Three Essays on Asymmetric Financial Access

by

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Abstract

This dissertation consists of three essays on issues related to asymmetric financial access in two-country general equilibrium models with sticky prices. The form of asymmetric financial access is in terms of two groups of households: One group has full access to both bond and money markets, while the other is prohibited from bond trade or even monetary adjustments. The first essay is to examine effects of financial asymmetry on economic volatility. It finds that the effects depend on whether, in addition to restrictions on bond trade, you also have restrictions on monetary adjustments, among households who face financial limitation. If financially constrained households are prohibited from bond trade only, then inter-household monetary adjustments serve as a shock absorber and we have similar economic volatility under different degrees of financial asymmetry. If financially constrained households are prohibited from both bond trade and monetary adjustments, then we have positive correlation between degrees of economic volatility and financial imperfection. The second essay is to examine welfare effects of economic uncertainty under financial asymmetry. The welfare measure is defined as how much initial steady-state consumption a household is willing to give up to negate effects of economic uncertainty. The essay finds that lower degrees of foreign financial openness increase welfare loss of financially unconstrained households but decrease welfare loss of financially constrained households. Moreover, welfare loss of both types of households is reduced with lower degrees of home financial openness. It also finds that if financially constrained households are prohibited from both bond trade and monetary adjustments, then welfare loss of both types of households increases. The third essay is to examine welfare effects of exchange-rate regimes under financial asymmetry. It is assumed that governments fix their money supply at initial steady-state levels in the flexible exchange-rate regime, while coordinating their monetary policies to maintain the exchange rate level in the fixed exchange-rate regime. The welfare measure is defined as expected utility excluding the term associated with real balances. The essay finds that under financial asymmetry, fixed nominal exchange rates are in many cases preferable to flexible nominal exchange rates by both types of households. For financially unconstrained households,

wealth effects associated with the monetary policies that aim to maintain the exchange rate level can dominate the welfare cost of fixed nominal exchange rates. For financially constrained households, they can not enjoy the benefit brought by expenditure switching effects due to their financial restriction, but need to bear the associated cost of higher economic variability. Therefore by reducing expenditure switching effects, the fixed exchange-rate regime can increase their welfare.

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Chapter 1

Financial Asymmetry and Macroeconomic Volatility

1.1 Introduction

The literature about financial market imperfection on business cycle volatility has grown with a considerable volume in the last decade.[1] For a brief review of different approaches on the theoretical level, Mendoza (1994) adopts the traditional neo-classical model of savings and investment to examine different degrees of capital mobility and macroeconomic volatility. Razin and Rose (1994) also apply the neo-classical framework, but focus on different effects among idiosyncratic and global disturbances on the link between volatility and openness. Sutherland (1996) incorporates transaction costs of bond markets into the model of new open economy macroeconomics introduced by Obstfeld and Rogoff (1995, 1996).[2] In recent years, using asymmetric information of financial markets to explain volatility has drawn increasing attention. Related studies include Faia (2001), Aghion, Bacchetta and Banerjee (1999) and Cespedes, Chang and Velasco (2000). Among them, Faia and Cespedes et al. combine new open economy macroeconomics with the newly developed concept of financial accelerators.[3]

Despite the rich theoretical contents, a clear prediction for the effects of financial market imperfection on business cycle volatility is unfortunately absent. On the empirical level, moreover, even though studies such as Basu and Taylor (1999) document likely connections between openness and volatility based on stylized facts, it is still difficult to establish more systematic relations. Razin and Rose (1994) argue that the lack of empi-

[1] For a survey of the literature see Buch (2002).

[2] Henceforth NOEM refers to new open economy macroeconomics, and OR refers to Obstfeld and Rogoff.

[3] Asymmetric information of financial markets makes firms' net worth and their external finance premiums inversely related. If net worth is pro-cyclical, then external finance premiums will be counter-cyclical. Potentially they can enhance business cycle volatility.

rical evidence may be due to improper identification of idiosyncratic and global shocks. Mendoza (1994) suggests another explanation that economic structures have changed over time, and hence a stable link between openness and volatility does not exist. Given close interactions between financial openness and financial systems, more recent studies have tried to find the missing link by separating these two forces. Cecchetti and Krause (2001) and Easterly, Islam and Stiglitz (2000), for example, attribute the declining volatility in the past twenty years to financial deregulation.

The ambiguous predictions of theoretical and empirical studies imply that the issue of financial imperfection and economic volatility remains as an essential field of research. This paper points out a new direction for the literature, by exploring the importance of money markets when financial access is not perfect. In the paper a two-country general equilibrium model is developed. A distinguishing feature of the model is that financial imperfection takes the form of two groups of households having asymmetric financial access, while most previous studies assume homogeneous financial limitation. The financial homogeneity assumed in previous studies enables easier equilibrium derivation. But it overlooks monetary interactions between households that may have caused the weak correlation between volatility and openness.

The model is built on the basic framework of new open economy macroeconomics introduced by Obstfeld and Rogoff. The OR model incorporates well established microfoundations of aggregate demand and supply, imperfect competition with short-run price rigidity, and explicit welfare evaluation. These features make the OR model a powerful analytic framework for business cycle volatility and international macroeconomic policies.[4] In the OR model, home and foreign households are assumed to reside on a continuum of interval. This paper follows this assumption and models financial asymmetry by dividing home and foreign households into two groups: One group has full access to both bond and money markets, while the other is prohibited from bond trade or even monetary adjustments. Changing the lengths for different types of households along the continuum

[4] For a survey of the literature see Lane (2001).

of interval then allows us to examine economic volatility under different degrees of home and foreign financial openness.[5]

Two additional modifications are applied to make the baseline model more realistic. First, it is assumed that short-run price rigidity takes the form of Calvo-staggering pricing following Calvo (1983). In the OR model, one-period-in-advance pricing has the counterfactual implication that price levels exhibit large and discrete jumps. By adopting Calvo-staggering pricing the model permits smooth price adjustments that are more consistent with observations. The Calvo-staggering assumption means that in each period the opportunity of adjusting its prices arrives stochastically to each firm. Provided independent decision making and a large number of firms, a fixed fraction gets to adjust prices each period and hence price levels gradually change over time. Second, some firms can charge different prices in different countries for the same commodity, a market segmentation commonly known as pricing-to-market.[6] Engel (1999) documents that PTM together with sticky prices account for a large proportion of real exchange rate fluctuations. Betts and Devereux (1996, 2000a) show that PTM enlarges the size of exchange rate movements when incorporated into the OR model. Gagnon and Knetter (1995), Goldberg and Knetter (1997) and Marston (1990) provide empirical evidence for PTM. According to their findings, PTM exists in many export countries with significant cross-country and cross-industry differences.

The first important finding of the paper is that, with asymmetric financial access expansionary macroeconomic disturbances induce financially constrained households to raise their money balances, if these households are prohibited from holding both foreign and domestic bonds. Under permanent monetary expansion, for example, higher income levels in the current period motivate households to transfer wealth into the future. If bond markets are not available, households will be forced to take money balances as an inferior alternative for consumption smoothing. Hence inter-household monetary adjustments

[5] If we want to make household types endogenous, we need a deeper model to incorporate economic and social factors that affect households' financial abilities. Because this is not the main purpose of the paper, I examine economic volatility taking different degrees of home and foreign financial openness as given.

[6] Henceforth PTM refers to pricing-to-market.

from households without financial limitation to those who are financially constrained result.[7]

Second, the above inter-household monetary adjustments serve as a shock absorber to eliminate excess economic volatility originated from financial imperfection, resulting in similar economic dynamics under different degrees of financial asymmetry. Although households may be financially constrained, they are entitled with the same right to hold and to adjust money balances. This fact, together with the one that different households coexist, causes macroeconomic disturbances to be buffered by the adjustments of money balances between them. The resulting economic dynamics of most variables hence exhibits small differences across various degrees of financial asymmetry unless in extreme cases. This finding may provide an explanation for the weak correlation between openness and volatility suggested by empirical studies.

Third, if financially constrained households are prohibited from not only bond trade but also monetary adjustments, then financial imperfection result in higher degrees of economic volatility compared to an economy with perfect financial markets. In this case, we have positive correlation between economic volatility and financial imperfection. The second and third findings imply that, the impacts of financial access on economic volatility depend on whether, in addition to restrictions on bond trade, you also have restrictions on monetary adjustments, among the agents who face financial limitation. Financial imperfection presenting in bond markets only is insufficient to cause large differences of economic dynamics or any systematic relation with economic volatility.

The rest of the chapter is organized as follows: Section 1.2 gives a brief description of the model. Section 1.3 and Section 1.4 analyze economic adjustments under money supply shocks and government spending shocks. Section 1.5 concludes.

1.2 Model

[7] Note that inter-household monetary adjustments act as a way of consumption smoothing across both time and states.

In this section I briefly describe the model structure. The description focuses on the home country because of model symmetry. Readers can refer to Appendix A at the end of the dissertation for complete model equations.

In each of the following subsections, I will write down households, governments and firms' optimization problems first, followed by notation definitions.

1.2.1 Households

Take a standard NOEM economy with two countries in the world. Assume that two types of households reside in each country: Types i and i^* have full access to the bond market, while types j and j^* have no access.[8] This financial asymmetry reflects in households' budget constraints, such that only i and i^* can hold bonds. Note that j and j^* can not borrow from or lend to domestic unconstrained households by bond trade either, and in this economy there is no government-issued asset. A [0, 1] interval represents the continuum of households, where i, j, i^* and j^* belong to subintervals $[0, n]$, $(n, .5]$, $(.5, .5 + n^*]$ and $(.5 + n^*, 1]$, respectively. The values of n and n^* are between 0 and .5, which are proportions of unconstrained home and foreign households. Larger values of n or n^* then stand for higher degrees of financial openness.

In the original OR model, sizes of the home and foreign countries are not necessarily the same. But in the current model, different country sizes affect the model results only in magnitudes rather than in signs. Therefore it is assumed that the two countries have the same size of .5 to simplify the underlying driving forces. The case of small open economies can be regarded as a special example of different country sizes, and hence the above argument applies. Also note that because the financial market is not perfect when n or n^* is less than .5, Ricardian equivalence generally does not hold in this economy.

Households earn wage income by labor supply, get equal dividends from domestic firms, pay taxes, choose consumption and money balances, and decide bond holdings if applicable. Despite their different budget constraints, all households have the same CES utility function that depends on consumption, labor supply and real balances. A typical household i's utility-maximization problem takes the form:

[8] Variables with an abstract mark denote foreign equivalents.

$$\text{Max} \qquad U_t^i = \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma - 1} C_s^{i\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon}(\frac{M_s^i}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i\mu}],$$

$$\text{subject to} \qquad M_t^i + d_t F_t^i = M_{t-1}^i + F_{t-1}^i + w_t N_t^i + \Pi_t - P_t C_t^i - P_t T_t^i .$$

It gives first-order conditions with respect to bond holdings, money balances and labor supply as

$$C_t^i = (\beta \frac{P_t}{d_t P_{t+1}})^{-\sigma} C_{t+1}^i ,$$

$$\frac{M_t^i}{P_t} = (\frac{\chi}{1-d_t} C_t^{i\frac{1}{\sigma}})^{\frac{1}{\varepsilon}},$$

$$N_t^i = (\frac{1}{\kappa} \frac{w_t}{P_t} C_t^{i-\frac{1}{\sigma}})^{\frac{1}{\mu-1}},$$

with $0 < \beta < 1$, $\sigma, \kappa, \varepsilon, \chi > 0$ and $\mu > 1$. On the other hand, a typical household *j*'s utility-maximization problem takes the form:

$$\text{Max} \qquad U_t^j = \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma - 1} C_s^{j\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon}(\frac{M_s^j}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j\mu}],$$

$$\text{subject to} \qquad M_t^j = M_{t-1}^j + w_t N_t^j + \Pi_t - P_t C_t^j - P_t T_t^j .$$

It gives first-order conditions with respect to money balances and labor supply as

$$\frac{M_t^j}{P_t} = \chi^{\frac{1}{\varepsilon}} [C_t^{j-\frac{1}{\sigma}} - \beta(\frac{P_t}{P_{t+1}}) C_{t+1}^{j-\frac{1}{\sigma}}]^{-\frac{1}{\varepsilon}},$$

$$N_t^j = (\frac{1}{\kappa} \frac{w_t}{P_t} C_t^{j-\frac{1}{\sigma}})^{\frac{1}{\mu-1}}.$$

Note that if households *j* get no dividend or less dividends than households *i* do, then the effects of economic disturbances on households *j*'s consumption, labor supply and real balances will be similar to the case of equal dividends, except with smaller magnitudes.

In the above equations, the variable C_t of either household *i* or *j* is a consumption index defined by

$$C_t = [\int_0^{\frac{1}{2}} c_t(z)^{\frac{\theta-1}{\theta}} dz + \int_{\frac{1}{2}}^{1} c_t(z^*)^{\frac{\theta-1}{\theta}} dz^*]^{\frac{\theta}{\theta-1}},$$

where $\theta > 1$; $c_t(z)$ and $c_t(z^*)$ stand for consumption of output produced by the home firm z and the foreign firm z^* respectively.[9] The price index P_t and consumption demand $c_t(z)$ and $c_t(z^*)$ can be derived from C_t such that

$$P_t = [\int_0^{\frac{1}{2}} p_t(z)^{1-\theta} dz + \int_{\frac{1}{2}}^{1} p_t(z^*)^{1-\theta} dz^*]^{\frac{1}{1-\theta}},$$

$$c_t(z) = [\frac{p_t(z)}{P_t}]^{-\theta} C_t,$$

$$c_t(z^*) = [\frac{p_t(z^*)}{P_t}]^{-\theta} C_t,$$

with $p_t(z)$ and $p_t(z^*)$ standing for individual commodity prices.[10] The nominal discount bond F_t is denominated in the home currency.[11] Variables M_t, N_t, Π_t, and T_t denote the money balance, labor supply, the profit transfer and the tax payment. Variables w_t and d_t denote the wage rate and the bond price.

In addition to bond trade, this paper also examines the case where households j and j^* are further prohibited from adjusting money balances. When this complete financial restriction is applied, money balances and tax payments of households j and j^* are set at their initial steady-state levels over time. It is assumed that the initial steady-state values of tax payments are equal to 0 for both types of households in both countries. A typical household j's utility-maximization problem becomes:

$$\text{Max} \qquad U_t^j = \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{j\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{\overline{M}_0^j}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j\mu}],$$

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[9] Pricing-to-market is permitted in this model, and hence a firm z may refer to either a firm x with local-currency pricing or a firm y with producer-currency pricing.

[10] P_t can be derived by solving the problem

$$\min \; Z_t = \int_0^{\frac{1}{2}} p_t(z) c_t(z) dz + \int_{\frac{1}{2}}^{1} p_t(z^*) c_t(z^*) dz^*, \text{ subject to } [\int_0^{\frac{1}{2}} c_t(z)^{\frac{\theta-1}{\theta}} dz + \int_{\frac{1}{2}}^{1} c_t(z^*)^{\frac{\theta-1}{\theta}} dz^*]^{\frac{\theta}{\theta-1}} = 1.$$

$c_t(z)$ and $c_t(z^*)$ can be derived by solving the problem

$$\max \; C_t = [\int_0^{\frac{1}{2}} c_t(z)^{\frac{\theta-1}{\theta}} dz + \int_{\frac{1}{2}}^{1} c_t(z^*)^{\frac{\theta-1}{\theta}} dz^*]^{\frac{\theta}{\theta-1}}, \text{ subject to } \int_0^{\frac{1}{2}} p_t(z) c_t(z) dz + \int_{\frac{1}{2}}^{1} p_t(z^*) c_t(z^*) dz^* = Z_t.$$

[11] We can assume that trading of bonds involve a small adjustment cost to ensure stationarity. But note that in this paper the economic predictions will not change with or without the adjustment cost.

subject to $\quad M_0^j = M_0^j + w_t N_t^j + \Pi_t - P_t C_t^j$.

And there is only one first-order condition taken with respect to labor supply as

$$N_t^j = (\frac{1}{\kappa}\frac{w_t}{P_t}C_t^{j^{-\frac{1}{\sigma}}})^{\frac{1}{\mu-1}}.$$

1.2.2 Governments

The home government sets its spending, taxes and money supply according to the budget constraint

$$G_t = T_t + \frac{M_t - M_{t-1}}{P_t},$$

where

$$\frac{1}{2}T_t = nT_t^i + (\frac{1}{2} - n)T_t^j,$$

$$\frac{1}{2}M_t = nM_t^i + (\frac{1}{2} - n)M_t^j.$$

Like other real composite variables government spending G_t is measured in units of the consumption index. Therefore, government expenditure demand $g_t(z)$ and $g_t(z^*)$ can be derived similar to household consumption demand as

$$g_t(z) = [\frac{p_t(z)}{P_t}]^{-\theta} G_t,$$

$$g_t(z^*) = [\frac{p_t(z^*)}{P_t}]^{-\theta} G_t.$$

Note that with two types of households, governments control total money supply but not individual money balances. This is very different from models with homogeneous agents where money balances are identical across households. When households are free to choose money balances over time, economic disturbances initiate inter-household monetary adjustments. It is shown later that these adjustments play an important role in stabilizing the economy.

1.2.3 Firms

Assume that there are two types of firms in each country. Types x and x^* can price to markets by local-currency pricing, while types y and y^* can only use producer-currency pricing.[12] For x and x^*, they set one price for each country and these prices do not need to follow the law of one price. On the other hand, prices set by y and y^* are governed by the law of one price and hence affected by exchange rates. Consequently, purchasing power parity generally does not hold in this economy. Similar to the continuum of households, firms locate on another [0, 1] interval with x, x^*, y and y^* belonging to subintervals $[0, u]$, $(u, .5]$, $(.5, .5 + u^*]$ and $(.5 + u^*, 1]$ respectively. The values of u or u^* are between 0 and .5, which are proportions of home and foreign LCP firms. Larger values of u or u^* then stand for higher degrees of market segmentation.

Firms produce differentiated products, engage in monopolistic competition, maximize the present value of profits, and transfer profits back to domestic households evenly. It is assumed that firms' pricing decisions are subject to Calvo-staggering rigidity. In other words, the opportunity of adjusting its prices arrives stochastically to each firm in each period. Given independent decision making and a large number of firms, the final price set by firms in each type can be represented by their averaged price in each type. It is calculated as the sum of the final price in the previous period and the current target price, weighted by γ and 1-γ respectively. Other decision variables set by firms in each type are then calculated using these final prices.

A typical firm x maximizes the discounted sum of its current and future profits by choosing one target price for each country in each period, given the probability γ that any price chosen today remains to be the price tomorrow. Its profit-maximization problem takes the form:

$$\text{Max} \qquad V_t'^x = \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} \Pi_s'^x ,$$

$$\text{subject to} \qquad \Pi_s'^x = p_t'^x(z) x_s'(z) + e_s q_t'^x(z) x_s'^*(z) - w_s N_s'^x ,$$

$$x_s'(z) = x_s'^d(z) = [\frac{p_t'^x(z)}{P_s}]^{-\theta} [nC_s^i + (\frac{1}{2} - n) C_s^j + \frac{1}{2} G_s],$$

[12] Henceforth LCP refers to local-currency pricing and PCP refers to producer-currency pricing.

$$x_s'^{*}(z) = x_s'^{d^*}(z) = [\frac{q_t'^x(z)}{P_s^*}]^{-\theta}[n^* C_s^{i^*} + (\frac{1}{2} - n^*)C_s^{j^*} + \frac{1}{2}G_s^*],$$

$$x_s'(z) + x_s'^{*}(z) = A_s N_s'^x.$$

It gives two first-order conditions with respect to $p_t'^x(z)$ and $q_t'^x(z)$ as

$$(\theta - 1)p_t'^x(z)\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}P_s^{\theta}[nC_s^i + (\frac{1}{2} - n)C_s^j + \frac{1}{2}G_s]$$

$$= \theta\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}P_s^{\theta}[nC_s^i + (\frac{1}{2} - n)C_s^j + \frac{1}{2}G_s]\frac{w_s}{A_s},$$

$$(\theta - 1)q_t'^x(z)\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}e_s P_s^{*\theta}[n^* C_s^{i^*} + (\frac{1}{2} - n^*)C_s^{j^*} + \frac{1}{2}G_s^*]$$

$$= \theta\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}P_s^{*\theta}[n^* C_s^{i^*} + (\frac{1}{2} - n^*)C_s^{j^*} + \frac{1}{2}G_s^*]\frac{w_s}{A_s}.$$

In the above equations, $p_t'^x(z)$, $q_t'^x(z)$, $x_t'(z)$ and $x_t'^*(z)$ are target prices and target output chosen by the firm x for the home and foreign countries respectively. $N_t'^x$ is target labor demand of the firm x, A_t is the technology level and e_t is the exchange rate. Final prices and other decision variables set by firms x are calculated as

$$p_t^x(z) = \gamma p_{t-1}^x(z) + (1-\gamma)p_t'^x(z),$$

$$q_t^x(z) = \gamma q_{t-1}^x(z) + (1-\gamma)q_t'^x(z),$$

$$x_t(z) = [\frac{p_t^x(z)}{P_t}]^{-\theta}[nC_t^i + (\frac{1}{2} - n)C_t^j + \frac{1}{2}G_t],$$

$$x_t^*(z) = [\frac{q_t^x(z)}{P_t^*}]^{-\theta}[n^* C_t^{i^*} + (\frac{1}{2} - n^*)C_t^{j^*} + \frac{1}{2}G_t^*],$$

$$N_t^x = \frac{1}{A_t}[x_t(z) + x_t^*(z)],$$

$$\Pi_t^x = p_t^x(z)x_t(z) + e_t q_t^x(z)x_t^*(z) - w_t N_t^x.$$

A typical firm y has a similar profit-maximization problem but it only chooses one target price:

$$\text{Max} \qquad V_t'^y = \sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}\Pi_s'^y,$$

subject to $\Pi_s'^y = p_t'^y(z) y_s'(z) + p_t'^y(z) y_s'^*(z) - w_s N_s'^y$,

$$y_s'(z) = y_s'^d(z) = [\frac{p_t'^y(z)}{P_s}]^{-\theta}[nC_s^i + (\frac{1}{2} - n)C_s^j + \frac{1}{2}G_s],$$

$$y_s'^*(z) = y_s'^{d^*}(z) = [\frac{p_t'^y(z)}{e_s P_s^*}]^{-\theta}[n^* C_s^{i^*} + (\frac{1}{2} - n^*)C_s^{j^*} + \frac{1}{2}G_s^*],$$

$$y_s'(z) + y_s'^*(z) = A_s N_s'^y.$$

The only first-order condition taken with respect to $p_t'^y(z)$ becomes

$$(\theta - 1) p_t'^y(z) \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} \left\{ P_s^\theta [nC_s^i + (\frac{1}{2} - n)C_s^j + \frac{1}{2}G_s] + (e_s P_s^*)^\theta [n^* C_s^{i^*} + (\frac{1}{2} - n^*)C_s^{j^*} + \frac{1}{2}G_s^*] \right\}$$

$$= \theta \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} \left\{ P_s^\theta [nC_s^i + (\frac{1}{2} - n)C_s^j + \frac{1}{2}G_s] + (e_s P_s^*)^\theta [n^* C_s^{i^*} + (\frac{1}{2} - n^*)C_s^{j^*} + \frac{1}{2}G_s^*] \right\} \frac{w_s}{A_s}.$$

Final prices and other decision variables set by firms y are calculated as

$$p_t^y(z) = \gamma p_{t-1}^y(z) + (1 - \gamma) p_t'^y(z),$$

$$y_t(z) = [\frac{p_t^y(z)}{P_t}]^{-\theta}[nC_t^i + (\frac{1}{2} - n)C_t^j + \frac{1}{2}G_t],$$

$$y_t^*(z) = [\frac{p_t^y(z)}{e_t P_t^*}]^{-\theta}[n^* C_t^{i^*} + (\frac{1}{2} - n^*)C_t^{j^*} + \frac{1}{2}G_t^*],$$

$$N_t^y = \frac{1}{A_t}[y_t(z) + y_t^*(z)],$$

$$\Pi_t^y = p_t^y(z) y_t(z) + p_t^y(z) y_t^*(z) - w_t N_t^y.$$

1.2.4 Market-Clearing Conditions

There are six market-clearing conditions in the model:

$$nF_t^i = -n^* F_t^{i^*},$$

$$\frac{1}{2}M_t = nM_t^i + (\frac{1}{2} - n)M_t^j,$$

$$\frac{1}{2}M_t^* = n^* M_t^{i^*} + (\frac{1}{2} - n^*)M_t^{j^*},$$

$$uN_t^x + (\frac{1}{2} - u)N_t^y = nN_t^i + (\frac{1}{2} - n)N_t^j,$$

$$u^* N_t^{x^*} + (\frac{1}{2} - u^*)N_t^{y^*} = n^* N_t^{i^*} + (\frac{1}{2} - n^*)N_t^{j^*},$$

$$C_t^w + G_t^w = nC_t^i + (\frac{1}{2} - n)C_t^j + n^* C_t^{i^*} + (\frac{1}{2} - n^*)C_t^{j^*} + \frac{1}{2}G_t + \frac{1}{2}G_t^*$$

$$= u[\frac{p_t^x(z)}{P_t}x_t(z) + \frac{q_t^x(z)}{P_t^*}x_t^*(z)] + (\frac{1}{2} - u)[\frac{p_t^y(z)}{P_t}y_t(z) + \frac{p_t^y(z)}{e_t P_t^*}y_t^*(z)]$$

$$+ u^*[\frac{q_t^{x^*}(z^*)}{P_t}x_t(z^*) + \frac{p_t^{x^*}(z^*)}{P_t^*}x_t^*(z^*)]$$

$$+ (\frac{1}{2} - u^*)[\frac{e_t p_t^{y^*}(z^*)}{P_t}y_t(z^*) + \frac{p_t^{y^*}(z^*)}{P_t^*}y_t^*(z^*)] = Y_t^w.$$

The first equation is the bond market clearing condition. It states that total values of bonds held by home and foreign households must sum up to zero when evaluated in the home currency. The second and third equations are money market clearing conditions. They are part of the home and foreign government budget constraints and must hold all the time. The forth and fifth equations are labor market clearing conditions. Because in the model labor is assumed to be internationally immobile, total labor demand must equal total labor supply within each country. The last equation is the goods market clearing condition. Aggregate demand of household consumption C_t^w and government spending G_t^w must equal aggregate output of the global economy Y_t^w.

1.2.5 Solution Methods

After solving households' and firms' optimization problems, all optimal conditions are first-order log-linearized around a specific initial steady state. It is assumed that in this steady state the law of one price and purchasing power parity hold. All target prices and actual prices are equal when evaluated in the same currency. It is also assumed that in this steady state home and foreign bond holdings, tax payments and government spending are equal to 0, and technology levels are equal to 1. Numerical results of the linearized model are generated by Matlab simulation under monetary and fiscal disturbances.

Literature on degrees of financial imperfection and market segmentation provides a wide range of estimates for u and n. Campbell and Mankiw (1989) test the permanent income hypothesis, and suggest about 50 percent of total income consumed by current-income consumers. Jappelli and Pagano (1989) document substantial deviations in the extent of financial imperfection from cross-country comparisons. Their estimates range from .1 to .7 for seven developed countries including the United Kingdoms, the United States and Japan.[13] [14] [15] For degrees of market segmentation, Gagnon and Knetter (1995) find stark differences in the extent of pricing-to-market across export countries, with estimates ranging from 0 to .9. Marston (1990) finds similar pricing-to-market diversities across industries, with estimates ranging from .3 to near 1. Despite the suggested ambiguity, both studies have averaged degrees of market segmentation fall in the neighborhood of .5. It is also consistent with findings of Goldberg and Knetter (1997).

In this paper, two cases of (n, n^*), (.5, .5) and (.01, .01), are chosen to present in Figure 1.1 and Figure 1.2 under a once-and-for-all home monetary expansion. (n, n^*) equaling (.5, .5) implies well developed financial markets without financial friction, while (n, n^*) equaling (.01, .01) stands for a nearly closed economy. The difference between Figure 1.1 and Figure 1.2 is that the former assumes complete PCP and the latter assumes complete LCP. The reason of choosing these extreme values for (n, n^*) is to allow easier understandings of underlying economic meanings. Cause without the restriction on monetary adjustments most other values of (n, n^*) merely result in similar economic dynamics. This can be seen in Table 1.1 and Table 1.2, which summarize standard errors of major

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[13] Developing countries are excluded due to data limitation.

[14] Because in this model money can serve as an inferior asset to smooth consumption, strictly speaking the complete liquidity constraints assumed by Campbell and Mankiw (1989) and Jappelli and Pagano (1989) are applicable only when financially constrained households are prohibited from both bond trade and monetary adjustments.

[15] Generally speaking most households in the real world are only partially liquidity constrained, and hence Campbell and Mankiw (1989) and Jappelli and Pagano (1989) imply even higher population ratios under financial limitation.

economic variables for four sets of (n, n^*) given different pricing behaviors. The simulation results are generated with identical and independent random-walk monetary disturbances in both countries. This paper also examines economic volatility when financially constrained households are further prohibited from monetary adjustments. Because the graphical illustrations are difficult in some cases where economic dynamics exhibits large differences, the simulation results are presented by showing the standard errors of major economic variables in Table 1.3 and Table 1.4. Again the results are generated with independent and identical random-walk monetary disturbances in both countries. Similar to monetary disturbances, economic dynamics under a once-and-for-all home fiscal expansion is presented in Figure 1.3 and Figure 1.4, where the former assumes complete PCP and the latter assumes complete LCP.

Other parameters used by Matlab are as follows: The elasticity of consumption demand θ is set to 11 to reproduce a wage-price markup of 10 percent. It is consistent with findings of Basu and Fernald (1997) and Burnside, Eichenbaum and Rebelo (1995). The elasticity of labor supply $1/(\mu - 1)$ is set to 1 following Betts and Devereux (2000a, 2000b) and Christiano, Eichenbaum and Evans (1997), which gives μ a value of 2. The consumption elasticity of money demand for households i and i^* is $1/\varepsilon$ given log utility. According to Mankiw and Summers (1986), this variable is very close to unity and hence ε is set to 1. Finally, the elasticity of intertemporal substitution σ and the discount factor β are set to 1 and .96 respectively. These values are commonly used in quantitative real business cycle studies.[16]

1.3 Money Supply Shock

1.3.1 Restrictions on Bond Trade with Complete Producer-Currency Pricing

In this section I assume complete PCP in that all home and foreign firms set their prices in domestic currencies. Consider a pure and permanent home monetary expansion

[16] Setting the elasticity of intertemporal substitution σ to 1 provides a benchmark case of the model. But note that the economic predictions of this paper are not sensitive to the value of σ.

adopted at period one, which permanently raises total money supply by .1, while keeping government spending unchanged by reducing short-run taxes evenly across different households. Figure 1.1 summarizes simulation results of major economic variables, with continuous lines representing the case of (n, n^*) equaling (.5, .5) and dashed lines representing the case of (n, n^*) equaling (.01, .01). Because consumption and labor supply of households i and i^*, and prices and output of individual firms exhibit similar economic dynamics across different cases, these variables are excluded from the illustration.

The case of (n, n^*) equaling (.5, .5) with complete PCP is close to the original OR model. All households have two alternatives to save as no financial limitation applies. They can hold bonds that generate interest revenues, or hold money that yields direct utility. In this economy home monetary expansion increases home households' money balances. Because there is only one type of households, each of them shares the same and constant amount of monetary increment over time. The home monetary expansion also increases the value of the exchange rate, which jumps immediately to its long-run level. This exchange rate depreciation raises home output and hence home labor supply relative to foreign output and foreign labor supply in the short run. It creates a wealth effect that increases home households' consumption and their bond holdings to smooth consumption. It also increases foreign households' consumption by making the foreign price of home output less expensive. Therefore the home country runs a current account surplus in the short run. In the long-run equilibrium, bond holdings and money balances of home households increase, and consumption of all home and foreign households increases.[17]

On the other hand if asymmetric financial access presents, the only way households j can smooth consumption is to increase their money balances further. At the same time, households i must decrease their money balances by increasing their bond holdings to satisfy this extra money demand. Consequently, money moves from households without financial limitation to those who are financially constrained as the monetary expansion occurs. As illustrated in Figure 1.1, bond holdings of households i are much higher when (n, n^*) equals (.01, .01) than in the benchmark case of (n, n^*) equaling (.5, .5) at period one. And because of the small population of households i, even they largely reduce their money balances, each household j only shares a tiny amount. Consumption smoothing of

[17] Betts and Devereux (1996, 2000a, 2000b) and Obstfeld and Rogoff (1995, 1996).

households j is hence highly inefficient, which causes their period-one consumption to be higher compared to the benchmark case. However, this is not the case for households i, whose consumption is not affected by the financial asymmetry. The extra money demand of households j for the purpose of consumption smoothing also reduces exchange rate depreciation. This results in lower home output, lower home labor supply and the lower home wage rate compared to the benchmark case at period one. In the long run, money is inferior to bonds for value storing in the sense that it does not generate interest revenues. Therefore, consumption of households j decreases more rapidly and to a lower level than the benchmark case in the long-run equilibrium. Their money balances also decrease accordingly, and we find reversed monetary movements compared to the first period. The lower money demand of households j causes the exchange rate to further depreciate in the long run. This makes home output, home labor supply and the home wage rate decrease less rapidly and to higher levels than the benchmark case in the long-run equilibrium. The current account of the home country is negative both at period one and in the long run. The first reason is the low population of households i. And the second reason is the smaller magnitude of exchange rate depreciation pointed out earlier that makes home output more expensive than the benchmark case. The underlying reasons for the resulting economic dynamics of the foreign country are similar to those of the home country, and hence will not repeat here.

The particular adjustment pattern of money balances can be further explained by the different characteristics between bonds and money. When both financial instruments are feasible, households keep money because it yields direct utility from the utility function, and hold bonds because they smooth consumption more efficiently. This design emphasizes the transaction motive of keeping money, compared to holding bonds as a major store of values. Once asymmetric financial access emerges, households without financial limitation will continue to choose bonds for better consumption smoothing, while financially constrained households must choose money as an inferior but the only way of value storing. The induced financial substitution of using money to replace bonds then results in the observed monetary movements. In this model, the facts that money balances do not generate interest revenues and are required when doing transactions make them close to saving accounts. The inter-household monetary adjustments then imply that financially constrained households raise money balances or low-interest savings upon domestic monetary expansion. This contradicts the general impression that monetary expansion reduces the real value of money, and hence induces the public to switch their portfolios into interest-bearing assets.

In addition to Figure 1.1, Table 1.1 provides the simulation results with a more complete set of n-n^* combinations. It summarizes standard errors of major economic variables under independent and identical random-walk monetary disturbances in both countries. The table shows that degrees of variability for most variables exhibit small differences across different (n, n^*). Exceptions emerge mostly for bond holdings and money balances, or when the proportions of households i and i^* are reduced to very small values such as (.01, .01). This fact implies that inter-household monetary adjustments have very important effects on economic volatility. When the populations of households i and i^* are above some reasonable levels, under monetary disturbances the extra money demand of households j or j^* for consumption smoothing can be fulfilled efficiently by households i or i^*. Inter-households monetary adjustments then serve as a shock absorber to eliminate excess variability in other variables. This is also why we observe large differences of standard errors across different (n, n^*) for bond holdings and money balances but not other variables in Table 1.1. On the other hand, if the populations of households i and i^* are reduced to very small levels, then large amounts of total money demand from households j or j^* can no longer be fulfilled efficiently by households i or i^*. Inter-households monetary adjustments are restricted, which also results in the large differences of standard errors between (n, n^*) equaling (.01, .01) and other cases.

1.3.2 Restrictions on Bond Trade with Complete Local-Currency Pricing

Consider the same home monetary expansion as the one in the previous section, but now assume complete LCP in that all home and foreign firms set their prices in local currencies. Figure 1.2 summarizes simulation results of major economic variables, again with continuous lines representing the case of (n, n^*) equaling (.5, .5) and dashed lines representing the case of (n, n^*) equaling (.01, .01). To provide easier comparisons all variables that have been shown in Figure 1.1 are included, even they have similar adjustment paths across different cases here.

According to Figure 1.2, when (n, n^*) equals (.5, .5) the home monetary expansion raises home households' money balances evenly and constantly. The home monetary expansion depreciates the exchange rate, which jumps immediately to its long-run level. Note that the feature of PTM has made the exchange rate overshoot compared to the benchmark case in Figure 1.1. With complete LCP, once prices are set they will not be changed by the exchange rate when output is imported into the other country. In other words, the foreign price of home output will not be reduced by the exchange rate depreciation. And hence the expenditure switching effect of shifting world production from the foreign country to the home country is not observed here. Home labor supply decreases, and home output is lower both at period one and in the long-run equilibrium compared to the benchmark case in Figure 1.1. The extra money supply increases home households' consumption and bond holdings, but the magnitude of their bond holdings is small due to less home production. Consequently, the current account of the home country is negative both at period one and in the long-run equilibrium.

The case of (n, n^*) equaling (.01, .01) has very similar economic dynamics to that of (n, n^*) equaling (.5, .5) except bond holdings and money balances. Under the restriction on bond trade, households j still need to smooth consumption by holding more money at period one even with complete LCP. Hence we still find higher bond holdings of households i, as well as monetary movements from households i to households j upon the home monetary expansion. Nonetheless, because there is no expenditure switching effect with complete LCP, the magnitude of home output rise and the need of home consumption smoothing are limited. Therefore we only observe moderate adjustments in home households' bond holdings and money balances. And these adjustments of bond and money are sufficient to eliminate excess variability in other variables, leaving their adjustment paths similar across different cases even with the small population of households i.

Table 1.2 provides consistent simulation results with the above findings. It shows that variability of bond holdings and money balances is much lower compared to Table 1.1 where complete PCP is assumed. It also shows that variability of other variables exhibits little difference across different cases even when (n, n^*) equals (.01, .01). However, these do not imply that inter-household monetary adjustments are minor in affecting economic volatility under complete LCP. In the next section I will examine the case where financially constrained households are further prohibited from adjusting money balances to show the importance of inter-household monetary adjustments in stabilizing the economy.

1.3.3 Restrictions on Bond Trade and Monetary Adjustments

In this section I modify the model by assuming money balances of households j and j^* fixed at initial steady-state levels over time. In other words, financially constrained households are now prohibited from not only bond trade but also monetary adjustments. This extreme financial restriction helps us to understand the importance of inter-household monetary adjustments in stabilizing the economy. Note that with the complete financial limitation, economic volatility increases dramatically especially for the case of (n, n^*) equaling (.01, .01). This creates difficulties for graphical illustrations and hence I only present the standard errors of major economic variables here. Table 1.3 and Table 1.4 summarize simulation results with complete PCP and complete LCP respectively. Standard errors are generated under independently and identically distributed random-walk monetary disturbances in both countries.

In Table 1.3, when (n, n^*) equals (.5, .5) the simulation results are the same as those in Table 1.1 for there is no financially constrained household in this case. But as the populations of financially constrained households increase in both countries, standard errors of all variables begin to deviate significantly across different cases. Moreover, financial imperfection and economic volatility generally have positive correlation, with higher degrees of financial imperfection resulting in higher standard errors. These two facts are in contrast to what the simulation results implied in Table 1.1, where the variability degrees of most variables have no large difference across different (n, n^*) except (.01, .01), and there is no obvious relation between financial imperfection and economic volatility. The reason is that in Table 1.1 households j and j^* still can use money to smooth consumption although they can not hold bonds. Hence different degrees of financial asymmetry only have limited effects on economy volatility. On the other hand, when households j and j^* are prohibited from both bond trade and monetary adjustments, there is no way for them to smooth consumption upon monetary disturbances. Therefore, higher populations of financially constrained households result in higher degrees of economic volatility. This argument also applies on Table 1.2 and Table 1.4, where complete LCP is assumed. The previous section has discussed the reasons of complete LCP reducing the differences of economic volatility across different (n, n^*), as shown in Table 1.2. But with the restriction on monetary adjustments, again we observe larger degrees of variability in economic variables as well as positive correlation between financial imperfection and economic volatility, as shown in Table 1.4.

The above argument suggests that inter-household monetary adjustments play a very important role in stabilizing the economy. The impacts of financial imperfection on economic volatility depend on whether you have restrictions on both bond trade and monetary adjustments among the agents who face financial limitation. In other words, financial imperfection presenting in bond markets only is insufficient to cause any large difference of economic dynamics or systematic relation with economic volatility.

Many empirical studies have tried to explain the weak correlation between volatility and openness, but the real underlying reason is still unrevealed. The financial asymmetry modeled in this paper points out a new direction that may help to explain the weak correlation. Many financial markets are not fully open in the sense that some households can not trade bonds freely. But as long as these households are free to adjust money, inter-household monetary adjustments serve as a substitute to smooth consumption and eliminate excess economic volatility upon economic disturbances. Consequently, we observe no systematic relation between volatility and openness.

1.4 Government Spending Shock

Consider a pure and permanent home fiscal expansion adopted at period one, which permanently raises government spending by .1, and keeps total money supply unchanged by increasing taxes evenly across different households. Figure 1.3 and Figure 1.4 summarize simulation results of major economic variables, with the former assuming complete PCP and the latter assuming complete LCP. Following the specification from previous sections, in these figures continuous lines represent the case of (n, n^*) equaling (.5, .5) and dashed lines represent the case of (n, n^*) equaling (.01, .01). Note that consumption and labor supply of households i and i^*, and prices and output of individual firms are excluded from the illustration because they exhibit similar economic dynamics across different cases.

In the benchmark case of (n, n^*) equaling (.5, .5) with complete PCP, home fiscal expansion causes higher taxes that reduce home consumption and home money demand. The exchange rate depreciates accordingly, and the associated expenditure switching effect increases home production and labor supply while decreasing foreign production and labor supply. Because the tax burden is permanent but its effects on output are larger at the present than in the future, if no financial imperfection presents home households will raise bond holdings to compensate future consumption. Consequently, the home country runs a current account surplus upon the home fiscal expansion. When financial asymmetry emerges as in the case of (n, n^*) equaling (.01, .01), on the other hand, households j must acquire higher money balances to smooth consumption. This extra money demand reduces the exchange rate depreciation. It also induces monetary movements from households i to households j. Because the population of households i is small, each household j only shares a tiny amount of monetary increment. The inefficient consumption smoothing then results in higher consumption and lower labor supply of households j compared to the benchmark case. For households i, they increase bond holdings to substitute the decrease of their money balances, and there is effectively no difference in their consumption and labor supply compared to the benchmark case. The home output is lower due to lower total labor supply compared to the benchmark case, and the current account surplus of the home country reduces.

The economic reasons behind the differences of Figure 1.4 from Figure 1.3 are similar to those of Figure 1.2 from Figure 1.1, where monetary disturbances are examined. With complete LCP there is no expenditure switching effect upon the home fiscal expansion. Hence even the populations of households i and i^* are small, inter-household monetary adjustments are sufficient to absorb excess economic volatility originated from financial imperfection. This is why we observe similar economic dynamics across different cases for most variables except bond holdings and money balances.

Table 1.5 and Table 1.6 provide more simulation results to support the above findings. Similar to previous sections, they summarize standard errors of major economic variables under independent and identical random-walk fiscal disturbances in both countries, with complete PCP and complete LCP respectively. According to Table 1.5, variability degrees of most variables have small differences across different (n, n^*) except bond holdings, money balances, or when the two countries are nearly close economies as (n, n^*) equals (.01, .01). If the pricing behavior changes to complete LCP, then variability degrees have even smaller deviations including (n, n^*) equaling (.01, .01). Exceptions now are only bond holdings and money balances, but their magnitudes of deviations are also small. These results are consistent with the above argument that under complete LCP, a small extent of inter-household monetary adjustments is sufficient to offset excess economic volatility. Note that if financially constrained households are prohibited from monetary adjustments in addition to bond trade, we will observe significant differences of economic volatility across different cases, as well as positive correlation between financial imperfection and economic volatility, even under complete LCP. The underlying reasons and economic implications are the same as those for monetary disturbances.

1.5 Conclusion

In this paper a two-country sticky-price general equilibrium model is developed to examine the effects of financial imperfection on economic volatility. In the model financial imperfection takes the form of two groups of households with only one group having access to the bond market. This specification of financial imperfection is different from previous studies but supported by empirical evidence. It turns out to have some explanation power on the empirically weak correlation between volatility and openness.

When financially constrained households are prohibited from bond trade but not monetary adjustments, expansionary macroeconomic disturbances induce them to raise their money balances for consumption smoothing. Inter-household monetary adjustments from households without financial limitation to those financially constrained then serve as a shock absorber to eliminate excess economic volatility originated from financial asymmetry, resulting in the weak correlation suggested by empirical studies. This argument is further supported by the experiment that restricts both bond trade and monetary adjustments of financially constrained households. With this complete financial limitation, higher degrees of financial imperfection result in higher degrees of economic volatility, and we observe positive correlation between volatility and openness. Hence the impacts of financial imperfection on economic volatility depend on whether you have restrictions on both bond trade and monetary adjustments. In other words, financial imperfection presenting in bond markets only is insufficient to cause large differences of economic dynamics or any systematic relation with economic volatility.

Asymmetric financial access can cause important policy issues due to its effects on bond trade and monetary adjustments. In particular, the prediction of the OR model that permanent monetary expansion evenly raises utility of home and foreign households may no longer hold under financial asymmetry. Its welfare effects are open for future research, and its welfare results can have important implications on welfare policies.

Chapter 2

Welfare and Financial Asymmetry

2.1 Introduction

The welfare tradeoff between economic stability and economic efficiency has been an important issue in economics discussions. Allowing an economic entity to function under smaller controls on its manufacture, financial or trade sector permits more efficient economic adjustments. On the one hand, it is welfare improving in the sense that any deviation from the optimal economic allocation can be corrected quickly. But on the other hand, the associated higher degree of economic variability and economic uncertainty may result in larger values of welfare loss.

For the most classical example in existing literature, Lucas (1987) evaluates welfare as changes of steady-state consumption required to achieve the same expected utility. He shows that economic variability implied by business cycles tends to have small welfare effects. In addition to Lucas, many other economists also suggest that welfare loss associated with economic uncertainty is not significant. And hence governments should adopt the economic policies that aim to permit efficient economic adjustments.

More recently, Bergin and Tchakarov (2003) apply second-order approximation on a two-country sticky-price general equilibrium model to examine welfare under monetary and technology shocks. They find that welfare effects of economic uncertainty are likely to be small for a wide range of cases. But when households exhibit habit persistence or when there is an international market for bonds in the currency of only one of the two countries, welfare loss of economic uncertainty increases. In the latter case, the country whose currency serves as denomination tends to save more and have higher welfare while the other tends to save less and have lower welfare. This is because saving in international assets allows a country to hedge against exchange rate risk more efficiently if it can save in terms of its own currency.

The findings of Bergin and Tchakarov (2003) imply that different types of financial asymmetry may play important roles in directing welfare results. Following Bergin and Tchakarov (2003), this paper uses a two-country sticky-price general equilibrium model to study welfare effects of economic uncertainty. Different from the authors' concern about how welfare is changed when there is cross-country inequality, this paper explores the feature of inter-household heterogeneity and its important impacts on welfare. In the paper, financial structures are generalized such that households in the same country face different financial limitations. These different financial limitations then alter households' economic behaviors and cause asymmetric welfare effects upon economic disturbances. Compared to previous studies where economic agents in the same country are assumed to be homogeneous, this paper examines welfare by taking into account complicated interactions between different types of households.

The model is built on the basic framework of new open economy macroeconomics introduced by Obstfeld and Rogoff. Similar to Chapter 1, this paper models financial asymmetry by dividing home and foreign households into two groups: One group has full access to both bond and money markets, while the other is prohibited from bond trade or even monetary adjustments. Changing the lengths for different types of households along the continuum of interval then allows us to examine welfare under different degrees of home and foreign financial openness.

The welfare measure adopted in this paper follows Bergin and Tchakarov (2003). First compute unconditional expectation of household utility under economic disturbances. Then calculate how much consumption in the initial steady state the household is willing to give up to negate effects of economic uncertainty. This consumption cost is the welfare measure. Using second-order Taylor expansion, moreover, we can enhance the accuracy of welfare evaluation. In addition to variances of consumption and labor supply, the welfare measure also captures welfare effects of economic uncertainty through means of those variables.

According to simulation results, this paper finds that lower degrees of foreign financial openness cause welfare loss to increase for financially unconstrained home households but to decrease for financially constrained home households. Moreover, it finds that lower degrees of home financial openness can cause welfare loss of both types of home households to decrease. These findings are quite different from the general impression that financial restrictions reduce welfare, especially for households who have full access to both bonds and money. The reason is as follows: For households who have full access to both bonds and money, they smooth consumption mainly by adjusting bond holdings. With lower degrees of home financial openness and hence fewer numbers of unconstrained home households, consumption smoothing by bond trade becomes more efficient. This enhanced financial privilege then decreases welfare loss of those remaining unconstrained home households. For households who can not trade bonds, on the other hand, they smooth consumption only by adjusting money balances. Because lower degrees of home financial openness raise home money demand and the purchasing power of home money, consumption smoothing by monetary adjustments becomes more efficient. Consequently, welfare loss of financially constrained home households also decreases. For the welfare effects associated with lower degrees of foreign financial openness the economic reasons are similar. This paper also examines monetary restrictions by further prohibiting financially constrained households from monetary adjustments. It finds that not only these households experience larger welfare loss, but for households who have full access to both bonds and money welfare loss also increases. The experiment shows the importance of money as a store of value for financially constrained households. It also shows the close interactions between different types of households under financial asymmetry.

The rest of the chapter is organized as follows: Section 2.2 gives a brief description of the model. Section 2.3 describes the solution method. Section 2.4 provides simulation results. Section 2.5 concludes.

2.2 Model

In this section I briefly describe the model structure. The description focuses on the home country because of model symmetry. Readers can refer to Appendix B at the end of the dissertation for complete model equations.

In each of the following subsections, I will write down households, governments and firms' optimization problems first, followed by notation definitions.

2.2.1 Households

The household structure in this model is identical to that of Chapter 1, and readers can refer to Section 1.2 for detailed model descriptions.

Households earn wage income by labor supply, get equal dividends from domestic firms, pay taxes, choose consumption and money balances, and decide bond holdings if applicable. Despite their different budget constraints, all households have the same CES utility function that depends on consumption, labor supply and real balances. A typical household i's utility-maximization problem takes the form:

$$\text{Max} \qquad E_t U_t^i = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{i\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon}(\frac{M_s^i}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i\mu}],$$

$$\text{subject to} \qquad M_t^i + d_t F_t^i + e_t d_t^* F_t^{*i} = M_{t-1}^i + F_{t-1}^i + e_t F_{t-1}^{*i} + w_t N_t^i + \Pi_t^z - P_t C_t^i - P_t T_t^i - D_t^{F^*},$$

$$D_t^{F^*} = \frac{\tau}{2} \frac{[e_t (F_t^{*i} - \overline{F_0}^{*i})]^2}{P_t Y_t}.$$

It gives first-order conditions with respect to bond holdings, money balances and labor supply as

$$E_t \left\{ \frac{d_t}{P_t} C_t^{i-\frac{1}{\sigma}} - \beta \frac{1}{P_{t+1}} C_{t+1}^{i-\frac{1}{\sigma}} \right\} = 0,$$

$$E_t \left\{ \frac{e_t d_t^*}{P_t} C_t^{i-\frac{1}{\sigma}} - \beta \frac{e_{t+1}}{P_{t+1}} C_{t+1}^{i-\frac{1}{\sigma}} + \tau \frac{e_t^2}{P_t^2 Y_t} (F_t^{*i} - \overline{F_0}^{*i}) \right\} = 0,$$

$$E_t \left\{ C_t^{i-\frac{1}{\sigma}} - \beta \frac{P_t}{P_{t+1}} C_{t+1}^{i-\frac{1}{\sigma}} - \chi (\frac{M_t^i}{P_t})^{-\varepsilon} \right\} = 0,$$

$$E_t \left\{ \frac{w_t}{P_t} C_t^{i-\frac{1}{\sigma}} - \kappa N_t^{i\mu-1} \right\} = 0,$$

with $0 < \beta < 1, \sigma, \kappa, \varepsilon, \chi > 0$ and $\mu > 1$. On the other hand, a typical household j's utility-maximization problem takes the form:

$$\text{Max} \qquad E_t U_t^j = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{j\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon}(\frac{M_s^j}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j\mu}],$$

$$\text{Subject to} \qquad M_t^j = M_{t-1}^j + w_t N_t^j + \Pi_t^z - P_t C_t^j - P_t T_t^j.$$

It gives first-order conditions with respect to money balances and labor supply as

$$E_t\left\{C_t^{j^{-\frac{1}{\sigma}}} - \beta\frac{P_t}{P_{t+1}}C_{t+1}^{j^{-\frac{1}{\sigma}}} - \chi(\frac{M_t^j}{P_t})^{-\varepsilon}\right\} = 0,$$

$$E_t\left\{\frac{w_t}{P_t}C_t^{j^{-\frac{1}{\sigma}}} - \kappa N_t^{j\mu-1}\right\} = 0.$$

In the above equations, the variable C_t of either household i or j is a consumption index defined by

$$C_t = [\int_0^{\frac{1}{2}} c_t(z)^{\frac{\theta-1}{\theta}} dz + \int_{\frac{1}{2}}^{1} c_t(z^*)^{\frac{\theta-1}{\theta}} dz^*]^{\frac{\theta}{\theta-1}},$$

where $\theta > 1$; $c_t(z)$ and $c_t(z^*)$ stand for consumption of output produced by the home firm z and the foreign firm z^* respectively. The price index P_t and consumption demand $c_t(z)$ and $c_t(z^*)$ can be derived from C_t such that

$$P_t = [\int_0^{\frac{1}{2}} p_t(z)^{1-\theta} dz + \int_{\frac{1}{2}}^{1} p_t(z^*)^{1-\theta} dz^*]^{\frac{1}{1-\theta}},$$

$$c_t(z) = [\frac{p_t(z)}{P_t}]^{-\theta} C_t,$$

$$c_t(z^*) = [\frac{p_t(z^*)}{P_t}]^{-\theta} C_t,$$

with $p_t(z)$ and $p_t(z^*)$ standing for individual commodity prices. Variables F_t and F_t^* are nominal discount bonds denominated in home and foreign currencies respectively. Trading of bonds denominated in the currency of the other country is assumed to involve a small adjustment cost D_t^{F*} to ensure stationarity in the foreign-asset position. For other variables, M_t, N_t, Π_t, T_t and Y_t denote the money balance, labor supply, the profit transfer, the tax payment and total output of the home country. e_t, w_t and d_t denote the exchange rate, the wage rate and the bond price.

In addition to bond trade, this paper also examines the case where households j and j^* are further prohibited from adjusting money balances. When this complete financial restriction is applied, money balances and tax payments of households j and j^* are set at their initial steady-state levels over time. It is assumed that the initial steady-state values of tax payments are equal to 0 for both types of households in both countries. A typical household j's utility-maximization problem becomes:

Max $\qquad E_t U_t^j = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma - 1} C_s^{j\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{\overline{M}_0^j}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j\mu}]$,

subject to $\quad M_0^j = M_0^j + w_t N_t^j + \Pi_t^z - P_t C_t^j$.

And there is only one first-order condition taken with respect to labor supply as

$$E_t \left\{ \frac{w_t}{P_t} C_t^{j-\frac{1}{\sigma}} - \kappa N_t^{j\mu-1} \right\} = 0 .$$

2.2.2 Governments

The home government sets its taxes and money supply according to the budget constraint

$$0 = T_t + \frac{M_t - M_{t-1}}{P_t},$$

where

$$\frac{1}{2} T_t = n T_t^i + (\frac{1}{2} - n) T_t^j,$$

$$\frac{1}{2} M_t = n M_t^i + (\frac{1}{2} - n) M_t^j .$$

In this paper, economic disturbances are assumed to originate only from money markets and technology levels. Hence both home and foreign government spending are set at their initial steady-state values of 0 over time for simplicity.

2.2.3 Firms

Similar to the continuum of households, firms locate on another [0, 1] interval with home firms z and foreign firms z^* belonging to subintervals [0, .5] and (.5, 1] respectively. Firms produce differentiated products, engage in monopolistic competition, maximize the expected present value of profits, and transfer profits back to domestic households evenly. Following Bergin and Tchakarov (2003), it is assumed that firms' pricing decisions are subject to a quadratic adjustment cost. A typical firm z's profit-maximization problem takes the form:

Max $$E_t V_t^z = E_t \sum_{s=t}^{\infty} \beta^{s-t} \Pi_s^z ,$$

subject to $$\Pi_s^z = p_s(z) y_s(z) - w_s N_s^z - D_s^p ,$$

$$y_s(z) = y_s^d(z) = [\frac{p_s(z)}{P_s}]^{-\theta} [nC_s^i + (\frac{1}{2} - n)C_s^j + n^* C_s^{i^*} + (\frac{1}{2} - n^*)C_s^{j^*}],$$

$$y_s(z) = A_s N_s^z ,$$

$$D_s^p = \frac{\upsilon}{2} \frac{[p_s(z) - p_{s-1}(z)]^2}{p_{s-1}(z)} .$$

It gives one first-order condition with respect to $p_t(z)$ as

$$E_t \left\{ (1-\theta) p_t(z)^{-\theta} P_t^{\theta} C_s^w + \theta p_t(z)^{-\theta-1} P_t^{\theta} C_s^w \frac{w_t}{A_t} \right.$$

$$\left. -\upsilon \frac{p_t - p_{t-1}}{p_{t-1}} + \beta \upsilon \frac{p_{t+1} - p_t}{p_t} + \beta \frac{\upsilon}{2} (\frac{p_{t+1} - p_t}{p_t})^2 \right\} = 0 .$$

In the above equations, $p_t(z)$, $y_t(z)$ and N_t^z are the price, output and labor demand of the firm z. A_t is the technology level, and the quadratic adjustment cost of pricing decisions is defined by D_t^p.

2.2.4 Economic Uncertainty

Economic disturbances in this economy are originated from money markets and technology levels. They are governed by the following money growth rules and technology innovation processes:

$$\ln M_t = \ln M_{t-1} + \phi(e_t - \bar{e}_0) + v_t ,$$

$$\ln M_t^* = \ln M_{t-1}^* + \phi(e_t^{-1} - \bar{e}_0^{-1}) + v_t^* ,$$

$$\ln A_t = \rho \ln A_{t-1} + u_t ,$$

$$\ln A_t^* = \rho \ln A_{t-1}^* + u_t^* ,$$

where

$$v_t = \lambda v_{t-1} + s_t$$

,

$$v_t^* = \lambda v_{t-1}^* + s_t^*$$

.

In the above equations, s_t, s_t^*, u_t and u_t^* are independently distributed random variables from normal distribution.

2.2.5 Market-Clearing Conditions

There are seven market-clearing conditions in the model:

$$nF_t^i = -n^* F_t^{i^*} ,$$

$$nF_t^{*i} = -n^* F_t^{*i^*} ,$$

$$\frac{1}{2} M_t = nM_t^i + (\frac{1}{2} - n) M_t^j ,$$

$$\frac{1}{2} M_t^* = n^* M_t^{i^*} + (\frac{1}{2} - n^*) M_t^{j^*} ,$$

$$\frac{1}{2} N_t^z = nN_t^i + (\frac{1}{2} - n) N_t^j ,$$

$$\frac{1}{2} N_t^{z^*} = n^* N_t^{i^*} + (\frac{1}{2} - n^*) N_t^{j^*} ,$$

$$C_t^w = nC_t^i + (\frac{1}{2} - n) C_t^j + n^* C_t^{i^*} + (\frac{1}{2} - n^*) C_t^{j^*} = \frac{1}{2} \frac{p_t(z)}{P_t} y_t(z) + \frac{1}{2} \frac{p_t^*(z^*)}{P_t^*} y_t(z^*) = Y_t^w .$$

The first and second equations are bond market clearing conditions. They state that total values of international assets held by home and foreign households must sum up to zero, for both home- and foreign-currency denominated bonds. The third and fourth equations are money market clearing conditions. They are part of the home and foreign government budget constraints and must hold all the time. The fifth and sixth equations are labor market clearing conditions. Because in the model labor is assumed to be internationally immobile, total labor demand must equal total labor supply within each country. The last equation is the goods market clearing condition, that aggregate demand of household consumption C_t^w must equal aggregate output of the global economy Y_t^w.

2.3 Solution Method

After solving households' and firms' optimization problems, all optimal conditions are approximated by second-order Taylor expansion around a specific initial steady state. It is assumed that in this steady state all prices are equal when evaluated in the same currency. It is also assumed that in this steady state home and foreign bond holdings, tax payments and government spending are equal to 0, and technology levels are equal to 1. Different from standard first-order log linearization, second-order approximation captures welfare effects of economic uncertainty from not only the second moments but also the first moments of economic variables. It permits more accurate welfare evaluation and is suggested by many economists when analyzing welfare.

To better understand the importance of second-order approximation, an example of a closed and static economy is provided below. Let C, P, N, M, M^e, y, p, and w stand for the consumption index, the price index, labor supply, money demand, money endowment, output, the output price, and the wage rate respectively. And suppose households' and firms' optimization problems are

$$\text{Max} \qquad EU = E[\frac{1}{1-a}C^{1-a} + \ln(\frac{M}{P}) - bN],$$

$$\text{subject to} \qquad M = M^e + wN + \Pi - PC,$$

and

$$\text{Max} \qquad E\Pi = E[py - wN],$$

$$\text{subject to} \qquad y = (\frac{p}{P})^{-\theta} C,$$

$$y = N,$$

with first-order conditions of consumption, labor and the price derived as

$$M = PC^a,$$

$$w = bPC^a,$$

$$p = \frac{\theta}{\theta - 1}\frac{E[wC]}{EC}.$$

Assume further that the parameter a equals 1 and the variable M follows log-normal distribution. Then the above first-order conditions imply

$$1=\frac{\theta b}{\theta-1}\exp^{-1}[E_c+\frac{\sigma_c^2}{2}]\exp[2E_c+2\sigma_c^2],$$

with E_c and σ_c standing for the mean and the standard error of consumption.

According to the first-order condition of consumption, the variance of consumption is affected by the variance of money demand. Moreover, the last equation shows that the mean of consumption is decided once the variance of consumption is given. Hence any disturbance in the money market not only directly changes the variance but also indirectly changes the mean of consumption. If these first-order conditions are first-order approximated, the above effects of economy uncertainty through the first moments of economic variables will lose. Consequently, welfare evaluation will bias.

Numerical results of the model are generated by Matlab simulation. For the degrees of financial asymmetry, related literature provides a wide range of estimates for n and n^*. Campbell and Mankiw (1989) test the permanent income hypothesis, and suggest about 50 percent of total income consumed by current-income consumers. Jappelli and Pagano (1989) document substantial deviations in the extent of financial asymmetry from cross-country comparisons. Their estimates range from .1 to .7 for seven developed countries including the United Kingdoms, the United States and Japan. In this paper, welfare is evaluated using several sets of n-n^* combinations to examine how financial asymmetry affects welfare.

Other parameters used by Matlab are as follows: The elasticity of consumption demand θ is set to 11 to reproduce a wage-price markup of 10 percent. It is consistent with findings of Basu and Fernald (1997) and Burnside, Eichenbaum and Rebelo (1995). The elasticity of labor supply $1/(\mu - 1)$ is set to 1 following Betts and Devereux (2000a, 2000b) and Christiano, Eichenbaum and Evans (1997), which gives μ a value of 2. The interest elasticity and consumption elasticity of money demand are $1/\varepsilon$ and $1/\sigma\varepsilon$ respectively. According to Bergin and Feenstra (2001) and Mankiw and Summers (1986), the former is about .25 and the latter is very close to 1. Therefore ε is set to 4 and σ is set to .25. The discount factor β is set to .96 by interpreting a period in the model as one year. Finally, monetary random processes s_t and s_t^* are assumed to follow normal distribution of mean 0 and standard deviation .03 with the degree of persistence λ set to .99; technology random processes u_t and u_t^* are assumed to follow normal distribution of mean 0 and standard deviation .01 with the degree of persistence ρ set to .9. These random processes are assumed to be uncorrelated with each other for simplicity.

2.4 Simulation Result

2.4.1 Welfare Measures

The welfare measure adopted in this paper follows Bergin and Tchakarov (2003). First compute unconditional expectation of utility under economic disturbances for the type of households we want to examine. Then calculate how much consumption in the initial steady state this type of households is willing to give up to negate effects of economic uncertainty. In other words, find out how much consumption deduction in the initial steady state gives this type of households the same expected utility as that under economic disturbances. This consumption cost is the welfare measure.

Because the objective of this paper is to examine how financial asymmetry affects welfare, the above welfare measure is evaluated using several sets of n-n^* combinations, as summarized in the next section. They help us to compare welfare loss across various degrees of financial openness for different types of households.

To derive the welfare measure, apply second-order Taylor expansion and unconditional expectation on the utility function to get

$$EU_t = \overline{U}_0 + \overline{C}_0^{\frac{\sigma-1}{\sigma}} E(\hat{C}_t) - \frac{1}{2\sigma}\overline{C}_0^{\frac{\sigma-1}{\sigma}} V(\hat{C}_t) - \kappa \overline{N}_0^{\mu} E(\hat{N}_t) - \frac{\kappa}{2}(\mu-1)\overline{N}_0^{\mu} V(\hat{N}_t),$$

where

$$\hat{C}_t = \frac{C_t - \overline{C}_0}{\overline{C}_0},$$

$$\hat{N}_t = \frac{N_t - \overline{N}_0}{\overline{N}_0}.$$

Let U^m and U^v denote shifts of initial steady-state consumption that delivers the same expected utility, associated with the mean and variance parts respectively. Then it must hold that

$$U[(1+U^m)\overline{C}_0,\overline{N}_0]=\frac{\sigma}{\sigma-1}[(1+U^m)\overline{C}_0]^{\frac{\sigma-1}{\sigma}}-\frac{\kappa}{\mu}\overline{N}_0^{\mu}=\overline{U}_0+\overline{C}_0^{\frac{\sigma-1}{\sigma}}E(\dot{C}_t)-\kappa\overline{N}_0^{\mu}E(\dot{N}_t),$$

$$U[(1+U^v)\overline{C}_0,\overline{N}_0]=\frac{\sigma}{\sigma-1}[(1+U^v)\overline{C}_0]^{\frac{\sigma-1}{\sigma}}-\frac{\kappa}{\mu}\overline{N}_0^{\mu}$$

$$=\overline{U}_0-\frac{1}{2\sigma}\overline{C}_0^{\frac{\sigma-1}{\sigma}}V(\dot{C}_t)-\frac{\kappa}{2}(\mu-1)\overline{N}_0^{\mu}V(\dot{N}_t).$$

Solving the above equations gives us formulas of welfare measures U^m and U^v. It also gives us a formula of the welfare measure U^a, defined as the sum of U^m and U^v to capture total welfare effects of economic uncertainty. The formulas of U^m and U^v are

$$U^m=\left\{1+\frac{\sigma-1}{\sigma}[E(\dot{C}_t)-\kappa\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}E(\dot{N}_t)]\right\}^{\frac{\sigma}{\sigma-1}}-1,$$

$$U^v=\left\{1-\frac{\sigma-1}{2\sigma}[\frac{1}{\sigma}V(\dot{C}_t)+\kappa(\mu-1)\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}V(\dot{N}_t)]\right\}^{\frac{\sigma}{\sigma-1}}-1.$$

According to the formulas, welfare depends on means and variances of consumption and labor supply rates of changes. Take derivatives on the formulas with respect to the means and variances, we obtain the following equations:

$$\frac{dU^m}{dE(\dot{C}_t)}=\left\{1+\frac{\sigma-1}{\sigma}[E(\dot{C}_t)-\kappa\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}E(\dot{N}_t)]\right\}^{\frac{1}{\sigma-1}}=(1+U^m)^{\frac{1}{\sigma}}, \quad [2.1]$$

$$\frac{dU^m}{dE(\dot{N}_t)}=-\kappa\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}\left\{1+\frac{\sigma-1}{\sigma}[E(\dot{C}_t)-\kappa\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}E(\dot{N}_t)]\right\}^{\frac{1}{\sigma-1}}$$

$$=-\kappa\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}(1+U^m)^{\frac{1}{\sigma}}, \quad [2.2]$$

$$\frac{dU^v}{dV(\dot{C}_t)}=-\frac{1}{2\sigma}\left\{1-\frac{\sigma-1}{2\sigma}[\frac{1}{\sigma}V(\dot{C}_t)+\kappa(\mu-1)\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}V(\dot{N}_t)]\right\}^{\frac{1}{\sigma-1}}$$

$$=-\frac{1}{2\sigma}(1+U^v)^{\frac{1}{\sigma}}, \quad [2.3]$$

$$\frac{dU^v}{dV(\dot{N}_t)}=-\frac{1}{2}\kappa(\mu-1)\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}\left\{1-\frac{\sigma-1}{2\sigma}[\frac{1}{\sigma}V(\dot{C}_t)+\kappa(\mu-1)\overline{C}_0^{-\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}V(\dot{N}_t)]\right\}^{\frac{1}{\sigma-1}}$$

$$= -\frac{1}{2}\kappa(\mu-1)\overline{C}_0^{\frac{\sigma-1}{\sigma}}\overline{N}_0^{\mu}(1+U^v)^{\frac{1}{\sigma}}. \qquad [2.4]$$

Because values of $(1 + U^m)$ and $(1 + U^v)$ are generally positive, Equation 2.1 and Equation 2.2 imply that U^m is positively correlated to the mean of the consumption rate of changes but negatively correlated to the mean of the labor supply rate of changes. Moreover, Equation 2.3 and Equation 2.4 imply that U^v is negatively correlated to the variance of both consumption and labor supply rates of changes.

2.4.2 Welfare Evaluation

Table 2.1 and Table 2.2 summarize welfare results using two sets of n-n^* combinations. In Table 2.1, first it is assumed that there is no financial asymmetry in the home country by setting n to .5. Then it is assumed that only half of home households are able to smooth consumption through bond trade by setting n to .25. Finally, it is assumed that the proportion of home households with unrestricted financial access is reduced to n equaling .05. The degree of foreign financial openness is changed gradually in each case to generate welfare results for home households. Table 2.2 examines the opposite scenario, where n^* is fixed at .5, .25 and .05 while the degree of home financial openness is changed gradually in each case to generate welfare results for home households. Because economic reasons of welfare results for foreign households are similar to those for home households, the welfare analyses focus on home households only.

According to Table 2.1, overall welfare loss U^a of households i increases with lower degrees of foreign financial openness for n equaling either .5, .25 or .05, while overall welfare loss U^a of households j decreases with lower degrees of foreign financial openness for n equaling either .25 or .05. The opposite welfare results for different types of households are due to their different ways of consumption smoothing and the imperfect structures of financial markets. For households i, they have full access to both bond and money markets. When economic disturbances occur, they smooth consumption mainly by adjusting bond holdings through the international bond market. Hence the efficiency of the international bond market is critical for them to hedge against risk. If the foreign country is more financially constrained in that less foreign households are allowed to trade bonds, consumption smoothing of households i will be less efficient. Consequently, the larger consumption and labor variances as well as the higher associated welfare loss of households i result.

For households j, however, the story is different. Given their financial limitation, the efficiency of the international bond market is minor for them to hedge against risk. Households j smooth consumption only by adjusting money balances, and hence any factor that affects the purchasing power of money will directly affect their welfare. Take an expansionary home monetary disturbance for example, this type of economic uncertainty induces home households to save for the future. If the international bond market is more restricted due to lower degrees of foreign financial openness, the importance of home money will increase. Home households will tend to save by holding more money, which causes home money demand to rise. The higher home money demand stabilizes exchange rate depreciation, raises the purchasing power of home money, and in turns makes home money a better financial instrument for value storing. Consequently, the variances of consumption and labor supply as well as the associated welfare loss of households j decrease. In fact, even with other types of economic disturbances, lower degrees of foreign financial openness also reduce welfare loss of households j. The key reason is the more favorable financial environment created for this type of households, by raising the importance of home money in consumption smoothing.

Table 2.2 provides more welfare results that are consistent with the above arguments. In this table, overall welfare loss U^a of both households i and j decreases with lower degrees of home financial openness for n^* equaling either .5, .25 or .05. Recall that in this paper the degree of financial openness is defined as how many households who have full access to the bond market, rather than how severe financial restrictions are homogeneously imposed on every household. Therefore, although the welfare results of households i may seem to be quite different from the general impression that financial restrictions reduce welfare, they have their economic reasons. Note that households i are those who have been endowed with the privilege of unrestricted financial access. Given the degree of foreign financial openness, lowering degrees of home financial openness only reduces the number of this type of households. The financial privilege of the remaining households i is not only unchanged, but also enhanced due to the increasing pricing advantage over the international bond market. Consequently, welfare loss of the remaining households i decreases because of more efficient consumption smoothing. This argument is justified by comparing welfare loss of households i across different degrees of foreign financial openness. As n^* changes from .5 to .25, for example, the same degree of home financial openness corresponds to larger welfare loss of households i. It is because fewer foreign households of unrestricted financial access imply that the financial advantage of households i is relatively more limited. Only more restricted access to the bond market imposed on the home country, namely lower n, can regain the financial advantage for the remaining households i and reduce their welfare loss.

For households j, the economic reasons are more straightforward. Lower degrees of home financial openness reduce their welfare loss by altering home money demand in a way similar to the case of lower degrees of foreign financial openness. Again take an expansionary home monetary disturbance for example. Lower degrees of home financial openness imply that more home households need to smooth consumption by holding money. The higher home money demand stabilizes exchange rate depreciation, raises the purchasing power of home money, and makes home money a better financial instrument for value storing. Consequently, the variances of consumption and labor supply as well as the associated welfare loss of households j decrease.

Lowering the degree of home financial openness seems to be welfare improving for both types of home households, but in fact the home government will not use it as its welfare policy. The extreme case where welfare loss of both types of home households is minimized by turning the home country into a closed economy will not happen in this model. The reason is that lowering the degree of home financial openness creates more financially constrained home households. These households are worse off compared to when they are still financially unconstrained. Moreover, overall welfare loss increases with lower degrees of home financial openness. Hence the home government will choose to maintain the openness of the home country.

2.4.3 Sensitivity Analyses

Table 2.3, Table 2.4 and Table 2.5 provide three sets of sensitivity analyses for the welfare results summarized in Table 2.1. In these tables n is fixed at .5, .25 and .05 with the degree of foreign financial openness being changed gradually. Table 2.3 decreases the coefficient of the adjustment cost in firms' pricing decisions, Table 2.4 increases the elasticity of consumption demand, and Table 2.5 increases the elasticity of labor supply. The opposite scenario of fixing n^* at .5, .25 and .05 while changing the degree of home financial openness are excluded.

The function of the pricing adjustment cost implies that firms tend to set higher prices on average. It is because a higher current price means that any adjustment in the future is a smaller percentage change. When the cost coefficient is reduced, firms' reactions to economic disturbances become more efficient and hence the overall price level decreases. Compared to Table 2.1, the welfare loss of both types of households is lower given the smaller cost coefficient, and the magnitude of welfare adjustments is larger for households j than that for households i. The reason behind the larger welfare adjustment of households j is that, this type of households only use money to smooth consumption and effects crucially depend on its real value. Because the lower price level raises the real value of home money, welfare loss of both types of home households decreases but more obviously for households j.

The welfare results summarized in Table 2.4 and Table 2.5 are more intuitive. Higher elasticity of consumption demand permits higher flexibility in consumption decisions and hence lower volatility of composite consumption levels. Lower elasticity of labor supply causes lower flexibility in working decisions and hence lower volatility of labor supply levels. They both reduce overall welfare loss of households i and households j compared to Table 2.1.

2.4.4 Monetary Restrictions

In previous sections we have discussed welfare effects under different degrees of financial openness and parameter values. All the welfare analyses so far are based on the assumption that all households can hold and adjust money, although not all of them can trade bonds. It is found that when monetary adjustments are allowed between different types of households, the efficiency of using money to smooth consumption is critical to affect welfare of households j. Although welfare results can be changed by many factors, basically the main reason is that these factors alter this efficiency in some way.

An interesting question then rises: What happens if monetary adjustments are shut down between different types of households? Note that money can serve as an alternative of bonds to smooth consumption only because the government allows it to adjust between different types of households. If monetary adjustments are prohibited, then financially constrained households will have no way to smooth consumption upon economic disturbances. Table 2.6 summarizes related welfare results by assuming that money balances of households j and households j^* are fixed at their initial steady-state levels over time. In this economy, financially constrained households can not smooth consumption by either bonds or money. The variances of their consumption and labor supply inevitably increase, and their welfare loss is much higher compared to Table 2.1.

For households i, although they still can smooth consumption by bond trade, they now embrace all the direct effects of monetary uncertainty. When the number of households j increases as the degree of home financial openness decreases, households i face increasing impacts from monetary disturbances. It is interesting to find that the variances of their consumption and labor supply also increase, and their welfare loss is also much higher compared to Table 2.1.

The above findings not only show the importance of money as a store of value for financially constrained households. They also show the close interactions between different types of households under financial asymmetry. Hence welfare policies can not just consider different households separately, but must take into account these welfare interactions in order to obtain optimal welfare results.

2.5 Conclusion

In this paper, a two-country sticky-price general equilibrium model is developed to examine welfare effects of economic uncertainty under financial asymmetry. The financial asymmetry is defined as two groups of households with different levels of financial privileges: One group is allowed to trade bonds and adjust money freely, while the other is prohibited from bond trade even with domestic households. This paper finds that the financial asymmetry alters households' economic behaviors, and changes the general impression that financial restrictions reduce welfare. According to the simulation results, welfare loss of financially unconstrained households increases but welfare loss of financially constrained households decreases with lower degrees of foreign financial openness. Moreover, welfare loss of both types of households decreases with lower degrees of home financial openness. The underlying reason is that the financial restrictions assumed in this model are not homogeneously imposed on every household. And hence when the degree of financial openness is changed, the financial asymmetry creates externalities between households that alter their welfare. The close interactions between different types of households can also be shown by examining monetary restrictions. If financially constrained households are further prohibited from monetary adjustments, not only their welfare loss will increase but welfare loss of financially unconstrained households will also increase.

The welfare effects of financial asymmetry studied in this paper can be used for policy analyses in future research. Because different types of households have different ways of consumption smoothing, they react differently upon economic disturbances and also interact closely with each other. These facts imply sophisticated welfare tradeoffs between different types of home households as well as households in different countries. They raise new considerations when we study domestic welfare policies and international macroeconomic coordination.

Chapter 3

Financial Asymmetry and Different Exchange-Rate Regimes

3.1 Introduction

Exchange rate variability is an important feature of the real world, and also a major field of economics research. One reason for this issue to draw such high attention is that, exchange rate variability is believed closely relating to reduced gains from trade and hence welfare. Mundell (1968) suggests that an optimal exchange rate policy should be decided by cost-benefit analyses: On the one hand flexible exchange rates permit efficient economic adjustments, but on the other hand they may also lower welfare because of their associated uncertainty. Based on Mundell's theory, currency areas or free-trade areas and various exchange rate regulations have been designed trying to increase welfare by reducing exchange rate risk. One famous example is the European Union, which integrates 25 independent countries to enhance political, social as well as economic cooperation.

Mundell's theory provides a theoretical guideline for exchange rate policies, and also serves as a theoretical support for exchange rate controls. Nonetheless, practically speaking precise cost-benefit analyses are difficult. This fact causes disputes on whether and how exchange rate regulations should perform to increase welfare. It also induces reconsiderations on whether currency areas are necessary to exist. In particular, many economists suggest that welfare loss associated with economic variability is not significant. And hence governments should adopt flexible exchange rates to permit efficient economic adjustments. For the most classical example, Lucas (1987) evaluates welfare as changes of steady-state consumption required to achieve the same expected utility. He shows that economic variability implied by business cycles tends to have small welfare effects.

More recently, Bergin and Tchakarov (2003) apply second-order approximation on a two-country sticky-price general equilibrium model to examine welfare under monetary and technology shocks. As pointed out in Section 2.1, they find that welfare effects of economic variability are likely to be small for a wide range of cases. But when households exhibit habit persistence or when there is an international market for bonds in the currency of only one of the two countries, welfare loss of economic variability increases. The findings of Bergin and Tchakarov (2003) imply that different types of financial asymmetry may play important roles in directing welfare results, and hence in affecting optimal exchange rate policies.

Lahiri, Singh and Vegh provide two related studies that analyze the issue of optimal exchange rate policies under financial asymmetry. Lahiri, Singh and Vegh (2004a) find that if only some agents can participate in the financial market and there is no price rigidity, flexible exchange rates are optimal under monetary shocks and fixed exchange rates are optimal under real shocks. Because this result is opposite to the standard Mundellian prescription, the paper suggests that optimal exchange rate policies may depend on types of shocks as well as types of frictions. Moreover, Lahiri, Singh and Vegh (2004b) find that in a small open economy without price rigidity, policies targeting monetary aggregates welfare-dominate policies targeting the exchange rate. The paper thus suggests that fixed exchange rates are never optimal, and tends to support monetary policies implementing flexible exchange rates.

In contrast to the above two studies, this chapter examines optimal exchange rate policies under financial asymmetry with price rigidity. The model is built on the basic framework of new open economy macroeconomics introduced by Obstfeld and Rogoff. Similar to Chapter 1 and Chapter 2, the paper models financial asymmetry by dividing home and foreign households into two groups: One group has full access to both bond and money markets, while the other is prohibited from bond trade and monetary adjustments. Changing the lengths for different types of households along the continuum of interval then allows us to examine welfare under different degrees of home and foreign financial openness.

The welfare measure adopted in this paper follows Devereux and Engel (2003) and Obstfeld and Rogoff (1995, 1996), defined as expected utility excluding the term associated with real balances. It is assumed that in the flexible exchange-rate regime, both home and foreign governments fix their money supply at initial steady-state levels, while allowing the exchange rate to move freely. On the other hand, in the fixed exchange-rate regime, it is assumed that the home and foreign governments coordinate their monetary policies to maintain the exchange rate level. Given country-specific random processes of technology levels and one-period-in-advance price rigidity, this paper finds that fixed exchange rates are in many cases preferable to flexible exchange rates by all types of households under financial asymmetry. In the fixed exchange-rate regime, all the changes of money supply go to financially unconstrained households. Hence for these households if their number is relatively small compared to the magnitude of money supply changes, then the wealth effects associated with the monetary policies that aim to maintain the exchange rate level can dominate the welfare cost of fixed exchange rates. For financially constrained households, they can not enjoy the benefit brought by expenditure switching effects due to their financial restriction, but need to bear the associated cost of higher economic variability. Therefore by reducing the expenditure switching effects, the fixed exchange rate regime can increase their welfare.

The rest of the chapter is organized as follows: Section 3.2 gives a brief description of the model. Section 3.3 describes the solution method. Section 3.4 provides welfare results. Section 3.5 concludes.

3.2 Model

In this section I briefly describe the model structure. The description focuses on the home country because of model symmetry. Readers can refer to Appendix C at the end of the dissertation for complete model equations.

In each of the following subsections, I will write down households, governments and firms' optimization problems first, followed by notation definitions.

3.2.1 Households

The household sector in this model is similar to those of Chapter 1 and Chapter 2, and readers can refer to Section 1.2 or Section 2.2 for detailed model descriptions. The only difference is that in addition to bond trade, households j and j^* are also prohibited from adjusting money balances. Their money balances and tax payments are set at initial steady-state levels over time. It is assumed that the initial steady-state values of tax payments are equal to 0 for both types of households in both countries. The reason of controlling money balances of households j and j^* is to clearly define them as liquidity constrained households. If this monetary restriction does not hold, there will be monetary adjustments between different types of households over time. The resulting effects of wealth redistribution are likely to be of second-order importance for the purpose of this paper, and ruling them out simplifies equilibrium derivation and welfare analyses.

Households earn wage income by labor supply, get equal dividends from domestic firms, pay taxes, choose consumption and money balances, and decide bond holdings if applicable. For those households who have full financial access, there are complete bond markets and hence they trade state-contingent nominal bonds. It is assumed that these bonds are denominated in the home currency. Despite their different budget constraints, all households have the same CES utility function that depends on consumption, labor supply and real balances. A typical household i's utility-maximization problem takes the form:

$$\text{Max} \qquad E_t U_t^i = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{i\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^i}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i\mu}],$$

$$\text{subject to} \qquad M_t^i + \sum_{x_{t+1} \in X} d(x_{t+1}, x_t) F^i(x_{t+1}) = M_{t-1}^i + F^i(x_t) + w_t N_t^i + \Pi_{ht}^z - P_t C_t^i - P_t T_t^i . \tag{3.1}$$

It gives first-order conditions with respect to bond holdings, money balances and labor supply as

$$d(x_{t+1}, x_t) \frac{1}{P_t} C_t^{i^{-\frac{1}{\sigma}}} = q(x_{t+1}, x_t) \beta \frac{1}{P_{t+1}} C_{t+1}^{i^{-\frac{1}{\sigma}}}, \tag{3.2}$$

$$\frac{M_t^i}{P_t} = \chi^{\frac{1}{\varepsilon}} (1 - E_t D_{t+1})^{-\frac{1}{\varepsilon}} C_t^{i\frac{1}{\varepsilon\sigma}} \qquad D_{t+1} = \beta \frac{P_t C_t^{i\frac{1}{\sigma}}}{P_{t+1} C_{t+1}^{i\frac{1}{\sigma}}}, \tag{3.3}$$

$$N_t^i = (\frac{1}{\kappa} \frac{w_t}{P_t} C_t^{i^{-\frac{1}{\sigma}}})^{\frac{1}{\mu-1}}, \tag{3.4}$$

with $0 < \beta < 1, \sigma, \kappa, \varepsilon, \chi > 0, \mu > 1$, and $E_t D_{t+1}$ the inverse of the gross nominal interest rate. On the other hand, a typical household j's utility-maximization problem takes the form:

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

$$\text{subject to} \qquad M_0^j = M_0^j + w_t N_t^j + \Pi_{ht}^z - P_t C_t^j. \tag{3.5}$$

It gives first-order conditions with respect to labor supply as

$$N_t^j = \left(\frac{1}{\kappa} \frac{w_t}{P_t} C_t^{j\,-\frac{1}{\sigma}} \right)^{\frac{1}{\mu-1}}. \tag{3.6}$$

Recall that households j are prohibited from adjusting money balances, and hence their money balances and tax payments are set at initial steady-state levels over time with the latter equal to 0.

In the above equations, the variable C_t of either household i or j is a consumption index defined by a geometric average of home and foreign consumption

$$C_t = \frac{C_{ht}^m C_{ft}^{1-m}}{m^m (1-m)^{1-m}}, \tag{3.7}$$

where m stands for the size of the home country. Note that the home and foreign countries have the same sizes that sum up to 1, and hence m is set to .5 in this paper. Variables C_{ht} and C_{ft} are indexes over consumption of output produced in the home and foreign countries respectively, defined by

$$C_{ht} = \left[m^{-\frac{1}{\lambda}} \int_0^m c_{ht}(z)^{\frac{\lambda-1}{\lambda}} dz \right]^{\frac{\lambda}{\lambda-1}}, \tag{3.8}$$

$$C_{ft} = \left[(1-m)^{-\frac{1}{\lambda}} \int_m^1 c_{ft}(z^*)^{\frac{\lambda-1}{\lambda}} dz^* \right]^{\frac{\lambda}{\lambda-1}}, \tag{3.9}$$

with $\lambda > 1$. According to these consumption indexes, the elasticity of consumption substitution between goods produced within a country is λ, while the elasticity of consumption substitution between the home and foreign goods indexes is 1.

The price index P_t in the above equations is defined by

$$P_t = P_{ht}^m P_{ft}^{1-m}, \tag{3.10}$$

where m again stands for the size of the home country. Variables P_{ht} and P_{ft} are price indexes of home and foreign output respectively, defined by

$$P_{ht} = [\frac{1}{m}\int_0^m p_{ht}(z)^{1-\lambda}dz]^{\frac{1}{1-\lambda}}, \tag{3.11}$$

$$P_{ft} = [\frac{1}{1-m}\int_m^1 p_{ft}(z^*)^{1-\lambda}dz^*]^{\frac{1}{1-\lambda}}. \tag{3.12}$$

The consumption and price indexes characterize the following consumption decisions, which are useful when we derive other equilibrium conditions:

$$c_{ht}(z) = \frac{1}{m}[\frac{p_{ht}(z)}{P_{ht}}]^{-\lambda}C_{ht}, \tag{3.13}$$

$$c_{ft}(z^*) = \frac{1}{1-m}[\frac{p_{ft}(z^*)}{P_{ft}}]^{-\lambda}C_{ft}, \tag{3.14}$$

$$P_{ht}C_{ht} = \int_0^m p_{ht}(z)c_{ht}(z)dz = mP_tC_t, \tag{3.15}$$

$$P_{ft}C_{ft} = \int_m^1 p_{ft}(z^*)c_{ft}(z^*)dz^* = (1-m)P_tC_t. \tag{3.16}$$

In this paper there are complete bond markets, and hence households who have full financial access trade home-currency denominated state-contingent nominal bonds $F(x)$, with any state realization x belonging to the state space X. The variable $d(x_{t+1}, x_t)$ is the price of the bond in the next period when x_{t+1} is realized, given the current state x_t. And the variable $q(x_{t+1}, x_t)$ is the probability of x_{t+1} to be realized in the next period, conditional on the current state x_t.

Chari, Kehoe and McGrattan (1997) show that complete bond markets imply the condition of complete risk sharing

$$\frac{e_tP_t^*}{P_t} = \Gamma_0(\frac{C_t^{i^*}}{C_t^i})^{-\frac{1}{\sigma}}, \tag{3.17}$$

where the variable e_t is the price of the foreign currency in terms of the home currency, and Γ_0 is a constant depending on initial conditions. Assume that in the initial steady state the home and foreign countries are symmetric in every aspect, such that consumption is equal, purchasing power parity holds, and Γ_0 is equal to 1. Then under producer-currency pricing as purchasing power parity holds in all following periods after the initial steady state, the condition of complete risk sharing further implies

$$C_t^i = C_t^{i^*}.$$

Note that if firms are subject to producer-currency pricing, then consumption risk is completely shared due to the law of one price among financially unconstrained households, even if bond markets are not complete. But if firms are subject to local-currency pricing, then the existence of complete bond markets becomes necessary for complete risk sharing to hold among financially unconstrained households. Hence the assumption of complete bond markets allows us to have perfect capital mobility in both cases, while simplifying equilibrium derivation and welfare analyses by ruling out dynamic effects of wealth redistribution, which are likely to be of second-order importance.

For other variables, M_t, N_t, Π_{ht} and T_t denote the money balance, labor supply, the profit transfer and the tax payment of the home country. w_t denotes the wage rate.

3.2.2 Governments

The home government sets its taxes and money supply according to the budget constraint

$$0 = T_t + \frac{M_t - M_{t-1}}{P_t},$$

where

$$\frac{1}{2}T_t = nT_t^i,$$

$$\frac{1}{2}M_t = nM_t^i + (\frac{1}{2} - n)M_0^j,$$

In this paper, economic disturbances are assumed to originate from technology levels only. Hence both home and foreign government spending are set at their initial steady-state values of 0 over time for simplicity.

3.2.3 Firms

Similar to the continuum of households, firms locate on another [0, 1] interval with home firms z and foreign firms z^* belonging to subintervals [0, .5] and (.5, 1] respectively. Firms produce differentiated products, engage in monopolistic competition, maximize the expected present value of profits, and transfer profits back to domestic households evenly. It is assumed that firms' pricing decisions are subject to one-period-in-advance rigidity, and hence prices are set before information of random technology levels is released.

A typical firm z faces consumption demand on its product from two types of households and two countries. Assume producer-currency pricing and let $y_{ht}^{d}(z)$ denote total consumption demand, using Equation 3.13, Equation 3.15 and their foreign equivalents it can be derived that

$$y_{ht}^{d}(z) = nc_{ht}^{i}(z) + (\frac{1}{2}-n)c_{ht}^{j}(z) + n^{*}c_{ht}^{i^{*}}(z) + (\frac{1}{2}-n^{*})c_{ht}^{j^{*}}(z)$$

$$= \frac{1}{m}[\frac{p_{ht}(z)}{P_{ht}}]^{-\lambda}[nC_{ht}^{i} + (\frac{1}{2}-n)C_{ht}^{j} + n^{*}C_{ht}^{i^{*}} + (\frac{1}{2}-n^{*})C_{ht}^{j^{*}}]$$

$$= \frac{P_t}{P_{ht}}[\frac{p_{ht}(z)}{P_{ht}}]^{-\lambda}[nC_t^{i} + (\frac{1}{2}-n)C_t^{j} + n^{*}C_t^{i^{*}} + (\frac{1}{2}-n^{*})C_t^{j^{*}}].$$

Let $p_{ht}(z)$, $y_{ht}(z)$ and N_{ht}^{z} represent the price, output and labor demand levels of the firm, and let D_t and A_t represent the discount factor and random technology level in the home country. Then the firm's profit-maximization problem takes the form:

Max $\quad E_{t-1}V_{ht}^{z} = E_{t-1}D_t\Pi_{ht}^{z},$

subject to $\quad \Pi_{ht}^{z} = p_{ht}(z)y_{ht}(z) - w_t N_{ht}^{z},$

$$y_{ht}(z) = y_{ht}^{d}(z) = \frac{P_t}{P_{ht}}[\frac{p_{ht}(z)}{P_{ht}}]^{-\lambda}[nC_t^{i} + (\frac{1}{2}-n)C_t^{j} + n^{*}C_t^{i^{*}} + (\frac{1}{2}-n^{*})C_t^{j^{*}}],$$

$$y_{ht}(z) = A_t N_{ht}^{z},$$

$$D_t = \beta P_{t-1}C_{t-1}^{i\,\frac{1}{\sigma}} P_t C_t^{i\,-\frac{1}{\sigma}},$$

which gives one first-order condition with respect to $p_{ht}(z)$ as

$$p_{ht}(z) = \frac{\lambda}{\lambda-1}\frac{E_{t-1}\left\{\frac{w_t}{A_t}[n+(\frac{1}{2}-n)\frac{C_t^{j}}{C_t^{i}}+n^{*}\frac{C_t^{i^{*}}}{C_t^{i}}+(\frac{1}{2}-n^{*})\frac{C_t^{j^{*}}}{C_t^{i}}]C_t^{i\,1-\frac{1}{\sigma}}\right\}}{E_{t-1}\left\{[n+(\frac{1}{2}-n)\frac{C_t^{j}}{C_t^{i}}+n^{*}\frac{C_t^{i^{*}}}{C_t^{i}}+(\frac{1}{2}-n^{*})\frac{C_t^{j^{*}}}{C_t^{i}}]C_t^{i\,1-\frac{1}{\sigma}}\right\}}. \quad [3.18]$$

The foreign price of the firm's output is affected by the exchange rate. Under producer-currency pricing the law of one price always holds and hence we have

$$p_{ht}^{*}(z)=\frac{p_{ht}(z)}{e_t}. \qquad [3.19]$$

3.2.4 Market-Clearing Conditions

There are six market-clearing conditions in the model, if we first exclude bond markets from the discussion:

$$\frac{1}{2}M_t-(\frac{1}{2}-n)M_0^j=nM_t^i, \qquad [3.20]$$

$$\frac{1}{2}M_t^*-(\frac{1}{2}-n^*)M_0^{j^*}=n^*M_t^{i^*}, \qquad [3.21]$$

$$\frac{1}{2}N_{ht}^z=nN_t^i+(\frac{1}{2}-n)N_t^j, \qquad [3.22]$$

$$\frac{1}{2}N_{ft}^{z^*}=n^*N_t^{i^*}+(\frac{1}{2}-n^*)N_t^{j^*}, \qquad [3.23]$$

$$C_{ht}^w=nC_{ht}^i+(\frac{1}{2}-n)C_{ht}^j+n^*C_{ht}^{i^*}+(\frac{1}{2}-n^*)C_{ht}^{j^*}=\frac{1}{2}\frac{p_{ht}(z)}{P_{ht}}y_{ht}(z)=Y_{ht}^w, \qquad [3.24]$$

$$C_{ft}^w=nC_{ft}^i+(\frac{1}{2}-n)C_{ft}^j+n^*C_{ft}^{i^*}+(\frac{1}{2}-n^*)C_{ft}^{j^*}=\frac{1}{2}\frac{p_{ft}^*(z^*)}{P_t^*}y_{ft}(z^*)=Y_{ft}^w. \qquad [3.25]$$

The first and second equations are money market clearing conditions. They are part of the home and foreign government budget constraints and must hold all the time. Because households j are prohibited from monetary adjustments, total money demand of households i must equal total money supply of the home country minus total initial steady-state money balances of households j. Similarly, total money demand of households i^* must equal total money supply of the foreign country minus total initial steady-state money balances of households j^*. The third and forth equations are labor market clearing conditions. Because in the model labor is assumed to be internationally immobile, total labor demand must equal total labor supply within each country. The fifth and last equations are goods market clearing condition. Aggregate demand of household consumption C_{ht}^w and C_{ft}^w must equal aggregate output of the global economy Y_{ht}^w and Y_{ft}^w for home and foreign goods respectively.

For bond market clearing conditions, recall that there are complete bond markets and hence the number of equations depend on the size of the state space. Assume a finite number of state realizations, and then the set of bond market clearing conditions can be characterized as

$$nF^{i}(x_{t+1}) = -n^{*}F^{i^{*}}(x_{t+1}) \qquad \forall x_{t+1} \in X. \qquad [3.26]$$

It states that total values of state-contingent nominal bonds held by home and foreign households must sum up to zero when evaluated in the home currency.

3.2.5 Model Equilibrium

To establish the system of equilibrium conditions, we first need to combine Equation 3.5, Equation 3.15 and Equation 3.24. Equation 3.15 and Equation 3.24 imply that

$$y_{ht}(z) = 2\frac{P_{ht}}{p_{ht}(z)}[nC^{i}_{ht} + (\frac{1}{2}-n)C^{j}_{ht} + n^{*}C^{i^{*}}_{ht} + (\frac{1}{2}-n^{*})C^{j^{*}}_{ht}]$$

$$= \frac{P_{t}}{p_{ht}(z)}[nC^{i}_{t} + (\frac{1}{2}-n)C^{j}_{t} + n^{*}C^{i^{*}}_{t} + (\frac{1}{2}-n^{*})C^{j^{*}}_{t}],$$

which together with Equation 3.5 gives us

$$P_{t}C^{j}_{t} - w_{t}N^{j}_{t} = \Pi^{z}_{ht} = [p_{ht}(z) - \frac{w_{t}}{A_{t}}]y_{ht}(z)$$

$$= P_{t}[1 - \frac{1}{A_{t}}\frac{w_{t}}{p_{ht}(z)}][nC^{i}_{t} + (\frac{1}{2}-n)C^{j}_{t} + n^{*}C^{i^{*}}_{t} + (\frac{1}{2}-n^{*})C^{j^{*}}_{t}]. \qquad [3.27]$$

We then need to combine Equation 3.22, Equation 3.15 and Equation 3.24, which give us

$$nN^{i}_{t} + (\frac{1}{2}-n)N^{j}_{t} = \frac{1}{2}N^{z}_{ht} = \frac{1}{2}\frac{y_{ht}(z)}{A_{t}}$$

$$= \frac{1}{2A_{t}}\frac{P_{t}}{p_{ht}(z)}[nC^{i}_{t} + (\frac{1}{2}-n)C^{j}_{t} + n^{*}C^{i^{*}}_{t} + (\frac{1}{2}-n^{*})C^{j^{*}}_{t}]. \qquad [3.28]$$

Also note that because all firms are identical within each country, Equation 3.11 and its foreign equivalent imply that

$$p_{ht}(z) = P_{ht},$$

$$p^{*}_{ht}(z) = P^{*}_{ht}.$$

Given exogenous values of $M_t^i, M_0^j, M_t^{i^*}$ and $M_0^{j^*}$, and properly defined random processes governing A_t and A_t^*, we now have 17 functions depending on the state realization: $C_t^i, C_t^j, C_t^{i^*}, C_t^{j^*}, N_t^i, N_t^j, N_t^{i^*}, N_t^{j^*}, P_{ht}, P_{ht}^*, P_{ft}, P_{ft}^*, P_t, P_t^*, w_t, w_t^*$ and e_t, determined by the 17 equilibrium conditions: Equations 2.3, 2.4, 2.6, 2.10, 2.18, 2.19, 2.27, 2.28 and their foreign equivalents, and Equation 2.17.

3.3 Solution Method

Among the equilibrium conditions summarized in the previous section, the only dynamic component is the inverse of the gross nominal interest rate $E_t D_{t+1}$. Devereux and Engel (2003) show that, as long as log of nominal money supply in each country follows a random walk (with drift), this term is constant. Hence the solution of the model may be obtained by solving the equations for each period in isolation. The same assumption is made in the current analysis. In other words, for any economic agent the optimization problem is identical in every period although the model itself is infinite-horizon. We only need to take one representative period and calculate the solution of the system as if in a static model.

Numerical results of the model are computed by Matlab command fsolve, which solves nonlinear equations using a least-squares method given a particular starting point. For the system of equilibrium conditions in this paper, I define the starting point as a specific initial steady state where the home and foreign countries are symmetric in every aspect. It is assumed that in this steady state all prices are equal when evaluated in the same currency, and all types of households have the same money balances when evaluated in the same currency. It is also assumed that in this steady state home and foreign bond holdings, tax payments and government spending are equal to 0, and technology levels are equal to 1.

For the random processes governing A_t and A_t^*, assume that these technology levels are independently and identically distributed random variables following Bernoulli distribution. In each period, the home technology level takes one of the two values: H for $(1 + a)A_0$ and L for $(1 - a)A_0$ with equal probability, where the constant A_0 is its initial steady-state value and the coefficient a is between 0 and 1. The probability definition for the foreign technology level is analogous, and these random processes imply that there are four states in this economy. The state space X hence consists of four elements each with probability .25: *HH, HL, LH* and *LL*, where the first and second letters of each element denote values of the home and foreign technology levels respectively.

For the values of $M_t^i, M_0^j, M_t^{i^*}$ and $M_0^{j^*}$, recall that households j and j^* are prohibited from adjusting money balances, and hence their money balances are always set at initial steady-state levels. On the other hand, money balances of households i and i^* are directly determined by governments' decisions on money supply. When considering the flexible exchange-rate regime, I assume both home and foreign governments fix their money supply at initial steady-state levels, while allowing the exchange rate to move freely. This implies that money balances of households i and i^* are fixed at their initial steady-state levels as well. When considering the fixed exchange-rate regime, I assume the home and foreign governments coordinate their monetary policies to maintain the exchange rate level. Specifically they adjust their money supply with equal absolute amounts to stabilize the exchange rate, and then money balances of households i and i^* are determined accordingly. This setting is natural given the symmetry of the two countries, and it allows us to understand the resulting welfare effects more clearly by simplifying underlying driving forces.

Other parameters used by Matlab are as follows: The elasticity of consumption substitution λ is set to 11 to reproduce a wage-price markup of 10 percent. It is consistent with findings of Basu and Fernald (1997) and Burnside, Eichenbaum and Rebelo (1995). The elasticity of labor supply $1/(\mu - 1)$ is set to 1 following Betts and Devereux (2000a, 2000b) and Christiano, Eichenbaum and Evans (1997), which gives μ a value of 2. The interest elasticity and consumption elasticity of money demand are $1/\varepsilon$ and $1/\sigma\varepsilon$ respectively. According to Bergin and Feenstra (2001) and Mankiw and Summers (1986), the former is about .25 and the latter is very close to 1. Therefore ε is set to 4 and σ is set to .25. Finally, the inverse of the gross nominal interest rate E_tD_{t+1} is set to .96, and the coefficient of technology random processes a is set to .05.

The purpose of this paper is to examine welfare effects of different exchange-rate regimes under financial asymmetry. Hence for each exchange-rate regime, numerical results of consumption and labor supply are used to calculate expected utility under a full set of n-n^* combinations. Because utility associated with real balances is likely to be of minor importance, this term is excluded from calculation following Devereux and Engel (2003) and Obstfeld and Rogoff (1995, 1998). The formula of expected utility can be represented as

$$E_{t-1}U_t = \frac{\sigma}{\sigma-1}E_{t-1}C_t^{\frac{\sigma-1}{\sigma}} - \frac{\kappa}{\mu}E_{t-1}N_t^{\mu}.$$

3.4 Welfare Result

Table 3.1 to Table 3.4 summarize welfare results using a full set of n-n^* combinations for households i, j, i^* and j^* respectively. In each table, the first number from each pair of welfare data is expected utility for the particular type of households under the flexible exchange-rate regime, while the second number is expected utility for the particular type of households under the fixed exchange-rate regime, given the particular n-n^* combination. Different n and n^* represent different degrees of financial openness for the home and foreign countries respectively. When (n, n^*) equals (.5, .5), there is no household j and j^* in the economy and hence the financial market is perfect. When n or n^* gets smaller, the number of households i or i^* decreases and the economy is of a lower degree of financial openness.

Upon country-specific real shocks, relative price levels between different countries need to adjust in order to bring real exchange rates to their equilibriums. As a leading study in the case for flexible nominal exchange rates, Friedman (1953) points out that whether flexible nominal exchange rates are preferred at the presence of country-specific real shocks depends on the efficiency of nominal price adjustments. If nominal prices are as flexible as nominal exchange rates, relative price levels between different countries can react to country-specific real shocks quickly through nominal price adjustments. Consequently the importance of nominal exchange-rate flexibility is reduced. Nonetheless, nominal prices are usually sticky in the real world due to various types of administrative actions of firms and governments. It usually takes a period of time with the cost of employment distortions before nominal prices can adjust properly. Hence flexible nominal exchange rates are in many cases preferable to fixed nominal exchange rates to permit instant adjustments of relative price levels.

The argument of Friedman (1953) is consistent with the findings of Devereux and Engel (2003). Devereux and Engel (2003) examine optimal monetary policies with one-period-in-advance price rigidity, for two different types of pricing assumptions. They show that when firms are subject to producer-currency pricing, which is the one discussed by Friedman (1953), the optimal monetary policy is one employing flexible nominal exchange rates. With nominal exchange-rate flexibility, the optimal monetary policy even can replicate the equilibrium of the economy as if nominal prices are fully flexible. On the other hand, when firms are subject to local-currency pricing, there is no advantage to employ flexible nominal exchange rates because all nominal prices are set in consumers' currencies. Nominal exchange-rate flexibility only brings the cost of welfare loss from exchange rate risk, and hence the optimal monetary policy is one employing fixed nominal exchange rates.

This paper introduces another situation where fixed nominal exchange rates are preferable to flexible nominal exchange rates. Different from the argument of Friedman (1953), however, it suggests that the optimal choice of exchange-rate regimes depends on not only the efficiency of nominal price adjustments, but also on financial structures of the economy. Go back to the welfare results summarized in Table 3.1 to Table 3.4. Note that under financial asymmetry, fixed nominal exchange rates are in many cases preferable to flexible nominal exchange rates by all types of households. Also note that the welfare results are generally non-monotonic, which may be attributed to the absence of real balances from the calculation of expected utility.

When (n, n^*) equals (.5, .5), the financial market is perfect. We get an ordinary economy with homogeneous households having full access to both bond and money markets. Given the country-specific technology random processes and one-period-in-advance price rigidity, the argument of Friedman (1953) applies: We need flexible nominal exchange rates as substitutes for sticky nominal prices to permit instant adjustments of relative price levels. The welfare results show consistency that the values of expected utility of households i and i^* are higher in the flexible exchange-rate regime than in the fixed exchange-rate regime when (n, n^*) equals (.5, .5).

When (n, n^*) deviates from (.5, .5), on the other hand, financially unconstrained households can be better off with fixed nominal exchange rates than with flexible nominal exchange rates. In the flexible exchange-rate regime, both home and foreign governments fix their money supply at initial steady-state levels, while allowing the nominal exchange rate to move freely. This implies that money balances of households i and i^* are fixed at their initial steady-state levels as well. But in the fixed exchange-rate regime, the home and foreign governments coordinate their monetary policies in order to maintain the exchange rate level. Because households j and j^* are prohibited from adjusting money balances, all the changes of money supply go to households i and i^*. If the number of households i or i^* is relatively small compared to the magnitude of money supply changes, then an increase of home or foreign money supply for example will cause a large amount of monetary increment for each household i or i^*. The associated wealth effects can dominate the welfare cost of fixed nominal exchange rates, bringing even higher values of expected utility for households i or i^* than those with flexible nominal exchange rates.

When (n, n^*) deviates from (.5, .5), there are also some households in the economy not able to trade bonds and adjust money. These financially constrained households are actually current-income consumers, whose utility-maximization problems are static. Compared to financially unconstrained households, those who have full access to both bond and money markets, financially constrained households are more vulnerable to economic variability because they can not smooth consumption by either bond trade or monetary adjustments. Given the country-specific technology random processes and one-period-in-advance price rigidity, financially constrained households can be better off with fixed nominal exchange rates than with flexible nominal exchange rates. This is because in the flexible exchange-rate regime, expenditure switching effects upon economic disturbances cause further output variability that requires subsequent consumption smoothing. For financially constrained households, they can not enjoy the benefit brought by expenditure switching effects due to their financial restriction. And they need to bear the associated cost of higher economic variability. Therefore by reducing expenditure switching effects, the fixed exchange rate regime can increase welfare for financially constrained households.

According to the welfare results, cases that the fixed exchange-rate regime is preferable to the flexible exchange-rate regime for households j and j^* mostly occur when n or n^* is reduced to some lower level. Recall that in this economy households i and i^* are those who bear all the changes of money supply to maintain the exchange rate level. When the number of households i or i^* is small, each household i or i^* shares a large amount of monetary adjustments, but the overall impact of wealth redistribution is less severe compared to an economy with a large number of households i or i^*. Hence with the smaller effects of wealth redistribution from changes of money supply, the values of expected utility of households j and j^* are higher in the fixed exchange-rate regime than in the flexible exchange-rate regime.

3.5 Conclusion

In this paper, a two-country sticky-price general equilibrium model is developed to examine welfare effects of different exchange-rate regimes under financial asymmetry. The financial asymmetry is defined as two groups of households with different degrees of financial access: One group is allowed to trade bonds and adjust money, while the other is prohibited from bond trade and monetary adjustments. Given the country-specific technology random processes and one-period-in-advance price rigidity, this paper finds that fixed nominal exchange rates are in many cases preferable to flexible nominal exchange rates by all types of households under financial asymmetry. For financially unconstrained households, the wealth effects associated with the monetary policies that aim to maintain the exchange rate level can dominate the welfare cost of fixed nominal exchange rates. For financially constrained households, they can not enjoy the benefit brought by expenditure switching effects due to their financial restriction, but need to bear the associated cost of higher economic variability. Therefore by reducing expenditure switching effects, the fixed exchange rate regime can increase their welfare.

The welfare results found in this paper imply that different types of monetary rules may be affecting the optimal choice of exchange-rate regimes. In this paper, I assume the home and foreign governments adjust their money supply with equal absolute amounts to maintain the exchange rate level. This setting is natural given the symmetry of the two countries, and it allows us to understand the resulting welfare effects more clearly by simplifying underlying driving forces. But in future studies, other types of monetary rules still can be used to evaluate different exchange-rate regimes, based on the particular interaction of monetary policies between different countries of the real world.

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Appendix A

Appendices of Chapter 1

A.1 Optimization Problem and First-Order Condition

A.1.1 Households i

Optimization Problem:

$$\text{Max} \qquad U_t^i = \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{i\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^i}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i\mu}]$$

$$\text{Subject to} \quad M_t^i + d_t F_t^i = M_{t-1}^i + F_{t-1}^i + w_t N_t^i + \Pi_t - P_t C_t^i - P_t T_t^i$$

First-Order Condition on Bond Holdings:

$$C_t^i = (\beta \frac{P_t}{d_t P_{t+1}})^{-\sigma} C_{t+1}^i$$

First-Order Condition on Money Balances:

$$\frac{M_t^i}{P_t} = (\frac{\chi}{1-d_t} C_t^{i\frac{1}{\sigma}})^{\frac{1}{\varepsilon}}$$

First-order Condition on Labor Supply:

$$N_t^i = (\frac{1}{\kappa} \frac{w_t}{P_t} C_t^{i\,-\frac{1}{\sigma}})^{\frac{1}{\mu-1}}$$

Equation of Profit Sharing:

$$\frac{1}{2} \Pi_t = u \Pi_t^x + (\frac{1}{2} - u) \Pi_t^y$$

A.1.2 Households i^*

Optimization Problem:

$$\text{Max} \qquad U_t^{i^*} = \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{i^*\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^{i^*}}{P_s^*})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i^*\mu}]$$

Subject to $$M_t^{i^*} + \frac{d_t}{e_t} F_t^{i^*} = M_{t-1}^{i^*} + \frac{1}{e_t} F_{t-1}^{i^*} + w_t^* N_t^{i^*} + \Pi_t^* - P_t^* C_t^{i^*} - P_t^* T_t^{i^*}$$

First-Order Condition on Bond Holdings:

$$C_t^{i^*} = (\beta \frac{e_t}{e_{t+1}} \frac{P_t^*}{d_t P_{t+1}^*})^{-\sigma} C_{t+1}^{i^*}$$

First-Order Condition on Money Balances:

$$\frac{M_t^{i^*}}{P_t^*} = (\frac{\chi}{1 - \frac{e_{t+1}}{e_t} d_t} C_t^{i^* \frac{1}{\sigma}})^{\frac{1}{\varepsilon}}$$

First-Order Condition on Labor Supply:

$$N_t^{i^*} = (\frac{1}{\kappa} \frac{w_t^*}{P_t^*} C_t^{i^* -\frac{1}{\sigma}})^{\frac{1}{\mu-1}}$$

Equation of Profit Sharing:

$$\frac{1}{2} \Pi_t^* = u^* \Pi_t^{x^*} + (\frac{1}{2} - u^*) \Pi_t^{y^*}$$

A.1.3 Households j

Optimization Problem without Bond Trade:

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

Subject to $$M_t^j = M_{t-1}^j + w_t N_t^j + \Pi_t - P_t C_t^j - P_t T_t^j$$

First-Order Condition on Money Balances without Bond Trade:

$$\frac{M_t^j}{P_t} = \chi^{\frac{1}{\varepsilon}} [C_t^{j -\frac{1}{\sigma}} - \beta (\frac{P_t}{P_{t+1}}) C_{t+1}^{j -\frac{1}{\sigma}}]^{-\frac{1}{\varepsilon}}$$

First-Order Condition on Labor Supply without Bond Trade:

$$N_t^j = (\frac{1}{\kappa} \frac{w_t}{P_t} C_t^{j -\frac{1}{\sigma}})^{\frac{1}{\mu-1}}$$

Optimization Problem without Bond Trade and Monetary Adjustment:

Max $$U_t^j = \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{j \frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{\overline{M}_0^j}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j\mu}]$$

Subject to $M_0^j = M_0^j + w_t N_t^j + \Pi_t - P_t C_t^j$

First-Order Condition on Labor Supply without Bond Trade and Monetary Adjustment:

$$N_t^j = (\frac{1}{\kappa}\frac{w_t}{P_t}C_t^{j^{-\frac{1}{\sigma}}})^{\frac{1}{\mu-1}}$$

Equation of Profit Sharing:

$$\frac{1}{2}\Pi_t = u\Pi_t^x + (\frac{1}{2}-u)\Pi_t^y$$

A.1.4 Households j^*

Optimization Problem without Bond Trade:

$$\text{Max} \qquad U_t^{j^*} = \sum_{s=t}^{\infty}\beta^{s-t}[\frac{\sigma}{\sigma-1}C_s^{j^*\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon}(\frac{M_s^{j^*}}{P_s^*})^{1-\varepsilon} - \frac{\kappa}{\mu}N_s^{j^*\mu}]$$

Subject to $M_t^{j^*} = M_{t-1}^{j^*} + w_t^* N_t^{j^*} + \Pi_t^* - P_t^* C_t^{j^*} - P_t^* T_t^{j^*}$

First-Order Condition on Money Balances without Bond Trade:

$$\frac{M_t^{j^*}}{P_t^*} = \chi^{\frac{1}{\varepsilon}}[C_t^{j^{*}-\frac{1}{\sigma}} - \beta(\frac{P_t^*}{P_{t+1}^*})C_{t+1}^{j^{*}-\frac{1}{\sigma}}]^{-\frac{1}{\varepsilon}}$$

First-Order Condition on Labor Supply without Bond Trade:

$$N_t^{j^*} = (\frac{1}{\kappa}\frac{w_t^*}{P_t^*}C_t^{j^{*}-\frac{1}{\sigma}})^{\frac{1}{\mu-1}}$$

Optimization Problem without Bond Trade and Monetary Adjustment:

$$\text{Max} \qquad U_t^{j^*} = \sum_{s=t}^{\infty}\beta^{s-t}[\frac{\sigma}{\sigma-1}C_s^{j^*\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon}(\frac{\overline{M}_0^{j^*}}{P_s^*})^{1-\varepsilon} - \frac{\kappa}{\mu}N_s^{j^*\mu}]$$

Subject to $M_0^{j^*} = M_0^{j^*} + w_t^* N_t^{j^*} + \Pi_t^* - P_t^* C_t^{j^*}$

First-Order Condition on Labor Supply without Bond Trade and Monetary Adjustment:

$$N_t^{j^*} = (\frac{1}{\kappa}\frac{w_t^*}{P_t^*}C_t^{j^{*}-\frac{1}{\sigma}})^{\frac{1}{\mu-1}}$$

Equation of Profit Sharing:

$$\frac{1}{2}\Pi_t^* = u^*\Pi_t^{x^*} + (\frac{1}{2}-u^*)\Pi_t^{y^*}$$

A.1.5 Firms x

Optimization Problem:

$$\text{Max} \qquad V_t^{\prime x} = \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} \Pi_s^{\prime x}$$

$$\text{Subject to} \qquad \Pi_s^{\prime x} = p_t^{\prime x}(z) x_s^{\prime}(z) + e_s q_t^{\prime x}(z) x_s^{\prime *}(z) - w_s N_s^{\prime x}$$

$$x_s^{\prime}(z) = [\frac{p_t^{\prime x}(z)}{P_s}]^{-\theta} [n C_s^i + (\frac{1}{2} - n) C_s^j + \frac{1}{2} G_s]$$

$$x_s^{\prime *}(z) = [\frac{q_t^{\prime x}(z)}{P_s^*}]^{-\theta} [n^* C_s^{i^*} + (\frac{1}{2} - n^*) C_s^{j^*} + \frac{1}{2} G_s^*]$$

$$x_s^{\prime}(z) + x_s^{\prime *}(z) = A_s N_s^{\prime x}$$

First-Order Condition on Target Prices:

$$(\theta - 1) p_t^{\prime x}(z) \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} P_s^{\theta} [n C_s^i + (\frac{1}{2} - n) C_s^j + \frac{1}{2} G_s]$$

$$= \theta \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} P_s^{\theta} [n C_s^i + (\frac{1}{2} - n) C_s^j + \frac{1}{2} G_s] \frac{w_s}{A_s}$$

$$(\theta - 1) q_t^{\prime x}(z) \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} e_s P_s^{*\theta} [n^* C_s^{i^*} + (\frac{1}{2} - n^*) C_s^{j^*} + \frac{1}{2} G_s^*]$$

$$= \theta \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} P_s^{*\theta} [n^* C_s^{i^*} + (\frac{1}{2} - n^*) C_s^{j^*} + \frac{1}{2} G_s^*] \frac{w_s}{A_s}$$

Equation of Final Prices:

$$p_t^x(z) = \gamma p_{t-1}^x(z) + (1 - \gamma) p_t^{\prime x}(z)$$

$$q_t^x(z) = \gamma q_{t-1}^x(z) + (1 - \gamma) q_t^{\prime x}(z)$$

A.1.6 Firms x^*

Optimization Problem:

$$\text{Max} \qquad V_t^{\prime x^*} = \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} \Pi_s^{\prime x^*}$$

Subject to $\Pi_s'^{x^*} = \frac{q_t'^{x^*}(z^*)}{e_s} x_s'(z^*) + p_t'^{x^*}(z^*) x_s'^*(z^*) - w_s^* N_s'^{x^*}$

$$x_s'(z^*) = [\frac{q_t'^{x^*}(z^*)}{P_s}]^{-\theta}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]$$

$$x_s'^*(z^*) = [\frac{p_t'^{x^*}(z^*)}{P_s^*}]^{-\theta}[nC_s^{i^*} + (\frac{1}{2}-n)C_s^{j^*} + \frac{1}{2}G_s^*]$$

$$x_s'(z^*) + x_s'^*(z^*) = A_s^* N_s'^{x^*}$$

First-Order Condition on Target Prices:

$$(\theta-1)p_t'^{x^*}(z^*)\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}P_s^{*\theta}[nC_s^{i^*} + (\frac{1}{2}-n)C_s^{j^*} + \frac{1}{2}G_s^*]$$

$$= \theta\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}P_s^{*\theta}[nC_s^{i^*} + (\frac{1}{2}-n)C_s^{j^*} + \frac{1}{2}G_s^*]\frac{w_s^*}{A_s^*}$$

$$(\theta-1)q_t'^{x^*}(z^*)\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}\frac{P_s^{\theta}}{e_s}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]$$

$$= \theta\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}P_s^{\theta}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]\frac{w_s^*}{A_s^*}$$

Equation of Final Prices:

$$p_t^{x^*}(z^*) = \gamma p_{t-1}^{x^*}(z^*) + (1-\gamma)p_t'^{x^*}(z^*)$$

$$q_t^{x^*}(z^*) = \gamma q_{t-1}^{x^*}(z^*) + (1-\gamma)q_t'^{x^*}(z^*)$$

A.1.7 Firms y

Optimization Problem:

Max $V_t'^{y} = \sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}\Pi_s'^{y}$

Subject to $\Pi_s'^{y} = p_t'^{y}(z)y_s'(z) + p_t'^{y}(z)y_s'^*(z) - w_s N_s'^{y}$

$$y_s'(z) = [\frac{p_t'^{y}(z)}{P_s}]^{-\theta}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]$$

$$y_s'^*(z) = [\frac{p_t'^{y}(z)}{e_s P_s^*}]^{-\theta}[n^* C_s^{i^*} + (\frac{1}{2}-n^*)C_s^{j^*} + \frac{1}{2}G_s^*]$$

$$y_s^{\prime}(z) + y_s^{\prime *}(z) = A_s N_s^{\prime y}$$

First-Order Condition on Target Prices:

$$(\theta-1)p_t^{\prime y}(z)\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}\Big\{P_s^{\theta}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]$$

$$+(e_s P_s^*)^{\theta}[n^* C_s^{i^*} + (\frac{1}{2}-n^*)C_s^{j^*} + \frac{1}{2}G_s^*]\Big\}$$

$$= \theta\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}\Big\{P_s^{\theta}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]$$

$$+(e_s P_s^*)^{\theta}[n^* C_s^{i^*} + (\frac{1}{2}-n^*)C_s^{j^*} + \frac{1}{2}G_s^*]\frac{w_s}{A_s}\Big\}$$

Equation of Final Prices:

$$p_t^y(z) = \gamma p_{t-1}^y(z) + (1-\gamma)p_t^{\prime y}(z)$$

A.1.8 Firms y^*

Optimization Problem:

Max $\qquad V_t^{\prime y^*} = \sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}\Pi_s^{\prime y^*}$

Subject to $\qquad \Pi_s^{\prime y^*} = p_t^{\prime y^*}(z^*)y_s^{\prime}(z^*) + p_t^{\prime y^*}(z^*)y_s^{\prime *}(z^*) - w_s^* N_s^{\prime y^*}$

$$y_s^{\prime}(z^*) = [\frac{e_s p_t^{\prime y^*}(z^*)}{P_s}]^{-\theta}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]$$

$$y_s^{\prime *}(z^*) = [\frac{p_t^{\prime y^*}(z^*)}{P_s^*}]^{-\theta}[n^* C_s^{i^*} + (\frac{1}{2}-n^*)C_s^{j^*} + \frac{1}{2}G_s^*]$$

$$y_s^{\prime}(z^*) + y_s^{\prime *}(z^*) = A_s^* N_s^{\prime y^*}$$

First-Order Condition on Target Prices:

$$(\theta-1)p_t^{\prime y^*}(z^*)\sum_{s=t}^{\infty}\gamma^{s-t}\beta^{s-t}\Big\{(\frac{P_s}{e_s})^{\theta}[nC_s^i + (\frac{1}{2}-n)C_s^j + \frac{1}{2}G_s]$$

$$+P_s^{*\theta}[n^* C_s^{i^*} + (\frac{1}{2}-n^*)C_s^{j^*} + \frac{1}{2}G_s^*]\Big\}$$

$$= \theta \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} \left\{ (\frac{P_s}{e_s})^{\theta} [nC_s^i + (\frac{1}{2} - n) C_s^j + \frac{1}{2} G_s] \right.$$

$$\left. + P_s^{*\theta} [n^* C_s^{i^*} + (\frac{1}{2} - n^*) C_s^{j^*} + \frac{1}{2} G_s^*] \frac{w_s^*}{A_s^*} \right\}$$

Equation of Final Prices:

$$p_t^{y^*}(z^*) = \gamma p_{t-1}^{y^*}(z^*) + (1-\gamma) p_t'^{y^*}(z^*)$$

A.2 Table

Table 1.1:
Standard Errors under IID Random-Walk Home and Foreign Monetary Disturbances - Restrictions on Bond Trade with Complete PCP

		(n, n^*) =(.5,.5)	(n, n^*) =(.25,.5)	(n, n^*) =(.25,.25)	(n, n^*) =(.01,.01)
F^i	Bond Holding of Household i	.1306	.2506	.1867	.2488
F^{i^*}	Bond Holding of Household i^*	.1305	.1253	.1867	.2461
M^i	Money Balance of Household i	.0561	.0410	.0441	.0662
M^j	Money Balance of Household j	na	.0740	.0703	.0568
M^{i^*}	Money Balance of Household i^*	.0797	.0796	.0673	.0822
M^{j^*}	Money Balance of Household j^*	na	na	.0935	.0803
C^i	Consumption of Household i	.0206	.0192	.0203	.0209
C^j	Consumption of Household j	na	.0217	.0219	.0217
C^{i^*}	Consumption of Household i^*	.0265	.0264	.0251	.0251
C^{j^*}	Consumption of Household j^*	na	na	.0270	.0257
N^i	Labor Supply of Household i	.0161	.0183	.0175	.0138
N^j	Labor Supply of Household j	na	.0175	.0167	.0123
N^{i^*}	Labor Supply of Household i^*	.0225	.0239	.0233	.0201
N^{j^*}	Labor Supply of Household j^*	na	na	.0231	.0186
e	Exchange Rate	.0930	.0898	.0895	.0906
w	Home Wage Rate	.0459	.0483	.0478	.0446
w^*	Foreign Wage Rate	.0611	.0624	.0616	.0615
P	Home Price Index	.0370	.0373	.0369	.0364
P^*	Foreign Price Index	.0553	.0552	.0553	.0569
C	Aggregate Home Consumption	.0103	.0102	.0105	.0108
C^*	Aggregate Foreign Consumption	.0132	.0132	.0130	.0128
Y	Aggregate Home Output	.0105	.0082	.0077	.0051
Y^*	Aggregate Foreign Output	.0112	.0107	.0106	.0087
CA	Home Current Account	.0165	.0157	.0157	.0151

Table 1.2:
Standard Errors under IID Random-Walk Home and Foreign Monetary Disturbances - Restrictions on Bond Trade with Complete LCP

		(n, n^*) =(.5,.5)	(n, n^*) =(.25,.5)	(n, n^*) =(.25,.25)	(n, n^*) =(.01,.01)
F^i	Bond Holding of Household i	.0066	.0131	.0066	.0189
F^{i^*}	Bond Holding of Household i^*	.0066	.0065	.0066	.0189
M^i	Money Balance of Household i	.0561	.0555	.0556	.0541
M^j	Money Balance of Household j	na	.0566	.0566	.0561
M^{i^*}	Money Balance of Household i^*	.0797	.0796	.0792	.0784
M^{j^*}	Money Balance of Household j^*	na	na	.0801	.0797
C^i	Consumption of Household i	.0215	.0216	.0215	.0215
C^j	Consumption of Household j	na	.0218	.0216	.0216
C^{i^*}	Consumption of Household i^*	.0271	.0268	.0270	.0271
C^{j^*}	Consumption of Household j^*	na	na	.0271	.0271
N^i	Labor Supply of Household i	.0128	.0127	.0128	.0129
N^j	Labor Supply of Household j	na	.0129	.0129	.0129
N^{i^*}	Labor Supply of Household i^*	.0191	.0191	.0190	.0191
N^{j^*}	Labor Supply of Household j^*	na	na	.0191	.0191
e	Exchange Rate	.0957	.0956	.0955	.0955
w	Home Wage Rate	.0436	.0434	.0436	.0435
w^*	Foreign Wage Rate	.0608	.0609	.0607	.0608
P	Home Price Index	.0369	.0365	.0369	.0369
P^*	Foreign Price Index	.0556	.0560	.0555	.0556
C	Aggregate Home Consumption	.0108	.0109	.0108	.0108
C^*	Aggregate Foreign Consumption	.0135	.0134	.0135	.0136
Y	Aggregate Home Output	.0050	.0049	.0050	.0049
Y^*	Aggregate Foreign Output	.0075	.0076	.0075	.0074
CA	Home Current Account	.0141	.0141	.0141	.0142

Table 1.3:
Standard Errors under IID Random-Walk Home and Foreign Monetary Disturbances - Restrictions on Bond Trade and Monetary Adjustments with Complete PCP

		(n, n^*) =(.5,.5)	(n, n^*) =(.25,.5)	(n, n^*) =(.25,.25)	(n, n^*) =(.01,.01)
F^i	Bond Holding of Household i	.1306	.3450	.3691	3.4218
F^{i^*}	Bond Holding of Household i^*	.1306	.1725	.3694	3.4437
M^i	Money Balance of Household i	.0561	.1122	.1127	6.5820
M^j	Money Balance of Household j	na	.0000	.0000	.0000
M^{i^*}	Money Balance of Household i^*	.0797	.0797	.1589	11.1256
M^{j^*}	Money Balance of Household j^*	na	na	.0000	.0000
C^i	Consumption of Household i	.0206	.0365	.0384	.8179
C^j	Consumption of Household j	na	.0690	.0657	1.4508
C^{i^*}	Consumption of Household i^*	.0265	.0265	.0525	1.0785
C^{j^*}	Consumption of Household j^*	na	na	.0681	1.5292
N^i	Labor Supply of Household i	.0161	.0454	.0441	1.3168
N^j	Labor Supply of Household j	na	.0264	.0260	.3502
N^{i^*}	Labor Supply of Household i^*	.0225	.0247	.0560	1.1555
N^{j^*}	Labor Supply of Household j^*	na	na	.0366	.3907
e	Exchange Rate	.0930	.1286	.1829	1.9930
w	Home Wage Rate	.0459	.1060	.1039	2.0981
w^*	Foreign Wage Rate	.0611	.0634	.1286	2.0998
P	Home Price Index	.0370	.0771	.0774	1.2055
P^*	Foreign Price Index	.0553	.0586	.1110	1.1219
C	Aggregate Home Consumption	.0103	.0247	.0242	.7145
C^*	Aggregate Foreign Consumption	.0132	.0132	.0280	.7562
Y	Aggregate Home Output	.0105	.0128	.0135	.1910
Y^*	Aggregate Foreign Output	.0112	.0108	.0181	.1935
CA	Home Current Account	.0165	.0294	.0307	.8133

Table 1.4:
Standard Errors under IID Random-Walk Home and Foreign Monetary Disturbances - Restrictions on Bond Trade and Monetary Adjustments with Complete LCP

		(n, n^*) =(.5,.5)	(n, n^*) =(.25,.5)	(n, n^*) =(.25,.25)	(n, n^*) =(.01,.01)
F^{i}	Bond Holding of Household i	.0066	.0103	.0070	.1709
F^{i^*}	Bond Holding of Household i^*	.0066	.0051	.0070	.1688
M^{i}	Money Balance of Household i	.0561	.1122	.1124	2.7986
M^{j}	Money Balance of Household j	na	.0000	.0000	.0000
M^{i^*}	Money Balance of Household i^*	.0796	.0797	.1595	3.9767
M^{j^*}	Money Balance of Household j^*	na	na	.0000	.0000
C^{i}	Consumption of Household i	.0215	.0424	.0427	1.0701
C^{j}	Consumption of Household j	na	.0432	.0438	1.0920
C^{i^*}	Consumption of Household i^*	.0271	.0260	.0546	1.3566
C^{j^*}	Consumption of Household j^*	na	na	.0547	1.3537
N^{i}	Labor Supply of Household i	.0128	.0253	.0253	.6286
N^{j}	Labor Supply of Household j	na	.0254	.0260	.6451
N^{i^*}	Labor Supply of Household i^*	.0191	.0196	.0382	.9597
N^{j^*}	Labor Supply of Household j^*	na	na	.0381	.9499
e	Exchange Rate	.0956	.1351	.1915	4.7738
w	Home Wage Rate	.0436	.0874	.0877	2.1850
w^*	Foreign Wage Rate	.0608	.0605	.1216	3.0281
P	Home Price Index	.0369	.0746	.0744	1.8485
P^*	Foreign Price Index	.0555	.0571	.1107	2.7691
C	Aggregate Home Consumption	.0108	.0214	.0216	.5458
C^*	Aggregate Foreign Consumption	.0135	.0130	.0273	.6769
Y	Aggregate Home Output	.0050	.0101	.0099	.2456
Y^*	Aggregate Foreign Output	.0075	.0079	.0146	.3683
CA	Home Current Account	.0141	.0283	.0283	.7119

Table 1.5:
Standard Errors under IID Random-Walk Home and Foreign Fiscal Disturbances - Restrictions on Bond Trade with Complete PCP

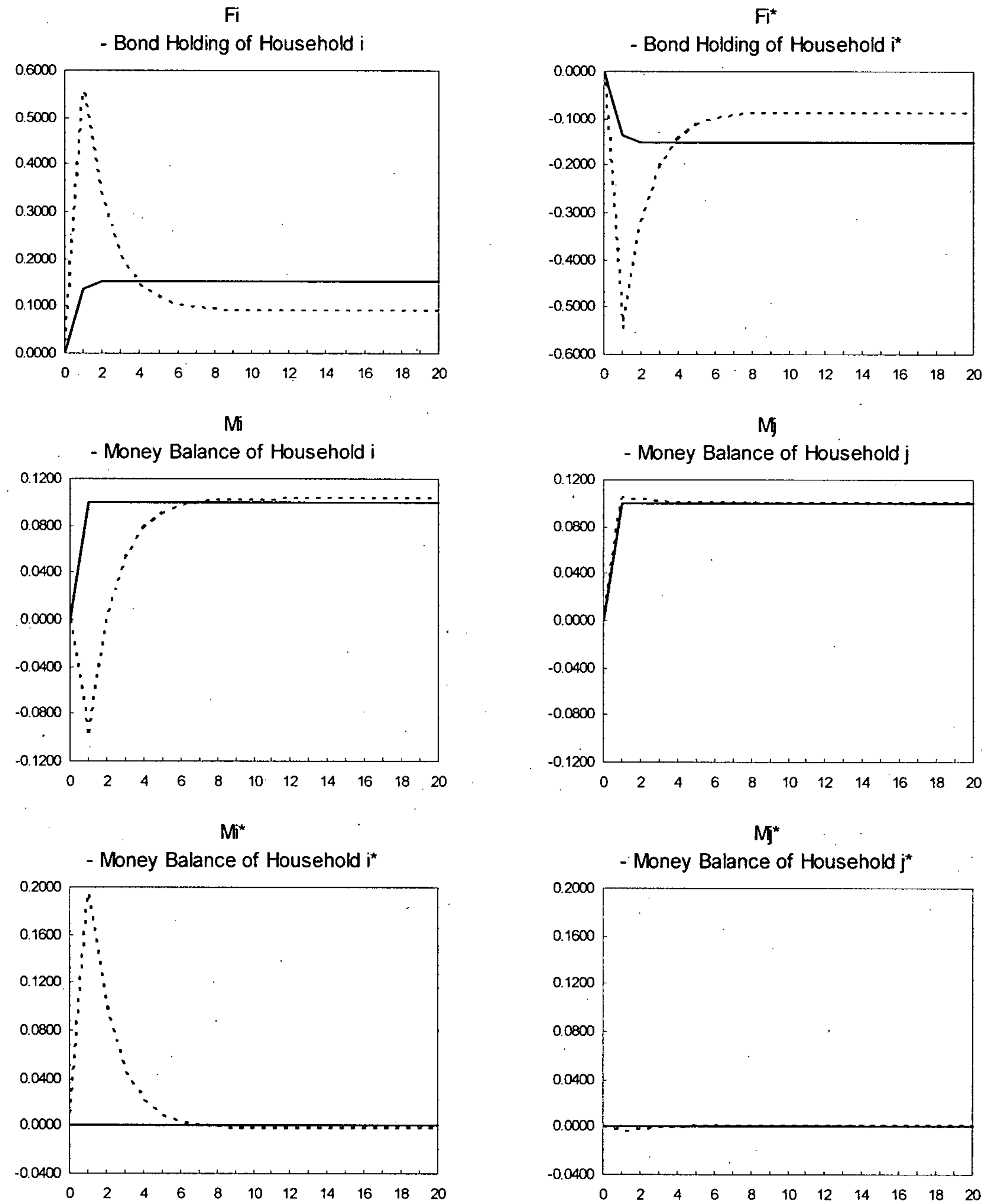
		(n, n^*) =(.5,.5)	(n, n^*) =(.25,.5)	(n, n^*) =(.25,.25)	(n, n^*) =(.01,.01)
F^i	Bond Holding of Household i	.0445	.0572	.0485	.0583
F^{i^*}	Bond Holding of Household i^*	.0445	.0286	.0485	.0584
M^i	Money Balance of Household i	.0000	.0048	.0042	.0164
M^j	Money Balance of Household j	na	.0048	.0041	.0003
M^{i^*}	Money Balance of Household i^*	.0000	.0000	.0037	.0163
M^{j^*}	Money Balance of Household j^*	na	na	.0037	.0003
C^i	Consumption of Household i	.0097	.0101	.0096	.0099
C^j	Consumption of Household j	na	.0095	.0091	.0097
C^{i^*}	Consumption of Household i^*	.0138	.0133	.0145	.0138
C^{j^*}	Consumption of Household j^*	na	na	.0138	.0137
N^i	Labor Supply of Household i	.0113	.0114	.0111	.0106
N^j	Labor Supply of Household j	na	.0107	.0105	.0102
N^{i^*}	Labor Supply of Household i^*	.0147	.0143	.0149	.0143
N^{j^*}	Labor Supply of Household j^*	na	na	.0140	.0141
e	Exchange Rate	.0235	.0233	.0228	.0235
w	Home Wage Rate	.0118	.0111	.0110	.0102
w^*	Foreign Wage Rate	.0142	.0143	.0136	.0140
P	Home Price Index	.0103	.0098	.0095	.0097
P^*	Foreign Price Index	.0132	.0133	.0133	.0136
C	Aggregate Home Consumption	.0048	.0049	.0047	.0049
C^*	Aggregate Foreign Consumption	.0069	.0067	.0071	.0069
Y	Aggregate Home Output	.0052	.0050	.0051	.0047
Y^*	Aggregate Foreign Output	.0070	.0069	.0067	.0068
CA	Home Current Account	.0098	.0097	.0096	.0094

Table 1.6:
Standard Errors under IID Random-Walk Home and Foreign Fiscal Disturbances - Restrictions on Bond Trade with Complete LCP

		(n, n^*) =(.5,.5)	(n, n^*) =(.25,.5)	(n, n^*) =(.25,.25)	(n, n^*) =(.01,.01)
F^i	Bond Holding of Household i	.0042	.0045	.0047	.0139
F^{i^*}	Bond Holding of Household i^*	.0042	.0023	.0047	.0139
M^i	Money Balance of Household i	.0000	.0005	.0004	.0046
M^j	Money Balance of Household j	na	.0005	.0004	.0001
M^{i^*}	Money Balance of Household i^*	.0000	.0000	.0004	.0047
M^{j^*}	Money Balance of Household j^*	na	na	.0004	.0001
C^i	Consumption of Household i	.0097	.0097	.0097	.0097
C^j	Consumption of Household j	na	.0097	.0097	.0097
C^{i^*}	Consumption of Household i^*	.0134	.0135	.0134	.0135
C^{j^*}	Consumption of Household j^*	na	na	.0134	.0134
N^i	Labor Supply of Household i	.0099	.0099	.0099	.0099
N^j	Labor Supply of Household j	na	.0099	.0099	.0099
N^{i^*}	Labor Supply of Household i^*	.0139	.0140	.0139	.0140
N^{j^*}	Labor Supply of Household j^*	na	na	.0140	.0139
e	Exchange Rate	.0247	.0248	.0248	.0248
w	Home Wage Rate	.0099	.0099	.0099	.0099
w^*	Foreign Wage Rate	.0139	.0139	.0139	.0139
P	Home Price Index	.0097	.0096	.0097	.0097
P^*	Foreign Price Index	.0134	.0135	.0134	.0134
C	Aggregate Home Consumption	.0048	.0048	.0049	.0049
C^*	Aggregate Foreign Consumption	.0067	.0067	.0067	.0067
Y	Aggregate Home Output	.0049	.0050	.0050	.0050
Y^*	Aggregate Foreign Output	.0074	.0074	.0075	.0075
CA	Home Current Account	.0096	.0097	.0097	.0097

A.3 Figure

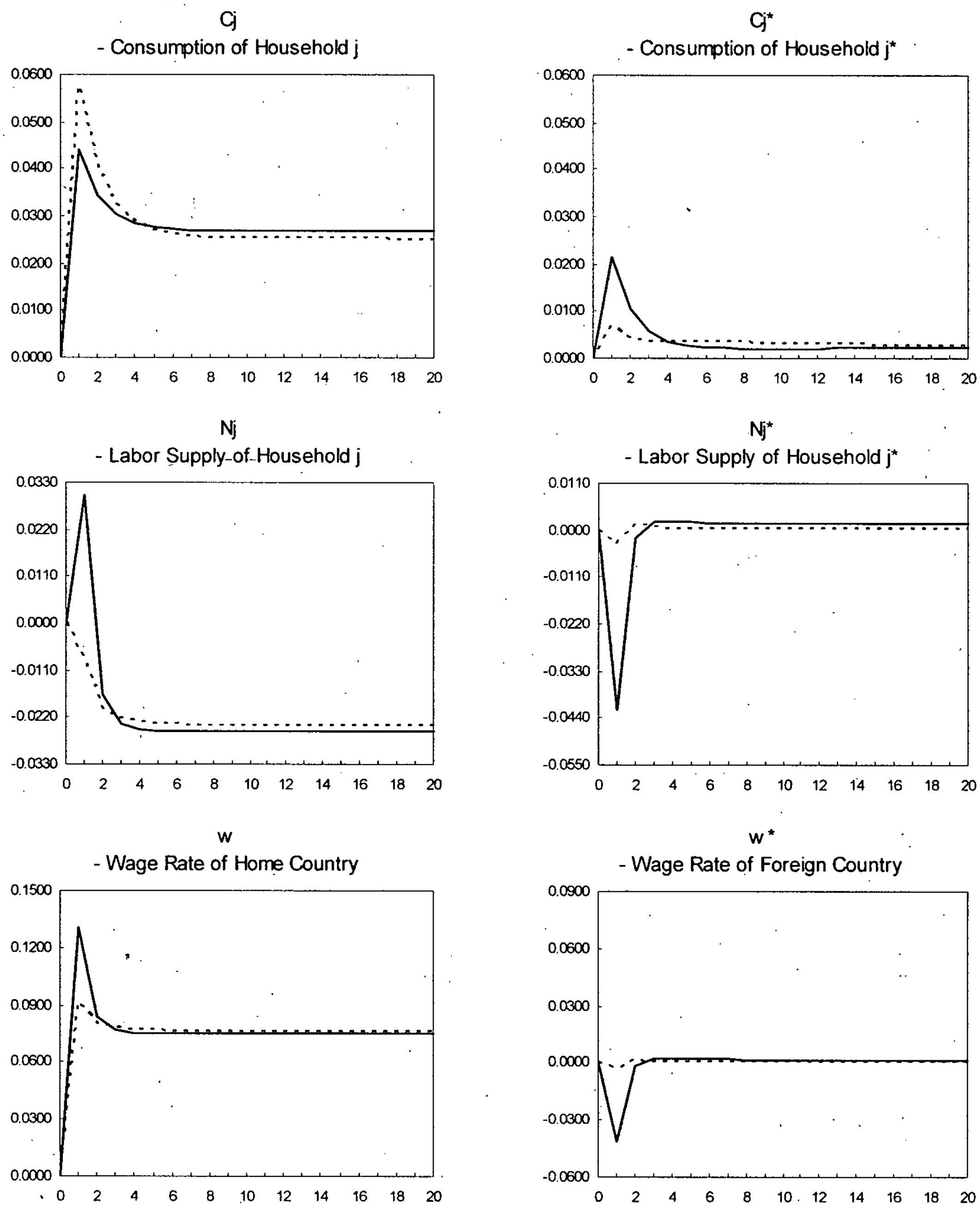
Figure 1.1 (3-1): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Monetary Expansion - Restrictions on Bond Trade with Complete PCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households *j* are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households *i* for clearer comparisons.

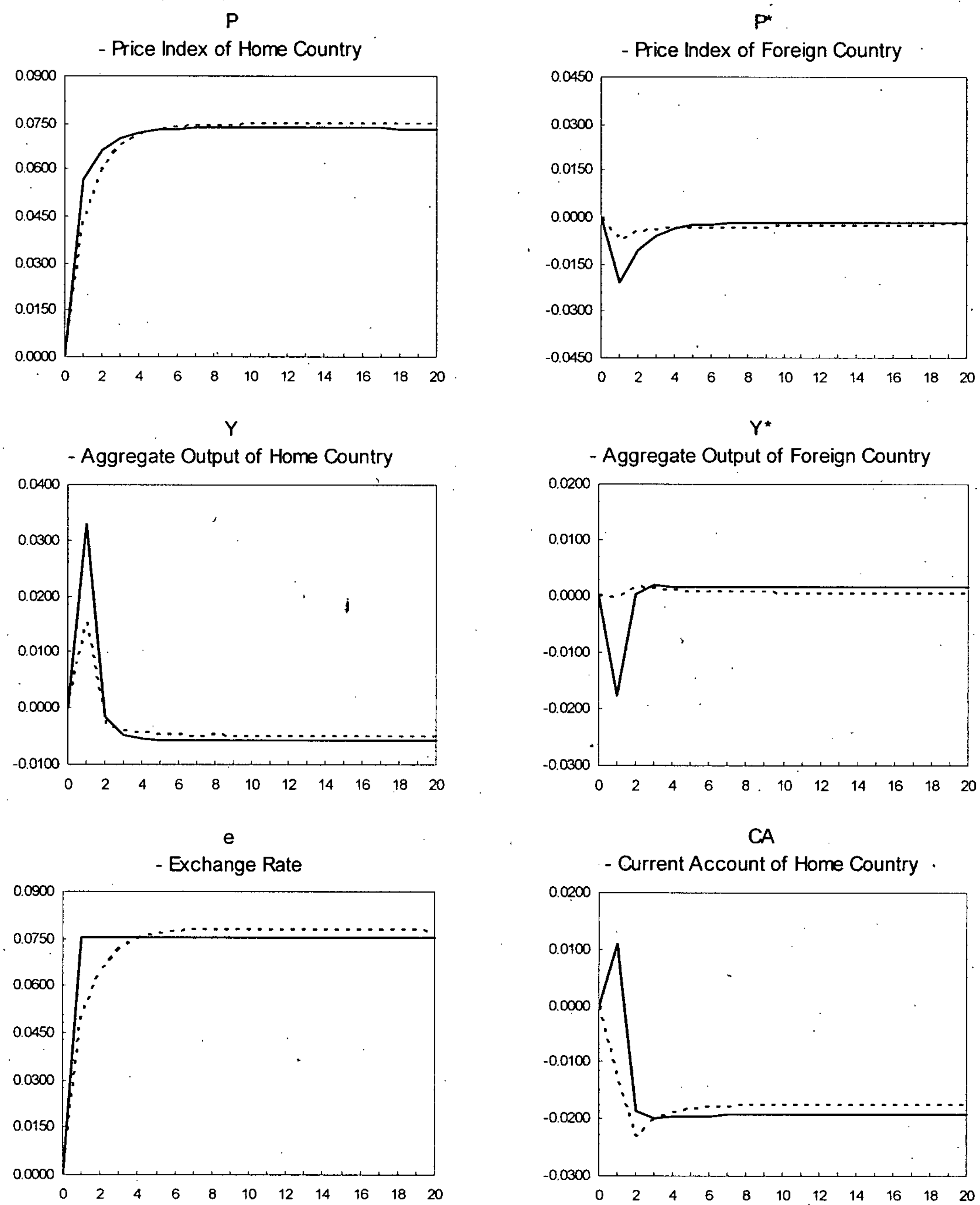
Figure 1.1 (3-2): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Monetary Expansion - Restrictions on Bond Trade with Complete PCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

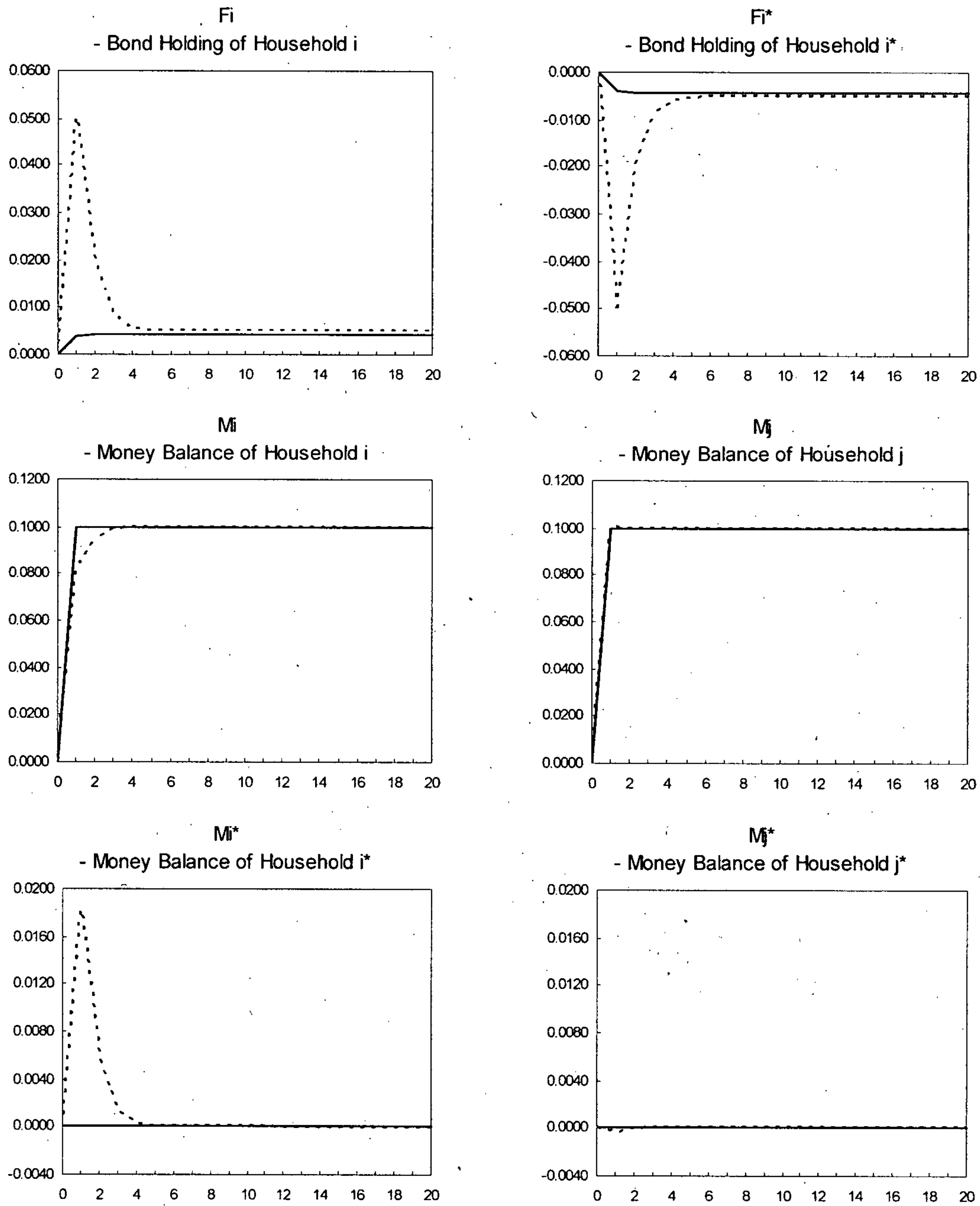
Figure 1.1 (3-3): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Monetary Expansion - Restrictions on Bond Trade with Complete PCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

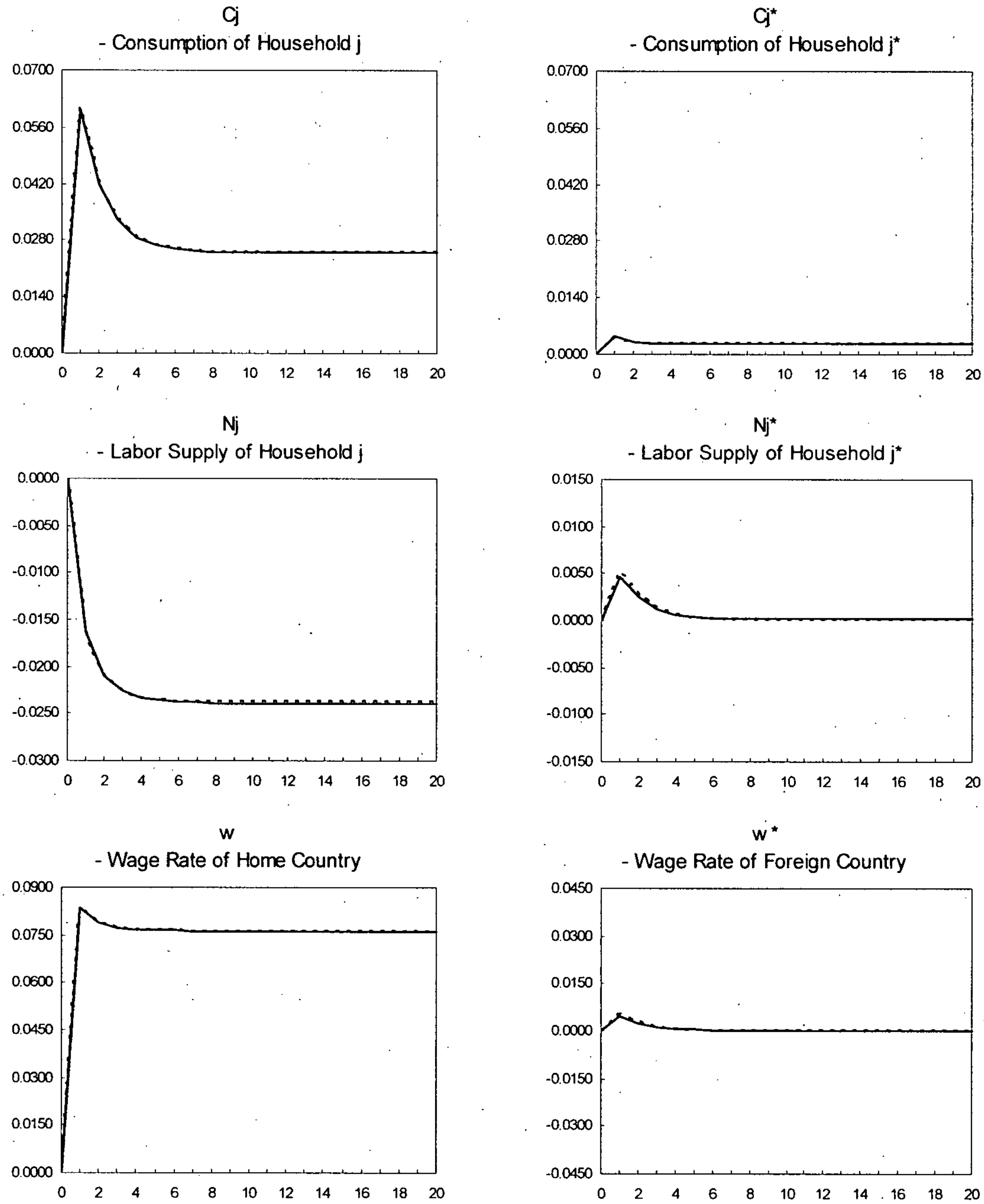
Figure 1.2 (3-1): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Monetary Expansion - Restrictions on Bond Trade with Complete LCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

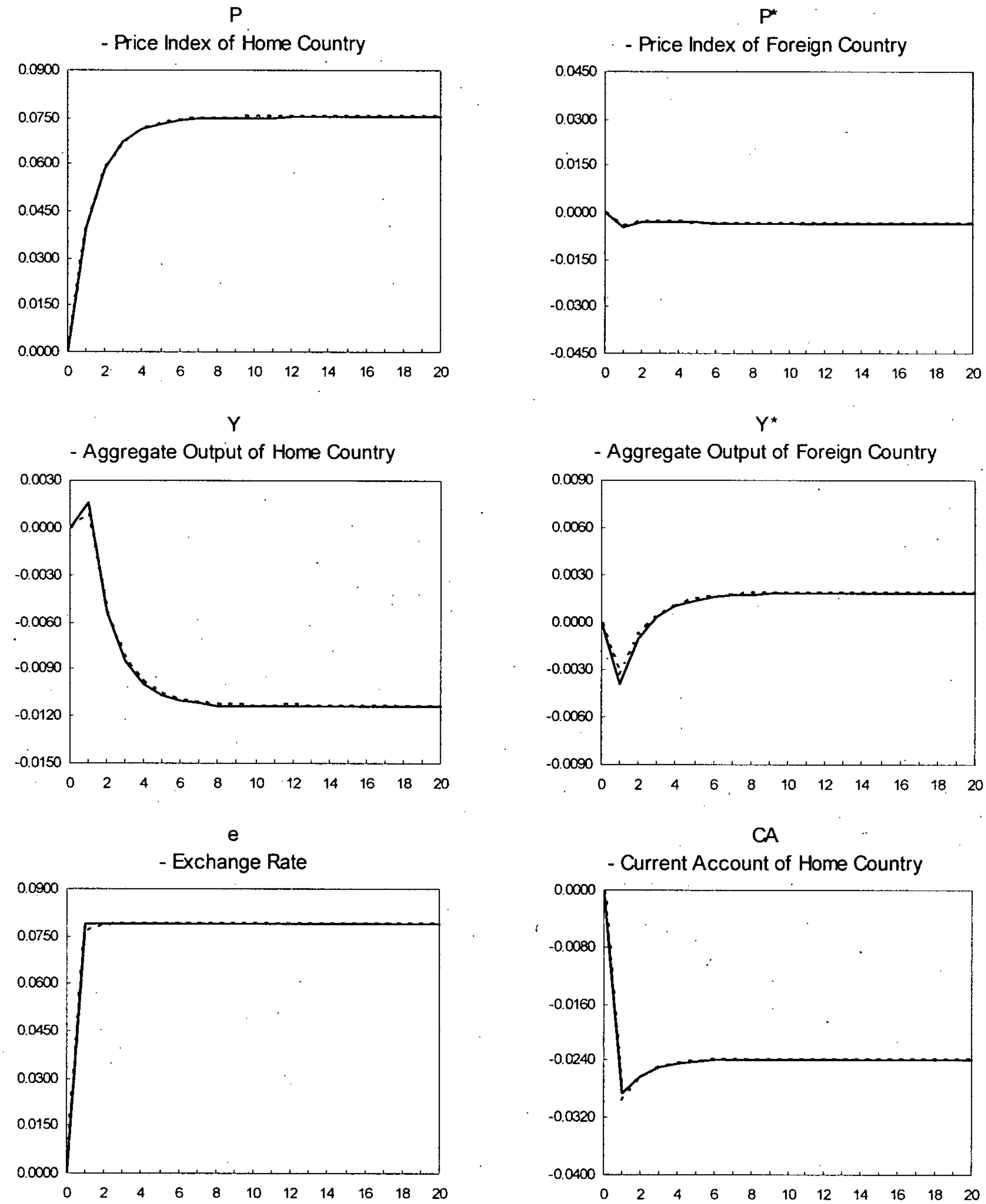
Figure 1.2 (3-2): Simulation Results of (n, n^{*}) Equaling (.5, .5) and (.01, .01) under the Permanent Home Monetary Expansion - Restrictions on Bond Trade with Complete LCP



The continuous lines represent the case of (n, n^{*}) equaling (.5, .5), and the dashed lines represent the case of (n, n^{*}) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^{*}) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

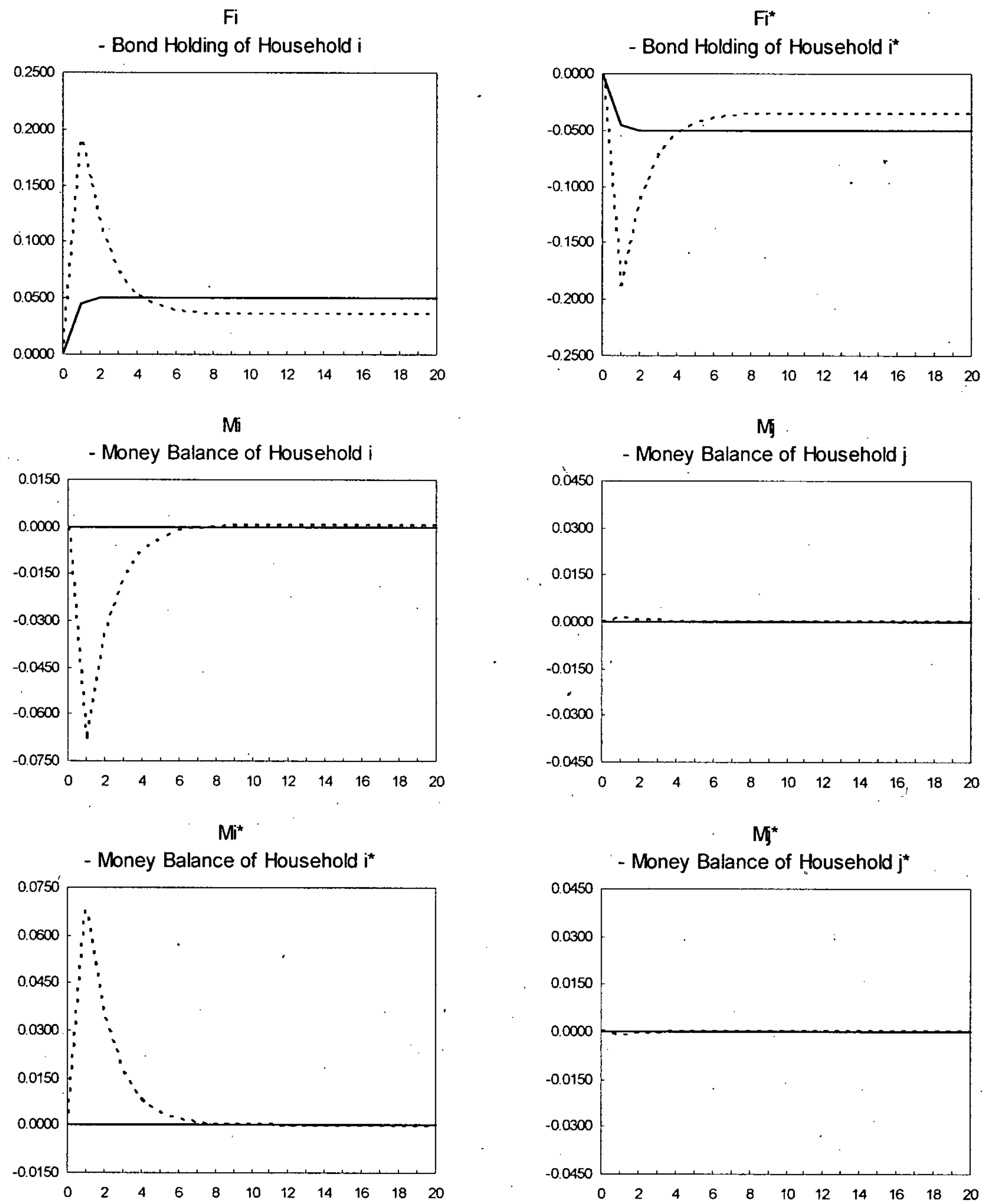
Figure 1.2 (3-3): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Monetary Expansion - Restrictions on Bond Trade with Complete LCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

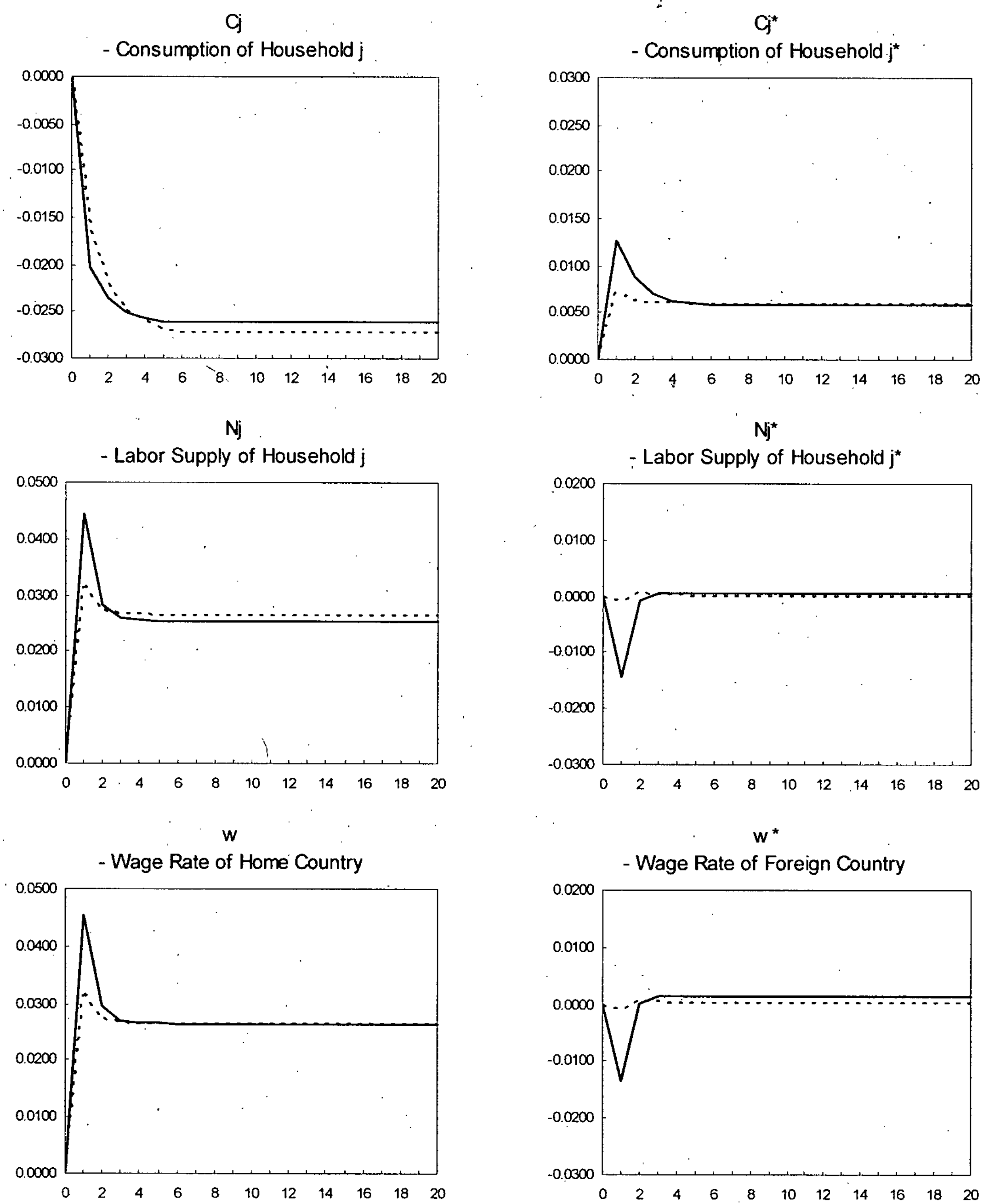
Figure 1.3 (3-1): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Fiscal Expansion - Restrictions on Bond Trade with Complete PCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

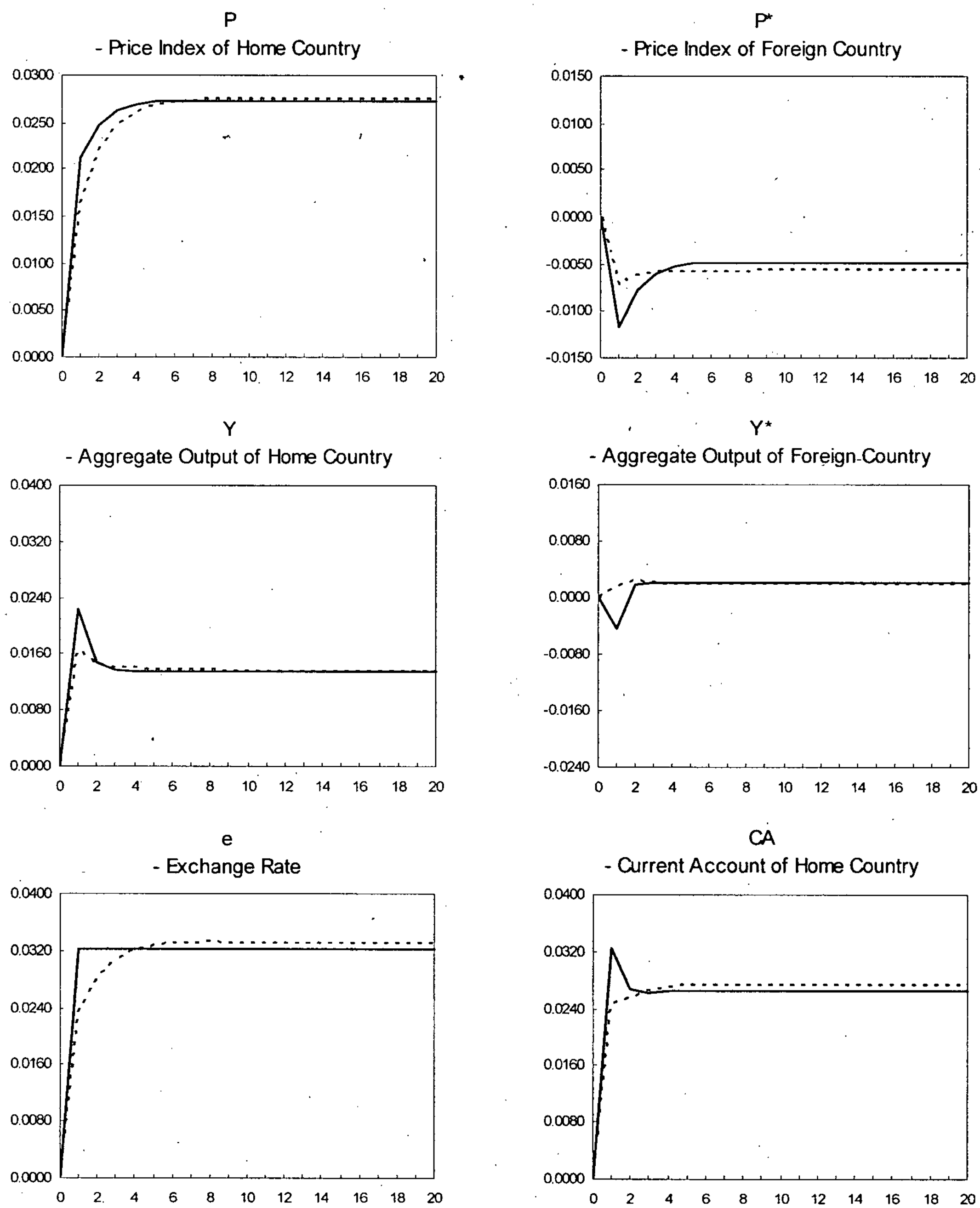
Figure 1.3 (3-2): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Fiscal Expansion - Restrictions on Bond Trade with Complete PCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

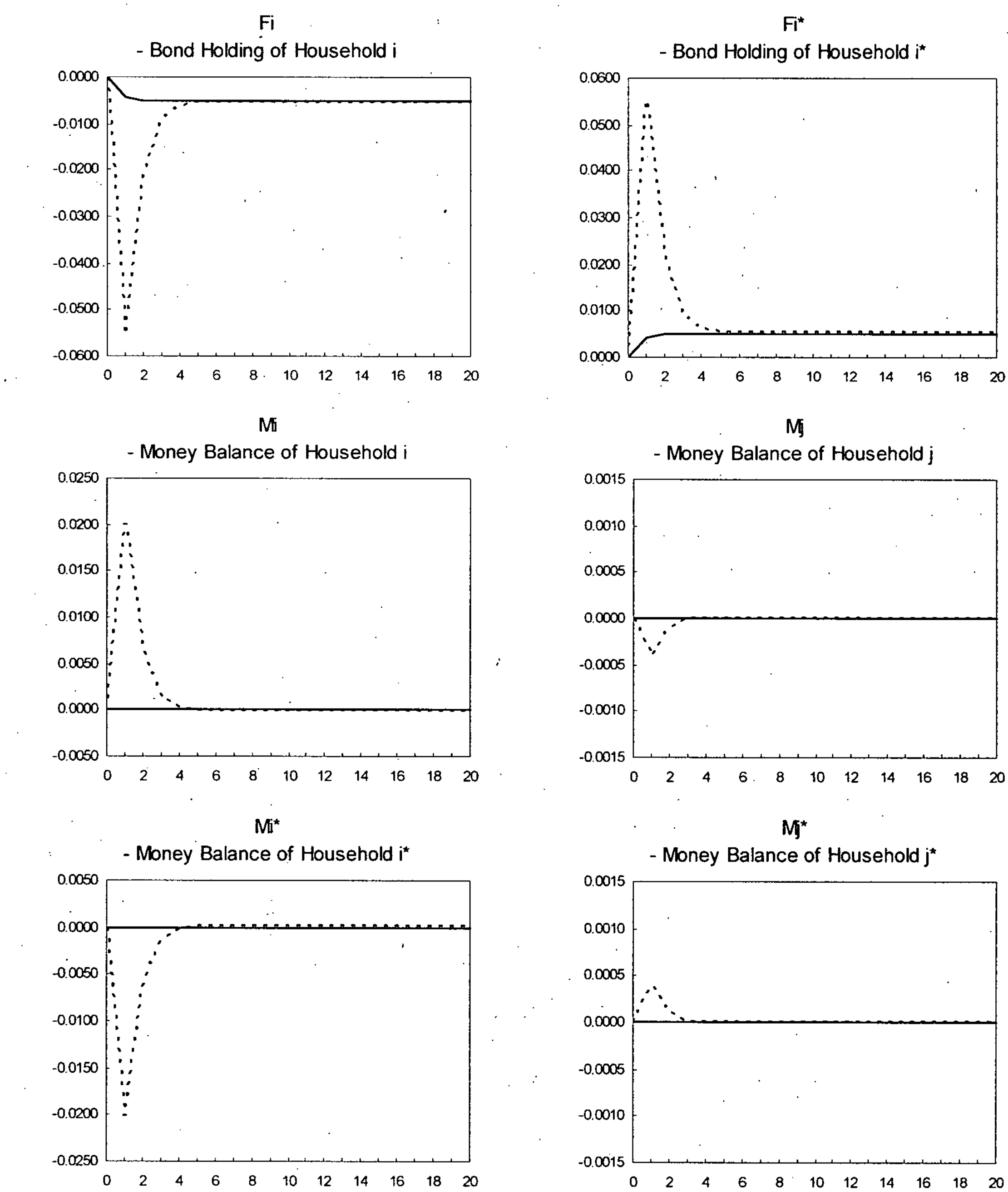
Figure 1.3 (3-3): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Fiscal Expansion - Restrictions on Bond Trade with Complete PCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

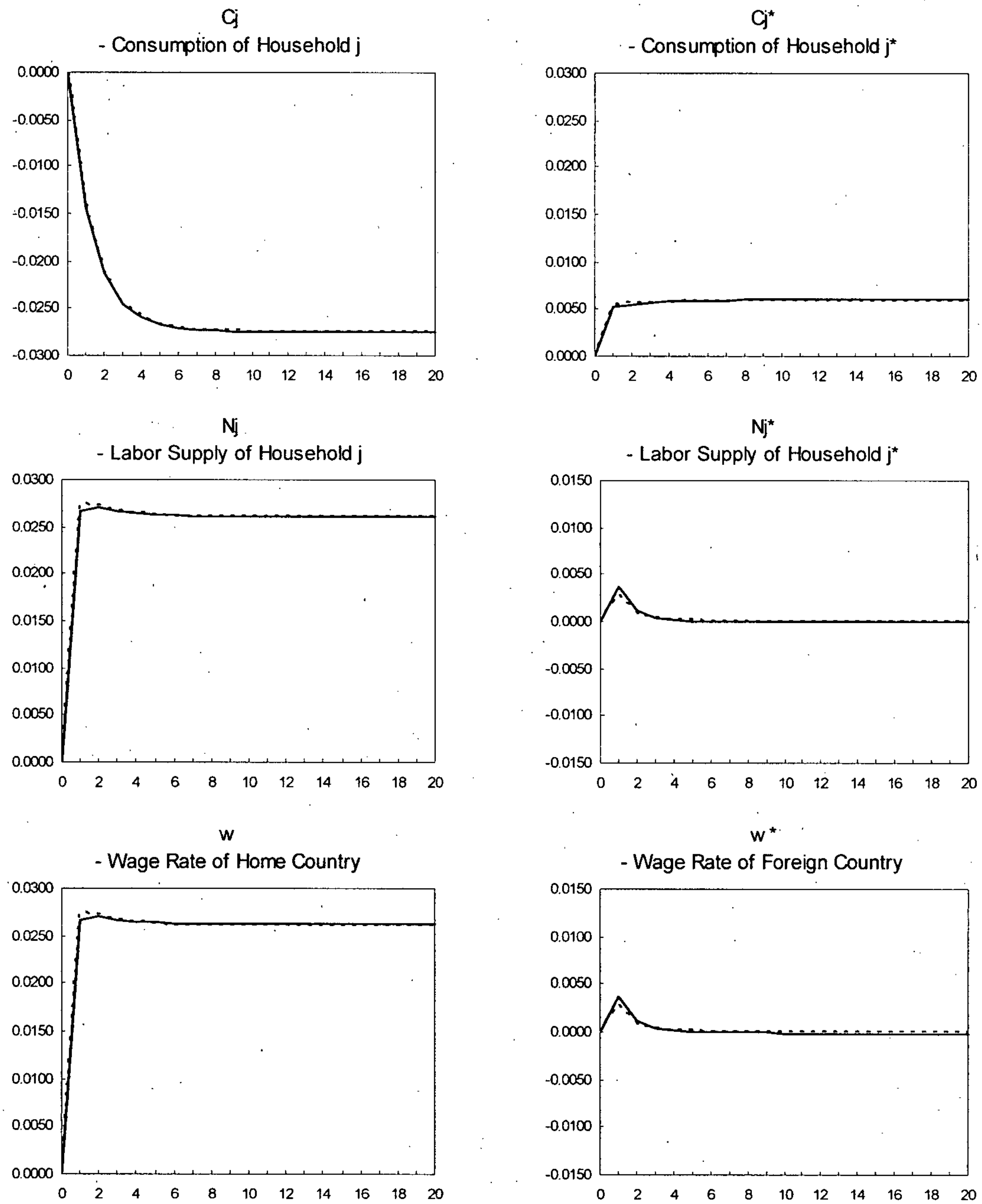
Figure 1.4 (3-1): Simulation Results of (n, n^{*}) Equaling (.5, .5) and (.01, .01) under the Permanent Home Fiscal Expansion - Restrictions on Bond Trade with Complete LCP



The continuous lines represent the case of (n, n^{*}) equaling (.5, .5), and the dashed lines represent the case of (n, n^{*}) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^{*}) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

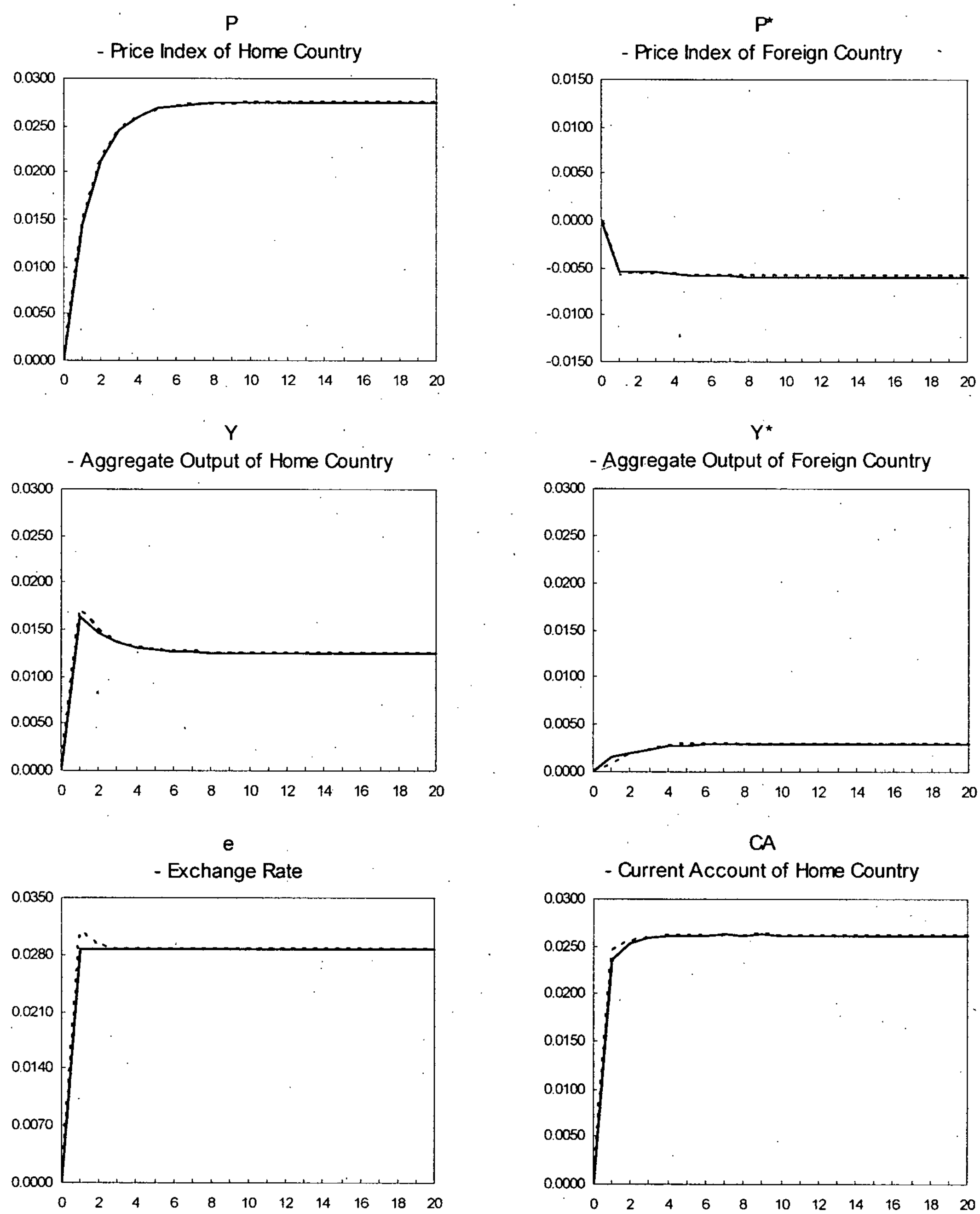
Figure 1.4 (3-2): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Fiscal Expansion - Restrictions on Bond Trade with Complete LCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households j are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households i for clearer comparisons.

Figure 1.4 (3-3): Simulation Results of (n, n^*) Equaling (.5, .5) and (.01, .01) under the Permanent Home Fiscal Expansion - Restrictions on Bond Trade with Complete LCP



The continuous lines represent the case of (n, n^*) equaling (.5, .5), and the dashed lines represent the case of (n, n^*) equaling (.01, .01). The categories of the horizontal and vertical axes are time and the rate of changes from the initial steady state respectively.

When households *j* are undefined as in the case of (n, n^*) equaling (.5, .5), variables associated with them are replaced by those with households *i* for clearer comparisons.

Appendix B

Appendices of Chapter 2

B.1 Optimization Problem and First-Order Condition

B.1.1 Households i

Optimization Problem:

$$\text{Max} \qquad E_t U_t^i = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma - 1} C_s^{i\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \left(\frac{M_s^i}{P_s} \right)^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i\mu} \right]$$

$$\text{Subject to} \qquad M_t^i + d_t F_t^i + e_t d_t^* F_t^{*i}$$

$$= M_{t-1}^i + F_{t-1}^i + e_t F_{t-1}^{*i} + w_t N_t^i + \Pi_t^z - P_t C_t^i - P_t T_t^i - D_t^{F^*}$$

$$D_t^{F^*} = \frac{\tau}{2} \frac{[e_t (F_t^{*i} - \overline{F}_0^{*i})]^2}{P_t Y_t}$$

First-Order Condition on Bond Holdings:

$$E_t \left\{ \frac{d_t}{P_t} C_t^{i-\frac{1}{\sigma}} - \beta \frac{1}{P_{t+1}} C_{t+1}^{i-\frac{1}{\sigma}} \right\} = 0$$

$$E_t \left\{ \frac{e_t d_t^*}{P_t} C_t^{i-\frac{1}{\sigma}} - \beta \frac{e_{t+1}}{P_{t+1}} C_{t+1}^{i-\frac{1}{\sigma}} + \tau \frac{e_t^2}{P_t^2 Y_t} (F_t^{*i} - \overline{F}_0^{*i}) \right\} = 0$$

First-Order Condition on Money Balances:

$$E_t \left\{ C_t^{i-\frac{1}{\sigma}} - \beta \frac{P_t}{P_{t+1}} C_{t+1}^{i-\frac{1}{\sigma}} - \chi \left(\frac{M_t^i}{P_t} \right)^{-\varepsilon} \right\} = 0$$

First-order Condition on Labor Supply:

$$E_t \left\{ \frac{w_t}{P_t} C_t^{i-\frac{1}{\sigma}} - \kappa N_t^{i\mu-1} \right\} = 0$$

Equation of Aggregate Output:

$$Y_t = \frac{1}{2} y_t(z)$$

B.1.2 Households i^*

Optimization Problem:

$$\text{Max} \qquad E_t U_t^{i^*} = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma - 1} C_s^{i^* \frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^{i^*}}{P_s^*})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i^* \mu}]$$

$$\text{Subject to} \quad M_t^{i^*} + \frac{d_t}{e_t} F_t^{i^*} + d_t^* F_t^{*i^*}$$

$$= M_{t-1}^{i^*} + \frac{1}{e_t} F_{t-1}^{i^*} + F_{t-1}^{*i^*} + w_t^* N_t^{i^*} + \Pi_t^{z^*} - P_t^* C_t^{i^*} - P_t^* T_t^{i^*} - D_t^F$$

$$D_t^F = \frac{\tau}{2} \frac{[e_t^{-1}(F_t^{i^*} - \overline{F}_0^{i^*})]^2}{P_t^* Y_t^*}$$

First-Order Condition on Bond Holdings:

$$E_t \left\{ \frac{d_t}{e_t P_t^*} C_t^{i^* -\frac{1}{\sigma}} - \beta \frac{1}{e_{t+1} P_{t+1}^*} C_{t+1}^{i^* -\frac{1}{\sigma}} + \tau \frac{1}{e_t^2 P_t^{*2} Y_t^*} (F_t^{i^*} - \overline{F}_0^{i^*}) \right\} = 0$$

$$E_t \left\{ \frac{d_t^*}{P_t^*} C_t^{i^* -\frac{1}{\sigma}} - \beta \frac{1}{P_{t+1}^*} C_{t+1}^{i^* -\frac{1}{\sigma}} \right\} = 0$$

First-Order Condition on Money Balances:

$$E_t \left\{ C_t^{i^* -\frac{1}{\sigma}} - \beta \frac{P_t^*}{P_{t+1}^*} C_{t+1}^{i^* -\frac{1}{\sigma}} - \chi (\frac{M_t^{i^*}}{P_t^*})^{-\varepsilon} \right\} = 0$$

First-Order Condition on Labor Supply:

$$E_t \left\{ \frac{w_t^*}{P_t^*} C_t^{i^* -\frac{1}{\sigma}} - \kappa N_t^{i^* \mu-1} \right\} = 0$$

Equation of Aggregate Output:

$$Y_t^* = \frac{1}{2} y_t(z^*)$$

B.1.3 Households j

Optimization Problem without Bond Trade:

Max $\quad E_t U_t^j = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{j\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^j}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j\mu}]$

Subject to $\quad M_t^j = M_{t-1}^j + w_t N_t^j + \Pi_t^z - P_t C_t^j - P_t T_t^j$

First-Order Condition on Money Balances without Bond Trade:

$$E_t \left\{ C_t^{j-\frac{1}{\sigma}} - \beta \frac{P_t}{P_{t+1}} C_{t+1}^{j-\frac{1}{\sigma}} - \chi (\frac{M_t^j}{P_t})^{-\varepsilon} \right\} = 0$$

First-Order Condition on Labor Supply without Bond Trade:

$$E_t \left\{ \frac{w_t}{P_t} C_t^{j-\frac{1}{\sigma}} - \kappa N_t^{j\mu-1} \right\} = 0$$

Optimization Problem without Bond Trade and Monetary Adjustment:

Max $\quad E_t U_t^j = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{j\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{\overline{M}_0^j}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j\mu}]$

Subject to $\quad M_0^j = M_0^j + w_t N_t^j + \Pi_t^z - P_t C_t^j$

First-Order Condition on Labor Supply without Bond Trade and Monetary Adjustment:

$$E_t \left\{ \frac{w_t}{P_t} C_t^{j-\frac{1}{\sigma}} - \kappa N_t^{j\mu-1} \right\} = 0$$

B.1.4 Households j^*

Optimization Problem without Bond Trade:

Max $\quad E_t U_t^{j^*} = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{j^*\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^{j^*}}{P_s^*})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j^*\mu}]$

Subject to $\quad M_t^{j^*} = M_{t-1}^{j^*} + w_t^* N_t^{j^*} + \Pi_t^{z^*} - P_t^* C_t^{j^*} - P_t^* T_t^{j^*}$

First-Order Condition on Money Balances without Bond Trade:

$$E_t \left\{ C_t^{j^*-\frac{1}{\sigma}} - \beta \frac{P_t^*}{P_{t+1}^*} C_{t+1}^{j^*-\frac{1}{\sigma}} - \chi (\frac{M_t^{j^*}}{P_t^*})^{-\varepsilon} \right\} = 0$$

First-Order Condition on Labor Supply without Bond Trade:

$$E_t\left\{\frac{w_t^*}{P_t^*}C_t^{j^*-\frac{1}{\sigma}}-\kappa N_t^{j^*\mu-1}\right\}=0$$

Optimization Problem without Bond Trade and Monetary Adjustment:

Max $\quad E_tU_t^{j^*}=E_t\sum_{s=t}^{\infty}\beta^{s-t}[\frac{\sigma}{\sigma-1}C_s^{j^*\frac{\sigma-1}{\sigma}}+\frac{\chi}{1-\varepsilon}(\frac{\overline{M}_0^{j^*}}{P_s^*})^{1-\varepsilon}-\frac{\kappa}{\mu}N_s^{j^*\mu}]$

Subject to $\quad M_0^{j^*}=M_0^{j^*}+w_t^*N_t^{j^*}+\Pi_t^{z^*}-P_t^*C_t^{j^*}$

First-Order Condition on Labor Supply without Bond Trade and Monetary Adjustment:

$$E_t\left\{\frac{w_t^*}{P_t^*}C_t^{j^*-\frac{1}{\sigma}}-\kappa N_t^{j^*\mu-1}\right\}=0$$

B.1.5 Firms z

Optimization Problem:

Max $\quad E_tV_t^z=E_t\sum_{s=t}^{\infty}\beta^{s-t}\Pi_s^z$

Subject to $\quad \Pi_s^z=p_s(z)y_s(z)-w_sN_s^z-D_s^p$

$$y_s(z)=[\frac{p_s(z)}{P_s}]^{-\theta}[nC_s^i+(\frac{1}{2}-n)C_s^j+\frac{1}{2}G_s+n^*C_s^{i^*}+(\frac{1}{2}-n^*)C_s^{j^*}+\frac{1}{2}G_s^*]$$

$$y_s(z)=A_sN_s^z$$

$$D_s^p=\frac{\upsilon}{2}\frac{[p_s(z)-p_{s-1}(z)]^2}{p_{s-1}(z)}$$

First-Order Condition on Output Prices:

$$E_t\left\{(1-\theta)p_t(z)^{-\theta}P_t^\theta(C_s^w+G_s^w)+\theta p_t(z)^{-\theta-1}P_t^\theta(C_s^w+G_s^w)\frac{w_t}{A_t}\right.$$

$$\left.-\upsilon\frac{p_t-p_{t-1}}{p_{t-1}}+\beta\upsilon\frac{p_{t+1}-p_t}{p_t}+\beta\frac{\upsilon}{2}(\frac{p_{t+1}-p_t}{p_t})^2\right\}=0$$

B.1.6 Firms z^*

Optimization Problem:

Max $\quad E_t V_t^{z^*} = E_t \sum_{s=t}^{\infty} \beta^{s-t} \Pi_s^{z^*}$

Subject to $\quad \Pi_s^{z^*} = p_s^*(z^*) y_s(z^*) - w_s^* N_s^{z^*} - D_s^{p^*}$

$$y_s(z^*) = [\frac{p_s^*(z^*)}{P_s^*}]^{-\theta} [nC_s^i + (\frac{1}{2} - n) C_s^j + \frac{1}{2} G_s + n^* C_s^{i^*} + (\frac{1}{2} - n^*) C_s^{j^*} + \frac{1}{2} G_s^*]$$

$$y_s^*(z^*) = A_s^* N_s^{z^*}$$

$$D_s^{p^*} = \frac{\upsilon}{2} \frac{[p_s^*(z^*) - p_{s-1}^*(z^*)]^2}{p_{s-1}^*(z^*)}$$

First-Order Condition on Output Prices:

$$E_t \left\{ (1-\theta) p_t^*(z^*)^{-\theta} P_t^{*\theta} (C_s^w + G_s^w) + \theta p_t^*(z^*)^{-\theta-1} P_t^{*\theta} (C_s^w + G_s^w) \frac{w_t^*}{A_t^*} \right.$$

$$\left. - \upsilon \frac{p_t^* - p_{t-1}^*}{p_{t-1}^*} + \beta \upsilon \frac{p_{t+1}^* - p_t^*}{p_t^*} + \beta \frac{\upsilon}{2} (\frac{p_{t+1}^* - p_t^*}{p_t^*})^2 \right\} = 0$$

B.2 Table

Table 2.1: Welfare Results of Home Households with n Equaling .50, .25 and .05

	n = .50 / Household i			n = .25 / Household i			n = .25 / Household j			n = .05 / Household i			n = .05 / Household j		
n^*	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a
.50	-.5500	-.0377	-.5878	-.5472	-.0280	-.5752	-.5514	-.0633	-.6147	-.5374	-.0160	-.5534	-.5505	-.0610	-.6115
.45	-.5500	-.0383	-.5883	-.5473	-.0287	-.5760	-.5514	-.0631	-.6145	-.5380	-.0163	-.5543	-.5505	-.0610	-.6115
.40	-.5500	-.0390	-.5890	-.5475	-.0295	-.5770	-.5514	-.0629	-.6143	-.5388	-.0167	-.5554	-.5504	-.0610	-.6113
.35	-.5500	-.0398	-.5898	-.5478	-.0305	-.5783	-.5514	-.0627	-.6141	-.5396	-.0171	-.5567	-.5504	-.0609	-.6113
.30	-.5500	-.0409	-.5909	-.5480	-.0318	-.5798	-.5514	-.0625	-.6139	-.5405	-.0177	-.5582	-.5503	-.0609	-.6112
.25	-.5501	-.0422	-.5923	-.5484	-.0334	-.5817	-.5513	-.0623	-.6136	-.5416	-.0184	-.5600	-.5503	-.0608	-.6112
.20	-.5501	-.0439	-.5941	-.5487	-.0354	-.5842	-.5513	-.0620	-.6133	-.5427	-.0195	-.5623	-.5503	-.0608	-.6111
.15	-.5502	-.0462	-.5964	-.5491	-.0383	-.5873	-.5512	-.0617	-.6129	-.5441	-.0212	-.5653	-.5503	-.0607	-.6110
.10	-.5502	-.0492	-.5994	-.5495	-.0422	-.5917	-.5511	-.0613	-.6124	-.5457	-.0243	-.5700	-.5503	-.0606	-.6109
.05	-.5502	-.0534	-.6036	-.5498	-.0484	-.5982	-.5508	-.0608	-.6116	-.5477	-.0310	-.5787	-.5503	-.0605	-.6107

U^m denotes the shift of initial steady-state consumption delivering the same expected utility associated with the mean part.
U^v denotes the shift of initial steady-state consumption delivering the same expected utility associated with the variance part.
U^a is the sum of U^m and U^v.
When households j are undefined as in the case of n equaling .5, welfare measures associated with them are excluded.

Table 2.2 (2-1): Welfare Results of Home Households with n^* Equaling .50, .25 and .05

	n^* = .50 / Household i			n^* = .50 / Household j			n^* = .25 / Household i			n^* = .25 / Household j		
n	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a
.50	-.5500	-.0377	-.5878	na	na	na	-.5501	-.0422	-.5923	na	na	na
.45	-.5498	-.0362	-.5860	-.5523	-.0643	-.6166	-.5498	-.0409	-.5907	-.5519	-.0628	-.6147
.40	-.5494	-.0344	-.5838	-.5521	-.0641	-.6162	-.5496	-.0394	-.5890	-.5518	-.0627	-.6145
.35	-.5488	-.0325	-.5813	-.5519	-.0639	-.6158	-.5493	-.0377	-.5870	-.5517	-.0626	-.6143
.30	-.5481	-.0304	-.5784	-.5516	-.0636	-.6152	-.5489	-.0357	-.5846	-.5515	-.0625	-.6140
.25	-.5472	-.0280	-.5752	-.5514	-.0633	-.6147	-.5484	-.0334	-.5817	-.5513	-.0623	-.6136
.20	-.5461	-.0254	-.5715	-.5511	-.0629	-.6140	-.5477	-.0306	-.5783	-.5511	-.0620	-.6132
.15	-.5445	-.0226	-.5671	-.5508	-.0624	-.6132	-.5467	-.0273	-.5739	-.5509	-.0618	-.6127
.10	-.5422	-.0195	-.5617	-.5505	-.0618	-.6123	-.5450	-.0233	-.5683	-.5506	-.0614	-.6120
.05	-.5374	-.0160	-.5534	-.5505	-.0610	-.6115	-.5416	-.0184	-.5600	-.5503	-.0608	-.6112

U^m denotes the shift of initial steady-state consumption delivering the same expected utility associated with the mean part.
U^v denotes the shift of initial steady-state consumption delivering the same expected utility associated with the variance part.
U^a is the sum of U^m and U^v.

Table 2.2 (2-2): Welfare Results of Home Households with n^* Equaling .50, .25 and .05 (Continuous)

	n^* = .05 / Household i			n^* = .05 / Household j		
n	U^m	U^v	U^a	U^m	U^v	U^a
.50	-.5502	-.0534	-.6036	na	na	na
.45	-.5502	-.0527	-.6029	-.5509	-.0608	-.6117
.40	-.5501	-.0520	-.6021	-.5509	-.0608	-.6117
.35	-.5501	-.0510	-.6011	-.5509	-.0608	-.6116
.30	-.5500	-.0499	-.5998	-.5508	-.0608	-.6116
.25	-.5498	-.0484	-.5982	-.5508	-.0608	-.6116
.20	-.5497	-.0463	-.5960	-.5508	-.0607	-.6115
.15	-.5494	-.0435	-.5929	-.5507	-.0607	-.6114
.10	-.5489	-.0390	-.5879	-.5506	-.0606	-.6112
.05	-.5477	-.0310	-.5787	-.5503	-.0605	-.6107

U^m denotes the shift of initial steady-state consumption delivering the same expected utility associated with the mean part.
U^v denotes the shift of initial steady-state consumption delivering the same expected utility associated with the variance part.
U^a is the sum of U^m and U^v.

Table 2.3: Welfare Results of Home Households under Lower Price Rigidity with n Equaling .50, .25 and .05

	n = .50 / Household i			n = .25 / Household i			n = .25 / Household j			n = .05 / Household i			n = .05 / Household j		
n^*	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a
.50	-.5119	-.0274	-.5394	-.5090	-.0202	-.5292	-.5138	-.0466	-.5605	-.4976	-.0110	-.5086	-.5132	-.0457	-.5589
.45	-.5119	-.0278	-.5397	-.5091	-.0207	-.5298	-.5138	-.0465	-.5604	-.4983	-.0112	-.5095	-.5131	-.0457	-.5588
.40	-.5119	-.0283	-.5402	-.5093	-.0212	-.5305	-.5138	-.0465	-.5603	-.4992	-.0115	-.5107	-.5131	-.0457	-.5588
.35	-.5119	-.0289	-.5408	-.5096	-.0220	-.5315	-.5138	-.0464	-.5602	-.5002	-.0118	-.5120	-.5130	-.0456	-.5587
.30	-.5120	-.0297	-.5417	-.5099	-.0229	-.5328	-.5138	-.0463	-.5601	-.5012	-.0123	-.5135	-.5130	-.0456	-.5586
.25	-.5121	-.0307	-.5428	-.5103	-.0241	-.5344	-.5138	-.0462	-.5600	-.5025	-.0128	-.5153	-.5130	-.0456	-.5586
.20	-.5122	-.0321	-.5443	-.5107	-.0257	-.5364	-.5138	-.0460	-.5599	-.5039	-.0137	-.5175	-.5129	-.0456	-.5585
.15	-.5123	-.0339	-.5462	-.5112	-.0279	-.5391	-.5138	-.0459	-.5597	-.5055	-.0150	-.5205	-.5129	-.0455	-.5584
.10	-.5125	-.0363	-.5488	-.5117	-.0310	-.5427	-.5137	-.0457	-.5594	-.5074	-.0173	-.5247	-.5129	-.0455	-.5584
.05	-.5127	-.0398	-.5525	-.5123	-.0359	-.5481	-.5135	-.0455	-.5590	-.5097	-.0225	-.5322	-.5129	-.0454	-.5583

U^m denotes the shift of initial steady-state consumption delivering the same expected utility associated with the mean part.
U^v denotes the shift of initial steady-state consumption delivering the same expected utility associated with the variance part.
U^a is the sum of U^m and U^v.
When households j are undefined as in the case of n equaling .5, welfare measures associated with them are excluded.

Table 2.4: Welfare Results of Home Households under Higher Elasticity of Consumption Demand with n Equaling .50, .25 and .05

	n = .50 / Household i			n = .25 / Household i			n = .25 / Household j			n = .05 / Household i			n = .05 / Household j		
n^*	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a
.50	-.5202	-.0291	-.5493	-.5165	-.0212	-.5377	-.5237	-.0498	-.5735	-.5019	-.0108	-.5127	-.5235	-.0484	-.5719
.45	-.5202	-.0295	-.5497	-.5168	-.0218	-.5386	-.5237	-.0497	-.5734	-.5031	-.0111	-.5142	-.5234	-.0484	-.5717
.40	-.5203	-.0300	-.5503	-.5172	-.0224	-.5396	-.5238	-.0496	-.5733	-.5044	-.0115	-.5159	-.5234	-.0484	-.5717
.35	-.5204	-.0307	-.5511	-.5177	-.0233	-.5409	-.5238	-.0495	-.5732	-.5058	-.0120	-.5178	-.5233	-.0483	-.5716
.30	-.5206	-.0316	-.5522	-.5182	-.0243	-.5425	-.5238	-.0493	-.5731	-.5074	-.0125	-.5199	-.5233	-.0483	-.5716
.25	-.5209	-.0327	-.5536	-.5188	-.0256	-.5444	-.5238	-.0492	-.5730	-.5091	-.0132	-.5223	-.5232	-.0483	-.5715
.20	-.5212	-.0341	-.5553	-.5194	-.0273	-.5467	-.5239	-.0490	-.5729	-.5110	-.0142	-.5252	-.5232	-.0483	-.5715
.15	-.5215	-.0360	-.5575	-.5201	-.0296	-.5497	-.5239	-.0488	-.5727	-.5131	-.0157	-.5288	-.5232	-.0482	-.5714
.10	-.5219	-.0386	-.5605	-.5209	-.0329	-.5538	-.5238	-.0486	-.5724	-.5156	-.0183	-.5339	-.5232	-.0482	-.5714
.05	-.5224	-.0421	-.5645	-.5218	-.0380	-.5598	-.5237	-.0482	-.5719	-.5186	-.0238	-.5424	-.5232	-.0480	-.5713

U^m denotes the shift of initial steady-state consumption delivering the same expected utility associated with the mean part.
U^v denotes the shift of initial steady-state consumption delivering the same expected utility associated with the variance part.
U^a is the sum of U^m and U^v.
When households j are undefined as in the case of n equaling .5, welfare measures associated with them are excluded.

Table 2.5: Welfare Results of Home Households under Lower Elasticity of Labor Supply with n Equaling .50, .25 and .05

	n = .50 / Household i			n = .25 / Household i			n = .25 / Household j			n = .05 / Household i			n = .05 / Household j		
n^*	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a
.50	-.5385	-.0320	-.5705	-.5333	-.0230	-.5563	-.5462	-.0552	-.6014	-.5097	-.0118	-.5215	-.5461	-.0537	-.5998
.45	-.5386	-.0324	-.5710	-.5339	-.0235	-.5574	-.5461	-.0551	-.6011	-.5118	-.0118	-.5236	-.5460	-.0537	-.5997
.40	-.5388	-.0330	-.5718	-.5345	-.0243	-.5588	-.5460	-.0550	-.6010	-.5141	-.0119	-.5260	-.5459	-.0537	-.5996
.35	-.5392	-.0337	-.5729	-.5353	-.0251	-.5605	-.5459	-.0548	-.6007	-.5166	-.0122	-.5288	-.5458	-.0537	-.5995
.30	-.5396	-.0347	-.5743	-.5362	-.0263	-.5625	-.5458	-.0547	-.6005	-.5192	-.0127	-.5319	-.5457	-.0536	-.5993
.25	-.5402	-.0359	-.5761	-.5372	-.0277	-.5649	-.5457	-.0545	-.6002	-.5221	-.0134	-.5355	-.5457	-.0536	-.5993
.20	-.5409	-.0375	-.5784	-.5384	-.0296	-.5680	-.5456	-.0544	-.6000	-.5253	-.0145	-.5398	-.5456	-.0536	-.5992
.15	-.5416	-.0397	-.5813	-.5396	-.0323	-.5719	-.5455	-.0542	-.5997	-.5288	-.0163	-.5451	-.5456	-.0535	-.5991
.10	-.5426	-.0426	-.5851	-.5411	-.0360	-.5771	-.5455	-.0539	-.5994	-.5328	-.0192	-.5520	-.5456	-.0535	-.5991
.05	-.5437	-.0467	-.5904	-.5428	-.0419	-.5847	-.5454	-.0536	-.5990	-.5377	-.0255	-.5632	-.5456	-.0534	-.5990

U^m denotes the shift of initial steady-state consumption delivering the same expected utility associated with the mean part.
U^v denotes the shift of initial steady-state consumption delivering the same expected utility associated with the variance part.
U^a is the sum of U^m and U^v.
When households j are undefined as in the case of n equaling .5, welfare measures associated with them are excluded.

Table 2.6: Welfare Results of Home Households under Monetary Restrictions with n Equaling .50, .45 and .40

	n = .50 / Household i			n = .45 / Household i			n = .45 / Household j			n = .40 / Household i			n = .40 / Household j		
n^*	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a	U^m	U^v	U^a
.50	-.5501	-.0377	-.5879	-.5832	-.0538	-.6370	-.5853	-.1046	-.6898	-.6162	-.0778	-.6940	-.6184	-.1514	-.7698
.45	-.5509	-.0392	-.5901	-.5834	-.0553	-.6386	-.5852	-.1032	-.6884	-.6164	-.0799	-.6962	-.6184	-.1495	-.7679
.40	-.5510	-.0404	-.5914	-.5835	-.0569	-.6404	-.5851	-.1017	-.6868	-.6165	-.0822	-.6988	-.6183	-.1475	-.7658
.35	-.5511	-.0417	-.5928	-.5837	-.0588	-.6425	-.5849	-.1002	-.6851	-.6167	-.0849	-.7016	-.6182	-.1453	-.7635
.30	-.5512	-.0432	-.5944	-.5838	-.0609	-.6448	-.5848	-.0985	-.6833	-.6169	-.0880	-.7049	-.6180	-.1429	-.7610
.25	-.5513	-.0449	-.5963	-.5840	-.0634	-.6474	-.5846	-.0967	-.6813	-.6171	-.0915	-.7086	-.6179	-.1403	-.7582
.20	-.5514	-.0469	-.5984	-.5841	-.0663	-.6504	-.5844	-.0947	-.6791	-.6172	-.0957	-.7129	-.6177	-.1375	-.7552
.15	-.5515	-.0493	-.6007	-.5841	-.0697	-.6538	-.5842	-.0926	-.6768	-.6173	-.1006	-.7179	-.6175	-.1343	-.7519
.10	-.5515	-.0521	-.6036	-.5842	-.0737	-.6579	-.5839	-.0902	-.6742	-.6174	-.1064	-.7238	-.6173	-.1309	-.7481
.05	-.5515	-.0554	-.6069	-.5842	-.0785	-.6627	-.5836	-.0877	-.6714	-.6174	-.1135	-.7308	-.6170	-.1270	-.7440

U^m denotes the shift of initial steady-state consumption delivering the same expected utility associated with the mean part.
U^v denotes the shift of initial steady-state consumption delivering the same expected utility associated with the variance part.
U^a is the sum of U^m and U^v.
When households j are undefined as in the case of n equaling .5, welfare measures associated with them are excluded.

Appendix C

Appendices of Chapter 3

C.1 Optimization Problem and First-Order Condition

C.1.1 Households i

Optimization Problem:

$$\text{Max} \qquad E_t U_t^i = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{i\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^i}{P_s})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i\mu}]$$

$$\text{Subject to} \quad M_t^i + \sum_{x_{t+1} \in X} d(x_{t+1}, x_t) F^i(x_{t+1}) = M_{t-1}^i + F^i(x_t) + w_t N_t^i + \Pi_{ht}^z - P_t C_t^i - P_t T_t^i$$

First-Order Condition on Bond Holdings:

$$d(x_{t+1}, x_t) \frac{1}{P_t} C_t^{i\,-\frac{1}{\sigma}} = q(x_{t+1}, x_t) \beta \frac{1}{P_{t+1}} C_{t+1}^{i\,-\frac{1}{\sigma}}$$

First-Order Condition on Money Balances:

$$\frac{M_t^i}{P_t} = \chi^{\frac{1}{\varepsilon}} (1 - E_t D_{t+1})^{-\frac{1}{\varepsilon}} C_t^{i\frac{1}{\varepsilon\sigma}} \qquad D_{t+1} = \beta \frac{P_t C_t^{i\frac{1}{\sigma}}}{P_{t+1} C_{t+1}^{i\frac{1}{\sigma}}}$$

First-order Condition on Labor Supply:

$$N_t^i = (\frac{1}{\kappa} \frac{w_t}{P_t} C_t^{i\,-\frac{1}{\sigma}})^{\frac{1}{\mu-1}}$$

C.1.2 Households i^*

Optimization Problem:

$$\text{Max} \qquad E_t U_t^{i^*} = E_t \sum_{s=t}^{\infty} \beta^{s-t} [\frac{\sigma}{\sigma-1} C_s^{i^*\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} (\frac{M_s^{i^*}}{P_s^*})^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{i^*\mu}]$$

Subject to $$M_t^{i^*} + \sum_{x_{t+1}\in X} \frac{d(x_{t+1},x_t)}{e_t} F^{i^*}(x_{t+1})$$

$$= M_{t-1}^{i^*} + \frac{1}{e_t} F^{i^*}(x_t) + w_t^* N_t^{i^*} + \Pi_{ft}^{z^*} - P_t^* C_t^{i^*} - P_t^* T_t^{i^*}$$

First-Order Condition on Bond Holdings:

$$d(x_{t+1},x_t)\frac{1}{P_t^*} C_t^{i^* -\frac{1}{\sigma}} = q(x_{t+1},x_t)\beta \frac{1}{P_{t+1}^*} C_{t+1}^{i^* -\frac{1}{\sigma}}$$

First-Order Condition on Money Balances:

$$\frac{M_t^{i^*}}{P_t^*} = \chi^{\frac{1}{\varepsilon}} (1 - E_t D_{t+1}^*)^{-\frac{1}{\varepsilon}} C_t^{i^* \frac{1}{\varepsilon\sigma}} \qquad D_{t+1}^* = \beta \frac{P_t^* C_t^{i^* \frac{1}{\sigma}}}{P_{t+1}^* C_{t+1}^{i^* \frac{1}{\sigma}}}$$

First-Order Condition on Labor Supply:

$$N_t^{i^*} = \left(\frac{1}{\kappa}\frac{w_t^*}{P_t^*} C_t^{i^* -\frac{1}{\sigma}}\right)^{\frac{1}{\mu-1}}$$

C.1.3 Households j

Optimization Problem:

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

Subject to $$M_0^j = M_0^j + w_t N_t^j + \Pi_{ht}^z - P_t C_t^j$$

First-Order Condition on Labor Supply:

$$N_t^j = \left(\frac{1}{\kappa}\frac{w_t}{P_t} C_t^{j -\frac{1}{\sigma}}\right)^{\frac{1}{\mu-1}}$$

C.1.4 Households j^*

Optimization Problem:

Max $$E_t U_t^{j^*} = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} C_s^{j^* \frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon}\left(\frac{\overline{M}_0^{j^*}}{P_s^*}\right)^{1-\varepsilon} - \frac{\kappa}{\mu} N_s^{j^*\mu}\right]$$

Subject to $$M_0^{j^*} = M_0^{j^*} + w_t^* N_t^{j^*} + \Pi_{ft}^{z^*} - P_t^* C_t^{j^*}$$

First-Order Condition on Labor Supply:

$$N_t^{j^*} = (\frac{1}{\kappa}\frac{w_t^*}{P_t^*}C_t^{j^{*}-\frac{1}{\sigma}})^{\frac{1}{\mu-1}}$$

C.1.5 Firms z

Optimization Problem:

Max $\quad E_{t-1}V_{ht}^z = E_{t-1}D_t\Pi_{ht}^z$

Subject to $\quad \Pi_{ht}^z = p_{ht}(z)y_{ht}(z) - w_t N_{ht}^z$

$$y_{ht}(z) = y_{ht}^d(z) = \frac{P_t}{P_{ht}}[\frac{p_{ht}(z)}{P_{ht}}]^{-\lambda}[nC_t^i + (\frac{1}{2}-n)C_t^j + n^* C_t^{i^*} + (\frac{1}{2}-n^*)C_t^{j^*}]$$

$$y_{ht}(z) = A_t N_{ht}^z$$

$$D_t = \beta P_{t-1}C_{t-1}^{i\,\frac{1}{\sigma}}P_t C_t^{i\,-\frac{1}{\sigma}}$$

First-Order Condition on Output Prices:

$$p_{ht}(z) = \frac{\lambda}{\lambda-1}\frac{E_{t-1}\left\{\frac{w_t}{A_t}[n+(\frac{1}{2}-n)\frac{C_t^j}{C_t^i}+n^*\frac{C_t^{i^*}}{C_t^i}+(\frac{1}{2}-n^*)\frac{C_t^{j^*}}{C_t^i}]C_t^{i\,1-\frac{1}{\sigma}}\right\}}{E_{t-1}\left\{[n+(\frac{1}{2}-n)\frac{C_t^j}{C_t^i}+n^*\frac{C_t^{i^*}}{C_t^i}+(\frac{1}{2}-n^*)\frac{C_t^{j^*}}{C_t^i}]C_t^{i\,1-\frac{1}{\sigma}}\right\}}$$

C.1.6 Firms z^*

Optimization Problem:

Max $\quad E_{t-1}V_{ft}^{z^*} = E_{t-1}D_t^*\Pi_{ft}^{z^*}$

Subject to $\quad \Pi_{ft}^{z^*} = p_{ft}^*(z^*)y_{ft}(z^*) - w_t^* N_{ft}^{z^*}$

$$y_{ft}(z^*) = \frac{P_t^*}{P_{ft}^*}[\frac{p_{ft}^*(z^*)}{P_{ft}^*}]^{-\lambda}[nC_t^i + (\frac{1}{2}-n)C_t^j + n^* C_t^{i^*} + (\frac{1}{2}-n^*)C_t^{j^*}]$$

$$y_{ft}(z^*) = A_t^* N_{ft}^{z^*}$$

$$D_t^* = \beta P_{t-1}^* C_{t-1}^{i^*\,\frac{1}{\sigma}}P_t^* C_t^{i^*\,-\frac{1}{\sigma}}$$

First-Order Condition on Output Prices:

$$p^{*}_{fi}(z^{*}) = \frac{\lambda}{\lambda-1}\frac{E_{t-1}\left\{\frac{w^{*}_{t}}{A^{*}_{t}}[n\frac{C^{i}_{t}}{C^{i^{*}}_{t}}+(\frac{1}{2}-n)\frac{C^{j}_{t}}{C^{i^{*}}_{t}}+n^{*}+(\frac{1}{2}-n^{*})\frac{C^{j^{*}}_{t}}{C^{i^{*}}_{t}}]C^{i^{*}1-\frac{1}{\sigma}}_{t}\right\}}{E_{t-1}\left\{[n\frac{C^{i}_{t}}{C^{i^{*}}_{t}}+(\frac{1}{2}-n)\frac{C^{j}_{t}}{C^{i^{*}}_{t}}+n^{*}+(\frac{1}{2}-n^{*})\frac{C^{j^{*}}_{t}}{C^{i^{*}}_{t}}]C^{i^{*}1-\frac{1}{\sigma}}_{t}\right\}}$$

C.2 Table

Table 3.1: Welfare Results of Financially Unconstrained Home Households *i*

n^* \ n	.50	.40	.30	.20	.15	.10	.05	.01
.50	-12.8792, -15.4458	-15.0733, -15.9481	-11.8055, -10.8160	-13.2814, -11.5190	-17.1220, -16.4275	-11.9068, -14.9313	-10.3143, -10.5455	-12.7093, -9.9839
.40	-12.1244, -13.4514	-17.0315, -15.0590	-14.2933, -13.0362	-14.0794, -15.5838	-13.3704, -12.7345	-13.1786, -13.9941	-11.2714, -11.8633	-12.7717, -11.6126
.30	-13.9102, -17.9424	-13.6980, -15.0515	-15.4796, -17.0480	-14.6518, -15.4157	-13.6172, -11.2750	-13.7300, -11.1711	-14.8088, -10.1752	-12.8802, -8.7531
.20	-13.7645, -17.7887	-11.8424, -16.5284	-12.9052, -15.4339	-12.6691, -14.3610	-13.8049, -11.2387	-14.0894, -9.0688	-14.1083, -15.4816	-15.8844, -11.4573
.15	-12.2311, -12.9052	-18.3281, -16.9643	-14.5884, -11.1443	-12.9442, -12.4763	-17.0607, -12.4903	-12.6243, -11.8340	-14.9345, -10.2380	-13.3643, -10.5124
.10	-15.8832, -13.8091	-16.7244, -15.4061	-12.5050, -12.4653	-14.3271, -11.7346	-13.1162, -10.2035	-14.2803, -10.9647	-13.2158, -11.1282	-14.7908, -14.0855
.05	-12.7723, -11.9833	-16.6253, -13.4537	-17.9751, -11.6601	-12.9009, -10.1174	-13.1116, -11.3532	-14.6689, -15.2033	-14.2363, -9.0063	-16.0855, -11.4884
.01	-11.7044, -10.5282	-14.5989, -11.0016	-12.1414, -8.5781	-14.4611, -10.8776	-12.7939, -12.1764	-14.3219, -13.5946	-11.9179, -11.0337	-15.3838, -10.2906

The first number from each pair of welfare data is expected utility under the flexible exchange-rate regime given the particular n-n^* combination.
The second number from each pair of welfare data is expected utility under the fixed exchange-rate regime given the particular n-n^* combination.

Table 3.2: Welfare Results of Financially Unconstrained Foreign Households i^*

n^* \ n	.50	.40	.30	.20	.15	.10	.05	.01
.50	-12.8793, -15.4457	-15.0735, -15.9480	-11.8052, -10.8162	-13.2812, -11.5190	-17.1219, -16.4275	-11.9063, -14.9310	-10.3121, -10.5444	-12.7078, -9.9818
.40	-12.1242, -13.4511	-17.0316, -15.0590	-14.2937, -13.0361	-14.0792, -15.5847	-13.3701, -12.7339	-13.1783, -13.9938	-11.2694, -11.8625	-12.7698, -11.6116
.30	-13.9102, -17.9424	-13.6977, -15.0514	-15.4796, -17.0481	-14.6518, -15.4155	-13.6171, -11.2744	-13.7296, -11.1704	-14.8075, -10.1733	-12.8783, -8.7500
.20	-13.7649, -17.7888	-11.8423, -16.5286	-12.9050, -15.4341	-12.6692, -14.3613	-13.8048, -11.2386	-14.0890, -9.0681	-14.1070, -15.4808	-15.8822, -11.4557
.15	-12.2314, -12.9056	-18.3283, -16.9646	-14.5888, -11.1445	-12.9443, -12.4764	-17.0606, -12.4904	-12.6237, -11.8341	-14.9332, -10.2366	-13.3616, -10.5087
.10	-15.8831, -13.8093	-16.7243, -15.4065	-12.5055, -12.4658	-14.3280, -11.7346	-13.1168, -10.2042	-14.2803, -10.9651	-13.2146, -11.1279	-14.7890, -14.0840
.05	-12.7732, -11.9842	-16.6257, -13.4549	-17.9756, -11.6613	-12.9027, -10.1193	-13.1132, -11.3544	-14.6695, -15.2038	-14.2364, -9.0055	-16.0846, -11.4877
.01	-11.7058, -10.5299	-14.6002, -11.0030	-12.1442, -8.5822	-14.4630, -10.8804	-12.7967, -12.1789	-14.3242, -13.5956	-11.9192, -11.0350	-15.3838, -10.2905

The first number from each pair of welfare data is expected utility under the flexible exchange-rate regime given the particular n-n^* combination.
The second number from each pair of welfare data is expected utility under the fixed exchange-rate regime given the particular n-n^* combination.

Table 3.3: Welfare Results of Financially Constrained Home Households j

n^* \ n	.50	.40	.30	.20	.15	.10	.05	.01
.50	na	-15.0755, -15.9500	-11.8002, -10.8198	-13.2825, -11.5189	-17.1242, -16.4306	-11.9206, -14.9379	-10.3180, -10.5516	-12.7247, -9.9907
.40	na	-17.0354, -15.0597	-14.2997, -13.0354	-14.0807, -15.6205	-13.3869, -12.7377	-13.1978, -14.0019	-11.2789, -11.8868	-12.7884, -11.6481
.30	na	-13.6953, -15.0548	-15.4835, -17.0505	-14.6561, -15.4199	-13.6228, -11.2804	-13.7424, -11.1854	-14.8089, -10.1870	-12.9385, -8.8312
.20	na	-11.8372, -16.5292	-12.9017, -15.4396	-12.6824, -14.3793	-13.8072, -11.2613	-14.1413, -9.1134	-14.1538, -15.4854	-15.8907, -11.6278
.15	na	-18.3287, -16.9656	-14.5980, -11.1580	-12.9560, -12.5015	-17.0555, -12.5153	-12.6809, -11.9294	-14.9811, -10.4846	-13.4579, -10.5993
.10	na	-16.7260, -15.4117	-12.5120, -12.4897	-14.3406, -11.8287	-13.1332, -10.2029	-14.3067, -11.1885	-13.3281, -11.4009	-14.9588, -14.3854
.05	na	-16.6181, -13.4467	-17.9846, -11.6740	-12.9201, -10.1743	-13.1718, -11.5081	-14.7495, -15.3100	-14.4566, -9.3911	-16.6187, -12.3615
.01	na	-14.6055, -11.0197	-12.1591, -8.5941	-14.4978, -10.9656	-12.9079, -12.2703	-14.4614, -13.6792	-12.7277, -11.8259	-15.9862, -15.2335

The first number from each pair of welfare data is expected utility under the flexible exchange-rate regime given the particular n-n^* combination.
The second number from each pair of welfare data is expected utility under the fixed exchange-rate regime given the particular n-n^* combination.

Table 3.4: Welfare Results of Financially Constrained Foreign Households j^*

n^* \ n	.50	.40	.30	.20	.15	.10	.05	.01
.50	na	na	na	na	na	na	na	na
.40	-12.1299, -13.4560	-17.0315, -15.0595	-14.2960, -13.0339	-14.0764, -15.6133	-13.3855, -12.7354	-13.1901, -13.9993	-11.2757, -11.8783	-12.7786, -11.6376
.30	-13.9107, -17.9427	-13.7056, -15.0574	-15.4914, -17.0491	-14.6539, -15.4193	-13.6204, -11.2806	-13.7365, -11.1812	-14.8058, -10.1789	-12.9217, -8.8110
.20	-13.7653, -17.7891	-11.8480, -16.5309	-12.9117, -15.4391	-12.6769, -14.3749	-13.8053, -11.2597	-14.1332, -9.1123	-14.1463, -15.4827	-15.8913, -11.6015
.15	-12.2363, -12.9103	-18.3311, -16.9676	-14.5969, -11.1670	-12.9595, -12.5025	-17.0578, -12.5136	-12.6762, -11.9238	-14.9782, -10.4713	-13.4540, -10.5900
.10	-15.8979, -13.8162	-16.7383, -15.4144	-12.5123, -12.4960	-14.3395, -11.8397	-13.1353, -10.2072	-14.3061, -11.1879	-13.3262, -11.3839	-14.9532, -14.3736
.05	-12.7850, -11.9929	-16.6291, -13.4410	-17.9887, -11.6811	-12.9278, -10.1863	-13.1752, -11.5216	-14.7633, -15.3115	-14.4572, -9.4000	-16.6191, -12.3492
.01	-11.7322, -10.5420	-14.6127, -11.0347	-12.1650, -8.6052	-14.5152, -10.9783	-12.9210, -12.2801	-14.4664, -13.6819	-12.7357, -11.8298	-15.9854, -15.2317

The first number from each pair of welfare data is expected utility under the flexible exchange-rate regime given the particular n-n^* combination.
The second number from each pair of welfare data is expected utility under the fixed exchange-rate regime given the particular n-n^* combination.