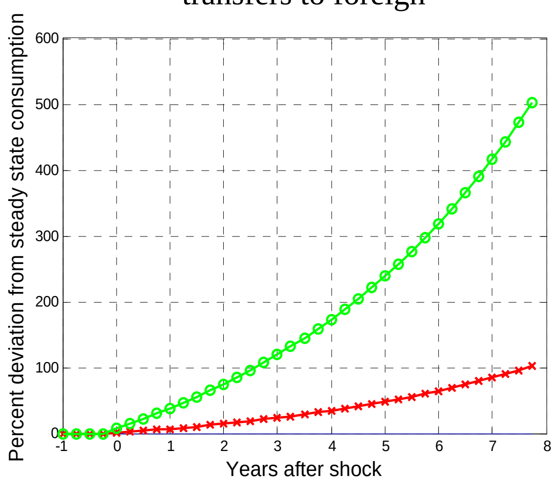
(p) Foreign demand for domestically produced good (q) Foreign demand for foreign produced good



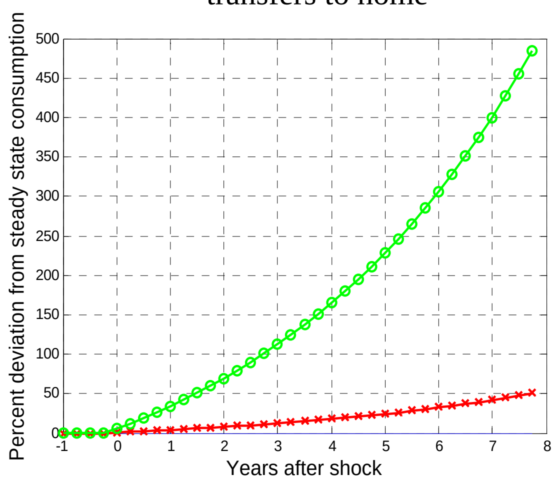
(r) Quantity of funds home agents transfers to foreign



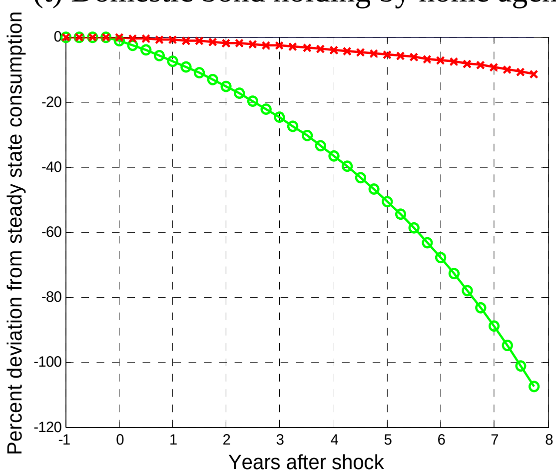
(s) Quantity of funds foreign agents transfers to home



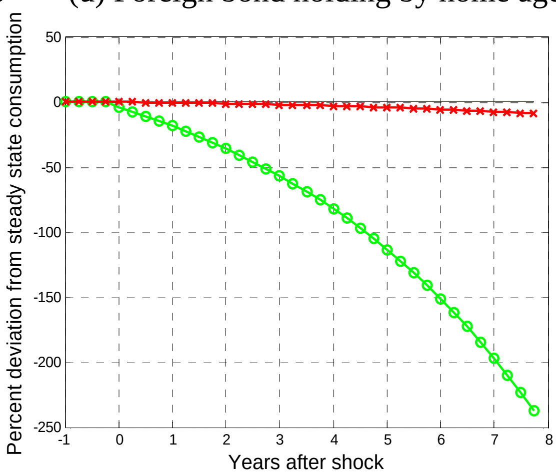
(t) Domestic bond holding by home agents



(u) Foreign bond holding by home agents



(v) Domestic bond holding by foreign agents



(w) Foreign bond holding by foreign agents

○ Degree of capital mobility: High × Degree of capital mobility: Low

Unit of measurement:
Consumptions, prices, wages, nominal exchange rate, money supply – Percentage deviation from initial equilibrium
Bond holdings and flow of funds – Deviation as a percentage of the initial consumption level
Interest rates – Percentage point deviation from initial equilibrium

In summary, the main feature of interest that apparently comes out from looking at the various graphs in Figure 7.2 is that when labor market friction in the form of barrier to across-border migration exists, the effect of monetary policy on macroeconomic volatilities is considerably diminished. As a result of lower aggregate oversea capital trading of home agents when the world have borderless labor periphery, the labor market integration leads to more volatility in exchange rate, prices, wages, consumptions, and foreign bond holdings in both home and foreign country.[4] Therefore, labor market integration enhances the role of monetary policy in changing the dynamics of most of the macroeconomic variables in our model. Besides, interestingly, though they create an opposite effect on the volatility of interest rate, this way of how labor market integration affects economic responses to the shock does not seem to change significantly with the presence of highly complete (case 7.2.1) or incomplete (case 7.2.2) financial market integration.

Last but not least, the evidence from Figure 7.2 asserts that, with complete labor market integration, effectiveness of monetary policy in changing the volatility of economy, more often than not, increases with the degree of capital mobility. That is to say, the increasing financial market integration induces less volatility in interest rate but increase volatility of exchange rate, prices, wages, consumption, and foreign bond holdings. Resembling what is true when labor market is still segmented, the effect of relative asset return on exchange rate change is clearly a key element in determining this effect of monetary policy. In the end, financial market integration strengthens the effect of monetary policy in changing volatility of most of the economic variables when there is a close connection between labors in each nation. More importantly, these results are not much affected by the extent to which labor market integration has

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[4]These results do not coincide with what is found in the two-country version of Mundell-Fleming model with floating exchange rate where a monetary policy change is transmitted abroad through the channel of trade balance. In their model, because the big country succeeds in increasing nominal interest rate everywhere simultaneously, the monetary contraction there will not cause as big an exchange rate appreciation as in a small-country case for any degree of capital mobility. This prediction is not true in our model, nonetheless. This is so because of the effect that international labor migration imposes on the price level, causing currency in foreign country, which becomes a big country in our model after home emigration, to appreciate by more from the contractionary monetary policy.

been developed. Obviously from Figure 7.1 and 7.2, with or without international labor migration, the power of monetary policy to affect prices, wages, and exchange rate tend to be amplified given the increase in international capital mobility. Therefore, regardless of the situation concerning the boundary in world labor market, we can definitely conclude that, despite the differences in model formulation, our flexible-price NOEM model and the Mundell-Fleming model share some implications in that both models predict that the nominal exchange rate effect of monetary policy tends to increase in the world of high capital mobility. At the same time, the flexile-price NOEM model analyzed in this paper and the monetarist approach also have in common in terms of output implication of monetary policy. That is, both agree to the fact that monetary authority has comparatively restricted room for supervising monetary policy that is effective in changing output if prices and wages do adjust immediately after a shock.

7.3 Summary of the Results

Having discussed in detail the specific movements and causalities underlying the responses of macroeconomic variables to monetary shock, it is useful to summarize the implications of financial and labor market integration on these response. Table 7.1 presents the direction of change in impact effect of shock in money supply. Providing that impact effect of money supply is measured by volatility, a negative sign here exhibits that the integration leads to less volatility in the variables in question whereas a positive sign serves as the case where volatility increase. By bringing together all the results discussed in the previous sections, this table seeks to provide a summary of how differ the economy behaves in the upshot of money shock under different regime of integration in world's financial and labor market.

Table 7.1

Summary of the effects of a monetary shock on macroeconomic volatilities with regard to the process of markets integration

Case	Interest rate i, r	Consumption $C, c(z)$	Exchange rate E	Price $P, p(z)$	Output y, Y	Funds transferred I
(1) Financial market integration						
(i) Sutherland (1996)	-	-	+	0	+	+
(ii) Imperfectly integrated labor market	-	-	+	+	0	-
(iii) Perfectly integrated labor market	-*	+	+	+	0	+
Case	Interest rate i, r	Consumption $C, c(z)$	Exchange rate E	Price $P, p(z)$	Output y, Y	Funds transferred I
(2) Labor market integration						
(i) Highly integrated financial market	+	+*	+	+	0	+
(ii) Less integrated financial market	-	+*	+	+	0	+

Note: * implies that the variable under consideration moves in the opposite direction in aftermath of shock as a result of market integration.

Two general points emerge from the above table:

1) The effect of increased financial market integration on volatility of macro variables following a monetary shock does not depend strongly on the degree of labor market integration between the two countries. In other word, at any degree of labor market integration, it would be unmistakable to establish the financial market integration as the factor that reduces volatility of interest rates and increases volatility of prices and exchange rate in response to change in money supply. Hence, along the lines of Mundell-Fleming model and Sutherland (1996), the monetary policy effect toward exchange rate tends to be stronger, the higher is the degree of international capital mobility. These effects take place through the interaction between the relative return on domestic and foreign bond and exchange rate. On the contrary, while it enhances the effect on exchange rate, antithetical to typical New Keynesian model, its effect on output deteriorates as perfectly flexible prices and wages bring about the classical neutrality property of monetary policy. As required by the monetarist position, the appreciable changes in the rate of growth of stock of money are a necessary and sufficient condition for appreciable changes in rate of growth of only money, not real, income.

2) The same applies to labor market integration. The presence of incomplete financial market integration does not seem to alter the sign of the volatility effect of monetary policy. Due to a lower aggregate oversea capital trading of home individuals when the labor market is well integrated, the effect of monetary policy on prices, exchange rate, consumption, and funds transferred increases with the degree of international labor mobility.

In conclusion, the clear-cut patterns initiating from the above results are conceivably that the nominal adjustments of the economy to an unanticipated changes in monetary policy, i.e., change in prices and exchange rate, are an increasing function of the degree of integration in both financial and labor market and that the integration in one market is, more or less, independent of the extent of the integration in the other.

CHAPTER 8

SENSITIVITY ANALYSIS

In chapter seven, the dynamic solution paths that explain the consequences of a financial and labor market openness on the propagation of a monetary shock is presented in the benchmark parameterization. Here, to provide some further examples that confirmed the derived results, I will analyze the simulation of the model under several alternative levels of international capital and labor market integration. To this end, the implications of changes in the calibration of the model for the effectiveness of monetary policy in altering the volatility of macro variables under the regimes of high and low capital mobility are evaluated.[1] First, I will begin my examination by studying how change in value of trading friction in financial market affects the main results. Then, I will look into the outcomes for various cases with different amounts of labor migration in the last part of this chapter.

8.1 The Variation of the Degree of Capital Mobility and the Macroeconomic Impacts of Monetary Policy

The following few paragraphs depict additional results for alternative calibration of the model in terms of financial market integration for the economy with (Figure 8.1) and without (Figure 8.3) labor migration. For each impulse response function of the selected variables, the process of financial market integration is considered in progression by moving from $\psi = 2$ to $\psi = 0.85, 0.2, \text{and } 0.001$. This logical succession of change in ψ, from high to low value, represents the historical evolution of the international financial system, as the process of liberalization has gradually diminished the barriers between countries.

[1]Note that since the response of the foreign economy is a mirror image of that of domestic economy, only variables for home country will be illustrated in the following analysis.

8.1.1 Economy before international labor market integration

The first half of this section focuses on the implication of progressively higher degree of capital mobility for a regime with little ties between labors in a global market. As clarified in section 7.1.2, the responsiveness of exchange rate to the movement of relative asset return is the main channel through which the effectiveness of monetary policy is determined. In the case with a lower transaction cost of holding foreign bonds, the resulting asset accumulation exerts a smaller negative direct effect in international relative yield differential via the cost-adjusted version uncovered interest rate parity.

$$\left(1-\beta\right)\hat{i}_t^H - \left(1-\beta\right)\hat{i}_t^F - E_t\left(\hat{E}_{t+1} - \hat{E}_t\right) = \psi \bar{N}^H \bar{C}^H E_t\left(\hat{I}_{t+1}^H - \hat{I}_t^H\right)$$

The result is a less departure in each country nominal interest rate when there is a freer access to take on the investor roles in oversea financial market. Thus, as confirmed by shifting from $\psi = 2$ to $\psi = 0.85$ in case 1, $\psi = 0.2$ in case 2, and $\psi = 0.001$ in case 3, this causes domestic nominal interest rate to go down in smaller proportion, in comparison to the case of lesser mobile capital. (In the extreme case of almost perfect capital mobility, case 2 and 3, there is effectively only one interest rate. See panel 8.1 a) At the same time, along with the above results, the lower level of the relative asset return also produces a relatively strong monetary policy-induced depreciation of home currency in the world where a barrier to investing in offshore financial market is less important. Therefore, the higher degree of capital mobility precisely strengthens the exchange rate effect of a monetary policy as we process through all variations of the model (See panel 8.1 b).

Figure 8.1

Variation in the degree of international capital mobility and the dynamic macroeconomic effects of a unit asymmetric monetary policy shock: Prior to labor market integration

Case 1	Case 2	Case 3
Scale of financial market integration: lowest	Middle	Highest

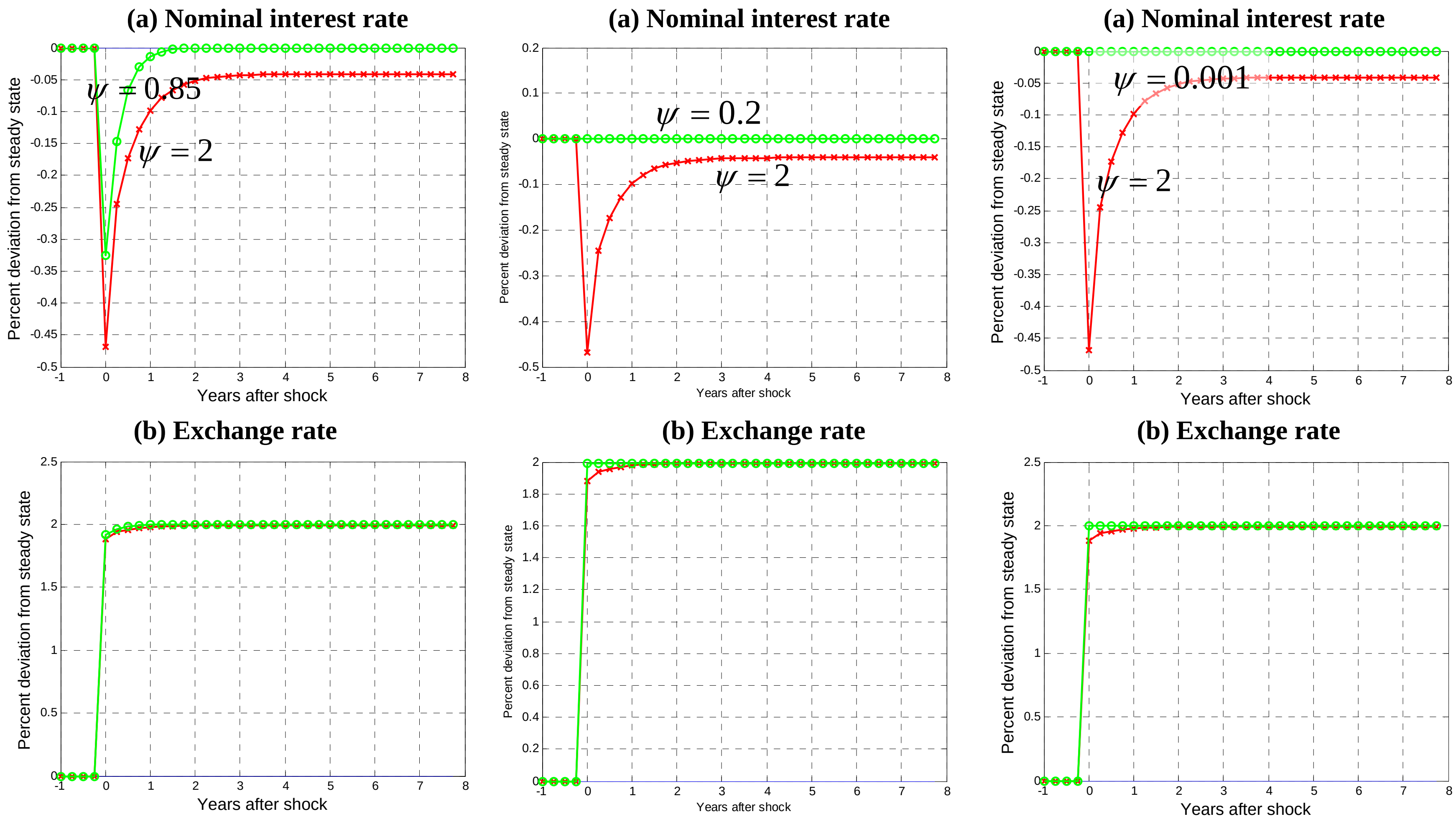
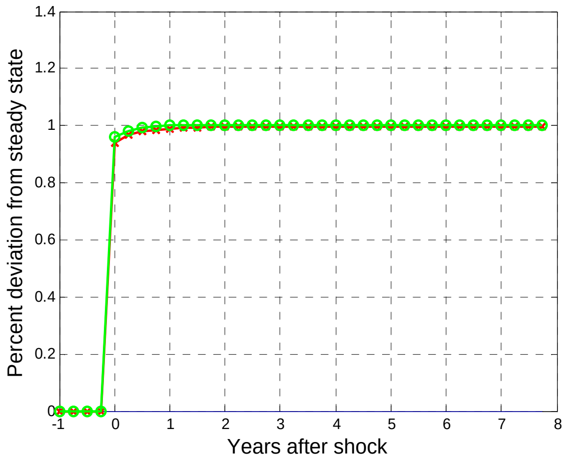


Figure 8.1 (Continued)

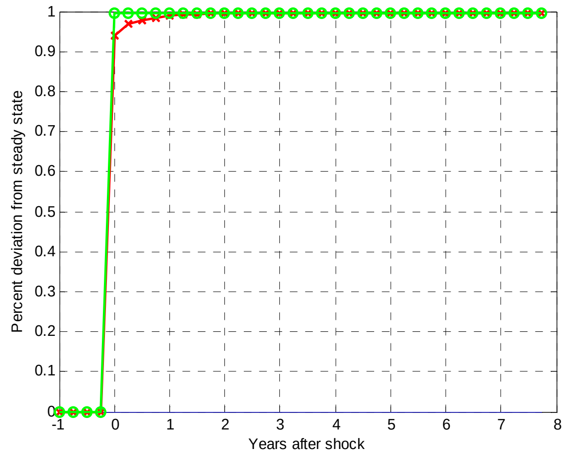
Case 1

(c) General price index (wage)



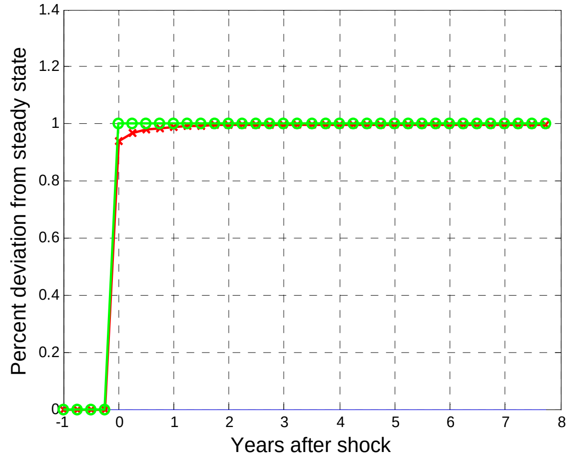
Case 2

(c) General price index (wage)

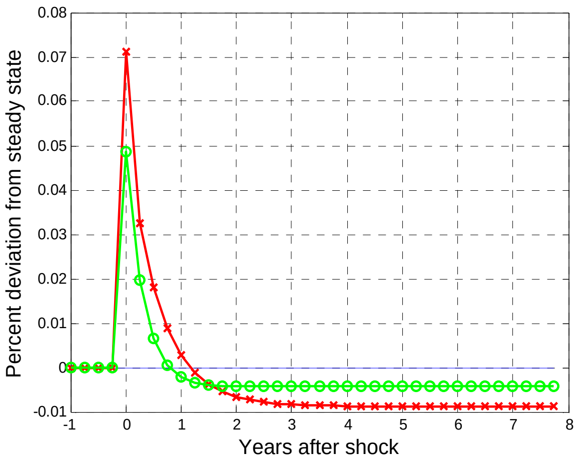


Case 3

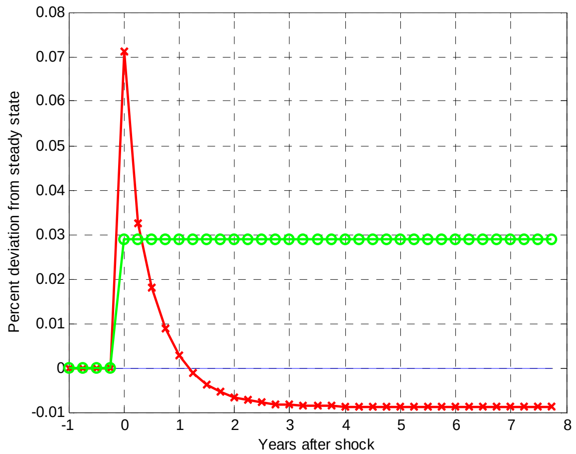
(c) General price index (wage)



(d) Consumption index



(d) Consumption index



(d) Consumption index

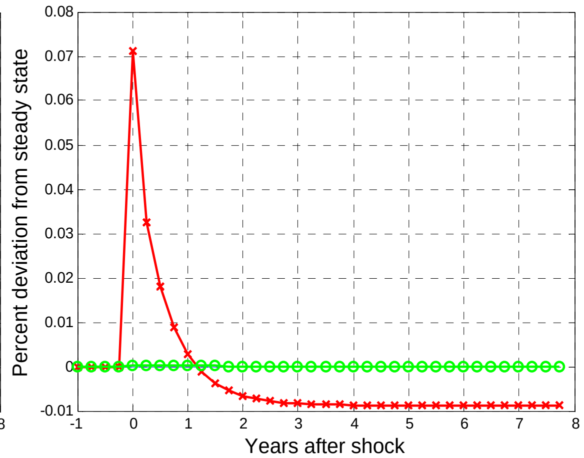
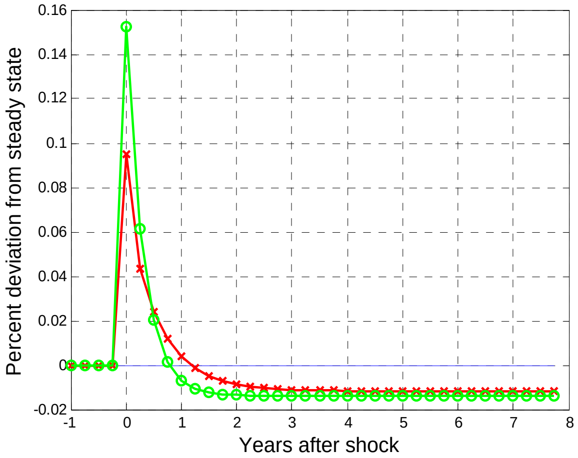


Figure 8.1 (Continued)

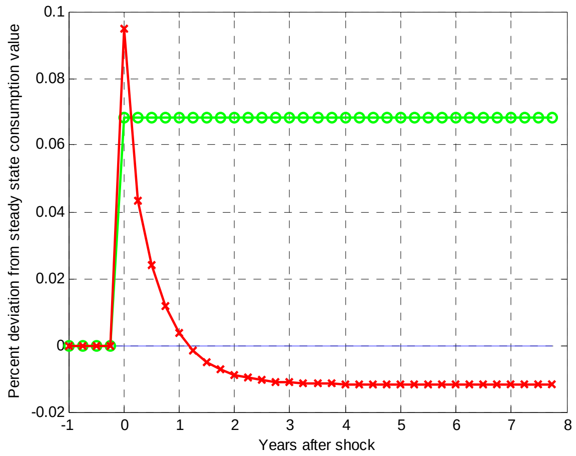
Case 1

(e) Quantity of funds transferred abroad



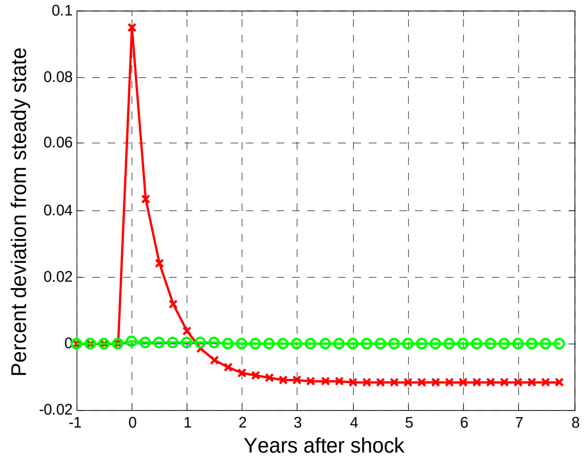
Case 2

(e) Quantity of funds transferred abroad



Case 3

(e) Quantity of funds transferred abroad



Note: The entire figure is the impulse response function for domestic economy only.

Before labors can migrate, the proportion of labor supply resided in each country is set to unity.

The lines with mark (x) in all three cases are obtained by setting $\psi = 2$.

To analyze the implication of increasing mobility of capital,

In Case 1 (First column), lines with circle (o) represent the case where $\psi = 0.85$.

In Case 2 (Second column), lines with circle correspond to the case where $\psi = 0.2$ (the case presented in chapter seven).

In Case 3 (Third column), lines with circle denote the case where $\psi = 0.001$.

To go further, given this nontrivial increase in exchange rate, it can be easily seen from panel 8.1 c that the positive effect of an expansionary monetary policy on the home price is enlarged when an extra amount of integration in financial market is introduced by constantly lowering the cost parameters. This, together with the flat movement in interest rate, in turn, implies that, in the aftermath of a money shock, home consumption will rise by a lower level in an once-and-for-all step manner to new long run equilibrium in the case where there is increasingly higher liberated way to close oversea capital deal, as illustrated in panel 8.1 d. As for the oversea financial transaction, given that an economy has flat income, the domestic country runs a declining value of current account surplus when agents can trade financial assets between countries with less and less difficulty. This occurs, despite the lower rise in consumption, because home households drop their demand for holding of bonds lower and lower. Consequently, in panel 8.1 e (except when $\psi = 0.85$ in case 1), the amount of funds transferred abroad is reported lower for an increasingly higher degree of loosing up in the international financial market. (When the financial market integration is most completed, domestic agents maintain the same level of consumption and asset holding. So, the current account balance, hence funds transferred, is preserved at equilibrium, as seen when $\psi = 0.001$ in case 3.).

In total, two general points become known from the above explanations.

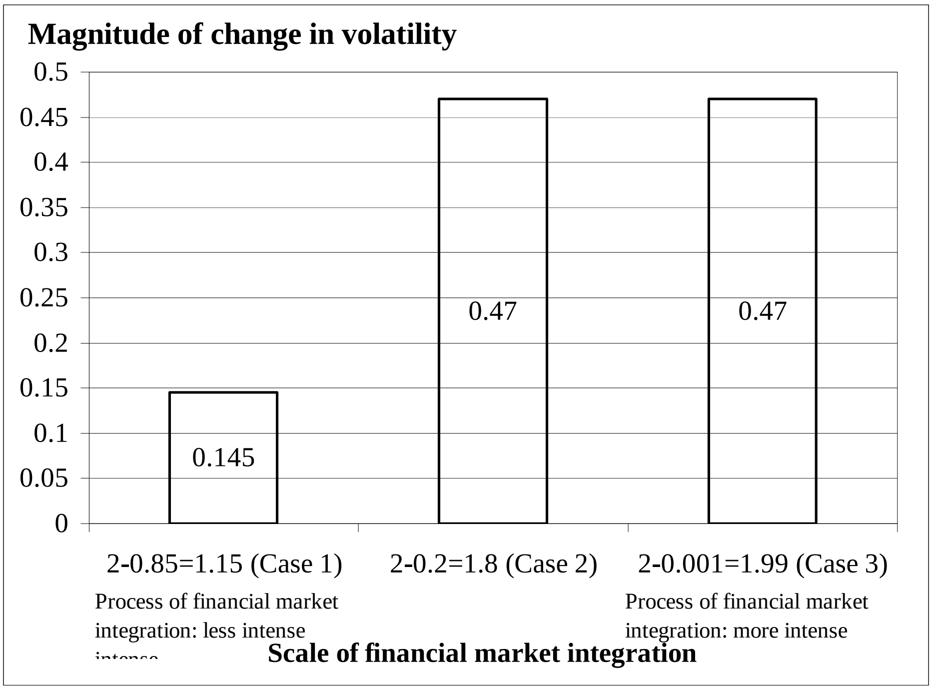
First, if financial market integration is measured by comparing between the circumstances of higher and lower capital mobility in each diagram, the results turn out to be that whether the financial integration raises or lowers macroeconomic volatility in the face of a change in money supply does not depend upon the scale of the integration (By scales of financial integration, I mean the differences in size of adjustment cost parameter, ψ, in each case. So, by this definition, we have case 1, with smallest difference, as the least integrated case of all). Above all, as obvious in Figure 8.1, the result in all three cases, to some extent, concur with those in section 7.1. That is, regardless of the extent of the integration, all figures entirely suggest that the while financial market integration reduces volatility of interest rate and consumption, it increases volatility of exchange rate and price in response to the change in money shock, and thus, diminishes the output effect of a monetary policy.

Second, how strong are these results? Since total value of relative return of assets originated from the two countries shrinks by less steadily when the degree of capital mobility is, little by little, enhanced, it appears from Figure 8.1 that the above outcomes tend to improve as the intensity of financial market integration evolves, from a lower (case 1) to higher (case 2 and case 3) level. In other words, the gaps, generated by changing degree of capital mobility in each case (spaces between the two plots, i.e., plots with mark x and circle o), would become wider, the larger are the differences between the adjustment cost parameters. Using this information, Figure 8.2 is plotted with differences between the impact effects of a monetary shock under high and low capital mobility on the vertical axis and the differences in an adjustment cost parameter, ψ , on the horizontal axis. These diagrams are intended to summarize the quantitative significance of the effect caused by the different ranges of financial market integration for some of the variables being discussed.

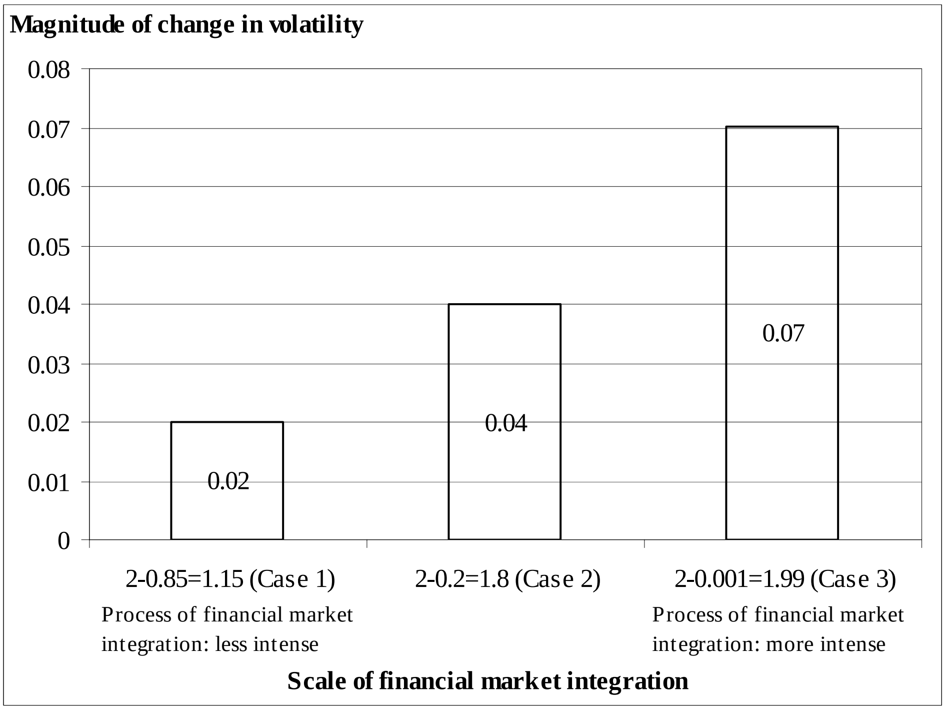
Figure 8.2

The scale of financial market integration and the magnitude of change in volatilities: Prior to labor market integration

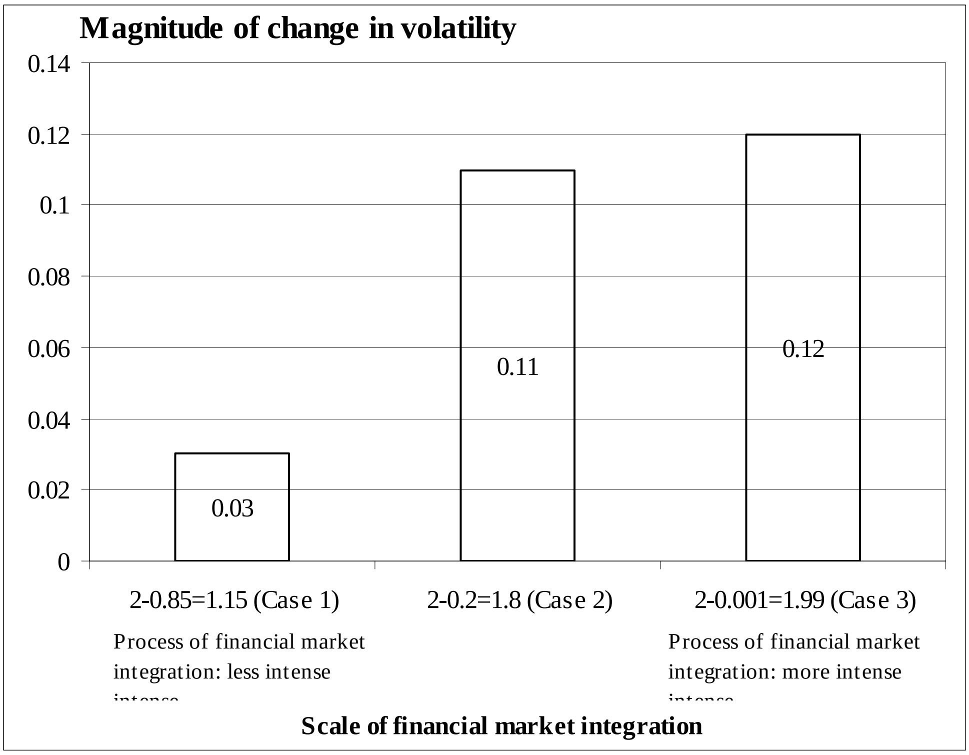
(a) Nominal interest rate



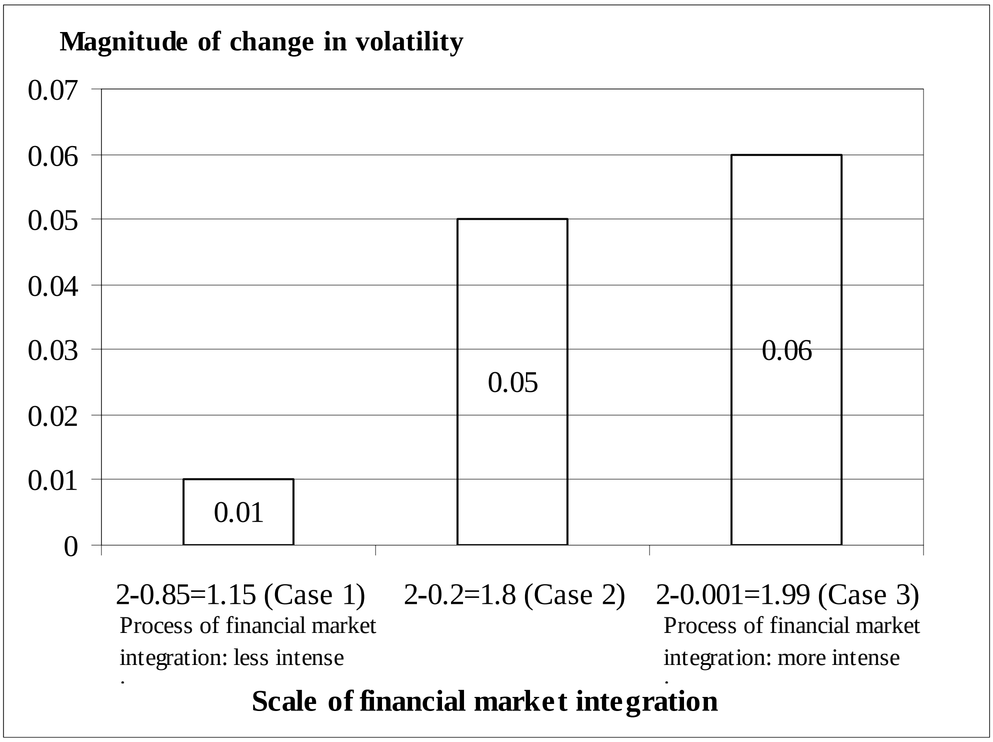
(b) Consumption



(c) Exchange rate



(d) Price



Note: The entire figures are drawn from the domestic economy only.

Taken together, the figures truly reveal that the effect of financial market integration on the relative magnitude of the interest rate, consumption, exchange rate, and price effect of monetary policy in the regime of high and low capital mobility can be substantial. Evidently from the increasing height of the bar charts, as the amount of financial market integration is greater (moving from left to right), the magnitude of the change in volatilities as a result of financial market integration is bigger as well. Therefore, as with the Mundell-Fleming model, the effectiveness of monetary policy in changing exchange rate is enhanced in the case of highly mobile capital (similar to conclusion in section 7.1), with the most significant effect when the volume of the financial market integration is greatest, case 3.

8.1.2 Economy after international labor market integration

On top of the above additional simulation, I also identify whether the results will turn aside once the international flow of labors is introduced in Figure 8.3. Apparently, the key elements, reflected from such figure, are that the effect of labor market integration on exchange rate, price, wage, interest rate, consumption, and funds transferred in the aftermath of monetary shock, examined in section 7.2, does not seem to vary despite the change in value of ψ. To put it differently, in all three variations, both for the case of high and low capital mobility, if we allow for labors to shift their residence from home to foreign country, the plunge in aggregate amount of funds transferred abroad of home households would result in the smaller fall in relative yield differential, thus producing the more significant domestic currency depreciation in response to increase in domestic money supply. Therefore, looking at the panel 8.3 a, we can literally witness the higher rise in exchange rate, as compared to the situation of disconnected global labor market in panel b of Figure 8.1. Equipped with the movement of exchange rate, it is known, from panel 8.3 b and c (weigh against panel 8.1c), that after the disturbance hits the economy, home price index will increase higher (due to the price index effect), as is the wage rate set by home firms (due to the home market effect). Then, on account of the higher rise in home price, consumption in home declines in all three cases, as shown in panel 8.3 e, thus making a larger surplus in home current account following the cross-border home emigration in panel 8.3 f. Finally, note that these roles played by international labor market integration are likely to increase with the degree of capital mobility, i.e. as we develop from $\psi = 2$ to $\psi = 0.85, 0.2,$ and 0.001 (because the lower value of ψ reinforces the fall in relative yield differential as described in the next paragraph). As such, it can be seen that, among the whole cases, the effect of a switch in location of labors' habitation from home to foreign can be most recognized in case 3 when the extent of financial market integration is highest.[1]

[1]The interest rate effect of monetary policy is depicted in panel d of Figure 8.3. Obviously, we can notice that the expected inflation effect of an expansion in home money supply does occur only in case 2, where $\psi = 0.2$. To explain the plunge in home interest rate despite a higher rise in home price after home labors departure in all other cases, we need to look at the demand and supply for holding of bonds. Subsequent to the emigration of domestic labors, there are stronger demands toward home bonds. This excess demand of home bonds, then, leads to a rise in bonds price and, hence, a fall in interest rate in domestic economy, as appeared in the case with $\psi = 2, 0.85,$ and 0.001.

Figure 8.3

Variation in the degree of international capital mobility and the dynamic macroeconomic effects of a unit asymmetric monetary policy shock: Subsequent to labor market integration

Case 1	Case 2	Case 2
Scale of financial market integration: lowest	**Middle**	**Highest**
(a) Exchange rate	**(a) Exchange rate**	**(a) Exchange rate**

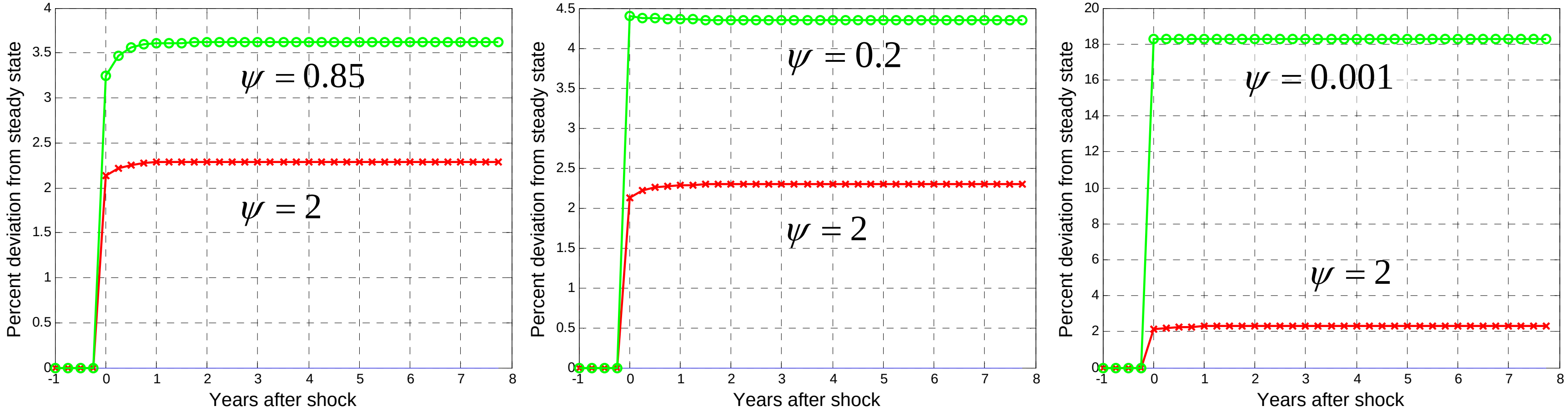
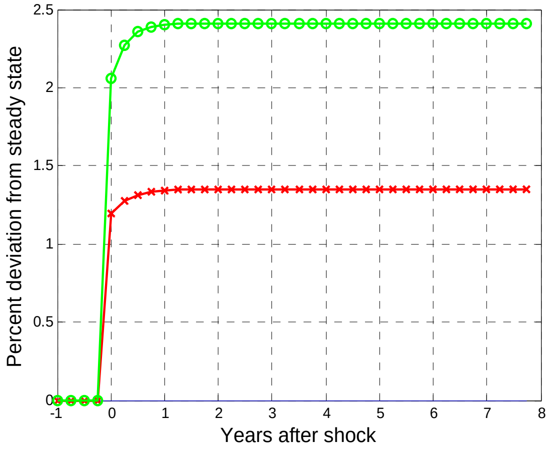


Figure 8.3 (Continued)

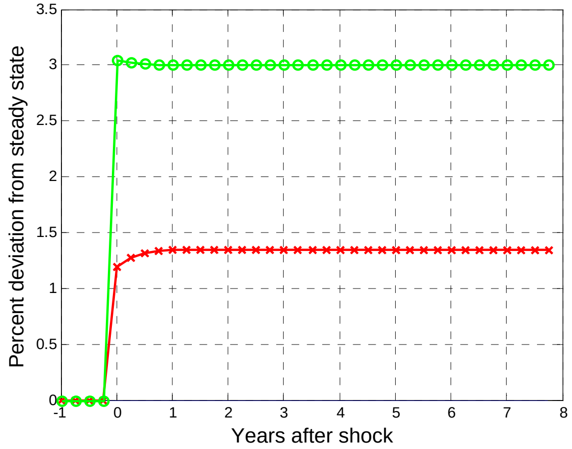
Case 1

(b) General price index



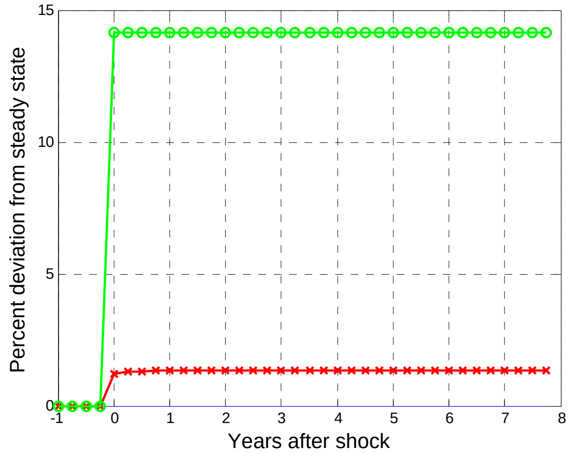
Case 2

(b) General price index

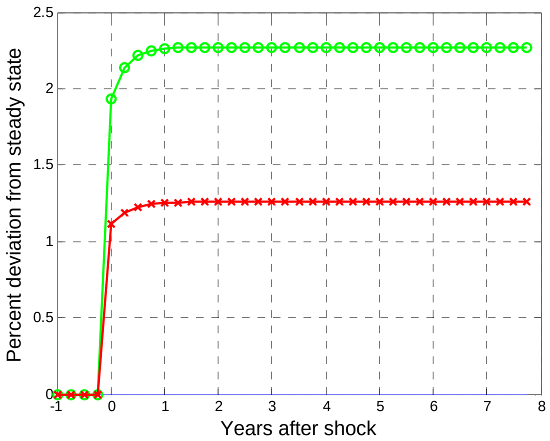


Case 2

(b) General price index



(c) Wage



(c) Wage

(c) Wage

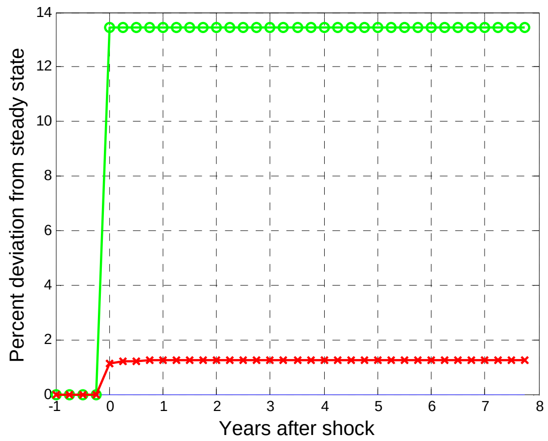


Figure 8.3 (Continued)

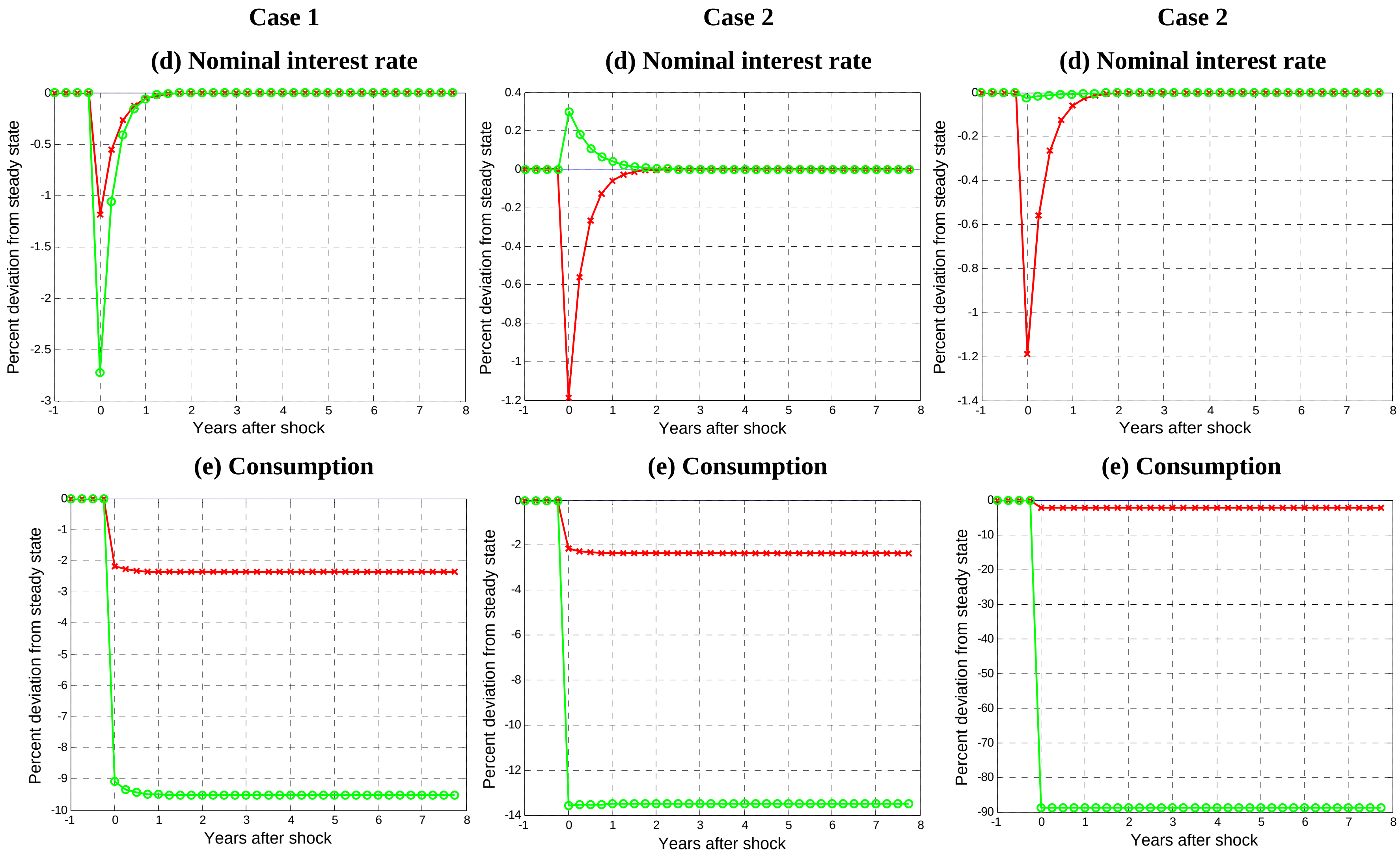
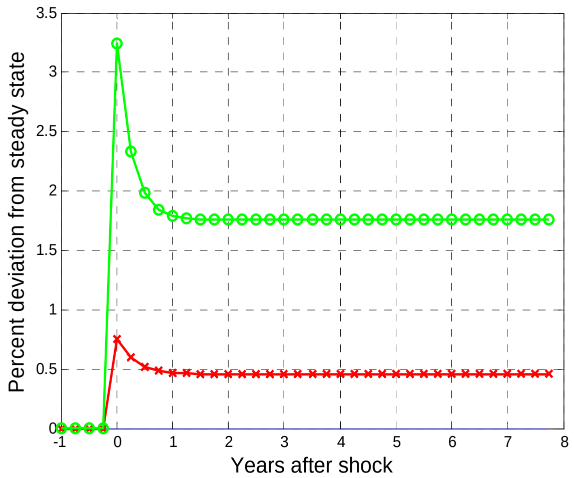


Figure 8.3 (Continued)

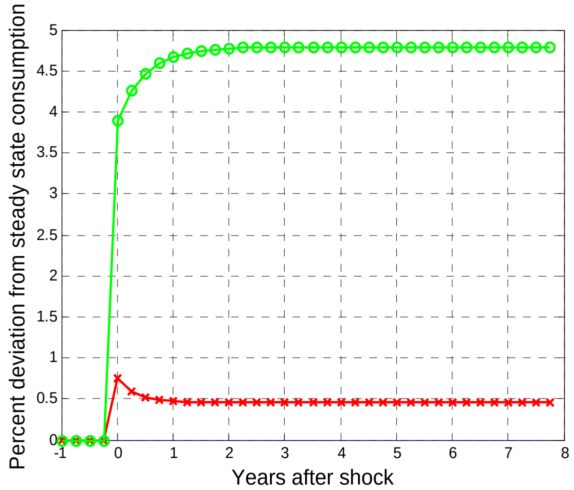
Case 1

(f) Quantity of funds transferred aboard



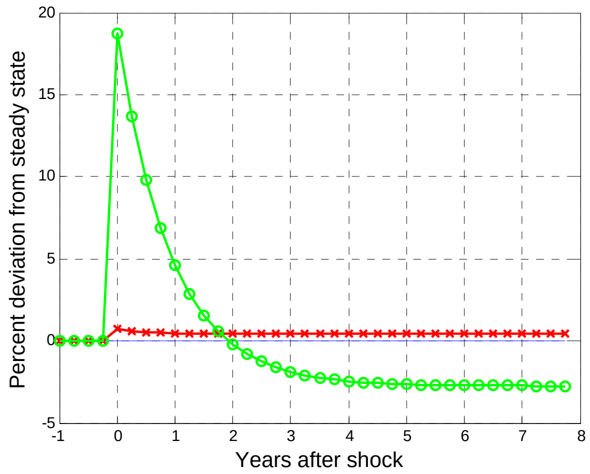
Case 2

(f) Quantity of funds transferred aboard



Case 2

(f) Quantity of funds transferred aboard



Note: The entire figure is the impulse response function for domestic economy only.

Labor market integration is incorporated by setting $\bar{N}^H = 0.94$ and $\bar{N}^F = 1.06$.

The lines with mark (x) in all three cases are obtained by setting $\psi = 2$.

To analyze the implication of increasing mobility of capital,

In Case 1 (First column), lines with circle (o) represent the case where $\psi = 0.85$.

In Case 2 (Second column), lines with circle correspond to the case where $\psi = 0.2$ (the case considered in chapter seven).

In Case 3 (Third column), lines with circle denote the case where $\psi = 0.001$.

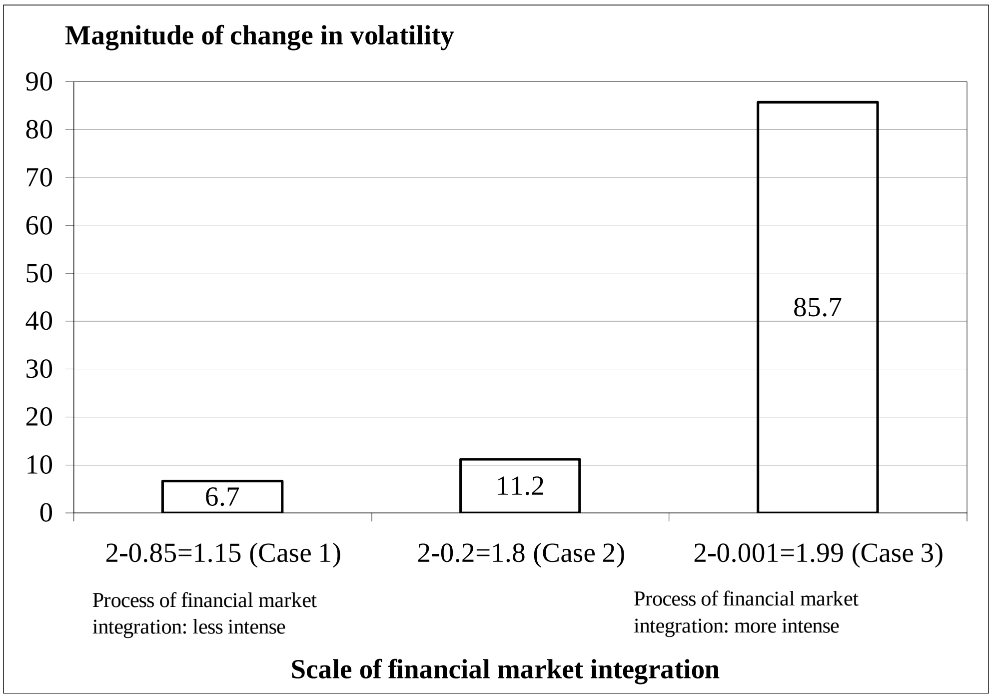
Likewise, in terms of financial market integration, the effect of increased unitization in world financial market on the way macro variables react to a shock after the labor resettlement, discussed in section 7.2.2, is not much affected given that we employ the different choices of financial market transaction constraint. As pointed out in section 8.1.1, the extent to which the monetary expansion would brings about the change in relative yield differential and thus exchange rate depends drastically upon the value of transaction cost parameter. Not surprisingly, with gradually lower value of ψ, there would be increasingly less downward pressure on the relative yield gained from a country's assets. In consequence, following the shock, the nominal interest rates in each nation turn out to be less differ (except when $\psi = 0.85$ in case 1) while the exchange rate effect of monetary policy becomes more pronounced for a progressively greater degree of worldwide capital mobility. Furthermore, as exchange rate reveals a considerable increase, home price and wage will increase higher, consumption will be fall lower, and domestic economy will run higher current account surplus in response to change in a relative money supply when smaller amount of international financial business are forbidden. These are demonstrated by transferring from the lines with a high to low value of financial trading friction in Figure 8.3. Accordingly, paralleling to what is found in section 7.2.2, the financial market integration, represented by shifting from plots with mark to plots with circle, clearly creates an increase in volatility of exchange rate, prices, wages, consumption, and foreign bond holdings when more and more control on international immigrant and emigrant are abandoned.

As a final point, the messages put across from the Figure 8.3 are that, like in section 8.1.1, where there are difficulties to migrate across border, although the extent of financial market integration does not alter the direction of change in the impact effect of each variable to a monetary shock, it does, unambiguously, influence the size in which the volatilities change in a specific manner. In particular, by extending the amount of the integration further, the magnitude of change in volatility for consumption, exchange rate, price, wage, and the quantity of funds transferred considerably increases. As reflected in Figure 8.4, the higher are the volumes of reduction in cost of trading financial assets offshore; the greater are the changes in adjustment of the economy in propagation of monetary shock.

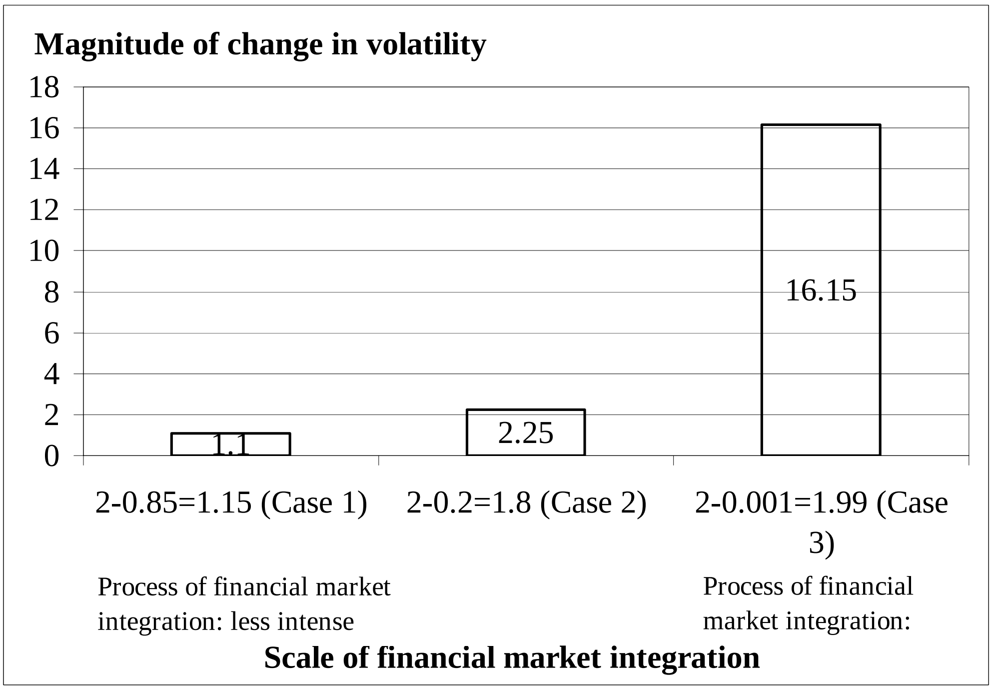
Figure 8.4

The scale of financial market integration and the magnitude of change in volatilities: Subsequent to labor market integration

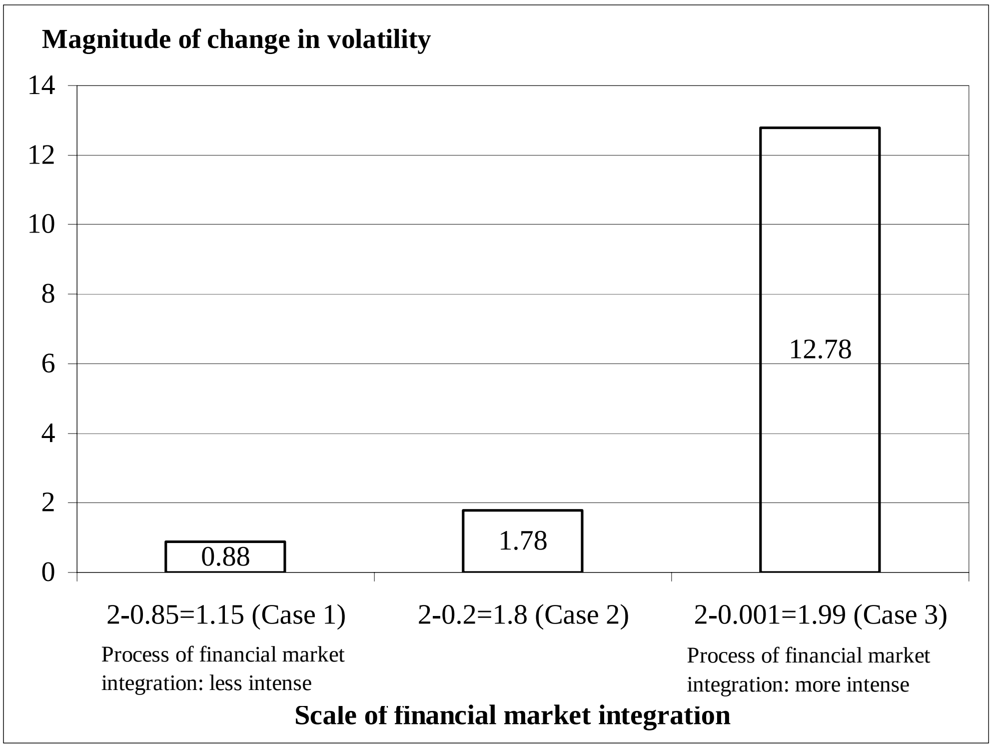
(a) Consumption



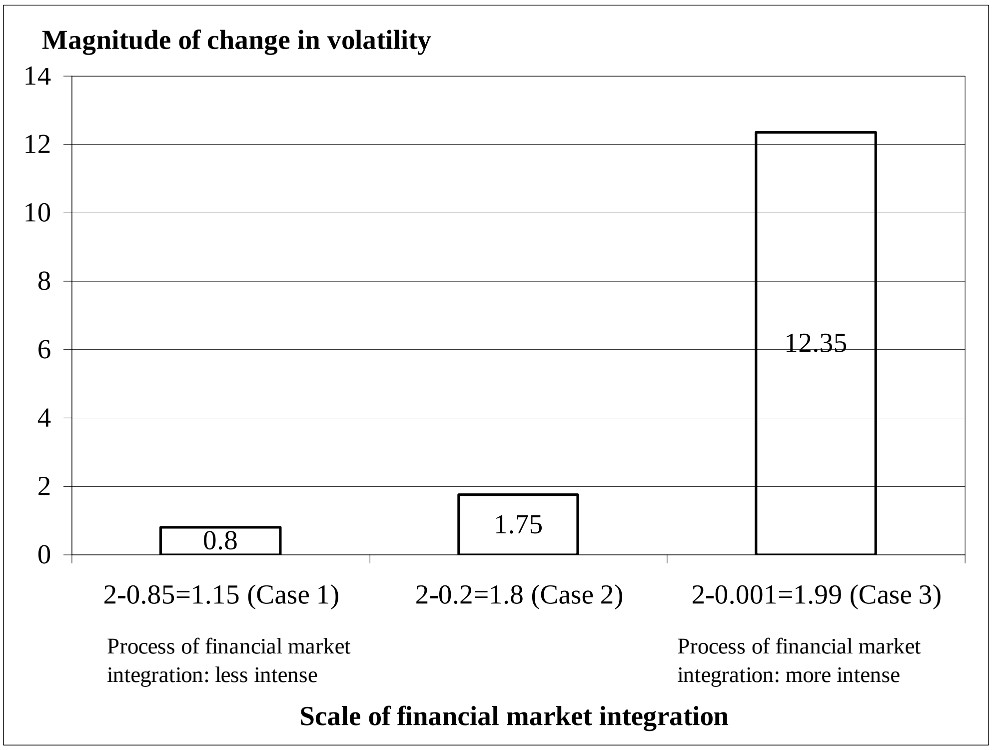
(b) Exchange rate



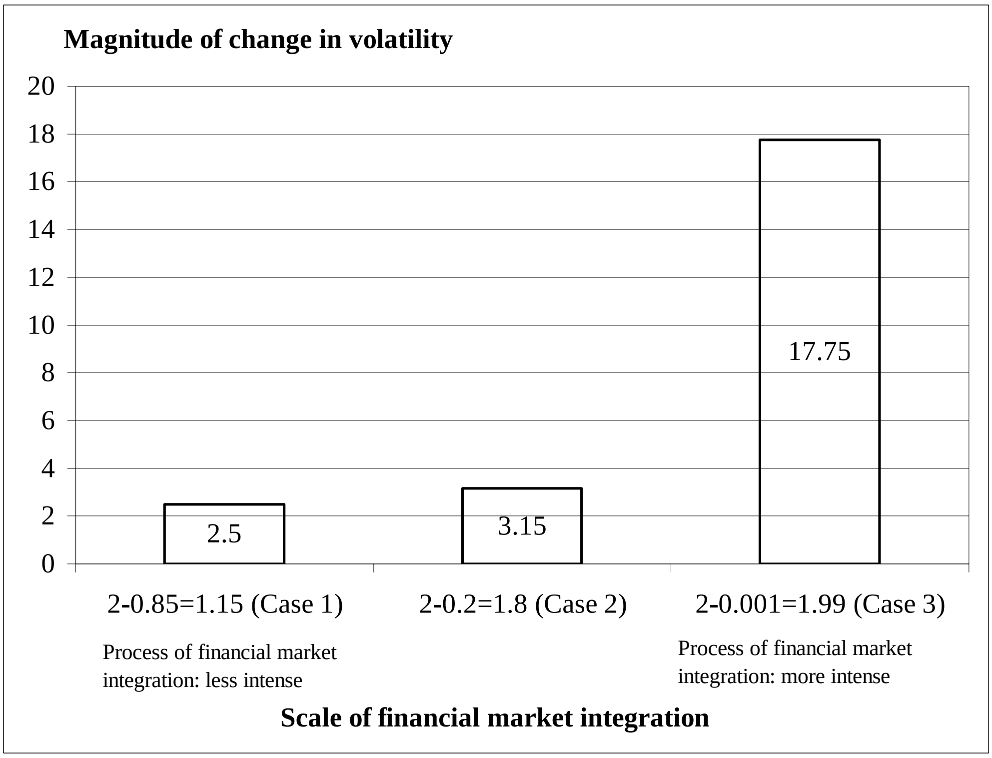
(c) Price



(d) Wage



(e) Quantity of funds transferred



Note: The entire figures are drawn from the domestic economy only.

In sum, the above paragraphs, both in section 8.1.1 and 8.1.2, altogether indicate that our results concerning the implication financial market integration, both for the economy prior and subsequent to labor market integration, derived in chapter seven, are certainly robust even when different values of the intermediary cost incurred in transferring funds are assumed.

8.2 The Variation of the Amount of Labor Migration and the Macroeconomic Impacts of Monetary Policy

To round up this section, I also assess the robustness of the results by working on the simulation results for two alternative steady state values regarding the different degrees of labor market integration, i.e., $\bar{N}^H = 0.99, \bar{N}^F = 0.01$ and $\bar{N}^H = 0.83, \bar{N}^F = 0.17$. Figure 8.5 gives the dynamic responses to a shock for each macroeconomic variable, ranging from low to high degree of international labor migration.

Figure 8.5

Variation in the degree of international labor migration and

the dynamic macroeconomic effects of a unit asymmetric monetary policy shock

Case 1	Case 2	Case 3
Labor market integration: Poorly integrated	**moderately integrated**	**highly integrated**
(a) Exchange rate	**(a) Exchange rate**	**(a) Exchange rate**

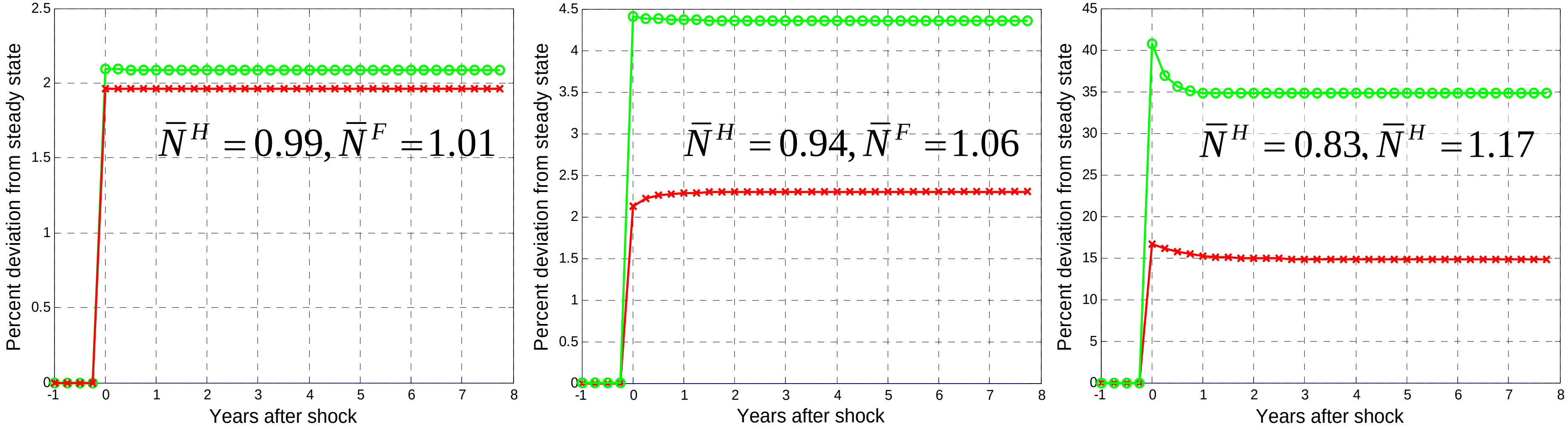
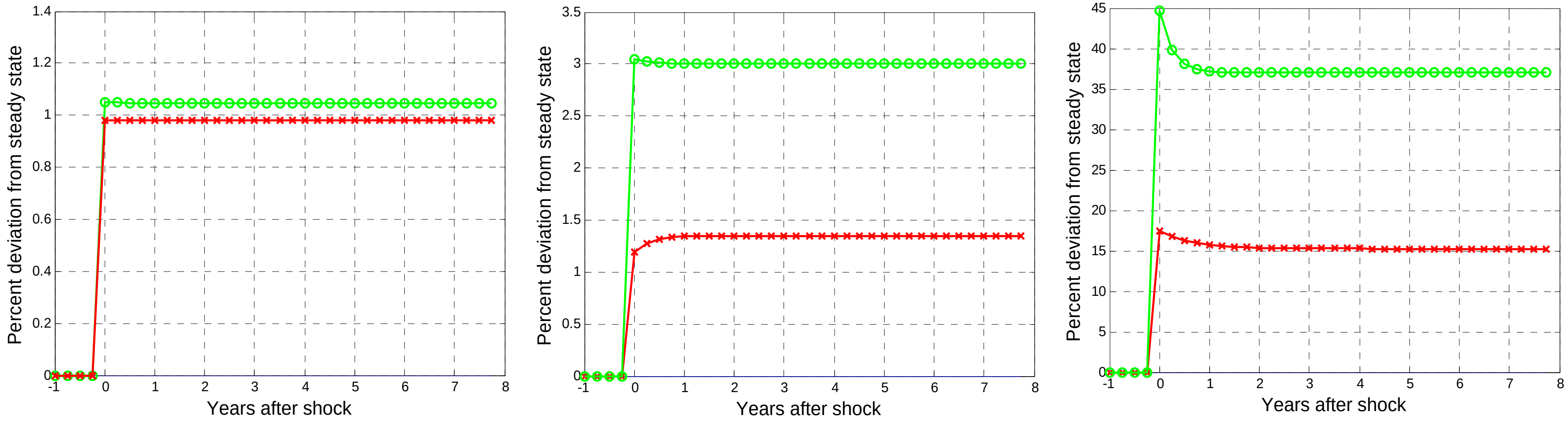


Figure 8.5 (Continued)

Case 1 **Case 2** **Case 3**

(b) General price index **(b) General price index** **(b) General price index**



(c) Wage **(c) Wage** **(c) Wage**

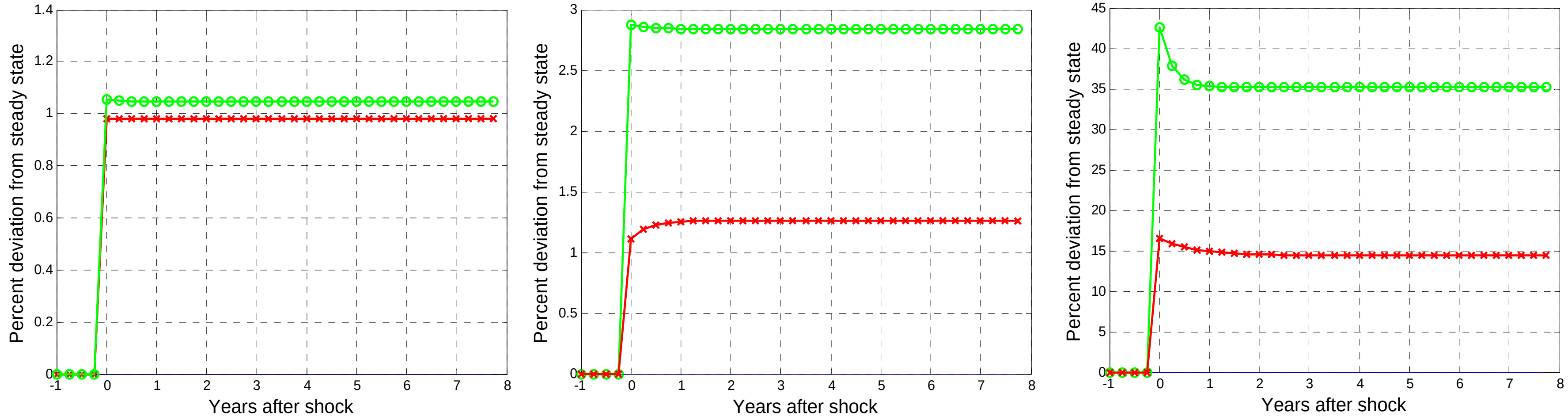


Figure 8.5 (Continued)

Case 1	Case 2	Case 3
(d) Nominal interest rate	(d) Nominal interest rate	(d) Nominal interest rate

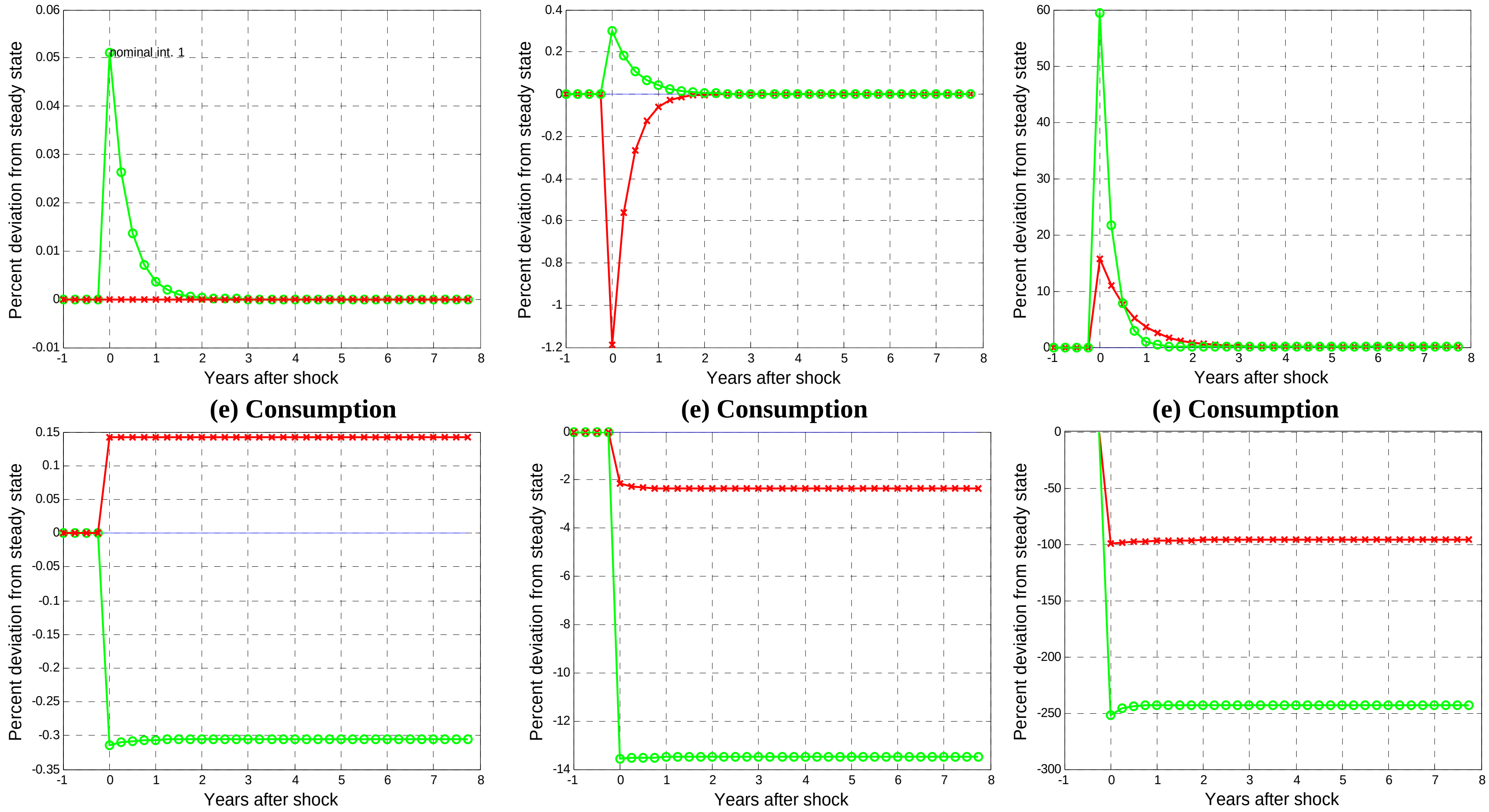
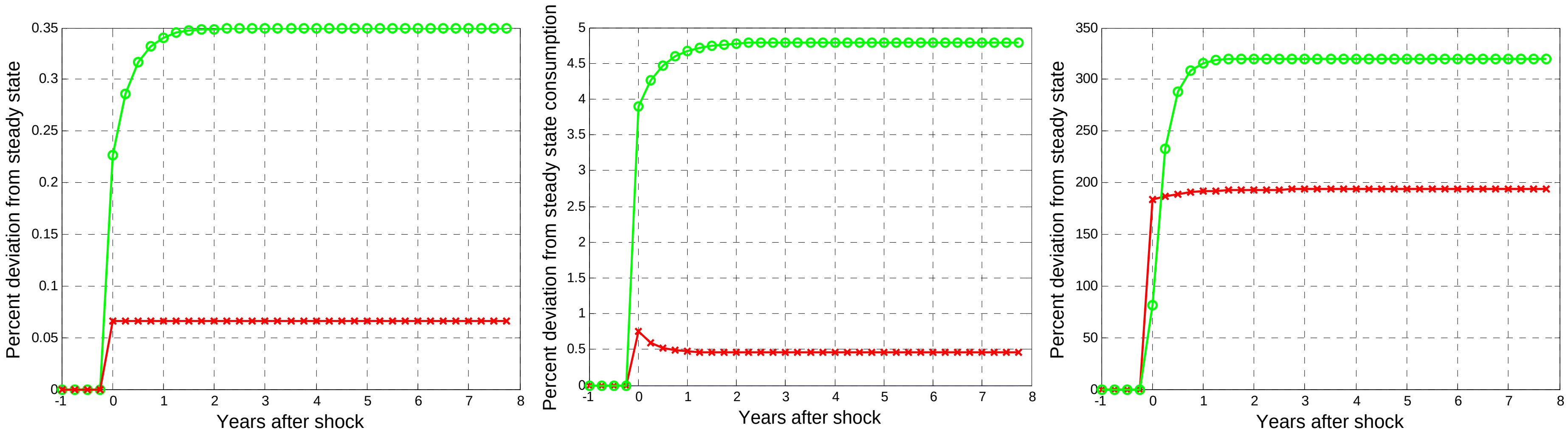


Figure 8.5 (Continued)

Case 1 — **(f) Quantity of funds transferred abroad**

Case 2 — **(f) Quantity of funds transferred abroad**

Case 3 — **(f) Quantity of funds transferred abroad**



Note: The entire figure is the impulse response function for domestic economy only.

The lines with mark in all three cases are obtained by setting $\psi = 0.2$ and lines with circle correspond to the case where $\psi = 2$.

The shift of line from mark (x) to circle (o) gives a picture of the process of financial market integration.

To analyze the implication of increasing mobile labors,

In Case 1 (First column), home (foreign) labors are assumed to be 0.99 (1.01) following home emigration.

In Case 2 (Second column), home (foreign) labors are assumed to be 0.94 (1.06) following home emigration (the case depicted in chapter 7).

In Case 3 (Third column), home (foreign) labors are assumed to be 0.83 (1.17) following home emigration.

The general impressions centered in these simulation results are that, similar explanations regarding the effect of labor market integration, obtained in section 7.2, remain true beyond single case of migration calibration. In comparison to the case where labors hardly move (Figure 8.1, case 2 since all panel in Figure 8.5 are derived by setting $\psi = 0.2$ and 2), exchange rate, price (as a result of the price index effect), and wage (owing to the home market effect) are verified by panel 8.5 a, b, and c to rise by more after it is easier for labors to engage in a cross-border migration. At the same time, the higher increase in interest rate (caused by the expected inflation effect), larger decline in domestic consumption[1] and greater rise in quantity of funds transferred are also self-evident after the disturbance strikes as we proceed from Figure 8.1 through case 1 to 3 in panel 8.5 d, e, and f. Therefore, as a result of integration in international labor market, the volatility of these variables under consideration increases. Naturally, it goes without saying that these effects rise respectively in order corresponding to the extent of integration, i.e., the higher is the access to other countries' labor market, hence, larger home labor departure, the stronger are the changes in adjustment of economy in response of a change in monetary policy.

In addition, another important finding come off from Figure 8.5 is that the changing in the scale of labor market integration does leave the results concerning the effect of the reduction in adjustment cost in financial market, derived in section 7.2, somewhat unaffected. To be more specific, as the extent of labor migration is increased from a low (case 1) to the higher level (case 2 and case 3), the sign of the volatility effects of financial market integration does not change from what is suggested in section 7.2. In all variation of the simulation experiments, when the effect of monetary shock on the volatility is observed, the integration in financial market (moving from lines with mark to circle) still causes an increase in the volatility of exchange rate, prices, wages, consumption, and foreign bond holdings when labors in each nation are subject to lesser difficulty to migrate across border. As a consequence, the way financial market integration affects the direction of change in

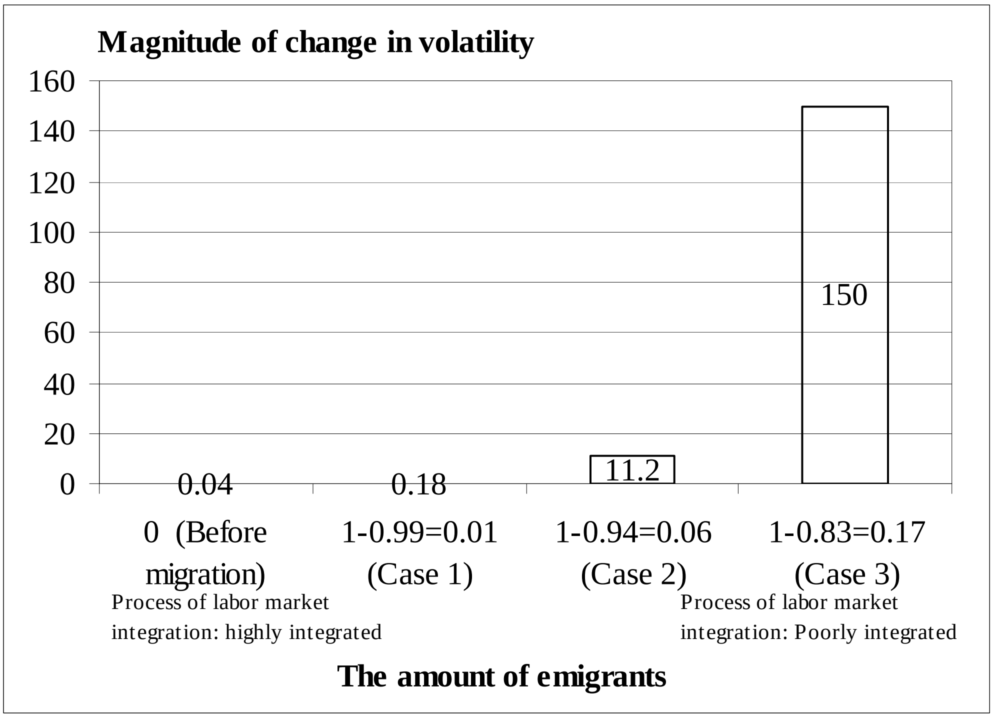
[1] Note that, attributed to the small proportion of increase in price level, only domestic consumption in case of $\bar{N}^H = 0.99, \bar{N}^H = 0.01$ with $\psi = 2$ rise in aftermath of the expansion in home money supply.

economic variables in response to a money supply shock seems to be independent from different levels of international labor relocation. On the other hand, the intensity of the global labor market linkage does have major quantitative implications toward the magnitude of the effect of a monetary policy in the regime of high and low capital mobility. In effect, Figure 8.6 undoubtedly indicates that as the number of home emigrants approaches its upper limit (from zero to 0.17), the importance of capital mobility for effect of monetary policy, namely on consumption, exchange rate, price, wage, and international funds transferred, rapidly expands. Hence, the direct implication of the above results is that the opportunity of international labor market integration consistently plays a very crucial part in determining how strong the effect of increasing degree of capital mobility have on the reaction of macro variables to the monetary policy change. Without changing the direction, higher volume of migration means greater importance of integration of the world's financial market.

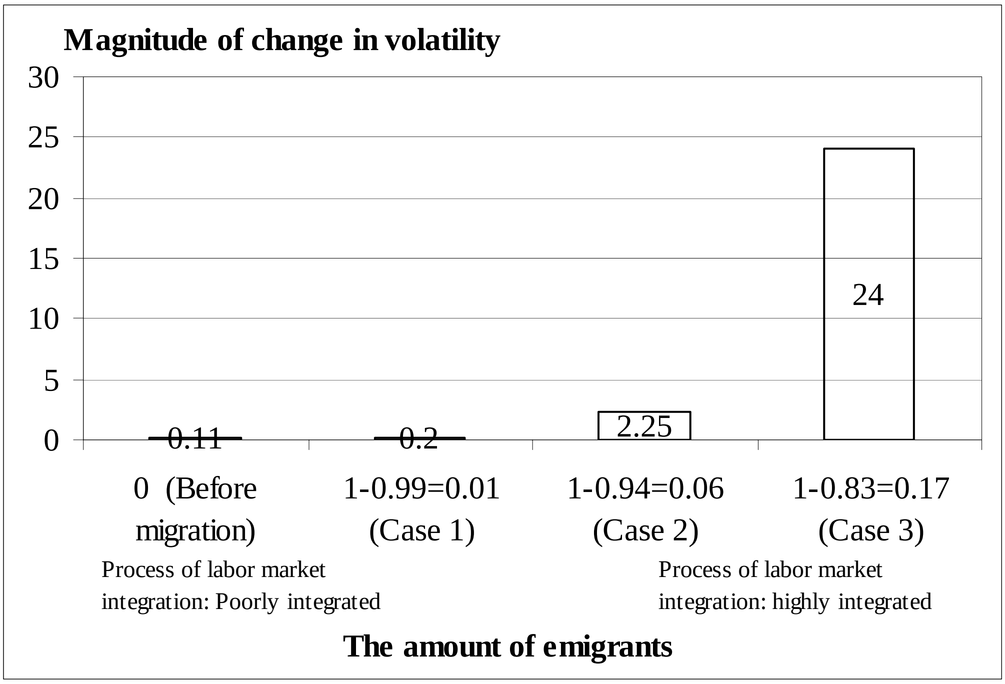
Figure 8.6

The scale of labor market integration and the magnitude of change in volatilities

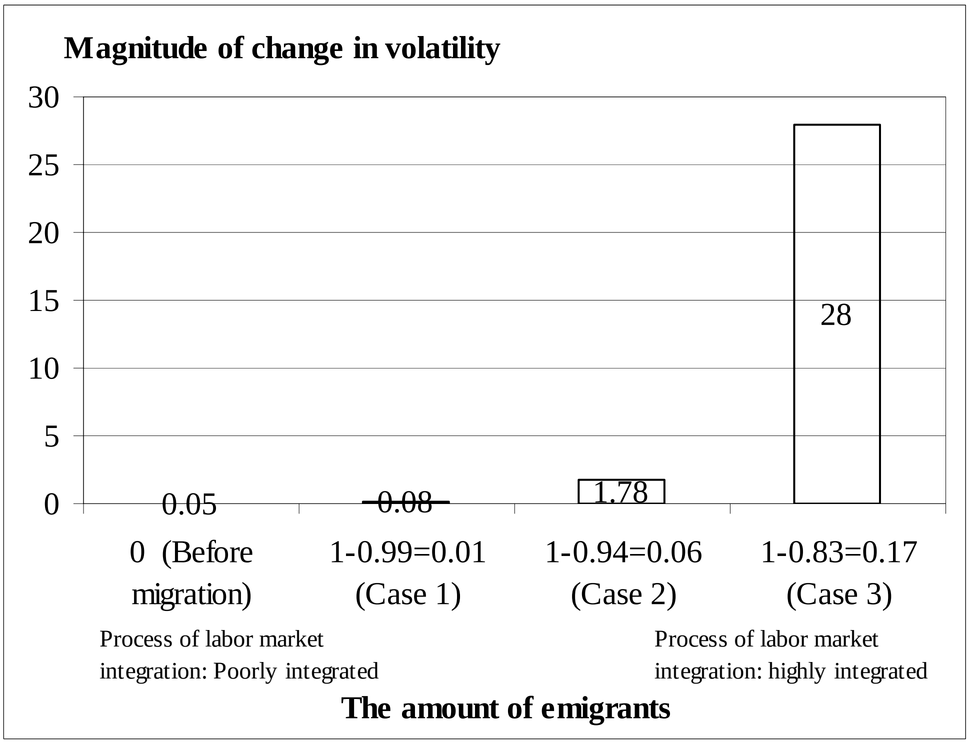
(a) Consumption



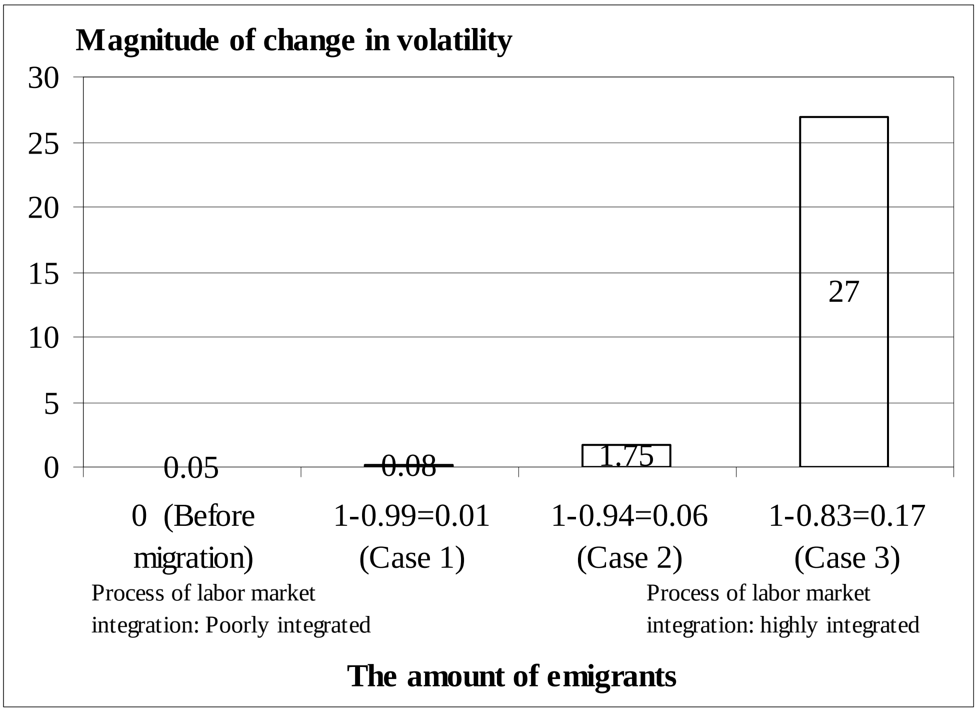
(b) Exchange rate



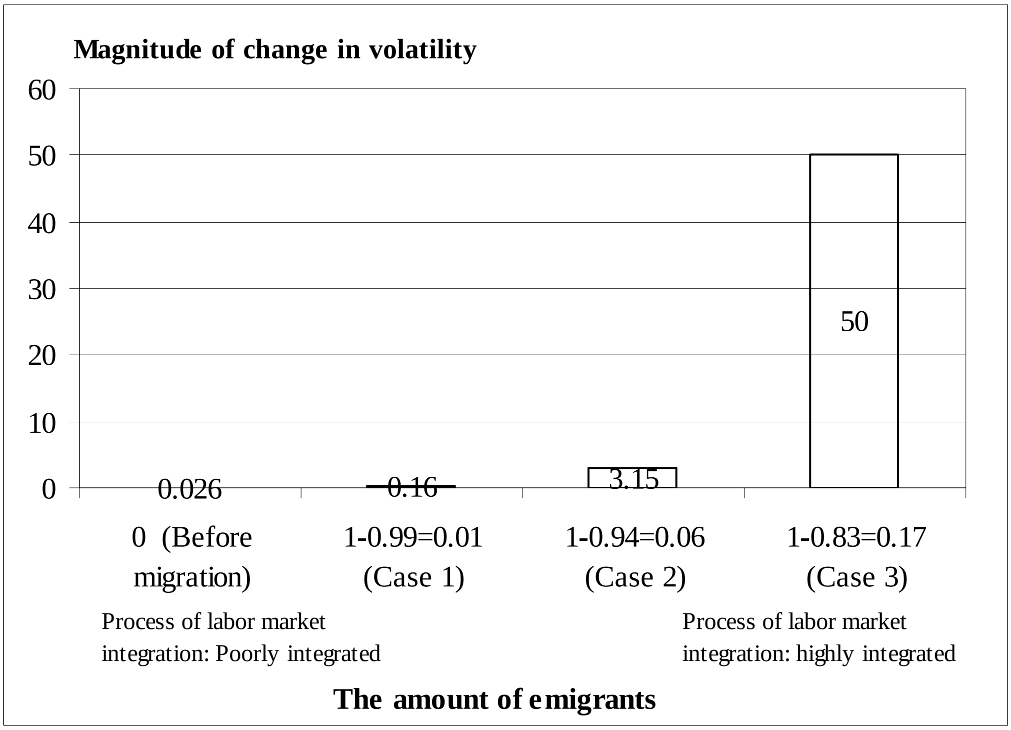
(c) General price index



(d) Wage



(e) Quantity of funds transferred aboard



Note: The entire figures are drawn from the domestic economy only.

In conclusion, evidently from Figure 8.1-8.6, the main results obtained in chapter seven are relatively robust with respect to changes in the values of adjustment cost and the numbers of labors migrated. For all variations of the model, while monetary authority has limited room for conducting monetary policy that is effective in changing output (because of price effect of a shock), the higher degree of capital mobility amplifies the exchange rate effect of monetary policy at business-cycle frequencies, as agreed with the conventional wisdom of Mundell-Fleming model.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 Non-technical Summary

For good or ill, the globalization has literally been the economic buzz-word since 1990s. Two stylized facts originate from considering the experiences beneath global financial and labor market overtime:

1) Financial market integration: It is commonly understood that the last decades have been characterized by freer financial connections among countries. Since 1960s and 1970s, although the amalgamation process has proceeded at different speeds in different places, we can undeniably observe, in the world economy, the tendency toward the financial relationships that are less isolated. For Thailand, the comprehensive liberalization of the financial system was implemented according to schedules laid out in two three-year plan in the 1990s. The plan was intended to enhance the efficiency of financial system and to increase the competitiveness of Thai financial institutions with the key policy measures to deregulate domestic financial system and relax controls in capital account. Given these reform programs, the evidences from a narrow gap between onshore and offshore interest rate, a surge in the private capital inflows and an increase reliance in foreign capital definitely confirm the pattern of reasonably high degree of financial market integration in Thailand until recent times.

2) Labor market integration: Migration of people to other countries in search of employment has occurred throughout history and, thus, by no means a new phenomenon. The international movement of labor is a natural response to the differences in the political, social, and economic conditions in the sending and receiving countries. Therefore, by this description, labor migration can be seen as a mechanism for adjusting the supply of and demand for labor across economic sectors and geographic divisions. For Thailand, Thai labors started moving overseas in the early 1970s to work in the Gulf region. The direction of labor flows gradually shifted to East Asia, as Japan and the NIEs began having labor shortages in the 1980s. At

present (2004), the actual number of Thai workers registered aboard is almost 150,000 persons. As for incoming of foreign workers, enormous amount of inflow of foreign workers has been drawn from mostly Myanmar, Cambodia, and Laos. Aggregate number of legal aliens in Thailand reached 316,174 in 1996, a sizable increase from 1994. In 2003, total of 2,225,142 alien workers registered to work in Thailand.

In any event, the technological progress and the resulting rapid expansion of cross-border financial and labor flows are certainly not reversible. Hence, in order to prolong the maintenance of a stable macroeconomic environment, and therefore, achieve the highest gain under globalization, the above two important facts of today's economies should, in principle, be taken into account in examining the international macroeconomic implications of monetary policy conduct. The two deliberate aims of this paper, thus, are:

1) To study the effect of financial market integration (introduced by decline in trading friction) on macroeconomic volatility that occurs as a result of a change in monetary policy.

2) To bringing in the possibility of international migration of labor into macroeconomic model of a small open economy with an intertemporal properties. Specifically, since labor markets of most countries do not conform to the assumption of no migration, the analysis here seeks to fully appreciate the role of financial market integration for the propagation of monetary shock by examining the consequences that international mobility of labors and the countries' size (which is represented by changing number of fixed labor supply in each country) have on the way domestic economy response to shock under different degree of financial integration.

A recent paper by Obstfeld and Rogoff (1995) provides an ideal framework for the purpose. Their model adds imperfect competition and sluggish price adjustment into a two-country intertemporal optimizing framework with flexible exchange rate. It is, therefore, possible to analyze the nature of imperfect competition while taking proper accounts of the role of financial markets in allowing intertemporal substitution. In spite of the complexity of the model, this approach truthfully yields intuitive insights into the international discussion of monetary and fiscal policy and their effect on various macroeconomic variables. So, given these real payoffs, this thesis examines such issues as the impact of monetary policy in an open economy with numerous mixes of the integration in the world of international financial and labor market based on this type of model.

Still, given that we want to find implications of worldwide shift in labor location, the model is yet to be subjected to one key adjustment. In particular, this thesis modifies NOEM for more decent consideration of labor market integration by allowing price flexibility into the model. To see this, note that, under monopolistic competitive market with free entry and fixed labor supply, assumed to facilitate the labor migration, firm has zero profit. To satisfy the zero-profit condition, the model has, then, produced a pricing rule such that prices adjust freely in response to wages. Accordingly, the model used in this thesis is, essentially, a combination of the two main paradigms in international macroeconomic theory, i.e., micro-founded approach of New Keynesian and flexible-price monetary model of current account and exchange rate.

In search for the optimal response of each variable to a unit asymmetric permanent shock in money supply, the model is built on a log-linearizing equilibrium conditions, to which we can first apply the method of undetermined coefficient to solve for all recursive equilibrium laws of motion that obey the dynamic of the model. Then, to explore the implications of varying degree of international capital and labor mobility, I perform simulation experiments so as to trace out what happen to all economic variables in aftermath of a monetary shock under several ranges of parameter and steady state values. After all, the numerical results from simulating the calibrated log-linearized model demonstrate remarkably that

1) As reflected in the impulse response analysis, the macroeconomic effect of monetary policy changes significantly depending on a presence of different degree of openness in international financial market. If the volatility is measured by the impact effects of monetary shock, then, increasing financial market integration leads to a reduction in the volatility of interest rates and consumptions, but induces an increase in the volatility of nominal exchange rate. Thus, it follows that the insight on exchange rate as analyzed under the Mundell-Fleming model still applies because the nominal exchange rate effect of a monetary shock is found to be larger; the higher is the degree of capital mobility.

However, at the same time that the exchange rate change is larger, financial market integration also raises volatility of wages and prices level as they are modeled to be flexible, thus, causing monetary policy to lose all its effectiveness in stimulating output and other real economic variables (the neutrality property of monetary policy). Obviously, where full employment is assured by wage and price flexibility, monetary policy has impact that would be predicted from the basic Monetarist propositions, i.e., they argue that the macroeconomic fluctuations arise only from shocks in real supply-side variables, for example, technology shock, while the nominal demand shock is looked upon as unnecessary in the long run. Therefore, as opposed to Sutherland (1996) where there is price-rigidity, the general level of price will change in proportion to the change in money stock, leaving the role of monetary policy in stimulating output rather limited. Eventually, money is all that matters for a change in nominal, not real, income, as reflected precisely in the fundamental quantity theory of money.

2) Other interesting results concern the impact of having a particular amount of labors migrates from home to foreign country. It can be seen that the labor market integration hardly affects the change in business cycle volatility that is occurred as a result of lowering the cost of undertaking transaction in the international financial market. To put it differently, the effect that financial market integration has on the propagation of monetary shock seems to react quite insensitively if one switches from economy with high barrier to cross-border migration to the one where labors can easily change place to stay. Apparently, volatility of interest rate keeps on falling and volatility of exchange rate, prices, and wages still increases whether or not labors in each economy are subject to difficulty to move across a national boundary. As a consequence, the way financial market integration affects the economic variables in response to a monetary shock is, in a large part, independent from different levels of international labor relocation.

3) Last but not least, from sensitivity studies (chapter eight), I also discuss the effect that different scales of market integration impinge on the main results. At last, the conclusion that the country's interest rates are less diverge, that price, wage, and exchange rate rise by more, and that output is kept unchanged as economy encounters a lower barrier in international financial market, can also be obtained upon

carrying out the different size of reduction in the transaction cost of transferring funds or different numbers of emigrants. This certainly means that the signs of the volatility effects of financial market integration barely change as a reduction in a cost of investing in international financial market is more intense or volume of labor migration increases. Nonetheless, despite the persistence in signs, these changing extents of international market integration do consistently take a very vital role in pinning down how strong the volatilities alter. Without changing in the direction, the higher is the size of drop in cost of trading financial assets offshore; the more volatile is the adjustment of the economy in propagation of monetary shock. Similarly, as the amount of home labor departure is greater, the magnitude of the change in volatilities as a result of financial market integration is bigger as well. Therefore, altogether our results indicate unquestionably that the overtone of financial market integration, both for the economy prior and subsequent to labor market integration, is unambiguously robust with the extended level of market integration positively means a greater importance of integration of the world's financial market.

The perfect integrated financial market rests only in theory, but, in the end, the arguments in this thesis offer ideas on how significance such integration is on the way macroeconomic variables optimally response to a change in monetary policy in the world with and without cross-border boundary in labor market.

9.2 Possible extension of the analysis

Of course, it goes without saying that the results reported in this thesis should not be stretched too far. Before definitive policy conclusions can be reached, more research needs to be done. To highlight both the potentials and the limitations of our framework, I briefly catalog a number of possible extensions below.

1) The model's dynamics can be developed further in a number of directions.

- Introducing overlapping generation in place of homogeneous infinite lived agents would enrich the dynamic of the model while permitting real effect of change in a government budget balance.
- Besides, there are also strong empirical and theoretical arguments for supposing that current account behavior is driven, in a great deal, by capital

accumulation (See Sachs(1981) and Baxter and Crucini (1993)). Consequently, the exclusion of domestic investment, while a useful strategic simplification for some purposes, prevents some important business cycle regularities.

- Next, according to the Mundell-Fleming model, the choice of exchange rate regime is likely to have important implications for the effect of financial integration. Therefore, it could be interesting to broaden the model in the thesis by comparing the impact of financial market integration on business cycle volatility under fixed and flexible exchange rate.

- Also, just as there are many variants of Mundell-Fleming-Dornbusch model that allow for intermediate goods and nontraded goods, one can imagine analogous extension to our presenting model as well.

2) In addition, another fruitful area for further research is in terms of labor market integration.

- First, the assumption of irreversible relocation of labor could be removed to enhance the model's empirical applicability

- Plus, T, the time of migration, should also become one of the decision variables. Specifically, this would come about if we allow for uncertainty and consider, instead, a stochastic version of the model. To be explicit, when households have no ability to foresight the future, they would better choose the optimal time to relocate the place to stay. If this is actually the case, then, unless the economy is reaching this optimal time, households will find the original resident more attractive to stay and will keep on believing so until the time when marginal gain of waiting equal to marginal cost.

- Lastly, one can also find a possible extension to our analysis by adding the optimization migration decision of labors into the model. In other word, the present model can be formulated in such a way that workers themselves can decide, after time T is reached, whether they will continue living in home country or move aborad by comparing the discounted value of utility received from living in each country from period T onward. This process of endogenizing the amount of labor supply and total output of the economy would not only enable us to derive the output effect of monetary policy under various parameter calibrations, but also allow us to address the policy issues in the empirical-oriented short-run nominal rigidity setting, the setting that is familiarized in a typical Keynesian model.

3) Additionally, provided that the model makes available a meaningful analysis of welfare implications of alternative policies by providing explicit micro-foundation, another direction of improvement is, then, in a measurement of welfare. Given that a truer measure of wellbeing is provided by the level of utility enjoyed by consumers, rather than focusing on the economic volatilities, a more rigorous welfare analysis should be considered as an incredibly interesting extension.

4) Finally, along with the above suggestion, one or two final points here concern the procedures to get the main finding of the model.

- Given that some of the impulse responses that is derived from the simulation of the model, such as the holding of domestic and foreign bonds, does not seem to have a visible convergence, the explicit terminal conditions, which say that lender will not permit the individual to die with unpaid debt and nor can it be optimal for individual to leave seen with unused resources, should be directly incorporated in order to obtain the most accurate simulation results. Why are these the conditions we seek? Think about the economy that is continually borrowing to meet the interest payments on its foreign debt rather than transferring real resources to its creditors by reducing spending below income. In such situation, foreigners will not allow such a Ponzi scheme at their expense: that would amount to providing another economy with free resources. If that is the case, they would rather prefer to consume those resources themselves. Now, in the opposite scenario, the present value of the resources home economy uses never converges up to the present value of its output. In that case, domestic agents are making an unrequited gift to foreigners. Plainly, they could raise their lifetime utility by consuming a little more. So, only when such transversality conditions hold is the economy asymptotically using up exactly resources its budget constraint allows, no more or no less.

- Furthermore, as pointed out by many economists and policymakers, an empirical performance will ultimately decide whether this new generation of models (NOEM) will supplant the time-honored Mundell-Fleming-Dornbush framework as the main tool for understanding interdependences and for putting together policy advices. Therefore, as a finishing touch, one could explore in the other promising direction for giving the NOEM a truthful empirical dimension. (See Paul R. Bergin (2002) and Fabio Ghironi (2000) for the econometric approach to NOEM)

APPENDICES

APPENDIX A

CHRONOLOGY OF MAJOR FINANCIAL LIBERALIZATION MEASURES IN THAILAND, 1986-2003

A1 Liberalization of Domestic Financial System

Date		Interest Rate Control
1986		Interest rate ceiling for lending to priority sectors was removed
1989	June	Interest rate ceiling on time deposits of commercial banks with maturity more than one year (9.5 percent per annum) was removed
1990	March	Interest rate ceiling on time deposits of commercial banks with maturity less than and equal to one year (9.5 percent per annum) was removed.
1992	Jan.	Interest rate ceiling on time deposits of commercial banks (12 percent per annum) was removed.
	June	- Interest rate ceiling in commercial banks' lending (19 percent per annum) was removed. Also lifted was the interest rate ceiling (21 percent) on finance companies' lending as well as on lending rate by credit foncier companies - The interest rate ceiling on finance companies' and credit foncier companies' borrowings and deposits (18 percent per annum) was removed.
1993	Oct.	Commercial banks were required to announced the minimum lending rate (MLR), the minimum retail rate (MRR), and the maximum margin to be added to the MRR. The MRR is calculated from the actual cost of deposits plus operating cost, as reference rate for retail prime borrowers.

Date		Control on Portfolio Composition and Scope of Activities of Financial Institutions
1987		Commercial banks and finance companies were authorized to do the businesses of (1) Custodial service (2) Loan syndication (3) Advisory service regarding merger and acquisition (M2A) (4) Feasibility study
1990		Requirement on the minimum denomination of promissory notes issued by the finance companies was lifted. (This implies more flexibility on finance companies' fund mobilization.)
1991	April	The definition of target rural credits under the rural credit extension requirement was broadened to include credits for crop wholesaling and industrial estates in rural areas.
	Dec.	Finance companies were allowed to operate leasing businesses.
1992	Jan.	The targeted rural credits extension requirement was further relaxed as follow: (1) Broadening definition to include credits for farmers' secondary occupation and for agricultural product wholesaling and exporting. (2) Changing small industry definition from 5 million baht net assets outstanding to 10 million baht. (3) Interbank deposits were excluded from the deposit base in calculation under the rural credits extension requirement.
	March	Commercial banks were allowed to operate as: (1) Selling agents for debt instruments issued by the government and state enterprises (2) Information service providers in relation to economic, financial, and investment matters (3) Providers of financial consulting service Finance companies were allowed to operate as:

Date		Control on Portfolio Composition and Scope of Activities of Financial Institutions
		(1) Selling agents for debt instruments issued by the government and state enterprises (2) Information service providers in relation to economic, financial, and investment matters (3) Sponsoring service providers, i.e. preparing necessary documents for companies applying for listing in the stock exchange. Securities companies were allowed to operate as: (1) Custodial service providers (2) Registrars and paying agents for securities (3) Information service providers (4) Sponsoring service providers
1992	June	The scope of the business activities of commercial banks were further expanded as: (1) Arranging, underwriting, and dealing in debt instruments (2) Representing secured debenture holders (3) Trusting of mutual funds (4) Registering securities (5) Selling of investment units, e.g. mutual funds
	July	Commercial banks were allowed to issue negotiable certificates of deposit (NCDs) with maturity of three months to three years.
	Sep.	Finance companies and securities companies were permitted to operate as debenture holder representatives and trustees of mutual funds.
	Oct.	Finance companies were allowed to further expand their scope of business activities as (1) Provide custodial services for NCDs and debt instrument (2) Act as registrars and paying agents for securities (3) Arranging, underwriting, and dealing in debt instruments

Date		Control on Portfolio Composition and Scope of Activities of Financial Institutions
	Nov.	Finance companies were permitted to issue NCDs
1993	May	The branch-opening requirement for commercial banks to hold eligible securities was removed.
1994	Sept.	Commercial banks were allowed to invest in any businesses, or in their shares, of not more than 10 percent of total amount of shares sold.

A2 Liberalization of Capital Account

Date		Controls on Exchange Rate Arrangement and Capital Flows
1986		The tax on income earned from mutual funds was lowered for nonresidents and juristic persons, if they used foreign funds transferred to Thailand to purchase them. For capital gain earned from selling shares in mutual funds, investors received a reduction in income tax from 25 percent to 12.5 percent.
1989	July	- Some initial relaxations of foreign exchange regulations was introduced. The maximum amount of (1) Thai baht which individuals can bring into or take out of the country was increased to B10,000 (2) Foreign currencies allowed to be brought from and sold to individual customers by commercial banks were raised to $ 5,000 per annum. - Commercial banks were given authorization to sell foreign exchange and transfer Thai baht into transferable nonresidents' baht accounts of foreign investors or borrowers of foreign loans who had registered the fund with the Bank of Thailand.
1990	May	- After the acceptance of Article 8 of the IMF agreement in May 1990, the first round of partial relaxation of foreign exchange regulations was introduced: (1) Commercial banks were allowed to grant permission to all

Date		Controls on Exchange Rate Arrangement and Capital Flows
		applications of foreign exchange transactions relating to international trade. (2) Commercial banks were authorized to approve remittances of funds and repatriation of interest payments. - Three new closed-end mutual funds were approved to mobilize foreign capital.
1991	April	- The second round of the relaxation of foreign exchange regulations was undertaken. (1) Residents were permitted to purchase an unlimited amount of foreign exchanges from authorized banks (2) The limit on foreign currencies brought into country or taken out of country was removed. - The repatriation of investment funds, loan repayment, and interest rate payments by foreign investors could be made without any restrictions. - Foreign exchange earners were allowed to open foreign exchange account with commercial banks up to $500,000 for individuals and $ 2 million for corporations.
1992	May	- Several taxes in Thai stock market were reduced: dividend taxes and taxes on interest payments from debentures. - The third round of changes in exchange rate regulations took place. The changes include: Exporters were allowed to receive payments in baht from nonresident baht accounts and were permitted to use the proceeds to service external obligations without depositing in domestic banking account.
1993	March	Thailand's offshore banking facility, the Bangkok International Banking Facility (BIBF) commenced operations.
1994	Feb	- The ceiling on the amount authorized banks are permitted to lend to nonresidents in foreign currency was eliminated (previously the limit was $ 5 million).

Date		Controls on Exchange Rate Arrangement and Capital Flows
		- Foreign currencies borrowed be residents from BIBF, or borrowed by nonresidents from authorized banks, or from withdrawal of nonresident baht accounts, could all be freely deposited in foreign currency accounts - The maximum amount permitted for direct investment abroad by Thai residents or lending to companies abroad that have at least 25% Thai equity participation was increased to $ 10 million (previously $ 5 million).
1995		- The authorities imposed a 7% reserve requirements on nonresident baht accounts and on finance companies' short-term promissory notes - A similar 7% reserve requirement was imposed on nonresident borrowing, with maturity of less than one year, by commercial banks, BIBF banks, and finance companies.
1997	May	The Bank of Thailand requested commercial banks to co-operate in not selling baht in offshore foreign exchange markets. This is intended to cut off the supply of baht to the speculators in the offshore market who need baht to fulfill their contracts in the forward sale of baht (short-covering in Baht). This results in the de facto two-tier or dual foreign exchange market i.e. offshore and onshore baht market.
	June	- The baht proceeded from sales of stocks by non-residents was required to be only converted into foreign currency at the onshore exchange rate (The onshore baht value was higher than the offshore baht under the two-tier foreign exchange market). - The Bank of Thailand temporarily limited baht lending to non-residents through foreign exchange swap, currency option, outright forward, as well as other transactions, including direct loan overdraft and interest rate swap and option. - The BOT also limited selling of baht against foreign currencies

Date		Controls on Exchange Rate Arrangement and Capital Flows
		to non-residents.
1997	July	- Effective July 2, 1997, the BOT adopted the managed exchange rate regime. The baht was managed within an unpublished band. - All affected financial institutions were required to submit daily reports of foreign exchange transactions with non-residents including spot, forward, and swap transactions, as well as all purchase of debt instruments from non-residents to the BOT.
	Sept.	- Foreign exchange owners were allowed to deposit their foreign exchange receipts in their foreign currency deposit accounts only if they have obligations to pay out such amounts to non-residents abroad within three months from the deposit dates. - Exporters receiving packing credits from the BOT, through Export-Import Bank of Thailand, were required to sign a forward contract to sell their foreign exchange to a commercial bank selling promissory notes to the Export-Import Bank. The forward foreign exchange sold must not be less than 50 percent of the face value of the promissory notes.
1998	Jan.	- Export proceeds exceeding 500,000 baht must be brought back to the country upon receipt of payments no later than 120 days (previously 180 days) after the shipment of export. - The period of foreign exchange surrender requirement (the duration in which foreign currency proceeds is converted into baht or deposit in the allowable foreign currency accounts with authorized banks in Thailand) was reduced to 7 days (previously 15 days) upon receipt. - The BOT lifted the control of foreign exchange transactions with the non-residents resulting in an abolishment of the two-tier foreign exchange market regime imposed during May-December 1997. Financial institutions were allowed to carry out foreign exchange transactions (both spot and forward transactions) with

Date		Controls on Exchange Rate Arrangement and Capital Flows
		non-residents up to total outstanding limit of 50 million baht per customer. All the currency transactions must be related only to underlying trade and investment transactions.
2002	July	-The maximum amount permitted for direct investment abroad by Thai residents or lending to companies abroad that have at least 10 percent Thai equity participation (preciously 25 percent) remained $ 10 million. -The maximum amount permitted for buying real estate for housing purpose abroad was $ 500,000.
2004	April	Purchasing, selling, depositing, and withdrawing of foreign exchange with an amount of $20,000 (preciously $ 10,000) and above must be reported to the BOT.

Source: Kawai, Masahiro and Takayasu, Hen-ichi (1999), Charenkal, Siriporn (2005), Padmasakul, Supanee (1999), and Johnson, R. Barry, et. al. (1997)

Note:- The measures taken in May and June of 1997, described above, were parts of the Bank of Thailand's attempt to reduce the baht supply mainly to the short-run speculative activities, especially during the serious crisis period of 1997-1998. These measures were intended to limit the short-term speculative capital outflows. They were not applied to the export and import of goods and services, direct investments, and various types of portfolio investments in Thailand.

- From 1999-2004, there were no other major measures issued on the foreign exchange arrangement and capital flows. Most of the measures have remained relatively the same.

APPENDIX B

INDIVIDUAL DEMAND AND PRICE INDEX

This appendix clears up the computation of individual demand for goods z and describes how to write it compactly as a function of consumption-base price index P (equation 5.14 for home)

B1 The Optimal Demand of Good z

Individuals in the two countries will each choose to consume goods z, $c\left(z\right)$, produced domestically and aboard in order to minimize aggregate cost of attaining $\bar{N}^H C^H$. Since there are home and foreign consumers and goods, we could think of the problem according to four combinations of each category, i.e. home consumption of home and foreign goods and foreign consumption of home and foreign goods.

B1.1 Home consumption of home and foreign goods

For whatever value of aggregate consumption, $\bar{N}^H C^H$, each $c^H\left(z\right), z = h, f$, need to be chosen so as to[1]

$$\underset{c^H(h),\, c^H(f)}{Min} \int_0^{\bar{n}} p^H(h)\bar{N}^H c^H(h)dh \quad + \int_{\bar{n}}^1 p^H(f)\bar{N}^H c^H(f)df$$

$$\text{subject to } \left(\int_0^{\bar{n}} \left(\bar{N}^H c^H(h)\right)^{\frac{\theta-1}{\theta}} dh + \int_{\bar{n}}^1 \left(\bar{N}^H c^H(f)\right)^{\frac{\theta-1}{\theta}} df \right)^{\frac{\theta}{\theta-1}} = \bar{N}^H C^H$$

Forming an associated Lagrange equation yields

[1] Given that the consumption index of an individual is

$$C^H = \left[\int_0^{\bar{n}} c^H(h)^{\frac{\theta-1}{\theta}} dh + \int_{\bar{n}}^1 c^H(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}},$$

we have that aggregate consumption index that is

$$\bar{N}^H C^H = \left(\int_0^{\bar{n}} \left(\bar{N}^H c^H(h)\right)^{\frac{\theta-1}{\theta}} dh + \int_{\bar{n}}^1 \left(\bar{N}^H c^H(f)\right)^{\frac{\theta-1}{\theta}} df \right)^{\frac{\theta}{\theta-1}}$$

$$L^{H} = \int_{0}^{\bar{n}} p^{H}(h)\bar{N}^{H}c^{H}(h)dh \quad + \int_{\bar{n}}^{1} p^{H}(f)\bar{N}^{H}c^{H}(f)df$$

$$+\lambda^{H}\left[\bar{N}^{H}C^{H} - \left(\int_{0}^{\bar{n}}\left(\bar{N}^{H}c^{H}(h)\right)^{\frac{\theta-1}{\theta}}dh + \int_{\bar{n}}^{1}\left(\bar{N}^{H}c^{H}(f)\right)^{\frac{\theta-1}{\theta}}df\right)^{\frac{\theta}{\theta-1}}\right]$$

Then, we solve for the first-order conditions for each goods as

$$\frac{\partial L}{\partial c^{H}(h,i)} = \bar{N}^{H}p^{H}(h,i) - \lambda^{H}\left(\frac{\theta}{\theta-1}\right)\left(\int_{0}^{\bar{n}}\left(\bar{N}^{H}c^{H}(h)\right)^{\frac{\theta-1}{\theta}}dh + \int_{\bar{n}}^{1}\left(\bar{N}^{H}c^{H}(f)\right)^{\frac{\theta-1}{\theta}}df\right)^{\frac{1}{\theta-1}}\left(\frac{\theta-1}{\theta}\right)\bar{N}^{H}c^{H}(h,i)^{\frac{-1}{\theta}} = 0$$

$$\lambda^{H}\left(\int_{0}^{\bar{n}}\left(\bar{N}^{H}c^{H}(h)\right)^{\frac{\theta-1}{\theta}}dh + \int_{\bar{n}}^{1}\left(\bar{N}^{H}c^{H}(f)\right)^{\frac{\theta-1}{\theta}}df\right)^{\frac{1}{\theta-1}}\bar{N}^{H}c^{H}(h,i)^{\frac{-1}{\theta}} = \bar{N}^{H}p^{H}(h,i), \quad i\in[0,\bar{n}]$$

(B1.1)

$$\frac{\partial L}{\partial c^{H}(h,j)} = \bar{N}^{H}p^{H}(h,j) - \lambda^{H}\left(\frac{\theta}{\theta-1}\right)\left(\int_{0}^{\bar{n}}\left(\bar{N}^{H}c^{H}(h)\right)^{\frac{\theta-1}{\theta}}dh + \int_{\bar{n}}^{1}\left(\bar{N}^{H}c^{H}(f)\right)^{\frac{\theta-1}{\theta}}df\right)^{\frac{1}{\theta-1}}\left(\frac{\theta-1}{\theta}\right)\bar{N}^{H}c^{H}(h,j)^{\frac{-1}{\theta}} = 0$$

$$\lambda^{H}\left(\int_{0}^{\bar{n}}\left(\bar{N}^{H}c^{H}(h)\right)^{\frac{\theta-1}{\theta}}dh + \int_{\bar{n}}^{1}\left(\bar{N}^{H}c^{H}(f)\right)^{\frac{\theta-1}{\theta}}df\right)^{\frac{1}{\theta-1}}\bar{N}^{H}c^{H}(h,j)^{\frac{-1}{\theta}} = \bar{N}^{H}p^{H}(h,j), \quad for\ j\in[0,\bar{n}]$$

(B1.2)

$$\frac{\partial L}{\partial c^{H}(f,m)} = \bar{N}^{H}p^{H}(f,m) - \lambda^{H}\left(\frac{\theta}{\theta-1}\right)\left(\int_{0}^{\bar{n}}\left(\bar{N}^{H}c^{H}(h)\right)^{\frac{\theta-1}{\theta}}dh + \int_{\bar{n}}^{1}\left(\bar{N}^{H}c^{H}(f)\right)^{\frac{\theta-1}{\theta}}df\right)^{\frac{1}{\theta-1}}\left(\frac{\theta-1}{\theta}\right)\bar{N}^{H}c^{H}(f,m)^{\frac{-1}{\theta}} = 0$$

$$\lambda^{H}\left(\int_{0}^{\bar{n}}\left(\bar{N}^{H}c^{H}(h)\right)^{\frac{\theta-1}{\theta}}dh + \int_{\bar{n}}^{1}\left(\bar{N}^{H}c^{H}(f)\right)^{\frac{\theta-1}{\theta}}df\right)^{\frac{1}{\theta-1}}\bar{N}^{H}c^{H}(f,m)^{\frac{-1}{\theta}} = \bar{N}^{H}p^{H}(f,m), \quad for\ m\in[\bar{n},1]$$

(B1.3)

For any pair i,j and m,j, the optimal conditions to this aggregate expenditure minimization problem give the equality of marginal rates of substitution to price ratios,

$$\left(\frac{c^{H}(h,i)}{c^{H}(h,j)}\right)^{\frac{-1}{\theta}} = \frac{p^{H}(h,i)}{p^{H}(h,j)} \qquad i,j\in[0,n]$$

$$\left(\frac{c^{H}(f,m)}{c^{H}(h,j)}\right)^{\frac{-1}{\theta}} = \frac{p^{H}(f,m)}{p^{H}(h,j)} \qquad m\in[n,1]$$

After rearranging, the above two equations lead to

$$c^H(h,i)^{\frac{-1}{\theta}} = c^H(h,j)^{\frac{-1}{\theta}} \frac{p^H(h,i)}{p^H(h,j)} \tag{B1.4}$$

$$c^H(h,i) = c^H(h,j)\left(\frac{p^H(h,i)}{p^H(h,j)}\right)^{-\theta}$$

$$and\ c^H(f,m) = c^H(h,j)\left(\frac{p^H(f,m)}{p^H(h,j)}\right)^{-\theta} \tag{B1.5}$$

Substituting (B1.4) and (B1.5) into original constraint (first-order condition with respect to Lagrange multiplier) and bring common term, $\left(\bar{N}^H c^H(h,j)\right)^{\frac{\theta-1}{\theta}} p^H(h,j)^{\theta-1}$, outside the integral and parenthesis, we have that

$$\left(\int_0^{\bar{n}}\left(\bar{N}^H c^H(h,j)\left(\frac{p^H(h,i)}{p^H(h,j)}\right)^{-\theta}\right)^{\frac{\theta-1}{\theta}} di + \int_{\bar{n}}^1\left(\bar{N}^H c^H(h,j)\left(\frac{p^H(f,m)}{p^H(h,j)}\right)^{-\theta}\right)^{\frac{\theta-1}{\theta}} dm\right)^{\frac{\theta}{\theta-1}} = \bar{N}^H C^H$$

$$\left(\int_0^{\bar{n}}\left(\bar{N}^H c^H(h,j)\right)^{\frac{\theta-1}{\theta}}\left(\frac{p^H(h,i)}{p^H(h,j)}\right)^{1-\theta} di + \int_{\bar{n}}^1\left(\bar{N}^H c^H(h,j)\right)^{\frac{\theta-1}{\theta}}\left(\frac{p^H(f,m)}{p^H(h,j)}\right)^{1-\theta} dm\right)^{\frac{\theta}{\theta-1}} = \bar{N}^H C^H$$

$$\left(\left(\bar{N}^H c^H(h,j)\right)^{\frac{\theta-1}{\theta}} p^H(h,j)^{\theta-1}\int_0^{\bar{n}} p^H(h,i)^{1-\theta} di + \left(\bar{N}^H c^H(h,j)\right)^{\frac{\theta-1}{\theta}} p^H(h,j)^{\theta-1}\int_{\bar{n}}^1 p^H(f,m)^{1-\theta} dm\right)^{\frac{\theta}{\theta-1}} = \bar{N}^H C^H$$

$$\bar{N}^H c^H(h,j) p^H(h,j)^{\theta}\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta} di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta} dm\right)^{\frac{\theta}{\theta-1}} = \bar{N}^H C^H$$

$$c^H(h,j) = \frac{p^H(h,j)^{-\theta}}{\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta} di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta} dm\right)^{\frac{\theta}{\theta-1}}} C^H \tag{B1.6}$$

The above expression is simply the compensated demand function of individual consumers, who reside in home country, for j th variety of commodities produced domestically.

To find domestic individuals' compensated demand for m th variety of foreign goods, substitute (B1.6) into (B1.5),

$$c^H(f,m) = \frac{p^H(h,j)^{-\theta}}{\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} C^H \left(\frac{p^H(f,m)}{p^H(h,j)}\right)^{-\theta}$$

$$c^H(f,m) = \frac{p^H(f,m)^{-\theta}}{\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} C^H \qquad \text{(B1.7)}$$

B1.2 Foreign consumption of home and foreign goods

Again, the steps in calculating compensated demand for h and f for each foreign consumer resemble what are done for home. By solving aggregate constraint optimization

$$\underset{c^F(h),\, c^F(f)}{Min} \int_0^{\bar{n}} p^F(h)\bar{N}^F c^F(h)dh + \int_{\bar{n}}^1 p^F(f)\bar{N}^F c^F(f)df$$

subject to $\left(\int_0^{\bar{n}} \left(\bar{N}^F c^F(h)\right)^{\frac{\theta-1}{\theta}} dh + \int_{\bar{n}}^1 \left(\bar{N}^F c^F(f)\right)^{\frac{\theta-1}{\theta}} df\right)^{\frac{\theta}{\theta-1}} = \bar{N}^F C^F$

with respect to $c^F(z), where\, z = h, f$, the results are

$$c^F(h,j) = \frac{p^F(h,j)^{-\theta}}{\left(\int_0^{\bar{n}} p^F(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^F(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} C^F \quad \text{and}$$

$$c^F(f,m) = \frac{p^F(f,m)^{-\theta}}{\left(\int_0^{\bar{n}} p^F(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^F(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} C^F \qquad \text{(B1.8)}$$

B2 The Minimum Cost of Attaining C and Consumption-base Price Index

B2.1 Home expenditure and price index

We can also derive an expression for the minimum cost of attaining C^H.

The expenditure on the j th variety demanded by all home agents is $p^H(h,j)\bar{N}^H c^H(h,j)$. So, using domestic demand function $c^H(h,j)$ and integrating over all j give aggregate expenditure of domestically-produced goods as

$$\int_0^{\bar{n}} p^H(h)\bar{N}^H c^H(h)dh = \int_0^{\bar{n}} p^H(h,j)\bar{N}^H \frac{p^H(h,j)^{-\theta}}{\left(\int_0^{n} p^H(h,i)^{1-\theta}di + \int_n^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} C^H dj$$

$$= \frac{\int_0^{n} p^H(h,j)^{1-\theta}dj}{\left(\int_0^{n} p^H(h,i)^{1-\theta}di + \int_n^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} \bar{N}^H C^H \qquad \text{(B2.1)}$$

Likewise, the aggregate expenditure on foreign-produced products is equivalently derived to be

$$\int_{\bar{n}}^1 p^H(f)\bar{N}^H c^H(f)df = \frac{\int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm}{\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} \bar{N}^H C^H \qquad \text{(B2.2)}$$

In total, given that $\forall i = \forall j$, a summation of (B2.1) and (B2.2) certainly implies the total expenditure on both goods of all home agents or the total minimum cost of obtaining $\bar{N}^H C^H$

$$\int_0^{\bar{n}} p^H(h)\bar{N}^H c^H(h)dh + \int_{\bar{n}}^1 p^H(f)\bar{N}^H c^H(f)df$$

$$= \frac{\int_0^{\bar{n}} p^H(h,j)^{1-\theta}dj}{\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} \bar{N}^H C^H + \frac{\int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm}{\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} \bar{N}^H C^H$$

$$= \frac{\int_0^{\bar{n}} p^H(h,j)^{1-\theta}dj + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm}{\left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{\theta}{\theta-1}}} \bar{N}^H C^H$$

$$= \left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta}di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta}dm\right)^{\frac{1}{1-\theta}} \bar{N}^H C^H$$

From above equation, it is natural to define the term multiplying $\bar{N}^H C^H$ on the right-hand side as a price index, so that the general price index times the aggregate quantity composite is equal the total expenditure of all agents. Consequently, we have derived the consumption-base price index for home goods, which is the minimum expenditure

$$\int_0^{\bar{n}} p^H(h)\bar{N}^H c^H(h)dh + \int_{\bar{n}}^1 p^H(f)\bar{N}^H c^H(f)df$$

when aggregate consumption $\bar{N}^H C^H$ is equal to one, as (equation (5.3) in chapter 5)

$$P^H = \left(\int_0^{\bar{n}} p^H(h,i)^{1-\theta} di + \int_{\bar{n}}^1 p^H(f,m)^{1-\theta} dm\right)^{\frac{1}{1-\theta}} or \left(\int_0^{\bar{n}} p^H(h)^{1-\theta} dh + \int_{\bar{n}}^1 p^H(f)^{1-\theta} df\right)^{\frac{1}{1-\theta}} \quad \text{(B2.3)}$$

B2.2 Foreign expenditure and price index

By the same token, substituting $c^F(h,j)$ and $c^F(f,m)$ into objective function of foreign consumers' aggregate maximization problem, we get the following value function,

$$\int_0^{\bar{n}} p^F(h)\bar{N}^F c^F(h)dh + \int_{\bar{n}}^1 p^F(f)\bar{N}^F c^F(f)df = \left(\int_0^{\bar{n}} p^F(h,i)^{1-\theta} di + \int_{\bar{n}}^1 p^F(f,m)^{1-\theta} dm\right)^{\frac{1}{1-\theta}} \bar{N}^F C^H$$

Therefore, similar to above case, the overall price index faced by consumers aboard in purchasing home and foreign goods is

$$P^F = \left(\int_0^{\bar{n}} p^F(h,i)^{1-\theta} di + \int_{\bar{n}}^1 p^F(f,m)^{1-\theta} dm\right)^{\frac{1}{1-\theta}} or \left(\int_0^{\bar{n}} p^F(h)^{1-\theta} dh + \int_{\bar{n}}^1 p^F(f)^{1-\theta} df\right)^{\frac{1}{1-\theta}} \quad \text{(B2.4)}$$

B3 The Individual Demand for Good z As a Function of Price Index

Now, we can rewrite the consumption demand of good h and f of domestic and foreign consumers in section B1, by replacing general price index P from section B2. This would evidently generate the consumption equation, which offers the individual consumption as a function of real-consumption index and pricing index.

B3.1 Home consumption of home and foreign goods

From equation (B1.6) and (B1.7), the home individual demand for good z, where z = h,f is

$$c^H(h) = \frac{p^H(h)^{-\theta}}{\left(\int_0^n p^H(h)^{1-\theta}dh + \int_n^1 p^H(f)^{1-\theta}df\right)^{\frac{\theta}{\theta-1}}} C^H \text{ and}$$

$$c^H(f) = \frac{p^H(f)^{-\theta}}{\left(\int_0^n p^H(h)^{1-\theta}dh + \int_n^1 p^H(f)^{1-\theta}df\right)^{\frac{\theta}{\theta-1}}} C^H \text{, respectively.}$$

Given price index (B2.3), $P^H = \left(\int_0^n p^H(h)^{1-\theta}dh + \int_n^1 p^H(f)^{1-\theta}df\right)^{\frac{1}{1-\theta}}$, we have

$$\left(\int_0^n p^H(h)^{1-\theta}dh + \int_n^1 p^H(f)^{1-\theta}df\right)^{\frac{\theta}{\theta-1}} = \left(P^H\right)^{-\theta}$$

Accordingly, $c^H(h) = \left[\frac{p^H(h)}{P^H}\right]^{-\theta} C^H$ and

$$c^H(f) = \left[\frac{p^H(f)}{P^H}\right]^{-\theta} C^H \text{ (As in equation (5.14))}$$

A3.2 Foreign consumption of home and foreign goods

Again, using individual demand for both goods from (B1.8), price index (B2.4), and applying the same step yield

$$c^F(h) = \left[\frac{p^F(h)}{P^F}\right]^{-\theta} C^F \text{ and } c^F(f) = \left[\frac{p^F(f)}{P^F}\right]^{-\theta} C^F$$

APPENDIX C

CONSUMER UTILITY MAXIMIZATION

This section deliberately offers details in finding the optimal conditions for individual consumers' utility maximization problem in each country.

C1 Optimization Problem for Home Households

As explained clearly in chapter 5, solving the lifetime aggregate utility maximization problem involves finding optimal conditions for consumption, domestic bond, domestic currency, and foreign bond holding. Since the total amount of effort consumers want to supply is fixed, the aggregate utility maximization problem is formulated as,

$$\underset{\{C^H, D^H, M^H, F^H\}_{s=t}^{\infty}}{Max} \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma - 1} \bar{N}^H \left(C_s^H \right)^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \bar{N}^H \left(\frac{M_s^H}{P_S^H} \right)^{1-\varepsilon} - \frac{\kappa}{\mu} \bar{N}^H \right]$$

Subject to $\bar{N}^H D_t^H = (1+i_{t-1}^H)\bar{N}^H D_{t-1}^H + \bar{N}^H M_{t-1}^H - \bar{N}^H M_t^H + w_t^H \bar{N}^H$

$$- P_t^H \bar{N}^H C_t^H - P_t^H \bar{N}^H I_t^H - P_t^H \bar{N}^H Z_t^H + \bar{N}^H \pi_t^H - P_t^H \bar{N}^H T_t^H$$

where $\bar{N}^H Z_t^H = \frac{1}{2} \psi \left(\bar{N}^H I_t^H \right)^2 \qquad t = t, ..., \infty$

$$\bar{N}^H F_t^H = (1+i_{t-1}^F)\bar{N}^H F_{t-1}^H + P_t^F \bar{N}^H I_t^H$$

$\bar{N}^H$ is given.

From the evolution of foreign bond holding and the convex adjustment cost, intertemporal budget constraint can be rewritten explicitly as

$$\bar{N}^H D_t^H = (1+i_{t-1}^H)\bar{N}^H D_{t-1}^H + \bar{N}^H M_{t-1}^H - \bar{N}^H M_t^H + w_t^H \bar{N}^H - P_t^H \bar{N}^H C_t^H$$

$$-P_t^H \left(\frac{\bar{N}^H F_t^H}{P_t^F} - \frac{(1+i_{t-1}^F)\bar{N}^H F_{t-1}{}^H}{P_t^F} \right) - P_t^H \frac{1}{2} \psi \left(\frac{\bar{N}^H F_t^H}{P_t^F} - \frac{(1+i_{t-1}^F)\bar{N}^H F_{t-1}{}^H}{P_t^F} \right)^2 + \bar{N}^H \pi_t^H - P_t^H \bar{N}^H T_t^H$$

The Lagrange equation is, then,

$$L^H = \sum_{s=t}^{\infty} \beta^{s-t} \Bigg\{ \Bigg[\frac{\sigma}{\sigma-1} \bar{N}^H \left(C_s^H\right)^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \bar{N}^H \left(\frac{M_s^H}{P_s^H}\right)^{1-\varepsilon} - \frac{\kappa}{\mu} \bar{N}^H \Bigg]$$
$$+ \lambda_s^H \Big[(1+i_{s-1}^H) \bar{N}^H D_{s-1}^H - \bar{N}^H D_s^H + \bar{N}^H M_{s-1}^H - \bar{N}^H M_s^H + w_s^H \bar{N}^H - P_s^H \bar{N}^H C_s^H$$
$$- P_s^H \left(\frac{\bar{N}^H F_s^H}{P_s^F} - \frac{(1+i_{s-1}^F) \bar{N}^H F_{s-1}^H}{P_s^F} \right) - P_s^H \frac{1}{2} \psi \left(\frac{\bar{N}^H F_s^H}{P_s^F} - \frac{(1+i_{s-1}^F) \bar{N}^H F_{s-1}^H}{P_s^F} \right)^2$$
$$+ \bar{N}^H \pi_s^H - P_s^H \bar{N}^H T_s^H \Big] \Bigg\}$$

To find a set of first order conditions, take derivative of the above equation with respect to all the decision variables

- With respect to consumption, C_s^H

$$\frac{\partial L^H}{\partial C_s^H} = \beta^{s-t} \left[\bar{N}^H \left(C_s^H\right)^{-\frac{1}{\sigma}} - \lambda_s^H \bar{N}^H P_s^H \right] = 0$$

$$\left(C_s^H\right)^{-\frac{1}{\sigma}} = \lambda_s^H P_s^H$$

$$\lambda_s^H = \frac{\left(C_s^H\right)^{-\frac{1}{\sigma}}}{P_s^H} \qquad \text{(C1.1)}$$

- With respect to domestic bond holding D_s^H

$$\frac{\delta L^H}{\delta D_s^H} = -\beta^{s-t} \lambda_s^H \bar{N}^H + \beta^{s+1-t} \lambda_{s+1}^H \left(1+i_s^H\right) \bar{N}^H = 0$$

$$-\lambda_s^H + \beta \lambda_{s+1}^H \left(1+i_s^H\right) = 0$$

$$\lambda_s^H = \beta \lambda_{s+1}^H \left(1+i_s^H\right) \qquad \text{(C1.2)}$$

Substitute λ^H from (C1.1) into (C1.2)

$$\frac{\left(C_s^H\right)^{-\frac{1}{\sigma}}}{P_s^H} = \frac{\left(C_{s+1}^H\right)^{-\frac{1}{\sigma}}}{P_{s+1}^H} \beta \left(1+i_s^H\right)$$

$$\left(C_s^H\right)^{-\frac{1}{\sigma}} = \left(C_{s+1}^H\right)^{-\frac{1}{\sigma}} \frac{P_s^H}{P_{s+1}^H} \beta \left(1+i_s^H\right)$$

$$C_s^H = C_{s+1}^H \left[\frac{P_s^H}{P_{s+1}^H} \beta \left(1+i_s^H\right) \right]^{-\sigma}$$

$$C_{s+1}^H = C_s^H \left[\frac{P_s^H}{P_{s+1}^H} \beta \left(1+i_s^H\right) \right]^{\sigma}$$ as in equation (5.11)

- With respect to money demand, M_s^H (equation (5.12))

$$\frac{\partial L^H}{\partial M_s^H} = \beta^{s-t}\left[\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon}\left(\frac{N_T^H}{P_s^H}\right) - \lambda_s^H \bar{N}^H\right] + \beta^{s+1-T}\lambda_{s+1}^H \bar{N}^H = 0$$

$$\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon}\left(\frac{1}{P_s^H}\right) - \lambda_s^H + \beta\lambda_{s+1}^H = 0$$

$$\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon}\left(\frac{1}{P_s^H}\right) = \lambda_s^H - \beta\lambda_{s+1}^H$$

From (C1.2), $\beta = \dfrac{\lambda_s^H}{\lambda_s^H(1+i_s^H)}$

$$\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon}\left(\frac{1}{P_s^H}\right) = \lambda_s^H - \left(\frac{\lambda_s^H}{\lambda_{s+1}^H(1+i_s^H)}\right)\lambda_{s+1}^H$$

$$\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon}\left(\frac{1}{P_s^H}\right) = \frac{(1+i_s^H)\lambda_s^H - \lambda_s^H}{(1+i_s^H)}$$

$$\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon}\left(\frac{1}{P_s^H}\right) = \frac{i_s^H}{(1+i_s^H)}\lambda_s^H$$

With $\lambda_s^H = \dfrac{\left(C_s^H\right)^{-\frac{1}{\sigma}}}{P_s^H}$ from (C1.1),

$$\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon}\left(\frac{1}{P_s^H}\right) = \frac{i_s^H}{(1+i_s^H)}\frac{\left(C_s^H\right)^{-\frac{1}{\sigma}}}{P_s^H}$$

$$\chi\left(\frac{M_s^H}{P_s^H}\right)^{-\varepsilon} = \frac{i_s^H}{(1+i_s^H)}\left(C_s^H\right)^{-\frac{1}{\sigma}}$$

- With respect to foreign asset, F_s^H (equation (5.13))

$$\frac{\partial L^H}{\partial F_s^H} = -\beta^{s-t}\lambda_s^H \bar{N}^H\left[\frac{P_s^H}{P_s^F} + P_s^H\psi\left(\bar{N}^H I_s^H\right)\left(\frac{1}{P_s^F}\right)\right]$$
$$+\beta^{s+1-t}\lambda_{s+1}^H \bar{N}^H\left[\frac{P_{s+1}^H}{P_{s+1}^F}\left(1+i_s^F\right) + P_{s+1}^H\psi\left(\bar{N}^H I_{s+1}^H\right)\left(1+i_s^F\right)\left(\frac{1}{P_{s+1}^F}\right)\right] = 0$$

$$\lambda_s^H\frac{P_s^H}{P_s^F}\left(1+\psi\bar{N}^H I_s^H\right) = \beta\lambda_{s+1}^H\frac{P_{s+1}^H}{P_{s+1}^F}\left(1+i_s^F\right)\left(1+\psi\bar{N}^H I_{s+1}^H\right)$$

$$\frac{P_s^H}{P_s^F}\left(1+\psi\bar{N}^H I_s^H\right)=\beta\frac{\lambda_{s+1}^H}{\lambda_s^H}\frac{P_{s+1}^H}{P_{s+1}^F}\left(1+i_s^F\right)\left(1+\psi\bar{N}^H I_{s+1}^H\right)$$

Due to PPP that holds for price index and β from (C1.2), we have

$$\frac{E_s P_s^F}{P_s^F}\left(1+\psi\bar{N}^H I_s^H\right)=\frac{\lambda_s^F}{\lambda_{s+1}^F\left(1+i_s^H\right)}\frac{\lambda_{s+1}^F}{\lambda_s^F}\frac{E_{s+1}P_{s+1}^F}{P_{s+1}^F}\left(1+i_s^F\right)\left(1+\psi\bar{N}^H I_{s+1}^H\right)$$

$$\left(1+i_s^H\right)\left(1+\psi\bar{N}^H I_s^H\right)=\frac{E_{s+1}}{E_s}\left(1+i_s^F\right)\left(1+\psi\bar{N}^H I_{s+1}^H\right)$$

C2 Optimization Problem for Foreign Households

Not surprisingly, the utility maximization of foreign consumers is equivalent to that of home, with superscript F instead of H. Once again, to compute for the first-order conditions characterizing optimality, the following problem needs to be solved.

$$\underset{\{C^F,D^F,M^F,F^F\}_{s=t}^{\infty}}{Max}\sum_{s=t}^{\infty}\beta^{s-t}\left[\frac{\sigma}{\sigma-1}\bar{N}^F\left(C_s^F\right)^{\frac{\sigma-1}{\sigma}}+\frac{\chi}{1-\varepsilon}\bar{N}^F\left(\frac{M_s^F}{P_s^F}\right)^{1-\varepsilon}-\frac{\kappa}{\mu}\bar{N}^F\right]$$

Subject to $\bar{N}^F F_t^H=(1+i_{t-1}^F)\bar{N}^F F_{t-1}^F+\bar{N}^F M_{t-1}^F-\bar{N}^F M_t^F+w_t^F\bar{N}^F$

$$-P_t^F\bar{N}^F C_t^F-P_t^F\bar{N}^F I_t^F-P_t^F\bar{N}^F Z_t^F+\bar{N}^F\pi_t^F-P_t^F\bar{N}^F T_t^F$$

where $\bar{N}^F Z_t^F=\frac{1}{2}\psi\left(\bar{N}^F I_t^F\right)^2$ t=T,.....,∞

$$\bar{N}^F D_t^F=(1+i_{t-1}^H)\bar{N}^F D_{t-1}^F+P_t^H\bar{N}^F I_t^F$$

$\bar{N}^F$ is given.

The associated Lagrange equation is given by

$$\begin{aligned}L^F=\sum_{s=t}^{\infty}\beta^{s-t}&\left\{\left[\frac{\sigma}{\sigma-1}\bar{N}^F\left(C_s^F\right)^{\frac{\sigma-1}{\sigma}}+\frac{\chi}{1-\varepsilon}\bar{N}^F\left(\frac{M_s^F}{P_s^F}\right)^{1-\varepsilon}-\frac{\kappa}{\mu}\bar{N}^F\right]\right.\\&+\lambda_s^F\Big[(1+i_{s-1}^F)\bar{N}^F F_{s-1}^F-\bar{N}^F F_s^F+\bar{N}^F M_{s-1}^F-\bar{N}^F M_s^F+w_s^F\bar{N}^F-P_t^F\bar{N}^F C_s^F\\&-P_s^F\left(\frac{\bar{N}^F F_s^F}{P_s^H}-\frac{(1+i_{s-1}^H)\bar{N}^F F_{s-1}^F}{P_s^H}\right)-P_s^F\frac{1}{2}\psi\left(\frac{\bar{N}^F F_s^F}{P_s^H}-\frac{(1+i_{s-1}^H)\bar{N}^F F_{s-1}^F}{P_s^H}\right)^2\\&\left.+\bar{N}^F\pi_s^F-P_s^F\bar{N}^F T_s^F\Big]\right\}\end{aligned}$$

By the same method as problem of home consumers, the foreign consumers' first-order conditions, with respect to $C_t^F, D_t^F, F_t^F, M_t^F$ can be derived exactly as

$$C_{t+1}^{F} = C_{t}^{F}\left[\frac{P_{t}^{F}}{P_{t+1}^{F}}\beta\left(1+i_{t}^{F}\right)\right]^{\sigma} \qquad t = t, \ldots., \infty$$

$$\chi\left(\frac{M_{t}^{F}}{P_{t}^{F}}\right)^{-\varepsilon} = \frac{i_{t}^{F}}{1+i_{t}^{F}}(C_{t}^{F})^{-\frac{1}{\sigma}}$$

$$\left(1+i_{t}^{F}\right)\left(1+\psi\bar{N}^{F}I_{t}^{F}\right) = \frac{E_{t}}{E_{t+1}}\left(1+i_{t}^{H}\right)\left(1+\psi\bar{N}^{F}I_{t+1}^{F}\right)$$

APPENDIX D

CHARACTERIZATION OF STEADY STATE

The approach taken in this thesis is to explore the implications of the model by taking a linear approximation. This appendix calculates the point around which to linearize. In what follows, the equations that govern the initial steady state, in which domestic and foreign assets position are zero, are derived by forcing the value of all variables to be constant at the balance growth level. Formally, the steady state for our model can be found by taking out the time subscripts from all the optimal conditions (table 5.1) and other equations charactering equilibrium (table 5.2). In particular,

Let bar over variable denotes the steady state value.

(5.1.1) Home consumer Euler equation

$$C_{t+1}^{H} = C_t^{H}\left[\frac{P_t^{H}}{P_{t+1}^{H}}\beta(1+i_t^{H})\right]^{\sigma}$$

At steady state, $\bar{C}^{H} = \bar{C}^{H}\left[\frac{\bar{P}^{H}}{\bar{P}^{H}}\beta(1+\bar{i}^{H})\right]^{\sigma}$

As a result, the steady state value of interest rate is given by $\bar{i}^{H} = \frac{(1-\beta)}{\beta}$.

Note that, in order to save the space, only equilibrium equations for home country are implemented here. The process to compute for corresponding foreign counterparts is very straightforward and, thereby, proceeds similarly.

(5.1.3) Home optimal money demand schedule

$$\chi\left(\frac{M_t^{H}}{P_t^{H}}\right)^{-\varepsilon} = \frac{i_t^{H}}{1+i_t^{H}}(C_t^{H})^{-\frac{1}{\sigma}}$$

At steady state, $\chi\left(\frac{\bar{M}^{H}}{\bar{P}^{H}}\right)^{-\varepsilon} = \frac{\bar{i}^{H}}{1+\bar{i}^{H}}\left(\bar{C}^{H}\right)^{-\frac{1}{\sigma}}$

$$\chi\left(\frac{\bar{M}^{H}}{\bar{P}^{H}}\right)^{-\varepsilon} = (1-\beta)\left(\bar{C}^{H}\right)^{-\frac{1}{\sigma}}$$

The steady state real balance is, therefore,

$$\frac{\bar{M}^H}{\bar{P}^H} = \left(\frac{1-\beta}{\chi}\right)^{-\frac{1}{\varepsilon}} \left(\bar{C}^H\right)^{\frac{1}{\sigma\varepsilon}}$$

(5.1.5) Foreign assets holding Euler equation for home

$$\left(1+i_t^H\right)\left(1+\psi \bar{N}^H I_t^H\right) = \frac{E_{t+1}}{E_t}\left(1+i_t^F\right)\left(1+\psi \bar{N}^H I_{t+1}^H\right)$$

At steady state, $\left(1+\bar{i}^H\right)\left(1+\psi \bar{N}^H \bar{I}^{HH}\right) = \frac{\bar{E}}{\bar{E}}\left(1+\bar{i}^F\right)\left(1+\psi \bar{N}^H \bar{I}^{HH}\right)$

$$\bar{i}^H = \bar{i}^F$$

Similar to what is found in (5.1.1) and (5.1.2), home and foreign bonds pay the same interest rate in balanced growth path of the economy.

(5.1.7) Home pricing rule,

$$p_t^H = w_t^H$$

At steady state, $\bar{p}^H = \bar{w}^H$

(5.2.1) Home budget constraints

$$\bar{N}^H D_t^H = (1+i_{t-1}^H)\bar{N}^H D_{t-1}^H + \bar{N}^H M_{t-1}^H - \bar{N}^H M_t^H + w_t^H \bar{N}^H$$
$$-P_t^H \bar{N}^H C_t^H - P_t^H \bar{N}^H I_t^H - P_t^H \bar{N}^H Z_t^H + \bar{N}^H \Pi_t^H - P_t^H \bar{N}^H T_t^H$$

From (5.1.3) $P_t^H T_t^H = M_{t-1}^H - M_t^H$ and

zero-profit condition $\Pi^H = P_t^H Y_t^H - w_t^H \bar{N}^H = 0$,

$$D_t^H = (1+i_{t-1}^H)D_{t-1}^H + w_t^H \bar{N}^H - P_t^H C_t^H - P_t^H I_t^H - P_t^H Z_t^H$$

At steady state, $\bar{D}^H = (1+\bar{i}^H)\bar{D}^H + \bar{w}^H \bar{N}^H - \bar{P}^H \bar{C}^H - \bar{P}^H \bar{I}^H - \bar{P}^H \bar{Z}^H$

Since $\bar{D}^H = 0$, we have that $0 = \bar{w}^H \bar{N}^H - \bar{P}^H \bar{C}^H - \bar{P}^H \bar{I}^H - \bar{P}^H \bar{Z}^H$

Also, substituting evolution of foreign bond holding by home residents

(5.2.5) $\bar{N}^H F_t^H = (1+i_{t-1}^F)\bar{N}^H F_{t-1}^H + P_t^F \bar{N}^H I_t^H$

At steady state, $\bar{N}^H \bar{F}^H = (1+\bar{i}^F)\bar{N}^H \bar{F}^H + \bar{P}^F \bar{N}^H \bar{I}^H$

$$0 = 0 + \bar{P}^F \bar{N}^H \bar{I}^H$$
$$\bar{I}^H = 0$$

and the adjustment cost equation (5.2.7),

$$\bar{N}^H Z_t^H = \frac{1}{2}\psi\left(\bar{N}^H I_t^H\right)^2$$

At steady state, $\overline{N}^H \overline{Z}^H = \frac{1}{2}\psi\left(\overline{N}^H \overline{I}^H\right)^2 = 0$

give us $0 = \overline{w}^H \overline{N}^H - \overline{P}^H \overline{C}^H$

$$\frac{\overline{w}^H}{\overline{P}^H} = \frac{\overline{C}^H}{\overline{N}^H}$$

(5.2.9) Home general price index

$$P_t^H = \left[\overline{n} p_t^H (h)^{1-\theta} + (1-\overline{n})[E_t p_t^F (f)]^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

At steady state, $\overline{P}^H = \left[\overline{n}\overline{p}^H (h)^{1-\theta} + \left(1-\overline{n}\right)\left(\overline{E}\overline{p}^F (f)\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}$

(5.2.10) Foreign general price index

$$P_t^F = \left[\overline{n}\left[\frac{p_t^H (h)}{E}\right]^{1-\theta} + (1-\overline{n}) p_t^F (f)^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

At steady state, $\overline{P}^F = \left[\overline{n}\left(\frac{\overline{p}^H (h)}{\overline{E}}\right)^{1-\theta} + \left(1-\overline{n}\right)\left(\overline{p}^F (f)\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}$

Thus, as with the economy outside steady state, the relationship between the above price index implies that purchasing power parity condition always holds.

$\overline{P}^H = \overline{E}\overline{P}^F$

(5.2.11) Current account identity

$\overline{N}^H I_t^H + \overline{N}^F I_t^F = 0$

At steady state, $\overline{N}^H \overline{I}^H + \overline{N}^F \overline{I}^F = 0$

(5.2.16) Individual demand for goods z produced by home

$$y_t^{dH} = \left[\frac{p_t^H}{P_t^H}\right]^{-\theta} Q_t$$

At steady state, $\overline{y}^{dH} = \left[\frac{\overline{p}^H}{\overline{P}^H}\right]^{-\theta} \overline{Q}$

where $Q_t = \overline{N}^H \left(C_t^H + Z_t^H\right) + \overline{N}^F \left(C_t^F + Z_t^F\right)$

$\overline{Q} = \overline{N}^H \overline{C}^H + \overline{N}^F \overline{C}^F$

Therefore, $\bar{y}^{dH} = \left[\dfrac{\bar{p}^{H}}{\bar{P}^{H}}\right]^{-\theta}\left(\bar{N}^{H}\bar{C}^{H} + \bar{N}^{F}\bar{C}^{F}\right)$

(5.2.18) Home labor market equilibrium condition

The amount of outputs each firm produces and the aggregate outputs of the economy are taken the same value from the early steady state period. So, the following conditions always hold,

$$\bar{y}^{H} = \frac{\bar{N}^{H}}{\bar{n}} \text{ or } \bar{Y}^{H} = \overline{ny}^{H} = \bar{N}^{H}$$

(5.2.20) Home output market equilibrium condition:

$$\bar{y}^{dH} = \left[\frac{\bar{p}^{H}}{\bar{P}^{H}}\right]^{-\theta}\bar{Q} = \bar{y}^{H}$$

(5.2.22) Home money market equilibrium condition: $\bar{M}^{dH} = \bar{M}^{sH} = \bar{M}^{H}$

All these steady state relationships are put together in section 6.4.2 of chapter six.

APPENDIX E

MATLAB COMMANDING LINES FOR SOLVING FOR THE STEADY STATE

From chapter six, in the case of economy with worldwide movement of labors, the system of nonlinear equations (6.9) is needed to be solved by subjecting them to MATLAB M-file function, 'fsolve'. The command is generally used to solve a system of nonlinear equations, $F(x)=0$, for x where x is vector and F(x) is the function that returns the vector value. The details on syntax, input argument, output argument, option set, and algorithm used can be seen in toolbar help of MATLAB program.

The commanding code adopted for our exiting model is spitted into two distinguishing M_files. One is written so as to term all equations in system (6.9) and the other is to put into effect the optimization calculation. All of these are put in words correspondingly below.

1) Define system of equations that governed the steady state relationships

```
function H = steadystate(x)

%------------------------------------------- Setting paremetres ----------------------------------------------%

beta_1      = 1/1.05;  %Subjective discount factor for home
beta_2      = 1/1.05;  %Subjective discount factor for foreign
epsilon_1   = 9;        %Inverse of interest elasticity of money demand for home
epsilon_2   = 9;        %Inverse of interest elasticity of money demand for foreign
sigma_1     = 0.75;   %Elasticity of intertemporal substitution for home
sigma_2     = 0.75;   %Elasticity of intertemporal substitution for foreign
theta_1     = 6;         %Elasticity of substitution between home goods
theta_2     = 6;         %Elasticity of substitution between foreign goods
chi_1       = 1;          %Weight of real balances in home utility function
chi_2       = 1;          %Weight of real balances in foreign utility function
psi_1       = 0;          %adjustment cost parameter for home
psi_2       = 0;          %adjustment cost parameter for foreign
N_bar_1     = 0.94;  %Steady state value of home labor = N_T_1
N_bar_2     = 1.06;  %Steady state value of foreign labor = N_T_2
M_bar_1     = 1;       %Steady state value of home money supply
M_bar_2     = 2;       %Steady state value of foreign money supply
```

```
%------------------------------------------------------- Defining H(x) -------------------------------------------------------%

H = [   (M_bar_1/x(7))-((((1-beta_1)/chi_1)^(-1/epsilon_1))*(x(1)^(1/(sigma_1*epsilon_1))));
(M_bar_2/x(8))-((((1-beta_2)/chi_2)^(-1/epsilon_2))*(x(2)^(1/(sigma_2*epsilon_2))));
x(3)-x(4);
x(5)-x(6);
(x(4)/x(7))-(x(1)/N_bar_1);
(x(6)/x(8))-(x(2)/N_bar_2);
x(7)-(((x(9)*(x(3)^(1-theta_1)))+((1-x(9))*((x(10)*x(5))^(1-theta_1))))^(1/(1-theta_1)));
x(8)-(((x(9)*((x(3)/x(10))^(1-theta_2)))+((1-x(9))*(x(5)^(1-theta_2))))^(1/(1-theta_2)));
x(11)-(((x(3)/x(7))^(-theta_1))*((N_bar_1*x(1))+(N_bar_2*x(2))));
x(12)-(((x(5)/x(8))^(-theta_2))*((N_bar_1*x(1))+(N_bar_2*x(2))));
x(11)-(N_bar_1/x(9));
x(12)-(N_bar_2/(1-x(9)))    ];
```

2) Solve for Steady State

```
x0 = [ 0.6 1.4  1 1 1 1 1 1 0.15 1 2 2]
% Setting the starting values of optimization
options=optimset('Display','off',...
'MaxFunEvals', 1000000,...
'MaxIter', 50000,...
'TolFun',0.001);
% optimization option
```

```
[x,fval,exitflag,output] = fsolve('steadystate',x0,options)
% Call optimizer and option to display output

C_bar_1 = x(1)
C_bar_2 = x(2)
p_bar_1 = x(3)
p_bar_2 = x(5)
w_bar_1 = x(4)
w_bar_2 = x(6)
P_bar_1 = x(7)
P_bar_2 = x(8)
n_bar    = x(9)          %= n_T
E_bar    = x(10)
y_bar_1 = x(11)          %= y_T_1
y_bar_2 = x(12)          %= y_T_2
```

APPENDIX F

LOG-LINEARIZATION OF EQUILIBRIUM CONDITIONS

Given the value of variables at their steady state level, I am going to log-linearize equilibrium conditions around this steady state in the same fashion as in Campbell (1994). This attempt would convert the nonlinear model into a system of approximate loglinear difference equations that can be solved using the method of undetermined coefficient.

In what follow, the application of log-linearization procedure to all the Euler equations and other equations characterizing equilibrium, reported table 5.1 and 5.2, is shown, respectively. The general linearization approach is simply to perform a first order Taylor series expansion around the initial steady state with zero assets holdings. For simplicity, all the constant term will be suppressed in the approximated model.

Define $\hat{x}_t$ as a time t log-deviation from steady state value of x, i.e.,

$$\hat{x}_t = \log x_t - \log \bar{x} = \frac{dx_t}{\bar{x}}$$

The linearization experiment is as follows

(5.1.1) $C_{t+1}^H = C_t^H \left[\frac{P_t^H}{P_{t+1}^H} \beta (1 + i_t^H) \right]^\sigma$

Let start with the consumption Euler equation. Take ln on both sides:

$$\ln C_{t+1}^H = \ln C_t^H + \sigma \ln P_t^H - \sigma \ln P_{t+1}^H + \sigma \ln \beta + \sigma \ln \left(1 + i_t^H\right)$$

Taking first-order Taylor series expansion on both sides and dropping the constants yield

LHS: $\ln C_{t+1}^H \approx \ln \bar{C}^H + \frac{dC_{t+1}^H}{\bar{C}^H} \approx \hat{C}_{t+1}^H$

RHS: $\ln C_t^H + \sigma \ln P_t^H - \sigma \ln P_{t+1}^H + \sigma \ln \beta + \sigma \ln \left(1 + i_t^H\right)$

$$\approx \frac{1}{\bar{C}^H} dC_t^{HH} + \frac{\sigma}{\bar{P}^H} dP_t^H - \frac{\sigma}{\bar{P}^H} dP_{t+1}^H + \frac{\sigma}{\left(1+\bar{i}^H\right)} di_t^H$$

$$\approx \hat{C}_t^H + \sigma \hat{P}_t^H - \sigma \hat{P}_{t+1}^H + \frac{\sigma \bar{i}^H}{\left(1+\bar{i}^H\right)} \hat{i}_t^H$$

Making use of the steady state relationship, $\frac{\bar{i}^H}{1+\bar{i}^H} = (1-\beta)$, one get

$$\approx \hat{C}_t^H + \sigma \hat{P}_t^H - \sigma \hat{P}_{t+1}^H + \sigma(1-\beta)\hat{i}_t^H$$

Therefore, combining the two sides leads to following first log-linear approximate relationship.

$$\hat{C}_{t+1}^H \approx \hat{C}_t^H + \sigma \hat{P}_t^H - \sigma \hat{P}_{t+1}^H + \sigma(1-\beta)\hat{i}_t^H$$

Again, I will take no notice of all the calculation for foreign since the corresponding foreign counterparts are derived by the same way. One should not feel obliged to check all the linearization although one would probably find it useful to check just a couple of them.

(5.1.3) Home optimal money demand schedule

$$\chi\left(\frac{M_t^H}{P_t^H}\right)^{-\varepsilon} = \frac{i_t^H}{1+i_t^H}(C_t^H)^{-\frac{1}{\sigma}}$$

Take ln on both sides:

$$\ln \chi - \varepsilon \ln M_t^H + \varepsilon \ln P_t^H = \ln i_t^H - \ln\left(1+i_t^H\right) - \frac{1}{\sigma}\ln C_t^H$$

Take a taylor series expansion on both sides:

LHS: $\ln \chi - \varepsilon \ln M_t^H + \varepsilon \ln P_t^H \approx -\frac{\varepsilon dM_t^H}{\bar{M}^H} + \frac{\varepsilon dP_t^H}{\bar{P}^H} \approx -\varepsilon \hat{M}_t^H + \varepsilon \hat{P}_t^H$

RHS:

$$\ln i_t^H - \ln\left(1+i_t^H\right) - \frac{1}{\sigma}\ln C_t^H$$

$$\approx \frac{1}{\bar{i}^H(1+\bar{i}^H)} di_t^H - \frac{1}{\sigma \bar{C}^H} dC_t^H$$

$$\approx \frac{\bar{i}^H}{\bar{i}^H(1+\bar{i}^H)} \hat{i}_t^H - \frac{1}{\sigma}\hat{C}_t^H$$

$$\approx \beta \hat{i}_t^H - \frac{1}{\sigma}\hat{C}_t^H$$

Therefore, log-linear approximation of optimal money demand schedule for home is $-\varepsilon \hat{M}_t^H + \varepsilon \hat{P}_t^H \approx \beta \hat{i}_t^H - \frac{1}{\sigma}\hat{C}_t^H$. Rearranging,

$$\hat{P}_t^H - \hat{M}_t^H \approx \frac{\beta}{\varepsilon}\hat{i}_t^H - \frac{1}{\sigma\varepsilon}\hat{C}_t^H$$

(5.1.5) Foreign assets holding Euler equation for home

$$\left(1+i_t^H\right)\left(1+\psi \bar{N}^H I_t^H\right) = \frac{E_{t+1}}{E_t}\left(1+i_t^F\right)\left(1+\psi \bar{N}^H I_{t+1}^H\right)$$

Take ln on both sides:

$$\ln\left(1+i_t^H\right) + \ln\left(1+\psi \bar{N}^H I_t^{HH}\right) = \ln E_{t+1} - \ln E_t + \ln\left(1+i_t^F\right) + \ln\left(1+\psi \bar{N}^H I_{t+1}^{HH}\right)$$

Take a Taylor series expansion on both sides:

LHS:

$$\ln\left(1+i_t^H\right) + \ln\left(1+\psi \bar{N}^H I_t^H\right) \approx \frac{1}{\left(1+\bar{i}^H\right)} di_t^H + \frac{\psi \bar{N}^H}{\left(1+\psi n' \bar{I}^H\right)} dI_t^H$$

$$\approx \frac{\bar{i}^H}{\left(1+\bar{i}^H\right)}\hat{i}_t^H + \frac{\psi \bar{N}^H \bar{C}^H}{\left(1+\psi n' \bar{I}^H\right)}\hat{I}_t^H$$

$$\approx (1-\beta)\hat{i}_t^H + \psi \bar{N}^H \bar{C}^H \hat{I}_t^H$$

Note that because the steady state value of I is zero, its log deviation from steady state is not defined. As a result, $\hat{I}_t = dI_t / \bar{C}$ is used instead.

RHS:

$$\ln E_{t+1} - \ln E_t + \ln\left(1+i_t^F\right) + \ln\left(1+\psi \bar{N}^H I_{t+1}^H\right)$$

$$\approx \frac{dE_{t+1}}{\bar{E}} - \frac{dE_t}{\bar{E}} + \frac{1}{\left(1+\bar{i}^F\right)} di_t^F + \frac{\psi \bar{N}^H}{\left(1+\psi n' \bar{I}^H\right)} dI_{t+1}^H$$

$$\approx \hat{E}_{t+1} - \hat{E}_t + (1-\beta)\hat{i}_t^F + \psi \bar{N}^H \bar{C}^H \hat{I}_{t+1}^H$$

Equality of LHS and RHS implies

$$(1-\beta)\hat{i}_t^H + \psi \bar{N}^H \bar{C}^H \hat{I}_t^H \approx \hat{E}_{t+1} - \hat{E}_t + (1-\beta)\hat{i}_t^F + \psi \bar{N}^H \bar{C}^H \hat{I}_{t+1}^H$$

where $\hat{I}_t = dI_t / \bar{C}$

(5.1.7) Home pricing rule

$p_t^H = w_t^H$

Take ln on both sides: $\ln p_t^H = \ln w_t^H$

Take a Taylor series expansion on both sides:

$$\frac{dp_t^H}{\bar{p}^H} \approx \frac{dw_t^H}{\bar{w}^H}$$

$$\hat{p}_t^H \approx \hat{w}_t^H$$

Now, continue with other relationships in table 5.2

(5.2 1) Home budget constraint

$$\bar{N}^H D_t^H = (1+i_{t-1}^H)\bar{N}^H D_{t-1}^H + \bar{N}^H M_{t-1}^H - \bar{N}^H M_t^H + w_t^H \bar{N}^H$$
$$-P_t^H \bar{N}^H C_t^H - P_t^H \bar{N}^H I_t^H - P_t^H \bar{N}^H Z_t^H + \bar{N}^H \Pi_t^H - P_t^H \bar{N}^H T_t^H$$

According to equation (5.2.3) and zero-profit condition,

$$D_t^H = (1+i_{t-1}^H)D_{t-1}^H + w_t^H \bar{N}^H - P_t^H C_t^H - P_t^H I_t^H - P_t^H Z_t^H$$

Take a Taylor series expansion on both sides:

$$dD_t^H \approx (1+\bar{i}^H)dD_{t-1}^H + \bar{D}^H di_{t-1}^H + N_T^H dw_t^H$$
$$-\bar{P}^H dC_t^H - \bar{P}^H dI_t^H - \bar{P}^H dZ_t^H - \left(\bar{C}^H + \bar{I}^H + \bar{Z}^H\right)dP_t^H$$

Again, since domestic and foreign bonds holdings by home and foreign households, as well as a level of funds transferred and adjustment cost, are zero at steady state, the log-deviation from steady state of such variables is defined as $\hat{D}_t = dD_t / \bar{C}$, $\hat{F}_t = dF_t / \bar{C}$, $\hat{I}_t = dI_t / \bar{C}$, and $\hat{Z}_t = dZ_t / \bar{C}$. To computed for the log-linearized equation, therefore, one needs to divide both sides by $\bar{C}^H$

$$\frac{dD_t^H}{\bar{C}^H} \approx (1+\bar{i}^H)\frac{dD_{t-1}^H}{\bar{C}^H} + N_T^H \frac{dw_t^H}{\bar{C}^H}$$
$$-\bar{P}^H \frac{dC_t^H}{\bar{C}^H} - \bar{P}^H \frac{dI_t^H}{\bar{C}^H} - \bar{P}^H \frac{dZ_t^H}{\bar{C}^H} - \left(\bar{C}^H + \bar{I}^H + \bar{Z}^H\right)\frac{dP_t^H}{\bar{C}^H}$$

$$\hat{D}_t^H \approx \frac{1}{\beta}\hat{D}_{t-1}^H + \frac{N_T^H \bar{w}^H}{\bar{C}^H}\hat{w}_t^H - \bar{P}^H \hat{C}_t^H - \bar{P}^H \hat{I}_t^H - \bar{P}^H \hat{Z}_t^H - \bar{P}^H \hat{P}_t^H$$

$$\frac{\hat{D}_t^H}{\bar{P}^H} \approx \frac{1}{\bar{P}^H \beta}\hat{D}_{t-1}^H + \frac{N_T^H \bar{w}^H}{\bar{P}^H \bar{C}^H}\hat{w}_t^H - \hat{C}_t^H - \hat{I}_t^H - \hat{Z}_t^H - \hat{P}_t^H$$

$$\frac{\hat{D}_t^H}{\bar{P}^H} \approx \frac{1}{\bar{P}^H \beta}\hat{D}_{t-1}^H + \hat{w}_t^H - \hat{C}_t^H - \hat{I}_t^H - \hat{Z}_t^H - \hat{P}_t^H$$

where $\hat{D}_t = dD_t / \overline{C},\ \hat{F}_t = dF_t / \overline{C},\ \hat{I}_t = dI_t / \overline{C},$ and $\hat{Z}_t = dZ_t / \overline{C}$

Later on in this chapter, $\hat{Z}_t$ will be proved to be zero. Hence, linearized consumer budget constraint is

$$\frac{\hat{D}_t^H}{\overline{P}^H} \approx \frac{1}{\overline{P}^H \beta} \hat{D}_{t-1}^H + \hat{w}_t^H - \hat{C}_t^H - \hat{I}_t^H - \hat{P}_t^H$$

(5.2.5) the evolution of foreign bonds holding by home individuals

$$\overline{N}^H F_t^H = (1+i_{t-1}^F)\overline{N}^H F_{t-1}^H + P_t^F \overline{N}^H I_t^H$$

$$F_t^H = (1+i_{t-1}^F)F_{t-1}^H + P_t^F I_t^H$$

Take Taylor series expansion on both sides:

$$dF_t^H \approx (1+\overline{i}^F)dF_{t-1}^H + \overline{F}^H di_{t-1}^F + \overline{P}^F dI_t^H + \overline{I}^H dP_t^F$$

Again, divide both sides by $\overline{C}^H$ leads to

$$\frac{dF_t^H}{\overline{C}^H} \approx (1+\overline{i}^F)\frac{dF_{t-1}^H}{\overline{C}^H} + \overline{P}^F \frac{dI_t^H}{\overline{C}^H}$$

$$\hat{F}_t^H \approx \frac{1}{\beta}\hat{F}_{t-1}^H + \overline{P}^F \hat{I}_t^H$$

where $\hat{D}_t = dD_t / \overline{C},\ \hat{F}_t = dF_t / \overline{C},$ and $\hat{I}_t = dI_t / \overline{C}$

(5.2.7) The adjustment cost of making cross-border flow of funds

$$\overline{N}^H Z_t^H = \frac{1}{2}\psi\left(\overline{N}^H I_t^H\right)^2$$

Applying the same procedure by taking a Taylor series expansion on both sides: $\overline{N}^H dZ_t^H = \psi\left(\overline{N}^H\right)^2 \overline{I}^H dI_t^H$ and divide both sides by $\overline{C}^H$

$$\overline{N}^H \frac{dZ_t^H}{\overline{C}^H} \approx \psi\left(\overline{N}^H\right)^2 \overline{I}^H \frac{dI_t^H}{\overline{C}^H}$$

$$\overline{N}^H \hat{Z}_t^H \approx \psi\left(\overline{N}^H\right)^2 \overline{I}^H \hat{I}_t^H$$

$$\hat{Z}_t^H \approx \psi \overline{N}^H \overline{I}^H \hat{I}_t^H$$

Given that $\overline{I} = 0$, it is easy to see that $\hat{Z}_t^H \approx 0$

(5.2.9) Home price index

$$P_t^H = \left[\bar{n} p_t^H(h)^{1-\theta} + (1-\bar{n})[E_t p_t^F(f)]^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

Take ln on both sides: $\ln P_t^H = \dfrac{1}{1-\theta}\ln\left[\bar{n} p_t^H(h)^{1-\theta} + (1-\bar{n})[E p_t^F(f)]^{1-\theta}\right]$

Take a Taylor series on both sides:

LHS: $\ln P_t^H \approx \bar{P}^H + \dfrac{dP_t^H}{\bar{P}^H} \approx \hat{P}_t^H$

RHS:

$$\frac{1}{1-\theta}\ln\left[\bar{n}\left(p_t^H(h)\right)^{1-\theta} + (1-\bar{n})\left(E_t p_t^F(f)\right)^{1-\theta}\right]$$

$$\approx \frac{\bar{n}\left(\bar{p}^H(h)\right)^{-\theta} dp_t^H(h) + (1-\bar{n})\left[\bar{p}^F(f)^{1-\theta}\bar{E}^{-\theta} dE_t + \bar{E}^{1-\theta}\bar{p}^F(f)^{-\theta} dp_t^F(f)\right]}{\bar{n}\left(\bar{p}^H(h)\right)^{1-\theta} + (1-\bar{n})\left(\bar{E}\bar{p}^F(f)\right)^{1-\theta}}$$

$$\approx \frac{\bar{n}\left(\bar{p}^H(h)\right)^{1-\theta}\hat{p}_t^H(h) + (1-\bar{n})\left[\left(\bar{E}\bar{p}^F(f)\right)^{1-\theta}\hat{E}_t + \left(\bar{E}\bar{p}^F(f)\right)^{1-\theta}\hat{p}_t^F(f)\right]}{\left(\bar{P}^H\right)^{1-\theta}}$$

$$\approx \frac{\bar{n}\left(\bar{p}^H(h)\right)^{1-\theta}}{\left(\bar{P}^H\right)^{1-\theta}}\hat{p}_t^H(h) + \frac{(1-\bar{n})\left(\bar{E}\bar{p}^F(f)\right)^{1-\theta}}{\left(\bar{P}^H\right)^{1-\theta}}\left[\hat{E}_t + \hat{p}_t^F(f)\right]$$

Therefore, the general price index for all goods can be written as

$$\hat{P}_t^H \approx \omega_1^H\hat{p}_t^H(h) + \omega_2^H\left[\hat{E}_t + \hat{p}_t^F(f)\right]$$

where $\omega_1^H = \dfrac{\bar{n}\left(\bar{p}^H(h)\right)^{1-\theta}}{\left(\bar{P}^H\right)^{1-\theta}}$ and $\omega_2^H = \dfrac{(1-\bar{n})\left(\bar{E}\bar{p}^F(f)\right)^{1-\theta}}{\left(\bar{P}^H\right)^{1-\theta}}$

Turn now to foreign price index, given by equation (5.2.10). It is simple to derive following relationship for foreign price index

$$P_t^F = \left[\bar{n}\left[\frac{p_t^H(h)}{E}\right]^{1-\theta} + (1-\bar{n})p_t^F(f)^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

$$\hat{P}_t^F \approx \omega_1^F\left[\hat{p}_t^H(h) - \hat{E}_t\right] + \omega_2^F\hat{p}_t^F(f)$$

where $\omega_1^H = \dfrac{\bar{n}\left(\bar{p}^H(h)/\bar{E}\right)^{1-\theta}}{\left(\bar{P}^F\right)^{1-\theta}}$ and $\omega_2^H = \dfrac{(1-\bar{n})\left(\bar{p}^F(f)\right)^{1-\theta}}{\left(\bar{P}^F\right)^{1-\theta}}$

(5.2.11) Current account identity

$$\bar{N}^H I_t^H + \bar{N}^F I_t^F = 0$$

Taylor series expansion on both sides:

$$\bar{N}^H dI_t^H + \bar{N}^F dI_t^F \approx 0$$

Divide both sides by C:

$$\bar{N}^H \bar{C}^H \frac{dI_t^H}{\bar{C}^H} + \bar{N}^F \bar{C}^F \frac{dI_t^F}{\bar{C}^F} \approx 0$$

Thus, the current account identity are approximated by

$$\bar{N}^H \bar{C}^H \hat{I}_t^H + \bar{N}^F \bar{C}^F \hat{I}_t^F \approx 0$$

(5.2.12) Home individual demand for home-produced goods

$$c_t^H(h) = \left[\frac{p_t^H(h)}{P_t^H}\right]^{-\theta} C_t^H$$

Take ln on both sides: $\ln c_t^H(h) = -\theta \ln p_t^H(h) + \theta \ln P_t^H + \ln C_t^H$

Take a Taylor series expansion:

LHS: $\ln c_t^H(h) \approx \bar{c}^H(h) + \frac{dc_t^H(h)}{\bar{c}^H(h)} \approx \hat{c}_t^H(h)$

RHS:

$$-\theta \ln p_t^H(h) + \theta \ln P_t^H + \ln C_t^H$$

$$\approx -\frac{\theta}{\bar{p}^H(h)} dp_t^H(h) + \frac{\theta}{\bar{P}^H} dP_t^H + \frac{dC_t^H}{\bar{C}^H}$$

$$\approx -\theta \hat{p}_t^H(h) + \theta \hat{P}_t^H + \hat{C}_t^H$$

Equating both sides, thus, leads to

$$\hat{c}_t^H(h) \approx -\theta \hat{p}_t^H(h) + \theta \hat{P}_t^H + \hat{C}_t^H$$

Equivalently, the log-linearized version of equation (5.2.13), interpreted as a home demand for goods foreign produces, can also be derived as

$$\hat{c}_t^H(f) \approx -\theta\left(\hat{E}_t + \hat{p}_t^F(f)\right) + \theta \hat{P}_t^H + \hat{C}_t^H$$

(5.2.16) World demand for goods z produced by home

$$y_t^{dH} = \left[\frac{p_t^H}{P_t^H}\right]^{-\theta} Q_t$$

Take ln on both sides: $\ln y_t^{dH} = -\theta \ln p_t^H + \theta \ln P_t^H + \ln Q_t$

$$\ln y_t^{dH} = -\theta \ln p_t^H + \theta \ln P_t^H + \ln\left(N_T^H\left(C_t^H + Z_t^H\right) + N_T^F\left(C_t^F + Z_t^F\right)\right)$$

Take a Taylor series expansion:

LHS: $\ln y_t^{dH} \approx \bar{y}^H + \dfrac{dy_t^{dH}}{\bar{y}^{dH}} \approx \hat{y}_t^{dH}$

RHS:

$$-\theta \ln p_t^H + \theta \ln P_t^H + \ln\left(N_T^H\left(C_t^H + Z_t^H\right) + N_T^F\left(C_t^F + Z_t^F\right)\right)$$

$$\approx -\frac{\theta}{\bar{p}^H} dp_t^H + \frac{\theta}{\bar{P}^H} dP_t^H + \frac{N_T^H\left(dC_t^H + dZ_t^H\right) + N_T^F\left(dC_t^F + dZ_t^F\right)}{\left(N_T^H\left(\bar{C}^H + \bar{Z}^H\right) + N_T^F\left(\bar{C}^F + \bar{Z}^F\right)\right)}$$

$$\approx -\theta \hat{p}_t^H + \theta \hat{P}_t^H + \frac{N_T^H \bar{C}^H\left(\hat{C}_t^H + \hat{Z}_t^H\right) + N_T^F \bar{C}^F\left(\hat{C}_t^F + \hat{Z}_t^F\right)}{\left(N_T^H \bar{C}^H + N_T^F \bar{C}^F\right)}$$

$$\approx -\theta \hat{p}_t^H + \theta \hat{P}_t^H + \frac{N_T^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H + \hat{Z}_t^H\right) + \frac{N_T^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F + \hat{Z}_t^F\right)$$

Therefore, $\hat{y}_t^{dH} \approx -\theta \hat{p}_t^H + \theta \hat{P}_t^H + \dfrac{N_T^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H + \hat{Z}_t^H\right) + \dfrac{N_T^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F + \hat{Z}_t^F\right)$

According to equation (5.2.7), the adjustment cost of making cross-border flow of funds, $\hat{Z}_t$, is known to be zero. As such, the output demand equation takes the log-linear form as

$$\hat{y}_t^{dH} \approx -\theta \hat{p}_t^H + \theta \hat{P}_t^H + \frac{N_T^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H\right) + \frac{N_T^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F\right)$$

(5.2.18) Home labor market equilibrium condition

$$\bar{y}^H = \frac{\bar{N}^H}{\bar{n}} \text{ or } \bar{Y}^H = \left(1 - \bar{n}\right)\bar{y}^H = \bar{N}^H$$

Because all quantities in above equations are given as a constant since the initial balanced growth period, the log-linearization procedure gives us

$\hat{y}_t^H \approx 0$ and $\hat{Y}_t^H \approx 0$. This implies a zero deviation of outputs, both for the individual firm and the aggregate level, from their steady state levels.

Of course, the fact that log-deviation from steady state of output is equal to zero is not uncommon. It is rather a usual condition one obtains from the model where flexibility of wage and price ensures that outputs will stay on at the full employment level at all times.

Finally, after taking ln and applying Taylor series approximation in both sides for one last time, home output and money market equilibrium condition, equation (5.2.20) and (5.2.22), becomes

$$\hat{y}_t^{dH} \approx -\theta \hat{p}_t^H + \theta \hat{P}_t^H + \frac{N_T^H \bar{C}^H}{\bar{Q}}\left(\hat{C}_t^H\right) + \frac{N_T^F \bar{C}^F}{\bar{Q}}\left(\hat{C}_t^F\right) \approx 0 \text{ and}$$

$\hat{M}_t^{dH} \approx \hat{M}_t^{sH} \approx \hat{M}_t^H$, respectively.

The later condition, coupled with the linearized optimal money demand schedule in (5.1.3), implies the following version of money market equilibrium conditions

$$\hat{P}_t^H - \hat{M}_t^H - \frac{\beta}{\varepsilon}\hat{i}_t^H + \frac{1}{\sigma\varepsilon}\hat{C}_t^H \approx 0$$

All log-linearized equations, derived in this appendix, are summarized in section 6.4.3 in chapter six.

APPENDIX G

MATLAB COMMANDING LINES FOR SOLVING AND SIMULATING THE MODEL

Referring to chapter six, the pain of having to solve for all the undetermined coefficients by hand can be avoided by applying directly the theorem 6.1 and 6.2. The easiest way to do this is to obtain MATLAB routines to perform the calculations. The following program is used to solved and simulate the model in this thesis. It consists of the parameter values setting, steady state description, the variables declaration, specification of log-linearized equilibrium equations, and finally, the identified option set for all the computation processes. Once all the needed information is defined, the file do_it.m will does it all by calling all the other programs, namely solve.m and calc_qrs.m (briefly discussed in section 6.4.4), solve_out.m, impresp.m (briefly discussed in section 6.4.5), as well as option.m, to execute all the documented calculations. These M_files are written by Harald Uhilg (Copyright: H. Uhlig: VERSION 4.0, November 2002) and are available at http://www.wiwi.hu-berlin.de/wpol/html/toolkit.htm.

The MATLAB programs, clarified below, carry out, one at a time, the calculation for the effect of monetary shock under four different scenarios. That is,

1) High degree of capital mobility with incomplete labor market integration
2) Low degree of capital mobility with incomplete labor market integration
3) High degree of capital mobility with complete labor market integration
4) Low degree of capital mobility with complete labor market integration

The intuitions behind each result are exemplified in chapter 7

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% MATLAB code for "PEERING THORUH THE MONETARY MIST: MACROECONOMIC VOLATILITIES      %%
%%                    UNDER BORDERLESS WORLD OF FINANCIAL AND LABOR MARKET"            %%
%% Created by Suchanan Chunanantatham                                                  %%
%% The algorithm is based on H. Uhlig.                                                 %%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

disp('new open economy macroeconomic model with markets integration');

disp('Hit any key when ready...');
pause;

%------------------------------------------------ Setting parameters ------------------------------------------------%

beta_1      = 1/1.05;   %Subjective discount factor for home
beta_2      = 1/1.05;   %Subjective discount factor for foreign
epsilon_1   = 9;        %Inverse of interest elasticity of home money demand
epsilon_2   = 9;        %Inverse of interest elasticity of foreign money demand
sigma_1     = 0.75;     %Elasticity of intertemporal substitution for home
sigma_2     = 0.75;     %Elasticity of intertemporal substitution for foreign
theta_1     = 6;        %Elasticity of demand for consumption goods for home
theta_2     = 6;        %Elasticity of demand for consumption goods for foreign
chi_1       = 1;        %Weight of real balances in home utility function
chi_2       = 1;        %Weight of real balances in foreign utility function
```

```
% Process of financial market integration is represented by lowering value of the adjustment cost parameter, psi.
psi_1       = 0.2;     %implies that domestic and foreign bond market are closely linked
psi_2       = 0.2;
% or
psi_1       = 2;       %illustrates the case with separated labor market across countries
psi_2       = 2;

phi_1       = 1;       %autocorrelation of home monetary shock
sigma_xi_1  = 0;   %standard deviation of home monetary shock
phi_2       = 1;       %autocorrelation of foreign monetary shock
sigma_xi_2  = 0;   %standard deviation of foreign monetary shock
corr_1_2    = 0;     %Correlation of home and foreign monetary shock

% Note:--- The subscripts 1 and 2 stand for the country, to which each variables belongs.
%        In this worksheet, 1 denotes home and 2 speaks for foreign country.
%         ---  Since epsilon is one of the parameters in consumer utility, to prevent the double entry of value,
%         Xi is used here in the place of epsilon, which is specified in chapter six as
%        an innovation term in home and foreign money supply process.

%------------------------------------------------ Identifing the steady state---------------------------------------------%

% In Chapter six, section 6.4.2, we compute the steady state relationship of our model for two cases, i.e.,
% 1) Economy before international labor migration
```

```
N_bar_1 =  1
N_bar_2 =  1
M_bar_1 =  1.402;
M_bar_2 =  1.402;
n_bar   =  0.5;
y_bar_1 =  2;
y_bar_2 =  2;
C_bar_1 =  1;
C_bar_2 =  1;
p_bar_1 =  1;
p_bar_2 =  1;
P_bar_1 =  1;
P_bar_2 =  1;
E_bar   =  1;
% or
% 2) Economy after international labor migration
N_bar_1 = 0.94;      %N_T_1
N_bar_2 = 1.06;      %N_T_2
M_bar_1 = 1;
M_bar_2 = 2;
n_bar   = 0.0151;    %n_T
y_bar_1 = 62.0474;   %y_T_1
y_bar_2 = 1.0687;    %y_T_2
C_bar_1 = 0.5119;
```

```
C_bar_2 = 1.1397;
p_bar_1 = 0.4217;
p_bar_2 = 1.4773;
w_bar_1 = 0.4185;
w_bar_2 = 1.4760;
P_bar_1 = 0.7689;
P_bar_2 = 1.3743;
E_bar   = 0.5395;

Q_bar       = (N_bar_1*C_bar_1)+(N_bar_2*C_bar_2)
omega_1_1   = (n_bar*(p_bar_1^(1-theta_1)))/(P_bar_1^(1-theta_1))
omega_2_1   = ((1-n_bar)*((E_bar*p_bar_2)^(1-theta_1)))/(P_bar_1^(1-theta_1))
omega_1_2   = (n_bar*((p_bar_1/E_bar)^(1-theta_2)))/(P_bar_2^(1-theta_2))
omega_2_2   = ((1-n_bar)*(p_bar_2^(1-theta_2)))/(P_bar_2^(1-theta_2))


%--------------------------------------------------- Declaring the matrices ---------------------------------------------%

VARNAMES = ['do. bond holding 1             ',
            'do. bond holding 2             ',
            'for. bond holding 1            ',
            'for. bond holding 2            ',
            'ind. price 1                   ',
            'ind. price 2                   ',
```

```
          'consumption 1              ',
          'consumption 2              ',
          'gen. price index 1         ',
          'gen. price index 2         ',
          'fund transfered 1          ',
          'fund transfered 2          ',
          'nominal int. 1             ',
          'nominal int. 2             ',
          'exchange rate              ',
          'wage 1                     ',
          'wage 2                     ',
          'consumption of do. good 1  ',
          'consumption of for. good 2  ',
          'consumption of for. good 1  ',
          'consumption of do. good 2  ',
          'money 1                    ',
          'money 2                    ',   ];

%-------------------------------------------- Translating into coefficient matrices -----------------------------------------%
% The loglinearized equations are, conveniently ordered:

% 1,2) 0 = P(t,i)-M(t,i)-((beta_i/epsilon_i)*i(t,i))+((1/(sigma_i*epsilon_i))*C(t,i))
% 3,4) 0 = p(t,i)-w(t,i)
% 5,6) 0 = ((1/P_bar_(i))*D(t,i))-((1/(P_bar_i*beta_i))*D(t-1,i))-w(t,i)+C(t,i)+I(t,i)+P(t,i)
```

```
% 7) 0 = F_1(t)-((1/beta_1)*F_1(t-1))-(P_bar_2*I_1(t))
% 8) 0 = D_2(t)-((1/beta_2)*D_2(t-1))-(P_bar_1*I_2(t))
% 9) 0 = P_1(t)-(omega_1_1*p_1(t))-(omega_2_1*(E+p_2(t)))
% 10) 0 = P_2(t)-(omega_1_2*(p_1(t)-E(t)))-(omega_2_2*p_2(t))
% 11) 0 = (N_1*C_bar_1*I_1(t))+(N_2*C_bar_2*I_2(t))
% 12,13) 0 = (theta_i*p(t,i))-(theta_i*P(t,i))-((N_1*C_bar_1/Q_bar)*C_1(t))-((N_2*C_bar_2/Q_bar)*C_2(t))
% 14) 0 = c_1(1,t)+(theta_1*p_1(t))-(theta_1*P_1(t))-C_1(t)
% 15) 0 = c_2(2,t)+(theta_2*p_2(t))-(theta_2*P_2(t))-C_2(t)
% 16) 0 = c_1(2,t)+(theta_1*(E+p_2(t)))-(theta_1*P_1(t))-C_1(t)
% 17) 0 = c_2(1,t)+(theta_2*(p_1(t)-E))-(theta_2*P_2(t))-c_2(t)
% 18,19) 0 = E_t [ C(t+1,i)-C(t,i)-(sigma_i*P(t,i))+(sigma_i*P(t+1,i))-(sigma_i*(1-beta_i)*i(t,i)) ]
% 20) 0 = E_t [ ((1-beta_1)*i_1(t))+(psi_1*N_bar_1*C_bar_1*I_1(t))-E(t+1)+E(t)-((1-beta_1)*i_2(t))-(psi_1*N_bar_1*C_bar_1*I_1(t+1)) ]
% 21) 0 = E_t [ ((1-beta_2)*i_2(t))+(psi_2*N_bar_2*C_bar_2*I_2(t))-E(t)+E(t+1)-((1-beta_2)*i_1(t))-(psi_2*N_bar_2*C_bar_2*I_2(t+1)) ]
% 22,23) M(t+1,i) = phi_i M(t,i) + xi(t+1,i)
% CHECK:  23 equations, 23 variables (21 endogenous variables, 2 exogenous variables).

% Endogenous state variables "x(t)": D(t,i), F(t,i), p(t,i)  i = 1,2
% Endogenous other variables "y(t)": C(t,i), P(t,i), I(t,i), i(t,i), E(t), w(t,i), c(z,t,i)    i,z = 1,2
% Exogenous state variables “z(t)": M(t,i) i = 1,2.
% Switch to that notation.  Find matrices for format
% 0 = AA x(t) + BB x(t-1) + CC y(t) + DD z(t)
% 0 = E_t [ FF x(t+1) + GG x(t) + HH x(t-1) + JJ y(t+1) + KK y(t) + LL z(t+1) + MM z(t)]
% z(t+1) = NN z(t) + xi(t+1) with E_t [ xi(t+1) ] = 0,
```

```
% DETERMINISTIC EQUATIONS

% for D(t,i),F(t,i), p(t,i):
AA = [        0, 0, 0,        0,          0,          0
              0, 0, 0,        0,          0,          0
              0, 0, 0,        0,          1,          0
              0, 0, 0,        0,          0,          1
   1/P_bar_1, 0, 0,           0,          0,          0
              0, 0, 0, 1/P_bar_2,         0,          0
              0, 0, 1,        0,          0,          0
              0, 1, 0,        0,          0,          0
              0, 0, 0,        0, -omega_1_1, -omega_2_1
              0, 0, 0,        0, -omega_1_2, -omega_2_2
              0, 0, 0,        0,          0,          0
              0, 0, 0,        0,    theta_1,          0
              0, 0, 0,        0,          0,    theta_2
              0, 0, 0,        0,    theta_1,          0
              0, 0, 0,        0,          0,    theta_2
              0, 0, 0,        0,          0,    theta_1
              0, 0, 0,        0,    theta_2,          0      ];
```

```
% for D(t-1,i),F(t-1,i), p(t-1,i):
BB = [                    0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
     -1/(P_bar_1*beta_1),             0,         0,                       0, 0, 0
                          0,          0,         0, -1/(P_bar_2*beta_2), 0, 0
                          0,          0, -1/beta_2,                       0, 0, 0
                          0, -1/beta_1,          0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0
                          0,          0,         0,                       0, 0, 0      ];
```

```
% For C(t,i), P(t,i), I(t,i), i(t,i), E(t), w(t,i), c(z,t,i):

CC = [ 1/(sigma_1*epsilon_1),       0,             1,             0,                 0,                 0,   -beta_1/epsilon_1,       0,            0,      0, 0, 0, 0, 0, 0
                     0,      1/(sigma_2*epsilon_2),  0,             1,                 0,                 0,                 0,   -beta_2/epsilon_2,  0,      0, 0, 0, 0, 0, 0
                     0,                     0,             0,             0,                 0,                 0,                 0,                 0,            0,     -1, 0, 0, 0, 0, 0
                     0,                     0,             0,             0,                 0,                 0,                 0,                 0,            0,      0,-1, 0, 0, 0, 0
                     1,                     0,             1,              0,                 1,                 0,                 0,                 0,            0,     -1, 0, 0, 0, 0, 0
                     0,                     1,             0,              1,                 0,                 1,                 0,                 0,            0,      0,-1, 0, 0, 0, 0
                     0,                     0,             0,              0,          -P_bar_2,              0,                 0,                 0,            0,      0, 0, 0, 0, 0, 0
                     0,                     0,             0,              0,                 0,           -P_bar_1,           0,                 0,            0,      0, 0, 0, 0, 0, 0
                     0,                     0,             1,             0,                 0,                 0,                 0,                 0, -omega_2_1, 0, 0, 0, 0, 0, 0
                     0,                     0,             0,             1,                 0,                 0,                 0,                 0,  omega_1_2, 0, 0, 0, 0, 0, 0
                     0,                     0,             0,             0,     N_bar_1*C_bar_1, N_bar_2*C_bar_2, 0,                 0,            0,      0, 0, 0, 0, 0, 0
   -(N_bar_1*C_bar_1)/Q_bar, -(N_bar_2*C_bar_2)/Q_bar, -theta_1,0,  0,                 0,                 0,                 0,            0,     0, 0, 0, 0, 0, 0
   -(N_bar_1*C_bar_1)/Q_bar, -(N_bar_2*C_bar_2)/Q_bar, 0, -theta_2, 0,                 0,                 0,                 0,            0,     0, 0, 0, 0, 0, 0
                    -1,                     0,      -theta_1,           0,                 0,                 0,                 0,                 0,            0,     0, 0, 1, 0, 0, 0
                     0,                    -1,              0,   -theta_2,                 0,                 0,                 0,                 0,            0,     0, 0, 0, 1, 0, 0
                    -1,                     0,       -theta_1,           0,                 0,                 0,                 0,                 0,      theta_1,   0, 0, 0, 0, 1, 0
                     0,                    -1,              0,   -theta_2,                 0,                 0,                 0,                 0,     -theta_2,   0, 0, 0, 0, 0, 1      ];
```

```
% For M(t,i):

DD = [    -1, 0
           0,-1
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0
           0, 0   ];
```

```
% EXPECTATIONAL EQUATIONS:

% For D(t+1,i), F(t+1,i),p(t+1,i)  :
FF = [    0, 0, 0, 0, 0, 0
          0, 0, 0, 0, 0, 0
          0, 0, 0, 0, 0, 0
          0, 0, 0, 0, 0, 0   ];

% For D(t,i), F(t,i), p(t,i) :
GG = [   0, 0, 0, 0, 0, 0
          0, 0, 0, 0, 0, 0
          0, 0, 0, 0, 0, 0
          0, 0, 0, 0, 0, 0    ];

% For D(t-1,i), F(t-1,i), p(t-1,i) :
HH = [  0, 0, 0, 0, 0, 0
         0, 0, 0, 0, 0, 0
         0, 0, 0, 0, 0, 0
         0, 0, 0, 0, 0, 0     ];
```

```
% For C(t+1,i), P(t+1,i), I(t+1,i), i(t+1,i), E(t+1), w(t+1,i), c(z,t+1,i):
JJ = [    1, 0, sigma_1,          0,                               0,                                 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
          0, 1,          0,sigma_2,                                0,                                 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
          0, 0,          0,          0, -psi_1*N_bar_1*C_bar_1,                                       0, 0, 0,-1, 0, 0, 0, 0, 0, 0
          0, 0,          0,          0,                             0, -psi_2*N_bar_2*C_bar_2, 0, 0, 1, 0, 0, 0, 0, 0, 0    ];

% For C(t,i), P(t,i), I(t,i), i(t,i), E(t), w(t,i), c(z,t,i):
KK = [   -1, 0, -sigma_1,            0,               0,                    0, -sigma_1*(1-beta_1),                          0, 0, 0, 0, 0, 0, 0, 0
          0, -1,            0, -sigma_2,              0,                    0,                            0, -sigma_2*(1-beta_2), 0, 0, 0, 0, 0, 0, 0
          0, 0,             0,           0, psi_1*N_bar_1*C_bar_1,    0,                  1-beta_1,              -(1-beta_2), 1, 0, 0, 0, 0, 0, 0
          0, 0,             0,           0,                 0, psi_2*N_bar_2*C_bar_2,  -(1-beta_1),                 1-beta_2,-1, 0, 0, 0, 0, 0, 0    ];

% For M(t+1,i)
LL = [   0, 0
         0, 0
         0, 0
         0, 0    ];

% For M(t,i)
MM = [   0, 0
         0, 0
         0, 0
         0, 0    ];
```

```
%AUTOREGRESSIVE MATRIX FOR M(t)

NN = [  phi_1,       0
               0,   phi_2  ];

Sigma = [   sigma_xi_1^2,          corr_1_2
                      corr_1_2,   sigma_xi_2^2   ];

%------------------------------------------------ Setting the options -------------------------------------------------%

[l_equ,m_states] = size(AA);
[l_equ,n_endog ] = size(CC);
[l_equ,k_exog  ] = size(DD);


PERIOD        = 4;              % Number of periods per year, i.e. 4 for quarterly
DO_QZ         = 0;              % Employ the generalized eigenvector/eigenvalue decomposition to find the matrix P
IMP_SELECT    = [1:23];   % A vector containing the indices of the variables to be plotted
IMP_SINGLE    = 1;           % Each impulse response will be plotted in a single graph

%--------------------------------------------  Starting the calculations ----------------------------------------------%

do_it;
```

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