The Cost Channel and Exchange Rate Systems*

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Abstract

This paper investigates the role of the cost channel in the choice of exchange rate systems with a two-country model with financial intermediary. We compare macroeconomic stability and the properties of the international transmission of business cycles under three exchange rate systems, a flexible (FLEX), monetary union (MU) and a unilateral peg (PEG). When the firms finance limited parts of their operational costs from the commercial bank, or the cost channel is weak, macroeconomic volatility is highest under FLEX. This is because stabilization in the nominal exchange rate helps to stabilize other macro variables under MU and PEG. We assume the central bank in a monetary union follows a Taylor rule with inflation and output in both countries, thus, volatility becomes higher under PEG than MU. On the other hand, when the firms finance all their operational costs from the commercial bank, or the cost channel is strong, FLEX becomes the regime that realizes the lowest volatility. Responses in inflation and other variables to disturbances are amplified through the cost channel. Under FLEX, the central banks in each country controls the policy rates against the fluctuation in their own inflation and output. The choice of exchange rate system significantly depends on the existence of the cost channel.

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1 Introduction

How international monetary arrangements affect the macroeconomic volatility has always been one of the most important issues in the study of international finance. Many countries as Japan,

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Korea, the UK, and the US employ flexible exchange rate systems, the others as Brunei, Bulgaria, China, and Malaysia adopt fixed exchange rate systems. A part of the European countries had decided to introduce a common currency and get rid of exchange rate fluctuations among them eternally, although the value of their currency euro fluctuates to the other currencies. What types of exchange rate arrangements should be chosen is always an important policy topic for all the countries, and many researchers, from the classical Mundell-Fleming model on, dealt with that issue.

Given the international capital mobility, as implied by the impossible trinity of international finance, exchange rate arrangements and monetary policy decisions are two sides of the same coin. Remarkable development of the monetary policy study in the 1990s had inevitably stimulated the progress of the research on international monetary arrangements[1]. The cost channel is one of the topics that attract researchers in the monetary policy field. Most firms borrow from outside, namely external finance, and pay interest according to amounts of their liabilities. This implies that controlling the policy interest rate affects business cycles not only through the inter-temporal Euler equation but also through firms' marginal costs, say the cost channel. Barth and Ramey (2001) empirically supports the existence of the cost channel and Ravenna and Walsh (2006) finds that the monetary policy transmission depends on it based on a strict model. We imply that the choice of exchange rate system significantly depends on the existence of the cost channel by constructing a two-country model with financial intermediary.

The remainder of this paper proceeds as follows. Section 2 presents a model and Section 3 shows our calibration method. Section 4 compares volatility in alternative regimes and shows the role of the cost channel in the choice of exchange rate systems. Finally, Section 5 provides the conclusion.

2 Model

We model a world economy with two countries, Country 1 and 2. There are a household, a commercial banker, a central bank, a final good firm, and intermediate goods firms that produce a continuum of tradable intermediate goods. Each household owns the domestic producers and supplies labor to them. A commercial banker collects deposits from the domestic household, enters in the international call money market, and works on lending to domestic intermediate goods firms. Intermediate goods firms input capital and labor for their productions and borrow from a commercial banker to finance a fraction γ of their total costs. They are indexed by f in

[1] Collard and Dellas (2002), Ching and Devereux (2003), Kollmann (2004), Dellas and Tavlas (2005), and Gali and Monacelli (2005) are the examples for the study on international monetary arrangements.

both countries. A final good firm bundles domestic and imported intermediates into a nontradable final consumption / investment good. Preferences and technologies are symmetric across countries. The following description focuses on Country 1.

2.1 Household

The preference of the household is described by

$$u(c_{1,t}, n_{1,t}) = \ln c_{1,t} - n_{1,t} \tag{1}$$

$c_{1,t}$ and $n_{1,t}$ are consumption and labor effort, respectively. The household accumulates the physical capital $k_{1,t}$, subject to the law of motion

$$k_{1,t+1} = (1-\delta)k_{1,t} + x_{1,t} \tag{2}$$

where $x_{1,t}$ is gross investment, and $0 < \delta < 1$ is the depreciation rate of capital. The household holds deposit and obtains its interests. The budget constraint is:

$$p_{1,t}c_{1,t} + p_{1,t}x_{1,t} + d_{1,t+1} = r_{1,t}k_{1,t} + w_{1,t}n_{1,t} + (1 + i^d_{1,t-1})d_{1,t} + \xi_{1,t} \tag{3}$$

$d_{1,t}$ is the household's nominal holdings of deposits. The nominal interest rate on deposits $i^d_{1,t}$ is paid at the beginning of period $t+1$ and known at time t. $p_{1,t}$, $r_{1,t}$ and $w_{1,t}$ are the final good price, the nominal rental price of physical capital and the nominal wage, respectively. $\xi_{1,t}$ is the profit income from the firms.

Taking prices as given, the household maximizes $E_t \sum_{i=0}^{\infty} \beta^i u(c_{1,t+i}, n_{1,t+i})$ subject to (2) and (3) with respect to consumption, labor effort, capital, deposits, and investment. β is the discount rate of the household. The following equations are first-order conditions of this problem:

$$1 = \frac{w_{1,t}}{p_{1,t}c_{1,t}} \tag{4}$$

$$1 = \beta E_t \frac{c_{1,t}}{c_{1,t+1}} \left(\frac{r_{1,t+1}}{p_{1,t+1}} + (1-\delta) \right) \tag{5}$$

$$\frac{1}{1 + i^d_{1,t+1}} = \beta E_t \frac{p_{1,t}c_{1,t}}{p_{1,t+1}c_{1,t+1}} \tag{6}$$

2.2 Commercial banker

The preference of the commercial banker in Country j is described by

$$u(c^f_{1,t}, n^f_{1,t}) = \ln c^f_{1,t} - n^f_{1,t} \tag{7}$$

$c_{1,t}$ and $n_{1,t}$ are consumption and labor effort, respectively. The commercial banker consumes the final good and works on lending activity. We posit the following production function pertaining to the management of lending:

$$\frac{l_{1,t}}{q^a_{1,t}} = V e^{\nu_{1,t}} n^f_{1,t} \tag{8}$$

$l_{1,t}$ is the loans to the intermediate goods producers, and $q^a_{1,t}$ is the price of intermediate goods produced in Country 1. $\nu_{1,t}$ is the lending productivity and follows the AR(1) process $\nu_{1,t} = H\nu_{1,t-1} + \epsilon^f_{1,t}$. The commercial banker collects deposits from the domestic household, and enters in the international call money market. Accordingly, the budget constraint of the commercial banker in Country 1 is described as follows:

$$\begin{aligned}&(1 + i^l_{1,t-1})l_{1,t-1} + (1 + i^f_{1,t-1})l^f_{1,t-1} - (1 + i^d_{1,t-1})d_{1,t-1} - s_t(1 + i^f_{2,t-1})l^f_{2,t-1}\\ &+ s_t l^f_{2,t} + d_{1,t} = p_{1,t}c^f_{1,t} + l_{1,t} + l^f_{1,t} + \zeta d_{1,t}\end{aligned} \tag{9}$$

$l^f_{1,t}$ ($l^f_{2,t}$) is call loan of the banker in Country 1 (Country 2), and s_t denotes the nominal exchange rate denominated in Country 1's currency. $i^f_{1,t}$ ($i^f_{2,t}$) is the call rate in Country 1 (Country 2) and it stands for the policy interest rate adjusted by the central bank. We let ζ be the reserve ratio.

The commercial banker maximizes $E_t \sum_{i=0}^{\infty} \rho^i u(c^f_{1,t+i}, n^f_{1,t+i})$ subject to (8) and (9) with respect to $c^f_{1,t}$, $d_{1,t}$, $l_{1,t}$, $l^f_{1,t}$, and $l^f_{2,t}$. ρ is the discount rate of the commercial banker. We obtain the following first order conditions:

$$1 + i^l_{1,t} = \left[1 + \frac{p_{1,t}c^f_{1,t}}{V q^a_{1,t} e^{\nu_{1,t}}}\right](1 + i^f_{1,t}) \tag{10}$$

$$(1 - \zeta)(1 + i^f_{1,t}) = 1 + i^d_{1,t} \tag{11}$$

$$\frac{1}{1 + i^f_{1,t}} = E_t \frac{\rho p_{1,t} c^f_{1,t}}{p_{1,t+1} c^f_{1,t+1}} \tag{12}$$

$$1 + i^f_{1,t} = \frac{s_{t+1}}{s_t}(1 + i^f_{2,t}) \tag{13}$$

These conditions characterize the spreads between interest rates set in our model. (10) implies that lending rate $i^l_{1,t}$ becomes higher than the call rate $i^f_{1,t}$ because lending activity needs labor input. According to (11), the existence of reserves lets the call rate $i^f_{1,t}$ be higher than the deposit rate $i^d_{1,t}$. (13) shows that the interest rate parity is held between call rates $i^f_{1,t}$ and $i^f_{2,t}$, suggesting that the interest rates binded under a unilateral peg and a monetary union are those ones.

2.3 Final good producer

The final good is produced using the aggregate technology

$$g_{1,t} = \left[\omega a_{1,t}^{\frac{\sigma-1}{\sigma}} + (1-\omega) b_{1,t}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{14}$$

$g_{1,t}$ is final good output. $a_{1,t}$ and $b_{1,t}$ are quantity indexes of intermediate goods produced in Country 1 and 2, respectively, and defined as

$$a_{1,t} \equiv \left[\int_0^1 a_{1,t}(j)^{\frac{\varrho-1}{\varrho}} dj\right]^{\frac{\varrho}{\varrho-1}}, \tag{15}$$

$$b_{1,t} \equiv \left[\int_0^1 b_{1,t}(j)^{\frac{\varrho-1}{\varrho}} dj\right]^{\frac{\varrho}{\varrho-1}}. \tag{16}$$

with $\varrho > 1$, where $a_{1,t}(j)$ and $b_{1,t}(j)$ are quantities of the intermediates. Cost minimization in final good production implies:

$$a_{1,t}(j) = \left[\frac{q^a_{1,t}(j)}{q^a_{1,t}}\right]^{-\varrho} a_{1,t}, \tag{17}$$

$$b_{1,t}(j) = \left[\frac{q^b_{1,t}(j)}{q^b_{1,t}}\right]^{-\varrho} b_{1,t}. \tag{18}$$

$$a_{1,t} = \left(\omega \frac{p_{1,t}}{q^a_{1,t}}\right)^{\sigma} g_{1,t} \tag{19}$$

$$b_{1,t} = \left((1-\omega) \frac{p_{1,t}}{q^b_{1,t}}\right)^{\sigma} g_{1,t} \tag{20}$$

with

$$q^a_{1,t} = \left[\int_0^1 q^a_{1,t}(j)^{1-\varrho} dh\right]^{\frac{1}{1-\varrho}}, \tag{21}$$

$$q^b_{1,t} = \left[\int_0^1 q^b_{1,t}(j)^{1-\varrho} df\right]^{\frac{1}{1-\varrho}}. \tag{22}$$

$$p_{1,t} = \left[\omega^{\sigma} (q^a_{1,t})^{1-\sigma} + (1-\omega)^{\sigma} (q^b_{1,t})^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{23}$$

Perfect competition implies that the final good price is equal to $p_{1,t}$ or its marginal cost.

2.4 Intermediate goods producers

The technology of the firm that produces intermediate good j in Country 1 is:

$$y_{1,t}(j) = e^{z_{1,t}} k_{1,t}(j)^{\theta} n_{1,t}(j)^{1-\theta} \tag{24}$$

$y_{1,t}(j)$ is the firm's output. $z_{1,t}$ is the productivity and follows the AR(1) process $z_{1,t} = Hz_{1,t-1} + \epsilon_{1,t}$. Like Ravenna and Walsh (2006), we assume that the firm must borrow a fraction γ of total costs from the commercial banker at the nominal lending rate i_t^l, so the real marginal cost is the same for all firms and equal to

$$mc_{1,t} = \frac{\gamma(1+i_{1,t}^l)+(1-\gamma)}{q_{1,t}^a e^{z_{1,t}}} \left[\frac{r_{1,t}}{\theta}\right]^{\theta} \left[\frac{w_{1,t}}{1-\theta}\right]^{1-\theta} \tag{25}$$

We follow the specification proposed in Calvo (1983) for staggered price setting. The fraction $1-o$ of firms can adjust their prices in each period, and the others keep their prices unchanged. Thus, o naturally becomes a degree of the price stickiness. When they can adjust, they do so to maximize the expected discount value of profits. Accordingly, the inflation rate for the domestic price index in Country 1 is

$$\pi_{1,t}^a = \beta E_t \pi_{1,t+1}^a + \kappa \widehat{mc}_{1,t} \tag{26}$$

κ is defined as $\kappa \equiv \frac{(1-o)(1-\beta o)}{o}$. The upper-hat $(\widehat{\ })$ denotes the percentage deviation of the respective variable around its steady state value.

We suppose that the law of one price holds for the tradable intermediates:

$$q_{1,t}^a = s_t q_{2,t}^a \tag{27}$$

$$q_{1,t}^b = s_t q_{2,t}^b \tag{28}$$

2.5 Equilibrium conditions

The market clearing conditions for intermediates are:

$$a_{1,t} + a_{2,t} = y_{1,t} \tag{29}$$

$$b_{1,t} + b_{2,t} = y_{2,t} \tag{30}$$

The market clearing conditions for final goods are:

$$c_{1,t} + c^f_{1,t} + x_{1,t} = g_{1,t} \tag{31}$$

$$c_{2,t} + c^f_{2,t} + x_{2,t} = g_{2,t} \tag{32}$$

Loan market clearing is characterized as follows:

$$(1-\xi)d_{1,t} = l_{1,t} \tag{33}$$

$$(1-\xi)d_{2,t} = l_{2,t} \tag{34}$$

2.6 Monetary policy

Home and Foreign central banks are assumed to follow the Taylor rules

$$i^f_{1,t} = i^f_1 + \phi_\pi \pi^a_{1,t} + \phi_y \widehat{y}_{1,t} + \phi_s(\widehat{s}_t - \widehat{s}_{t-1}) \tag{35}$$

$$i^f_{2,t} = i^f_2 + \phi_\pi \pi^b_{2,t} + \phi_y \widehat{y}_{2,t} - \phi_s(\widehat{s}_t - \widehat{s}_{t-1}) \tag{36}$$

under a flexible exchange rate regime (FLEX). Under a unilateral peg regime (PEG), the central bank in Country 1 is absorbed in stabilizing nominal exchange rate ($\widehat{s}_t = 0$). Under a monetary union (MU), the union central bank follows the Taylor rule

$$i^f_t = i^f + \phi_\pi(0.5\pi^a_{1,t} + 0.5\pi^b_{2,t}) + \phi_y(0.5\widehat{y}_{1,t} + 0.5\widehat{y}_{2,t}) - \phi_s(\widehat{s}_t - \widehat{s}_{t-1}) \tag{37}$$

Note that $i^f_t \equiv i^f_{1,t} = i^f_{2,t}$ under MU as implied by (13).

3 Calibration

Baseline calibration is shown in Table 1. We assume $\beta = 0.99$ to imply that annual returns on deposits are about 4.9 percent in the steady state. V is calibrated so that the steady state annual returns on lending is equal to 10 percent. These correspond roughly to the US average[2]. Following Goodfriend and McCallum (2007), we set $\xi = 0.005$. In the calibration of the interest rate rules and the processes of technological shocks, we follow estimates in Kollmann (2004): $\phi_\pi = 34.59$, $\phi_y = 0.27$, $\phi_s = 0.56$ and $H = 0.97$. We set ω so that the share of imported intermediates corresponds to 15 percents in the steady state. For the other parameters, we follow

[2]We take the averages of the central bank policy rate from 1982Q3 to 2011Q1 and the bank prime loan rate from 1957Q1 to 2011Q1. Data are from International Financial Statistics Online.

Table 1: Baseline Parameterization

β	0.99	ρ	0.985	V	1.00	o	0.75	ω	0.87	ϱ	6	σ	1
θ	0.36	ϕ_π	34.59	ϕ_y	0.27	ϕ_s	0.56	H	0.97	δ	0.025		

Table 2: Standard deviation under alternative exchange rate systems

	$\gamma = 0.1$			$\gamma = 1$		
	FLEX	MU	PEG	FLEX	MU	PEG
$y_{1,t}$	0.25	0.09	0.15	0.31	3.48	1.21
$c_{1,t}$	0.11	0.04	0.06	0.11	1.96	0.46
$c^f_{1,t}$	0.28	0.06	0.09	0.32	3.02	0.14
$x_{1,t}$	1.00	0.11	0.21	0.96	16.63	5.13
$\pi^a_{1,t}$	0.01	0.02	0.05	0.01	1.07	0.07
$\pi_{1,t}$	0.06	0.02	0.04	0.06	0.78	0.06
$mc_{1,t}$	0.15	0.07	0.12	0.69	10.44	0.78
$i^d_{1,t}$	0.29	0.04	0.08	0.34	1.97	0.14
$i^f_{1,t}$	0.29	0.04	0.08	0.34	1.98	0.14
$i^l_{1,t}$	0.54	0.17	0.29	0.64	9.51	0.30
s_t	0.36	0.00	0.00	0.34	0.00	0.00

the convention. o is set equal to 0.75, a value consistent with an average period of one year between price adjustments. We assume $\varrho = 6$, implying that the steady state mark up is 1.2. σ, or substitutability between intermediates produced in Country 1 and 2 is 1.

4 The role of the cost channel under alternative regimes

Table 1 reports standard deviations of macroeconomic variables under the three exchange rate systems for both cases when the cost channel is weak ($\gamma = 0.1$) and strong ($\gamma = 1$), and Table 3 presents percent changes in standard deviations when the cost channel becomes stronger ($\gamma = 0.1 \rightarrow 1$). Standard deviations of most variables are higher when $\gamma = 1$ than when $\gamma = 0.1$. A rise in the volatility of the marginal cost is remarkable. This is because interest rate fluctuation directly amplifies marginal cost variability when the cost channel is strong. A rise in volatility under FLEX is modest relative to the other two regimes. This reflects the fact that the central bank can offset fluctuations in its own country by controlling policy rate independently under FLEX.

5 Dominance between alternative systems

Table 3 presents percent changes in standard deviations when the exchange rate regime is switched. We find that the macroeconomic volatility is highest under FLEX when $\gamma = 0.1$, although it is lowest under FLEX when $\gamma = 1$. This is because stabilization in the nominal exchange rate helps

Table 3: Percent changes in standard deviation: $\gamma = 0.1 \to 1$

	FLEX	MU	PEG
$y_{1,t}$	0.20	36.83	7.17
$c_{1,t}$	0.00	45.17	6.66
$c^f_{1,t}$	0.17	53.26	0.48
$x_{1,t}$	−0.04	154.83	23.15
$\pi^a_{1,t}$	0.02	42.15	0.39
$\pi_{1,t}$	−0.05	41.84	0.40
$mc_{1,t}$	3.45	139.13	5.46
$i^d_{1,t}$	0.17	44.96	0.69
$i^f_{1,t}$	0.17	44.87	0.69
$i^l_{1,t}$	0.17	54.12	0.03
s_t	−0.06	0.00	0.00

Table 4: Percent changes in standard deviation across alternative exchange rate systems

	$\gamma = 0.1$			$\gamma = 1$		
	FLEX → MU	FLEX → PEG	MU → PEG	FLEX → MU	FLEX → PEG	MU → PEG
$y_{1,t}$	−0.64	−0.42	0.61	10.38	2.95	−0.65
$c_{1,t}$	−0.61	−0.44	0.41	17.22	3.27	−0.77
$c^f_{1,t}$	−0.80	−0.66	0.68	8.33	−0.57	−0.95
$x_{1,t}$	−0.89	−0.79	0.99	16.36	4.36	−0.69
$\pi^a_{1,t}$	0.94	2.78	0.95	80.69	4.15	−0.94
$\pi_{1,t}$	−0.69	−0.28	1.30	13.18	0.06	−0.92
$mc_{1,t}$	−0.52	−0.22	0.63	14.20	0.14	−0.93
$i^d_{1,t}$	−0.85	−0.72	0.87	4.84	−0.60	−0.93
$i^f_{1,t}$	−0.85	−0.72	0.87	4.84	−0.60	−0.93
$i^l_{1,t}$	−0.68	−0.47	0.68	13.96	−0.53	−0.97
s_t	−1.00	−1.00	0.00	−1.00	−1.00	0.00

to stabilize other macro variables under MU and PEG.

6 Conclusions

We find that when the firms finance limited parts of their operational costs from the commercial bank, or the cost channel is weak, macroeconomic volatility is highest under FLEX. This is because stabilization in the nominal exchange rate helps to stabilize other macro variables under MU and PEG. We assume the central bank in a monetary union follows a Taylor rule with inflation and output in both countries, thus, volatility becomes higher under PEG than MU. On the other hand, when the firms finance all their operational costs from the commercial bank, or the cost channel is strong, FLEX becomes the regime that realizes the lowest volatility. Responses in inflation and other variables to disturbances are amplified through the cost channel. Under FLEX, the central banks in each country controls the policy rates against the fluctuation in their own inflation and output. The choice of exchange rate system significantly depends on the existence of the cost channel.

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