uOttawa

L'Université canadienne
Canada's university

FACULTÉ DES ÉTUDES SUPÉRIEURES ET POSTOCTORALES

uOttawa

L'Université canadienne
Canada's university

FACULTY OF GRADUATE AND POSDOCTORAL STUDIES

Jun Zhao
AUTEUR DE LA THÈSE / AUTHOR OF THESIS

Ph.D. (Economics)
GRADE / DEGREE

Department of Economics
FACULTÉ, ÉCOLE, DÉPARTEMENT / FACULTY, SCHOOL, DEPARTMENT

Three Essays Dealing with Open Economy Models Based on the Portfolio Balance Tradition

TITRE DE LA THÈSE / TITLE OF THESIS

Marc Lavoie
DIRECTEUR (DIRECTRICE) DE LA THÈSE / THESIS SUPERVISOR

CO-DIRECTEUR (CO-DIRECTRICE) DE LA THÈSE / THESIS CO-SUPERVISOR

EXAMINATEURS (EXAMINATRICES) DE LA THÈSE / THESIS EXAMINERS

Patrick George

Nicholas Rowe

Louis-Philippe Rochon

Mario Seccareccia

Gary W. Slater
Le Doyen de la Faculté des études supérieures et postdoctorales / Dean of the Faculty of Graduate and Postdoctoral Studies

Three Essays Dealing with Open Economy Models Based on the Portfolio Balance Tradition

Jun Zhao

Thesis submitted to the Faculty of
Graduate and Postdoctoral Studies
In partial fulfillment of the requirements
For the PhD degree in economics

Department of Economics
Faculty of Social Science
University of Ottawa

Your file Votre référence
ISBN: 978-0-494-48667-2
Our file Notre référence
ISBN: 978-0-494-48667-2

Abstract

This thesis consists of three papers on open economy models in the portfolio balance tradition. The first paper presents a dynamic stock-flow consistent model for three economies with both fixed and floating exchange rates. The model is applied to simulate the impact of internal and external shocks, and short-run and long-run effects of changes in the U.S. fiscal position on the economies of the three countries – the U.S., China and Euroland. The simulation results show that the compensation principle still holds in an open overdraft economy.

The second paper investigates the effect of the diversification of China's foreign reserves using the three-country model. The simulation results show that with the diversification of China's foreign reserves, the euro appreciates against the dollar and the RMB. China and the U.S. can benefit from the diversification, while the Euroland economy slows down. What is interesting is that the model generates some kind of path dependence. How the central bank of China will achieve its target diversification rate has an impact on the steady state values of the model.

The third paper examines the portfolio balance model for the determination of the nominal exchange rate of the Canadian dollar against the US dollar using the VAR model. One cointegration equation is found. Through the impulse response and the variance decomposition analyses, we find that the Canadian demand for the US bills and bonds play an important role in the dynamic changes of the exchange rate. The empirical test results indicate that it is difficult for the reduced form portfolio-balance models to consistently beat the random walk model.

Acceptance

Dedications

This thesis is dedicated to my wife, Yan Qiu, and my daughter, Alice Xinai Zhao

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LEGEND

AIC	Akaike Information Criterion
DM	Diebold and Mariano
ECB	European Central Bank
GDP	Gross Domestic Products
HQ	Hannan-Quinn Information Criterion
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
MSE	Mean Squared Errors
PBM	Portfolio Balance Model
PP	Phillips-Perron
RMB	Renminbi
RMSE	Root Mean Squared Errors
SC	Schwarz Information Criterion
SFC	Stock-flow Consistent
VAR	Vector Autoregressive
VECM	Vector Errors Correction Model
UIP	Uncovered Interest Parity

Abstract

This thesis consists of three papers on open economy models in the portfolio balance tradition. The first paper presents a dynamic stock-flow consistent model for three economies with both fixed and floating exchange rates. The model is applied to simulate the impact of internal and external shocks, and short-run and long-run effects of changes in the U.S. fiscal position on the economies of the three countries – the U.S., China and Euroland. The simulation results show that the compensation principle still holds in an open overdraft economy.

The second paper investigates the effect of the diversification of China's foreign reserves using the three-country model. The simulation results show that with the diversification of China's foreign reserves, the euro appreciates against the dollar and the RMB. China and the U.S. can benefit from the diversification, while the Euroland economy slows down. What is interesting is that the model generates some kind of path dependence. How the central bank of China will achieve its target diversification rate has an impact on the steady state values of the model.

The third paper examines the portfolio balance model for the determination of the nominal exchange rate of the Canadian dollar against the US dollar using the VAR model. One cointegration equation is found. Through the impulse response and the variance decomposition analyses, we find that the Canadian demand for the US bills and bonds play an important role in the dynamic changes of the exchange rate. The empirical test results indicate that it is difficult for the reduced form portfolio-balance models to consistently beat the random walk model.

Acknowledgement

I would like to express my sincere and deepest gratitude to my supervisor, Professor Lavoie, not only for his scholar direction throughout the work for this thesis, but also for his encouragement and financial support. I am grateful to Professor Lavoie, Professor Seccareccia, Professor Merette, Professor Rowe, Professor Rochon, and Professor Georges for their helpful comments and suggestions on my thesis. I am also indebted to my PhD classmate and friend, Jung-Hoon Kim, for his helpful technical advice on EViews programming.

I wish to thank the staffs at the Department of Economics of the University of Ottawa: Diane, Irene and Bernadette for their help during my PhD study.

Finally, I would like to take this opportunity to give my special thanks to my wife, Yan, for her endless support, and to my lovely daughter, Alice, for all the happiness that she has brought to me.

Introduction

Wynne Godley (1999) has written the first of a series of models the intent of which is to put together the real and monetary implications of international trade, using a stock-flow consistent approach based on portfolio analysis. The key feature of these models is that they track stocks and flows through time, dealing with several financial assets and rates of return, while taking account of financial and monetary policy operations, as well as the budget constraints and the adding-up constraints. As pointed out by Godley and Lavoie (2007b, p. 13), these features are in the tradition of Tobin (1982a), and these models can be linked to a renewal of the 'old' Yale school.

This thesis consists of three essays in the portfolio balance tradition. The purpose of the first two essays is to extend Godley and Lavoie's (2007a) (G & L model) three-country model to a different three-country model that describes some of the main characteristics of a world economy that would be made up of only three countries such as the U.S., Euroland, and China. Besides a series of discrepancies, the key difference between the G & L model and my model is that there are three different currencies in my model, with two kinds of exchange rate regimes. My contribution is to apply the model to the analysis of the impact of changes in China's foreign exchange policy and regime on the rest of the world – the U.S. and Euroland. The third essay is an empirical work dealing with the portfolio balance model.

In the first paper, a dynamic stock-flow consistent model with both fixed and floating exchange rates for three economies, such as the U.S., Euroland and China, is developed. The main model is applied to simulate the impact of internal and external shocks, and short-run and long-run effects of changes in the U.S. fiscal position. The simulation results support the compensation principle, as described by Lavoie (2001), showing that it also holds in an open overdraft economy. The compensation principle asserts that increases (decreases) in the foreign reserves of central banks will generally be compensated by decreases (increases) in other assets of the central bank (Lavoie, 2001). The changes in assets of the central bank are affected by the endogenous mechanism tied to the normal behaviour of the central bank and other agents in the economy (Godley and Lavoie, 2007b). The compensation principle is an extension of Tooke's reflux mechanism, underlined by Kaldor and Trevithick (1981). In the main closure of the model, the internal and external shocks lead to "twin deficits" or "twin surpluses". But through the compensation effects, in the quasi steady state, the "twin deficits" or "twin surpluses" have no impact on the overall monetary base or money supply. The central bank of China will not lose control of its monetary policy, because the "twin deficits" or "twin surpluses" have no endogenous effect on the interest rate level.

It must be noted that, in contrast to several mainstream models, this model does not entertain an intertemporal government budget constraint (a target public debt to GDP ratio). Still, in an alternative closure of the model, there is something like an intertemporal budget constraint. The alternative closure incorporates a partial adjustment mechanism, which makes Chinese government expenditures endogenous, responsive to current account deficits. The adjustment mechanism brings the three countries back to balanced budget positions and balanced current account positions. This means that the government debt to GDP ratio of all three governments eventually reaches a constant level. Thus, although there is no target public debt to GDP ratio in the model, the alternative closure analyses a case where public debt to GDP ratios eventually remain constant.

The second paper provides a theoretical framework to investigate the effects of the diversification of China's foreign reserves. In this paper, I extend my first model, still based on a stock-flow consistent approach, to the case where the central bank of China decides to diversify its reserves as it accumulates foreign reserves. The new model is applied to simulate the impact of this change on the economies of the three countries – the U.S., China and Euroland – through a set of experiments and parameter sensitivity tests. The experiment results show that with a one-step sudden diversification of China's foreign reserves, the euro appreciates against the dollar and the RMB, with an overshooting effect on the exchange rate. China and the U.S. can benefit from the diversification, while the Euroland economy slows down. By contrast, gradual diversification can overcome the overshooting effect on exchange rates. Through parameter sensitivity analysis, we find that the diversification of China's foreign reserves has a significant impact on the economies of the three countries. The bigger the share of euro bills in China's foreign reserve portfolio, the larger will be the negative effects on Euroland. What is interesting is that there is some kind of path dependence. How the central bank of China will achieve its target diversification rate has an impact on the steady state values of the model. The equilibrium levels of the key endogenous variables in our model depend on how one achieves the the target diversification rate.

In the first two essays, I focus on investigating the impact of the exchange rate. Interest rates are exogenous variable in my models. This assumption complies with the view of Post-Keynesian economists that central banks are essentially setting short-term interest rates while the supply of money is determined by portfolio demand (Moore, 1988). In the real world, a number of central banks, such as in Australia, Canada, Sweden and the U. S. etc., operate monetary policy by relying on changes in the short-term interest rates under their control (Lavoie, 2001; Fullwiler, 2006; Godley and Lavoie, 2007b). It should also be pointed out that, unlike saving-driven neoclassical models, my model is led by investment autonomous expenditures. The equality between saving and investment is essentially brought about through changes in quantities. Finally, it should be noted that the models in the first two essays are not calibrated, in contrast to computable general equilibrium models for instance. Thus my study focuses on the *qualitative* effects of internal and external shocks, not on empirical magnitudes. Hopefully, calibration will be done in future work

The third paper provides an empirical investigation of the portfolio balance model, in the case of the determination of the nominal exchange rate of the Canadian dollar against the US dollar, using the vector autoregressive (VAR) model. One cointegration equation among the log exchange rate, money demand, and domestic and foreign demands for bills and bonds is found. Through an analysis of the impulse response, we find that Canadian demand for US bills and bonds plays an important role in the dynamic changes in the exchange rate of the Canadian dollar against the US dollar. The variance decomposition analysis results show that the largest proportion of the variance in the exchange rate is accounted by innovations in Canadian demand for US financial assets. However, there is still a large proportion of the variance of the exchange rate that cannot be explained by the other endogenous variables in the VAR system. Based on the root mean squared errors (RMSE) of the dynamic out-of-sample forecast results, we find that the portfolio balance VAR model can outperform the random walk without drift at all forecast horizons. The degree of improvement of the portfolio balance model over the random walk without drift increases with the extension of the forecasting horizon. However, the Diebold and Mariano (DM) test results show that the VAR model cannot beat the random walk model with or without drift in the projection of the exchange rate, at the 0.05 level. Therefore, as one would expect, the reduced-form portfolio-balance model cannot consistently outperform the random walk model.

Reference

Fullwiler, S. T. (2006), "Setting Interest Rates in the Modern Money Era", *Journal of Post-Keynesian Economics*, 28(3) (Spring), pp. 495-526.

Godley, W. (1999), "Open Economy Macroeconomics Using Models of Closed System", WP No. 285, The Levy Economics Institute of Bard College: Annandale-on-Hudson, NY.

Godley, W., and Lavoie, M. (2007a), "A Three-Country Model with Comprehensive Accounting: Euroland and the USA", *Cambridge Journal of Economics*, January, 31 (1), pp. 1-24.

Godley, W., and Lavoie, M. (2007b), *Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth*, London: Macmillan/Palgrave.

Kaldor, N. and Trevithick, J. (1981), "A Keynesian Perspective on Money", *Lloyds Bank Review*, January, pp. 1-19.

Lavoie, M. (2001), "The Reflux Mechanism and the Open economy", in L.P. Rochon and M. Vernengo (Eds), *Credit, Interest Rates and the Open Economy,* pp. 215-242, Edward Elgar.

Moore, B. J. (1988), *Horizontalists and Verticalists: The Macroeconomics of Credit Money,* Cambridge: Cambridge University Press.

Tobin, J. (1982), "Money and Finance in the Macroeconomic Process", *Journal of Money, Credit, and Banking,* 14(2) (May), pp. 171-204.

1 Essay One: A three-country model with fixed and floating exchange rates under a stock-flow coherent approach

1.1 Introduction

This paper presents a dynamic three-country model which describes economies of three countries such as China, Euroland and the USA. "China" can be referred to as home economy, and "Euroland" and "the USA" as foreign economies. A fixed exchange rate regime and a floating exchange rate regime are employed simultaneously in the model. The exchange rate between the currencies of the two foreign countries is freely floating. The Chinese currency (RMB) is pegged to the U.S. Dollar (Dollar), while the exchange rate between the RMB and the Euroland currency (Euro) is floating. The purpose of this paper is to focus on analyzing the dynamic adjustment processes of three economies to internal and external shocks, and effects of change in the U.S. fiscal policy.

This paper uses a stock-flow consistent (SFC) approach. Based on a system-wide logic, the SFC framework relies on the intrinsic dynamics of stock-flow consistency with explicit budget constraints, adding-up constraints and various sectors and financial assets (Godley and Lavoie, 2007). The origin of the SFC method can be traced to Brainard and Tobin (1968). The SFC framework was actively developed by two schools: one at Yale University (the New Haven School or the "Pitfalls Approach" (1969)) and led by Tobin and his associates, and the other one at the Cambridge Economic Policy Group (the New Cambridge School (1970's)) and led by Godley. Godley (1996 and 1999) provided new impetus to the SFC framework by combining elements of these two strands and adding behavioural equations conducive to simulations, leading to a revival of interest in the SFC approach to macroeconomic modeling over the last few years, e.g. Flaschel et al. (2001), Dos Santos (2002), Dos Santos and Zezza (2004, 2005), Lavoie and Godley (2001-02), and Taylor (2004b), etc.

The stock-flow consistent framework takes into account not only the stocks of assets and liabilities of the various sectors of the economy, but also the flows of income, investment and saving (Godley and Lavoie (2007)). "This framework makes it essential to analyze the behaviour of all parties of any international transaction" (Godley and Lavoie 2004a, p. 1). Godley (1999), Izurieta (2003), Lequain (2003), Taylor (2004a), and Godley and Lavoie

(2003, 2004, 2005-06) applied this stock-flow consistent framework to build two-country models.

Lequain (2003) developed a three-country model in which two European countries shared a single central bank and a single currency (euro), operating with a fixed exchange rate with the USA, while all three countries ran independent fiscal policies. This three-country model was used to make a preliminary analysis of the conduct of economic policy in the eurozone vis-à-vis the USA. Godley and Lavoie (2007a) built a similar three-country model. Besides various discrepancies, the main difference between these two models is that Lequain assumes a fixed exchange rate between the euro and the dollar, while Godley and Lavoie consider a flexible exchange rate regime.

This paper is an extension of the three-country model of Godley and Lavoie (2007a) (G & L model). I add a set of realistic features into the model, such as investment, loans and deposits, private commercial banks, and advances that the central bank of China grants to Chinese commercial banks. The key difference between the G & L model and my model, however, is that there are three different currencies in my model, with China and the USA being tied up by a fixed exchange rate, while Europe is on a flexible exchange rate regime with both China and the USA.

The paper is organized as follows. Section 1.2 presents social accounting matrices. Section 1.3 describes the three-country model based on the stock-flow consistent approach. In section 1.4, I present simulation results for an increase in the import propensity of China to import goods from the U.S., an increase in the government expenditures of the U.S., and an increase in the propensity to consume of Chinese households. Section 1.4 focuses on analyzing the impacts of shocks on the main endogenous variables. Section 1.5 presents an alternative closure by making Chinese government expenditures endogenous. Section 1.6 provide further experiments based on the assumptions that the U.S. or Euroland increases its propensity to import goods from China. Section 1.7 summarizes and concludes.

1.2 Stock-flow matrices

<Table 1-1>

Table 1-1 shows the balance sheets of the three countries, the U.S., Euroland, and China. Each economy contains the following five sectors: households, firms, commercial banks, central bank, and government. In Table 1-1, all the columns sum to zero. All the rows related to assets, liabilities, and net worth sum to zero except tangible capital K and wealth balance.[1]

Households are assumed to hold a diversified portfolio of assets. The households' assets consist of high powered money, deposits, bills issued by the domestic government, and bills issued by foreign governments. I assume that these assets are imperfect substitutes. The allocation of the assets varies in response to changes in rates of return and risk considerations.

Firms do not hold cash money, deposits, and bills. They only hold tangible capital K. The net investment of firms is wholly financed by loans, taken from commercial banks. The firms of each country produce one type of final good. The goods are imperfect substitutes for foreign goods, and their production requires the use of imported intermediate inputs.

The private banking system is highly simplified in my model. The private banks have zero net wealth. Because I suppose that the private banks do not make profits, the interest rate on deposits is equal to the interest rate on loans. In each country, private banks only hold loans as assets. Private banks supply loans on demand to firms. There are no loans made to households. The liabilities of private banks in the U.S. and Euroland are only made up of deposits from households. I suppose however that China is an overdraft economy. Besides the deposits from households, commercial banks in China can also borrow from the central bank of China.

Each government issues bills denominated in its own currency. B_i describes the bills issued by the government of country i *(i=1,2,3). 1, 2, and 3* denote the U.S., Euroland, and

---

[1] "Tangible capital is not simultaneously an asset and a liability." (Godley and Lavoie, 2007b, p. 218). Since $\sum k + \sum(-V) = 0$, the last column also sums to zero.

China respectively. B_1 , B_2 *and* B_3 are denominated in Dollar ($), Euro (€) and RMB, respectively. I assume (perfect) capital mobility. $Bh_{i,j}$ denotes the bills issued by the government of country *j*, but held by the households of country *i*. $Bcb_{i,j}$ denotes the bills issued by the government of country *j*, but held by the central bank of country *i*.

Each central bank issues cash money, and holds bills which consist of bills issued by the domestic government and/or bills issued by foreign governments. Foreign bills constitute the foreign reserves of the central bank. The central bank of China also supplies advances to Chinese commercial banks on demand. In each country, high powered money is only held by domestic households, that is, the households of one country do not hold the high powered money of other countries. High powered money is supplied on demand.

< Table 1-2 >

Table 1-2 shows the flow matrix that describes all the transactions that take place among the three countries in any given period of time t. All rows and columns sum to zero in the matrix. It reflects the crucial feature of the stock-flow consistent approach that "everything comes from somewhere, and everything goes somewhere" (Lavoie and Godley, 2001-02, p. 278). All sources of funds appear with a plus sign, and all uses of funds with a minus sign. The top section of the table describes the variables corresponding to the components of the national income and product accounts. The middle section describes flows of interest payments. The bottom section describes the changes in stocks of financial assets and liabilities corresponding to the flow of funds account.

1.3 The Model

1.3.1 National income identity

(1) $$Y_{i,t} \equiv C_{i,t} + G_{i,t} + I_{i,t} + X_{i,t} - IM_{i,t}$$

Where Y denotes nominal gross domestic products *(GDP)*, C denotes nominal consumption, G is nominal government spending, I is investment, X is nominal export, and IM is nominal import. The subscript "i" on a variable stands for the country, with $i=1, 2, 3,$ representing the U.S., Euroland, and China respectively. The subscript "t" stands for a time index.

1.3.2 Trade

Export:

The exports of country i are the sum of exports to the other two countries. The exports of one country are the imports of the other country.

$$(2)\quad X_{i,t} = \sum_{j(j\neq i)} X_{i,j,t} \qquad i, j=1,2,3$$

$$(3)\quad X_{1,2,t} = IM_{2,1,t} / E_{1,t}$$

$$(4)\quad X_{1,3,t} = IM_{3,1,t} / E_{2,t}$$

$$(5)\quad X_{2,1,t} = IM_{1,2,t} \cdot E_{1,t}$$

$$(6)\quad X_{2,3,t} = IM_{3,2,t} / E_{3,t}$$

$$(7)\quad X_{3,1,t} = IM_{1,3,t} \cdot E_{2,t}$$

$$(8)\quad X_{3,2,t} = IM_{2,3,t} \cdot E_{3,t}$$

Where $X_{i,j}$ stands for the exports of country i to country j. E_1 (the nominal exchange rate between the Dollar and the Euro) denotes the price of the Dollar ($) in terms of the Euro (€). E_2 (the nominal exchange rate between the Dollar and the RMB) denotes the price of the Dollar ($) in terms of the RMB. E_3 (the nominal exchange rate between the Euro and the RMB) denotes the price of Euro in terms of the RMB.

Import:

The imports of country i are the sum of the imports from the other two countries. Imports (*IM*) depend on sales (*S*) and the real exchange rate.

$$(9)\quad IM_{i,t} = \sum_{j(j\neq i)} IM_{i,j,t} \qquad i, j = 1, 2, 3$$

$$(10)\quad IM_{1,2,t} = \mu_{10} + \mu_{11} \cdot S_{1,t} + \mu_{12} \cdot e_{1,t}$$

$$(11)\quad IM_{1,3,t} = \mu_{13} + \mu_{14} \cdot S_{1,t} + \mu_{15,t} \cdot e_{2,t}$$

$$(12)\quad IM_{2,1,t} = \mu_{20} + \mu_{21} \cdot S_{2,t} - \mu_{22} \cdot e_{1,t}$$

$$(13)\quad IM_{2,3,t} = \mu_{23} + \mu_{24} \cdot S_{2,t} + \mu_{25} \cdot e_{3,t}$$

$$(14)\quad IM_{3,1,t} = \mu_{30} + \mu_{31} \cdot S_{3,t} - \mu_{32} \cdot e_{2,t}$$

$$(15)\quad IM_{3,2,t} = \mu_{33} + \mu_{34} \cdot S_{3,t} - \mu_{35} \cdot e_{3,t}$$

Where $IM_{i,j}$ stands for the imports of the country i from country j. e_1 denotes the real exchange rate between the Dollar and the Euro, e_2 denotes the real exchange rate between the Dollar and the RMB, e_3 denotes the real exchange rate between the Euro and the RMB, and $0<\mu<1$, $0<(\mu_{11}+\mu_{14})<1$, $0 < (\mu_{21}+\mu_{24}) < 1$, $0 < (\mu_{31}+\mu_{34}) < 1$.

Suppose that the domestic and foreign price levels are fixed. There is no inflation. If we assume that $P_{1,t}=P_{2,t}=P_{3,t}=1$ (where P_i denotes the price level of economy i), then the nominal exchange rate is equal to the real exchange rate, and the real exchange rate can be replaced by the nominal exchange rate.

$$(16)\quad e_{1,t} = E_{1,t}$$

$$(17)\quad e_{2,t} = E_{2,t}$$

$$(18)\quad e_{3,t} = E_{3,t}$$

1.3.3 Households

The realized nominal incomes of households consist of wages, interest payments from domestic bills, interest payments from foreign bills, deposit interest payments and capital gains due to changes in the exchange rates.

$$
\begin{aligned}
(19)\quad YP_{1,t} &= W_{1,t} + r_{b,1,t-1} \cdot Bh^{d}_{1,1,t-1} + r_{b,2,t-1} \cdot Bh^{d}_{1,2,t-1} + r_{b,3,t-1} \cdot Bh^{d}_{1,3,t-1} \\
&\quad + r_{m,1,t-1} \cdot M_{1,t-1} + Bh^{d}_{1,2,t-1} \cdot \Delta(1/e_{1,t}) + Bh^{d}_{1,3,t-1} \cdot \Delta(1/e_{3,t}) \\
(20)\quad YP_{2,t} &= W_{2,t} + r_{b,1,t-1} \cdot Bh^{d}_{2,1,t-1} + r_{b,2,t-1} \cdot Bh^{d}_{2,2,t-1} + r_{b,3,t-1} \cdot Bh^{d}_{2,3,t-1} \\
&\quad + r_{m,2,t-1} \cdot M_{2,t-1} + Bh^{d}_{2,1,t-1} \cdot \Delta(e_{1,t}) + Bh^{d}_{2,3,t-1} \cdot \Delta(1/e_{3,t}) \\
(21)\quad YP_{3,t} &= W_{3,t} + r_{b,1,t-1} \cdot Bh^{d}_{3,1,t-1} + r_{b,2,t-1} \cdot Bh^{d}_{3,2,t-1} + r_{b,3,t-1} \cdot Bh^{d}_{3,3,t-1} \\
&\quad + r_{m,3,t-1} \cdot M_{3,t-1} + Bh^{d}_{3,1,t-1} \cdot \Delta(e_{2,t}) + Bh^{d}_{3,2,t-1} \cdot \Delta(e_{3,t})
\end{aligned}
$$

Where r_b denotes the interest rate of bills, r_m denotes the interest rate of deposits, W denotes the wage incomes of the households, M denotes deposits, YP denotes households' realized nominal income, and $Bh^{d}_{i,j}$ denotes bills demanded by country i households, but issued by the country j government. The superscript "s" on a variable stands for supply, and the superscript "d" stands for demand.

Equation (22) implies that banks accept to take in all deposits demanded by households. Equations (23)-(29) mean that the government supplies bills to the households on demand.

$$
\begin{aligned}
(22)\quad & M^{s}_{i,t} = M^{d}_{i,t} = M_{i,t} \\
(23)\quad & Bh^{s}_{i,i,t} = Bh^{d}_{i,i,t} \qquad i=1,2,3 \\
(24)\quad & Bh^{s}_{1,2,t} = Bh^{d}_{1,2,t} \cdot e_{1} \\
(25)\quad & Bh^{s}_{1,3,t} = Bh^{d}_{1,3,t} \cdot e_{2} \\
(26)\quad & Bh^{s}_{2,1,t} = Bh^{d}_{2,1,t} / e_{1} \\
(27)\quad & Bh^{s}_{2,3,t} = Bh^{d}_{2,3,t} \cdot e_{3} \\
(28)\quad & Bh^{s}_{3,1,t} = Bh^{d}_{3,1,t} / e_{2} \\
(29)\quad & Bh^{s}_{3,2,t} = Bh^{d}_{3,2,t} / e_{3}
\end{aligned}
$$

Where $Bh^{s}_{i,j}$ denotes bills supplied to the country i households, but issued by the country j government.

The disposal income of the households is equal to the realized nominal income minus taxes. The net wealth of the households, V, is described in equation (32). The consumption of the households depends on their disposal income and net wealth of the previous period.

$$(30) \quad YD_{i,t} = YP_{i,t} - T_{i,t}$$
$$(31) \quad T_{i,t} = \vartheta_i \cdot YP_{i,t}$$
$$(32) \quad V_{i,t} = V_{i,t-1} + YD_{i,t} - C_{i,t}$$
$$(33) \quad C_{i,t} = \alpha_{i,1} YD_{i,t} + \alpha_{i,2} V_{i,t-1}$$

Where ϑ_i denotes the tax rate, and $0 < \theta < 1$. $0<\alpha_{i,1}, \alpha_{i,2}<1$

The consumption functions can be rewritten as wealth adjustment functions

$$(33') \quad \Delta V_{i,t} = \alpha_{i,2}(\alpha_{i,3} YD_{i,t} - V_{i,t-1})$$

Where $\alpha_{i,3} = (1-\alpha_{i,1})/\alpha_{i,2}$, and $\alpha_{i,3}$ is a target wealth to income ratio.

According to the Brainard-Tobin (1968) pitfalls approach and the Post-Keynesian version developed by Godley (1999), in each country, households allocate their wealth among domestic high powered money, domestic deposits, and government bills issued by the domestic government and/or bills issued by the foreign governments.

The portfolio equations for the U.S. households are:

$$(34) \quad Hh^d_{1,t}/V_{1,t} = \lambda_{1,00} + \lambda_{1,01} \cdot r_{b,1,t} + \lambda_{1,02} \cdot r_{b,2,t} + \lambda_{1,03} \cdot r_{b,3,t} + \lambda_{1,04} \cdot r_{m,1,t}$$
$$(34') \quad Hh^d{}_{1,t} = V_{1,t} - Bh_{1,1,t} - Bh^d{}_{1,2,t} - Bh^d{}_{1,3,t} - M^s{}_{1,t}$$
$$(35) \quad Bh^d_{1,1,t}/V_{1,t} = \lambda_{1,10} + \lambda_{1,11} \cdot r_{b,1,t} + \lambda_{1,12} \cdot r_{b,2,t} + \lambda_{1,13} \cdot r_{b,3,t} + \lambda_{1,14} \cdot r_{m,1,t}$$
$$(28) \quad Bh^d_{1,2,t}/V_{1,t} = \lambda_{1,20} + \lambda_{1,21} \cdot r_{b,1,t} + \lambda_{1,22} \cdot r_{b,2,t} + \lambda_{1,23} \cdot r_{b,3,t} + \lambda_{1,24} \cdot r_{m,1,t}$$
$$(36) \quad Bh^d_{1,3,t}/V_{1,t} = \lambda_{1,30} + \lambda_{1,31} \cdot r_{b,1,t} + \lambda_{1,32} \cdot r_{b,2,t} + \lambda_{1,33} \cdot r_{b,3,t} + \lambda_{1,34} \cdot r_{m,1,t}$$
$$(37) \quad M^d_{1,t}/V_{1,t} = \lambda_{1,40} + \lambda_{1,41} \cdot r_{b,1,t} + \lambda_{1,42} \cdot r_{b,2,t} + \lambda_{1,43} \cdot r_{b,3,t} + \lambda_{1,44} \cdot r_{m,1,t}$$

Where Hh is the high powered money issued by the central bank, and $L^s_{i,t}$ denotes the supply of loans.

The equation (34)-(37) can be expressed in a form of matrix.

$$\begin{bmatrix} Hh_{1,t}^{d} \\ Bh_{1,1,t}^{d} \\ Bh_{1,2,t}^{d} \\ Bh_{1,3,t}^{d} \\ M_{1,t}^{d} \end{bmatrix} = \begin{bmatrix} \lambda_{1,00} \\ \lambda_{1,10} \\ \lambda_{1,20} \\ \lambda_{1,30} \\ \lambda_{1,40} \end{bmatrix} \cdot V_{1,t} + \begin{bmatrix} \lambda_{1,01} & \lambda_{1,02} & \lambda_{1,03} & \lambda_{1,04} \\ \lambda_{1,11} & \lambda_{1,12} & \lambda_{1,13} & \lambda_{1,14} \\ \lambda_{1,21} & \lambda_{1,22} & \lambda_{1,23} & \lambda_{1,24} \\ \lambda_{1,31} & \lambda_{1,32} & \lambda_{1,33} & \lambda_{1,34} \\ \lambda_{1,41} & \lambda_{1,42} & \lambda_{1,43} & \lambda_{1,44} \end{bmatrix} \cdot \begin{bmatrix} r_{b,1,t} \\ r_{b,2,t} \\ r_{b,3,t} \\ r_{m,1,t} \end{bmatrix} \cdot V_{1,t}$$

Where $0 < |\lambda_{1,ij}| < 1$, $i,j=0,1,2,3,4$

The vertical adding-up constraint[2] must hold.

$$\lambda_{1,00} + \lambda_{1,10} + \lambda_{1,20} + \lambda_{1,30} + \lambda_{1,40} = 1$$

$$\lambda_{1,01} + \lambda_{1,11} + \lambda_{1,21} + \lambda_{1,31} + \lambda_{1,41} = 0$$

$$\lambda_{1,02} + \lambda_{1,12} + \lambda_{1,22} + \lambda_{1,32} + \lambda_{1,42} = 0$$

$$\lambda_{1,03} + \lambda_{1,13} + \lambda_{1,23} + \lambda_{1,33} + \lambda_{1,43} = 0$$

$$\lambda_{1,04} + \lambda_{1,14} + \lambda_{1,24} + \lambda_{1,34} + \lambda_{1,44} = 0$$

Suppose that the horizontal adding-up constraint also holds. The horizontal constraint was emphasized by Godley (1996). The horizontal constraint is that in each portfolio equation, the sum of all the coefficients on rates of return should be zero.

$$\lambda_{1,11} = -(\lambda_{1,12} + \lambda_{1,13} + \lambda_{1,14})$$

$$\lambda_{1,22} = -(\lambda_{1,21} + \lambda_{1,23} + \lambda_{1,24})$$

$$\lambda_{1,33} = -(\lambda_{1,31} + \lambda_{1,32} + \lambda_{1,34})$$

$$\lambda_{1,44} = -(\lambda_{1,41} + \lambda_{1,42} + \lambda_{1,43})$$

The portfolio equations for the households of Euroland are:

[2] The vertical adding-up constraint was emphasized by Tobin (1969)

$$
\begin{aligned}
&(38) \quad Hh^{d}{}_{2,t}/V_{2,t} = \lambda_{2,00} + \lambda_{2,01}\cdot r_{b,1,t} + \lambda_{2,02}\cdot r_{b,2,t} + \lambda_{2,03}\cdot r_{b,3,t} + \lambda_{2,04}\cdot r_{m,2,t} \\
&(38') \quad Hh^{d}{}_{2,t} = V_{2,t} - Bh^{d}{}_{2,1,t} - Bh^{d}{}_{2,2,t} - Bh^{d}{}_{2,3,t} - M^{s}{}_{2,t} \\
&(39) \quad Bh^{d}{}_{2,1,t}/V_{2,t} = \lambda_{2,10} + \lambda_{2,11}\cdot r_{b,1,t} + \lambda_{2,12}\cdot r_{b,2,t} + \lambda_{2,13}\cdot r_{b,3,t} + \lambda_{2,14}\cdot r_{m,2,t} \\
&(40) \quad Bh^{d}{}_{2,2,t}/V_{2,t} = \lambda_{2,20} + \lambda_{2,21}\cdot r_{b,1,t} + \lambda_{2,22}\cdot r_{b,2,t} + \lambda_{2,23}\cdot r_{b,3,t} + \lambda_{2,24}\cdot r_{m,2,t} \\
&(41) \quad Bh^{d}{}_{2,3,t}/V_{2,t} = \lambda_{2,30} + \lambda_{2,31}\cdot r_{b,1,t} + \lambda_{2,32}\cdot r_{b,2,t} + \lambda_{2,33}\cdot r_{b,3,t} + \lambda_{2,34}\cdot r_{m,2,t} \\
&(42) \quad M^{d}{}_{2,t}/V_{2,t} = \lambda_{2,40} + \lambda_{2,41}\cdot r_{b,1,t} + \lambda_{2,42}\cdot r_{b,2,t} + \lambda_{2,43}\cdot r_{b,3,t} + \lambda_{2,44}\cdot r_{m,2,t}
\end{aligned}
$$

Equations (38)-(42) can be expressed in a form of matrix.

$$
\begin{bmatrix} Hh^{d}{}_{2,t} \\ Bh^{d}{}_{2,1,t} \\ Bh^{d}{}_{2,2,t} \\ Bh^{d}{}_{2,3,t} \\ M^{d}{}_{2,t} \end{bmatrix} = \begin{bmatrix} \lambda_{2,00} \\ \lambda_{2,10} \\ \lambda_{2,20} \\ \lambda_{2,30} \\ \lambda_{2,40} \end{bmatrix} \cdot V_{2,t} + \begin{bmatrix} \lambda_{2,01} & \lambda_{2,02} & \lambda_{2,03} & \lambda_{2,04} \\ \lambda_{2,11} & \lambda_{2,12} & \lambda_{2,13} & \lambda_{2,14} \\ \lambda_{2,21} & \lambda_{2,22} & \lambda_{2,23} & \lambda_{2,24} \\ \lambda_{2,31} & \lambda_{2,32} & \lambda_{2,33} & \lambda_{2,34} \\ \lambda_{2,41} & \lambda_{2,42} & \lambda_{2,43} & \lambda_{2,44} \end{bmatrix} \cdot \begin{bmatrix} r_{b,1,t} \\ r_{b,2,t} \\ r_{b,3,t} \\ r_{m,2,t} \end{bmatrix} \cdot V_{2,t}
$$

The vertical adding-up constraint:

$$\lambda_{2,00} + \lambda_{2,10} + \lambda_{2,20} + \lambda_{2,30} + \lambda_{2,40} = 1$$

$$\lambda_{2,01} + \lambda_{2,11} + \lambda_{2,21} + \lambda_{2,31} + \lambda_{2,41} = 0$$

$$\lambda_{2,02} + \lambda_{2,12} + \lambda_{2,22} + \lambda_{2,32} + \lambda_{2,42} = 0$$

$$\lambda_{2,03} + \lambda_{2,13} + \lambda_{2,23} + \lambda_{2,33} + \lambda_{2,43} = 0$$

$$\lambda_{2,04} + \lambda_{2,14} + \lambda_{2,24} + \lambda_{2,34} + \lambda_{2,44} = 0$$

The horizontal adding-up constraint:

$$\lambda_{2,11} = -(\lambda_{2,12} + \lambda_{2,13} + \lambda_{2,14})$$

$$\lambda_{2,22} = -(\lambda_{2,21} + \lambda_{2,23} + \lambda_{2,24})$$

$$\lambda_{2,33} = -(\lambda_{2,31} + \lambda_{2,32} + \lambda_{2,34})$$

$$\lambda_{2,44} = -(\lambda_{2,41} + \lambda_{2,42} + \lambda_{2,43})$$

Where $0 < |\lambda_{2,ij}| < 1$, $i,j = 0,1,2,3,4$

Portfolio equations for China's households are:

$$
\begin{array}{ll}
(43) & Hh^{d}{}_{3,t}/V_{3,t} = \lambda_{3,00} + \lambda_{3,01}\cdot r_{b,1,t} + \lambda_{3,02}\cdot r_{b,2,t} + \lambda_{3,03}\cdot r_{b,3,t} + \lambda_{3,04}\cdot r_{m,3,t} \\
(43') & Hh^{d}{}_{3,t} = V_{3,t} - Bh^{d}{}_{3,1,t} - Bh^{d}{}_{3,2,t} - Bh^{d}{}_{3,3,t} - M^{s}{}_{3,t} \\
(44) & Bh^{d}{}_{3,1,t}/V_{3,t} = \lambda_{3,10} + \lambda_{3,11}\cdot r_{b,1,t} + \lambda_{3,12}\cdot r_{b,2,t} + \lambda_{3,13}\cdot r_{b,3,t} + \lambda_{3,14}\cdot r_{m,3,t} \\
(45) & Bh^{d}{}_{3,2,t}/V_{3,t} = \lambda_{3,20} + \lambda_{3,21}\cdot r_{b,1,t} + \lambda_{3,22}\cdot r_{b,2,t} + \lambda_{3,23}\cdot r_{b,3,t} + \lambda_{3,24}\cdot r_{m,3,t} \\
(46) & Bh^{d}{}_{3,3,t}/V_{3,t} = \lambda_{3,30} + \lambda_{3,31}\cdot r_{b,1,t} + \lambda_{3,32}\cdot r_{b,2,t} + \lambda_{3,33}\cdot r_{b,3,t} + \lambda_{3,34}\cdot r_{m,3,t} \\
(47) & M^{d}{}_{3,t}/V_{3,t} = \lambda_{3,40} + \lambda_{3,41}\cdot r_{b,1,t} + \lambda_{3,42}\cdot r_{b,2,t} + \lambda_{3,43}\cdot r_{b,3,t} + \lambda_{3,44}\cdot r_{m,3,t}
\end{array}
$$

The equation (43)-(47) can be expressed in a form of matrix.

$$
\begin{bmatrix} Hh^{d}{}_{3,t} \\ Bh^{d}{}_{3,1,t} \\ Bh^{d}{}_{3,2,t} \\ Bh^{d}{}_{3,3,t} \\ M^{d}{}_{3,t} \end{bmatrix} = \begin{bmatrix} \lambda_{3,00} \\ \lambda_{3,10} \\ \lambda_{3,20} \\ \lambda_{3,30} \\ \lambda_{3,40} \end{bmatrix} \cdot V_{3,t} + \begin{bmatrix} \lambda_{3,01} & \lambda_{3,02} & \lambda_{3,03} & \lambda_{3,04} \\ \lambda_{3,11} & \lambda_{3,12} & \lambda_{3,13} & \lambda_{3,14} \\ \lambda_{3,21} & \lambda_{3,22} & \lambda_{3,23} & \lambda_{3,24} \\ \lambda_{3,31} & \lambda_{3,32} & \lambda_{3,33} & \lambda_{3,34} \\ \lambda_{3,41} & \lambda_{3,42} & \lambda_{3,43} & \lambda_{3,44} \end{bmatrix} \cdot \begin{bmatrix} r_{b,1,t} \\ r_{b,2,t} \\ r_{b,3,t} \\ r_{m,3,t} \end{bmatrix} \cdot V_{3,t}
$$

Where $0 < |\lambda_{3,ij}| < 1$,j,k=0,1,2,3,4, and the vertical constraint and horizontal constraint must hold.

1.3.4 Firms

$$
\begin{array}{ll}
(48) & S_{i,t} = C_{i,t} + G_{i,t} + I_{i,t} + X_{i,t} \\
(48') & S_{i,t} - IM_{i,t} = Y_{i,t} \\
(49) & W_{i,t} = S_{i,t} - r_{l,i,t-1}L_{i,t-1} - DA_{i,t} - IM_{i,t} \\
(49') & W_{i,t} = Y_{i,t} - r_{l,i,t-1}L_{i,t-1} - DA_{i,t}
\end{array}
$$

Where S is sales, and DA denotes depreciation, L denotes loan demand, and r_l denotes the loan interest rate.

Equation (48) reflects the sales of firms. Because we suppose that the net profits of firms are zero, wages can be described in the form of equation (49).

$$(50)\quad K_{i,t} = (1-\delta_i)K_{i,t-1} + I_{i,t}$$
$$(51)\quad I_{i,t} = \gamma_i(K_{i,t}^{\ T} - K_{i,t-1}) + DA_{i,t}$$
$$(52)\quad K_{i,t}^{\ T} = \kappa_{i,t} \cdot S_{i,t-1}$$
$$(53)\quad \kappa_{i,t} = \zeta_{i,1} - \zeta_{i,2} \cdot r_{i,t}$$
$$(54)\quad DA_{i,t} = \delta_i K_{i,t-1}$$

Where K denotes the stock of capital, δ denotes the rate of depreciation, $0<\delta<1$, and K^T denotes the capital stock target, κ_i denotes the target ratio of capital to the sales, $0 < \gamma_i < 1$, and $0 < \zeta_{i,1}, 0 < \zeta_{i,2}$.

Equations (51)-(54) describe the firms' investment behaviour. The targeted capital stock (K^T) depends on the sales achieved in the previous period (S_{t-1}), and on the target ratio of capital to sales (κ_i). The target ratio of capital to sales (κ_i) has a negative relationship with the interest rate. Net investment, $\gamma_i(K_{i,t}^{\ T} - K_{i,t-1})$, partially adjusts capital to the discrepancy between the targeted capital stock and the previous capital stock. Gross investment (I) is the sum of net investment and depreciation. From equations (50) and (51), we have that $\Delta K_{i,t} = \gamma_i(K_{i,t}^{\ T} - K_{i,t-1})$.

Since I assumed that the net profits of the firm are zero, net investment must be financed by loans taken from private banks.

$$(55)\quad \Delta L_{i,t}^d = I_{i,t} - DA_{i,t}$$

Where $L_{i,t}^d$ is demand for loans.

1.3.5 Commercial banks

$$(56)\quad L_{i,t}^s = L_{i,t}^d \equiv L_{i,t} \qquad i=1,2,3$$
$$(57)\quad Bcmb_{i,i,t}^d = M_{i,t} - L_{i,t} \qquad i=1,2.$$
$$(58)\quad A_{3,t} \equiv L_{3,t} - M_{3,t}$$
$$(58')\quad M_{3,t} + A_{3,t} \equiv L_{3,t}$$

Where B_{cmb} represents bills held by commercial banks, and A denotes the advances taken from the central bank of China.

Equations (56) reflect the assumption that the supply of loans is equal to the demand for loans. Equation (57) reflects the balance sheet of commercial banks of the U.S. and Euroland. In the USA and Euroland, besides loans to firms, the assets of commercial banks include Treasury bills which play the role of a buffer. Equation (58) reflects the Chinese commercial banks balance sheet. In China, besides the deposits from households, the liabilities of commercial banks include advances from the central bank of China. The advances from the central bank are equal to the discrepancy between loans and deposits, and play the role of a buffer.

For simplification, I suppose that interest rates on loans, deposits, and Treasury bills are all equal. For China, I suppose that interest rates on advances are also equal to interest rates on loans.

(59) $r_{m,i,t} = r_{l,i,t} \equiv r_{i,t}$

(60) $r_{A,3,t} = r_{3,t}$

1.3.6 Government

(61) $\Delta B_{i,t} = (G_{i,t} + r_{b,i,t-1} B_{i,t-1}) - (T_{i,t} + F_{i,t})$

(61a) $B_{i,t} = B_{i,t-1} + (G_{i,t} + r_{b,i,t-1} B_{i,t-1}) - (T_{i,t} + F_{i,t})$

(62) $G_{i,t} = \overline{G_i}$

(63) $r_{b,i,t} = r_{i,t}$

Where F denotes the profits of the central bank.

Equation (61) is the government budget constraint. The bills newly issued by the government are equal to the government expenditures minus the government revenues which consist of taxes and central bank profits transferred to the government. Equation (62) indicates that (pure) government spending is an exogenous variable. I will relax this assumption in an alternative closure, and set Chinese government spending as an endogenous variable. Equation (63) reflects the assumption that the interest rate on bills is equal to the interest rate on deposits and loans.

1.3.7 Central Bank

$$(64)\quad Hh^{s}_{i,t} = Hh^{d}_{i,t}$$
$$(65)\quad \Delta Bcb^{d}_{1,1,t} = \Delta Hh^{s}_{1,t} - \Delta Bcb^{d}_{1,2,t}$$
$$(66)\quad \Delta Bcb^{d}_{2,2,t} = \Delta Hh^{s}_{2,t} - \Delta Bcb^{d}_{2,1,t}$$
$$(65a)\quad \Delta Bcb^{d}_{1,1,t} = \Delta Hh^{s}_{1,t}$$
$$(66a)\quad \Delta Bcb^{d}_{2,2,t} = \Delta Hh^{s}_{2,t}$$
$$(67)\quad \Delta Bcb^{d}_{3,1,t} = \Delta Hh^{s}_{3,t} - \Delta Bcb^{d}_{3,3,t} - \Delta Bcb^{s}_{3,2,t} \cdot e_{3,t} - \Delta A^{s}_{3,t} - Bcb^{s}_{3,1,t-1} \cdot \Delta e_{2,t}$$
$$(67a)\quad \Delta Bcb^{d}_{3,1,t} = \Delta Hh^{s}_{3,t} - \Delta Bcb^{d}_{3,3,t} - \Delta A^{s}_{3,t} - Bcb^{s}_{3,1,t-1} \cdot \Delta e_{2,t}$$

The central bank provides cash money to the households. Cash money is endogenous and demand-led. Equation (64) means that the high powered money balance supplied by the Central Bank are equal to that demanded by households. Equations (65)-(66) reflect the balance sheet of the central bank of the U.S. and Euroland. Suppose that the Fed (Federal Reserve Board of the U.S.) and the ECB (European Central Bank) do not hold bills issued by the Chinese government.

Since the exchange rate between the Dollar and the Euro is freely floating, $Bcb^{d}_{1,2,t}$, and $Bcb^{d}_{2,1,t}$ can be set as constants. "The central bank lets market forces determine the exchange rate, without ever intervening. Indeed, because these foreign reserves play no fundamental role in the dynamics of a model with flexible exchange rate, we shall assume that they are equal to nil in the numerical simulations" (Godley and Lavoie, 2007a, p. 10). Equations (65)-(66) can be rewritten as (65a)-(66a).

The central bank of China holds bills issued by the Chinese government and bills issued by the U.S. government. Since the exchange rate between the Euro and the RMB is freely floating, $Bcb^{d}_{3,2,t}$ can also be set as a constant. Therefore, equation (67) can be rewritten as equation (67a).

Equations (68)-(71) reflect the assumptions that the supply of bills to central banks is equal to their demand.[3] Equations (72)-(74) describe the identity components of the bills issued by each government.

$$(68)\quad Bcb^{s}_{1,1,t} = Bcb^{d}_{1,1,t}$$
$$(69)\quad Bcb^{s}_{2,2,t} = Bcb^{d}_{2,2,t}$$
$$(70)\quad Bcb^{d}_{3,3,t} = Bcb^{s}_{3,3,t}$$
$$(71)\quad Bcb^{d}_{3,1,t} = Bcb^{s}_{3,1,t} \cdot e_2$$
$$(72)\quad B^{s}_{1,t} \equiv Bh^{s}_{1,1,t} + Bcmb^{s}_{1,1,t} + Bcb^{s}_{1,1,t} + Bh^{s}_{2,1,t} + Bh^{s}_{3,1,t} + Bcb^{s}_{3,1,t}$$
$$(72a)\quad Bcb^{s}_{3,1,t} = B^{s}_{1,t} - Bh^{s}_{1,1,t} - Bcmb^{s}_{1,1,t} - Bcb^{s}_{1,1,t} - Bh^{s}_{2,1,t} - Bh^{s}_{3,1,t}$$
$$(73)\quad B^{s}_{2,t} \equiv Bh^{s}_{1,2,t} + Bcmb^{s}_{2,2,t} + Bh^{s}_{2,2,t} + Bcb^{s}_{2,2,t} + Bh^{s}_{3,2,t}$$
$$(74)\quad B^{s}_{3,t} \equiv Bh^{s}_{1,3,t} + Bh^{s}_{2,3,t} + Bh^{s}_{3,3,t} + Bcb^{s}_{3,3,t}$$
$$(74a)\quad Bcb^{s}_{3,3,t} = B^{s}_{3,t} - Bh^{s}_{3,3,t} - Bh^{s}_{1,3,t} - Bh^{s}_{2,3,t}$$

Equation (73) will be used to determine the exchange rate between the Dollar and the Euro in section 1.3.8.

The profits of a central bank consist of interest payments from domestic bills, and/or interest payments from foreign bills. The profits of the central bank of China also include interest payments on advances.

$$(75)\quad F_{1,t} = r_{1,t-1} \cdot Bcb_{1,1,t-1}$$
$$(76)\quad F_{2,t} = r_{2,t-1} \cdot Bcb_{2,2,t-1}$$
$$(77)\quad F_{3,t} = r_{1,t-1} \cdot Bcb^{d}_{3,1,t-1} + r_{3,t-1} \cdot (Bcb_{3,3,t-1} + A_{3,t-1})$$

Where F_i is the central bank's profit of country i, $i=1,2,3$.

Equations (78)-(80) affirm that interest rates are exogenous. According to Post-Keynesian monetary theory, and as can be observed in the real world today, central banks use interest rates as their monetary policy instrument.

[3] Since we have two equations (equation 67a, and equation 71) to determine $Bcb^{d}_{3,1,t}$, equation (67a) will be the hidden, or redundant, equation in the model. This equation is then used to verify that the accounting of the model is correct, and that the data (the stocks) are consistent.

$$(78) \quad r_{1,t} = \overline{r_1}$$

$$(79) \quad r_{2,t} = \overline{r_2}$$

$$(80) \quad r_{3,t} = \overline{r_3}$$

1.3.8 Exchange rate dynamics

Since we assume that the Chinese currency (RMB) is pegged to the Dollar, the nominal exchange rate between the Dollar and the RMB is fixed.

$$(81) \quad e_{2,t} = \overline{e_2}$$

For the determination of the flexible exchange rate between the Dollar and Euro, I follow the approach proposed by Godley and Lavoie (2004a, and 2007a).

Substituting equation (24) into the equation (73), I have (73a):

$$(73a) \quad B^{s}{}_{2,t} \equiv Bh^{d}{}_{1,2,t} \cdot e_1 + Bh^{s}{}_{2,2,t} + Bcmb^{s}_{2,2,t} + Bcb^{s}{}_{2,2,t} + Bh^{s}{}_{3,2,t}$$

We can rewrite equation (73a) under the form:

$$(73b) \quad e_1 = (B^{s}{}_{2,t} - Bh^{s}{}_{2,2,t} - Bcmb^{s}_{2,2,t} - Bcb^{s}{}_{2,2,t} - Bh^{s}_{3,2,t}) / Bh^{d}{}_{1,2,t}$$

Equation (73b) describes the determination of the exchange rate between the Dollar and the Euro.

The exchange rate between the RMB and the Euro can be expressed as follows.

$$(82) \quad e_{3,t} = e_{2,t} / e_{1,t}$$

According to equation (82), if the U.S. Dollar depreciates compared to the Euro, the value of the RMB will also fall relative to the Euro because the RMB is pegged to the U.S. Dollar.

1.3.9 Current account balance and capital account balance

The balance of payment identities are given by the following two boxes:

$$CAB_{1,t} \equiv X_{1,t} - IM_{1,t} + r_{2,t-1} \cdot Bh^{d}{}_{1,2,t-1} + r_{3,t-1} Bh^{d}{}_{1,3,t-1} - r_{1,t-1}(B_{1,t-1} - Bh_{1,1,t-1} - Bcb_{1,1,t-1}) \tag{83}$$

$$CAB_{2,t} \equiv X_{2,t} - IM_{2,t} + r_{1,t-1} \cdot Bh^{d}{}_{2,1,t-1} + r_{3,t-1} Bh^{d}{}_{2,3,t-1} - r_{2,t-1}(B_{2,t-1} - Bh_{2,2,t-1} - Bcb_{2,2,t-1}) \tag{84}$$

$$CAB_{3,t} \equiv X_{3,t} - IM_{3,t} + r_{1,t-1} Bcb^{d}{}_{3,1,t-1} + r_{1,t-1} Bh^{d}_{3,1,t-1} + r_{2,t-1} Bh^{d}_{3,2,t-1} - r_{3,t-1}(B_{3,t-1} - Bh_{3,3,t-1} - Bcb_{3,3,t-1}) \tag{85}$$

Where *CAB* denotes the current account balance.

In the model introduced above, I have both flexible exchange rates and a fixed exchange rate. The exogenous variables include *government spending (G_i), interest rates (r_i), and E_2 (the exchange rate between the Chinese RMB and the Dollar).*[4] The endogenous variables are *GDP,* consumption, investment, capital, wages, imports, exports, government debts, current account balances, loans, deposits, advances, wealth and its allocations among the available assets, the exchange rate between the Dollar and the Euro, and the exchange rate between the RMB and the Euro. In the alternative closure, I will make Chinese *government spending (G_3)* endogenous.

1.4 Experiments

This section presents some simulation results for the model introduced above, and discusses the dynamic responses to the internal and external shocks, as well as the impact of a change in the U.S. fiscal policy.[5] The discussion of the simulation results focuses on the dynamic adjustment of the main endogenous variables.[6] The simulations below explore three

---

[4] Expectations about future exchange rates are set aside.

[5] I make simulations by using the software E-views 5.1.

[6] The main variables include: GDP (Y), investment (I), consumption (C), the trade account balance, the current account balance, the government budget deficit, the exchange rate between the Dollar and the Euro, exchange rate between the RMB and the Euro, the values of the change in the high powered money, and the change in the foreign reserves of China.

alternative types of changes and shocks: an increase in the propensity of China to import goods from the U.S., an increase in the government spending of the U.S., and an increase in the Chinese households' propensity to consume. In each simulation experiment, I start from a full stationary state where all the endogenous variables are at constant levels. In the initial stationary state, the government budget in each country is balanced, and the trade balance and current account balance of each country are in equilibrium.

1.4.1 An increase in the propensity of China to import goods from the U.S.

First, I examine what happens when China increases its propensity to import goods from the U.S. The increase in the imports of China results in a decrease in Chinese net exports, and hence in a trade deficit. This slows down the economy of China. As shown in Figure 1.1, China's GDP decreases dramatically. The decrease in the GDP of China leads to a decrease in Chinese firms' target capital stocks (K^T) with a one-period lag, and then a decrease in their investment. Following the decrease in the firms' sales, Chinese households' personal incomes and consumption decrease. In the long run, China GDP reaches a new lower constant level, and so do consumption and investment.

Through the feedback effects, the U.S. faces a trade surplus. The U.S. GDP increases dramatically and reaches a new higher constant level, and so do its consumption and investment. Euroland, in the short run, gets a trade surplus, leading to a slight increase in its GDP. But several periods later, its trade account returns to a balanced position due to the appreciation of the Euro. The Euroland GDP also returns to its initial level. The three economies reach a quasi steady state, which was first assessed by Godley and Cripps (1983, Ch. 14). In the quasi steady state, the households' assets in each country are at new constant levels, and so are the GDP, consumption and investment of each country. However, some of the main endogenous variables and ratios in each country, such as the government budget deficit (surplus), the current account balance, and the government debt ratio, are still changing.[7]

---

[7] There are over one hundred variables in our model. For space consideration, we focus on what we consider to be the main variables. In the appendix of this paper, we only present Figures for these main variables.

< Figures 1-1 – 1-8 >

Figure 1-5 shows the dynamic adjustment path for the exchange rate between the Dollar and Euro. As U.S. GDP increases, the U.S. households' disposal income and wealth increase. This leads to an increase in the U.S. households' demand for bills issued by the Euroland government, resulting in an appreciation of the euro against the dollar. As shown in Figure 1-5, the value of the dollar in terms of the Euro falls, and reaches a lower constant level in the quasi steady state. Since the RMB is pegged to the Dollar, the RMB will depreciate, relative to the Euro.

Figures 1-6 and 1-7 show the dynamic adjustment paths for the current account balance and government budget balance of the three countries. The Chinese government deficit increases along with its current account deficit, and in the long run, the government deficit is equal to the current account deficit. Thus, the increase in the import propensity leads to a "twin deficit" in China. But the U.S. faces "twin surpluses", in the government and current accounts. In contrast to the main closure of Godley and Lavoie's (2007a) three-country model, the "twin deficits" or "twin surpluses" property of quasi steady states holds in our model, and "twin deficits" and "twin surpluses" increase without limit. This result is similar to that achieved by Godley and Lavoie (2004) in their two-country model with fixed exchange rate closure. But the current account and government budget account of Euroland are at balanced positions in the long run.

Figure 1-8 shows the changes in assets and liabilities of China's central bank. While its foreign reserves decrease, the central bank of China increases its holdings of domestic bills. The change in the monetary base (high-powered money) only occurs in the short run, and the advances lent to the commercial banks follow a similar evolution. We find that in the quasi steady state, the increase in the holdings of domestic bills is exactly equal to the decrease in foreign reserves. In the long run, there is no change in the monetary base and the claims on domestic commercial banks. Hence, in the quasi steady state, there will be no change in the overall size of the assets of the central bank of China. The monetary base in the quasi steady state is at a constant level, and the central bank of China will not lose its control over the money supply. This result strongly supports the compensation principle (Lavoie 2001).[8] My result is similar to that achieved by Godley and Lavoie (2004) in their two-country model.

Let us now analyze the change in high-powered money from the households' side. In my model, interest rates are exogenous variables, but high-powered money is an endogenous variable. When China increases its imports from the U.S., the demand for high-powered money decreases in the initial period, and then increases. In the quasi steady state, the demanded high-powered money reaches a constant level. The dynamic adjustment of the high-powered money is led by the households' demand. The central bank supplies high-powered money to households on demand. Thus, in the quasi steady state, the monetary base of the central bank is at constant level. This result is similar to that obtained under a compensation approach. Since the change in the monetary base is zero in the long run, the central bank of China can keep the interest rate at a constant level. This result strongly supports the post-Keynesian view that "credit and money are demand-led endogenous variables, and that central banks have the ability to set interest rates at their choice" (Lavoie 2001, p. 237).

1.4.2 An increase in the government spending of the U.S.

In the first experiment, I achieved the result that the trade deficit (surplus) can cause a budget deficit (surplus) and a current account deficit (surplus). Next, I examine the impact of the government budget deficit. Starting from a full stationary state with a balanced budget, a balanced current account and balanced trade, I assume that the U.S. government increases its spending.

< Figures 1-9 – 1-16 >

As shown in Figure 1-9, the increase in U.S. government spending results in an increase in the U.S. GDP, leading to an increase in consumption and an increase in

[8] The compensation principle says that "the changes in foreign reserves will generally be compensated by endogenous mechanisms that are tied to the normal behavior of the central bank and to that of the other economic agents in the economy" (Godley and Lavoie, 2007a, p. 198).

investment. As GDP increases, the U.S. households' income and wealth increase. The increase in U.S. output raises U.S. imports, resulting in a trade deficit. Thus, the budget deficit leads to a deterioration of the trade balance – a trade deficit.

Through the feedback effects, China has a trade surplus, which increases its output. In the short run, Euroland has a small trade surplus, but in the long run, this surplus disappears. Figures 1-15 and 1-16 show that in the long run, the U.S. faces "twin deficits", and China faces "twin surpluses". But the Euroland current account and government budget are in balanced positions.

In the Mundell-Fleming model, an expansionary U.S. fiscal policy typically gives rise to higher interest rates in the U.S., which will induce a capital inflow and a rise in the Dollar value.[9] In contrast to the Mundell-Fleming model, in our model, rising budget deficits in the U.S. result in a rising stock of U.S. government debt outstanding. The supply of the U.S. government bills increases. Because the interest rates are exogenous in our model, the only variable free to adjust is the exchange rate between the Dollar and the Euro. The additional supply of U.S. bills is absorbed by the additional demand for U.S. bills expressed in U.S. Dollars. But since the demand for U.S. bills expressed in Euros does not change, this can only occur through a fall in the value of the Dollar expressed in Euros. Thus, in our model, the expansionary fiscal policy of the U.S. leads to a depreciation of the Dollar. Because the RMB is pegged to the Dollar, the RMB value also falls, relative to the Euro.

How can the interest rate remain unchanged? First, in this paper, as shown in the equations (34)-(47), the households' assets are modeled by using the Brainard-Tobin (1968) pitfalls approach and the Post-Keynesian version developed by Godley (1999). This approach is based on the assumption that distinct assets are imperfect substitutes. Thus, the uncovered interest parity theorem (UIP) does not hold in my model, because UIP is based on the assumptions of: (1) Free capital mobility; (2) No transaction cost; and (3) No default risk. "In other words, the uncovered interest parity theorem could only hold (in general) in a world of perfect asset substitutability" (Lavoie 2002-03, p. 239). Second, high-powered money only changes in the short run, but in the quasi steady state, high-powered money reaches a constant level. As analyzed in the previous experiment, the dynamic adjustment of the high-powered money is led by households' demand, and the high-powered money supply is equal

[9] For a more detailed discussion about the Mundell-Fleming model, see Rosenberg (2003), chapter 8.

to demand. Thus, in quasi steady state, the monetary base of the central bank is also at a constant level. The interest rates can be kept at a constant level. Third, simulation results also shows that the results comply with the compensation principle (Lavoie 2001). Especially for China, when foreign reserves increase (decrease), the central bank of China can reduce (increase) domestic bills holdings and claims on commercial banks, so that Chinese interest rates can also be kept at a constant level.

1.4.3 An increase in the propensity to consume of Chinese households

Now let us analyze the impact of an increase in the propensity to consume. I assume that Chinese households increase their propensity to consume (α_{31}). As the propensity to consume increases, the target wealth to income ratio of Chinese households (α_{33}) decreases.

< Figures 1-17 – 1-23 >

In the short run, the increase in the consumption expenditures out of disposal income results in an increase in aggregate demand, leading to a large increase in China's GDP, and an increase in investment with a one-period lag. The higher GDP leads to an increase in the imports of China, and thus a trade deficit. However, these effects are only temporary. The lower target wealth to income ratio (α_{33}) leads to a gradual reduction in the households' wealth. As shown in Figures 1-17 to 1-19, several periods later, the households' consumption expenditures begin to decrease because of the wealth effect, and so do GDP and investment. In the long run, Chinese GDP returns to a level which is lower than that in the initial steady state.

Through the feedback effects, in the short run, both the U.S. and Euroland have trade surpluses, which lead to an increase in their GDP. But in the long run, Euroland's GDP returns to a level which is lower than that of the initial full steady state. The U.S. GDP returns to a level which is slightly higher than its initial level, and so does the U.S. households' wealth.

The higher wealth level of the U.S. households results in an increase in the demand for the bills issued by the Euroland government. This leads to an appreciation of the Euro. As the RMB is pegged to the Dollar, the Euro also appreciates, relative to the RMB.

1.5 Alternative closure: making Chinese government spending endogenous

The simulation results of the previous experiments show that there exist "twin deficits" problems in the quasi steady state, and the "twin deficits" increase exponentially. Because I assume that the Chinese currency (RMB) is pegged to the U.S. dollar, while government spending and interest rates are all exogenous, there is no adjustment mechanism to bring back the economies to a balanced budget position and current account position. The economy with "twin deficits" will run out of foreign reserves at some period. In the real world, if this happened in the weak-economy China, China would experience a financial crisis. Thus, the economy with "twin deficits" will use fiscal policy instrument, monetary policy instrument, and/or exchange rate instruments to prevent a financial crisis. In this section, I propose an alternative closure to my model by making Chinese government spending endogenous, and examine what happens when the propensity to import jumps up.

In this alternative closure, I incorporate a partial adjustment mechanism into the main closure of the model by making China's government spending endogenous.[10] Suppose that China's government expenditures decrease as foreign reserves fall, and vice versa. Such an adjustment mechanism may bring back the economies to a balanced government budget position and a balanced current account position. Equation (62) is changed as follows:

(62a)	$G_{i,t} = \overline{G_{i,t}}$	Where $i=1,2$
(62b)	$G_{3,t} = G_{3,t-1} + \phi \cdot (\Delta Bcb^{d}{}_{3,1,t-1})$	Where $\varphi > 0$

[10] For details of the partially symmetric adjustment mechanism, see Godley and Lavoie (2007, chapter 6). In their two-economy model, the partially symmetric adjustment mechanism leads to a decrease (increase) in the pure government expenditures when gold reserves fall (rise). In my model, I use foreign reserves (foreign government bills) instead of gold reserves.

Let us now do an experiment. Starting with the full stationary steady state, I assume that China increases its propensity to import goods from the U.S. From the simulation results, I find that the three economies reach a super stationary state, unlike the quasi stationary state in the previous experiments. In the long run, all the endogenous variables reach constant levels.

< Figure 1-24 – 1-31 >

In the short run, the increase in the imports of China from the U.S. leads to a large trade deficit in China. This induces a decrease in the GDP of China, and a large decrease in the foreign reserves of China. However, in contrast to the main closure, the losses of foreign reserves in China will not last forever. As described in the adjustment mechanism equations (62b), China will decrease its government spending when its foreign reserves fall. The Chinese contractionary fiscal policy leads to a further decrease in the GDP of China. But this has a positive effect on the trade position of China because the decrease in GDP induces a decrease in Chinese imports, dominating the deterioration of the trade balance in the long run. The net exports of China gradually return to a positive level (Figure 1-27). Compared to the results in the experiment 1, the Chinese GDP level is much lower, because Chinese government expenditure decreases dramatically as shown in Figure 1-31.[11] As shown in Figures 1-30 and 1-31, in the long run, the adjustment mechanism brings back the Chinese economy to a balanced current account position and a balanced government budget position. Through the feedback effects, in the long run, the current account balances and government budget balances of the U.S. and Euroland return to equilibrium as well.

1.6 Further experiments

1.6.1 An increase in the propensity of the U.S. to import goods from China

[11] We can compare the simulation results in this Experiment with those in Experiment 1.

In experiment 1 (section 1.4.1), I have made a simulation by assuming that China increases its propensity to import goods from the U.S. The simulation results show that, in the quasi stationary state, China has "twin deficits", and the U.S. has "twin surpluses". Let us now simulate an opposite situation, probably more realistic, where the U.S. raises its propensity to import goods from China.

< Figures 1-32 – 1-38>

The increase in the imports of the U.S. results in a trade deficit for the U.S. This slows down the U.S. economy. Through the feedback effects, China gets a trade surplus, leading to an increase in its GDP. In the quasi stationary state, the U.S. has "twin deficits", but China has "twin surpluses". These results are opposite to those achieved in experiment 1.

However, simulation results show that the Euro value rises relative to the Dollar. Why is this result similar to that achieved in experiment 1? Recall the exchange rate equations (73b) and (82):

(73b) $e_1 = (B^s{}_{2,t} - Bh^s{}_{2,2,t} - Bcmb^s_{2,2,t} - Bcb^s{}_{2,2,t} - Bh^s_{3,2,t}) / Bh^d{}_{1,2,t}$

(82) $e_{3,t} = e_{2,t} / e_{1,t}$

Substituting equation (82) into equation (29), we have:

(29a) $Bh^s_{3,2,t} = Bh^d_{3,2,t} / e_3 = \dfrac{Bh^d_{3,2,t}}{e_{2,t} / e_{1,t}} = \dfrac{Bh^d_{3,2,t} \cdot e_{1,t}}{e_{2,t}}$

Substituting (29a) into equation (73b), we have:

$$e_1 = (B^s{}_{2,t} - Bh^s{}_{2,2,t} - Bcmb^s_{2,2,t} - Bcb^s{}_{2,2,t} - \frac{Bh^d_{3,2,t} \cdot e_{1,t}}{e_{2,t}}) / Bh^d{}_{1,2,t}$$

$$\Rightarrow e_1 = \frac{B^s{}_{2,t} - Bh^s{}_{2,2,t} - Bcmb^s_{2,2,t} - Bcb^s{}_{2,2,t}}{Bh^d{}_{1,2,t} + Bh^d_{3,2,t} / e_{2,t}}$$

Thus, the exchange rate between the Dollar and the Euro is jointly determined by $Bh^d{}_{1,2,t}$ and $Bh^d_{3,2,t}$. Since the increase in $Bh^d_{3,2,t} / e_{2,t}$ is more than the decrease in $Bh^d{}_{1,2,t}$, the total foreign demand for the bills issued by the government of Euroland

$(Bh^d{}_{1,2,t} + Bh^d_{3,2,t} / e_{2,t})$ rises. This leads to a decrease in e_1, that is, the Euro value rises, relative to the Dollar.

The floating exchange rates bring back the current account and budget account of Euroland to balanced positions in the long run. This result is similar to that achieved in experiment 1.

1.6.3 An increase in the propensity of China to import goods from Euroland

Let us now simulate a situation where China raises its propensity to import goods from Euroland.

< Figures 1-39 – 1-45>

In the short run, the increase in the imports of China induces a trade deficit in China. This slows down the economy of China. Through the feedback effects, Euroland gets a trade surplus, leading to an increase in its GDP. However, as the Euro value rises against the Dollar and the RMB, the trade surplus in Euroland gradually decreases, and so does the deficit in China. In the long run, Euroland has a trade deficit and a lower GDP level. In the quasi stationary state, China has "twin deficits", but the current account balance and budget balance in Euroland are in equilibrium due to the floating exchange rates.

Through the feedback effects, in the quasi stationary state, the U.S. has "twin surpluses", and a higher GDP level.

Why does the Euro value rise? Recall the exchange rate determination equation: $e_1 = \dfrac{B^s{}_{2,t} - Bh^s{}_{2,2,t} - Bcmb^s_{2,2,t} - Bcb^s{}_{2,2,t}}{Bh^d{}_{1,2,t} + Bh^d_{3,2,t} / e_{2,t}}$. In the short run, as the Euroland GDP increases, $Bh^s{}_{2,2,t}$ $(= Bh^d{}_{2,2,t})$ increases, leading to a decrease in the Euro bills supplied to the U.S. and China $(B^s{}_{2,t} - Bh^s{}_{2,2,t} - Bcmb^s_{2,2,t} - Bcb^s{}_{2,2,t})$. This induces an appreciation of the Euro. Thus, the change in $Bh^s{}_{2,2,t}$ has a dominating effect on the adjustment of the exchange rate in the short run. However, in the long run, the increase in $Bh^d{}_{1,2,t}$ (the U.S. households' demand for the Euro bills) has a dominating effect in the exchange rate movement, leading to a further rise of the Euro value.

1.6.4 An increase in the propensity of Euroland to import goods from China

Let us now simulate an opposite situation where Euroland raises its propensity to import goods from China.

< Figures 1-46 – 1-52 >

In the short run, the increase in the imports of Euroland induces a trade deficit in Euroland, leading to a decrease in the GDP of Euroland. Through the feedback effects, China gets a trade surplus. This stimulates the Chinese economy. However, as the Euro value falls, the trade deficit in Euroland gradually decreases, and so does the surplus in China. In the long run, Euroland has a trade surplus and a higher GDP level. In the quasi stationary state, China has "twin surpluses".

The depreciation of the Euro relative to the dollar stimulates European exports to the United States, and hence leads to a negative balance of trade and a negative current account of the United States (and a budget deficit). In the quasi stationary state, the U.S. has "twin deficits", and a lower GDP level. Thus, the U.S. could suffer from a trade deficit for no fault of its own; its trade deficit could be caused by an increase in the propensity of Euroland to import Chinese products.

1.6.5 Impact of changes in the propensity to import

Therefore, a rise in the propensity to import from China, whether it comes from the United States or from Europe, will lead to: (1) a trade surplus, and a surplus of the current account and a budget surplus ("twin surpluses") in China; (2) a trade deficit, and a deficit of current account and a budget deficit ("twin deficits") in the U.S..

An increase in propensity to import	Impact on the value of the dollar against the euro	Impact on current account		Impact on GDP	
		the US	China	the US	China
An increase in the propensity of China to import from the US	-	+	-	+	-
An increase in the propensity of China to import from Euroland	-	+	-	+	-
An increase in the propensity of the US to import from China	-	-	+	-	+
An increase in the propensity of Euroland to import from China	+	-	+	-	+

1.7 Conclusion

In this paper, I have developed a dynamic stock-flow consistent model for three economies with both a fixed exchange rate and floating exchange rates. The main model has been applied to simulate the impact of internal and external shocks, and short-run and long-run effects of changes in the U.S. fiscal position.

The simulation results in this paper support the compensation principle, which also holds in an open overdraft economy. In my model, I set up a link between the commercial banks and the central bank of China, through advances. I find that, in the main closure of the model, the internal and external shocks lead to "twin deficits" or "twin surpluses". But through the compensation effects, in the quasi steady state, the "twin deficits" or "twin surpluses" have no effect on the overall monetary base or money supply. "Money aggregates are still determined by demand-led factors. The only difference is that these foreign-induced disequilibria will change the composition of the balance sheet of the central bank" (Lavoie 2001, p. 237). Thus, the central bank of China will not lose control of its monetary policy, because "twin deficits" or "twin surpluses" have no endogenous effect on its interest rate level.

In the alternative closure, I have incorporated a partial adjustment mechanism into the model, and have made Chinese government expenditures endogenous. The simulation results have shown that in the long run, all three countries reach super steady states where all endogenous variables achieve constant levels. The adjustment mechanism has brought the three countries back to balanced budget positions and balanced current account positions. But in the long run, the equilibrium GDP level of China is lower than that of the main closure.

Reference

Backus D., Brainard W. C., Smith G. and Tobin, J. (1980), "A model of U.S. financial and non-financial economic behavior", *Journal of Money, Credit, and Banking,* Vol. 12 (2), pp. 259-293.

Brainard, W. C. and Tobin, J. (1968), "Pitfalls in financial modeling", *American Economic Review*, Vol. 58 (3), pp.99-122 .

Blanchard, O., Giavazzi, F., and Sa, F. (2005b), "International investors, the U.S. current account, and the dollar", *Brookings Papers on Economic Activity*, No. 1, pp. 1-49.

Branson, W.H. and D.W. Henderson (1985) 'The specification and influence of asset markets', in R. Jones and P.B. Kenen (eds), *Handbook of International Economics*, volume 2, Amsterdam: North Holland, pp. 749-805.

Dooley, M., Folkerts-Landau, D. and P. Garber (2004) "The revived Bretton Woods System: The effects of periphery intervention and reserve management on interest rates & exchange rates in center countries", NBER Working Paper Series, working paper 10332.

Dos Santos, C. and Zezza, G. (2004), "The role of Monetary Policy in Post-Keynesian Stock-Flow Consistent Macroeconomic Growth Models", in Lavoie Marc and Seccarecia Mario (eds.), *Modern Banking in the Modern World,* Edward Elgar: Cheltenham, pp.183-208.

Dos Santos, C. and Zezza, G. (2005), "A simplified Stock-Flow Consistent Post Keynesian Growth Model", WP No. 421, Jerome Levy Economics Institute of Bard College: Annandale-on-Hudson, NY.

Flaschel, P., G. Gong and W. Semmler (1997), *Dynamic Macroeconomics: Instability, Fluctuations and Growth in Monetary Economics*, Cambridge MA: MIT Press.

Godley, W., and Cripps, F. (1983), *Macroeconomics,* Oxford University Press.

Godley, W. (1996), "Money, finance and national income determination: An integrated approach", WP No. 167, The Levy Economics Institute of Bard College: Annandale-on-Hudson, NY.

Godley, W. (1999), "Open economy macroeconomics using models of closed system", WP No. 285, The Levy Economics Institute of Bard College: Annandale-on-Hudson, NY.

Godley, W. and M. Lavoie (2003), "Two-country stock-flow consistent macroeconomics using a closed model within a dollar exchange regime", Working Paper 10, Cambridge Endowment for Research in Finance, University of Cambridge.

Godley, W., and Lavoie, M. (2004), "Two-Country Stock-Flow-Consistent Macroeconomics Using A Closed Model within A Dollar Exchange Regime", *Working Paper,* April.

Godley, W. and M. Lavoie (2005-06), "Comprehensive accounting in simple open economy macroeconomics with endogenous sterilization or flexible exchange rates", *Journal of Post Keynesian Economics*, Winter, 28(2), pp. 241-276.

Godley, W. and M. Lavoie (2007a), "A Three-Country Model with Comprehensive Accounting: Euroland and the USA", *Cambridge Journal of Economics*, January, 31 (1), pp. 1-24.

Godley, W., and Lavoie, M. (2007b), *Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth*, London: Macmillan/Palgrave.

Izurieta, A. (2003) 'Dollarization as a tight rein on the fiscal stance', in L.P. Rochon and M. Seccareccia (eds), *Dollarization: Lessons from Europe and the Americas*, London: Routledge, pp. 143-164.

Lavoie, M. (1992), *Foundations of Post Keynesian Economic Analysis*, Aldershot, Hants: Edward Elgar Publishing.

Lavoie, M. (2000), "A Post Keynesian View of Interest Parity Theorems", *Journal of Post Keynesian Economics*, fall, pp.163-179.

Lavoie, M. (2001), "The Reflux Mechanism and the Open economy", in L.P. Rochon and M. Vernengo (Eds), *Credit, Interest Rates and the Open Economy, Chapter 10,* pp.215-242, Edward Elgar.

Lavoie, M. (2002-03), "Interest parity, risk premia, and Post Keynesian analysis", *Journal of Post Keynesian Economics,* Winter, 25 (2), pp. 237-249.

Lavoie, M. (2006) *Introduction to Post-Keynesian Economics*, London: Macmillan/Palgrave.

Lavoie, M. and Godley, W. (2001-02), "Kaleckian models of growth in a coherent stock-flow monetary framework: a Kaldorian view", *Journal of Post Keynesian Economics,* Vol. 24 (2), pp. 277-311.

Lequain, M. (2003), "A three-country study of the euro zone versus the rest of the world: the implications of a monetary union in an open environment", working paper, University of Ottawa, paper presented at the annual conference of the Eastern Economic Association, in New York.

Taylor, L. (2004a), "Exchange indeterminacy in portfolio balance, Mundell-Fleming, and uncovered interest rate parity models", *Cambridge Journal of Economics*, 28 (2), pp. 45-53.

Taylor, L. (2004b), *Reconstructing Macroeconomics: Structuralist Proposals and Critiques of the Mainstream,* Cambridge, MA: Harvard University Press.

Tobin, J. (1969), "A general equilibrium approach to monetary theory", *Journal of Money, Credit, and Banking*, February, 1 (1), pp.15-29.

Tobin, J. and J.B. De Macedo (1980) 'The short-run macroeconomics of floating exchange rates: An exposition', in J. Chipman and C. Kindleberger (eds), *Flexible Exchange Rates and the Balance of Payments: Essays in the Memory of Egon Sohmen*, Amsterdam: North Holland, pp. 5-28.

Appendix 1.1

Parameter values for simulations

$\mu_{i0}=6.9$ $\mu_{i1}=0.1$

$\mu_{i2}=0.1$ $\mu_{i3}=0.1$

$\mu_{i4}=0.1$ $\mu_{i5}=0.1$

$\theta_i=0.26$

$\alpha_{i,1}=0.8$ $\alpha_{i,2}=0.05$

$\lambda_{i,00}=0.2963$ $\lambda_{i,10}=0.1111$

$\lambda_{i,20}=0.1111$ $\lambda_{i,30}=0.1111$

$\lambda_{i,40}=0.3704$

$\lambda_{i,11}=0.6$ $\lambda_{i,12}=-0.2$

$\lambda_{i,13}=-0.2$ $\lambda_{i,14}=-0.2$

$\lambda_{i,21}=-0.2$ $\lambda_{i,22}=0.6$

$\lambda_{i,23}=-0.2$ $\lambda_{i,24}=-0.2$

$\lambda_{i,31}=-0.2$ $\lambda_{i,32}=-0.2$

$\lambda_{i,33}=0.6$ $\lambda_{i,34}=-0.2$

$\delta_i=0.1$ $\gamma_i=0.09$

$\kappa_i=2$

$\zeta_{i,1}=2.05$ $\zeta_{i,2}=1$

Where $i=1,2,3$.

Appendix 1.2

Table 1-1: Stock matrix

Items	the USA					Euroland					China					Sum
	Households	Frims	Bnaks	Government	Central Bank	Households	Frims	Bnaks	Government	Central Bank	Households	Frims	Bnaks	Government	Central Bank	
Tangible K		K1					K2					K3				$\sum K$
Cash	Hh1				-Hs1	Hh2				-Hs2	Hh3				-Hs3	0
Deposit	M1		-M1			M2		-M2			M3		-M3			0
Bill 1	Bh1,1		Bcmb1,1	-B1	Bcb1,1	Bh2,1				Bcb2,1	Bh3,1				Bcb3,1	0
Bill 2	Bh1,2				Bcb1,2	Bh2,2		Bcmb2,2	-B2	Bcb2,2	Bh3,2				Bcb3,2	0
Bill 3	Bh1,3					Bh2,3					Bh3,3			-B3	Bcb3,3	0
Loan		-L1	L1				-L2	L2				-L1	L1			0
Advance													-A3		A3	0
Balnace	-V1			-Vg1	0	-V2			-Vg2	0	-V3			-Vg3	-Vcb3	$-\sum V$
Sum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1-2: Flow matrix

	The U.S.						Euroland						China					
	Households	Firms		Banks	Government	Central Bank	Households	Firms		Banks	Government	Central Bank	Households	Firms		Banks	Government	Central Bank
Items		Current	Capital					Current	Capital					Current	Capital			
CONSUMPTION	-C1	+C1					-C2	+C2					-C3	+C3				
Government		+G1			-G1			+G2			-G2			+G3			-G3	
expenditure																		
Investment		+I1	-I1					+I2	-I2					+I3	-I3			
Import		IM1,2						IM2,1						IM3,1				
		IM1,3						IM2,3						IM3,2				
Export		EX1,2						EX2,1						EX3,1				
		EX1,3						EX2,3						EX3,2				
GDP		[Y1]						[Y2]						[Y3]				
WAGES	+W1	-W1					+W2	-W2					+W3	-W3				
Depreciation		-DA1	+DA1					0	0					0	0			
TAX	-T1				+T1		-T2				+T2		-T3				+T3	
Interest Payment	+r1*Bh1,1			+r1*Bomb1,1	-r1*B1	+r1*BCb1,1	+r1*Bh2,1*E1					+r1*BCb2,1*E1	+r1*Bh3,1*E2					+r1*BCb3,1*E2
	+r2*Bh1,2/E1					+r2*BCb1,2/E1	+r2*Bh2,2			+r2*Bomb2,2	-r2*B2	+r2*Bcb2,2	+r2*Bh3,2*E3					+r2*Bcb3,2*E3
	+r3*Bh1,3/E2						+r3*Bh2,3/E3						+r3*Bh3,3				-r3*B3	+r3*Bcb3,3
		-r1*L1		+r1*L1				-r2*L2		+r2*L2				-r3*L3		+r3*L3		
	+r1*M1			-r1*M1			+r2*M2			-r2*M2						-r3*A3		+r3*A3
													+r3*M3			-r3*M3		
Central Bank profit					+Fb1	-Fb1					+Fb2	-Fb2					+Fb3	-Fb3
Changes in																		
Loan			+ΔL1	-ΔL1					+ΔL2	-ΔL2					+ΔL3	-ΔL3		
Advance																+ΔA3		-ΔA3
Bank Deposit	-ΔM1			+ΔM1			-ΔM2			+ΔM2			-ΔM3			+ΔM3		
Cash	-ΔHh1					+ΔHs1	-ΔHh2					+ΔHs1	-ΔHh3					+ΔHs3
Bill1	-ΔBh1,1				+ΔB1	-ΔBcb1,1	-ΔBh2,1*E1					-ΔBcb21*E1	-ΔBh3,1*E2					-ΔBcb3,1*E2
Bill2	-ΔBh1,2/E1					-ΔBcb1,2/E1	-ΔBh2,2				+ΔB2	-ΔBcb2,2	-ΔBh3,2*E3					-ΔBcb3,2*E3
Bill3	-ΔBh1,3/E2						-ΔBh2,3/E3						-ΔBh3,3				+ΔB3	-ΔBcb3,3
SUM	0	0	0	0	0	0	0	0		0	0	0	0	0		0	0	0

Appendix 1.3

Experiment 1: An increase in the propensity of China to import goods from the U.S.

Figure 1-1: Impact on GDP

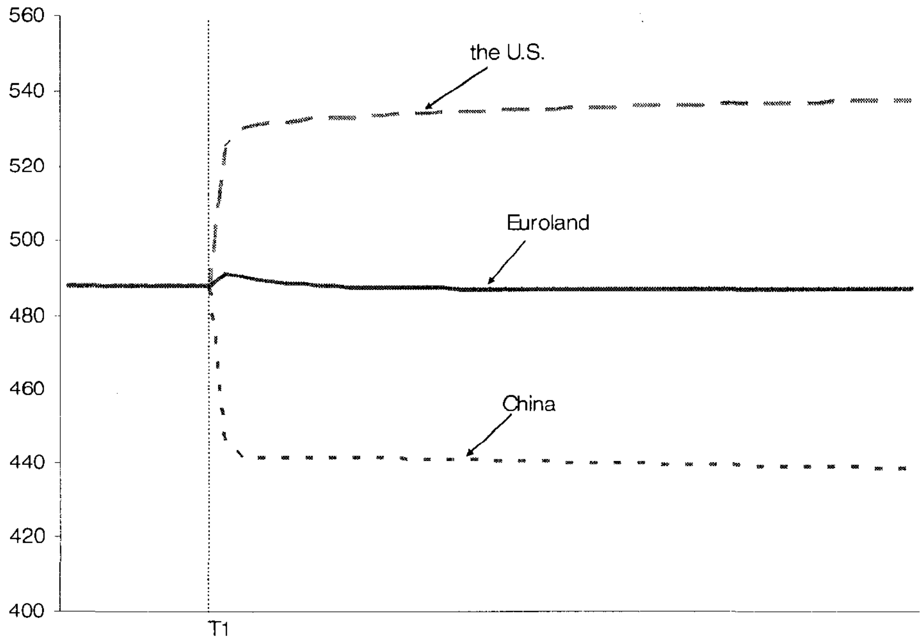


Figure 1-2: Impact on consumption

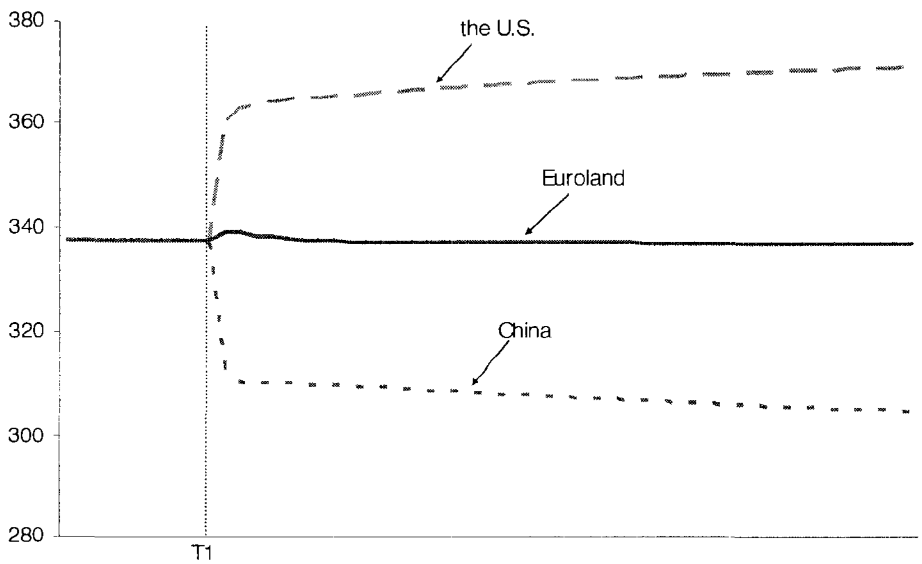


Figure 1-3: Impact on gross investment

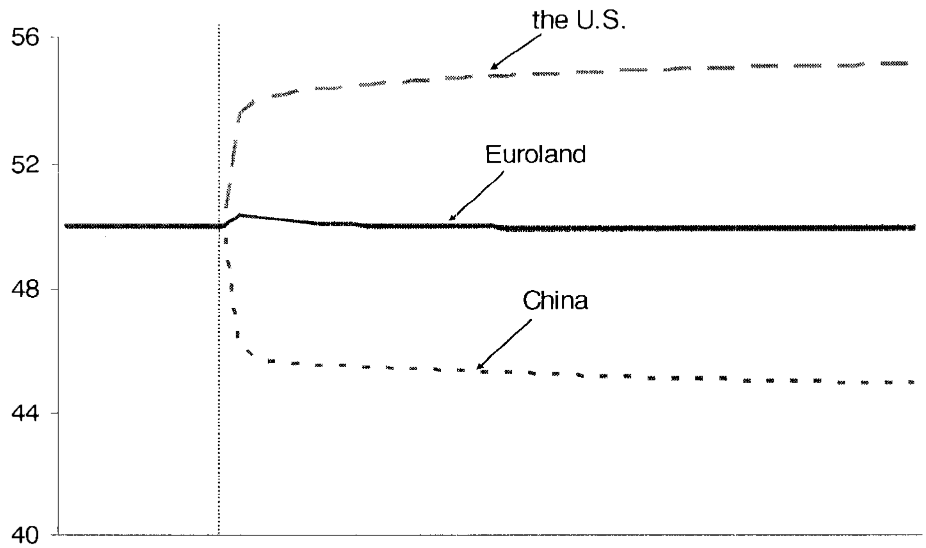


Figure 1-4: Impact on the trade balance

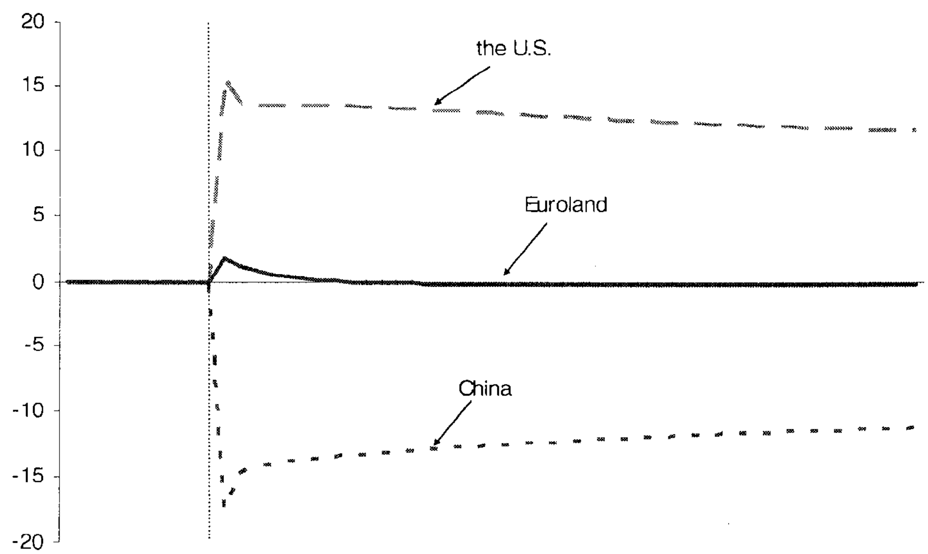


Figure 1-5: The value of the Dollar in terms of the Euro

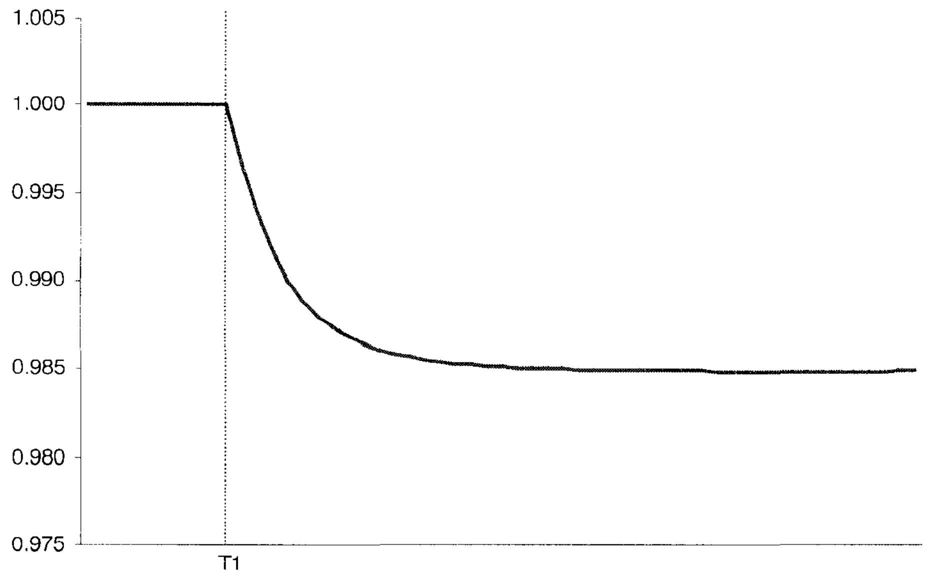


Figure 1-6: Impact on the current account balance

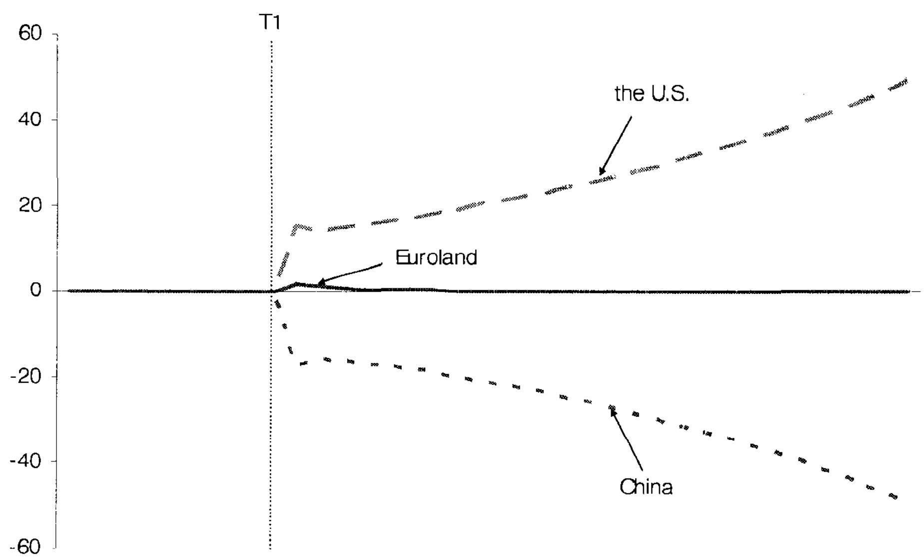


Figure 1-7: Impact on the government budget balance

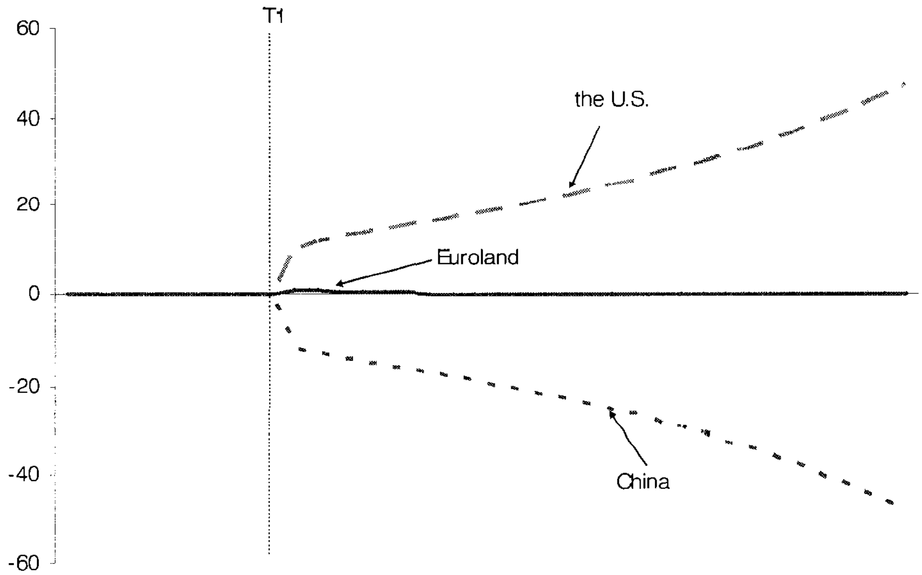
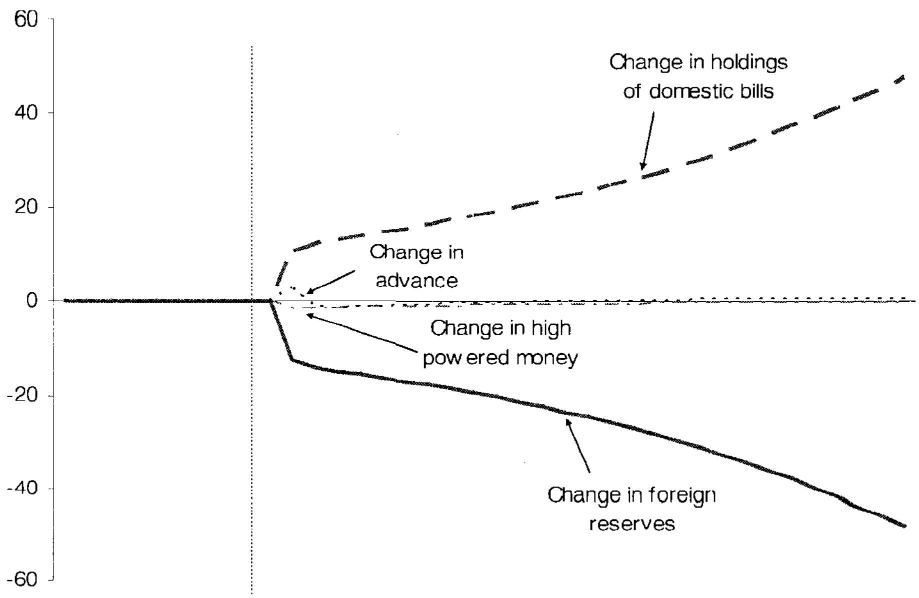


Figure 1-8: Impact on China variables



Experiment 2: An increase in the U.S. government spending

Figure 1-9: Effects on GDP

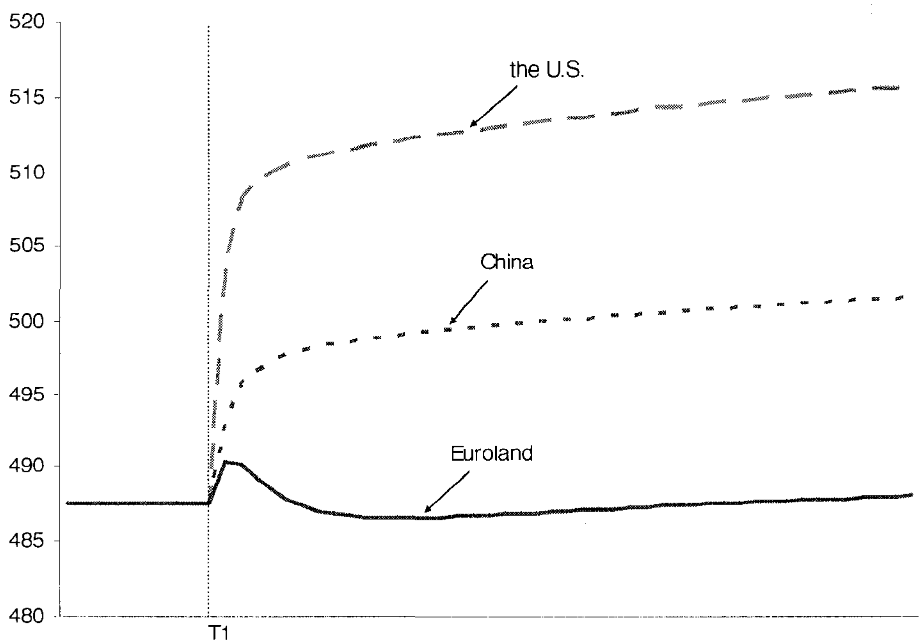


Figure 1-10: Impact on consumption

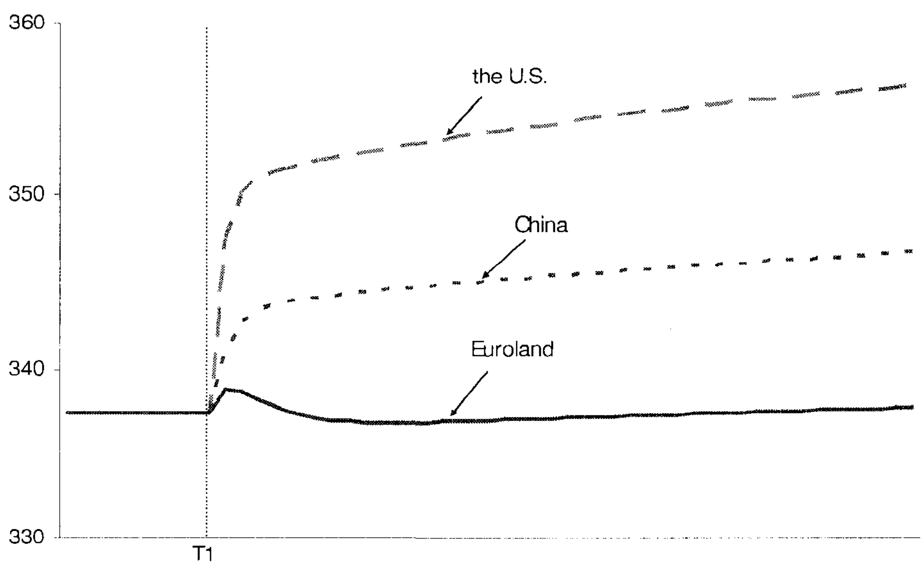


Figure 1-11: Impact on gross investment

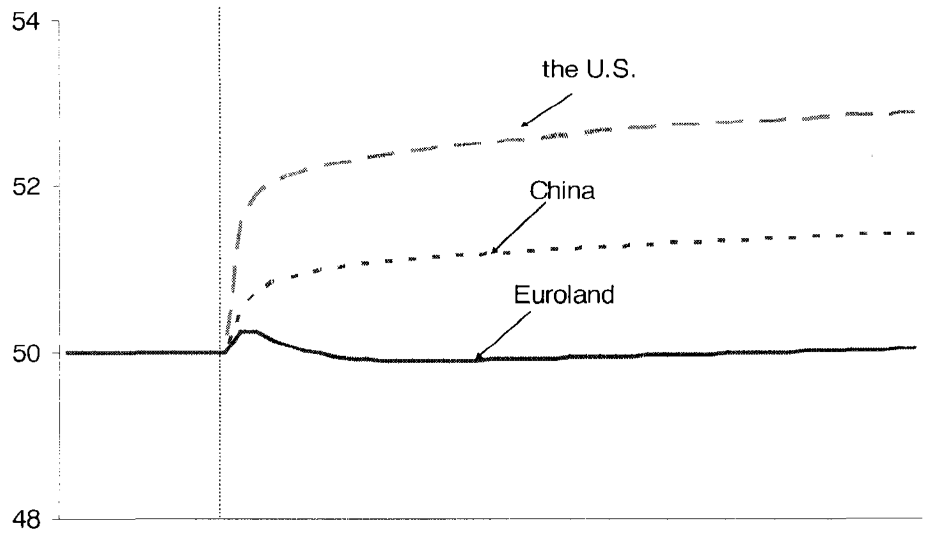


Figure 1-12: Impact on the trade balance

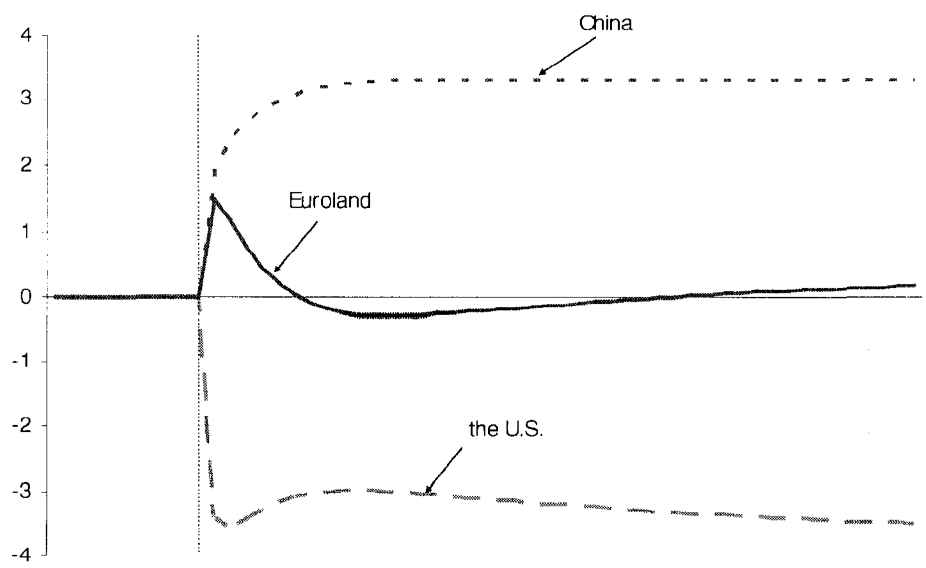


Figure 1-13: The value of the Dollar in terms of the Euro

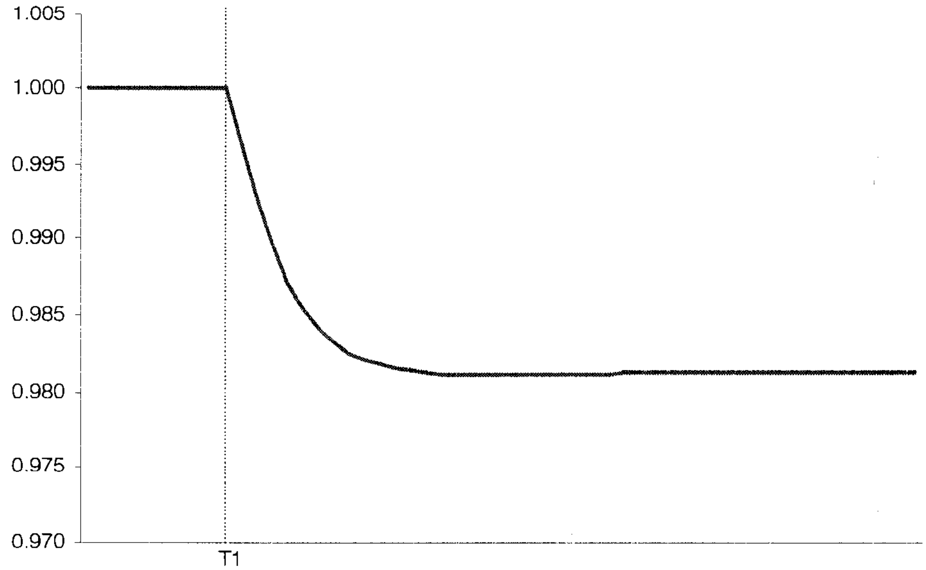


Figure 1-14: Impact on the current account balance

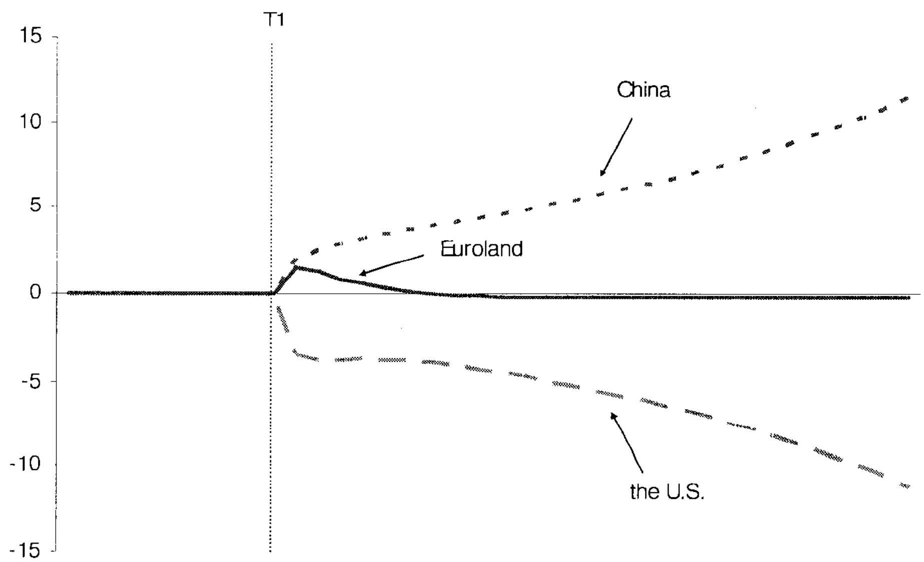


Figure 1-15: Impact on the government budget balance

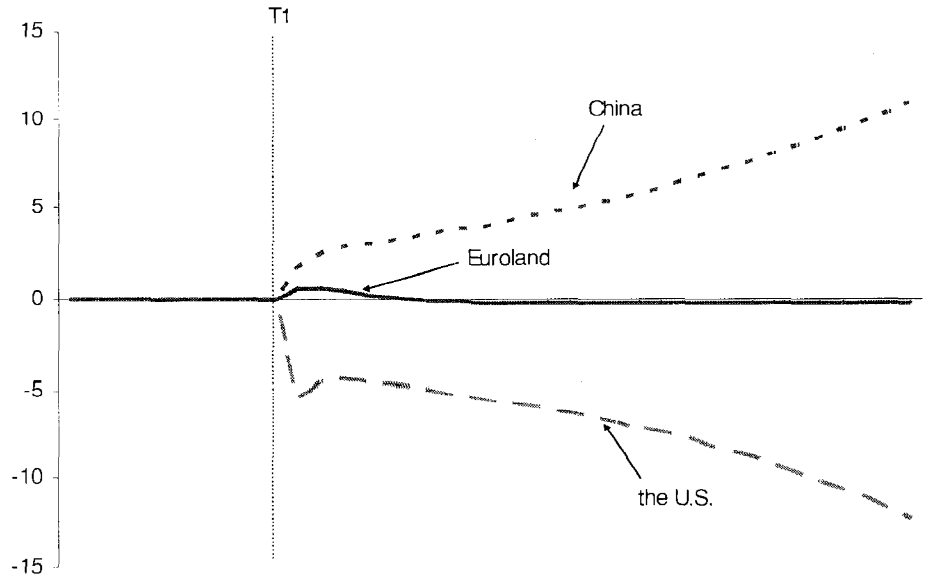
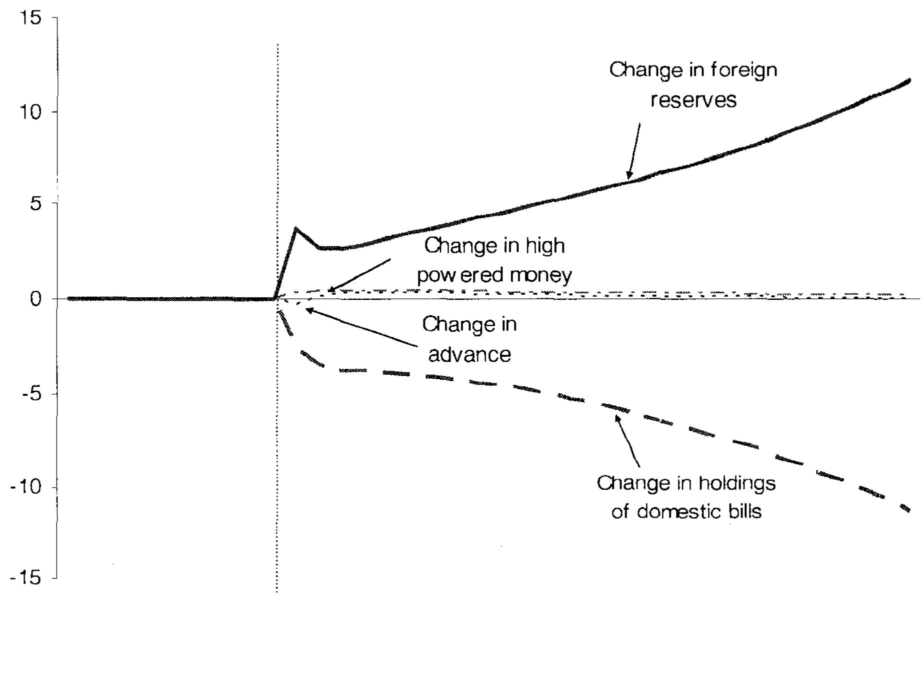


Figure 1-16: Impact on China variables



Experiment 3: An increase in Chinese households' consumption propensity

Figure 1-17: Impact on GDP

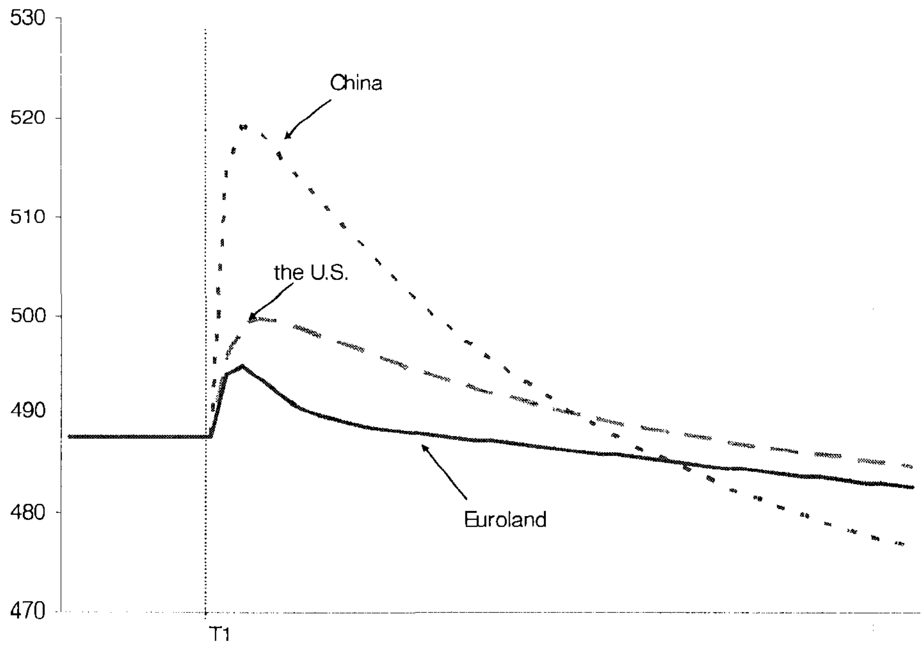


Figure 1-18: Impact on consumption

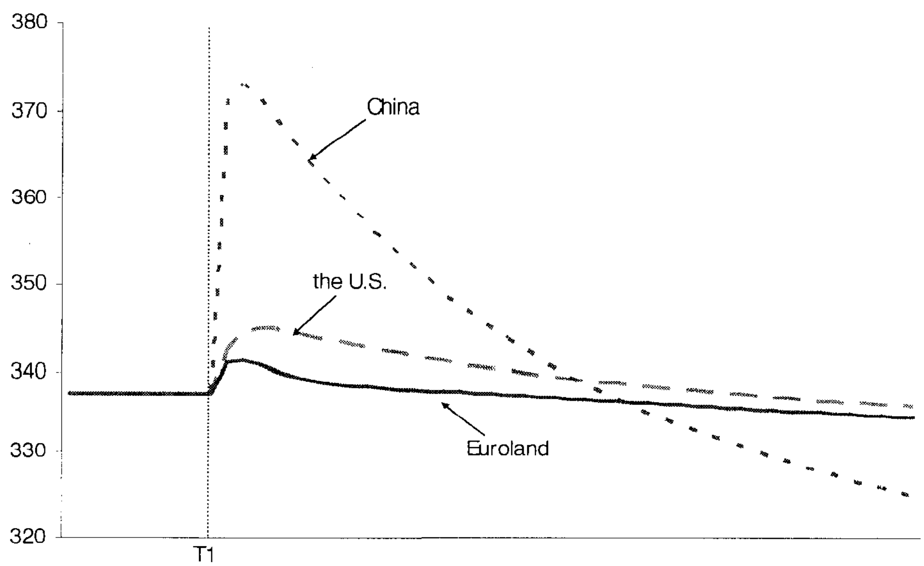


Figure 1-19: Impact on gross investment

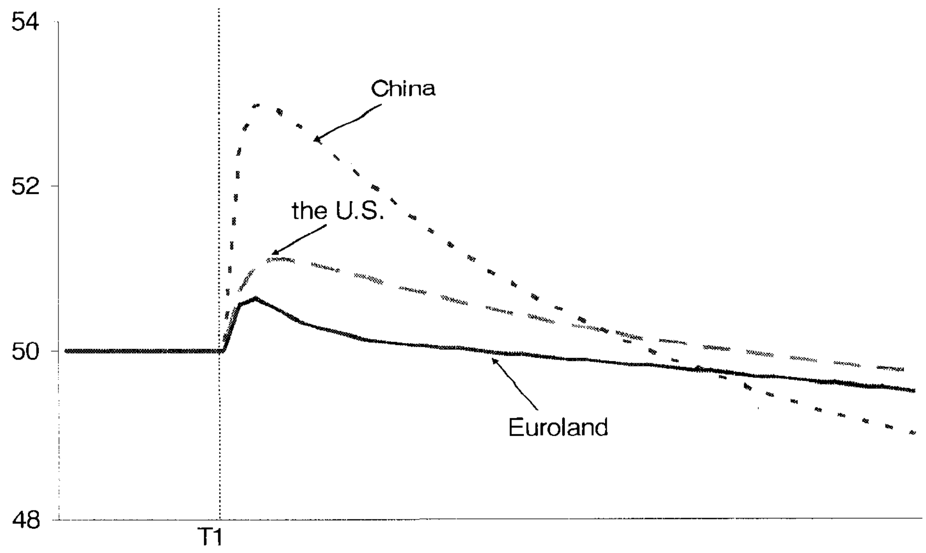


Figure 1-20: Impact on the trade balance

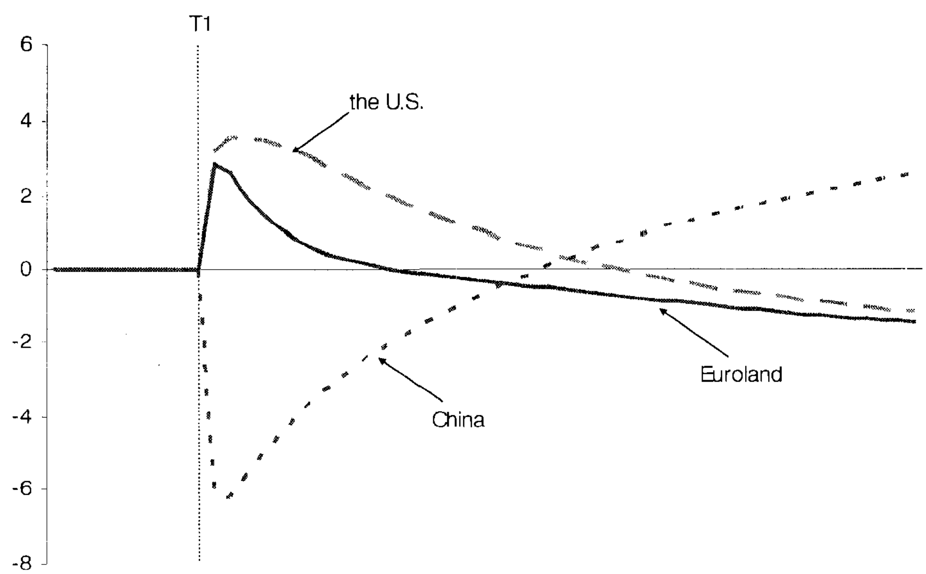


Figure 1-21: The value of the Dollar in terms of the Euro

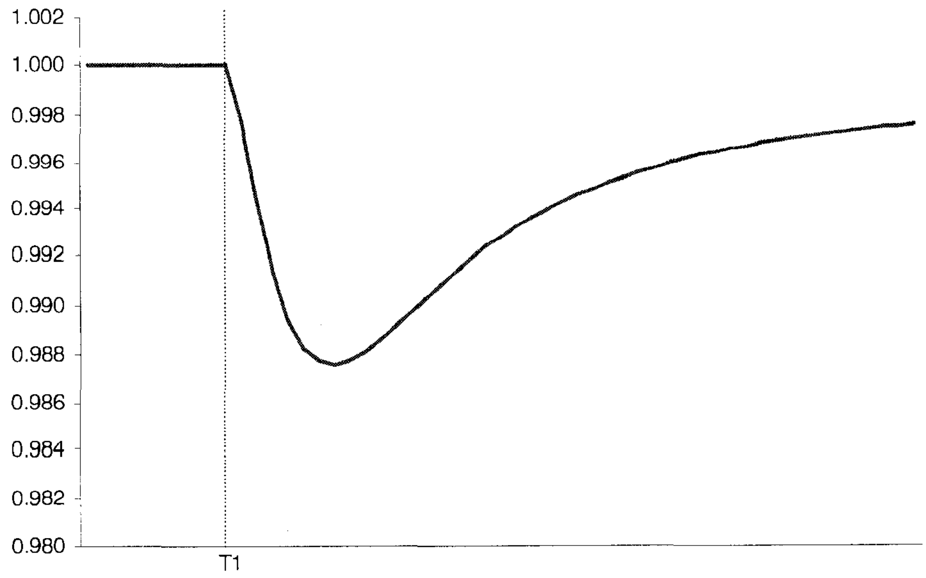


Figure 1-22: Impact on the current account balance

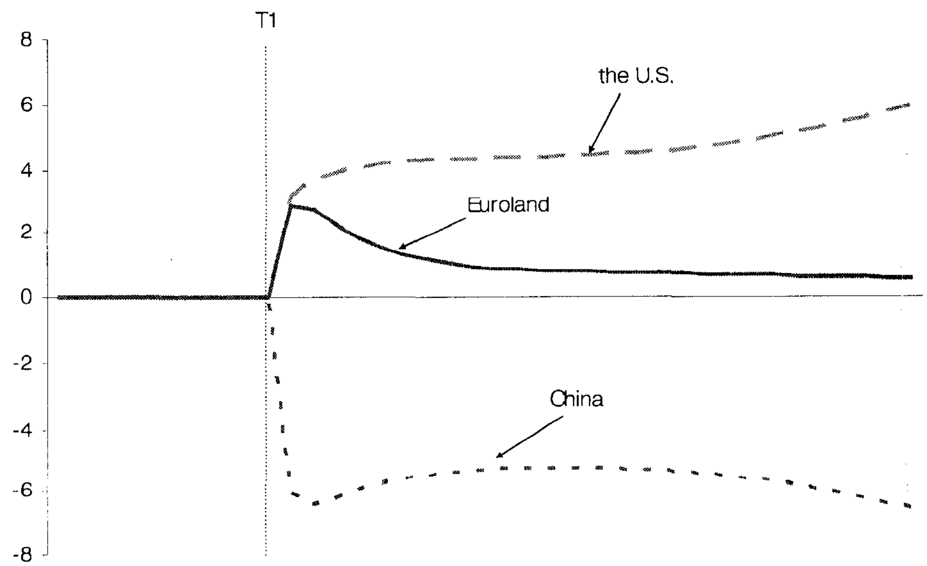
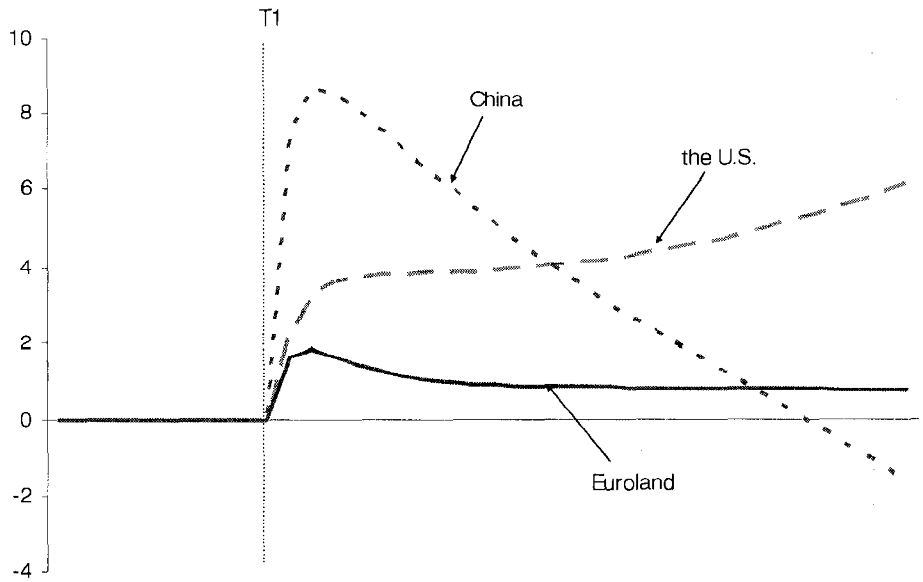


Figure 1-23: Impact on the government budget balance



Experiment 4 (Alternative closure): An increase in the propensity of China to import goods from the U.S.

Figure 1-24: Impact on GDP

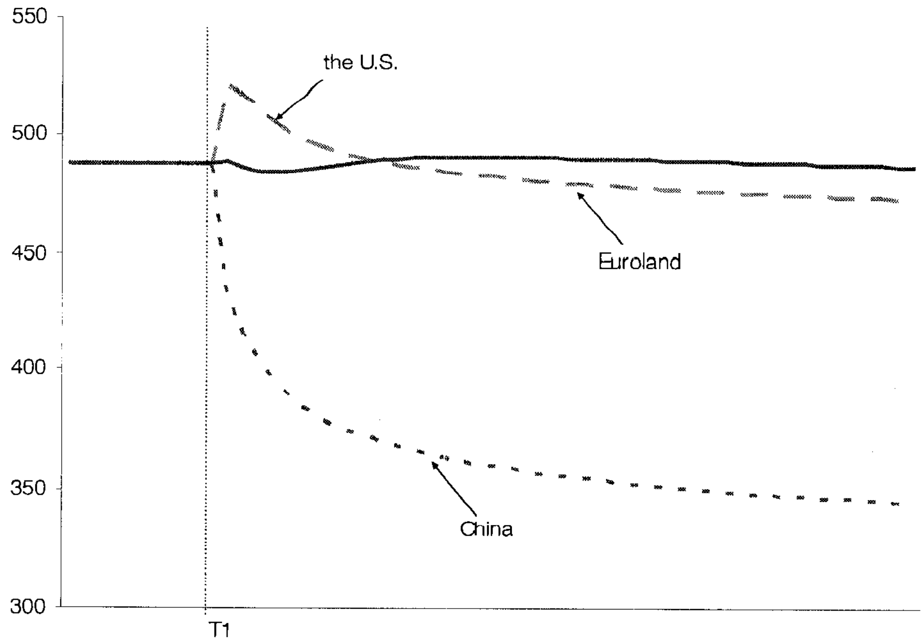


Figure 1-25: Impact on consumption

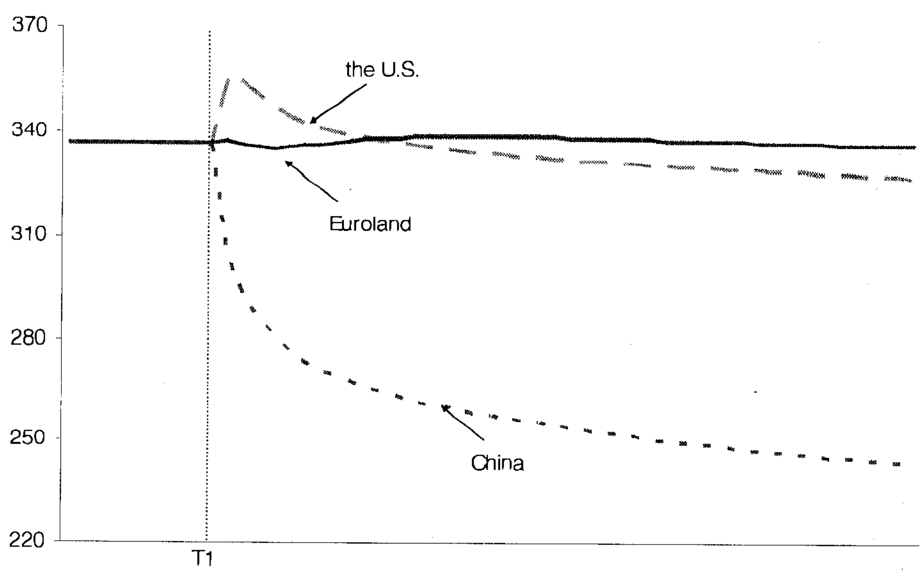


Figure 1-26: Impact on gross investment

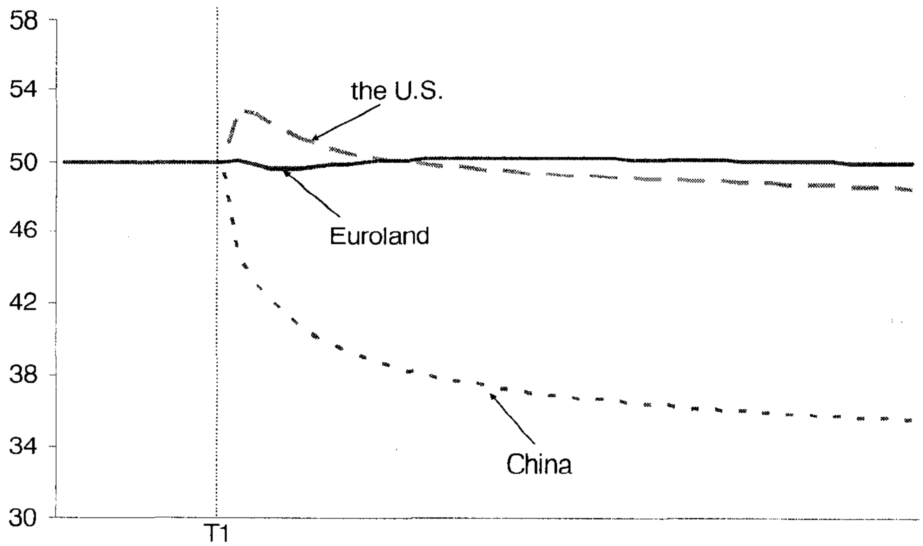


Figure 1-27: Impact on the trade balance

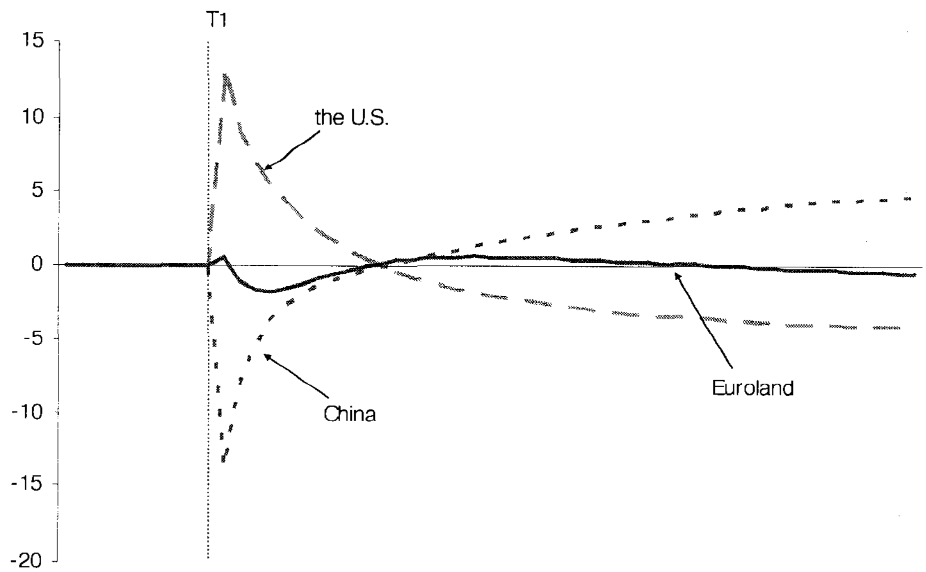


Figure 1-28: The value of the Dollar in terms of the Euro

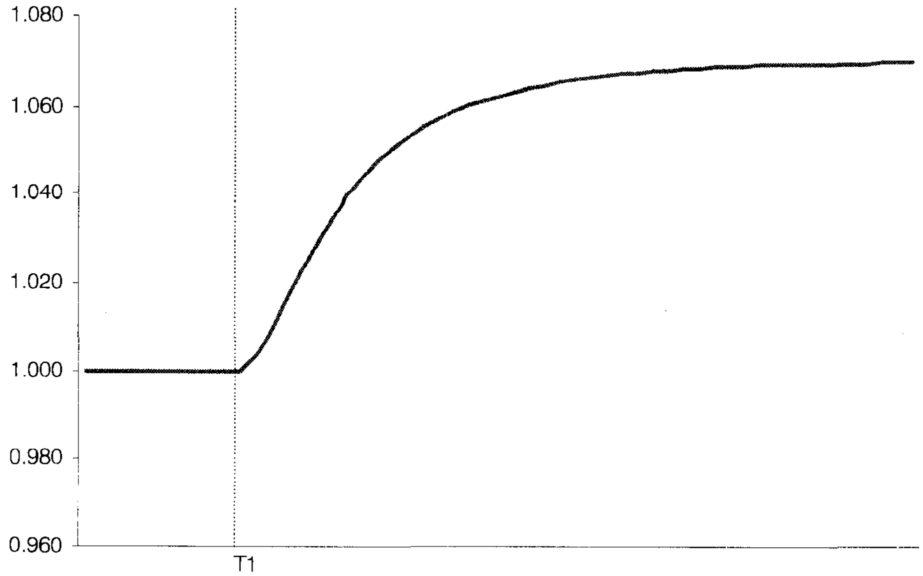


Figure 1-29: Impact on the current account balance

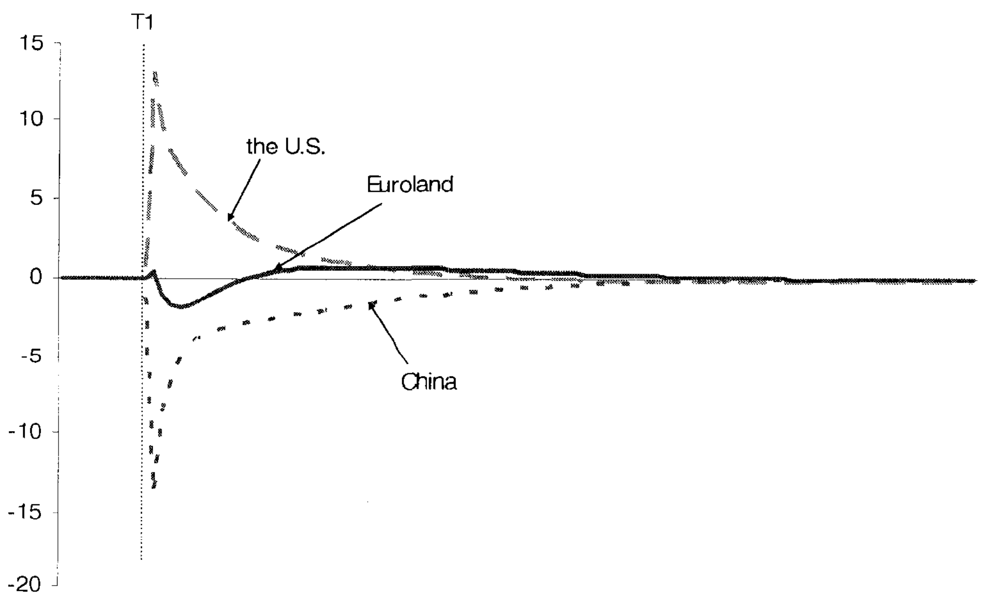


Figure 1-30: Impact on the government budget balance

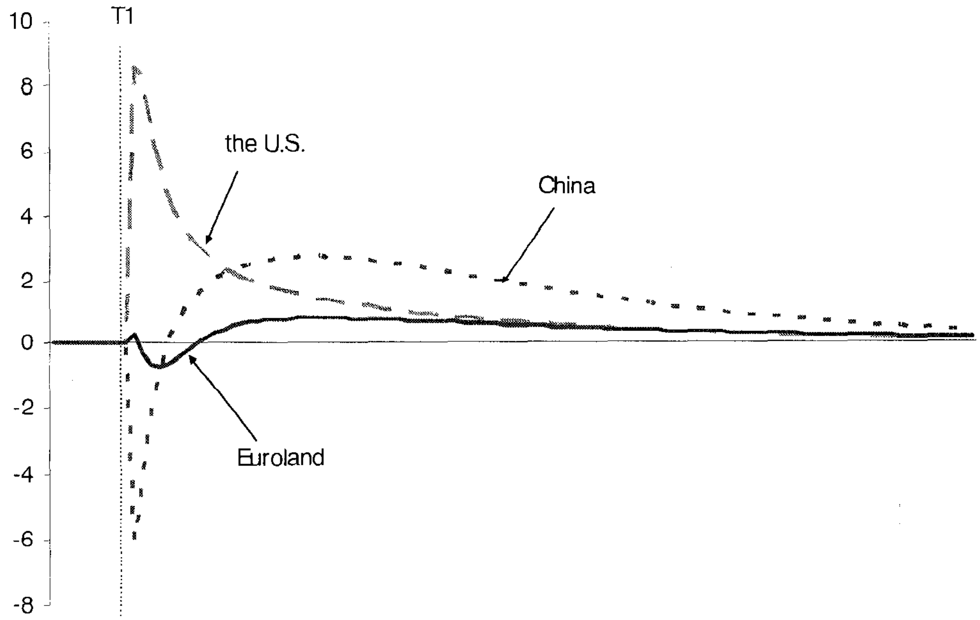
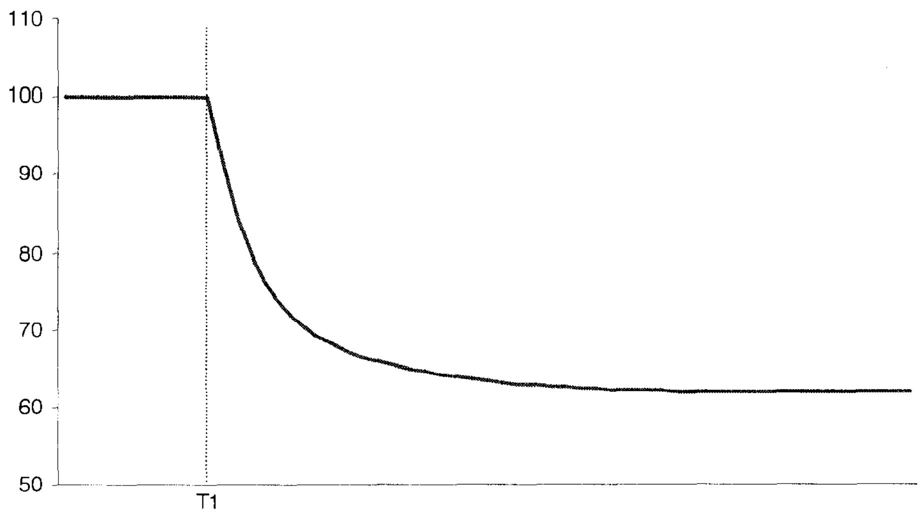


Figure 1-31: Impact on Chinese government expenditure



Experiment 5: An increase in the propensity of the U.S. to import goods from China

Figure 1-32: Impact on GDP

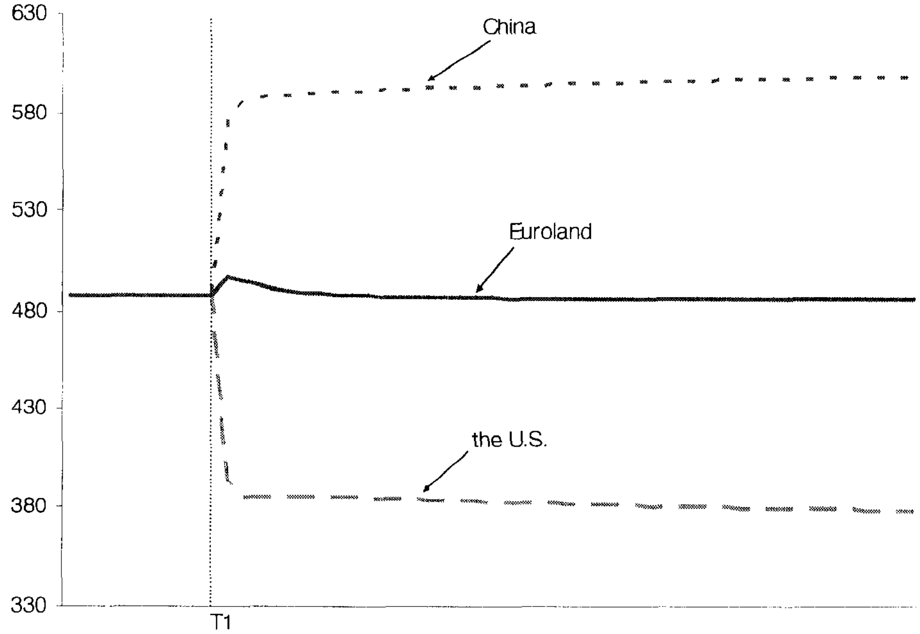


Figure 1-33: Impact on consumption

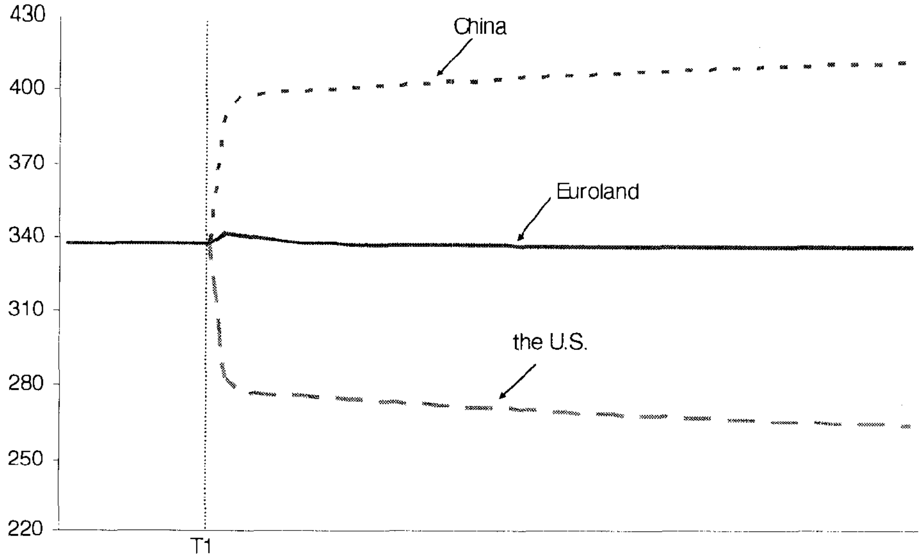


Figure 1-34: Impact on gross investment

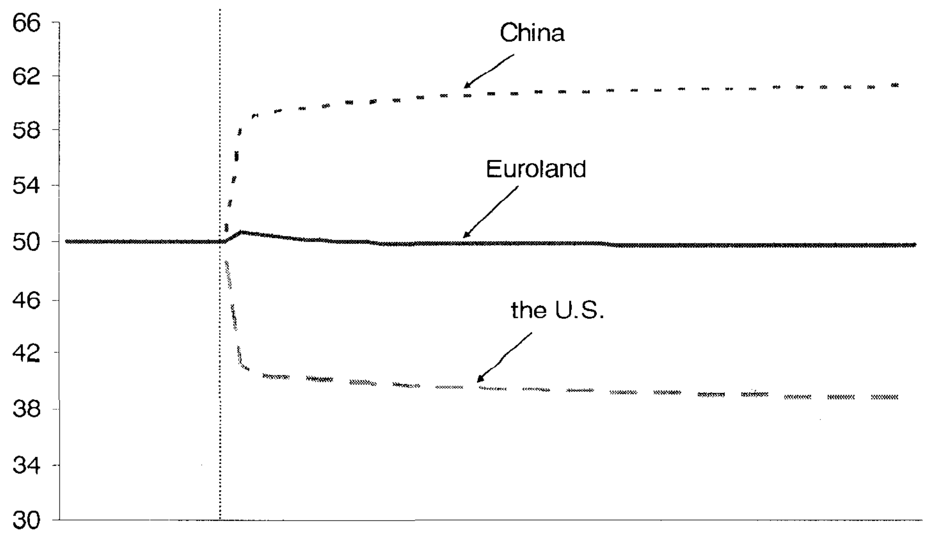


Figure 1-35: Impact on the trade balance

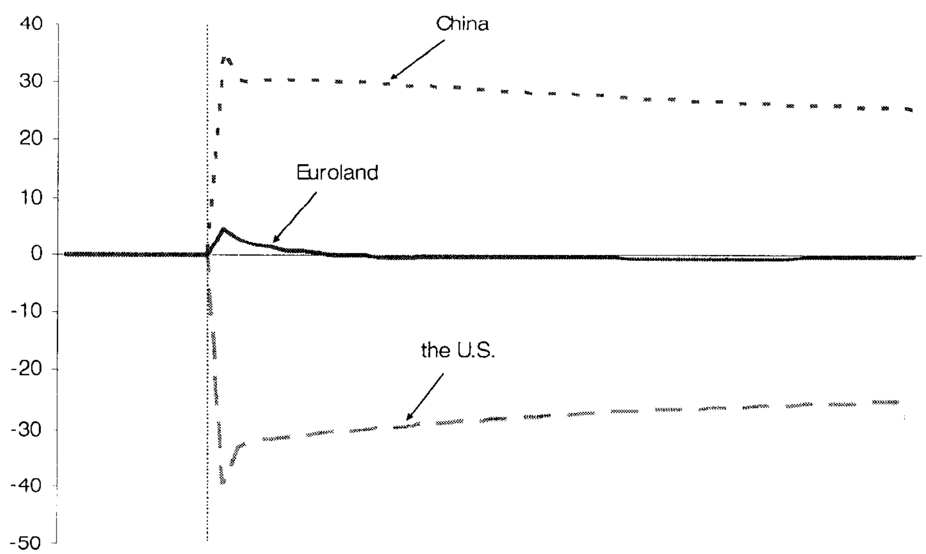


Figure 1-36: The value of the Dollar in terms of the Euro

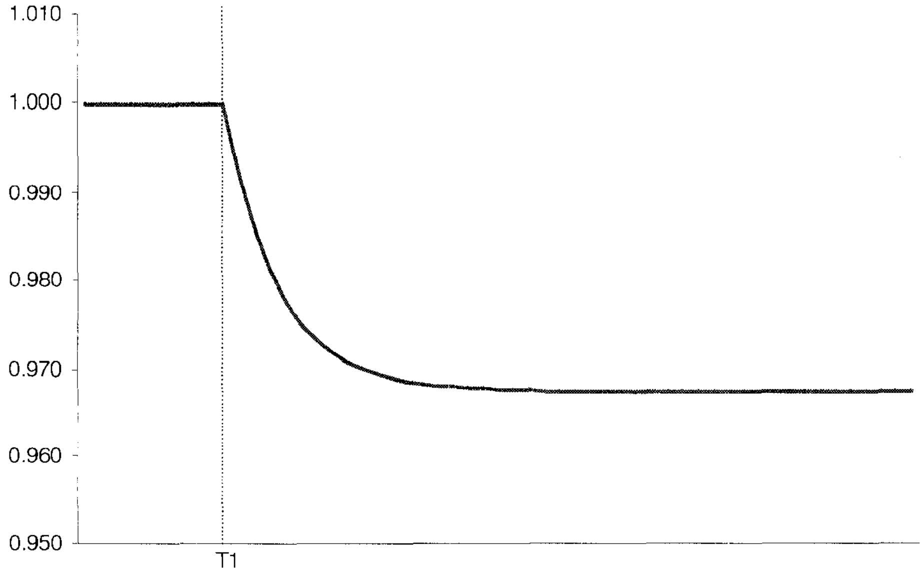


Figure 1-37: Impact on the current account balance

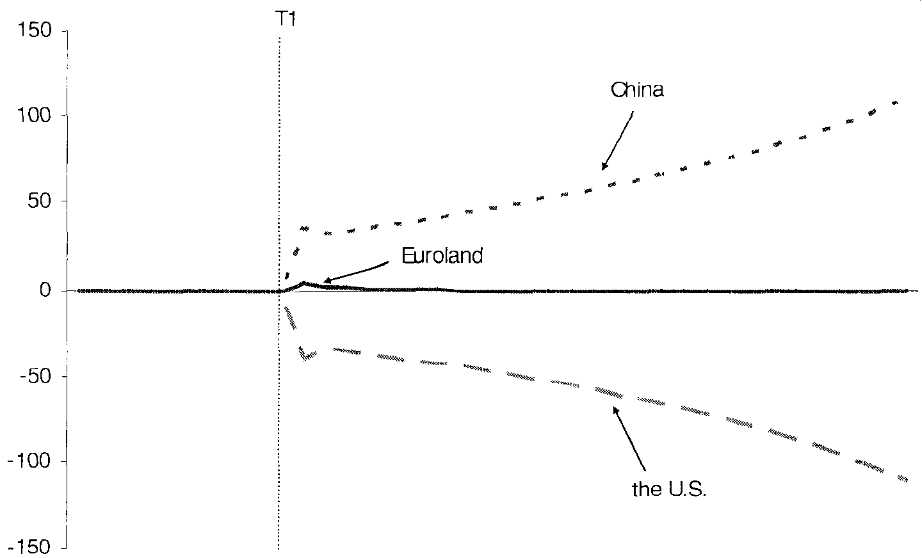
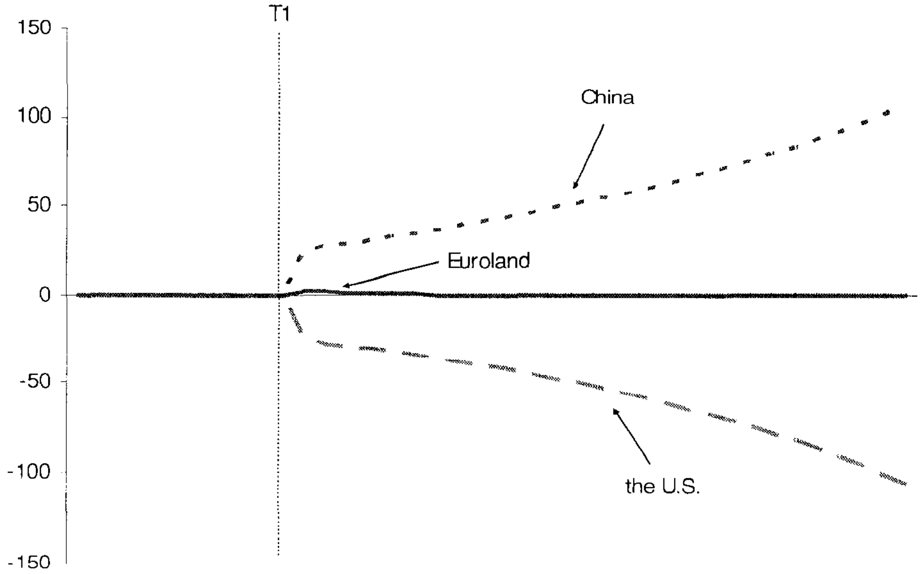


Figure 1-38: Impact on the government budget balance



Experiment 6: An increase in the propensity of China to import goods from Euroland

Figure 1-39: Impact on GDP

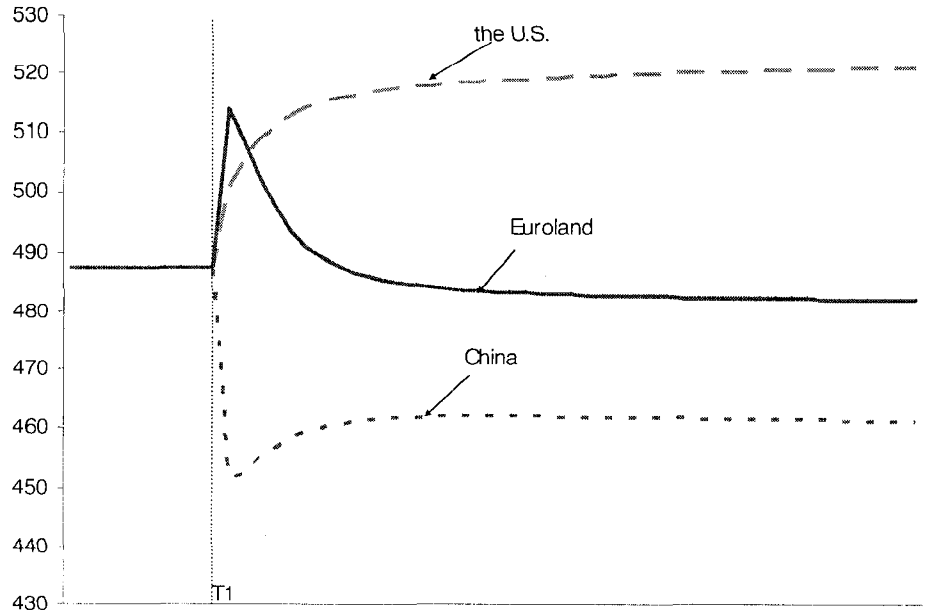


Figure 1-40: Impact on consumption

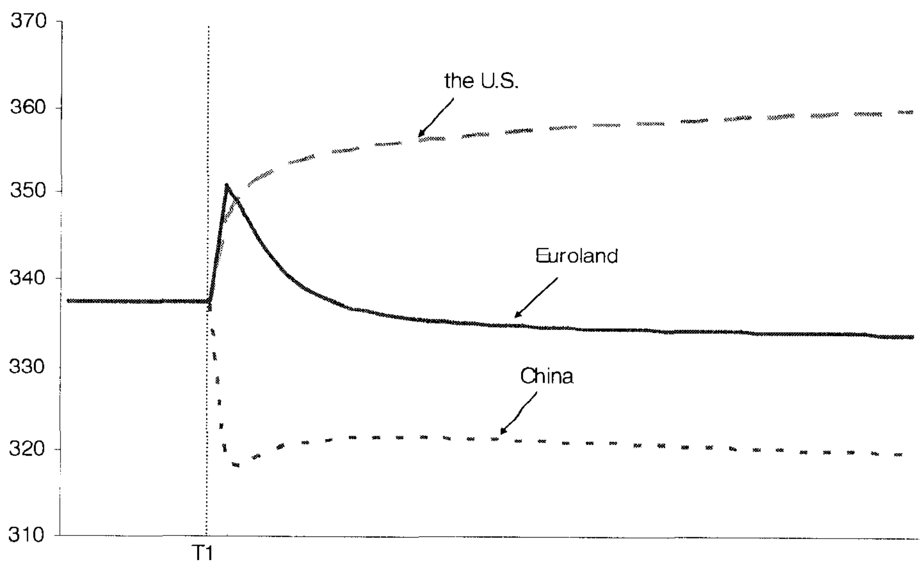


Figure 1-41: Impact on gross investment

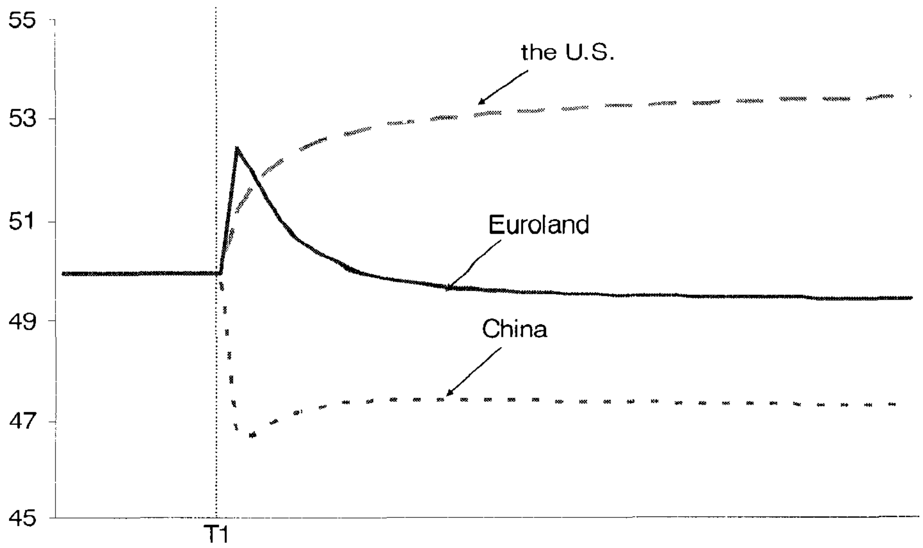


Figure 1-42: Impact on the trade balance

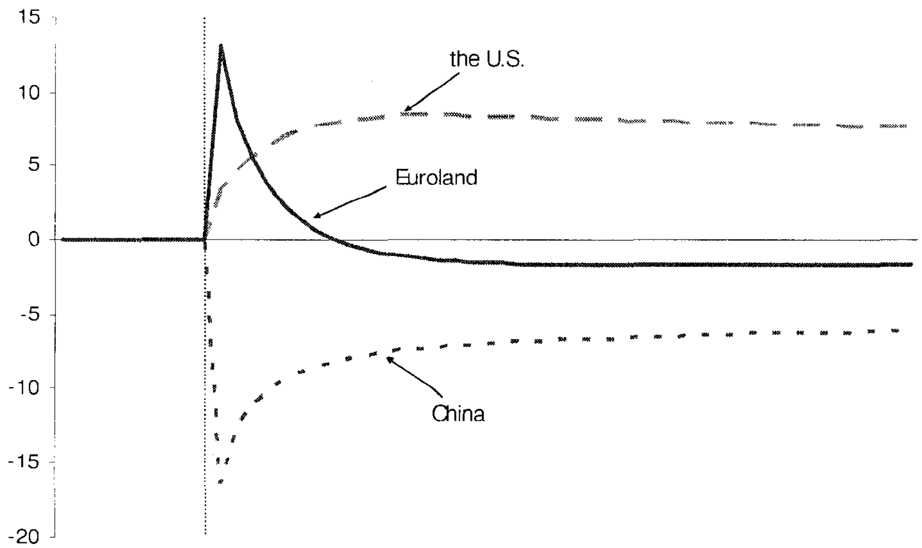


Figure 1-43: The value of the Dollar in terms of the Euro

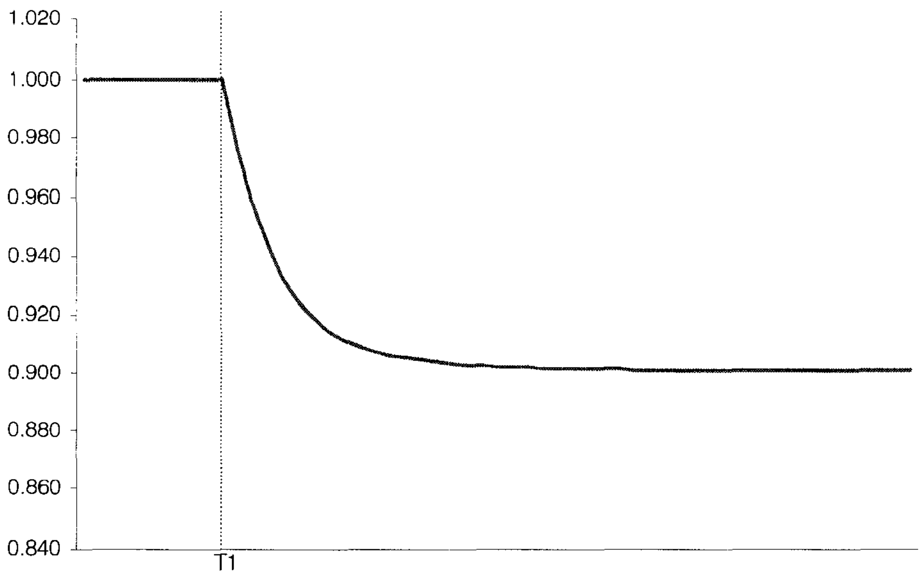


Figure 1-44: Impact on the current account balance

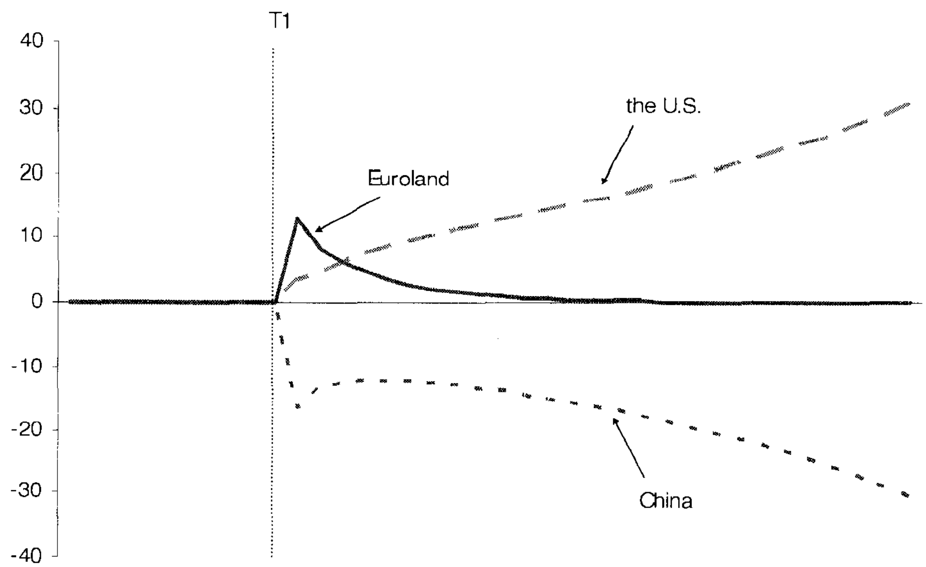
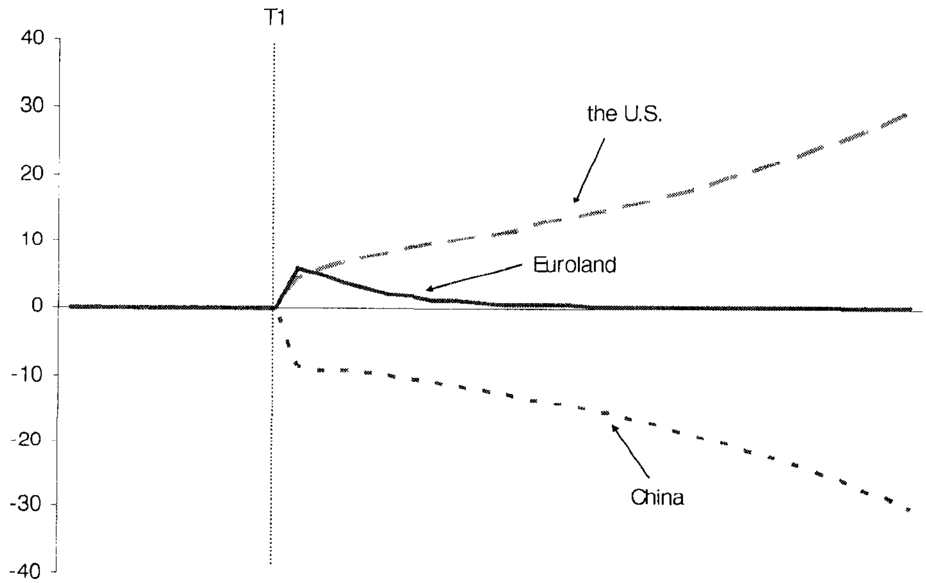


Figure 1-45: Impact on the government budget balance



Experiment 7: An increase in the propensity of Euroland to import goods from China

Figure 1-46: Impact on GDP

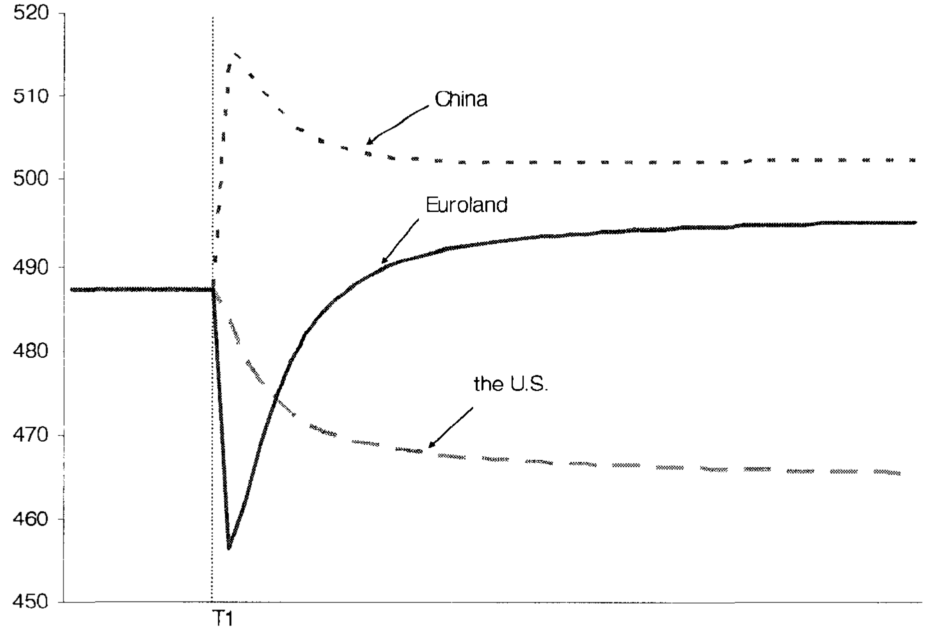


Figure 1-47: Impact on consumption

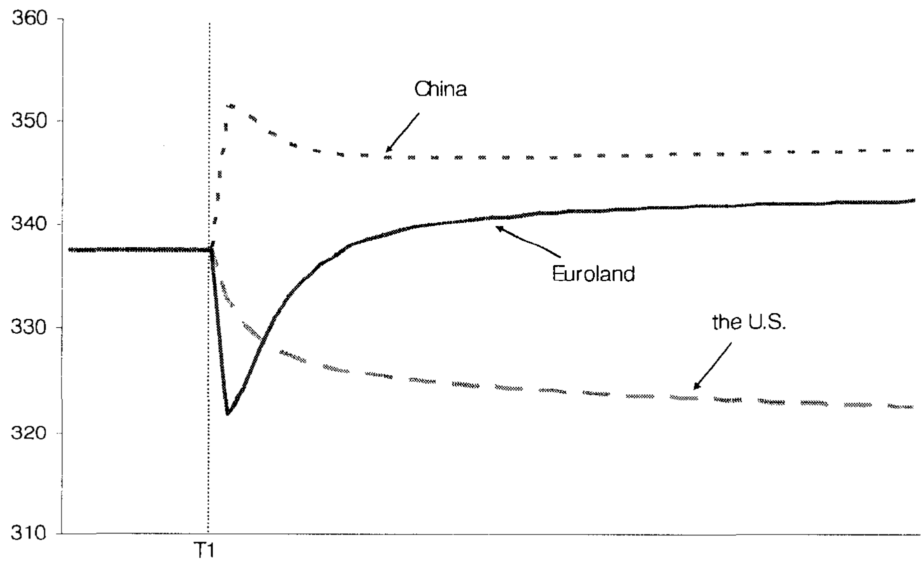


Figure 1-48: Impact on gross investment

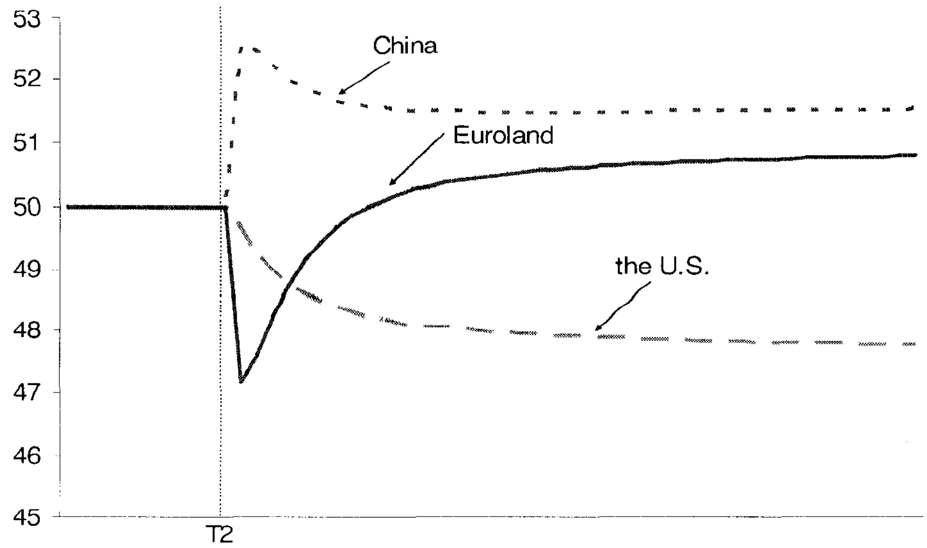


Figure 1-49: Impact on the trade balance

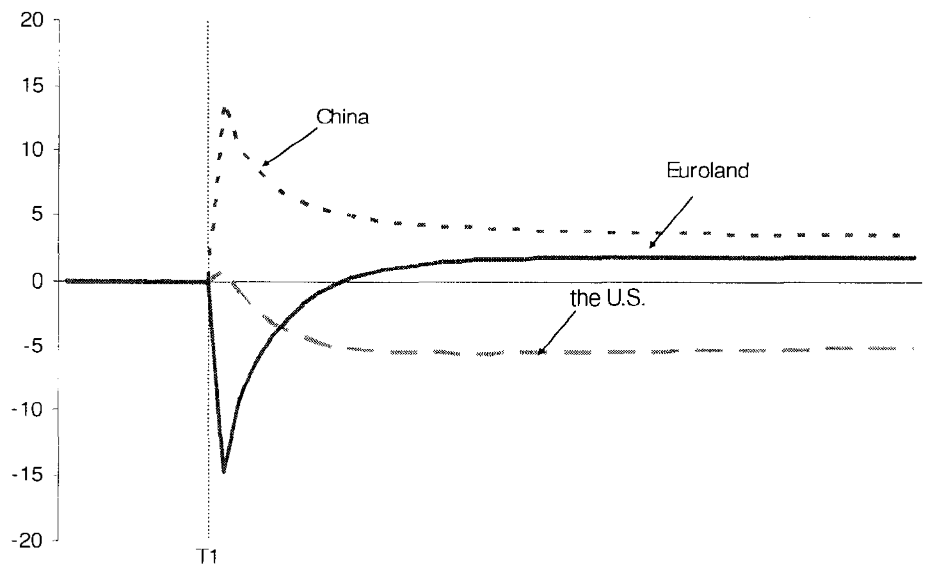


Figure 1-50: The value of the Dollar in terms of the Euro

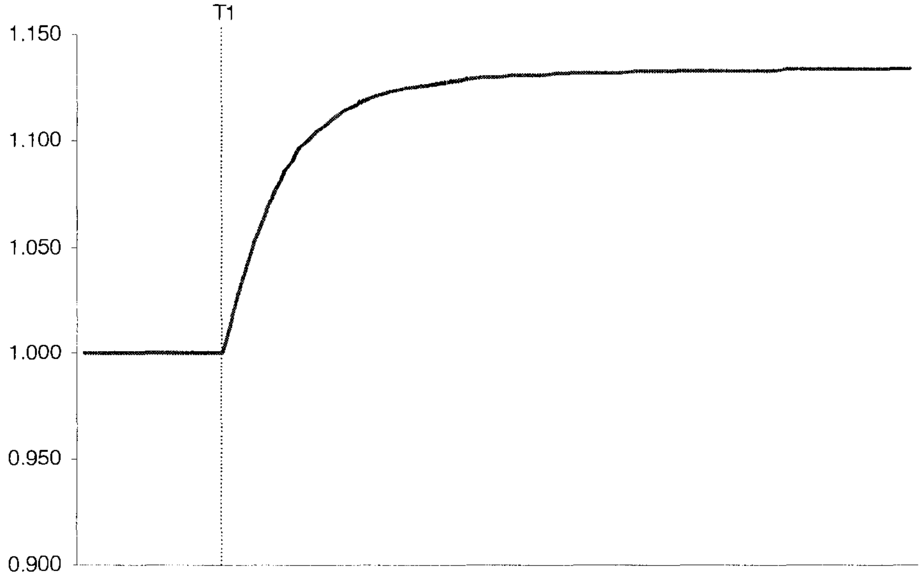


Figure 1-51: Impact on the current account balance

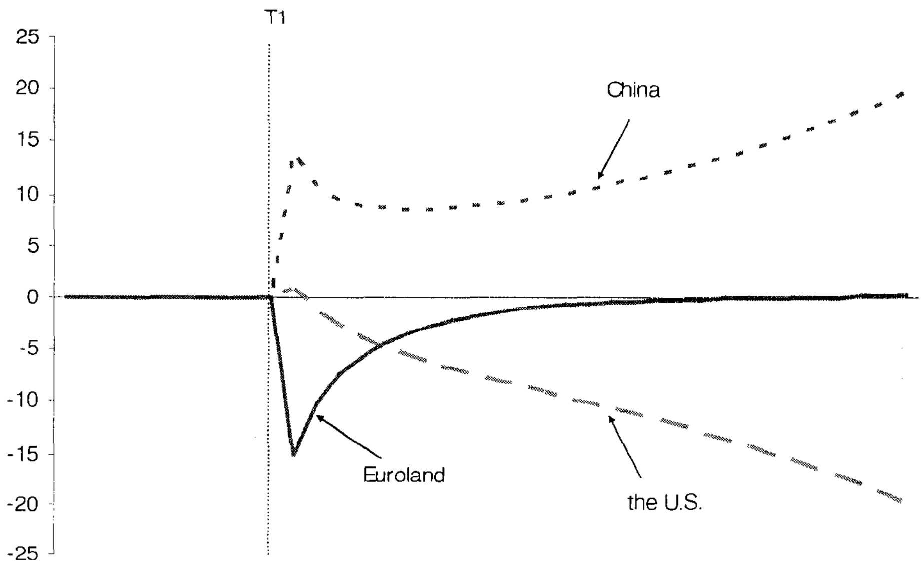
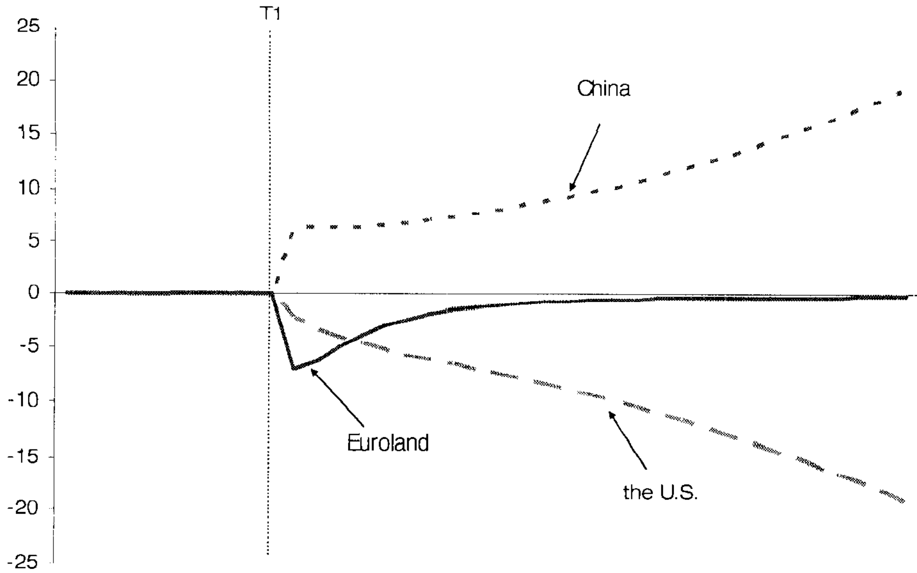


Figure 1-52: Impact on the government budget balance



2 Essay Two: A Three-Country Model with Fixed and Floating Exchange Rates Under a Stock-Flow Consistent Approach - A Study of the Diversification of China's Foreign Reserves

2.1 Introduction

Based on the data released by the China's State Administration of Foreign Exchange, China's total foreign exchange reserves rose to US$1.8 trillion at the end of June 2008. China's foreign reserves have exceeded those of Japan to become the largest in the world. The Chinese export boom, rapid growth of trade surplus and inflows of foreign direct investment have been mainly responsible for the huge accumulation of reserves.[12] China has invested a large part of its foreign reserves in US treasury bills and bonds and other US dollar securities. In order to finance its huge current account deficits, the United States has relied heavily on Asian purchases of its debt. Over the last few years, there has been some debate about the impact of the diversification of China's foreign reserves – changing the currency composition of its reserve portfolio or shift it across different asset classes.

Some Chinese economists (Zheng and Yi , 2007; Wang, 2006) have emphasized that China's huge foreign exchange accumulation has created large opportunity costs and wealth losses due to a weakening dollar, exacerbated inflationary pressures, and intensified pressure for the renminbi appreciation. They have estimated that China's actual reserves have far exceeded what could be considered as their normal demand. They have suggested that the objective of China should be to maintain an optimal level as a whole through diversification of foreign exchange reserves, and by spending and investing reserves. The diversification of reserves would allow China to shift more of its increasing foreign holdings into European and Asian bonds, to reduce its exposure to dollar denominated assets, thus alleviating fears over a weakening dollar. However, a shift away from dollar assets by China could destabilize financial markets and put upward pressure on U.S. interest rates. Therefore, they conclude that a gradual small–scale diversification of reserves out of the dollar would be beneficial and preferable.

Dooley, Folkerts-Landau, and Garber (2004) have argued that a portfolio shift in the foreign reserves of Asian countries would induce an appreciation of the euro. Dullien (2007) uses a simple three-asset-portfolio model to present an analytical framework to examine the impact of the diversification of the reserve holdings of Asian central banks, focusing on answering the questions raised from a European perspective both graphically and

[12] Speculative capital inflows are also one of main factors contributing to the increase in Chinese foreign reserves.

mathematically.[13] The results show that: (1) the dollar would plunge against the euro if Asian central banks stop buying dollars; (2) the diversification of the reserve holdings of Asian central banks would lead to a depreciation of the dollar against the euro; and (3) Asian central banks can keep the peg against the dollar intact and diversify their portfolios by buying euros and selling their own currency. Dullien concludes that a more threatening scenario from the European perspective would be for Asian central banks to move from buying dollars towards buying euros, because the euro would then strongly appreciate against the dollar and the competitiveness of European industries in the world markets would be affected negatively.

Based on imperfect substitutability in both goods and assets markets, Blanchard, Giavazzi, and Sa (2005) develop a simple portfolio balance model of exchange rate and current account determination, and extend the model to four regions such as the U.S., China, Japan, and the Euro Area. They use the model to discuss changes in the composition of reserves by Asian central banks, changes in U.S. interest rates, and changes in the peg of the Renminbi. They find that the path of adjustment is likely to be associated primarily with a further appreciation of the euro vis-à-vis the dollar, and with an appreciation of Asian currencies such as the yen and renminbi. They conclude that a large fall in the dollar leads to higher demand and higher output and offers the opportunity to reduce budget deficits without triggering a recession for the United States. A result for the authors is that it is not by itself a catastrophe for the U.S., while the danger is more serious for Japan and Western Europe.

This paper will focus on analyzing the diversification of currency composition of China's reserve portfolio using a three-country model with a stock-flow consistent approach. I will extend the first essay of my Ph.D. dissertation by relaxing the assumption that China's central bank does not hold Treasury bonds in Euro. In this paper, I assume that China will change the currency composition of its foreign portfolio reserves, that is, shift a proportion of its reserve holdings away from dollar bills towards euro bills, as Chinese foreign reserves continue to accumulate. The purpose of the paper is to examine how the diversification of Chinese foreign reserves will impact on the economies of China, the U.S., and Euroland.

The main differences between my work and that of Blanchard et al. (2005) and also of Dullien (2007) are that in this paper,

[13] The three currencies used by Dullien are the Euro, the Dollar, and the Yen.

- The model is based on a stock-flow consistent approach with all supply and demand equations dealing with portfolio balance, and adding-up properties;
- There are five sectors in my model, such as households, firms, commercial banks, government, and central bank;
- All relevant variables are endogenous, such as GDP, consumption, investment, taxes, debt servicing, the money supply, imports, exports, the current account and the capital account, the exchange rate, ...;
- The model is solved and simulated by using EViews software; and
- Both the short-run and long-run impacts of internal and external shocks are examined, while Dullien (2007) only looked at short-run effects.

The remainder of the paper is organized as follows. Section 2 describes social accounting matrices of a three-country economy. Section 3 sets up a three-country model with fixed and floating exchange rates based on a stock-flow consistent approach. Section 4 presents experiments and simulation results for diversification of China's reserve holdings – as they shift away from dollar securities towards euro securities. The first diversification experiment is based on the assumption that the large accumulation of China's foreign reserves is caused by an increase in the propensity of the U.S. to import goods from China. The second experiment is based on the assumption that the increase in China's reserves is a consequence of an increase in government spending of the United States. The third experiment deals with a sensitivity analysis. Comparisons of the main results relative to those of my first essay are also made for several key variables. Section 5 presents an alternative closure of the model by setting a target percentage composition of China's foreign reserves. Section 6 summarizes and concludes.

2.2 The matrices of a three-country economy

Similar to my first essay, there are three countries in the new model, such as China, the U.S., and Euroland. I assume that each economy contains the following five sectors: households, firms, commercial banks, central bank, and government. China and the U.S. are tied up by a fixed exchange rate, while Europe is on a floating exchange rate regime with China and the U.S. However, the main change in this new model is that we relax the assumption that bills issued by the European government and held by China's central bank are constant. Now, we assume that China's central bank starts to diversify its foreign reserves from time T_2 as its foreign reserves accumulate.[14]

< Table 2-1 >

Table 2-1 is the stock matrix of the three countries. As shown in Table 1, all the columns sum to zero and all the rows related to assets, liabilities, and net worth sum to zero except tangible capital K and wealth balance.[15] The change in this stock matrix is that $Bcb_{3,2,t}$, bills issued by the European Central Bank and held by China's Central Bank, is an endogenous variable instead of being a constant.

< Table 2-2 >

Table 2-2 is the transactions-flow matrix of the three countries. Since $Bcb_{3,2,t}$ is now assumed to be endogenous, the flows of interest payments between the European and Chinese central banks, the profits of central banks and of governments, and changes in the portfolios of central banks and households, etc., will all be affected, in particular, $\Delta Bcb_{3,2}$ will not be necessarily equal to zero.

2.3 The Model

Most of the equations of the model with foreign reserves diversification are identical to those of my first essay. Thus, equations dealing with the national income identity, exports, households, firms, private commercial banks, and governments are identical in these two models. Changes are required in the equations dealing with the Chinese central bank, the exchange rate

[14] In this paper, we will give two kinds of shocks to the model: at time T_1, the U.S. increases it propensity to import goods from China or increases its government expenditures; at time T_2, China starts to diversify its foreign reserves.

[15] Tangible capital is not simultaneously an asset and a liability (Godley and Lavoie, 2007). Since $\sum k + \sum(-V) = 0$, the last column also sums to zero.

determination and the Chinese current account and capital account. The following equations in this essay are different from those in my first essay: equation (10), (11), (12), (13), (14), (15), (72), (73), (75), (75a), (75b), (79), (85), (87), and (88). More detail about the changes will be presented in section 3.7 and 3.8.

2.3.1 National income identity and trade

(1) $Y_{i,t} \equiv C_{i,t} + G_{i,t} + I_{i,t} + X_{i,t} - IM_{i,t}$

(2) $X_{i,t} = \sum_{j(j \neq i)} X_{i,j,t}$ $\quad$ *i, j=1,2,3*

(3) $X_{1,2,t} = IM_{2,1,t} / E_{1,t}$

(4) $X_{1,3,t} = IM_{3,1,t} / E_{2,t}$

(5) $X_{2,1,t} = IM_{1,2,t} \cdot E_{1,t}$

(6) $X_{2,3,t} = IM_{3,2,t} / E_{3,t}$

(7) $X_{3,1,t} = IM_{1,3,t} \cdot E_{2,t}$

(8) $X_{3,2,t} = IM_{2,3,t} \cdot E_{3,t}$

(9) $IM_{i,t} = \sum_{j(j \neq i)} IM_{i,j,t}$ $\quad$ *i, j =1, 2, 3*

(10) $im_{1,2,t} = \mu_{10} + \mu_{11} \cdot y_{1,t} + \mu_{12} \cdot e_{1,t}$

(11) $im_{1,3,t} = \mu_{13} + \mu_{14} \cdot y_{1,t} + \mu_{15} \cdot e_{2,t}$

(12) $im_{2,1,t} = \mu_{20} + \mu_{21} \cdot y_{2,t} + \mu_{22} \cdot (1/e_{1,t})$

(13) $im_{2,3,t} = \mu_{23} + \mu_{24} \cdot y_{2,t} + \mu_{25} \cdot e_{3,t}$

(14) $im_{3,1,t} = \mu_{30} + \mu_{31} \cdot y_{3,t} + \mu_{32} \cdot (1/e_{2,t})$

(15) $im_{3,2,t} = \mu_{33} + \mu_{34} \cdot y_{3,t} + \mu_{35} \cdot (1/e_{3,t})$

(16) $e_{1,t} = E_{1,t}$

(17) $e_{2,t} = E_{2,t}$

(18) $e_{3,t} = E_{3,t}$

Here Y denotes nominal gross domestic products *(GDP)*, C denotes nominal consumption, G is nominal government spending, I is investment, X is nominal export, and IM is nominal import. The subscript *"i"* on a variable stands for the country, with $i=1, 2, 3$, representing the U.S., Euroland, and China respectively. The subscript *"t"* stands for a time index. X_i is the exports of country i which are the sum of exports to the other two countries. $X_{i,j}$ stands for the exports of country i to country j. The exports of one country are the imports of the other country. E_1 (the nominal exchange rate between the Dollar and the Euro) denotes the price of the Dollar in terms of the Euro. E_2 (the nominal exchange rate between the Dollar and the RMB) denotes the price of the Dollar in terms of the RMB. E_3 (the nominal exchange rate between the Euro and the RMB) denotes the price of Euro in terms of the RMB. IM_i is the imports of country i which are the sum of the imports from the other two countries. $IM_{i,j}$ stands for the imports of the country i from country j. Lower-case letters $im_{i,j}$ and y_i denote natural logs, in contrast to the equations of the first essay. e_1 denotes the real exchange rate between the Dollar and the Euro, e_2 denotes the real exchange rate between the Dollar and the RMB, e_3 denotes the real exchange rate between the Euro and the RMB. Imports are determined in each country by the relevant income and exchange rate.[16]

Suppose that the domestic and foreign price levels are fixed. There is no inflation. If we assume that $P_{1,t}=P_{2,t}=P_{3,t}=1$ (where P_i denotes the price level of economy i), then the nominal exchange rate is equal to real exchange rate, and the real exchange rates can be replaced by the nominal exchange rate. Equations (16)-(18) reflect the assumption.

2.3.2 Households

Households are assumed to hold a diversified portfolio of assets. Households' assets consist of high powered money, deposits, bills issued by the domestic government, and bills issued by foreign governments. I assume that these assets are imperfect substitutes. The allocation of the assets varies in response to changes in rates of return and risk considerations.

$$(19) \qquad YP_{1,t} = W_{1,t} + r_{b,1,t-1} \cdot Bh^d_{1,1,t-1} + r_{b,2,t-1} \cdot Bh^d_{1,2,t-1} + r_{b,3,t-1} \cdot Bh^d_{1,3,t-1}$$

[16] In this paper, I have changed the import functions and made them more appropriate.

$$+r_{m,1,t-1}\cdot M_{1,t-1}+Bh^{d}_{1,2,t-1}\cdot\Delta(1/e_{1,t})+Bh^{d}_{1,3,t-1}\cdot\Delta(1/e_{3,t})$$

(20) $$YP_{2,t}=W_{2,t}+r_{b,1,t-1}\cdot Bh^{d}_{2,1,t-1}+r_{b,2,t-1}\cdot Bh^{d}_{2,2,t-1}+r_{b,3,t-1}\cdot Bh^{d}_{2,3,t-1}$$
$$+r_{m,2,t-1}\cdot M_{2,t-1}+Bh^{d}_{2,1,t-1}\cdot\Delta(e_{1,t})+Bh^{d}_{2,3,t-1}\cdot\Delta(1/e_{3,t})$$

(21) $$YP_{3,t}=W_{3,t}+r_{b,1,t-1}\cdot Bh^{d}_{3,1,t-1}+r_{b,2,t-1}\cdot Bh^{d}_{3,2,t-1}+r_{b,3,t-1}\cdot Bh^{d}_{3,3,t-1}$$
$$+r_{m,3,t-1}\cdot M_{3,t-1}+Bh^{d}_{3,1,t-1}\cdot\Delta(e_{2,t})+Bh^{d}_{3,2,t-1}\cdot\Delta(e_{3,t})$$

(22) $M^{s}_{1,t}=M^{d}_{1,t}=M_{1,t}$

(23) $Bh^{s}_{i,i,t}=Bh^{d}_{i,i,t}$ $\quad i=1,2,3$

(24) $Bh^{s}_{1,2,t}=Bh^{d}_{1,2,t}\cdot e_{1}$

(25) $Bh^{s}_{1,3,t}=Bh^{d}_{1,3,t}\cdot e_{2}$

(26) $Bh^{s}_{2,1,t}=Bh^{d}_{2,1,t}/e_{1}$

(27) $Bh^{s}_{2,3,t}=Bh^{d}_{2,3,t}\cdot e_{3}$

(28) $Bh^{s}_{3,1,t}=Bh^{d}_{3,1,t}/e_{2}$

(29) $Bh^{s}_{3,2,t}=Bh^{d}_{3,2,t}/e_{3}$

(30) $YD_{i,t}=YP_{i,t}-T_{i,t}$

(31) $T_{i,t}=\vartheta_{i}\cdot YP_{i,t}$

(32) $V_{i,t}=V_{i,t-1}+YD_{i,t}-C_{i,t}$

(33) $C_{i,t}=\alpha_{i,1}YD_{i,t}+\alpha_{i,2}V_{i,t-1}$

(33') $\Delta V_{i,t}=\alpha_{i,2}(\alpha_{i,3}YD_{i,t}-V_{i,t-1})$

Here r_b denotes the interest rate of bills, r_m denotes the interest rate of deposits, W denotes the wage incomes of the households, *M* denotes deposits, *YP* denotes households' realized nominal income, and $Bh^{d}_{i,j}$ denotes bills demanded by country i households, but issued by the country j government. The superscript "s" on a variable stands for supply, and the superscript "d" stands for demand. $Bh^{s}_{i,j}$ denotes bills supplied to the country i households, but issued by the country j government. ϑ_i denotes the tax rate, and $0 < \theta < 1$. The net wealth of the households, V. 0<$\alpha_{i,1}$, $\alpha_{i,2}$<1. $\alpha_{i,3} = (1-\alpha_{i,1})/\alpha_{i,2}$, and $\alpha_{i,3}$ is a target wealth to income ratio.

Equation (19)-(21) mean that the realized nominal incomes of households consist of wages, interest payments from domestic bills, interest payments from foreign bills, deposit interest payments and capital gains due to changes in the exchange rates. Equation (22) implies that banks accept to take in all deposits demanded by households. Equations (23)-(29) mean that the government supplies bills to households on demand. The disposal income of households is equal to the realized nominal income minus taxes. The consumption of households depends on their disposal income and net wealth of the previous period. The consumption functions can be rewritten as wealth adjustment functions.

According to the Brainard-Tobin (1968) pitfalls approach and to the Post-Keynesian version developed by Godley (1999), in each country households allocate their wealth among domestic high powered money, domestic deposits, and government bills issued by the domestic government and/or bills issued by foreign governments. The portfolio equations for the U.S. households are:

$$Hh^d_{1,t}/V_{1,t} = \lambda_{1,00} + \lambda_{1,01}\cdot r_{b,1,t} + \lambda_{1,02}\cdot r_{b,2,t} + \lambda_{1,03}\cdot r_{b,3,t} + \lambda_{1,04}\cdot r_{m,1,t} \quad (34)$$

$$Hh^d{}_{1,t} = V_{1,t} - Bh_{1,1,t} - Bh^d{}_{1,2,t} - Bh^d{}_{1,3,t} - M^s{}_{1,t} \quad (34')$$

$$Bh^d_{1,1,t}/V_{1,t} = \lambda_{1,10} + \lambda_{1,11}\cdot r_{b,1,t} + \lambda_{1,12}\cdot r_{b,2,t} + \lambda_{1,13}\cdot r_{b,3,t} + \lambda_{1,14}\cdot r_{m,1,t} \quad (35)$$

$$Bh^d_{1,2,t}/V_{1,t} = \lambda_{1,20} + \lambda_{1,21}\cdot r_{b,1,t} + \lambda_{1,22}\cdot r_{b,2,t} + \lambda_{1,23}\cdot r_{b,3,t} + \lambda_{1,24}\cdot r_{m,1,t} \quad (28)$$

$$Bh^d_{1,3,t}/V_{1,t} = \lambda_{1,30} + \lambda_{1,31}\cdot r_{b,1,t} + \lambda_{1,32}\cdot r_{b,2,t} + \lambda_{1,33}\cdot r_{b,3,t} + \lambda_{1,34}\cdot r_{m,1,t} \quad (36)$$

$$M^d_{1,t}/V_{1,t} = \lambda_{1,40} + \lambda_{1,41}\cdot r_{b,1,t} + \lambda_{1,42}\cdot r_{b,2,t} + \lambda_{1,43}\cdot r_{b,3,t} + \lambda_{1,44}\cdot r_{m,1,t} \quad (37)$$

Where *Hh* is the high powered money issued by the central bank, and $L^s_{i,t}$ denotes supply of loans.[17]

[17] The vertical adding-up constraints were emphasized by Tobin (1969). I suppose that the horizontal adding-up constraints also hold. The horizontal constraint was emphasized by Godley (1996). The horizontal constraint is that in each portfolio equation, the sum of all the coefficients on rates of return should be zero.

The portfolio equations for the households of Euroland are:

$$(38)\quad Hh^{d}_{2,t}/V_{2,t} = \lambda_{2,00} + \lambda_{2,01}\cdot r_{b,1,t} + \lambda_{2,02}\cdot r_{b,2,t} + \lambda_{2,03}\cdot r_{b,3,t} + \lambda_{2,04}\cdot r_{m,2,t}$$

$$(38')\quad Hh^{d}_{2,t} = V_{2,t} - Bh^{d}_{2,1,t} - Bh^{d}_{2,2,t} - Bh^{d}_{2,3,t} - M^{s}_{2,t}$$

$$(39)\quad Bh^{d}_{2,1,t}/V_{2,t} = \lambda_{2,10} + \lambda_{2,11}\cdot r_{b,1,t} + \lambda_{2,12}\cdot r_{b,2,t} + \lambda_{2,13}\cdot r_{b,3,t} + \lambda_{2,14}\cdot r_{m,2,t}$$

$$(40)\quad Bh^{d}_{2,2,t}/V_{2,t} = \lambda_{2,20} + \lambda_{2,21}\cdot r_{b,1,t} + \lambda_{2,22}\cdot r_{b,2,t} + \lambda_{2,23}\cdot r_{b,3,t} + \lambda_{2,24}\cdot r_{m,2,t}$$

$$(41)\quad Bh^{d}_{2,3,t}/V_{2,t} = \lambda_{2,30} + \lambda_{2,31}\cdot r_{b,1,t} + \lambda_{2,32}\cdot r_{b,2,t} + \lambda_{2,33}\cdot r_{b,3,t} + \lambda_{2,34}\cdot r_{m,2,t}$$

$$(42)\quad M^{d}_{2,t}/V_{2,t} = \lambda_{2,40} + \lambda_{2,41}\cdot r_{b,1,t} + \lambda_{2,42}\cdot r_{b,2,t} + \lambda_{2,43}\cdot r_{b,3,t} + \lambda_{2,44}\cdot r_{m,2,t}$$

Where $0< | \lambda_{2,ij} | < 1$, $i,j=0,1,2,3,4$.

Portfolio equations for China's households are:

$$(43)\quad Hh^{d}_{3,t}/V_{3,t} = \lambda_{3,00} + \lambda_{3,01}\cdot r_{b,1,t} + \lambda_{3,02}\cdot r_{b,2,t} + \lambda_{3,03}\cdot r_{b,3,t} + \lambda_{3,04}\cdot r_{m,3,t}$$

$$(43')\quad Hh^{d}_{3,t} = V_{3,t} - Bh^{d}_{3,1,t} - Bh^{d}_{3,2,t} - Bh^{d}_{3,3,t} - M^{s}_{3,t}$$

$$(44)\quad Bh^{d}_{3,1,t}/V_{3,t} = \lambda_{3,10} + \lambda_{3,11}\cdot r_{b,1,t} + \lambda_{3,12}\cdot r_{b,2,t} + \lambda_{3,13}\cdot r_{b,3,t} + \lambda_{3,14}\cdot r_{m,3,t}$$

$$(45)\quad Bh^{d}_{3,2,t}/V_{3,t} = \lambda_{3,20} + \lambda_{3,21}\cdot r_{b,1,t} + \lambda_{3,22}\cdot r_{b,2,t} + \lambda_{3,23}\cdot r_{b,3,t} + \lambda_{3,24}\cdot r_{m,3,t}$$

$$(46)\quad Bh^{d}_{3,3,t}/V_{3,t} = \lambda_{3,30} + \lambda_{3,31}\cdot r_{b,1,t} + \lambda_{3,32}\cdot r_{b,2,t} + \lambda_{3,33}\cdot r_{b,3,t} + \lambda_{3,34}\cdot r_{m,3,t}$$

$$(47)\quad M^{d}_{3,t}/V_{3,t} = \lambda_{3,40} + \lambda_{3,41}\cdot r_{b,1,t} + \lambda_{3,42}\cdot r_{b,2,t} + \lambda_{3,43}\cdot r_{b,3,t} + \lambda_{3,44}\cdot r_{m,3,t}$$

Where $0 < | \lambda_{3,ij} | < 1$, $j,k=0,1,2,3,4$, and the vertical constraints and horizontal constraints must hold.

2.3.3 Firms

Firms do not hold cash money, deposits, and bills. They only hold tangible capital *K*. The net investment of firms is wholly financed by loans, taken from commercial banks. The firms of each country produce one type of final good. The goods are imperfect substitutes for foreign goods, and their production requires the use of imported intermediate inputs.

$$(48)\quad S_{i,t}=C_{i,t}+G_{i,t}+I_{i,t}+X_{i,t}$$

$$(48')\quad S_{i,t}-IM_{i,t}=Y_{i,t}$$

$$(49)\quad W_{i,t}=S_{i,t}-r_{l,i,t-1}L_{i,t-1}-DA_{i,t}-IM_{i,t}$$

$$(49')\quad W_{i,t}=Y_{i,t}-r_{l,i,t-1}L_{i,t-1}-DA_{i,t}$$

$$(50)\quad K_{i,t}=(1-\delta_i)K_{i,t-1}+I_{i,t}$$

$$(51)\quad I_{i,t}=\gamma_i(K_{i,t}{}^T-K_{i,t-1})+DA_{i,t}$$

$$(52)\quad K_{i,t}{}^T=\kappa_{i,t}\cdot S_{i,t-1}$$

$$(53)\quad \kappa_{i,t}=\zeta_{i,1}-\zeta_{i,2}\cdot r_{i,t}$$

$$(54)\quad DA_{i,t}=\delta_i K_{i,t-1}$$

$$(55)\quad \Delta L_{i,t}^d=I_{i,t}-DA_{i,t}$$

Where *DA* denotes depreciation, *L* denotes loan demand, and r_l denotes loan interest rate. *K* denotes stock of capital, δ denotes the rate of depreciation, 0<δ<1, and K^T denotes the capital stock target, κ_i denotes target ratio of capital to sales, $0<\gamma_i<1$, and $0<\zeta_{i,1}, 0<\zeta_{i,2}$. $L_{i,t}^d$ is demand for loans.

The sales of the firms are expressed in equation (48) and (48'). Because we suppose that the net profits of the firms are zero, wages can be described in the form of equation (49) and (49'). Equations (51)-(54) describe the firms' investment behaviour. The targeted capital stock (K^T) depends on the sales achieved in the previous period (S_{t-1}), and on the target ratio of capital to sales (κ_i). The target ratio of capital to sales (κ_i) has a negative relationship with the interest rate. The net investment, $\gamma_i(K_{i,t}{}^T-K_{i,t-1})$, is partially adjusted to the discrepancy between the targeted capital stock and the previous capital stock. Gross investment (*I*) is the sum of net investment and depreciation. From equations (50) and (51), we have that: $\Delta K_{i,t}=\gamma_i(K_{i,t}{}^T-K_{i,t-1})$. Since I assumed that net profits of firms are zero, net investment must be financed by loans taken from private banks.

2.3.4 Commercial banks

The private banking system is highly simplified in my model. Private banks have zero net wealth. Since private banks are assumed not to make profits, the interest rate on deposits is equal to the interest rate on loans. We assume that the U.S. and Euroland are auto-economies (Hicks, 1974) or asset-based financial systems (Lavoie, 2006). In the U.S. and Euroland, private banks hold loans and bills issued by the government of their own country. Private banks supply loans on demand to firms. There are no loans made to households. The liabilities of private banks in the U.S. and Euroland are only made up of deposits from households. I suppose however that China is an overdraft economy. Besides the deposits from households, commercial banks in China can also borrow from the central bank of China and Chinese commercial banks only hold loans as assets.

(56)	$L^s_{i,t} = L^d_{i,t} \equiv L_{i,t}$	$i=1,2,3$
(57)	$M_{i,t} = L_{i,t} + Bcmb_{i,i,t}$	$i=1,2.$
(58)	$A_{3,t} \equiv L_{3,t} - M_{3,t}$	
(58')	$M_{3,t} + A_{3,t} \equiv L_{3,t}$	
(59)	$r_{m,i,t} = r_{l,i,t} \equiv r_{i,t}$	$i=1,2,3.$
(60)	$r_{A,3,t} = r_{3,t}$	

Where A denotes the advances made by the central bank of China and $Bcmb_{i,i}$ stands for bills held by commercial banks of country i and issued by the government of country i.

Equations (56) reflects the assumptions that the supply of loans is equal to the demand of the loans. Equation 58 reflects the balance sheet of commercial banks of the U.S. and Euroland. Equation (58) reflects the balance sheet of Chinese commercial banks. The advances from the central bank are equal to the discrepancy between loans and deposits. Equation (59) and (60) reflect the assumption that interest rates on loans, deposits and Treasury bills are equal, and for China, interest rates on advances are also equal to interest rates on loans.

2.3.5 Government

Each government issues bills denominated in its own currency. B_i describes bills issued by the government of country i $(i=1,2,3)$. 1, 2, and 3 denote the U.S., Euroland, and China respectively. B_1, B_2 and B_3 are denominated in Dollar, Euro and RMB, respectively. I assume (perfect) capital mobility. $Bh_{i,j}$ denotes the bills issued by the government of country j, but held by the households of country i. $Bcb_{i,j}$ denotes the bills issued by the government of country j, but held by the central bank of country i.

(61) $\Delta B_{i,t} = (G_{i,t} + r_{b,i,t-1}B_{i,t-1}) - (T_{i,t} + F_{i,t})$

(61a) $B_{i,t} = B_{i,t-1} + (G_{i,t} + r_{b,i,t-1}B_{i,t-1}) - (T_{i,t} + F_{i,t})$

(62) $G_{i,t} = \overline{G_i}$ $\quad i=1,2,3$

(63) $r_{b,i,t} = r_{i,t}$

Where F denotes the profits of the central bank.

Equation (61) is the government budget constraint. The bills newly issued by the government are equal to government expenditures minus government revenues which consist of taxes and central bank profits transferred to the government. Equation (62) indicates that (pure) government spending is an exogenous variable. Equation (63) reflects the assumption that the interest rate on bills is equal to the interest rate on deposits and loans.

2.3.6 The Central Bank

Each central bank issues cash money, and holds bills which consist of bills issued by the domestic government and/or bills issued by foreign governments. The foreign bills constitute the foreign reserves of the central bank. The central bank of China also supplies advances to Chinese commercial banks on demand. In each country, high powered money is only held by its domestic households, that is, households of one country do not hold the cash currency of other countries. High powered money is supplied on demand.

(64)	$Hh^{s}_{i,t} = Hh^{d}_{i,t}$
(65)	$\Delta Bcb^{d}_{1,1,t} = \Delta Hh^{s}_{1,t} - \Delta Bcb^{d}_{1,2,t}$
(65a)	$\Delta Bcb^{d}_{1,1,t} = \Delta Hh^{s}_{1,t}$
(66)	$\Delta Bcb^{d}_{2,2,t} = \Delta Hh^{s}_{2,t} - \Delta Bcb^{d}_{2,1,t}$
(66a)	$\Delta Bcb^{d}_{2,2,t} = \Delta Hh^{s}_{2,t}$
(67)	$\Delta Bcb^{d}_{3,1,t} = \Delta Hh^{s}_{3,t} - \Delta Bcb^{d}_{3,3,t} - \Delta Bcb^{s}_{3,2,t} \cdot e_{3,t} - \Delta A^{s}_{3,t} - Bcb^{s}_{3,1,t-1} \cdot \Delta e_{2,t}$
(68)	$Bcb^{d}_{3,1,t} = \Delta Bcb^{s}_{3,1,t} \cdot e_{2} + Bcb^{s}_{3,1,t-1} \cdot \Delta e_{2,t}$
(69)	$Bcb^{s}_{2,2,t} = Bcb^{d}_{2,2,t}$
(70)	$Bcb^{d}_{3,3,t} = Bcb^{s}_{3,3,t}$
(71)	$Bcb^{s}_{1,1,t} = Bcb^{d}_{1,1,t}$
(72)	$Bcb^{s}_{3,2,t} = Bcb^{d}_{3,2,t} / e_{3,t}$
(73)	$Bcb^{d}_{3,2,t} = \beta \cdot Bcb^{d}_{3,1,t} \qquad \beta \geq 0$

Equation (64) means that the cash supplied by the central bank is equal to that demanded by the households. Equations (65)-(66) reflect the balance sheet of the central bank of the U.S. and Euroland. We suppose that the Fed (Federal Reserve Board of the U.S.) and the ECB (the European Central Bank) do not hold bills issued by the Chinese government. Since the exchange rate between the Dollar and the Euro is freely floating, $Bcb^{d}_{1,2,t}$, and $Bcb^{d}_{2,1,t}$ can be set as constants. Because these foreign reserves play no fundamental role in the dynamics of a model with flexible exchange rate, we shall assume that they are equal to nil in the numerical simulations (Godley and Lavoie, 2007a, p. 10).

Equations (68)-(72) reflect the assumptions that the supply of bills to central banks is equal to their demand.[18] The central bank of China holds bills issued by the Chinese government ($Bcb_{3,3}$), bills issued by the U.S. government ($Bcb_{3,1}$), and bills issued by the government of

[18] Since we have two equations (equation 67 and equation 68) to determine $Bcb^{d}_{3,1,t}$, equation (67) will be the hidden, or redundant, equation in the model. This equation is then used to verify that the accounting of the model is correct, and that the data (the stocks) are consistent. Equation (67) reflects the balance sheet constraint of the central bank of China.

Euroland ($Bcb_{3,2}$). $Bcb_{3,1}$ and $Bcb_{3,2}$ compose the foreign reserves of China's central bank. In equation (73), if $\beta = 0$, that is, Chinese central bank does not hold bills issued by the European government, then the model can be simplified to that of my first essay. If $\beta > 0$, we can say that the Chinese central bank diversifies its foreign reserves ($FR_{3,t}$). Therefore, the composition of China's foreign reserves can be expressed as[19]: $Bcb^d_{3,1,t} = \xi_1 \cdot FR_{3,t}$, and $Bcb^d_{3,2,t} = \xi_2 \cdot FR_{3,t}$ where $\xi_1 = \left(\frac{1}{1+\beta}\right)$, $\xi_2 = \left(\frac{\beta}{1+\beta}\right)$, and $\xi_1 + \xi_2 = 1$.

Would such a policy threaten the dollar peg of RBM? In this paper, our experiments and simulations are based on the assumption that China's dollar reserves keep going up over time due to a large trade surplus and current account surplus, especially in the bilateral trade with the U.S. China's dollar reserves are huge enough to keep the peg of RMB against the dollar. Therefore, diversification would not threaten the dollar peg of RBM. This assumption is actually consistent with what the Chinese central bank is currently facing in the real world.

(74) $B^s{}_{1,t} \equiv Bh^s{}_{1,1,t} + Bcmb^s_{1,1,t} + Bcb^s{}_{1,1,t} + Bh^s{}_{2,1,t} + Bh^s{}_{3,1,t} + Bcb^s{}_{3,1,t}$

(74a) $Bcb^s{}_{3,1,t} = B^s{}_{1,t} - Bh^s{}_{1,1,t} - Bcmb^s_{1,1,t} - Bcb^s{}_{1,1,t} - Bh^s{}_{2,1,t} - Bh^s{}_{3,1,t}$

(75) $B^s{}_{2,t} \equiv Bh^s{}_{1,2,t} + Bh^s{}_{2,2,t} + Bcmb^s_{2,2,t} + Bcb^s{}_{2,2,t} + Bh^s{}_{3,2,t} + Bcb^s_{3,2,t}$

(76) $B^s{}_{3,t} \equiv Bh^s{}_{1,3,t} + Bh^s{}_{2,3,t} + Bh^s{}_{3,3,t} + Bcb^s{}_{3,3,t}$

(76a) $Bcb^s{}_{3,3,t} = B^s{}_{3,t} - Bh^s{}_{3,3,t} - Bh^s{}_{1,3,t} - Bh^s{}_{2,3,t}$

(77) $F_{1,t} = r_{1,t-1} \cdot Bcb_{1,1,t-1}$

(78) $F_{2,t} = r_{2,t-1} \cdot Bcb_{2,2,t-1}$

(79) $F_{3,t} = r_{1,t-1} \cdot Bcb^d{}_{3,1,t-1} + r_{3,t-1} \cdot (Bcb_{3,3,t-1} + A_{3,t-1}) + r_{2,t-1} \cdot Bcb^d_{3,2,t-1}$

(80) $r_{1,t} = \overline{r_1}$

(81) $r_{2,t} = \overline{r_2}$

(82) $r_{3,t} = \overline{r_3}$

Where F_i is the central bank's profit of country *i*, *i=1,2,3*.

[19] $FR_{3,t} = Bcb^d_{3,1,t} + Bcb^d_{3,2,t} = (1+\beta) Bcb^d_{3,1,t}$

Equations (74)-(76) describe the identity components of the bills issued by each government. Equation (75) will be used to determine the exchange rate between the Dollar and the Euro in section 2.3.7. Equation (77)-(79) describe the profits of a central bank (F_i) which consist of interest payments from domestic bills, and/or interest payments from foreign bills. The profits of the central bank of China also include interest payments on advances. Equations (80)-(82) affirm that interest rates are exogenous. According to Post-Keynesian monetary theory, and as can be observed in the real world today, central banks use interest rates as their monetary policy instrument.

2.3.7 Exchange rate dynamics

Since we assume that the Chinese currency (RMB) is pegged to the Dollar, the nominal exchange rate between the Dollar and the RMB is fixed.

(83) $e_{2,t} = \overline{e_2}$

For the determination of the flexible exchange rate between the Dollar and Euro, I follow the approach proposed by Godley and Lavoie (2003).

Substituting equation (24) into equation (75), I have (75a):

(75a) $B^s{}_{2,t} \equiv Bh^d{}_{1,2,t} \cdot e_1 + Bh^s{}_{2,2,t} + Bcmb^s_{2,2,t} + Bcb^s{}_{2,2,t} + Bh^s{}_{3,2,t} + Bcb^s_{3,2,t}$

We can rewrite equation (75a) under the form:

(75b) $e_1 = (B^s{}_{2,t} - Bh^s{}_{2,2,t} - Bcmb^s_{2,2,t} - Bcb^s{}_{2,2,t} - Bh^s_{3,2,t} - Bcb^s_{3,2,t}) / Bh^d{}_{1,2,t}$

Equation (75b) describes the determination of the exchange rate between the Dollar and the Euro.

The exchange rate between the RMB and the Euro can be expressed as follows.

(84) $e_{3,t} = e_{2,t} / e_{1,t}$

According to equation (84), if the U.S. Dollar depreciates compared to the Euro, the value of the RMB will also fall relative to the Euro because the RMB is pegged to the U.S. Dollar.

2.3.8 Current account balance

We can derive the following balance of payment identities. We first start with the current account balance:

$$(85)\quad CAB_{1,t} \equiv X_{1,t} - IM_{1,t} + r_{2,t-1} \cdot Bh^{d}{}_{1,2,t-1} + r_{3,t-1} Bh^{d}{}_{1,3,t-1} - r_{1,t-1}(B_{1,t-1} - Bh_{1,1,t-1} - Bcb_{1,1,t-1})$$

$$(86)\quad CAB_{2,t} \equiv X_{2,t} - IM_{2,t} + r_{1,t-1} \cdot Bh^{d}{}_{2,1,,t-1} + r_{3,t-1} Bh^{d}{}_{2,3,t-1} - r_{2,t-1}(B_{2,t-1} - Bh_{2,2,t-1} - Bcb_{2,2,t-1})$$

$$(87)\quad CAB_{3,t} \equiv X_{3,t} - IM_{3,t} + r_{1,t-1} Bcb^{d}{}_{3,1,t-1} + r_{2,t-1} \cdot Bcb^{d}_{3,2,t-1} + r_{1,t-1} Bh^{d}_{3,1,t-1} + r_{2,t-1} Bh^{d}_{2,t-1} - r_{3,t-1}(B_{3,t-1} - Bh_{3,3,t-1} - Bcb_{3,3,t-1})$$

Where *CAB* denotes the current account balance.

In the model introduced above, I have both flexible exchange rates and a fixed exchange rate. The exogenous variables include *government spending* (G_i)*, interest rates* (r_i)*, and* E_2 *(the exchange rate between the Chinese RMB and the Dollar).*[20] The endogenous variables are *GDP*, consumption, investment, capital, wages, imports, exports, government debts, current account balances, loans, deposits, advances, wealth and its allocation among the available assets, the exchange rate between the Dollar and the Euro, and the exchange rate between the RMB and the Euro. $Bcb^{d}_{3,2,t}$ will also be an endogenous variable if $\beta > 0$.

2.4 Experiments

This section presents three experiments. The first two experiments are an extension of those conducted in my first essay. Recall that, starting from the steady state, one experiment in my first essay is to increase the propensity of the U.S. to import goods from China at time T_1, and another one is to increase the U.S. government expenditures at time T_1. Further to these two

[20] Expectations about future exchange rates are set aside.

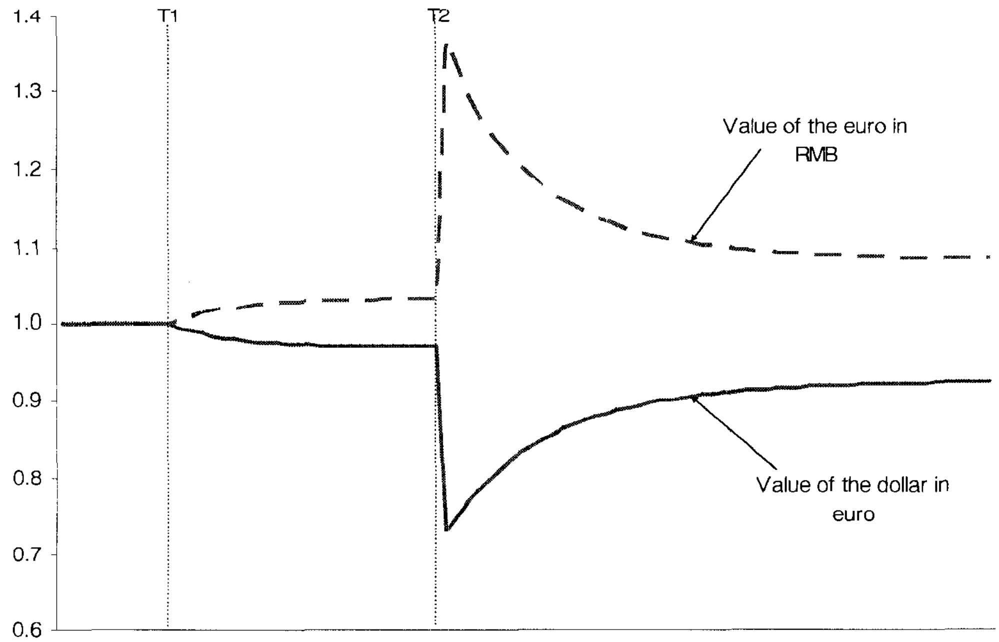
experiments, at time T_2 (T_2>T_1), we assume that China starts to diversify its foreign reserves, that is, to increase β. The simulations will be conducted based on this assumption, focusing on the impact of the diversification of China's foreign reserves. The third experiment will be conducted for the sensitivity analysis, focusing on the impact of different values of β parameter.

2.4.1 Experiment 1: The U.S. increases its propensity to import goods from China at time T_1 and China moves a proportion of its foreign reserves from dollar bills to euro bills starting from time T_2.

As shown in my first essay (Zhao, 2006), an increase in the American propensity to import goods from China at period T_1 leads to an increase in China's foreign reserves, as it creates a trade surplus for China. At time T_2, we assume that the value of β suddenly increases from 0 to 0.2. As described in the new model, the composition of China's foreign reserves will be changed after period T_2. Dollar bills will then constitute roughly 83.3% of Chinese foreign reserves, while euro bills will represent about 16.7% of these Chinese foreign reserves. How will this change affect the exchange rates, trade balances, and GDP of the three countries?

Figure 2-1 shows the dynamic adjustment path for the exchange rates of the euro against the RMB and that of the dollar against the euro. The higher U.S. propensity to import Chinese goods leads to a slight appreciation of the euro with respect to the RMB and the dollar. At time T2, overshooting of exchange rates can be observed. The diversification of China's foreign reserves results in a brisk appreciation in the value of the euro against the dollar and the RMB. This brisk appreciation is then followed by a gradual depreciation of the euro. However, in the new steady state values of the euro against the dollar and the RBM are much higher than those before diversification. This is due to the fact that the diversification of China's reserves leads to an increase in the demand for euro bills, resulting in a further appreciation of the euro vis a vis the dollar and the RBM. These results are similar to those achieved by Blanchard et al. (2007), except for the overshooting effect.

Figure 2-1: Impact of the diversification of China's foreign reserves on the exchange rate



Why does the overshooting effect exist in my model? Recall the exchange rate determination equations (75b) and (84) substituting equation (84) into equation (29) and (72) respectively, we have:

$$(29a)\quad Bh^{s}_{3,2,t} = Bh^{d}_{3,2,t}/e_3 = \frac{Bh^{d}_{3,2,t}}{e_{2,t}/e_{1,t}} = \frac{Bh^{d}_{3,2,t}\cdot e_{1,t}}{e_{2,t}}$$

$$(72a)\quad Bcb^{s}{}_{3,2,t} = Bcb^{d}{}_{3,2,t}/e_{3,t} = \frac{Bcb^{d}_{3,2,t}}{e_{2,t}/e_{1,t}} = \frac{Bcb^{d}_{3,2,t}\cdot e_{1,t}}{e_{2,t}}$$

Substituting (29a) and (72a) into equation (75b), we have:

$$e_1 = \frac{B^{s}{}_{2,t} - Bh^{s}{}_{2,2,t} - Bcmb^{s}_{2,2,t} - Bcb^{s}{}_{2,2,t}}{Bh^{d}{}_{1,2,t} + Bh^{d}_{3,2,t}/e_{2,t} + Bcb^{d}_{3,2,t}/e_{2,t}}$$

In the short run, as the Chinese central bank decides to diversify its foreign reserves, China's demand for the euro bills rises immediately, that is, $Bcb^{d}{}_{3,2,t}$ increases dramatically. The change in $Bcb^{d}{}_{3,2,t}$ has a dominating effect on the adjustment of the exchange rate (e_1) in the short run. This induces a jump in the value of the euro against the dollar and the RMB. However, in the long run, with the adjustment of demand for and supply of the euro bills, in particular the decrease in the demand from Euroland households due to the changes in their disposable income, the value of the euro returns to a new level, which is lower than that in the short run, but higher than what occurs in the scenario without diversification.

Figure 2-2: Impact of the diversification of China's foreign reserves on trade balances

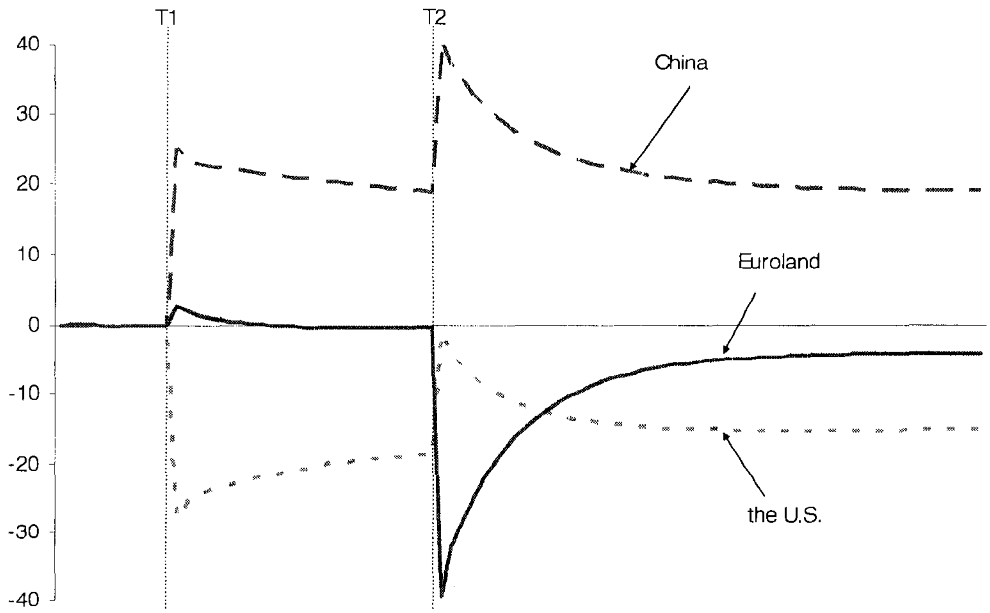
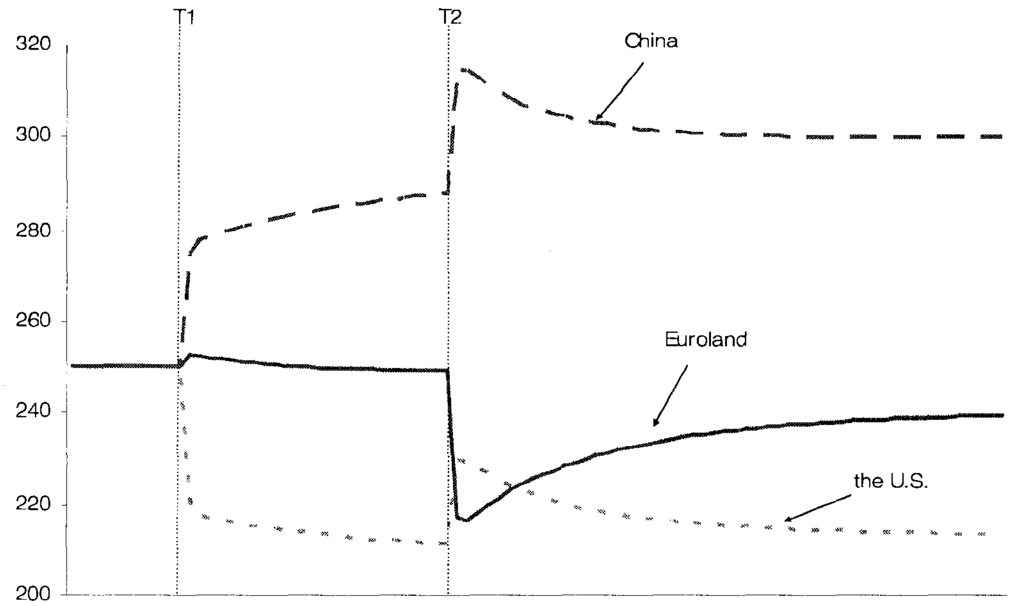


Figure 2-2 shows that trade imbalances get enlarged by the diversification of China's foreign reserves, especially in the short-run. This is not a surprising result. The steep appreciation of the euro against the dollar and the RMB decreases the competitiveness of Euroland on world markets, leading to the emergence of a large balance of trade deficit in the short run. At the same time, the Chinese trade surplus increases dramatically, while the U.S. trade deficit decreases substantially.

In the long run, as the value of the euro depreciates and reverts towards its original position, the Euroland trade balance returns towards a more neutral position, while the U.S. trade balance goes back towards its previous deficit level. In contrast, as shown in my first essay, without the diversification of China's foreign reserves, Euroland has an approximately balanced trade account in the long-run when the U.S. increases its propensity to import goods from China (Zhao, 2006). Therefore, the diversification of China's foreign reserves leads to a trade deficit in the Euroland, and a higher trade surplus in China.

Figure 2-3: Impact of the diversification of China's foreign reserves on GDP



Let us look at the impact of the diversification of China's reserves on the GDP of the three economies. As shown in Figure 2-3, both China and the U.S. benefit from the diversification at least in the short run. The GDP of the U.S. and of China both increase to higher levels. By contrast, the economy of the Euroland slows down, even in the long run. The trade deficit of Euroland is the key factor responsible for the decrease in the GDP of Euroland.

2.4.2 Experiment 2: The U.S. increases government expenditures at time T_1 and China moves a proportion of its foreign reserves from dollar bills to euro bills at time T_2.

In the previous experiment, the diversification of China's foreign reserves is based on the assumption that the large accumulation of China's foreign reserves is caused by an increase in the propensity of the U.S. to import goods from China. We now present a second experiment which is based on the assumption that the increase in China's reserves is a consequence of an increase in government spending in the United States. Further to experiment 2 in my first essay (Zhao, 2006) - an increase in the U.S. government expenditures at time T_1, I increase the value of β from 0 to 0.2 at period T_2.

Figure 2-4: Impact of the diversification of China's foreign reserves on the exchange rate

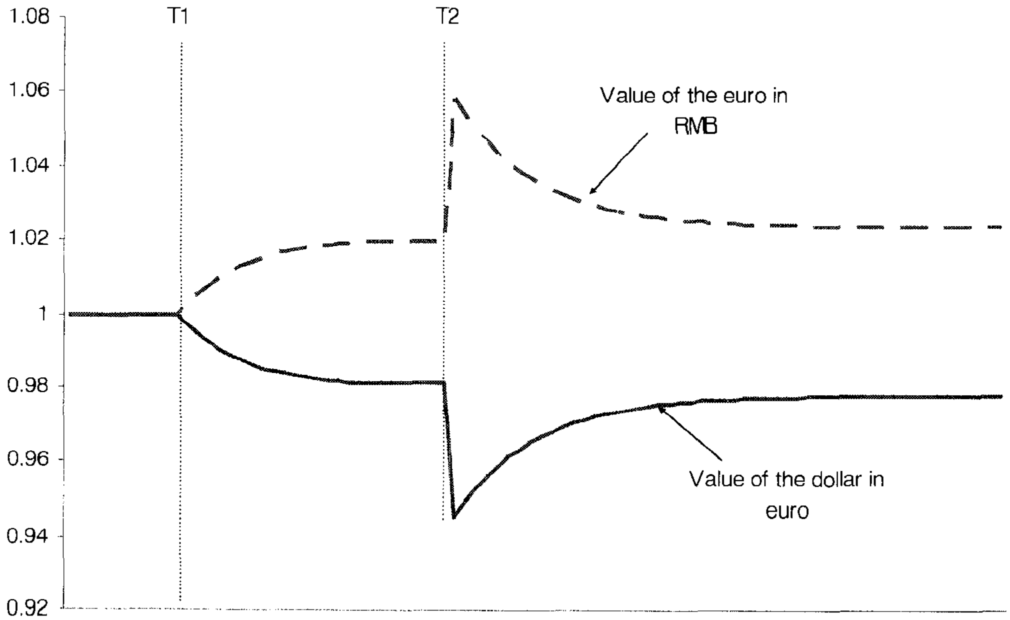


Figure 2-5: Impact of the diversification of China's foreign reserves on trade balances

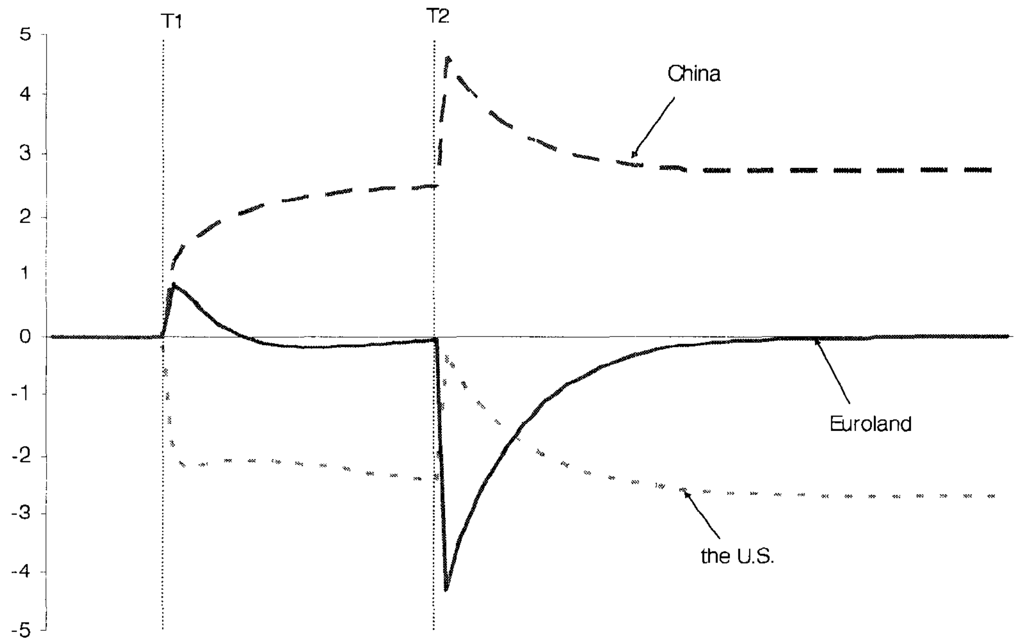


Figure 2-6: Impact of the diversification of China's foreign reserves on GDP

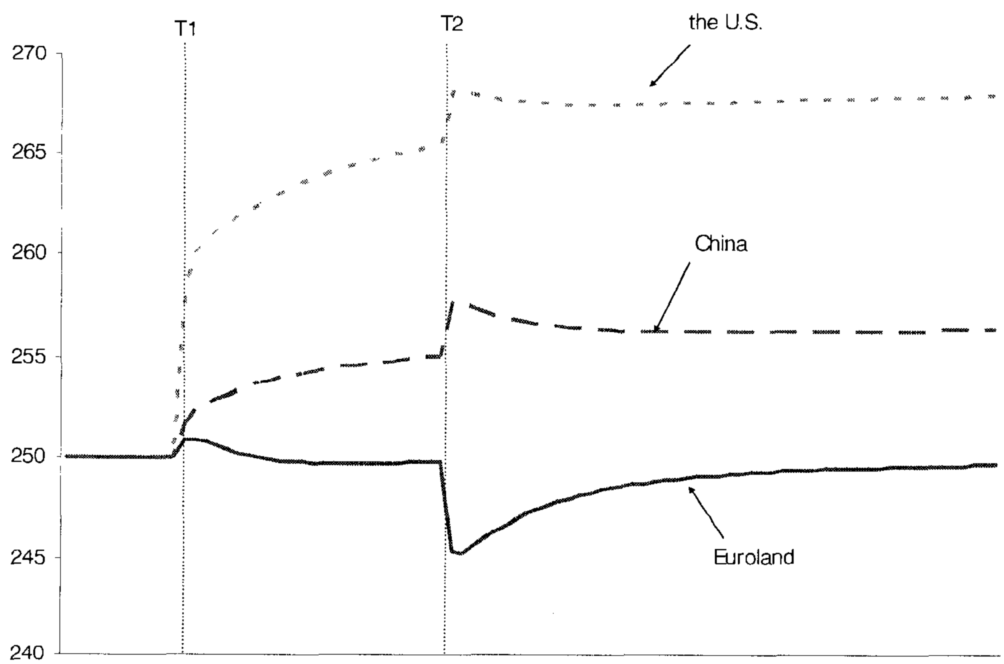


Figure 2-4 describes the evolution of the exchange rates of the euro against the dollar and the RMB. Similar to the experiment in the previous section, overshooting of exchange rates can also be found. The value of the euro falls steeply in the initial periods after the diversification of China's foreign reserves, and then gradually returns to a lower level in the long-run.

The steep appreciation of the euro against the dollar and the RBM leads to a trade deficit in Euroland in the short run. The trade deficits of Euroland decrease gradually in the long run.[21] Through feedback effects, the trade surplus of China is higher than that without diversification in the long run. The trade position of the U.S. is improved dramatically in the short run, while the effect on the U.S. trade deficits is small in the long run.

The diversification of China's foreign reserves stimulates the economies of the U.S. and China. GDP for both the U.S. and China increases to a higher level. In contrast, Euroland's economy slows down. In the long run, Euroland's economy recovers gradually to a level which is slightly lower than that without the diversification of China's reserves.

2.4.3 Experiment 3: Sensitivity analysis

In the previous two experiments, supposing that the value of β increase from 0 to 0.2, we find that the diversification of China's foreign reserves has a significant impact on the main variables of three countries. This section will use sensitivity analysis to determine the sensitivity of the key endogenous variables tied to changes in the value of the β parameter. Sensitivity analysis can help us to build confidence in the model by examining the range of fluctuations that are associated with the β parameter. It may give us some indication that the parameter values reflect, at least in part, the "real world".

[21] A further discussion will be presented in section 4.3.

Figure 2-7: Impact of changes in the β parameter on the value of the dollar in terms of the euro

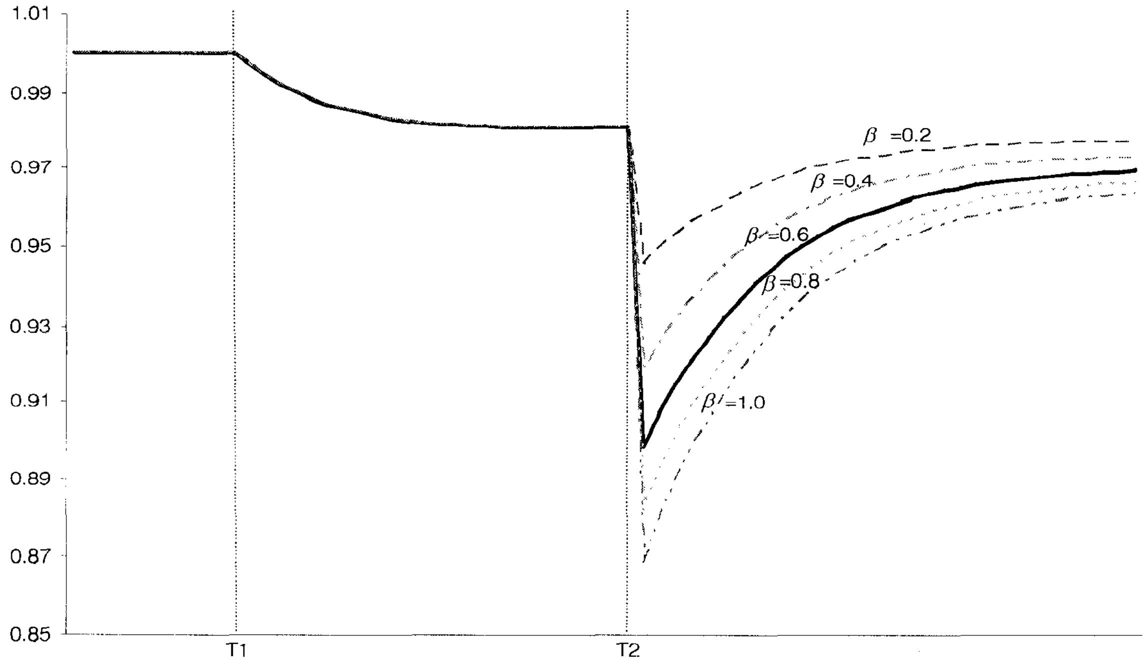


Figure 2-8: Impact of changes in the β parameter on Euroland GDP

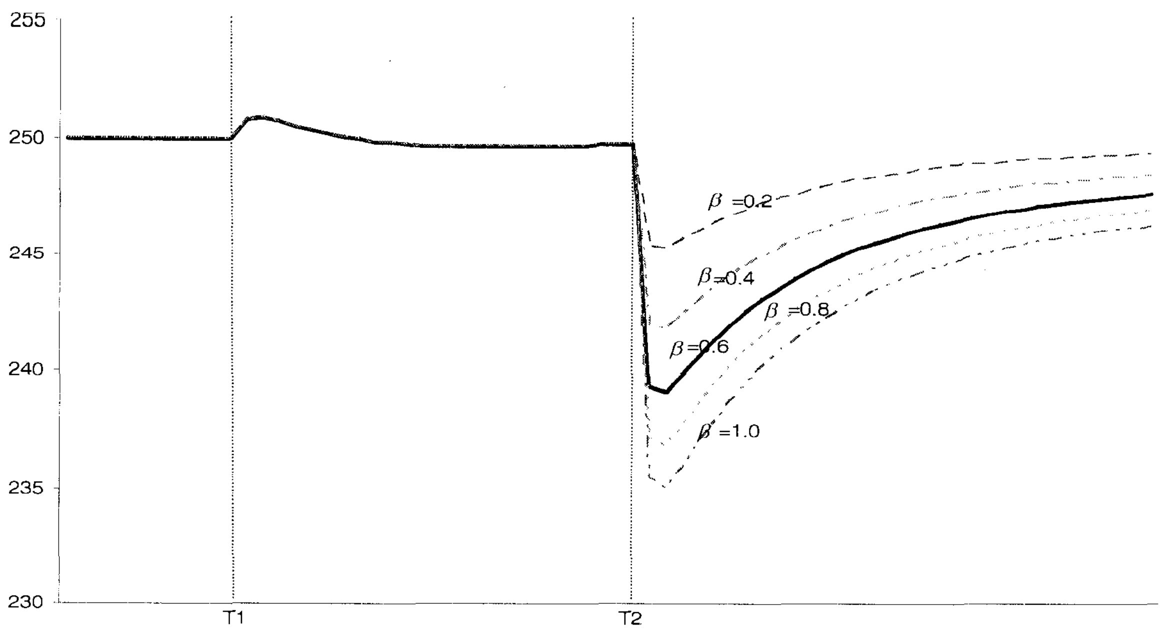
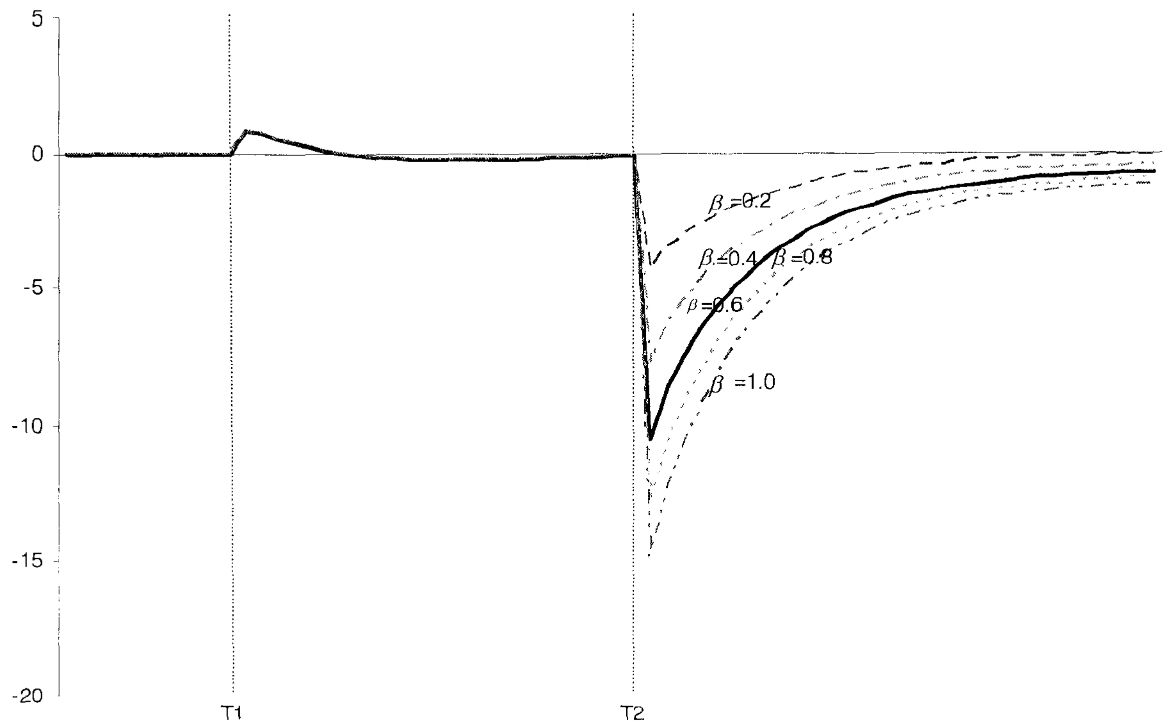


Figure 2-9: Impact of changes in the β parameter on the trade balance of Euroland



Following experiment 2, starting from the steady state, we assume that at time T_1, the U.S. increases its government expenditures. If the parameter β is always equal to zero (β =0), there is no diversification of China's reserves, and then the scenario is identical to that in my first essay. If the parameter β increases to 0.2 (β =0.2) at time T_2 , then the scenario is identical to that of section 2.4.2 of this paper. In the sensitivity analysis, we perform a series of new tests in which we set four additional values for the β at time T_2: 0.4, 0.6, 0.8, and 1.0. For each value of the parameter β, we can get a composition of China's foreign reserves by currency – the dollar vs. the euro (e.g. 100% vs. 0% for β =0; 83.3% vs. 16.7% for β =0.2; 71.4% vs. 28.6% for β =0.4; 62.5% vs. 37.5% for β =0.6; 55.6% vs. 44.4% for β =0.8; and 50.0% vs. 50% for β =1.0). We will see how a change in the β parameter causes a change in the dynamic behaviour of the endogenous variables. As in section 2.4.2, we will look at the three variables: the exchange rates, the trade balances, and GDP. We will focus on the impact in Euroland since Euroland will be worse off with the diversification of China's foreign reserves.

As shown in Figures 2-8, 2-9 and 2-10, a small change in a parameter results in relatively large changes in these three variables, especially in the short-run, as the β parameter changes from 0 to 1. We can say that the values of the euro exchange rates, the balance of trade and GDP are sensitive to the value taken by the β parameter. This may indicate that the choice of the value of parameter β needs to be determined very carefully because the composition of China's foreign reserves has a significant impact on the variables of the three countries.

Without the diversification of China's reserves ($\beta = 0$), the external shocks only have a short-term impact on the Euroland's trade position and GDP (temporary effects). However, diversification has both short-run and long-run negative effects on the Euroland's economy. The bigger the value of the parameter β, the larger the effects will be on the Euroland. Figures representing the impacts of diversification in the U.S. and China are attached in Appendix 2.2. As shown in Figure A1 in the appendix, if the parameter β is greater than 0.4, the trade balance position of the U.S. can move from deficit to surplus in the short run, while it returns back to a trade deficit in the long run.[22] This is an interesting result.

2.5 Alternative closure: a target percentage composition of China's foreign reserves

The simulation results in section 2.4 show that the diversification of China's reserves has a large impact on exchange rates, trade positions, and GDP of the three countries, especially in the short-run (e.g. overshooting of exchange rates of the euro against the dollar and the RMB). In the real world, this would destabilize international financial markets and the world economy. In this section, we propose an alternative closure to the main model. The Chinese central bank sets a target percentage composition of its foreign reserve holdings by currencies – the dollars vs. the

[22] In this paper, the maximum value of the parameter β examined is 1.0, that is, the composition of China's foreign reserves is: 50% dollar bills vs. 50% euro bills.

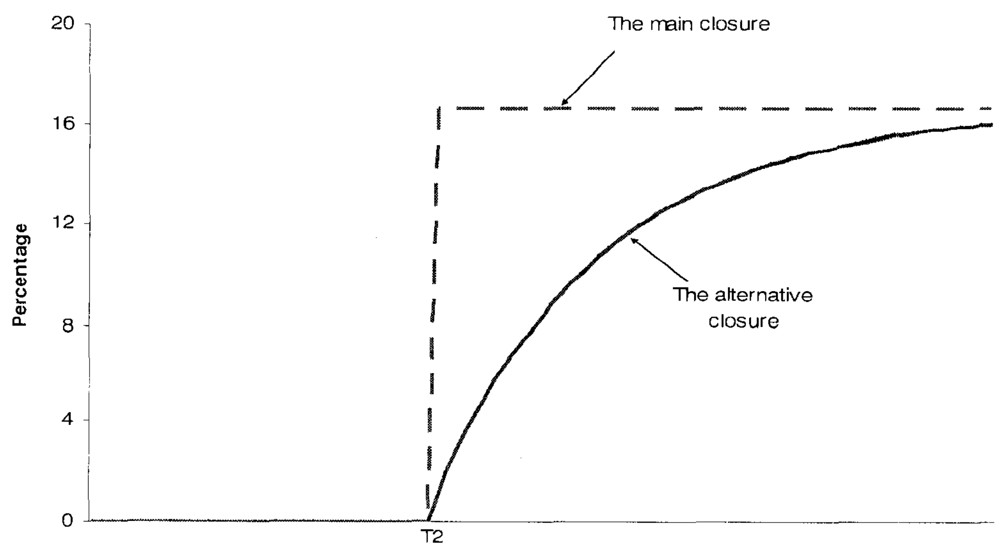
euro. China's central bank will gradually sell dollars and buy euros, and achieve its diversification target over a longer period.

In the alternative closure of the main model, we insert the following equations into the main model:

(73a)	$Bcb^d_{3,2,t} = \beta_t \cdot Bcb^d_{3,1,t}$	
(73b)	$\Delta\beta_t = \tau \cdot (\beta^T - \beta_{t-1})$	
(73b')	$\beta_t = \beta_{t-1} + \tau \cdot (\beta^T - \beta_{t-1})$	$\beta \geq 0$

Here β^T is an exogenous variable that represents the target percentage composition of China's foreign reserves, and τ is a speed reaction parameter. The beta (β) parameter is no longer a parameter in the alternative closure of the model; it is instead an endogenous variable that reflects the actual composition of the foreign reserves (in contrast to the target). The new value of β_t is partially adjusted to the discrepancy between the target β^T and the previous beta (β_{t-1}). In other words, there is a partial adjustment mechanism.

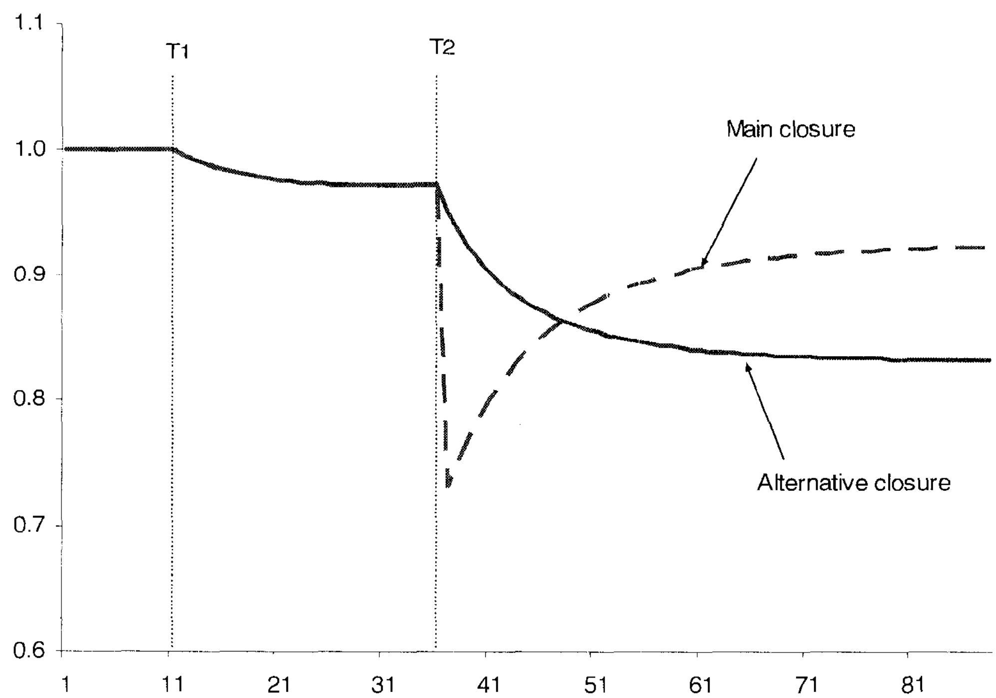
Figure 2-10: Impact of the diversification on the share of euros in the Chinese foreign reserves, compared to that of the main model



Suppose that the long-run target share of the euro bills in the foreign reserve holdings of the Chinese central bank is 16.7% while the share of dollar bills is 83.3%. This implies that $\beta^T = 0.2$, as in section 2.4.1 and 2.4.2. Let us redo experiment 1, and look at the simulation results.

As shown in Figure 2-10, as China's central bank sets a target share of the euro at time T_2, the share of the euro gradually increases in the short-run and reach the target in the long-run if we give a small value to the parameter τ, such as τ =0.05.

Figure 2-11: Impact of the diversification on the value of the dollar in terms of euro, comparison to that of the main model



Since the diversification of China's reserves away from the dollar is gradual and in a small-scale in the short run, the euro gradually appreciates against the dollar. There does not exist an overshooting effect of the exchange rates in the alternative closure of the model. However, in the long run, the value of the dollar in terms of the euro in the alternative closure is much smaller than that in the main model. In other words, the appreciation of the euro against the dollar and the RMB is larger in the long term than was the case in the main closure, when diversification was a one-shot affair.

Figure 2-12: Impact of target β on GDP of China

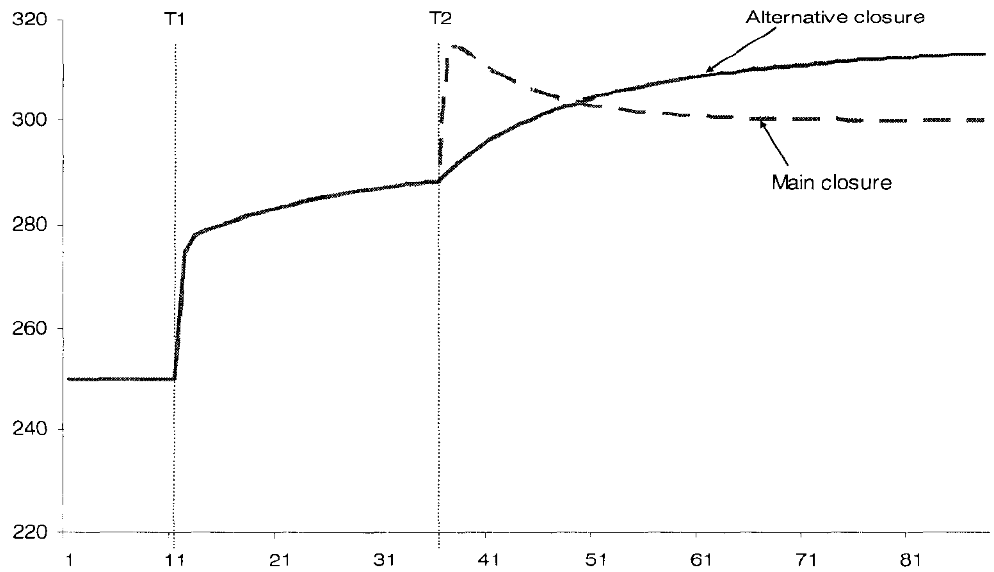


Figure 2-13: Impact of target β on GDP of the U.S.

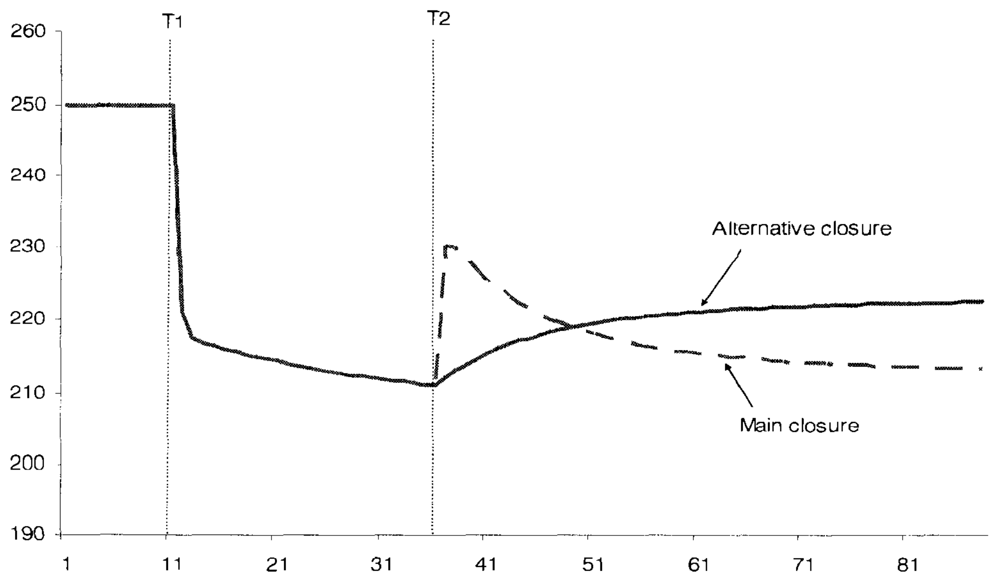
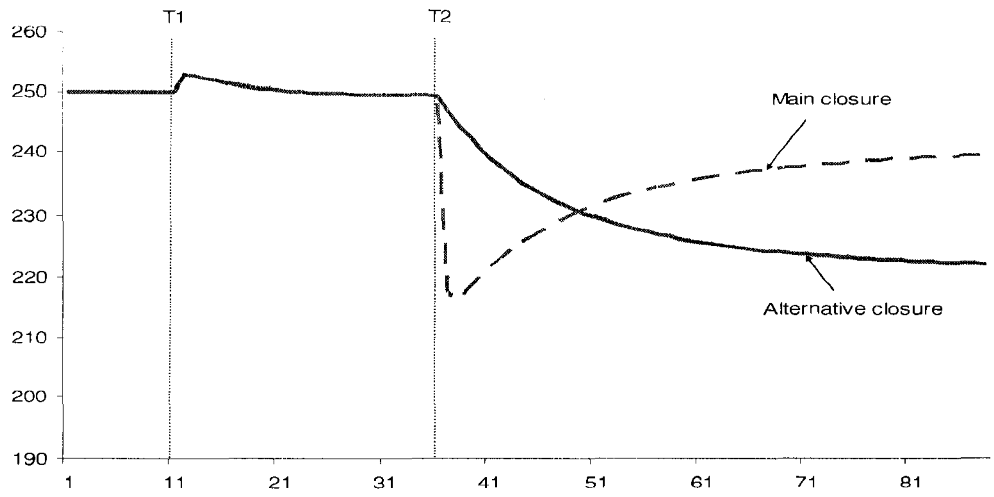


Figure 2-14: Impact of target β on GDP of the Euroland



Compared to the main model, in the long run, the large appreciation of the euro against the dollar and the RMB leads to a bigger trade deficit in Euroland. It is not surprising that Euroland GDP reaches a lower level in the steady state as shown in Figure 2-13. Through feedback effects, China has a larger trade surplus, resulting in a higher GDP level. The trade deficit in the U.S. decreases to a lower level. The GDP of the U.S. in the long run is also higher than that in the main closure.

Figure 2-15: Impact of target β on the trade position of China

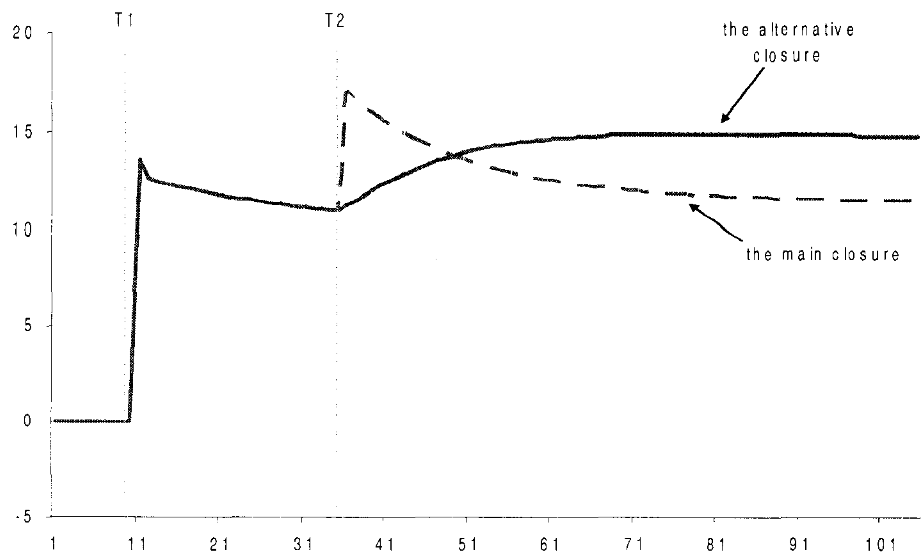


Figure 2-16: Impact of target β on the trade position of the U.S.

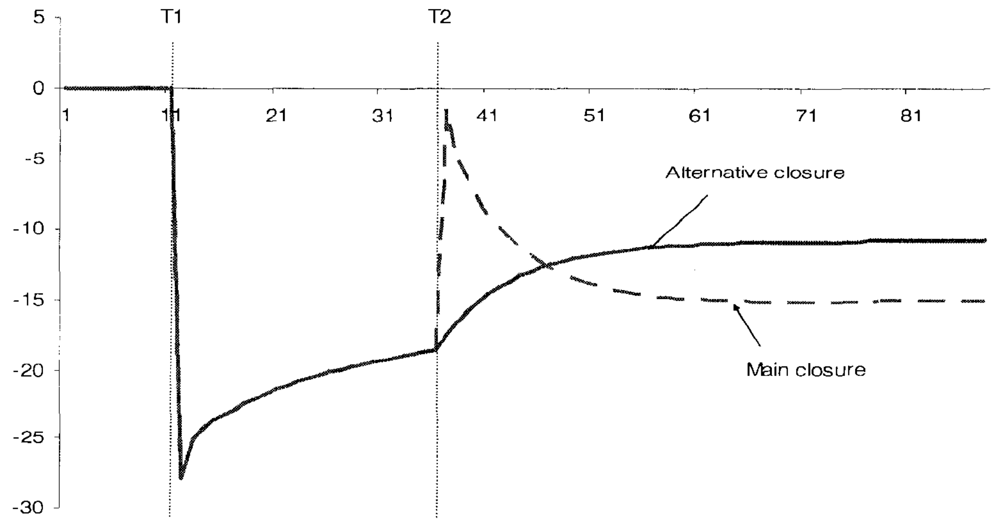
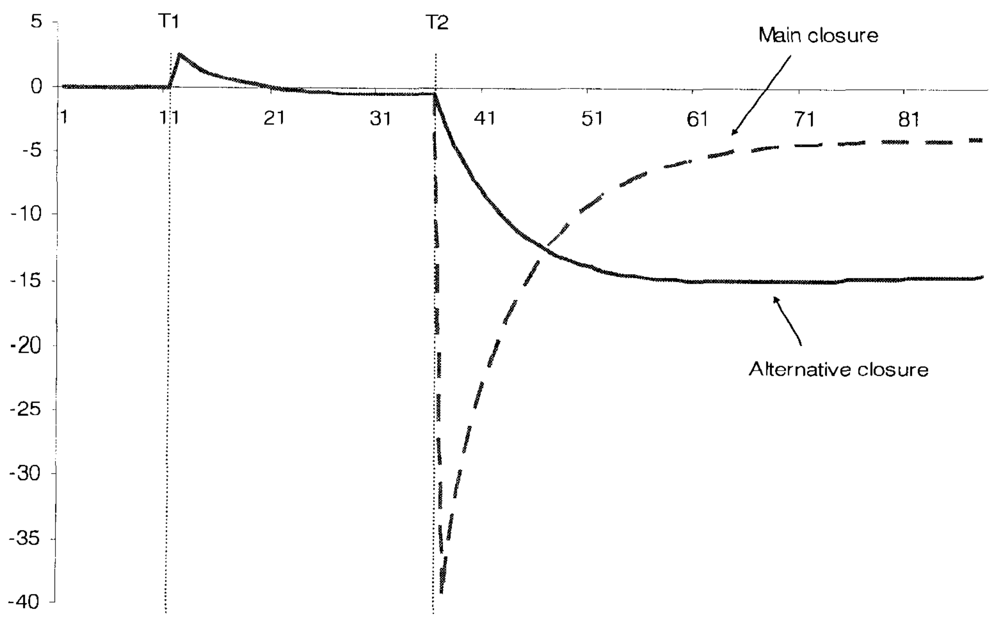


Figure 2-17: Impact of target β on the trade position of Euroland



Based on the comparison analysis between the main model and its alternative closure, we find that in the long run, most of the main endogenous variables do not converge towards a unique equilibrium, reaching instead different equilibria. How the central bank of China will achieve its target diversification rate has an impact on the steady state values of the model. In other words, the transition path towards the diversification target influences the long run equilibrium. This is mainly due to the characteristics of the stock-flow consistent framework. The SFC models pay considerable attention to portfolio balance, while at the same time taking into account Post-Keynesian assumptions on exchange rates. The exchange rates once determined in financial asset markets, feed back to change trade flows, and hence the demand for and supply of financial assets, income flows, and so back to exchange rates themselves. Thus, the equilibrium levels of the key endogenous variables in our model also depend on the path taken to get to the target. This dynamic path-dependent evolution is quite different from the neo-classical tradition. The usual assumption of the neo-classical economics tradition is that in the long run, only a unique equilibrium could possibly be reached, regardless of initial conditions or transitory events. However, the path dependence theory offers reasons to believe that some economic processes have multiple possible paths of outcomes, rather than a unique equilibrium or unique path of equilibria (Puffert, 2003; David, 2000). Our simulation results provide an example of path dependence, that is, both the starting steady state and shocks can have significant long-run effects.

2.6 The other alternative closure: appreciation of the RMB against the dollar

In the above experiments, we assume that the renminbi is pegged to the dollar. This is only partly true, because China moved onto a managed float exchange rate regime in July 2005, with the renminbi having appreciated by about 13 percent relative to the dollar at the time of writing. In this section, we will present the other alternative closure based on the assumption that the RMB appreciates against the dollar starting from time T_2. We propose the following adjustment mechanism of the exchange rate of the rebminbi against the dollar:

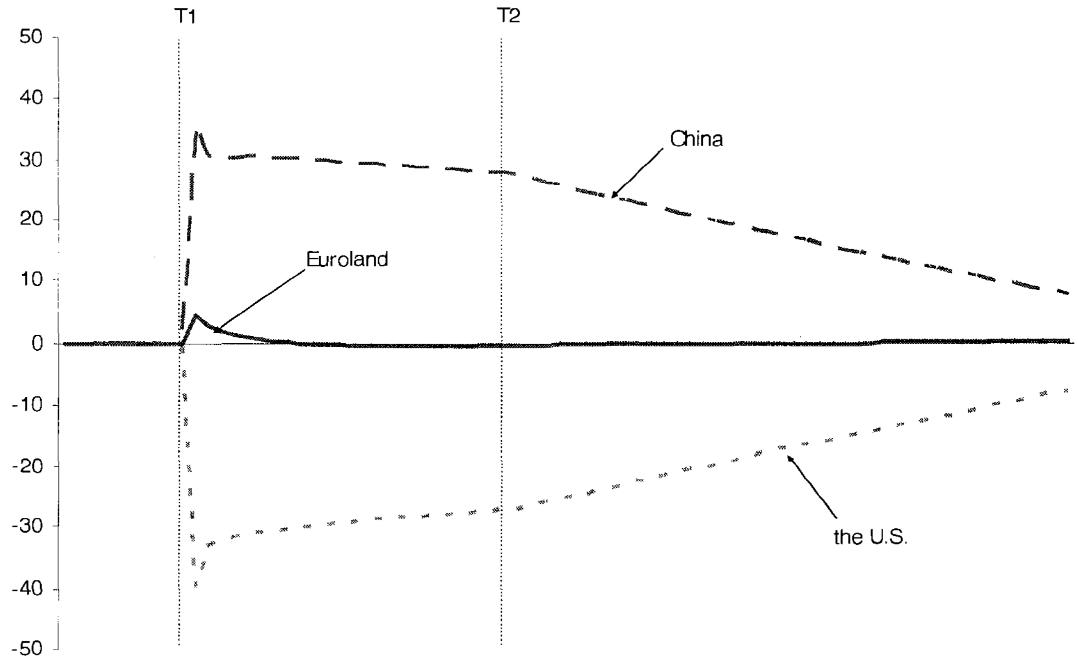
$$e_{2,t} = e_{2,t-1} \cdot (1 - \varpi) \quad (88)$$

Where ϖ is an exogenous variable, $0 \leq \varpi < 1$.

$\varpi = 0$ if $t < T_2$

$0 < \varpi < 1$ if $t \geq T_2$

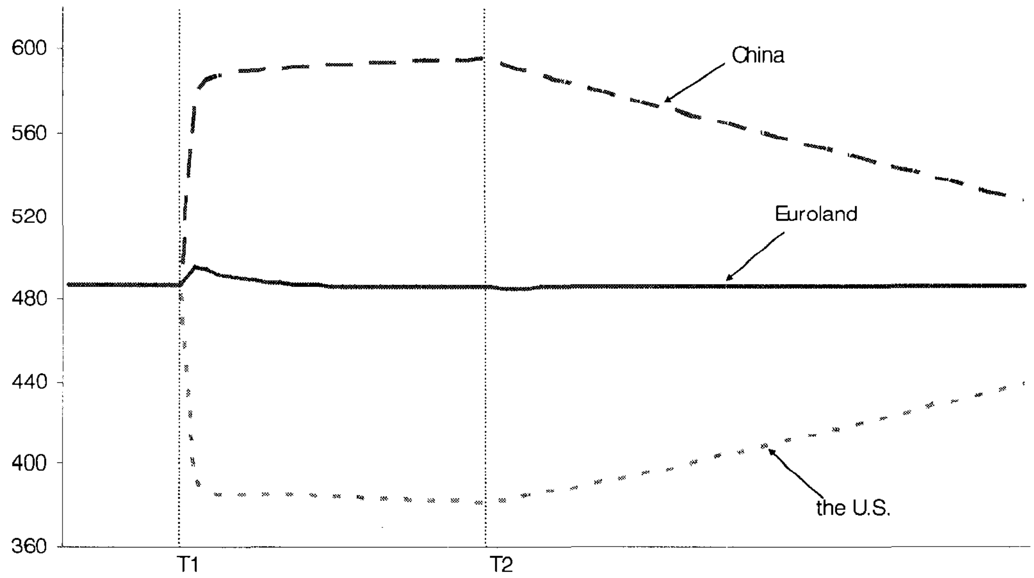
Figure 2-18: Impact of appreciation of the RMB against the dollar on trade balances



In this alternative closure of the model, the exchange rate of the renminbi against the dollar is now an endogenous variable. In the experiment, we assume that after T_2, $\varpi = 0.005$, that is, the RMB gradually appreciates against the dollar. What will happen to the trade positions and GDP of China and the USA?

As shown in Figure 2-18, RMB appreciation reduces the trade surpluses of China, mostly in the bilateral trade account between China and the US. This affects economic growth in China. Through feedback effects, the trade deficits of the US decrease dramatically. The U.S. benefits from the appreciation of the RMB. As shown in Figure 2-19, the U.S. GDP increases, while the GDP of China decreases. Not much happens to the GDP of Euroland.

Figure 2-19: Impact of appreciation of the RMB against the dollar on GDP



2.7 Conclusion

In this paper, I extend my first essay, based on a three-country model with a stock-flow consistent approach, to the case where the central bank of China diversifies its reserves as it accumulates foreign reserves. The new model has been applied to simulate the impact of this change on the economies of the three countries – the U.S., China and Euroland – through three experiments, including a set of parameter sensitivity tests.

The simulation results show that with the diversification of China's foreign reserves, the euro appreciates against the dollar and the RMB, with an overshooting effect on the exchange rate. China and the U.S. can benefit from the diversification, while the Euroland economy slows down. These findings are consistent with those achieved by Blanchard et al (2005) and Dullien (2007) in their portfolio balance models.

Using parameter sensitivity analysis, we find that the diversification of China's foreign reserves has a significant impact on the economies of the three countries. The bigger the share of euro bills in China's foreign reserve portfolio, the larger will be the negative effects on Euroland.

Gradual diversification can overcome the overshooting effect on exchange rates. However, as the share of euro bills in China's reserves gradually goes up based on its target level, the value of the euro against the dollar and the RMB gradually increases to a higher level. China's GDP will reach a higher level, while the economy of Euroland will be worse off.

What is interesting is that the model generates some kind of path dependence. How the central bank of China will achieve its target diversification rate has an impact on the steady state values of the model. In other words, the transition path towards the diversification target influences its long-run equilibrium. This is linked to interest payments. Different transaction paths generate different debt stocks, interest payments and capital account balances. This creates the path dependency through different exchange rates and trade balances.

Reference

Blanchard, O., Giavazzi, F., and Sa, F. (2005a), "The U.S. current account and the dollar", NBER Working Paper Series, working paper 11137, February. http://www.nber.org/papers/w11137

Blanchard, O., Giavazzi, F., and Sa, F. (2005b), "International investors, the U.S. current account, and the dollar", *Brookings Papers on Economic Activity*, No. 1, pp. 1-49.

Brainard, W.C. and J. Tobin (1968) 'Pitfalls in financial modelling', *American Economic Review*, May, 58 (3), pp. 99-122.

David, P. (2000), "Path dependence, its critics and the quest for 'historical economics'", *Working paper*, All Souls College, Oxford University, http://www-econ.stanford.edu/faculty/workp/swp00011.html

Dooley, M., Folkerts-Landau, D. and P. Garber (2004) "The revived Bretton Woods System: The effects of periphery intervention and reserve management on interest rates & exchange rates in center countries", NBER Working Paper Series, working paper 10332.

Dullien, S. (2007), "Who is afraid of Asian FX interventions? Lessons from Europe from a three-asset-portfolio model", Paper presented at the conference "Finance-led capitalism? Macroeconomic effects of changes in the financial sector", Berlin, November.

Godley, W. (1996), "Money, finance and national income determination: An integrated approach", WP No. 167, The Levy Economics Institute of Bard College: Annandale-on-Hudson, NY.

Godley, W. (1999), "Open economy macroeconomics using models of closed system", WP No. 285, The Levy Economics Institute of Bard College: Annandale-on-Hudson, NY.

Godley, W. and M. Lavoie (2003), "Two-country stock-flow consistent macroeconomics using a closed model within a dollar exchange regime", Working Paper 10, Cambridge Endowment for Research in Finance, University of Cambridge.

Godley, W. and M. Lavoie (2005-06) "Comprehensive accounting in simple open economy macroeconomics with endogenous sterilization or flexible exchange rates", *Journal of Post Keynesian Economics*, Winter, 28(2), pp. 241-276.

Godley, W. and M. Lavoie (2007a), "A Three-Country Model with Comprehensive Accounting: Euroland and the USA", *Cambridge Journal of Economics*, January, 31 (1), pp. 1-24.

Godley, W., and Lavoie, M. (2007b), *Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth*, London: Macmillan/Palgrave.

Hicks, J.R. (1974) *The Crisis in Keynesian Economics*, Oxford: Basil Blackwell.

Izurieta, A. (2003) 'Dollarization as a tight rein on the fiscal stance', in L.P. Rochon and M. Seccareccia (eds), *Dollarization: Lessons from Europe and the Americas*, London: Routledge, pp. 143-164.

Lavoie, M. (2000), "A Post Keynesian view of interest parity theorems", *Journal of Post Keynesian Economics*, Fall, 23 (1), pp.163-179.

Lavoie, M. (2002-2003), "Interest parity, risk premia, and Post Keynesian analysis", *Journal of Post Keynesian Economics*, Winter, 25 (2), pp. 237-249.

Lavoie, M. (2006), *Introduction to Post-Keynesian Economics*, London: Macmillan/Palgrave.

Lequain, M. (2003) "A three-country study of the euro zone versus the rest of the world: the implications of a monetary union in an open environment", working paper, University of Ottawa, paper presented at the annual conference of the Eastern Economic Association, in New York.
Puffert, D. J. (2003), "Path dependence, network form and technological change", in William A. Sundstrom, Timothy W. Guinnane, and Warren C. Whatley (ed.), *History Matters: Essays on Economic Growth, Technology, and Demographic Change,* Stanford University Press, pp. 63-95.

Setterfield, M. (1996), "Hysteresis and uncertainty: Complementary or competing visions of evolving economic systems?", in Steve Pressman (ed.), *Interactions in Political Economy: Malvern After Ten Years*, London and New York: Routledge, pp. 133- 148.

Tobin, J. (1969), "A general equilibrium approach to monetary theory", *Journal of Money, Credit, and Banking*, February, 1 (1), pp.15-29.

Tobin, J. and J.B. De Macedo (1980) 'The short-run macroeconomics of floating exchange rates: An exposition', in J. Chipman and C. Kindleberger (eds), *Flexible Exchange Rates and the Balance of Payments: Essays in the Memory of Egon Sohmen*, Amsterdam: North Holland, pp. 5-28.

Truman, E., and A. Wong. (2006), "The case for an international reserve diversification standard", working paper 06-02, the Institute for International Economics, May.

Wang, Y. (2006), "Rethinking fast growth in China's foreign exchange reserves", *China & World Economy*, Vol. 14, No. 2, p. 56-66.

Wong, A. (2007), "Measurement and inference in international reserve diversification", Working paper 07-6, Peterson Institute, Washington (DV), July.

Zheng, Y., and J. Yi. (2007), "China's rapid accumulation of foreign exchange reserves and its policy implication", *China & World Economy*, Vol. 15, No.1, p. 14-25.

Appendix 2.1

Parameter values for simulations

θ_i=0.55056

$\alpha_{i,1}$=0.8 $\alpha_{i,2}$=0.05

$\lambda_{i,00} = 0.266304$ $\lambda_{i,10} = 0.1111$

$\lambda_{i,20} = 0.1111$ $\lambda_{i,30} = 0.1111$

$\lambda_{i,40} = 0.3704$

$\lambda_{i,11} = 0.6$ $\lambda_{i,12} = -0.2$

$\lambda_{i,13} = -0.2$ $\lambda_{i,14} = -0.2$

$\lambda_{i,21} = -0.2$ $\lambda_{i,22} = 0.6$

$\lambda_{i,23} = -0.2$ $\lambda_{i,24} = -0.2$

$\lambda_{i,31} = -0.2$ $\lambda_{i,32} = -0.2$

$\lambda_{i,33} = 0.6$ $\lambda_{i,34} = -0.2$

δ_i=0.1 γ_i=0.09

κ_i=2

$\zeta_{i,1}$=2.05 $\zeta_{i,2}$=1

μ_{i0}= μ_{i3}= -0.996

μ_{i2}= μ_{i5}=1.0

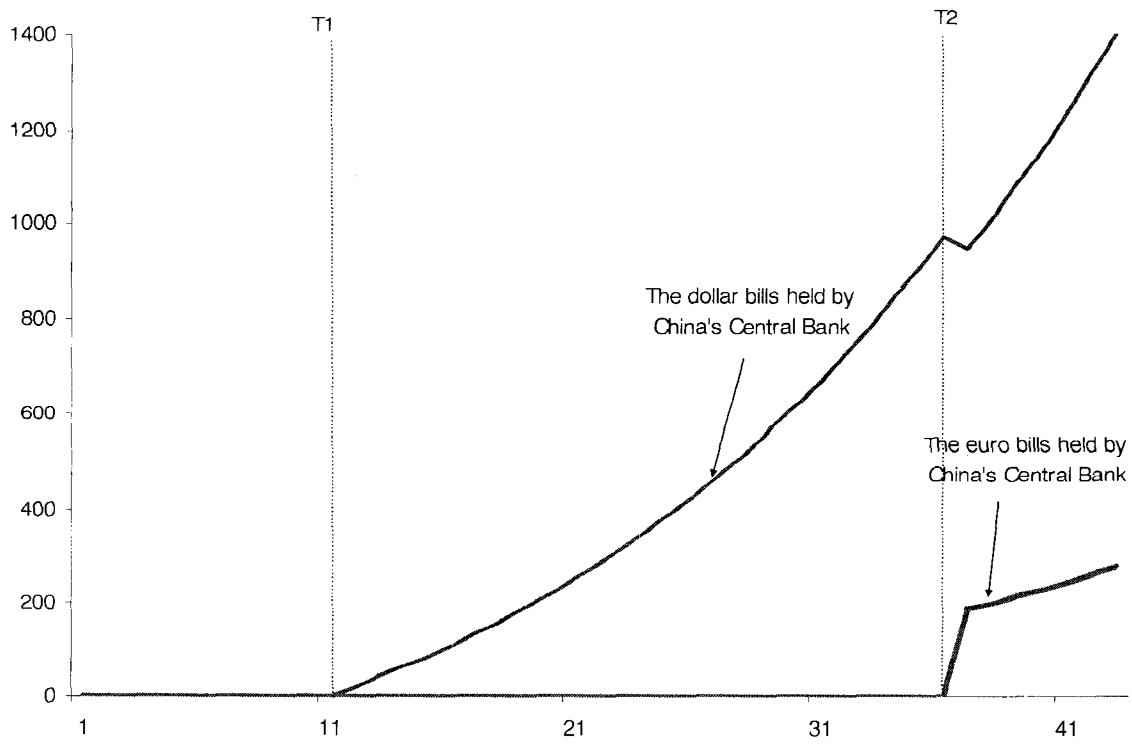
μ_{i1}= μ_{i4}=0.2

$\tau = 0.05$

Where i=1,2,3.

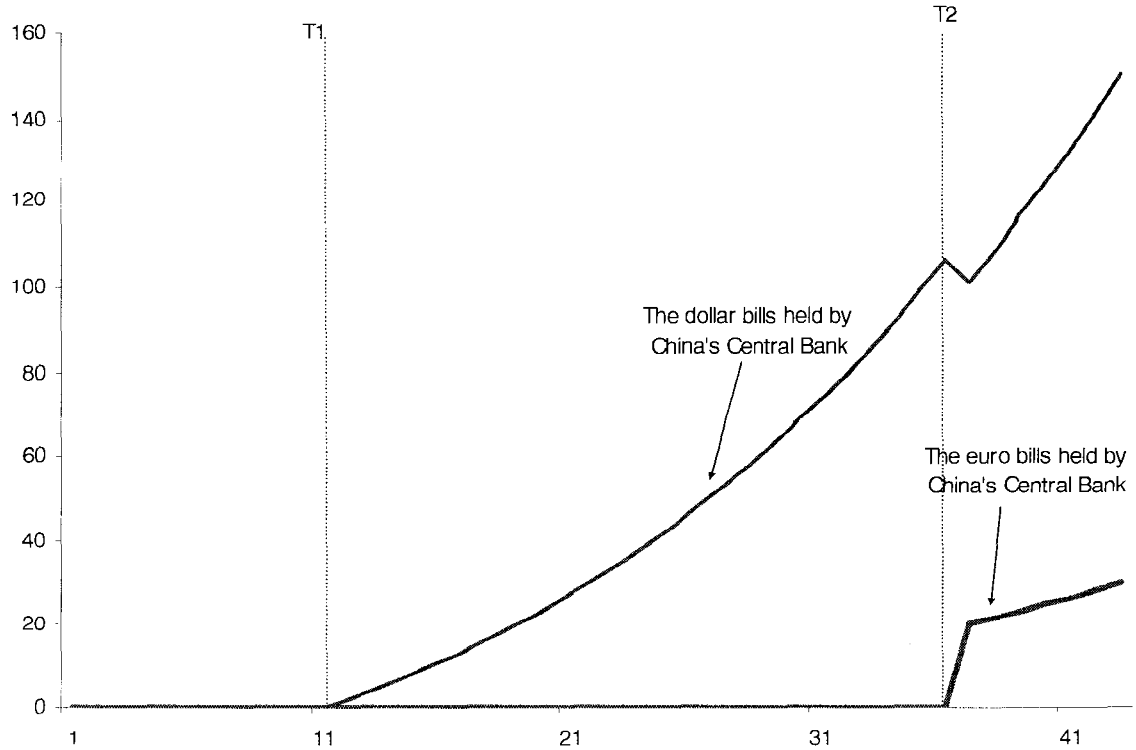
Appendix 2.2

Figure A1: Experiment 1 – Impact of the diversification on the foreign reserves of China



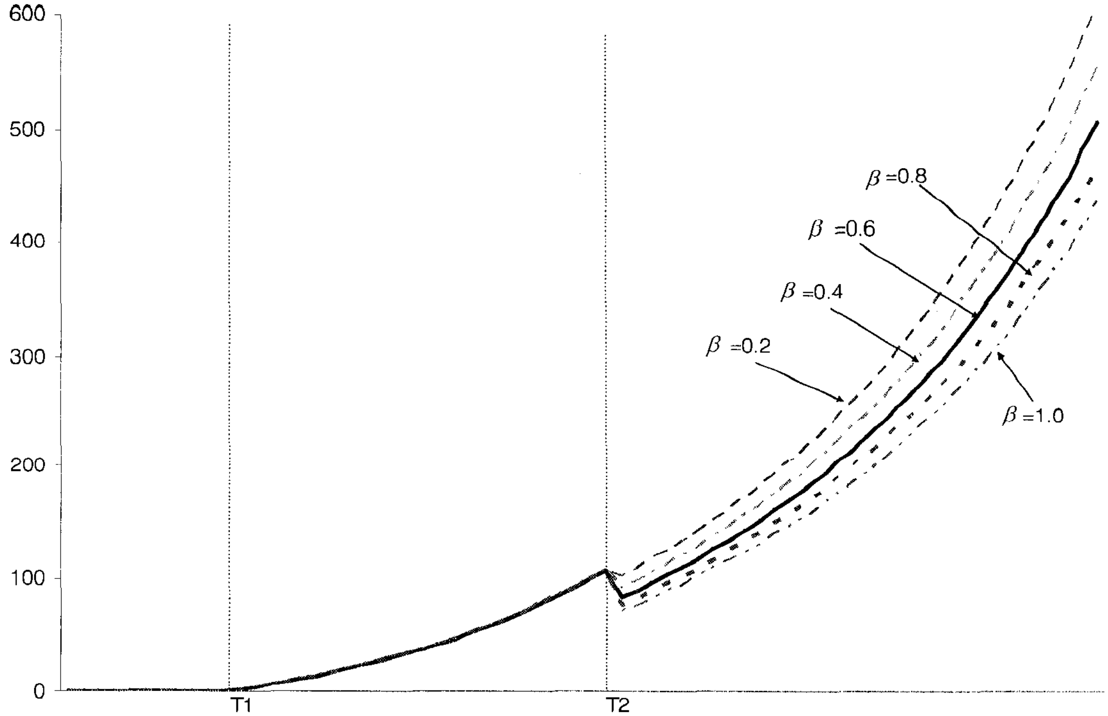
Note: The accumulation of dollar bills held by China's Central Bank is based on the assumption that the U.S. increases its propensity to import goods from China at time T_1.

Figure B1: Experiment 2 – Impact of the diversification on the foreign reserves of China



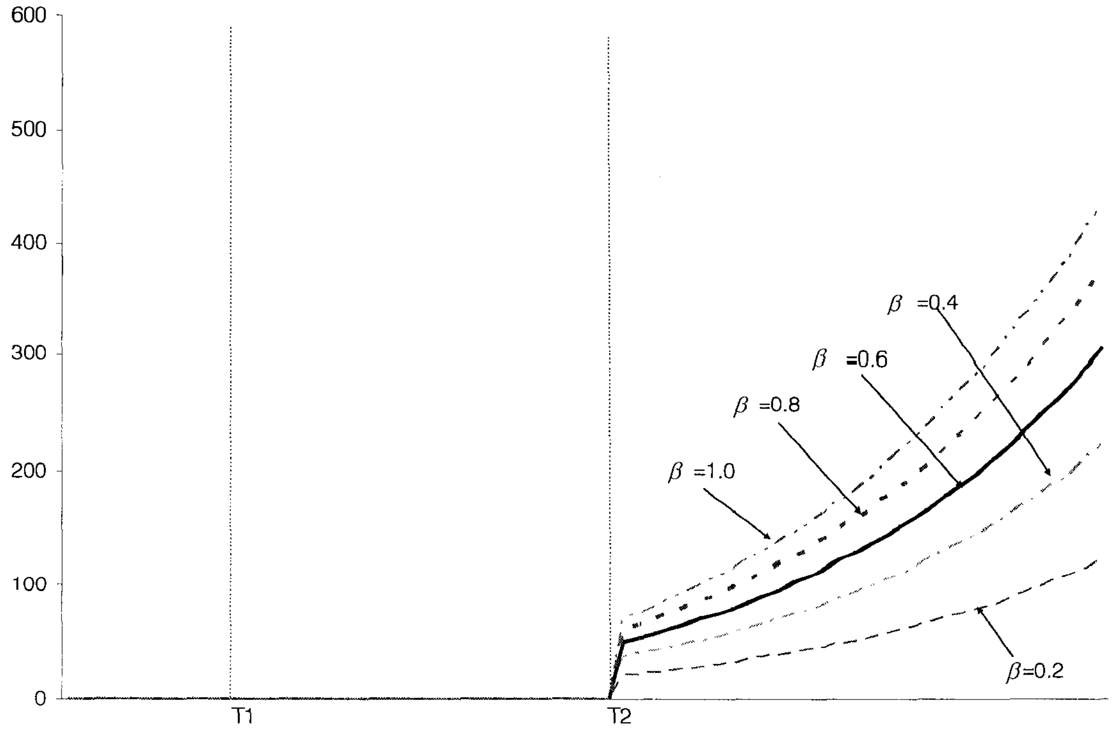
Note: The accumulation of dollar bills held by China's Central Bank is based on the assumption that the U.S. increases its government expenditures at time T_1.

Figure C1: Experiment 3 – Impact of changes in the β parameter on the dollar bills held by Chinese central bank



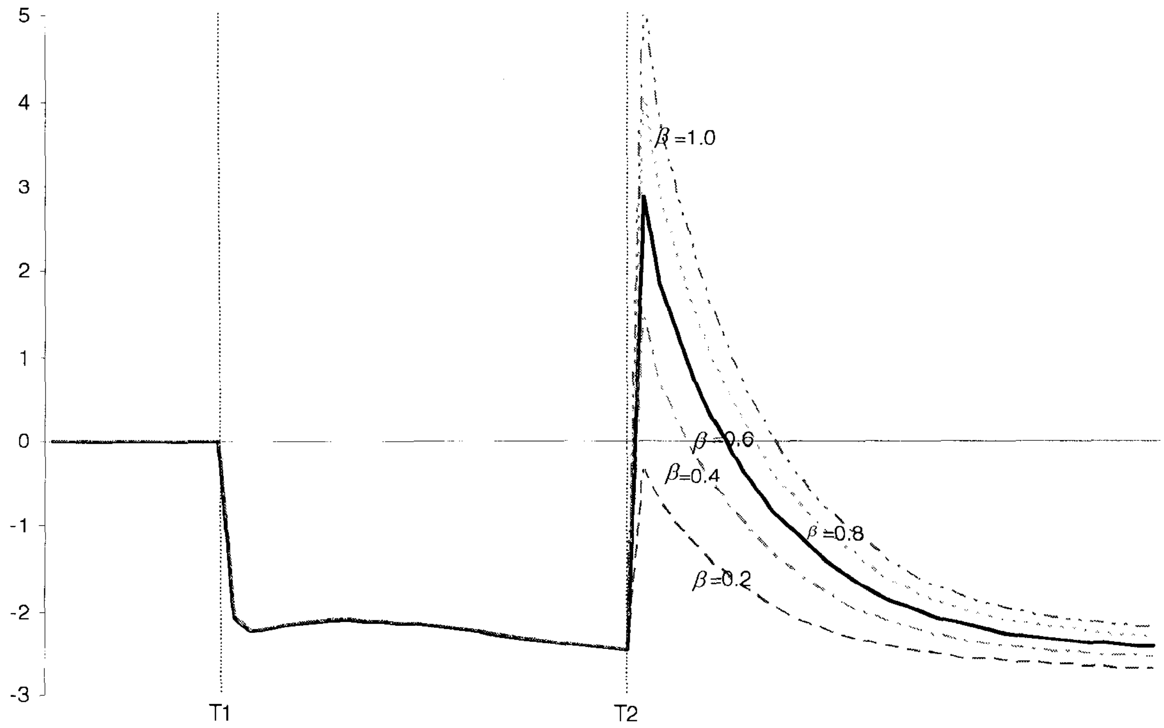
Note: The accumulation of dollar bills held by China's Central Bank is based on the assumption that the U.S. increases its government expenditures at time T_1.

Figure C2: Experiment 3 – Impact of changes in the β parameter on the euro bills held by Chinese central bank



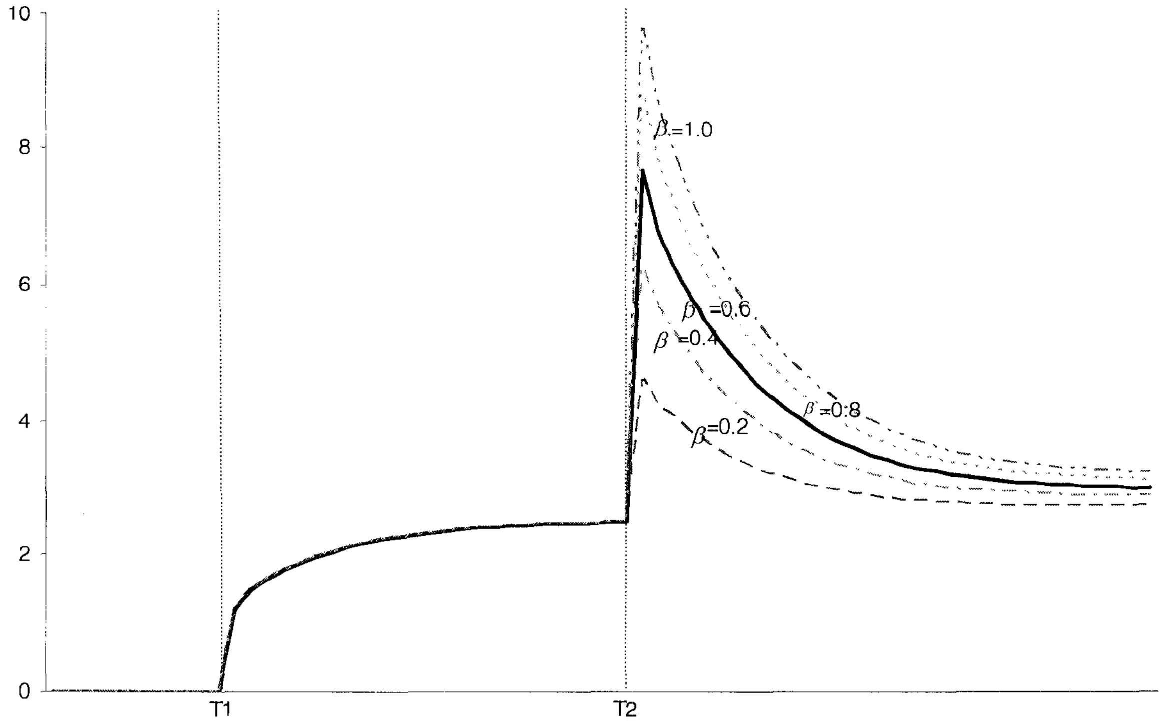
Note: The accumulation of dollar bills held by China's Central Bank is based on the assumption that the U.S. increases its government expenditures at time T_1.

Figure C3: Experiment 3 - Impact of changes in the β parameter on the trade balance of the U.S.



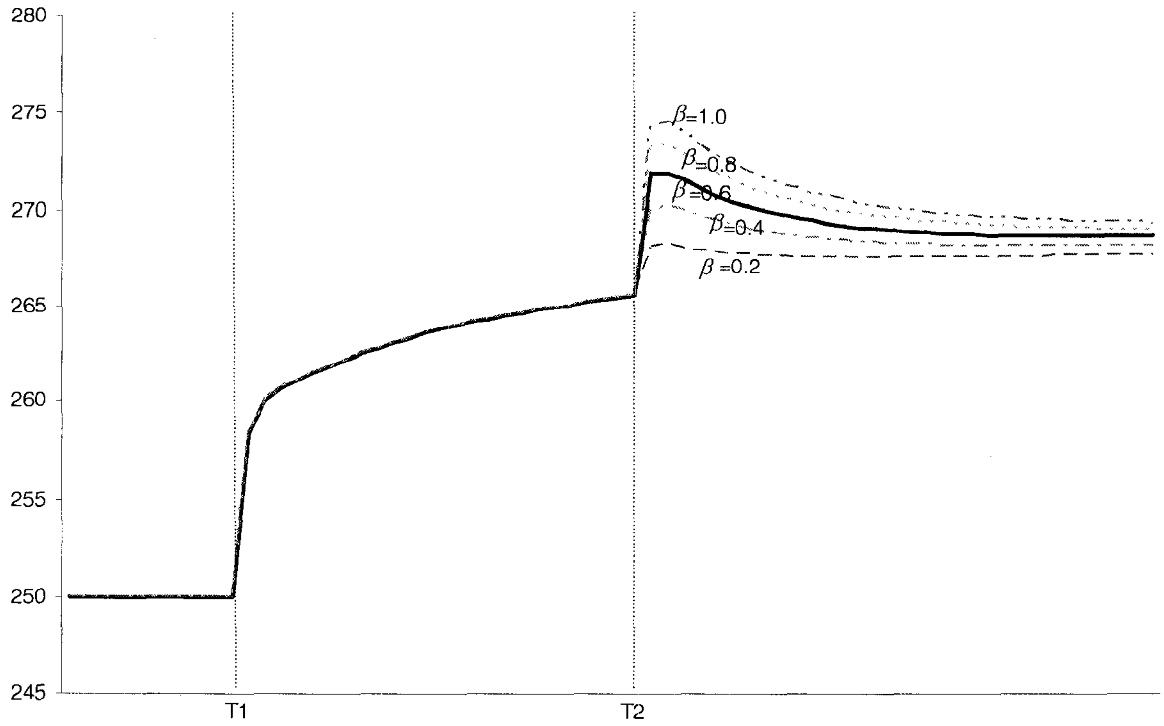
Note: The accumulation of dollar bills held by China's Central Bank is based on the assumption that the U.S. increases its government expenditures at time T_1.

Figure C4: Experiment 3 - Impact of changes in the β parameter on the trade balance of China



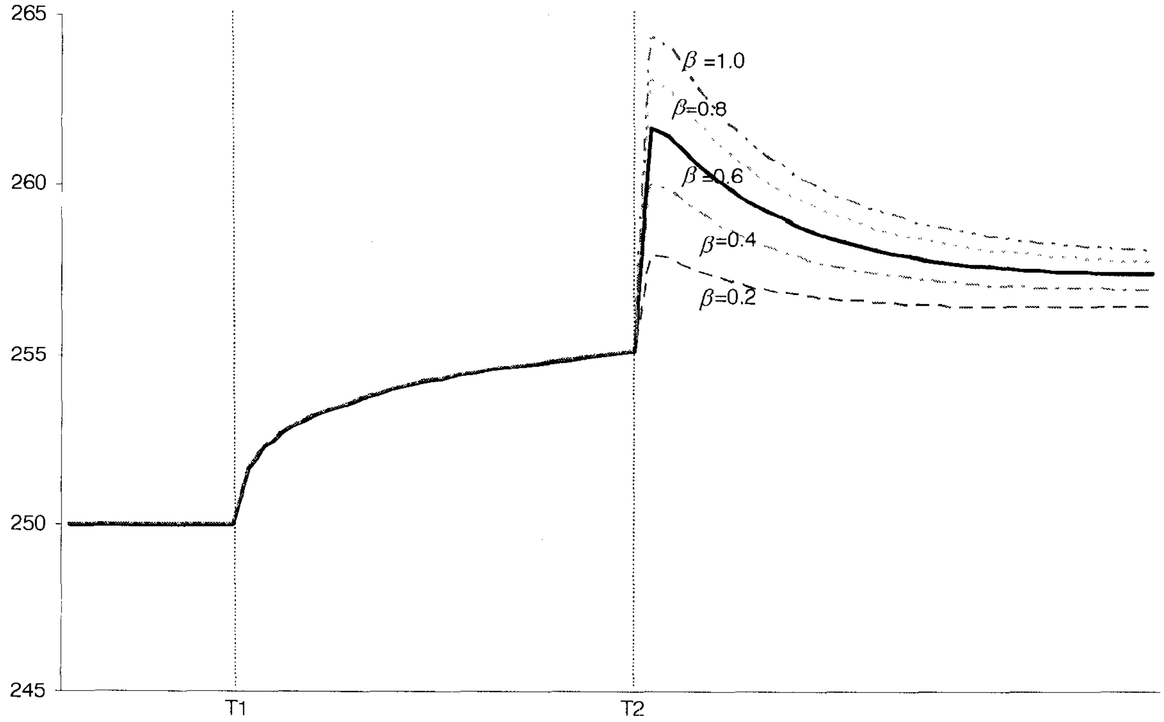
Note: The accumulation of dollar bills held by China's Central Bank is based on the assumption that the U.S. increases its government expenditures at time T_1.

Figure C5: Experiment 3 - Impact of changes in the β parameter on GDP of the U.S.



Note: The accumulation of dollar bills held by China's Central Bank is based on the assumption that the U.S. increases its government expenditures at time T_1.

Figure C6: Experiment 3 - Impact of changes in the β parameter on GDP of China



Appendix 2.3

Table 2-1: Stock matrix

Items	the USA					Euroland					China					Sum
	Households	Frims	Bnaks	Government	Central Bank	Households	Frims	Bnaks	Government	Central Bank	Households	Frims	Bnaks	Government	Central Bank	
Tangible K		K1					K2					K3				∑K
Cash	Hh1				-Hs1	Hh2				-Hs2	Hh3				-Hs3	0
Deposit	M1		-M1			M2		-M2			M3		-M3			0
Bill 1	Bh1,1		Bcmb1,1	-B1	Bcb1,1	Bh2,1				Bcb2,1	Bh3,1				Bcb3,1	0
Bill 2	Bh1,2				Bcb1,2	Bh2,2		Bcmb2,2	-B2	Bcb2,2	Bh3,2				Bcb3,2	0
Bill 3	Bh1,3					Bh2,3					Bh3,3			-B3	Bcb3,3	0
Loan		-L1	L1				-L2	L2				-L1	L1			0
Advance													-A3		A3	0
Balnace	-V1			-Vg1	0	-V2			-Vg2	0	-V3			-Vg3	-Vcb3	-∑V
Sum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2-2: Flow matrix

Items	The U.S.						Euroland						China					
	Households	Firms		Banks	Government	Central Bank	Households	Firms		Banks	Government	Central Bank	Households	Firms		Banks	Government	Central Bank
		Current	Capital					Current	Capital					Current	Capital			
CONSUMPTION	-C1	+C1					-C2	+C2					-C3	+C3				
Government		+G1			-G1			+G2			-G2			+G3			-G3	
expenditure																		
Investment		+I1	-I1					+I2	-I2					+I3	-I3			
Import		IM1,2						IM2,1						IM3,1				
		IM1,3						IM2,3						IM3,2				
Export		EX1,2						EX2,1						EX3,1				
		EX1,3						EX2,3						EX3,2				
GDP		[Y1]						[Y2]						[Y3]				
WAGES	+W1	-W1					+W2	-W2					+W3	-W3				
Depreciation		-DA1	+DA1					0	0					0	0			
TAX	-T1				+T1		-T2				+T2		-T3				+T3	
Interest Payment	+r1*Bh1,1			+r1*Bcmb1,1	-r1*B1	+r1*BCb1,1	+r1*Bh2,1*E1					+r1*BCb2,1*E1	+r1*Bh3,1*E2					+r1*BCb3,1*E2
	+r2*Bh1,2/E1					+r2*BCb1,2/E1	+r2*Bh2,2			+r2*Bcmb2,2	-r2*B2	+r2*Bcb2,2	+r2*Bh3,2*E3					+r2*Bcb3,2*E3
	+r3*Bh1,3/E2						+r3*Bh2,3/E3						+r3*Bh3,3				-r3*B3	+r3*Bcb3,3
		-r1*L1		+r1*L1				-r2*L2		+r2*L2				-r3*L3		+r3*L3		
	+r1*M1			-r1*M1			+r2*M2			-r2*M2						-r3*A3		+r3*A3
													+r3*M3			-r3*M3		
Central Bank profit					+Fb1	-Fb1					+Fb2	-Fb2					+Fb3	-Fb3
Changes in																		
Loan			+ΔL1	-ΔL1					+ΔL2	-ΔL2					+ΔL3	-ΔL3		
Advance																+ΔA3		-ΔA3
Bank Deposit	-ΔM1			+ΔM1			-ΔM2			+ΔM2			-ΔM3			+ΔM3		
Cash	-ΔHh1					+ΔHs1	-ΔHh2					+ΔHs1	-ΔHh3					+ΔHs3
Bill1	-ΔBh1,1				+ΔB1	-ΔBcb1,1	-ΔBh2,1*E1					-ΔBcb2,1*E1	-ΔBh3,1*E2					-ΔBcb3,1*E2
Bill2	-ΔBh1,2/E1					-ΔBcb1,2/E1	-ΔBh2,2				+ΔB2	-ΔBcb22	-ΔBh3,2*E3					-ΔBcb3,2*E3
Bill3	-ΔBh1,3/E2						-ΔBh2,3/E3						-ΔBh3,3				+ΔB3	-ΔBcb3,3
SUM	0	0	0	0	0	0	0	0		0	0	0	0	0		0	0	0

3 Essay Three: Testing the Portfolio Balance Model: A VAR Approach

3.1 Introduction

The portfolio balance model (PBM) is a natural extension of Tobin's (1969) financial market analysis from closed to open economy macroeconomics. The PBM is a dynamic model of floating exchange rate determination. "The portfolio balance approach – with its rich past but lack of recent attention – may warrant some fresh consideration" (Evans and Lyons, 2005, p. 2). New and powerful econometric techniques may allow researchers to conduct stronger empirical analysis of exchange rates in the PBM. Using advanced econometric methods – vector autoregressive (VAR) approach and vector error correction model (VECM) – the purpose of this paper is to examine whether or not there exists a cointegration relationship among the exchange rate and other variables for financial assets in the PBM. Through the impulse response and variance decomposition analyses, this paper will try to look at the explanatory power of the PBM on the exchange rate of the Canadian dollar against the US dollar. The predictive power of the PBM on the exchange rate also will be examined at various forecasting horizons.

Due to the lack of financial data for many countries, there are only a few empirical studies testing the PBM. Branson and Henderson (1985), MacDonald and Taylor (1992), and Isard (1995), and Sarno and Taylor (2002) conducted excellent surveys on the PBM. Overall, the empirical work on the PBM falls into two approaches: (1) tests based on reduced form exchange rate equations;[23] and (2) tests of perfect substitution of domestic and foreign bonds. The results in the empirical literature on the PBM have been mixed.

Branson, Halttunen and Masson (1977), Bisignano and Hoover (1982), and Dooley and Isard (1982) used cumulated current account balances to estimate the reduced log-linear form of PBM. Their regression results provided little support for the PBM. By contrast, Blundell-Wignall and Browne (1991), and Cushman, Lee and Thorgeirsson (1996) found portfolio balance effects from the cumulative current account balances. Lewis (1988) estimated foreign bonds equations from the PBM, and provided some empirical support for the PBM. Cushman (2007) applied cointegration procedures to his empirical analysis on the PBM for the Canadian-U.S. exchange rate based on the modified PBM and reduced form of PBM. He found two cointegrating vectors among the exchange rate and other variables in his modified PBM. He achieved some empirical

[23] We will discuss the reduced form of the PBM, $s_t = f(m, m^*, b, b^*, fb, fb^*)_t$, in section 3.2 of this paper.

success in beating a random walk model at some out-of-sample forecast horizons, while the significance was quantitatively and statistically modest. However, interest rates were set endogenously rather than exogenously in his modified PBM, and the money stock did not appear in his VAR model and VECM.

For tests of the imperfect substitutability of financial assets in the PBM, Loopersko (1984), Kearney and MacDonald (1986), Dominguez (1990), and Dominguez and Frankel (1993) are relatively successful in finding portfolio balance effects using measures of central bank asset demand, while the results from Frankel (1982) and Rogoff (1984) are not exclusively positive. Evans and Lyons (2005) developed a "micro portfolio balance model" embedding both Walrasian features and features more familiar to models for microstructure finance. They examined asset demand by the public broadly. They found strong evidence of price effects from imperfect substitutability. Their estimated results show that if central bank trades are sterilized, secret, and provide no signal, central bank intervention is most effective when the flow of macroeconomic news is strong. They concluded that there were economically meaningful effects arising from the imperfect substitutability between domestic and foreign assets even in a world of highly integrated financial markets, so that the portfolio balance theory was surprisingly alive.

There is also some literature testing models which combined features from the PBM, the monetary models, and/or other models such as behavioural equilibrium exchange rate (BEER) model etc. These combined models can be referred to as "hybrid money-portfolio balance exchange rate model (HMPBM)" (Sarno and Taylor, 2002) or "composite" model (Cheung et al., 2005). The results for the HMPBM are mixed, and their success is limited (e.g. Hacche and Townend, 1981; Hooper and Monton, 1982; and Frankel, 1984). Cheung et al. (2005) assessed exchange rate prediction using a wider set of models that had been proposed in the 1990s, which included the composite model incorporating the Balassa-Samuelson effect, the overshooting effect and the portfolio effect. The models were estimated in first-difference and error-correction specification, and the predictive power of the models was also examined along different dimensions. Their results are supportive of the assertion that it is very difficult to find forecasts that can consistently beat the random walk (Meese and Rogoff, 1983). They concluded that model/specification combinations working well in one period did not necessarily work well in another period.

Based on the log reduced form of PBM, VAR and VECM approaches, this paper focuses on examining the explanatory power of the PBM for the Canadian-US exchange rate. Unlike Cushman (2007), this paper sets money demand endogenously and interest rates exogenously. This is consistent with the Post-Keynesian monetary theory and that of Sarno and Taylor (2002). In addition, both the impulse responses and variance decomposition of the exchange rate are analyzed in this paper, besides the examination of predictive power of the PBM. In this paper, Canada and the US can be referred to as home and foreign countries respectively.[24]

The remainder of the paper is organized as follows. Section 2 presents the PBM model. Section 3 describes data and methodology. In section 4, regression results for unit root tests and cointegration tests are presented. Section 5 deals with impulse response and variance decomposition analyses. Section 6 contains the forecasting results. Section 7 summarizes and concludes.

3.2 The portfolio balance model

The key feature in the portfolio balance model is that a floating exchange rate should be determined by some contemporary financial market-clearing mechanism. This paper focuses on a two-country portfolio balance model. Following Brainard-Tobin (1968), Godley (1999), Sarno and Taylor (2002), and Bergman (2006), the basic assumptions for the PBM used in this paper are as follows:

- Domestic and foreign investors are the only agents holding financial assets. The net financial wealth of private sectors consists of money, and bills and bonds issued by domestic and foreign governments. Private investors in one country do not hold money of another country. The distribution of money and government bonds or T-bills are based on the domestic interest rate i and the foreign interest rate i^*, respectively.
- Domestic and foreign assets are imperfect substitutes. The changes in exchange rate are determined by supply of and demand for domestic and foreign financial assets, particularly in the short term.

[24] Since I am focusing on portfolio analysis, I will not deal with the Bank of Canada equation, based on interest rate differentials and the prices of commodities and energy, as can be found in the works of Amano and van Norden (1995) and also Issa, Lafrance and Murray (2006).

- The interest rates are set exogenously by the central banks. This is consistent with Post-Keynesian monetary theory.
- The domestic and foreign prices are assumed to be fixed. There is no inflation.
- Money demand and financial assets demand are assumed to be equal to their respective supplies.
- Expectations are assumed to be static.

For the Canadian private investors:

$$W_t = M_t + B_t + S_t \cdot FB_t \tag{1}$$

$$M_t = m(i_t, i_t^*) \cdot W_t \tag{2}$$

$$B_t = b(i_t, i_t^*) \cdot W_t \tag{3}$$

$$S_t \cdot FB_t = f(i_t, i_t^*) \cdot W_t \tag{4}$$

Where

$$\frac{\partial M}{\partial i} < 0, \frac{\partial M}{\partial i^*} < 0, \frac{\partial M}{\partial W} > 0;$$

$$\frac{\partial B}{\partial i} > 0, \frac{\partial B}{\partial i^*} < 0, \frac{\partial B}{\partial W} > 0;$$

$$\frac{\partial (S \cdot FB)}{\partial i} < 0, \frac{\partial (S \cdot FB)}{\partial i^*} > 0, \frac{\partial (S \cdot FB)}{\partial W} > 0; \text{ and}$$

$$m(i_t, i_t^*) + b(i_t, i_t^*) + f(i_t, i_t^*) = 1$$

W is total financial wealth of domestic private investors, M is money demand, B is domestic bills and bonds held by domestic investors, FB is foreign bills and bonds held by domestic investors, S is nominal exchange rate, i is domestic interest rate, and i^* is foreign interest rate. * denotes the foreign country – the US.

Similarly, for the U.S. private investors:

$$W_t^* = M_t^* + B_t^* + FB_t^* / S_t \tag{5}$$

$$M_t^* = m^*(i_t^*, i_t) \cdot W_t^* \tag{6}$$

$$B_t^* = b^*(i_t^*, i_t) \cdot W_t^* \tag{7}$$

$$FB_t^*/S_t = f^*(i_t^*, i_t)\cdot W_t^* \tag{8}$$

Where

$$\frac{\partial M^*}{\partial i^*} < 0, \frac{\partial M^*}{\partial i} < 0, \frac{\partial M^*}{\partial W^*} > 0;$$

$$\frac{\partial B^*}{\partial i^*} > 0, \frac{\partial B^*}{\partial i} < 0, \frac{\partial B^*}{\partial W^*} > 0; \text{ and}$$

$$\frac{\partial (FB^*/S)}{\partial i^*} < 0, \frac{\partial (FB^*/S)}{\partial i} > 0, \frac{\partial (FB^*/S)}{\partial W^*} > 0; \text{ and}$$

$$m^*(i_t, i_t^*) + b^*(i_t, i_t^*) + f^*(i_t, i_t^*) = 1$$

W^* is total financial wealth of foreign private investors, M^* is foreign money demand, B^* is foreign bills and bonds held by foreign investors, and FB^* is domestic bills and bonds held by foreign investors.

Therefore, according to equations (2)-(4) and (6)-(8), the log reduced-form of the PBM can be expressed as follows.[25]

$$s_t = g(m, m^*, b, b^*, fb, fb^*)_t \tag{10}$$

Where $s, m, m^*, b, b^*, fb, fb^*$ are the logarithms of *S, M, M^*, B, B^*, FB, and FB^**.

3.3 Methodology and data

3.3.1 Methodology

The econometric methods employed in our empirical analysis are those developed by Johansen and Juselius (1990), and Johansen (1991, 1995). The Vector Autoregressive (VAR) model and Vector Error Correction Model (VECM) can be used to examine whether or not there

[25] In the PBM, s, m, m^*, b, b^*, fb, and fb^* are set endogenously, while i and i^* are set exogenously. The reduced from of the PBM is the same as that proposed by Sarno and Taylor (2002).

exists a long-run relationship - cointegration equation among exchange rate and demand for financial assets, and to forecast exchange rates.

3.3.1.1 The Vector Autoregressive (VAR) model

The VAR model with n variables and a constant term has the following form:

$$Y_t = C + A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + BX_t + \varepsilon_t \tag{12}$$

Where Y_t is a set of non-stationary endogenous variables, X_t is a set of exogenous variables, ε_t is Gaussian errors, t is time, and p stands for the number of lags. A_p and B are the matrices with coefficients to be estimated.

We can define Y_t as: $Y_t = [s_t, m_t, m_t^*, b_t, b_t^*, fb_t, fb_t^*]'$. Since the data are non-seasonally adjusted, seasonal dummy variables will be added into the model. In order to avoid the impact of dummy variables on the trend of the level series Y_t, we use centered (orthogonalized) seasonal dummy variables. Centered seasonal dummy variables shift the mean other than the trend of the endogenous variables (Johansen, 1995). Therefore, we can define X_t as: $X_t = [dummy\_1, dummy\_2, dummy\_3]'$, where dummy_1, dummy_2, and dummy_3 are centered seasonal dummy variables. The equation (1) can be rewritten as:

$$\begin{bmatrix} s_t \\ m_t \\ m_t^* \\ b_t \\ b_t^* \\ fb \\ fb_t^* \end{bmatrix} = C + A_1 \begin{bmatrix} s_{t-1} \\ m_{t-1} \\ m_{t-1}^* \\ b_{t-1} \\ b_{t-1}^* \\ fb_{t-1} \\ fb_{t-1}^* \end{bmatrix} + \cdots + A_p \begin{bmatrix} s_{t-p} \\ m_{t-p} \\ m_{t-p}^* \\ b_{t-p} \\ b_{t-p}^* \\ fb_{t-p} \\ fb_{t-p}^* \end{bmatrix} + B \begin{bmatrix} dummy\_1 \\ dummy\_2 \\ dummy\_3 \end{bmatrix} + \varepsilon_t \tag{12'}$$

The VAR model can be reorganized as the following VECM form:

$$\Delta Y_t = C + \prod Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + B\Delta X_t + \varepsilon_t \tag{13}$$

Where

$$\prod = \sum_{i=1}^{p} A_i - I$$

$$\Gamma_i = -\sum_{j=i+1}^{p} A_j$$

The Granger representation theorem by Engle and Granger (1987) imply that if there exists cointegration amongst a group of variables, then there must also exist an error correction representation. So, if Π is full rank or zero rank, there will be no cointegration amongst the variables in the long-run relationship. If the coefficient matrix Π has reduced rank $r<k$, then there will exist k×r matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and βY_t is stationary. Then each column of β is the cointegrating vector. The α matrix is known as the adjustment matrix. Johansen's method is to estimate the Π matrix in an unrestricted form, then test whether we can reject the restrictions implied by the reduced rank of Π.

3.3.1.2 A technique for cointegration test

The maximum eigenvalue test by Johansen (1995) is used to test the null hypothesis of r cointegrating relations against the alternative of r+1 cointegrating relations. The test statistic can be computed as:

$$Q_{\max} = -T\log(1-\lambda_{r+1}) = Q_r - Q_{r+1} \tag{14}$$

Where r=0,1,2,……,k-1.

3.3.2 Data source and unit root test

3.3.2.1 Data source

This paper uses quarterly data for Canada and the United States over the period of 1970:1 to 2003:01.[26] Canada and the US can be referred to as home country and foreign country respectively. The exchange rate is measured by the quarterly average of the Canadian dollar vis-à-vis the US dollar – the value of the US dollar in terms of the Canadian dollar. Money demand is measured by M2. The money demand for Canada is collected from CANSIM II. The exchange rate and money demand for the US are collected from the IMF's International Financial Statistics (IFS). As in Cushman (2007), bills and bonds variables are collected from CANSIM II and the Federal Reserve Bank of St. Louis.[27] All variables are in logarithmic form and not seasonally adjusted.

3.3.2.2 Unit root test

In this paper, Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests are employed to investigate whether the variables in the VAR model are I(1), that is, they are non-stationary in levels and stationary in first differences. For the PP test, the null hypothesis is that the variable has a unit root, while the KPSS test use a null hypothesis that the variable is stationary. For the PP and KPSS tests, Bartlett kernel is selected as the kernel estimation method, and the optimal bandwidth selection is based on the New-West bandwidth selection method. As shown in the Appendix A, most of the variables in levels appear to possess trends, except for the exchange rate. Therefore, a linear trend and intercept are included in the unit root tests in levels for b, b*, m, m*, fb, and fb*, while only an intercept is included for s.

As shown in Table 3-1, both the PP and KPSS test results show that at the 0.05 level, all variables are not stationary in levels, while they are stationary in first differences. This means that all variables are I(1). Therefore, we can move on to the next step – the cointegration test.

[26] There are following two reasons for the selection of this sample period: (1) there are lags for the release of some financial assets data; and (2) the results in this paper can be comparable with those of the existing studies.
[27] For more details about the data source of bills and bonds, see the Appendix 2 of the paper by Cushman (2007).

Table 3-1: Unit root test results, sample period: 1970-2003

Variables	Unit root test statistics in level		Unit root test statistics in 1st difference	
	PP	KPSS	PP	KPSS
m	-0.744479	0.356813***	-5.740631***	1.072418
m*	-1.864705	0.345039***	-8.604708***	0.725101
b	1.040438	0.316063***	-9.010326***	0.675865
b*	0.329651	0.312141***	-9.095253***	0.498046
fb	-1.497535	0.19143**	-12.61518***	0.154054
fb*	-1.263808	0.18938**	-9.766223***	0.22265
s	-1.453968	0.939970***	-8.945737***	0.207628

Note: *** indicates significant at 1%; ** significant at 5%; and * significant at 10%. For the PP test, critical values are given in MacKinnon (1996). For KPSS test, critical values are given in Kwiatkowski-Phillips-Schmidt-Shin (1992).

3.4 Cointegration test

3.4.1 Cointegration test

Table 3-2: VAR Lag Order Selection Criteria

Lag	FPE	AIC	SC	HQ
2	1.14e-31*	-51.40709	-48.29599*	-50.14542*
3	1.25e-31	-51.34929	-47.02832	-49.59698
4	1.62e-31	-51.15901	-45.62816	-48.91605
5	1.98e-31	-51.06289	-44.32218	-48.32929
6	1.74e-31	-51.35671	-43.40612	-48.13245
7	2.02e-31	-51.43880	-42.27834	-47.72390
8	2.47e-31	-51.57004	-41.19971	-47.36449
9	3.33e-31	-51.73662	-40.15642	-47.04043
10	3.80e-31	-52.25406	-39.46398	-47.06721
11	4.16e-31	-53.08949	-39.08954	-47.41200
12	6.14e-31	-54.06836*	-38.85854	-47.90023

* indicates lag order selected by the criterion

The first step of the cointegration test is to choose an optimal order of lag for the VAR model. The Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quinn Information Criterion (HQ) are criteria which are used for the lag order selection. The minimum and maximum lag orders are 2 and 12 respectively. Based on the values of the selection criteria, FPE, SC and HQ indicate that the optimal lag order is 2, while AIC shows that the optimal lag number is 12. Therefore, it is plausible to choose a lag order of 2 for the VAR model.

Table 3-3: Cointegration rank test results - Eigenvalue tests

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.392737	58.85768	46.23142	0.0014
At most 1	0.284725	39.54044	40.07757	0.0574

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The next step for our empirical analysis is to test for the cointegration rank by using the eigenvalue test proposed by Johansen (1995). As shown in Table 3-3, the eigenvalue test results indicate that there is a unique cointegration equation for the VAR system at the 0.05 level. Therefore, we can say that there is a long-run relationship among the variables s, m, m*, b, b*, fb, and fb*.

Table 3-4 presents the cointegration equation including β-vector (normalized cointegrating coefficients) and α-vector (adjustment coefficients). In the cointegration equation, the coefficients of fb, fb*, and m are significant at the 0.05 level. All adjustment coefficients are significant at the 0.05 level, exception for the coefficient of d(fb) which is significant at the 0.10 level.

Table 3-4. Cointegration equation

1 Cointegrating Equation(s): Log likelihood 3142.755

Normalized cointegrating coefficients (standard error in parentheses)

s	b	b*	fb	Fb*	m	m*
1.000000	-0.176199	0.184610	-1.596012	1.264164	0.431257	-0.156880
	(0.14676)	(0.14232)	(0.44397)	(0.51276)	(0.12712)	(0.18758)

Adjustment coefficients (standard error in parentheses)

D(S)	-0.047282	(0.02709)
D(B1)	0.041454	(0.03622)
D(B2)	0.013627	(0.03372)
D(FB1)	-0.034145	(0.05117)
D(FB2)	-0.069289	(0.04007)
D(M1)	-0.042771	(0.01197)
D(M2)	-0.073903	(0.01308)

3.4.2 Stability test

Table 3-5: Stability test results

Roots of Characteristic Polynomial

Root	Modulus
0.994423	0.994423
0.984457 - 0.065451i	0.986631
0.984457 + 0.065451i	0.986631
0.917506 - 0.097346i	0.922656
0.917506 + 0.097346i	0.922656
0.904286	0.904286
0.598167 - 0.105813i	0.607453
0.598167 + 0.105813i	0.607453
-0.070232 - 0.237804i	0.247958
-0.070232 + 0.237804i	0.247958
0.172191 - 0.174333i	0.245034
0.172191 + 0.174333i	0.245034
0.221581 - 0.076374i	0.234374
0.221581 + 0.076374i	0.234374

Let us now look at the stability of the VAR model. The AR roots are employed in the stability analysis.[28] As mentioned above, our VAR model has 7 endogenous variables and the lag order is 2. Thus, there are 14 roots. Table 3-5 presents the inverse roots of the characteristic polynomial. The results indicate that all roots have modulus less than one, that is, no root lies outside the unit circle as shown in Appendix C-1. This means that the estimated VAR model is stable.

3.5 Impulse response and variance decomposition analyses

3.5.1 Impulse response analysis

Since the VAR system is stable, we can go to the next step – impulse response analysis, which can be used to investigate the dynamic characteristics of the model.[29] In order to orthogonalise the innovations in the VAR model and interpret the impulses, the estimated equations in the VAR model need to be transformed. We employ the generalized impulse method for transforming the impulses. Generalized impulse can construct an orthogonal set of innovation that does not depend on the ordering of the variables in the VAR (Pesaran and Shin, 1998). This enables impulse response and variance decompositions to be performed so as to trace the impact of a one-time shock to one variable on the current and future values of all the other endogenous variables.

In this paper, impulse responses of the VAR model are examined to assess the model's response to random shocks to innovations in each of the included variables. The responses over time of all 7 variables in the VAR model to each such random shock are illustrated in the Figures 3-1, 3-2, 3-3, and Figures in Appendix C. Each graph contains the plus/minus two standard error bands about the impulse responses. Upper and lower bands are calculated by analytic asymptotic standard errors at the 0.05 level. These responses present dynamic adjustment processes of the endogenous variables.

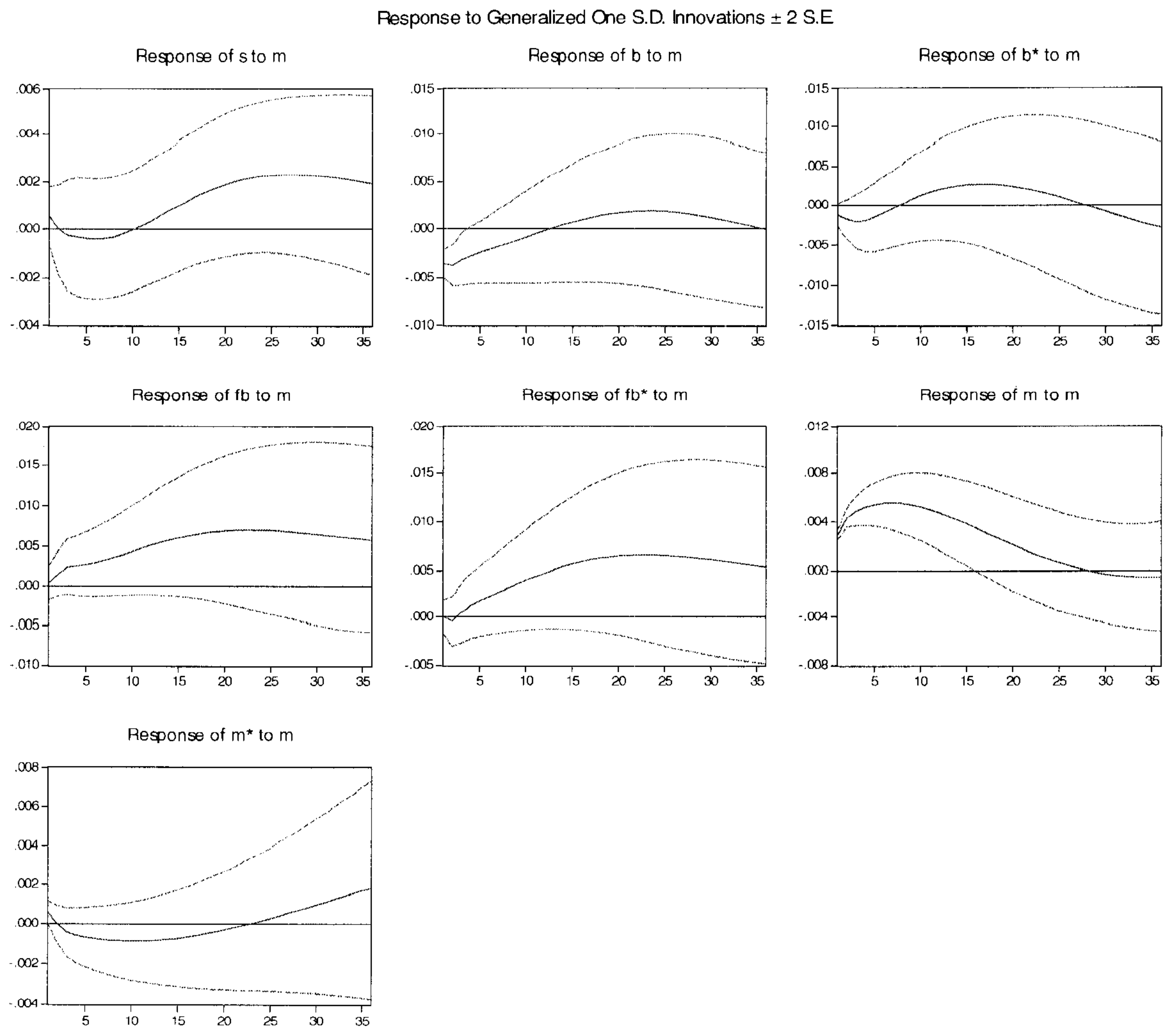
---

[28] For more details, see Lutkepohl (1991).

[29] If the VAR is not stable, impulse response standard errors are not valid.

Figure 3-1 presents dynamic adjustment paths of all endogenous variables based on a shock to Canada's residents money demand – m. The shock leads to an increase in domestic money demand during the initial several periods. An increase in m induces Canadian residents to adjust their portfolio of financial assets. Canada's residents demand for domestic bills and bonds - b falls immediately after the shock, while it starts to gradually increase after 2 periods.

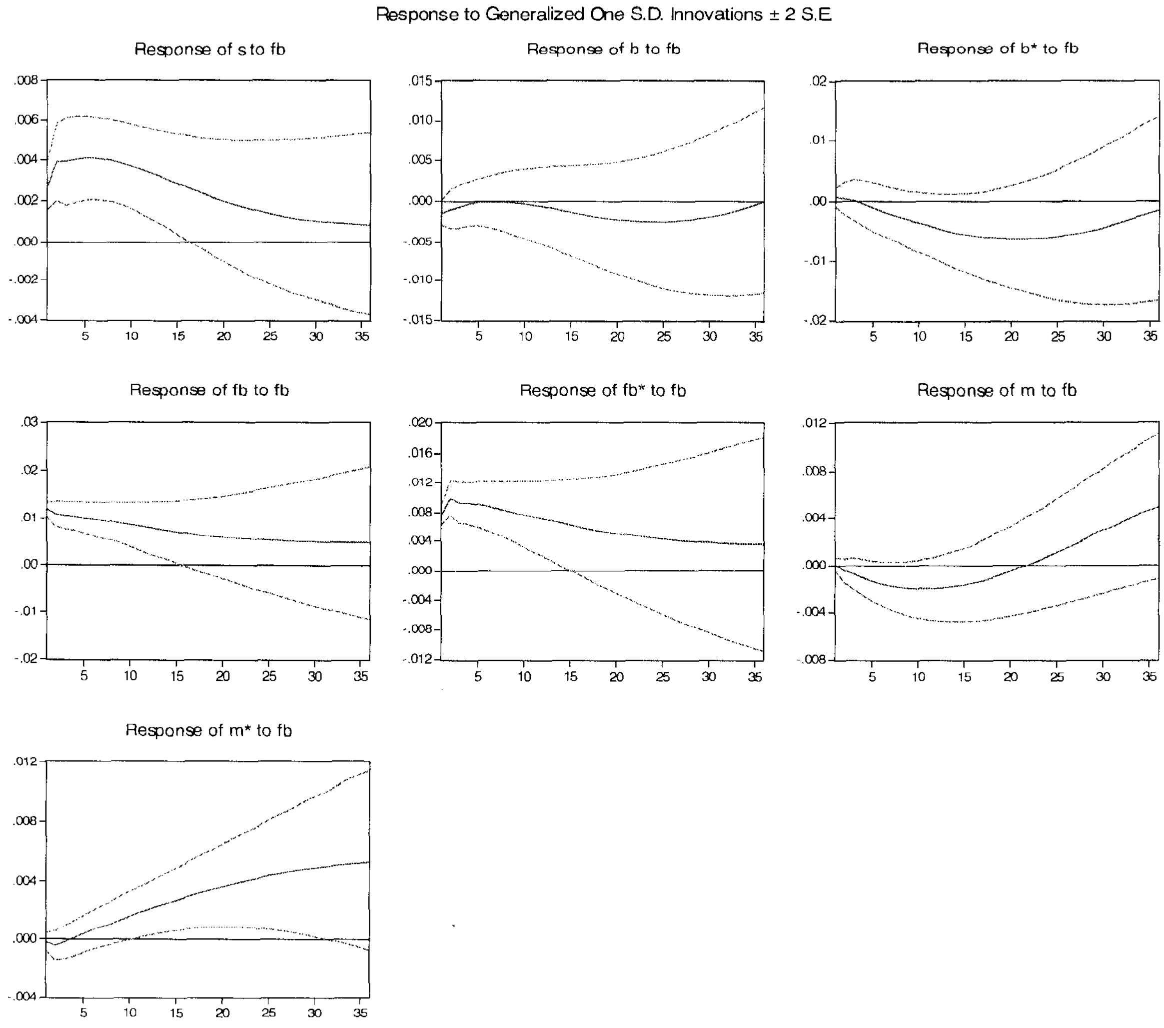
Figure 3-1: Response to generalized one standard deviation of m



m reaches its peak at 7 period after the shock, and then starts to decrease gradually. However, Canada's residents demand for the US Treasury bills and bonds – fb increases gradually.

The shock to money demand leads to a slight increase in the value of the US dollar in terms of the Canadian dollar immediately after the shock, followed by a gradual decrease. The value of the US dollar in terms of the Canadian dollar reaches its bottom as Canada's resident money demand peaks 7 periods after the shock. In the long run, this money demand shock eventually turns into an appreciation of the US dollar against the Canadian dollar. This result is consistent with the theoretical prediction of the portfolio balance model (Visser, 2004). This is due to the higher demand for US bills and bonds, which drives up the exchange rate of the US dollar against the Canadian dollar in the long-run.

Figure 3-2: Response to generalized one standard deviation of fb



Let us now have a close look at the effects of a shock to fb - Canada's residents demand for the US Treasury bills and bonds. Similarly, as shown in Figure 3-2, the shock leads to a jump of fb. The effects of increases in fb are straightforward. Increases in fb result in an appreciation of the US dollar against the Canadian dollar. The value of the US dollar peaks at 6 periods after the shock. After that, the US dollar depreciates gradually against the Canadian dollar as fb decreases over time. This result also provides a strong support to the above mentioned findings. fb plays a dominant role in the changes of the exchange rate. We will have a further discussion about this in the next section – variance decomposition analysis.

Figure 3-3: Response to generalized one standard deviation of b

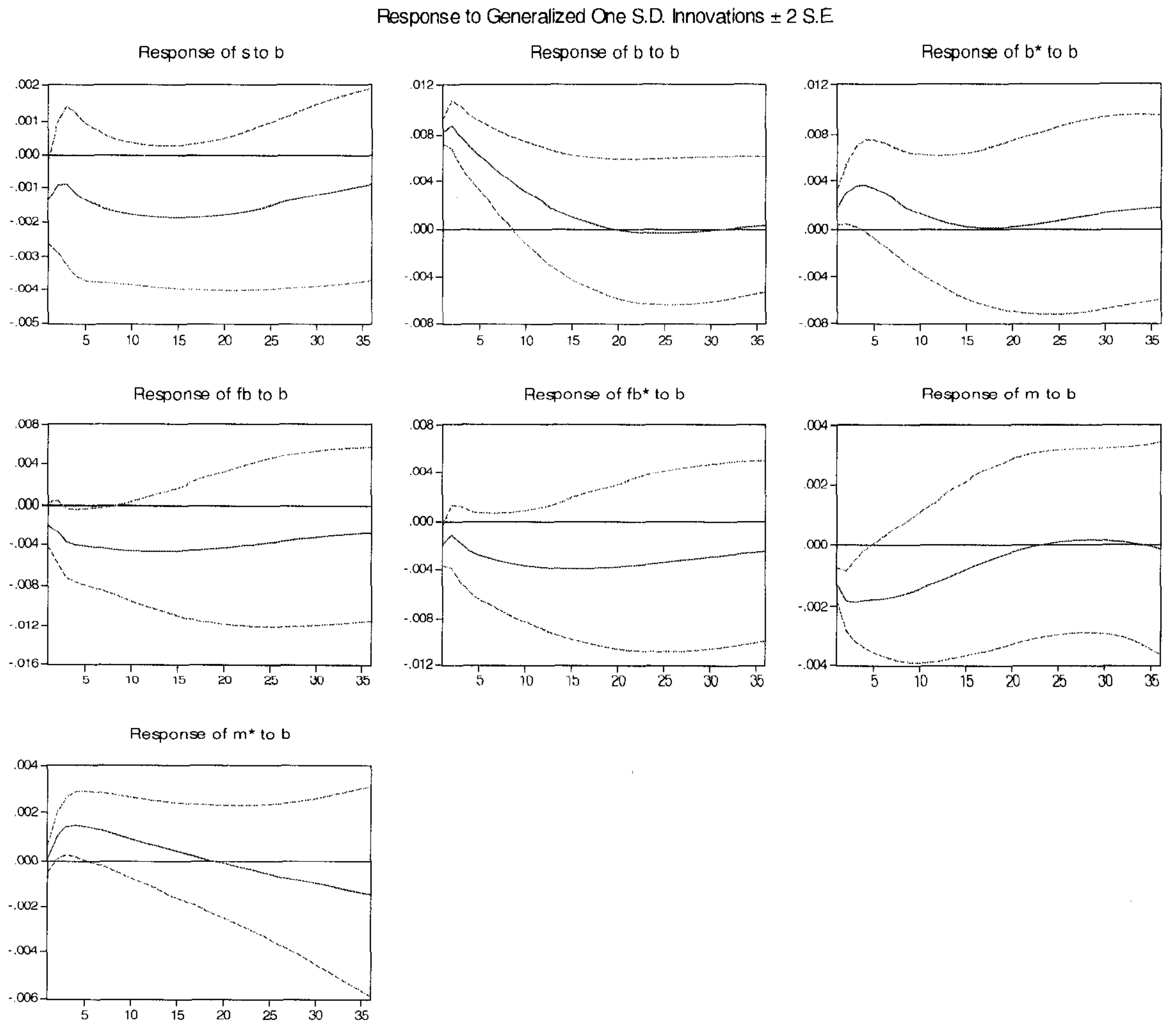


Figure 3-3 presents responses of all endogenous variables to one generalized deviation of b - the Canadian's residents demand for domestic bills and bonds. The shock immediately leads to a jump of b. This results in a re-allocation of the financial portfolio of Canada's residents, such as dramatic decreases in their demand for domestic money and for US Treasury bills and bonds. As Canada's investors decrease their holdings of the US bills and bonds, the Canadian dollar appreciates against the US dollar, that is, s – the value of the US dollar in terms of the Canadian dollar – falls.

3.5.2 Variance decomposition analysis

In the previous section, we analyzed the impulse response function which traced the effects of a shock to one innovation on to the other variables. Let us now look at variance decomposition which separates the variation in an endogenous variable into the component shocks to the VAR and provides information about the relative importance of each random innovation in affecting the variables in the VAR.

Table 3-6: Variance Decomposition of s [30]

Period	S.E.	s	b	b*	fb	fb*	m	m*
1	0.006666	78.58623	1.063297	1.115421	16.02041	0.015057	0.750649	2.448938
2	0.010352	76.16407	0.573284	0.513046	20.84011	0.133645	0.311385	1.464456
3	0.012853	74.54478	0.487889	0.447621	22.86118	0.119324	0.234283	1.304913
4	0.014643	72.04060	0.611508	0.637542	25.15526	0.114356	0.221649	1.219092
5	0.015988	68.84814	0.833991	1.004886	27.69414	0.247330	0.235433	1.136087
6	0.017036	65.35135	1.089211	1.470442	30.22401	0.534691	0.258471	1.071822
7	0.017880	61.81991	1.345948	1.939874	32.62091	0.965136	0.276528	1.031697
8	0.018577	58.45321	1.587571	2.330912	34.81648	1.511434	0.281601	1.018796
9	0.019164	55.38195	1.805150	2.593947	36.76797	2.139201	0.273483	1.038299
10	0.019671	52.67398	1.993820	2.716428	38.44595	2.812128	0.259766	1.097926
11	0.020120	50.34901	2.150697	2.717986	39.82620	3.494822	0.254348	1.206933
12	0.020533	48.39310	2.274027	2.641452	40.88737	4.154714	0.274928	1.374409
13	0.020928	46.77056	2.363012	2.542682	41.61281	4.763501	0.340026	1.607406
14	0.021321	45.43315	2.417931	2.480681	41.99444	5.298421	0.466013	1.909361
15	0.021724	44.32719	2.440321	2.508952	42.03649	5.743328	0.664595	2.279123
16	0.022148	43.39913	2.433019	2.668859	41.75771	6.089329	0.941190	2.710761
17	0.022598	42.59985	2.400023	2.985676	41.19108	6.334750	1.294430	3.194184
18	0.023076	41.88765	2.346159	3.467563	40.38112	6.484336	1.716783	3.716384
19	0.023581	41.22978	2.276638	4.107180	39.37955	6.547832	2.196041	4.262978
20	0.024111	40.60272	2.196610	4.885152	38.24034	6.538221	2.717227	4.819729
21	0.024661	39.99135	2.110782	5.774374	37.01525	6.469956	3.264518	5.373764
22	0.025224	39.38755	2.023168	6.744229	35.75043	6.357452	3.822824	5.914353
23	0.025795	38.78840	1.936962	7.764080	34.48444	6.213988	4.378885	6.433249
24	0.026366	38.19456	1.854537	8.805753	33.24757	6.051052	4.921861	6.924671

[30] The variance decomposition is based on the Cholesky factor.

Variance decomposition for the exchange rate in logarithm is presented in Table 3-6. It is apparent that the largest proportion of the variance in the exchange rate is accounted for by innovations in fb, except for the innovation of the exchange rate itself. The proportion of fb increases from roughly 16.02% at period 1 to 27.69% at period 5 and to roughly 42.04% at period 15, respectively. This suggests that the shock to Canada's private demand for US Treasury bills and bonds has the greatest impact on the exchange rate of the Canadian dollar against the US dollar. At period 24, the innovation of fb* accounts for 6.05% of the variance of the exchange rate, the fourth largest among the other endogenous variables. However, even in the long-run, there is still a large proportion of the variance of the exchange rate that cannot be explained by the other endogenous variables in the VAR system.

3.6 Forecasting results

In order to examine the constancy and the goodness of fit of the VAR model over the sample, this section presents the in-sample and out-of-sample forecasting results for the log exchange rate – s. The bootstrap method is used in generating the innovations to the stochastic VAR equations. The innovation is generated by drawing randomly from the set of actual innovations observed within the sample period. The in-sample size covers the 1970:q3 to 2000:q1 period. The observations corresponding to the 2000:q2 to 2003:q1 period are reserved for the out-of-sample forecasting test. For the forecasted values of the endogenous variables, we set a confidence interval given by the upper and lower bands. In this paper, the default size of the confidence interval is 0.95, which provides a 95% confidence interval with a weight of 2.5% in each tail. We will focus on the comparison analysis of forecasting errors between the VAR model and random walk model, and see whether the VAR model can outperform the random walk models with and without drifts respectively.

The forecast error statistics - root mean squared error (RMSE) is used as a relative measure to compare forecasts for the log exchange rate between the VAR and random walk model. The ratio of RMSE of the VAR model to that of random walk is calculated. If the ratio is smaller than one, we can say that the forecasting ability of the VAR model is better than that of random walk model, and vice versa.

Like the existing studies on the determination of nominal exchange rate, the test statistics proposed by Diebold and Mariano (1995) (DM) are also employed to test the accuracy of forecasts. The long-run variances of the loss differential series are estimated by using the spectral density at frequency zero with the Bartlett Kernel. Based on DM test method, the loss function L for the mean square errors (MSE) is as follows:

$$L(s_t)_j = (\hat{s}_{j,t} - s_t)^2 \tag{15}$$

Where $\hat{s}_{j,t}$ is forecasted log exchange rates, and j=1,2,3, which stand for the VAR model, random walk with drift and without drift respectively.

The MSE differential series between the VAR model and random walk are defined as:

$$d_{1,t} = L(s_t)_1 - L(s_t)_2 \tag{16}$$

$$d_{2,t} = L(s_t)_1 - L(s_t)_3 \tag{17}$$

Where $d_{1,t}$ is the MSE differential series between the VAR model and random walk with drift, and $d_{2,t}$ is the MSE differential series between the VAR model and random walk without drift.

The null hypothesis of the DM test is that the mean of $d_{1,t}$ (or $d_{2,t}$) is equal to zero, that is, the performance of the VAR model in forecasting the log of the exchange rate is not different from that the random walk. The DM test statistic is defined as:

$$DM - Statistic_i = \frac{\bar{d}_{i,t}}{\sqrt{\dfrac{2\pi \cdot \hat{f}_{d,i}(0)}{T_{f,i}}}} \tag{18}$$

Where $\bar{d}_{i,t}$ is mean of the MSE differential series, $\hat{f}_d(0)$ is the Bartlett kernel-based estimator of the frequency zero spectral density, T_f the number of forecasts, and i=1,2,.

Since the DM test statistic convergences generally to a standard normal distribution, we can compare it to the usual critical values of t-test at the 5% or 10% significant levels respectively.

3.6.1 In-sample forecasting results

Figure 3-4: In-sample one-period ahead projection of s, 1970Q3-2000Q1

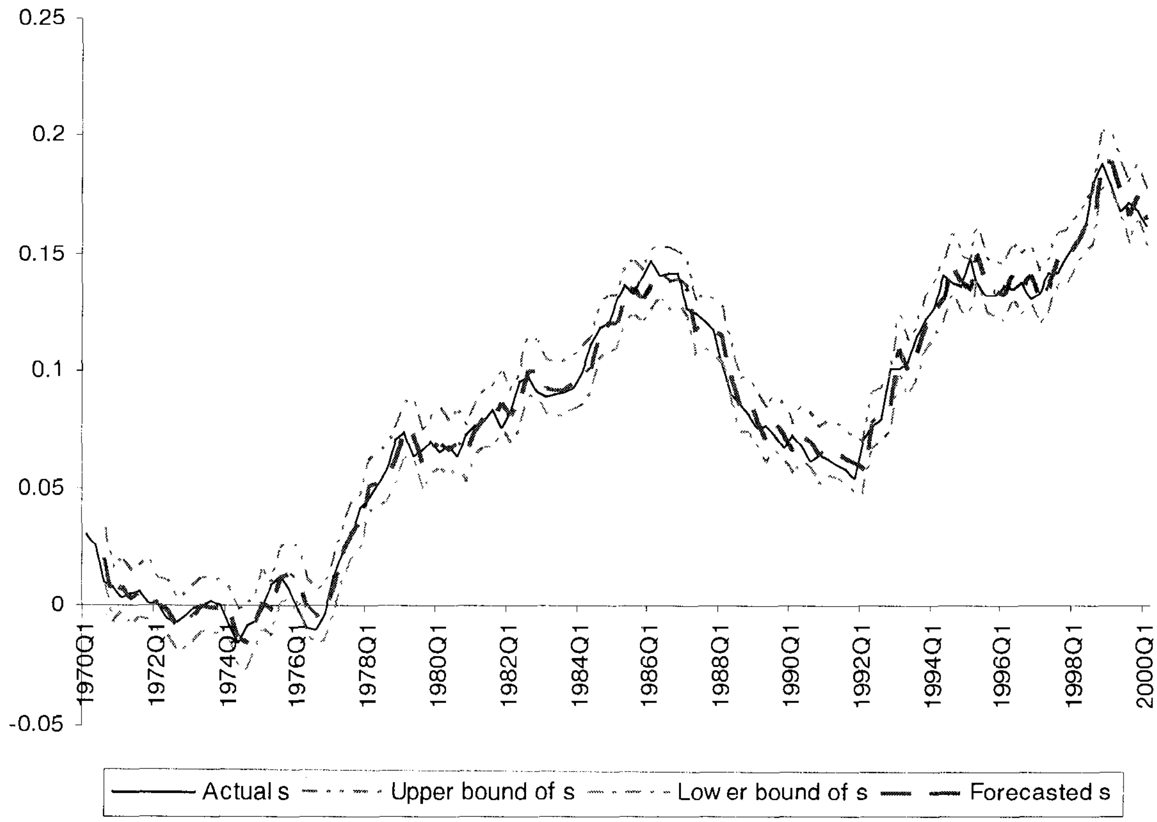
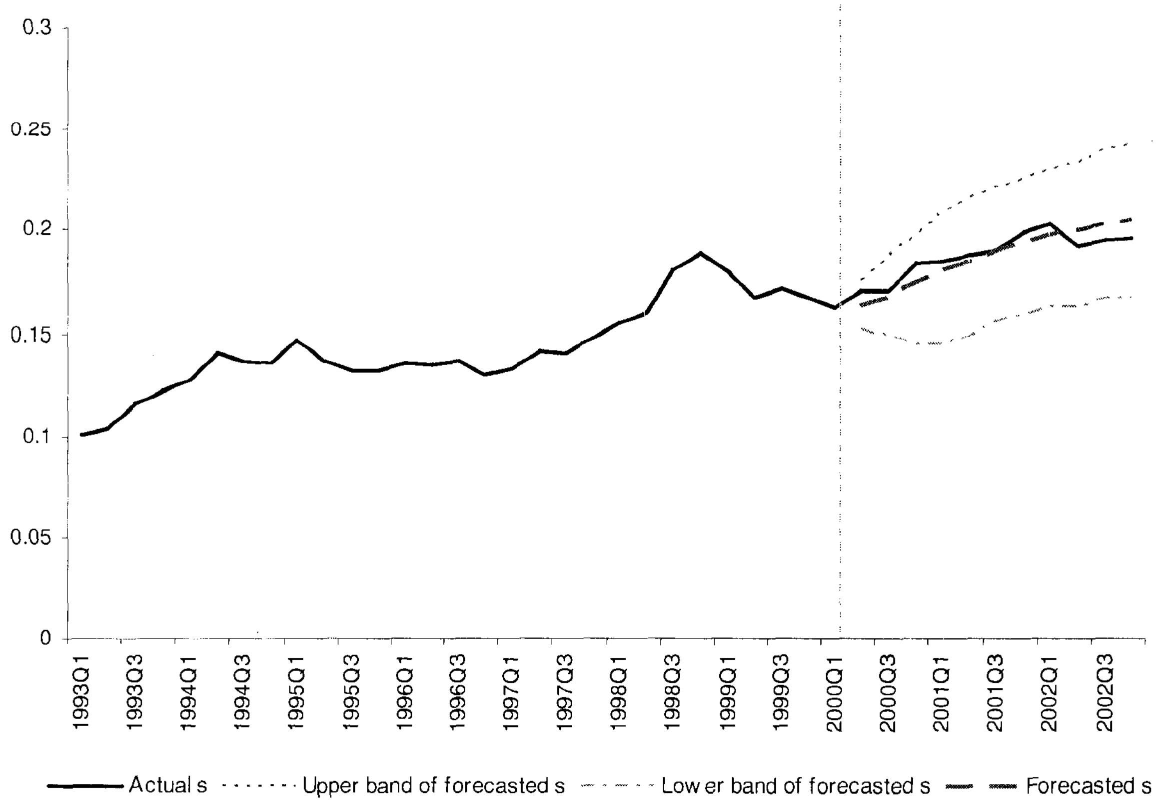


Figure 3-4 plots the in-sample static forecasted and actual log values of the US dollar in terms of the Canadian dollar, s, over the 1970:q3 to 2000:q1 period. For the static projection of the exchange rate, values of endogenous variables up to the previous period are used in running the VAR model. Lagged endogenous variables are based on actual values of the endogenous variables. The static forecasting method can produce a set of one-period ahead forecasts. As shown in Figure 3-4, overall, the static forecasting values of log exchange rate fit the actual values quite well.

3.6.2 Out-of-sample dynamic forecasting results

Figure 3-5: Out-of-sample dynamic projection of s, 2000Q2-2003Q1



In this section, we examine the out-of-sample forecast power of the VAR model. The period 2000:q2 to 2003:q1 period is used for the out-of-sample forecasting test. For the dynamic forecasting, lagged endogenous variables in the VAR model are calculated using the forecasted values in previous periods when forming the forecasting. The estimated values of endogenous variables are then fed back into the VAR model and a further set of forecasts are made (Tawadros, 2001). The dynamic forecasts can produce a set of multi-step ahead forecasts. Figure 3-5 presents the out-of-sample dynamic forecasted and actual values of the log of the exchange rate over the 2000:q2 to 2003:q1 period.

In order to test the performance of the out-of-sample forecasting of the VAR, the random walk model is employed as a comparison model (Meese and Rogoff, 1983). The RMSE and DM test statistic are calculated for the VAR and random walk models with and without drift. We will examine whether or not the VAR model can outperform the random walk model in the out-of-sample forecasts. The VAR and random walk models with drift and without drift are used to forecast log exchange rates for 6 forecasting horizons, such as 1, 3, 6, 9, 12, and 15 periods ahead over the 2000:q2 to 2003:q1 period, respectively.

Table 3-7: Out-of-sample forecasting errors statistics of log s: Ratio of the root mean square errors, Compared with random walk

	1 period ahead	3 periods ahead	6 periods ahead	9 periods ahead	12 periods ahead	15 periods ahead
VAR model/Random walk with drift	0.959267	0.975474	0.8365	1.003939	0.866676	0.42667
VAR model/Random walk without drift	0.925482	0.794527	0.65702	0.67211	0.485408	0.261491

As shown in Table 3-7, compared to the random walk model with drift, the RMSE of exchange rate are lower for the VAR model at 1, 3, 6, 12 and 15 forecast horizons, while it is slightly higher for the VAR model at 9-period ahead forecasts. At the 15-period horizon, the RMSE of the VAR is only 0.42667 of that of the random walk.

The RMSE ratios of the VAR model to the random walk without drift are smaller than one at all horizons. The RMSE ratios decrease dramatically from 0.925482 at one period ahead to 0.261491 at 15-period ahead. This reflects the fact that compared to the random walk model without drift, the VAR model performs better at all horizons. The degree of improvement of the VAR model over the random walk without drift increases as the forecasting horizon is extended. Therefore, we can say that the VAR model beats the random walk without drift at all forecast horizon.

Table 3-8: Out-of-sample forecasting errors statistics of log s: DM statistics, Compared with random walk

DM statistics for	1 period ahead	3 periods ahead	6 periods ahead	9 periods ahead	12 periods ahead	15 periods ahead
Differential between the VAR model and random walk with drift	0.3202	0.0441	0.3525	-0.0082	0.4148	1.558
Differential between the VAR model and random walk without drift	0.3835	0.2708	0.4782	0.6147	1.6826	1.8428*

Table 3-8 presents the DM test statistic of the differential series between the MSE of the VAR model and that of the random walk model with or without drift. The positive DM statistic means that the VAR model outperforms the random walk model. Let us now look at the significance of the DM statistic. All DM statistics are smaller than the critical values at the 0.05 level. Thus, we can say that the MSE of VAR model is not significantly different from that of the random walk model with or without drift in forecasting exchange rate at the 0.05 level.

At the 0.10 level, only the DM statistic for the VAR over the random walk without drift at the 15-period horizon is greater than the critical value. Therefore, the VAR model can beat significantly the random walk model without drift only at the 15-period horizon at the 0.10 level.

3.7 Conclusion

This paper has examined the portfolio balance model for the determination of the nominal exchange rate of the Canadian dollar against the US dollar using the VAR model. Over the 1970-2000 period, one cointegration equation - a long-run relationship among the log exchange rate, money demand, and domestic and foreign demands for bills and bonds was found.

Through an analysis of the impulse response, we find that the domestic (Canadian) demand for the foreign (the US) bills and bonds play an important role in the dynamic changes in the exchange rate of the Canadian dollar against the US dollar. A positive shock on the domestic demand for the foreign financial assets (fb) results in an appreciation of the US dollar against the Canadian dollar.

The variance decomposition analysis results show that the largest proportion of the variance in the exchange rate is accounted by innovations in the demand for foreign financial assets (fb), except for the exchange rate itself. However, there is still a large proportion of the variance of the exchange rate that cannot be explained by the other endogenous variables in the VAR system.

Based on the RMSE of the dynamic out-of-sample forecast results, we find that the portfolio balance VAR model can outperform the random walk without drift at all forecast horizons. The degree of improvement of the portfolio balance model over the random walk without drift increases with the extension of the forecasting horizon.

However, the DM test results show that the VAR model can not beat the random walk model with or without drift in the projection of the exchange rate at the 0.05 level, while at the 0.10 level, the VAR model can outperform the random walk model without drift only at the 15-period horizon.

So, it is difficult for the reduced form portfolio-balance models to consistently beat the random walk model. In order to outperform significantly the random walk model in the projection of exchange rate, one research direction may be to move away from reduced form models towards open economy macroeconomic or macroecometric models with the consideration of both stocks and flows of all endogenous variables (Gandolfo, 2001). The two-country stock-flow consistent model developed by Godley and Lavoie (2003) could be applied for exchange rate forecasting. The Godley and Lavoie model is in the Branson tradition, not only taking into account portfolio balance, but also showing how exchange rates, once determined in asset markets, feed back to changes in relative prices and therefore trade flows, and hence to demand for and supply of assets, income flows, and so back to exchange rates themselves (Godley and Lavoie, 2007, chapter 12).

Reference

Amano, R. and van Norden, S. (1995), "Terms of Trade and Real Exchange Rates: The Canadian Evidence." *Journal of International Money and Finance* 14(1), pp. 83–104.

Bergman, M. (2006), Note on money creation and the portfolio balance model, http://www.econ.ku.dk/okombe/IME2006/portfolio.pdf.

Bisignano, J. and Hoover, K. (1982), "Some suggested improvements to a simple portfolio balance model of exchange rate determination with special reference to the U.S. dollar/Canadian dollar rate", *Weltwirtschaftliches Archic,* 118, pp. 19-38.

Blundell-Wignall, A. and Browne, F. (1991), "Increasing financial market integration: real exchange rates and macroeconomic adjustment", *OECD Working Paper,* No. 96.

Branson, W. H., Halttunen, H. and Masson, P. (1977), "Exchange rates in the short-run: the dollar-deutschmark rate", *European Economic Review,* 10, pp.303-324.

Branson, W. H. and Herderson, D. W. (1985), "The specification and influence of asset markets", in Jones, R.W. and Kenen, D.W. (eds.), *Handbook of International Economics,* vol. II, Amsterdam: North-Holland, pp. 749-805.

Brainard, W.C. and J. Tobin (1968) 'Pitfalls in financial modelling', *American Economic Review*, May, 58 (3), pp. 99-122.

Cheung, Y.W., China, M.D. and Pascual, A.G. (2005), "What do we know about recent exchange rate models? In-sample fit and out-of-sample performance evaluated", in Grauwe, P.D. (eds), *Exchange Rate Economics: Where do we stand?* The MIT Press, Cambridge England.

Cushman, D.O., Lee, S.S. and Thorgeirsson, T. (1996), "Maximum Likelihood Estimation of Cointegration in Exchange Rate Models for Seven Inflationary OECD Countries," *Journal of International Money and Finance,* 15 (June), 337-368.

Cushman, D.O. (2007), "A Portfolio Balance Approach to the Canadian-U.S. Exchange Rate," *Review of Financial Economics,* 16 (no. 3), 305-320.

Dominguez, K.M. (1990), "Market Responses to Coordinated Central Bank Intervention", *Carnegie-Rochester Series on Public Policy,* 32, pp. 121-64.

Dominguez, K.M. and Frankel, J.A. (1993), "Does foreign-exchange intervention matter? The portfolio effect", *America Economic Review,* Vol. 83, No. 5.

Dooley, M. and Isard, P. (1982), "A portfolio-balance rational-expectations model of the dollar-mark exchange rate", *Journal of International Economics,* 12, pp. 257-276.

Diebold, F. and Mariano, R. (1995), "Comparing predictive accuracy", *Journal of Business and Economic Statistics*, 13, pp. 253-265.

Engle, R.F. and Granger, C.W.J (1987), "Co-integration and error correction: representation, estimation, and testing", *Econometrica,* 55, 251-276.

Evans, M. D. D. and Lyons, R. K. (2005), "Are different-currency assets imperfect substitutes?", in Grauwe, P. D. (eds.), *Exchange Rate Economics*, the MIT Press, Chapter 1, pp. 1-38.

Frankel, J.A. (1982), "In search of the exchange risk premium: a six-currency test assuming mean-variance optimization", *Journal of International Money and Finance*, 1, pp. 255-274.

Frankel, J.A. (1984), "Tests of monetary and portfolio balance models of exchange rate determination", in Bilson, J.F.O. and Marston, R.C. (eds.), *Exchange Rate Theory and Practice*, National Bureau of Economic Research Conference Report, Chicago: University of Chicago Press, pp. 239-260.

Gandolfo, G. (2001), *International Finance and Open-Economy Macroeconomics*, Springer.

Godley, W. (1999), "Open economy macroeconomics using models of closed system", WP No. 285, The Levy Economics Institute of Bard College: Annandale-on-Hudson, NY.

Godley, W. and Lavoie, M. (2003), "Two-Country Stock-Flow-Consistent Macroeconomics Using A Closed Model within A Dollar Exchange Regime", Cambridge Endowment for Research in Finance, Working Paper 10, University of Cambridge.

Godley, W. and Lavoie, M. (2007), *Monetary Economics: An Integration Approach to Credit, Money, Income, Production and Wealth,* London: Palgrave/Macmillan.

Hacche, G. and Townend, J.C. (1981), "Monetary models of exchange rates and exchange market pressure: some general limitations and an application to sterling's effective rate", *Weltwirtschaftliches Archic*, 117, pp. 622-637.

Hooper, P. and Morton, J. (1982), "Fluctuations in the dollar: a model of nominal and real exchange rate determination", *Journal of International Money and Finance*, 1, pp. 39-56.

Isard, P. (1995), *Exchange Rate Economics*, Cambridge: Cambridge University Press.

Issa, R., Lafrance, R. and Murray, J. (2006), "The turning black tide: Energy prices and the Canadian dollar", *Bank of Canada Working Paper*, No. 2006-29.

Johenson, S. (1991), "Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models", *Econometrica*, 59, 1551-1580.

Johenson, S. (1995), *Likelihood-based Inference in Cointegration Vector Autoregressive Models*, Oxford: Oxford University Press.

Johenson, S. and Juselius, K. (1990), "Maximum likelihood estimation and inferences on cointegration – with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Kearney, C.P. and MacDonald, R. (1986), "Intervention and sterilization under floating exchange rates: the U.K. 1973-1983", *European Economic Review*, 30, pp. 345-364.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992), "Testing the null hypothesis of stationary against the alternative of a unit root", *Journal of Econometrics*, 54, pp. 159-178.

Lewis, K.K. (1988), "Testing the portfolio balance model: a multi-lateral approach", *Journal of International Economics*, 24, pp. 109-127.

Loopersko, B.E. (1984), "Relationships among exchange rates intervention and interest rates: an empirical investigation", *Journal of International Money and Finance*, 3, 257-277.

MacDonald, R. and Taylor, M. P. (1992), "Exchange rate economics: a survey", *IMF Staff Papers*, 39, pp. 1-57.

MacDonald, R. and Taylor, M. P. (1993), "The monetary approach to the exchange rate: rational expectations, long-run equilibrium and forecasting", *IMF Staff Papers*, 40, pp. 89-107.

Mackinnon, J.G. (1996), "Numerical distribution functions for unit root and cointegration tests", *Journal of Applied Econometrics*, 11, pp. 601-618.

Mackinnon, J.G., Haug, A.A. and Michelis, L. (1999), "Numerical distribution functions of likelihood ratio tests for cointegration", *Journal of Applied Econometrics*, 14, pp. 563-577.

Meese, R.A. and Rogoff, K. (1983), "Empirical exchange rate models of the seventies: do they fit out of sample", *Journal of International Economics*, 14, pp. 3-24.

Rogoff, K. (1984), "On the effects of sterilized intervention: an analysis of weekly data", *Journal of Monetary Economics*, 14, pp. 133-150.

Pesaran, M.H. and Shin, Y. (1998), "Impulse response analysis in linear multivariate models", *Economics Letters*, 58, 17-29.

Sarno, L. S. and Taylor, M. (2002), *The Economics of Exchange Rates*, Cambridge: Cambridge University Press.

Tawadros, G. E. (2002), "The predictive power of the monetary model of exchange rate determination", *Applied Financial Economics*, 11, pp. 279-286.

Tobin, James (1969), "A general equilibrium approach to monetary theory", *Journal of Money, Credit, and Banking*, February, 1 (1), pp.15-29.

Visser, H. (2004), *A Guide to International Monetary Economics: Exchange Rate Theories, Systems and Policies*, Cheltenham(UK): Edward Elgar.

Appendix 3.1

Figure A-1. The log exchange rate of the values of the US dollar in terms of the Canadian dollar - s

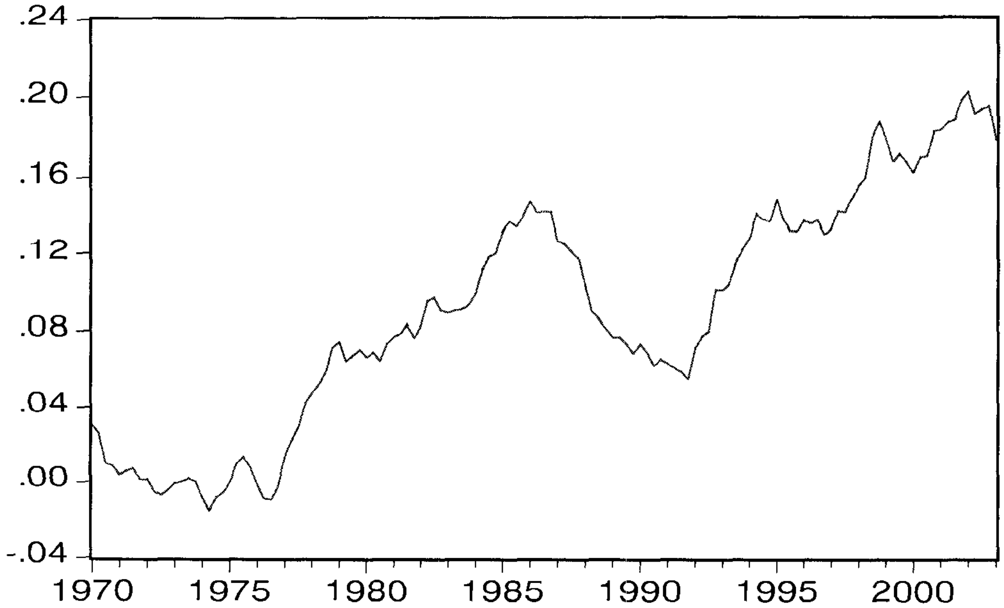


Figure A-2. The log money demand - m

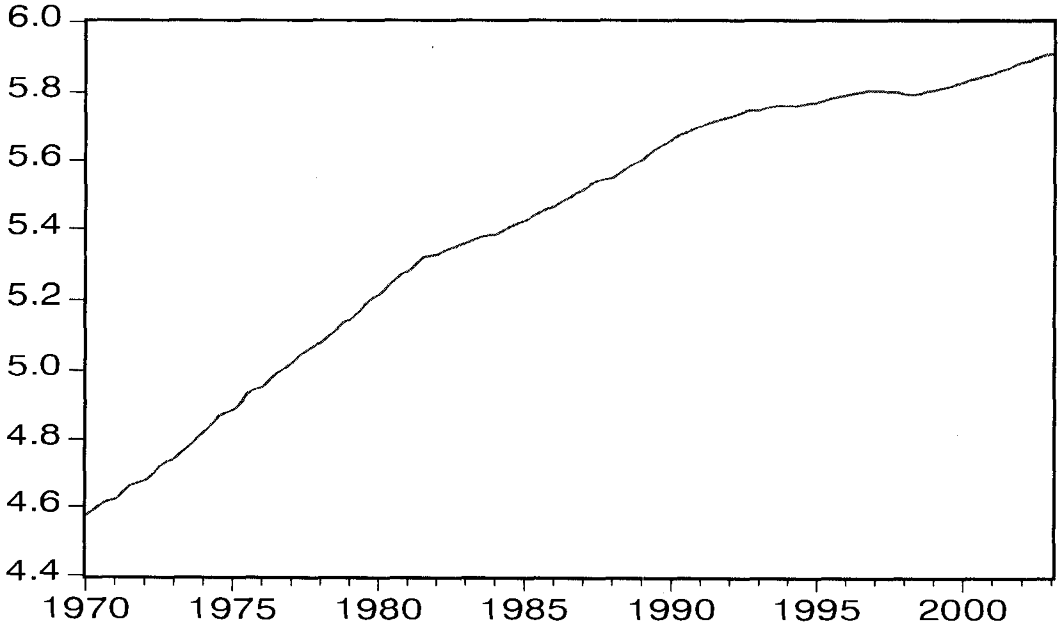


Figure A-3. The log money demand - m*

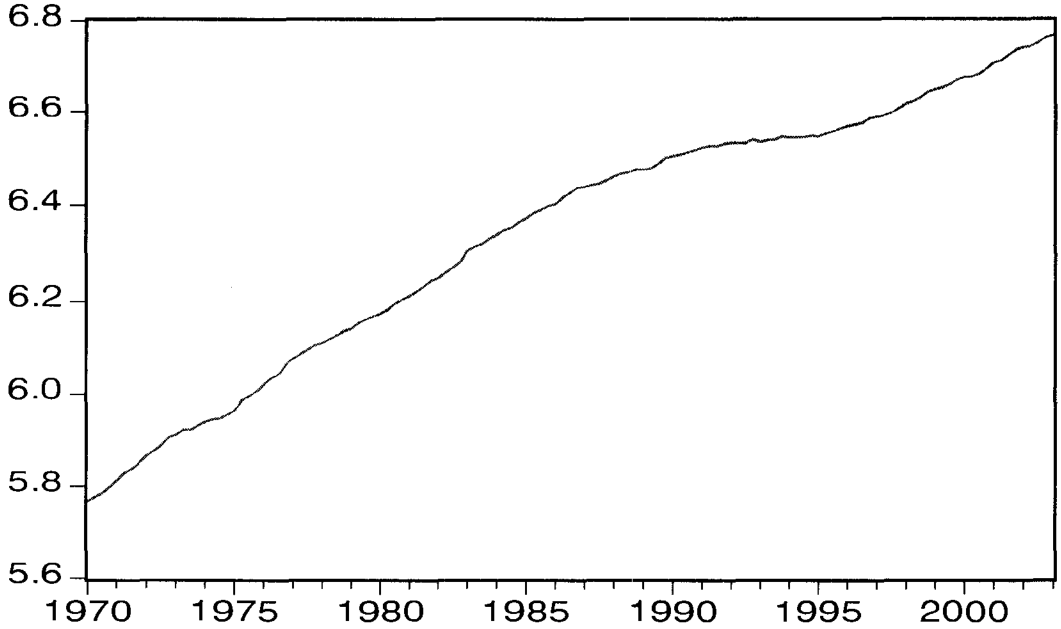


Figure A-4. The log bills and bonds demand - b

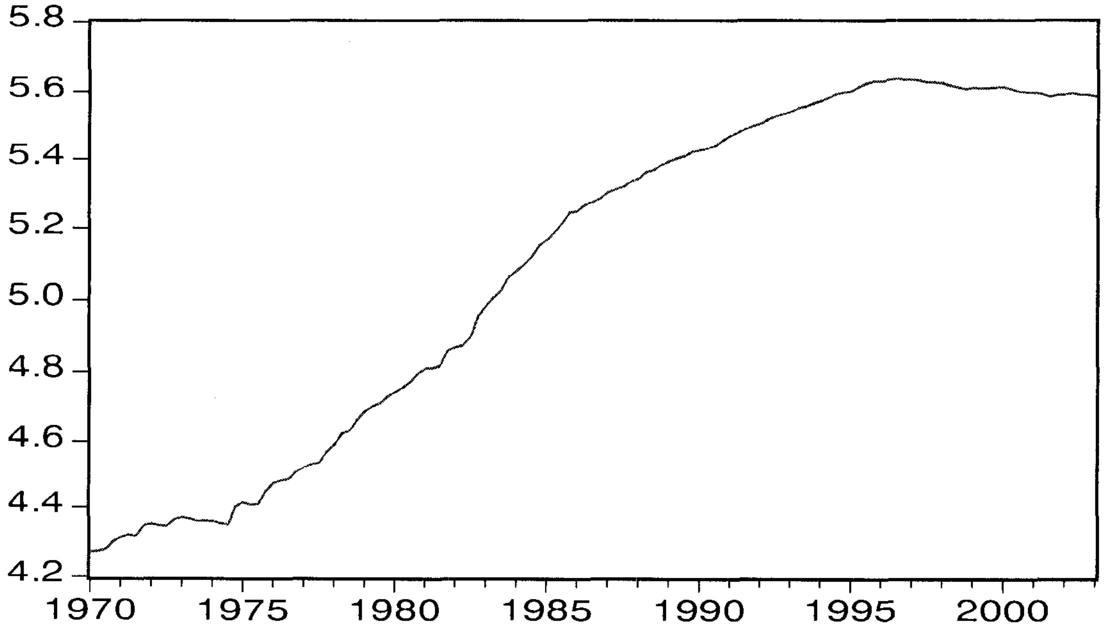


Figure A-5. The log bills and bonds demand - b*

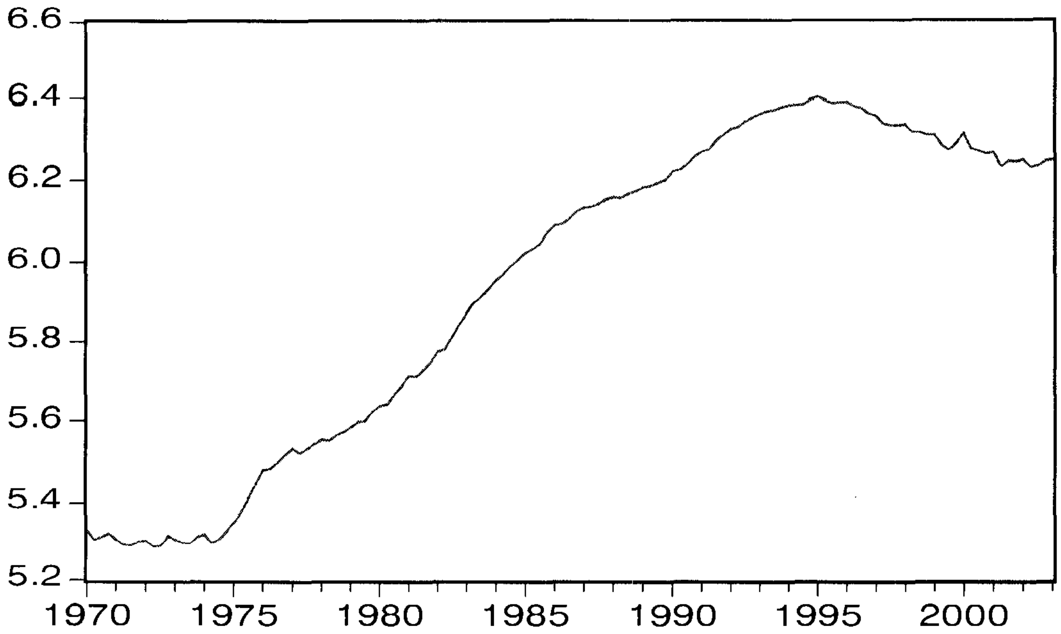


Figure A-6. The demand for the foreign bills and bonds - fb

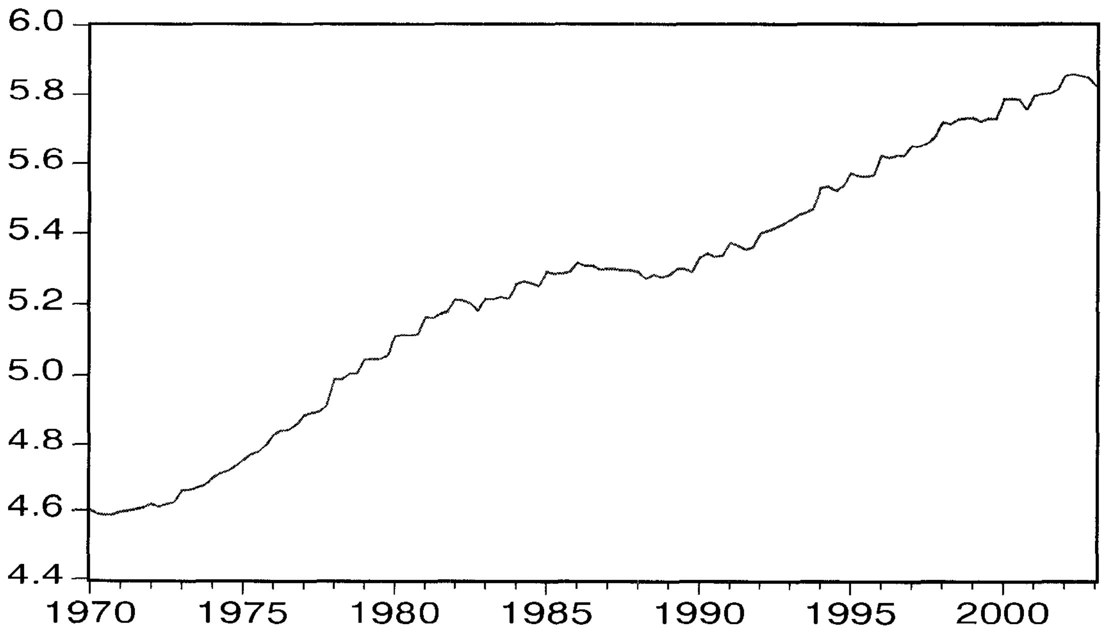
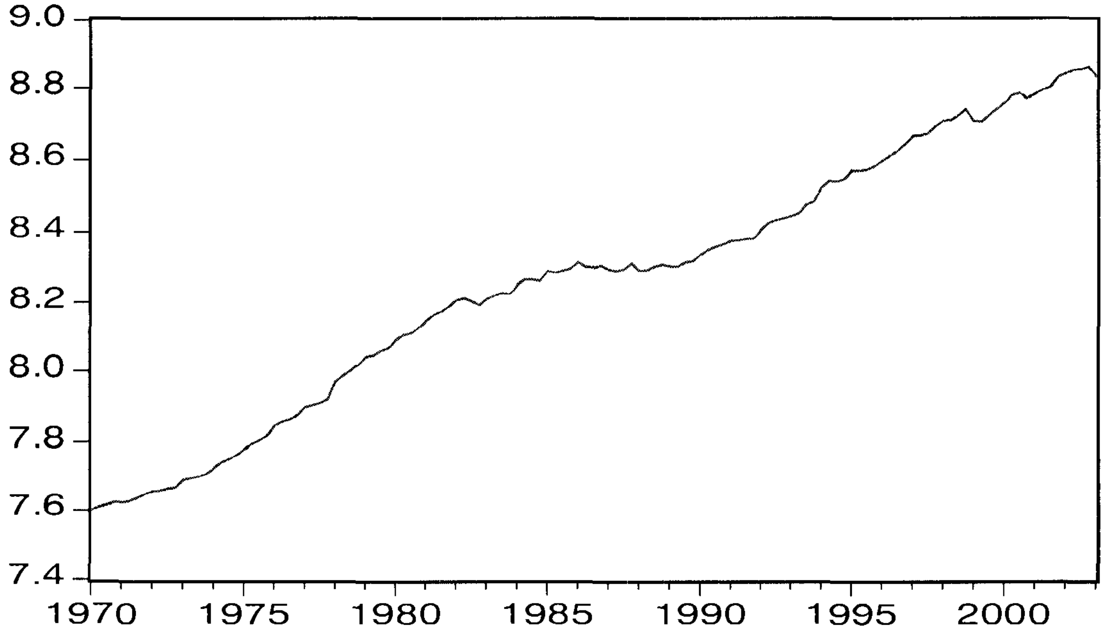


Figure A-7. The demand for the foreign bills and bonds - fb*



Appendix 3.2

Vector Autoregression Estimates
Standard errors in ( ) & t-statistics in [ ]

	s	b	b*	fb	fb*	m	m*
s(-1)	1.156487	0.159846	0.138375	0.025891	-0.127048	-0.04246	-0.023051
	[10.8327]	[1.21021]	[1.06508]	[0.13673]	[-0.84244]	[-0.89344]	[-0.44934]
s(-2)	-0.26799	-0.028716	0.037263	-0.062568	-0.029442	0.064108	-0.006088
	[-2.41554]	[-0.20921]	[0.27600]	[-0.31796]	[-0.18786]	[1.29810]	[-0.11420]
b(-1)	0.071162	1.039986	0.092975	0.010914	0.108358	0.004719	0.083651
	[0.78188]	[9.23591]	[0.83943]	[0.06761]	[0.84280]	[0.11648]	[1.91269]
b(-2)	-0.104174	-0.168985	-0.113279	-0.078348	-0.074527	0.000936	-0.078655
	[-1.23131]	[-1.61444]	[-1.10024]	[-0.52211]	[-0.62359]	[0.02487]	[-1.93473]
b*(-1)	-0.076132	0.269762	1.358322	-0.002008	-0.094352	-0.054548	0.047387
	[-0.92649]	[2.65349]	[13.5833]	[-0.01377]	[-0.81283]	[-1.49124]	[1.20008]
b*(-2)	0.100336	-0.165081	-0.402187	0.026055	0.054877	0.031281	-0.053132
	[1.21443]	[-1.61502]	[-4.00014]	[0.17780]	[0.47020]	[0.85053]	[-1.33831]
fb(-1)	0.139035	0.022964	-0.24934	0.722109	0.483912	-0.079074	-0.012369
	[1.44965]	[0.19353]	[-2.13630]	[4.24490]	[3.57176]	[-1.85213]	[-0.26839]
fb(-2)	-0.12136	-0.025369	0.018198	-0.09832	-0.264888	0.088455	0.042032
	[-1.24348]	[-0.21010]	[0.15322]	[-0.56797]	[-1.92132]	[2.03601]	[0.89625]
fb*(-1)	-0.088595	-0.072062	0.279071	0.272338	0.6277	0.067764	0.010559
	[-0.75174]	[-0.49422]	[1.94582]	[1.30283]	[3.77036]	[1.29168]	[0.18646]
fb*(-2)	0.100676	0.051978	-0.133628	0.16859	0.179366	-0.107969	-0.013353
	[1.00151]	[0.41794]	[-1.09233]	[0.94554]	[1.26311]	[-2.41280]	[-0.27644]
m(-1)	-0.218986	0.114408	0.046172	0.560867	-0.06452	1.445649	-0.102234
	[-0.98575]	[0.41626]	[0.17079]	[1.42342]	[-0.20560]	[14.6187]	[-0.95770]
m(-2)	0.209694	-0.092486	0.072367	-0.51141	0.097418	-0.43514	0.07287
	[0.89229]	[-0.31810]	[0.25304]	[-1.22691]	[0.29345]	[-4.15954]	[0.64528]
m*(-1)	0.17726	-0.257587	0.233435	-0.539862	-0.21012	0.155172	1.195798
	-0.19836	-0.24541	-0.2414	-0.35184	-0.28021	-0.0883	-0.09532
	[0.89361]	[-1.04960]	[0.96701]	[-1.53441]	[-0.74986]	[1.75730]	[12.5452]
m*(-2)	-0.157152	0.301126	-0.224339	0.494338	0.142061	-0.119953	-0.190186
	[-0.76780]	[1.18916]	[-0.90066]	[1.36167]	[0.49133]	[-1.31654]	[-1.93369]
C	-0.233898	-0.182958	-0.336327	-1.431541	0.783056	0.115009	0.007967
	[-0.61959]	[-0.39173]	[-0.73209]	[-2.13797]	[1.46839]	[0.68438]	[0.04392]
dummy_1	-0.00237	-0.011099	-0.007303	0.028369	0.006937	-0.002614	-0.00591
	[-1.05106]	[-3.97907]	[-2.66197]	[7.09435]	[2.17818]	[-2.60473]	[-5.45497]
dummy_2	-0.005565	-0.012242	-0.013298	0.002307	-0.011632	0.008122	-0.002519
	[-1.94092]	[-3.45104]	[-3.81125]	[0.45356]	[-2.87187]	[6.36325]	[-1.82847]
dummy_3	-0.001572	-0.010794	0.001625	0.000788	-0.002961	0.001451	-0.003853
	[-0.77037]	[-4.27520]	[0.65430]	[0.21777]	[-1.02726]	[1.59729]	[-3.92896]
R-squared	0.987596	0.99975	0.999646	0.99895	0.999295	0.999948	0.999866
Adj. R-squared	0.985508	0.999708	0.999586	0.998774	0.999177	0.999939	0.999844
Sum sq. resids	0.004488	0.006869	0.006646	0.014119	0.008956	0.000889	0.001036
S.E. equation	0.006666	0.008247	0.008112	0.011823	0.009416	0.002967	0.003203
F-statistic	473.04	23803.99	16774.26	5653.632	8426.721	113293.5	44452.07
Log likelihood	437.1837	411.8554	413.8189	368.9895	396.0755	533.496	524.3954
Akaike AIC	-7.045104	-6.619418	-6.652419	-5.898983	-6.35421	-8.663799	-8.510846
Schwarz SC	-6.624732	-6.199046	-6.232048	-5.478611	-5.933838	-8.243427	-8.090475
Mean dependent	0.080827	5.064222	5.921121	5.202302	8.211273	5.376489	6.311723
S.D. dependent	0.055373	0.483012	0.398852	0.337607	0.328209	0.379107	0.256351

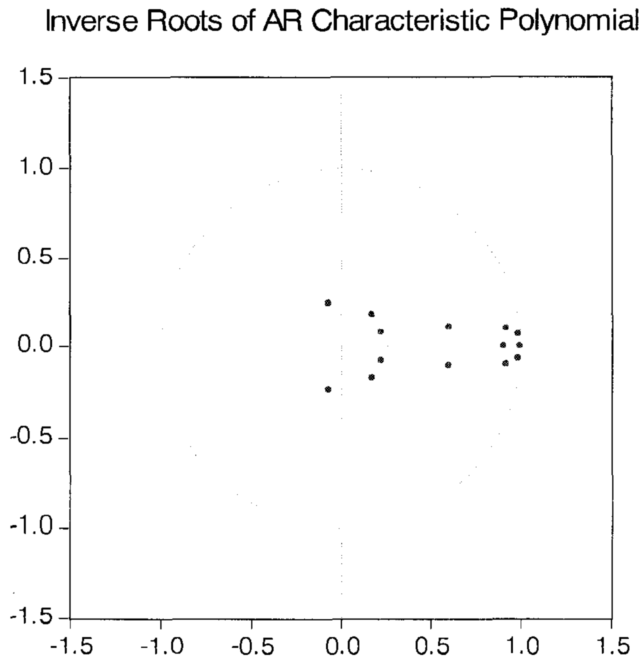
Vector Error Correction Estimates
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
s(-1)	1.000000		
b(-1)	-0.176199	(0.14676)	[-1.20055]
b*(-1)	0.184610	(0.14232)	[1.29715]
fb(-1)	-1.596012	(0.44397)	[-3.59483]
fb*(-1)	1.264164	(0.51276)	[2.46541]
m(-1)	0.431257	(0.12712)	[3.39264]
m*(-1)	-0.15688	(0.18758)	[-0.83634]
C	-3.68789		

Error Correction:	D(s)	D(b)	D(b*)	D(fb)	D(fb*)	D(m)	D(m*)
CointEq1	-0.047282	0.041454	0.013627	-0.034145	-0.069289	-0.042771	-0.073903
	[-1.74529]	[1.14463]	[0.40417]	[-0.66731]	[-1.72904]	[-3.57435]	[-5.64871]
D(s(-1))	0.198528	0.127412	0.036151	0.002543	-0.029335	-0.045896	0.028386
	[1.80136]	[0.86481]	[0.26356]	[0.01222]	[-0.17995]	[-0.94283]	[0.53333]
D(s(-2))	0.046329	0.215815	0.193066	0.183360	-0.061848	0.079668	0.041581
	[0.43216]	[1.50593]	[1.44708]	[0.90558]	[-0.39002]	[1.68250]	[0.80317]
D(b(-1))	0.028448	0.328254	0.114068	-0.038843	0.088867	-0.023672	0.047772
	[0.34203]	[2.95223]	[1.10195]	[-0.24726]	[0.72230]	[-0.64433]	[1.18932]
D(b(-2))	0.187237	-0.013356	0.001393	0.141146	0.120132	0.095060	-0.00161
	[2.26100]	[-0.12064]	[0.01352]	[0.90242]	[0.98070]	[2.59887]	[-0.04025]
D(b*(-1))	-0.04828	0.293409	0.434771	0.125473	0.048027	-0.031198	0.017221
	[-0.58259]	[2.64850]	[4.21548]	[0.80163]	[0.39179]	[-0.85232]	[0.43030]
D(b*(-2))	-0.021432	-0.037868	0.221684	-0.188393	-0.118658	0.046481	0.064747
	[-0.25563]	[-0.33786]	[2.12452]	[-1.18968]	[-0.95676]	[1.25513]	[1.59910]
D(fb(-1))	0.150108	0.080200	-0.129273	-0.01846	0.360539	-0.136161	-0.089602
	[1.58676]	[0.63419]	[-1.09802]	[-0.10331]	[2.71943]	[-3.25865]	[-1.96130]
D(fb(-2))	0.038318	0.079276	-0.092217	-0.001885	0.083328	-0.014208	-0.014556
	[0.39879]	[0.61718]	[-0.77116]	[-0.01038]	[0.58627]	[-0.33478]	[-0.31368]
D(fb*(-1))	-0.089846	-0.075298	0.236942	0.101083	-0.198882	0.091649	0.045422
	[-0.82548]	[-0.51752]	[1.74921]	[0.49172]	[-1.23530]	[1.90640]	[0.86416]
D(fb*(-2))	-0.044294	-0.104074	-0.035524	0.000727	-0.108996	-0.015492	-0.039162
	[-0.44896]	[-0.78911]	[-0.28932]	[0.00390]	[-0.74687]	[-0.35550]	[-0.82195]
D(m(-1))	-0.022136	0.293920	0.588074	0.613412	0.082440	0.717166	-0.075711
	[-0.09752]	[0.96864]	[2.08174]	[1.43083]	[0.24554]	[7.15319]	[-0.69068]
D(m(-2))	-0.330199	0.155450	-0.236611	-0.498303	-0.200442	0.002991	-0.147586
	(0.24110)	(0.32230)	(0.30005)	(0.45536)	(0.35663)	(0.10649)	(0.11643)
	[-1.36958]	[0.48232]	[-0.78857]	[-1.09430]	[-0.56205]	[0.02808]	[-1.26757]
D(m*(-1))	-0.197186	-0.160592	-0.107171	-0.920832	-0.482018	0.025245	0.172499
	[-0.92125]	[-0.56125]	[-0.40232]	[-2.27779]	[-1.52243]	[0.26703]	[1.66881]
D(m*(-2))	-0.019714	0.476231	0.078168	0.563355	-0.127315	-0.220139	-0.008274
	[-0.10022]	[1.81092]	[0.31928]	[1.51622]	[-0.43752]	[-2.53352]	[-0.08709]
C	0.003880	-0.001747	-0.001779	0.009843	0.012227	0.004109	0.006296
	[1.29940]	[-0.43755]	[-0.47873]	[1.74525]	[2.76822]	[3.11506]	[5.75262]
dummy_1	0.000504	-0.013633	-0.006281	0.035129	0.008310	-0.001515	-0.005698
	[0.21431]	[-4.33901]	[-2.14718]	[7.91320]	[2.39015]	[-1.45885]	[-5.01957]
dummy_2	-0.008939	-0.01275	-0.014751	-0.002765	-0.013148	0.008983	-0.003599
	[-2.72593]	[-2.90862]	[-3.61458]	[-0.44637]	[-2.71066]	[6.20243]	[-2.27245]
dummy_3	-0.003781	-0.009688	-0.001426	0.000152	-0.002704	0.000342	-0.005786
	[-0.98449]	[-1.88694]	[-0.29825]	[0.02101]	[-0.47599]	[0.20150]	[-3.11943]
R-squared	0.239404	0.548118	0.641678	0.568640	0.286401	0.840179	0.604988
Adj. R-squared	0.101113	0.465958	0.576529	0.490211	0.156656	0.811121	0.533168
Sum sq. resids	0.004382	0.007831	0.006787	0.015632	0.009588	0.000855	0.001022
S.E. equation	0.006653	0.008894	0.008280	0.012566	0.009841	0.002939	0.003213
F-statistic	1.731169	6.671321	9.849325	7.250376	2.207409	28.91356	8.423629
Log likelihood	434.4190	400.1657	408.6049	359.3826	388.2213	530.8409	520.3098
Akaike AIC	-7.040999	-6.460436	-6.603473	-5.769196	-6.257989	-8.675269	-8.496776
Schwarz SC	-6.594872	-6.014309	-6.157346	-5.323069	-5.811862	-8.229141	-8.050649
Mean dependent	0.001292	0.011319	0.008506	0.010151	0.009702	0.010364	0.007549
S.D. dependent	0.007017	0.012170	0.012724	0.017599	0.010716	0.006762	0.004702

Appendix 3.3

Figure C-1. Stability test



No root lies outside the unit circle.

VAR satisfies the stability condition.

Figure C-2. Response to generalized one standard deviation of m*

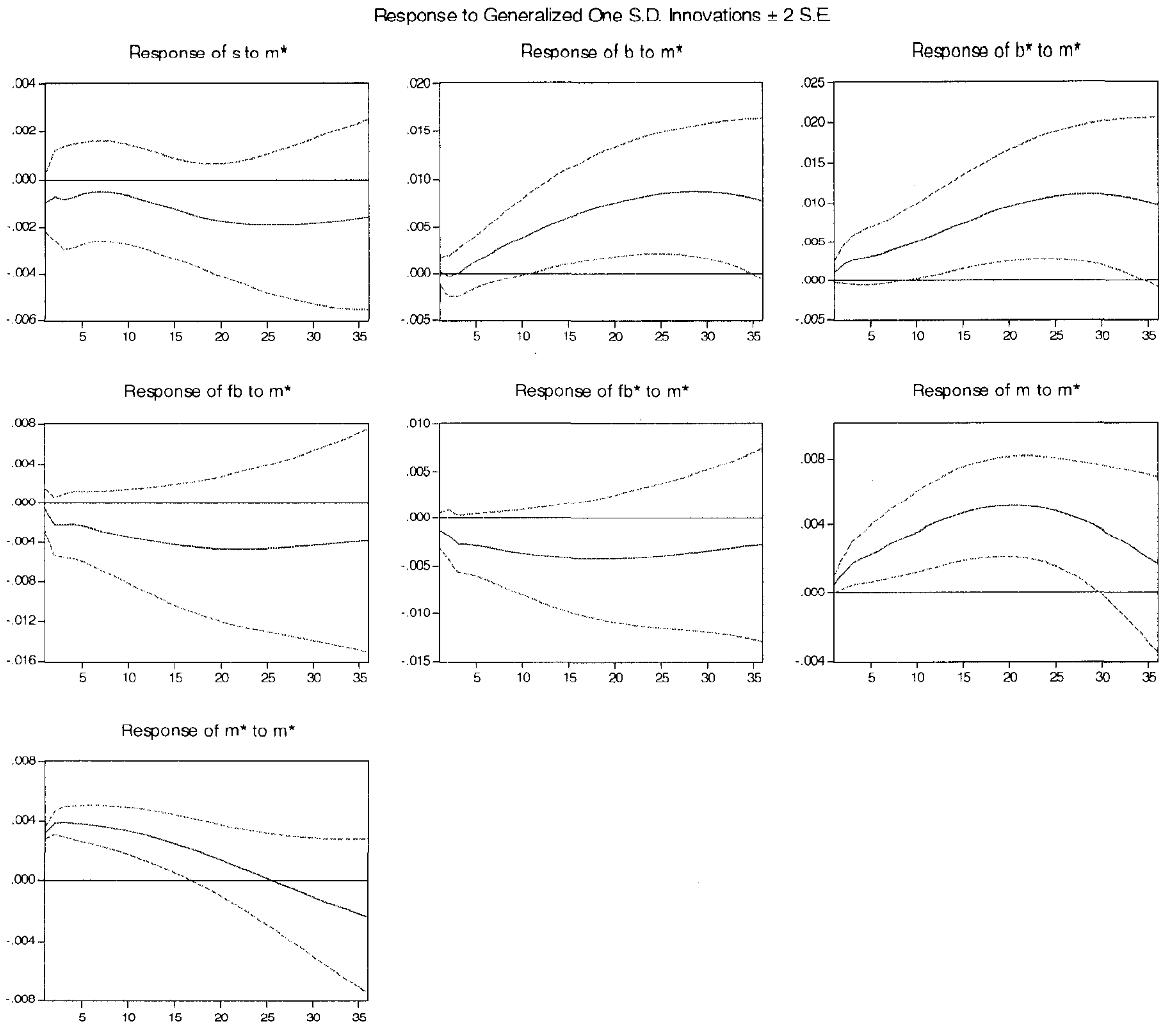


Figure C-3. Response to generalized one standard deviation of b*

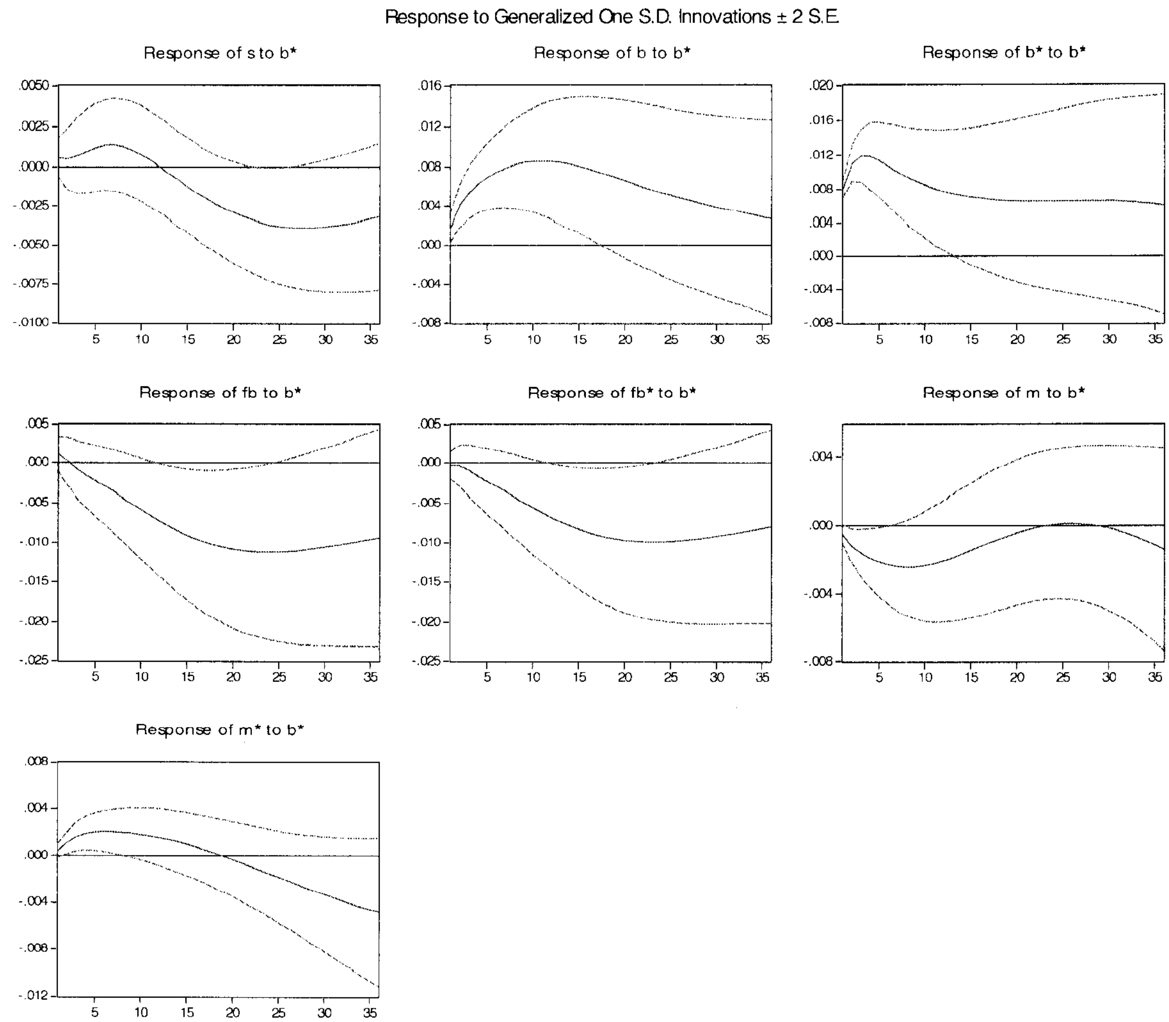


Figure C-4. Response to generalized one standard deviation of fb*

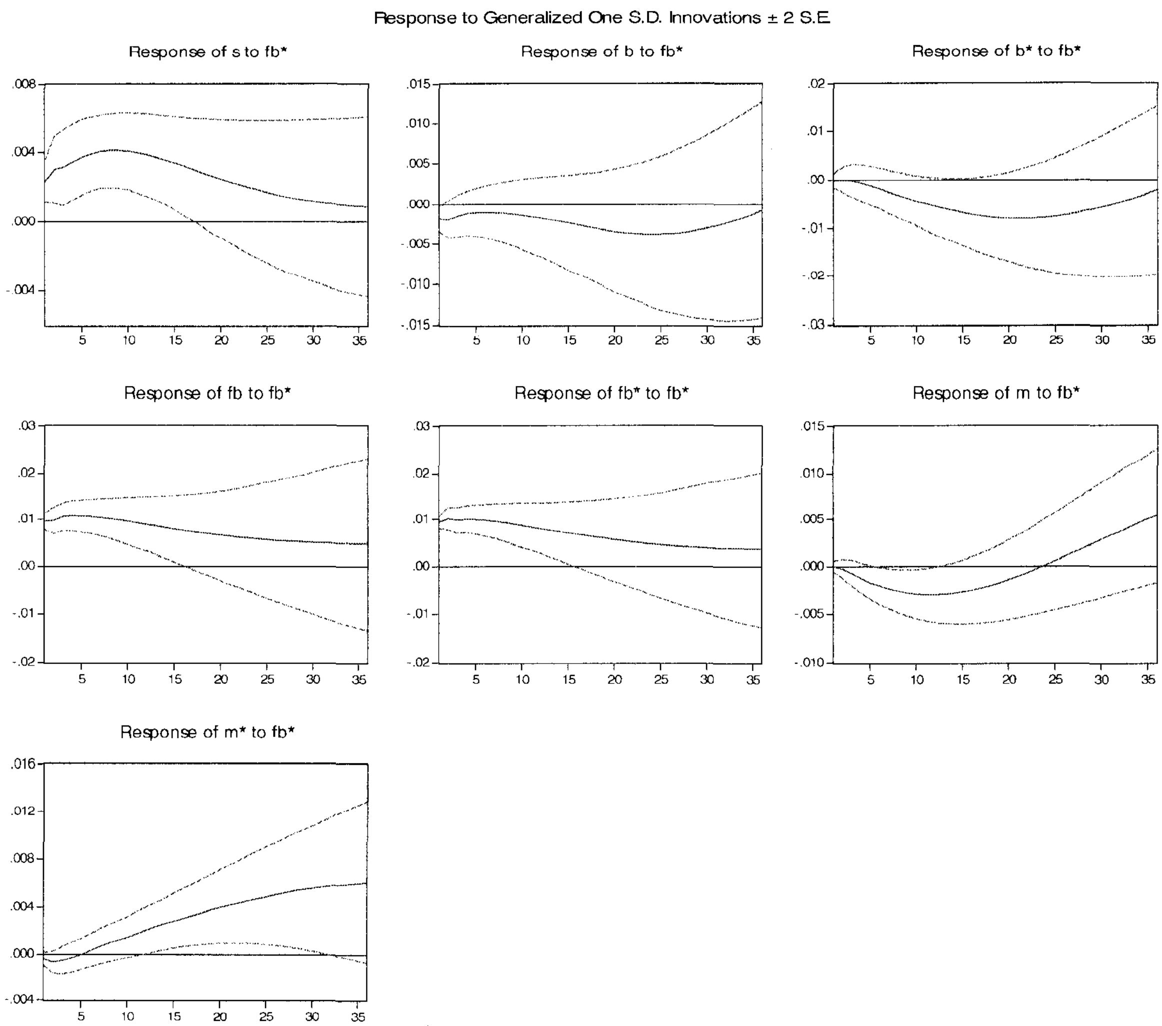
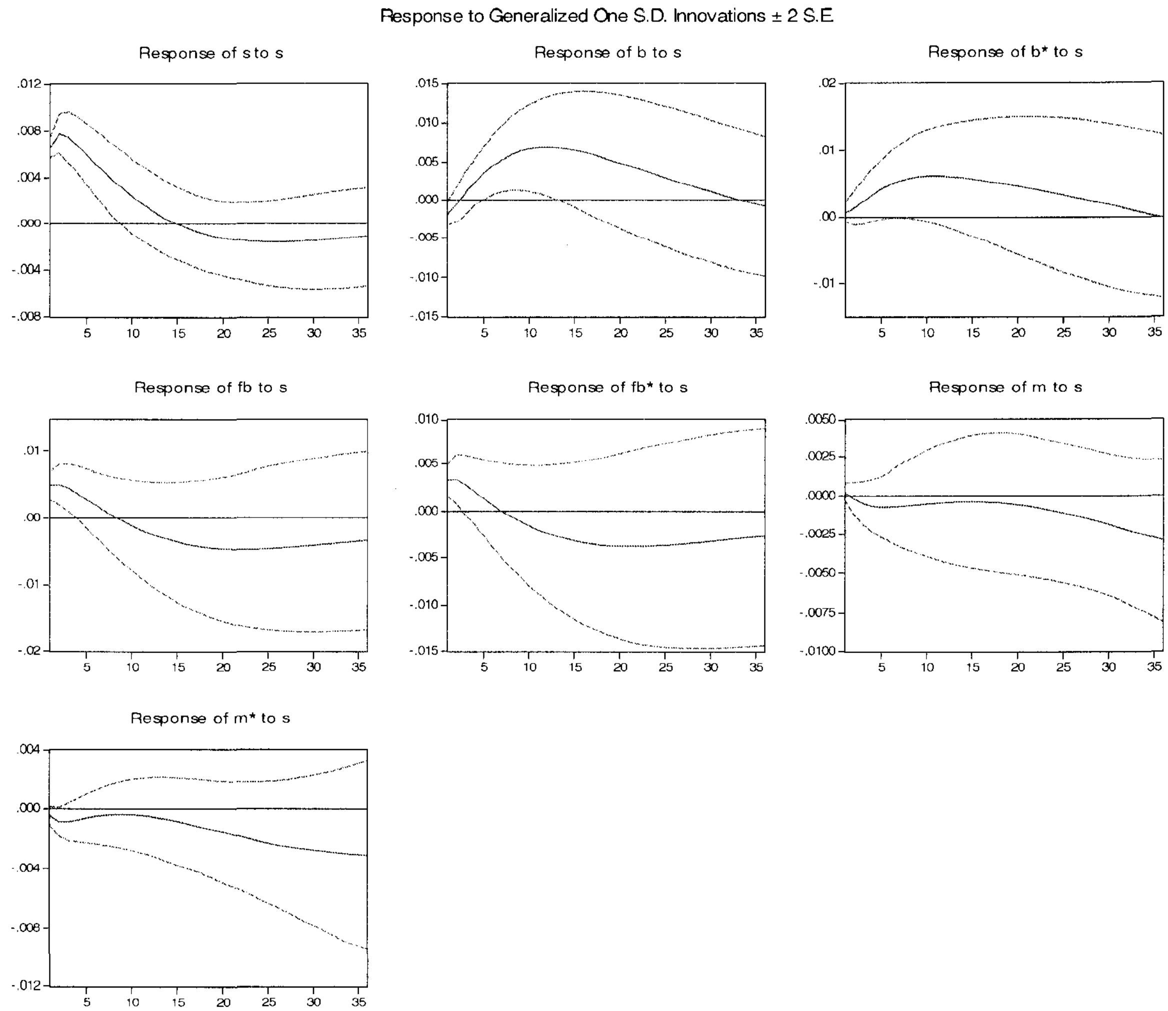


Figure C-5. Response to generalized one standard deviation of s



Appendix 3.4

Table D-1. Variance of decomposition of b

Period	S.E.	s	b	b*	fb	fb*	m	m*
1	0.008247	0.000000	76.38641	0.000000	2.091744	1.862689	18.52260	1.136564
2	0.012317	0.588133	73.55011	3.111589	1.422455	3.193675	17.52707	0.606967
3	0.015222	2.454125	68.99602	8.134212	1.045287	3.148233	15.66702	0.555103
4	0.017750	5.511596	62.87912	13.22963	0.776477	2.915390	13.81683	0.870960
5	0.020188	9.336691	56.04230	17.80882	0.600464	2.691275	12.07587	1.444587
6	0.022611	13.41525	49.26182	21.70274	0.481558	2.485809	10.47986	2.172974
7	0.025029	17.34214	43.01428	24.88673	0.396961	2.300492	9.058251	3.001138
8	0.027433	20.87833	37.51301	27.41756	0.333116	2.137294	7.823746	3.896945
9	0.029804	23.92111	32.79994	29.38445	0.282923	1.996916	6.773005	4.841650
10	0.032123	26.45514	28.82607	30.87876	0.243596	1.878892	5.892673	5.824864
11	0.034376	28.51187	25.50398	31.98137	0.214924	1.781921	5.164883	6.841051
12	0.036548	30.14279	22.73710	32.75962	0.198036	1.704250	4.570803	7.887404
13	0.038633	31.40418	20.43401	33.26833	0.194548	1.643976	4.092440	8.962510
14	0.040625	32.34957	18.51420	33.55217	0.205991	1.599218	3.713337	10.06551
15	0.042523	33.02666	16.90940	33.64802	0.233431	1.568187	3.418682	11.19562
16	0.044326	33.47665	15.56292	33.58700	0.277241	1.549195	3.195166	12.35183
17	0.046036	33.73461	14.42829	33.39592	0.336973	1.540637	3.030780	13.53279
18	0.047657	33.83040	13.46761	33.09830	0.411331	1.540961	2.914639	14.73676
19	0.049193	33.78949	12.65006	32.71509	0.498209	1.548635	2.836862	15.96164
20	0.050646	33.63387	11.95064	32.26505	0.594802	1.562131	2.788516	17.20499
21	0.052021	33.38265	11.34904	31.76497	0.697753	1.579913	2.761609	18.46407
22	0.053320	33.05262	10.82874	31.22980	0.803349	1.600451	2.749112	19.73592
23	0.054548	32.65864	10.37634	30.67273	0.907730	1.622232	2.744992	21.01733
24	0.055706	32.21391	9.980894	30.10516	1.007104	1.643794	2.744242	22.30490

Table D-2. Variance of decomposition of b*

Period	S.E.	s	b	b*	fb	fb*	m	m*
1	0.008112	0.000000	2.350951	88.62529	1.139723	2.456810	2.399515	3.027716
2	0.013815	0.350355	3.497695	88.00618	0.592002	0.896182	2.468327	4.189259
3	0.018528	1.446915	4.151114	85.75479	0.382833	0.504618	2.604837	5.154892
4	0.022453	3.386571	4.376852	83.36455	0.262906	0.355858	2.506104	5.747162
5	0.025802	5.979608	4.288298	80.70684	0.266560	0.296737	2.236248	6.225713
6	0.028760	8.945317	4.027560	77.72750	0.394628	0.296083	1.911606	6.697306
7	0.031459	12.01780	3.686909	74.49654	0.641661	0.347951	1.612314	7.196823
8	0.033990	14.98908	3.323018	71.11584	0.995477	0.449427	1.384259	7.742898
9	0.036415	17.72063	2.970266	67.68088	1.439560	0.595945	1.245818	8.346898
10	0.038771	20.13536	2.647737	64.27020	1.955519	0.780787	1.195493	9.014899
11	0.041083	22.20250	2.364249	60.94423	2.524414	0.995829	1.219625	9.749145
12	0.043365	23.92257	2.122088	57.74725	3.127727	1.232475	1.298780	10.54910
13	0.045623	25.31522	1.919648	54.71011	3.748046	1.482371	1.412330	11.41228
14	0.047859	26.41037	1.753243	51.85279	4.369534	1.737853	1.541317	12.33489
15	0.050073	27.24228	1.618269	49.18664	4.978227	1.992195	1.669977	13.31241
16	0.052261	27.84577	1.509933	46.71626	5.562177	2.239692	1.786312	14.33986
17	0.054418	28.25391	1.423668	44.44108	6.111496	2.475654	1.882073	15.41212
18	0.056539	28.49693	1.355351	42.35669	6.618300	2.696348	1.952393	16.52400
19	0.058617	28.60159	1.301393	40.45590	7.076604	2.898906	1.995275	17.67033
20	0.060646	28.59119	1.258752	38.72965	7.482164	3.081233	2.011027	18.84598
21	0.062619	28.48565	1.224899	37.16771	7.832316	3.241905	2.001722	20.04580
22	0.064531	28.30185	1.197771	35.75917	8.125800	3.380090	1.970708	21.26461
23	0.066376	28.05398	1.175703	34.49289	8.362596	3.495465	1.922193	22.49717
24	0.068150	27.75393	1.157372	33.35777	8.543770	3.588154	1.860895	23.73811

Table D-3. Variance of decomposition of fb

Period	S.E.	s	b	b*	fb	fb*	m	m*
1	0.011823	0.000000	0.000000	0.000000	99.47250	0.000000	0.110998	0.416504
2	0.016266	0.008847	0.001288	3.17E-06	95.33941	0.817077	1.067371	2.766004
3	0.019890	0.036053	0.074881	0.061155	90.69625	3.159200	2.198625	3.773835
4	0.023042	0.254678	0.150575	0.289554	87.12162	5.096763	2.897513	4.189296
5	0.025838	0.750887	0.200596	0.661031	83.84029	6.543799	3.422672	4.580722
6	0.028434	1.555293	0.234683	1.173703	80.46467	7.643194	3.928308	5.000146
7	0.030921	2.647773	0.254396	1.841611	76.90469	8.447917	4.464800	5.438812
8	0.033353	3.969995	0.261030	2.670895	73.16709	8.994570	5.046258	5.890163
9	0.035763	5.444804	0.257012	3.656214	69.30808	9.317483	5.670392	6.346011
10	0.038173	6.992083	0.245205	4.781445	65.40560	9.451226	6.326686	6.797757
11	0.040593	8.539757	0.228449	6.022001	61.54013	9.430947	7.001187	7.237529
12	0.043027	10.02993	0.209266	7.348210	57.78372	9.290840	7.679340	7.658692
13	0.045472	11.42098	0.189703	8.728760	54.19421	9.062403	8.347750	8.056190
14	0.047921	12.68681	0.171291	10.13356	50.81331	8.773201	8.995186	8.426641
15	0.050364	13.81451	0.155074	11.53574	47.66721	8.446236	9.613002	8.768231
16	0.052792	14.80138	0.141686	12.91278	44.76866	8.099881	10.19514	9.080470
17	0.055193	15.65200	0.131429	14.24690	42.11970	7.748203	10.73788	9.363898
18	0.057556	16.37561	0.124364	15.52485	39.71443	7.401505	11.23945	9.619791
19	0.059870	16.98411	0.120381	16.73751	37.54151	7.066973	11.69961	9.849900
20	0.062126	17.49052	0.119258	17.87920	35.58623	6.749307	12.11925	10.05624
21	0.064316	17.90792	0.120711	18.94704	33.83206	6.451292	12.50006	10.24092
22	0.066433	18.24880	0.124421	19.94034	32.26184	6.174296	12.84424	10.40606
23	0.068474	18.52470	0.130066	20.86003	30.85860	5.918664	13.15429	10.55365
24	0.070433	18.74593	0.137327	21.70824	29.60604	5.684033	13.43285	10.68559

Table D-4. Variance of decomposition of fb*

Period	S.E.	s	b	b*	fb	fb*	m	m*
1	0.009416	0.000000	0.000000	0.000000	65.19743	33.21569	0.003309	1.583567
2	0.014268	0.276888	0.277062	0.322300	76.82819	20.12745	0.090723	2.077390
3	0.017642	0.783673	0.289219	0.491452	76.91393	17.54250	0.125427	3.853799
4	0.020664	1.680962	0.222265	0.789988	75.07740	16.85529	0.433669	4.940432
5	0.023424	2.902373	0.175109	1.249870	72.67067	16.44352	0.870220	5.688233
6	0.025999	4.338059	0.142850	1.847108	69.84817	16.06891	1.406543	6.348360
7	0.028459	5.890434	0.119548	2.581418	66.75082	15.65866	2.035643	6.963473
8	0.030846	7.475196	0.102093	3.453502	63.49390	15.18685	2.744056	7.544408
9	0.033186	9.024532	0.088762	4.454789	60.16893	14.65351	3.515427	8.094051
10	0.035495	10.48828	0.078609	5.568271	56.85330	14.06951	4.331564	8.610476
11	0.037781	11.83274	0.071119	6.770964	53.61067	13.45016	5.173882	9.090459
12	0.040047	13.03841	0.066000	8.036804	50.49084	12.81195	6.024848	9.531144
13	0.042291	14.09728	0.063061	9.339372	47.53025	12.17034	6.868981	9.930719
14	0.044511	15.01001	0.062148	10.65398	44.75321	11.53859	7.693418	10.28864
15	0.046700	15.78344	0.063112	11.95903	42.17350	10.92722	8.488116	10.60558
16	0.048852	16.42832	0.065796	13.23663	39.79632	10.34401	9.245759	10.88317
17	0.050959	16.95759	0.070032	14.47278	37.62018	9.794162	9.961480	11.12378
18	0.053015	17.38507	0.075644	15.65713	35.63873	9.280757	10.63248	11.33020
19	0.055012	17.72447	0.082450	16.78257	33.84231	8.805118	11.25763	11.50546
20	0.056944	17.98884	0.090273	17.84470	32.21924	8.367243	11.83706	11.65264
21	0.058808	18.19019	0.098938	18.84135	30.75675	7.966165	12.37185	11.77476
22	0.060599	18.33929	0.108280	19.77203	29.44176	7.600253	12.86373	11.87465
23	0.062313	18.44562	0.118147	20.63762	28.26134	7.267454	13.31485	11.95497
24	0.063951	18.51744	0.128396	21.43989	27.20307	6.965479	13.72759	12.01814

Table D-5. Variance of decomposition of m

Period	S.E.	s	b	b*	fb	fb*	m	m*
1	0.002967	0.000000	0.000000	0.000000	0.000000	0.000000	100.0000	0.000000
2	0.005381	0.217428	7.46E-05	0.688439	1.175388	0.633654	96.61468	0.670336
3	0.007459	0.398311	0.010209	1.925133	1.834530	0.355430	93.68388	1.792501
4	0.009349	0.408125	0.028412	3.137556	2.691723	0.330416	90.76333	2.640438
5	0.011124	0.335878	0.036084	4.239915	3.550349	0.570510	87.88535	3.381919
6	0.012807	0.256939	0.036741	5.224740	4.323464	0.967625	85.04020	4.150293
7	0.014399	0.208607	0.034394	6.070761	4.998419	1.444151	82.24644	4.997225
8	0.015901	0.202647	0.030969	6.765466	5.568999	1.947101	79.53406	5.950755
9	0.017310	0.236813	0.027420	7.309528	6.032997	2.442534	76.92186	7.028845
10	0.018624	0.302474	0.024190	7.712917	6.392059	2.908867	74.41699	8.242506
11	0.019843	0.388823	0.021448	7.991004	6.650123	3.332390	72.01876	9.597454
12	0.020968	0.484985	0.019220	8.161588	6.812647	3.704564	69.72226	11.09474
13	0.022002	0.581041	0.017462	8.242903	6.886358	4.020352	67.52099	12.73089
14	0.022950	0.668540	0.016095	8.252398	6.879247	4.277236	65.40849	14.49799
15	0.023817	0.740813	0.015032	8.206046	6.800706	4.474648	63.37916	16.38360
16	0.024609	0.793221	0.014186	8.117970	6.661691	4.613669	61.42850	18.37076
17	0.025333	0.823399	0.013485	8.000270	6.474862	4.696855	59.55302	20.43811
18	0.025996	0.831486	0.012872	7.862986	6.254663	4.728143	57.74986	22.55999
19	0.026605	0.820335	0.012315	7.714146	6.017304	4.712775	56.01637	24.70675
20	0.027167	0.795677	0.011810	7.559884	5.780631	4.657213	54.34964	26.84515
21	0.027692	0.766192	0.011390	7.404624	5.563885	4.569031	52.74597	28.93891
22	0.028186	0.743470	0.011125	7.251314	5.387314	4.456761	51.20057	30.94945
23	0.028659	0.741823	0.011129	7.101713	5.271648	4.329701	49.70717	32.83681
24	0.029117	0.777907	0.011561	6.956714	5.237432	4.197653	48.25799	34.56074

Table D-6. Variance of decomposition of m*

Period	S.E.	s	b	b*	fb	fb*	m	m*
1	0.003203	0.000000	0.000000	0.000000	0.000000	0.000000	3.182324	96.81768
2	0.005133	0.070419	1.743199	0.453430	0.131037	0.037187	1.239310	96.32542
3	0.006684	0.152643	3.053281	1.404945	0.101450	0.135847	1.082849	94.06899
4	0.007973	0.196570	3.725580	2.453246	0.301203	0.147334	1.279504	91.89656
5	0.009093	0.220555	3.992410	3.328523	0.757953	0.116501	1.515596	90.06846
6	0.010092	0.243366	4.050774	3.970615	1.458209	0.102557	1.751125	88.42335
7	0.011001	0.279920	4.001944	4.407348	2.379852	0.130944	1.976534	86.82346
8	0.011838	0.345690	3.896151	4.675070	3.509426	0.213923	2.183919	85.17582
9	0.012617	0.459283	3.761008	4.802819	4.835105	0.358574	2.366728	83.41648
10	0.013352	0.642708	3.612440	4.813364	6.342483	0.568936	2.519782	81.50029
11	0.014053	0.920052	3.459616	4.726072	8.013504	0.846482	2.639130	79.39514
12	0.014728	1.315408	3.307649	4.559349	9.825934	1.190140	2.722006	77.07951
13	0.015387	1.850599	3.159193	4.332246	11.75314	1.596255	2.766874	74.54170
14	0.016039	2.543030	3.015439	4.065223	13.76416	2.058607	2.773535	71.78001
15	0.016691	3.403836	2.876757	3.780211	15.82421	2.568548	2.743227	68.80321
16	0.017351	4.436487	2.743112	3.500070	17.89560	3.115290	2.678659	65.63078
17	0.018027	5.635982	2.614327	3.247632	19.93908	3.686368	2.583951	62.29266
18	0.018726	6.988758	2.490249	3.044464	21.91562	4.268254	2.464467	58.82819
19	0.019453	8.473369	2.370829	2.909590	23.78840	4.847107	2.326525	55.28418
20	0.020215	10.06188	2.256152	2.858334	25.52474	5.409555	2.177025	51.71232
21	0.021016	11.72181	2.146421	2.901480	27.09781	5.943447	2.023029	48.16600
22	0.021860	13.41848	2.041919	3.044840	28.48788	6.438481	1.871344	44.69706
23	0.022749	15.11726	1.942962	3.289288	29.68285	6.886636	1.728146	41.35286
24	0.023685	16.78575	1.849848	3.631208	30.67819	7.282384	1.598711	38.17391