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Country-specific shocks and optimal monetary policy

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Abstract

This paper studies optimal monetary policy responses to country-specific shocks in a simple two-country new open macroeconomic model that features sticky-price and local-currency pricing. Technology shocks in the home country are allowed to diffuse to the foreign country with a one-period lag, and vice versa. We find, even in the presence of price-stickiness and local-currency pricing, real shocks may generate market overreaction, to which central banks respond by implementing contractionary monetary policy. This is exactly opposite to the Devereux and Engel's (2003) prediction and many other's. However, it may be consistent with empirical evidence of rising nominal interest rates during economic boom.

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1 Introduction

This paper studies optimal monetary policy responses to country-specific productivity shocks when prices are pre-set in local currency (local-currency pricing or LCP). In a similar framework, Devereux and Engel (2003) show that welfare-maximizing central banks respond to a favorable country-specific shock by implementing expansionary monetary policy. Obstfeld (2006) and Duarte and Obstfeld (2007) also make qualitatively same predictions[1].

With sticky prices, an optimal monetary policy response to a favorable shock needs to be expansionary so that consumptions fully respond to the shock as in the flexible prices equilibrium. In the absence of expenditure-switching role for exchange rates (due to LCP), no change in terms of trade is required so that both countries positively respond to the shock[2].

In aforementioned researches, technology innovations occur only within a country. Instead, this paper allows country-specific shocks to diffuse to other countries with a one-period time lag. In so doing, I show that consumption responses to real shocks can be amplified, and central banks may implement contractionary monetary policy in order to neutralize such market overreaction. Put it differently, central banks may raise nominal interest rates when there occurs a positive productivity shock. This outcome is exactly opposite to the Devereux and Engel's (2003) and the Obstfeld's (2006) predictions and many other's. It should be noted, however, that the prediction made in this paper may be consistent with empirical evidence of rising nominal interest rate during economic boom.

The rest of the paper is organized as follows. Section 2 presents the baseline model. In section 3, I characterize the solution under the flexible prices equilibrium as a benchmark. Section 4 provides the analytic solution of the main model that features price-stickiness and local-currency pricing. Section 5 describes the optimal interest rate rule by welfare-maximizing central banks. Section 6 concludes.

2 The Baseline Model

2.1 Preferences

There are two symmetrical countries, the home and the foreign country. Each country is populated by a continuum of identical monopolistically competitive producers/consumers, indexed by $h \in [0, 1]$ for the home country and $f \in [0, 1]$ for the foreign country. Each agent produces a single traded good. They also provide labor in a perfectly competitive domestic labor market.

[1] In the Devereux and Engel's (2003) model, the home and the foreign country identically respond to a country-specific shock. However, the Duarte and Obstfeld's (2007) model predicts a stronger domestic response to a domestic shock in the presence of nontraded goods. Nonetheless, both countries still positively respond to favorable technology shocks.

[2] With full expenditure-switching role (producer's currency pricing or PCP), an efficient allocation requires a change in relative prices. For instance, the home country needs to respond to a favorable home shock positively, while the foreign country implements contractionary policy. The resulting terms of trade deterioration will shift the demand in either country toward the home goods consumption.

The representative home consumer/producer h solves,

$$Max\ E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\rho}(h)}{1-\rho} - \kappa L_t(h) \right] \right\},\ \rho, \kappa > 0,\ \beta \in (0,1), \tag{1}$$

where C is a consumption index, L is labor supply, and κ is a labor disutility parameter. Following Obstfeld (2006), I don't explicitly model the demand for money[3]. The flow budget constraint that home representative agent faces is the following.

$$P_t C_t(h) = P_{H,t}(h) Y_{H,t}(h) + S_t P^*_{H,t}(h) Y^*_{H,t}(h) - WT_{t+1}(h) + (1 + R_{t+1}) WT_t(h), \tag{2}$$

where P_t is the nominal price index of C_t, S_t is the nominal exchange rate as the home-currency price of the foreign currency, WT_t is the nominal wealth, and R_{t+1} is the nominal *ex post* return on WT_t. We assume that the representative home producer h employs third-degree price discrimination by setting two different prices $P_{H,t}$ and $P^*_{H,t}$ in local currency for the good sold in the home country ($Y_{H,t}$) and in the foreign country ($Y^*_{H,t}$), respectively (LCP)[4].

The overall consumption index is defined as,

$$C_t = \frac{C_{H,t}^{\gamma} C_{F,t}^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}, \tag{3}$$

where $C_{H,t}$ and $C_{F,t}$ are the consumption sub-indexes for home and foreign goods, respectively. For simplicity, we assume that $\gamma = 1/2$, which implies that there is no home bias. Then, C_t can be rewritten as follows.

$$C_t = 2 C_{H,t}^{\frac{1}{2}} C_{F,t}^{\frac{1}{2}}, \tag{4}$$

where $C_{H,t}$ and $C_{F,t}$ are defined as the following general CES functions over available varieties.

$$C_{H,t} = \left[\int_0^1 C_{H,t}(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}},\ C_{F,t} = \left[\int_0^1 C_{F,t}(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}}, \tag{5}$$

θ (> 1) is the common constant elasticity of substitution across goods in each sector.

Corresponding price indexes are,

$$P_t = P_{H,t}^{\frac{1}{2}} P_{F,t}^{\frac{1}{2}}, \tag{6}$$

where

$$P_{H,t} = \left[\int_0^1 P_{H,t}(h)^{1-\theta} dh \right]^{\frac{1}{1-\theta}},\ P_{F,t} = \left[\int_0^1 P_{F,t}(f)^{1-\theta} df \right]^{\frac{1}{1-\theta}} \tag{7}$$

[3] Central banks are assumed to adopt interest rate rules so that the money supply adjusts endogenously. Then, we don't have to explicitly model the money demand in the utility function (see Woodford 2003). We also assume that the money demand has a negligible impact on the utility. This assumption is often adopted even when the real balance appears in the utility function (e.g., Devereux and Engel 2003).

[4] Under PCP, the agent chooses a single price for the traded good sold in both markets. That is, once the domestic price $P_{H,t}(h)$ is determined, the foreign price $P^*_{H,t}(h)$ will be automatically set by $P_{H,t}(h)/S_t$.

Then, the demand functions for the home good in each country are,

$$C_{H,t}(h) = \frac{1}{2}\left(\frac{P_{H,t}(h)}{P_{H,t}}\right)^{-\theta}\left(\frac{P_t}{P_{H,t}}\right)C_t \tag{8}$$

$$C^*_{H,t}(h) = \frac{1}{2}\left(\frac{P^*_{H,t}(h)}{P^*_{H,t}}\right)^{-\theta}\left(\frac{P^*_t}{P^*_{H,t}}\right)C^*_t \tag{9}$$

The foreign representative agent f also solves a similar problem. And foreign prices and demand functions have isomorphic expressions, denoted by a superscript asterisk ($*$).

2.2 Asset Market

We assume consumers in each country have access to a complete set of state-contingent nominal bonds[5]. We assume that they trade these bonds before the realization of the state of the world so that they will equalize the marginal consumption value of one unit of the nominal bonds across countries for all states of nature. Then, as in Backus and Smith (1993), the resulting *ex post* allocation implies the following risk-sharing condition.

$$\frac{C_t^{-\rho}}{P_t} = \frac{C_t^{*-\rho}}{S_t P_t^*} \tag{10}$$

for all dates and states.

2.3 Production Technologies

The production functions for each variety of goods are given by,

$$Y_{H,t} = A_t L_{H,t},\ Y^*_{F,t} = A^*_t L^*_{F,t}, \tag{11}$$

where L and A denote employment and technology level, respectively.

Letting lower-case letters (excluding interest rates) denote natural logarithms, the technologies obey the following stochastic processes.

$$a_t = \lambda a_{t-1} + u_t + u^*_{t-1},\ a^*_t = \lambda a^*_{t-1} + u^*_t + u_{t-1}, \tag{12}$$

where

$$\lambda \in (0,1),\ u \sim N(0,\sigma_u^2),\ u^* \sim N(0,\sigma_{u^*}^2)$$

This is a new feature of this paper. A productivity shock in the home country is allowed to diffuse to the foreign country with a one-period lag, and vice versa. For example, u_{t-1} will be fully incorporated to the home productivity (a_{t-1}) at time $t-1$. At time t, it will contribute to the the home productivity by λu_{t-1} (via λa_{t-1}), while it will be fully incorporated to the foreign productivity (a^*_t) due to technology diffusion. Note that u_t is an unanticipated shock to the home country at time t, while all agents can anticipate its impact on the foreign productivity at time $t+1$ with perfect foresight. The foreign productivity shock u^*_t has similar impacts.

[5] That is, each bond-holder receives her payoff in monies rather than goods.

2.4 Interest Rate Rules

Following Obstfeld (2006), I assume that the central bank in each country employs the nominal interest rate as the monetary instrument. That is, central banks adopt the following interest rate rules,

$$i_t = \iota + \psi p_t - \alpha_1 u_t - \alpha_2 u_t^*, \tag{13}$$

for the home country, and

$$i_t^* = \iota + \psi p_t^* - \alpha_1^* u_t^* - \alpha_2^* u_t, \tag{14}$$

for the foreign country, where i_t and i_t^* denote the nominal interest rates in the home and the foreign country, respectively[6]. Central banks are assumed to credibly commit to these rules with constant values for ψ and α's.

3 A Benchmark: The Flexible Prices Equilibrium

As Devereux and Engel (2003) show, with LCP, it is possible for central banks to alleviate distortion[7] due to price stickiness when there occurs a country-specific real shock. Therefore, it would be useful to analyze the solution under flexible prices as a benchmark case.

With fully flexible prices, firms set prices by constant markup ($\frac{\theta}{1-\theta}$) pricing over nominal marginal cost in each period. We assume that labor markets are perfectly competitive so that nominal marginal costs are $\frac{W_t}{A_t}$ for the home country, and $\frac{W_t^*}{A_t^*}$ for the foreign country.

From the optimal labor-consumption trade-off condition,

$$\frac{W_t}{P_t} C_t^{-\rho} = \kappa = \frac{W_t^*}{P_t^*} C_t^{*-\rho} \tag{15}$$

By the price index definition (6), markup pricing rules, and (15), we can show that equilibrium consumptions are (see Appendix),

$$C_t = \left[\left(\frac{\theta - 1}{\theta\kappa} \right) A_t^{\frac{1}{2}} A_t^{*\frac{1}{2}} \right]^{\frac{1}{\rho}} = C_t^* \tag{16}$$

That is, as in the Devereux and Engel's (2003) model, consumptions are perfectly synchronized across countries in the presence of a perfectly integrated financial market.

From (12) and (16), consumption innovations in the flexible prices equilibrium are,

$$\begin{aligned} c_t - E_{t-1} c_t &= \frac{1}{2\rho} (u_t + u_t^*) \\ &= c_t^* - E_{t-1} c_t^* \end{aligned} \tag{17}$$

That is, consumptions respond identically to a country-specific productivity shock. It should be also noted that, under flexible prices, technology diffusion has no impact on consumption

[6] It can be shown that the price level is determinate as long as ψ is strictly positive. See Appendix for details.

[7] It should be noted that, with LCP, optimal monetary policy can generate optimal consumption *responses* to country-specific real shocks, whereas optimal consumption *levels* can be obtained by optimal monetary policy with PCP.

in either country[8].

4 The Sticky-Price, Local-Currency Pricing Model

We assume that producers set their nominal prices for their goods in local currency one period in advance. For example, the representative home producer h sets the prices $P_{H,t}(h)$ and $P^*_{H,t}(h)$, at time $t-1$ using all available information, and maintains them for one period.

Taking all aggregate prices and quantities as given, the home agent h solves,

$$\underset{P_{H,t}(h),P^*_{H,t}(h)}{Max} \; E_{t-1}\left\{\frac{C_t(h)^{1-\rho}}{1-\rho} - \kappa L_t(h)\right\} \tag{18}$$

subject to the budget constraint (2), the demand equations (8), (9), and the labor demand function,

$$L_t(h) = \frac{Y_{H,t}(h) + Y^*_{H,t}(h)}{A_t} \tag{19}$$

Then, the first order condition with respect to $P_{H,t}(h)$ implies the following pricing equation for the home good sold in the home country (see Appendix).

$$P_{H,t}(h) = \frac{\theta\kappa}{\theta-1}\frac{P_t E_{t-1}\left[C_t/A_t\right]}{E_{t-1}\left[C_t(h)^{-\rho}C_t\right]}$$

Assuming a symmetric equilibrium ($C_t(h) = C_t$),

$$P_{H,t} = \frac{\theta\kappa}{\theta-1}\frac{P_t E_{t-1}\left[C_t/A_t\right]}{E_{t-1}\left[{C_t}^{1-\rho}\right]} \tag{20}$$

Foreign pricing equations are similarly defined.

It cab be shown that the realized home consumption in the equilibrium can be expressed as follows (see Appendix).

$$\begin{aligned} c_t =& \frac{1}{2\rho}\left(\frac{\psi\lambda}{1+\psi-\lambda}\right)(u_t + u^*_t) + \frac{1}{2\rho}\left(\frac{\psi}{1+\psi-\lambda}\right)(u_t + u^*_t) \\ &+ \frac{1}{\rho}(\alpha_1 u_t + \alpha_2 u^*_t) + \tilde{\nabla}, \end{aligned} \tag{21}$$

where $\tilde{\nabla}$ denotes a function of parameters, unconditional moments, and variables dated $t-1$. Foreign consumption function can be similarly expressed.

Assuming that policy parameters α's are all zero as in the flexible prices equilibrium, we,

[8] This feature is consistent with the work of Barro and King (1984) that shows, with time-separable preferences, current equilibrium allocations are not affected by expectations about the future. Adding the risk-sharing condition (10), Devereux and Engel (2007) illustrate a generalized version of this result in an open economy framework.

then, obtain the following.

$$c_t - E_{t-1}c_t = \{\underbrace{\frac{1}{2\rho}\left(\frac{\psi\lambda}{1+\psi-\lambda}\right)}_{\text{Sticky Price Effect}} + \underbrace{\frac{1}{2\rho}\left(\frac{\psi}{1+\psi-\lambda}\right)}_{\text{Tech Diffusion Effect}}\}(u_t + u_t^*) \tag{22}$$
$$= c_t^* - E_{t-1}c_t^*$$

Compared with (17), equation (22) demonstrates the following interesting results. First, under the current setup, u_t creates two types of distortions, the sticky price effect and the technology diffusion effect. With regard to the sticky price effect, neither country can generate a full amount of consumption innovation $\frac{1}{2\rho}$ under the flexible prices equilibrium, since p_t was already pre-determined at time $t-1$. Therefore, consumption responses will be muted ($\frac{\psi\lambda}{1+\psi-\lambda} < 1$).

At the same time, u_t generates the technology diffusion effect at time t. When u_t is realized, agents in both countries know it will diffuse to the foreign country, and thus $p_{F,t}$ will be lowered at time $t+1$, and so will p_{t+1}. Anticipating higher c_{t+1}, people will increase c_t right away (consumption smoothing), which is distortionary since A_t^* hasn't changed yet. Similar reasoning can be done with respect to u_t^*.

Interestingly, productivity shocks u_t and u_t^* may generate market overreaction. Note that the combined impacts of u_t or u_t^* on either country's consumption is,

$$\frac{1}{2\rho}\left(\frac{\psi(1+\lambda)}{1+\psi-\lambda}\right), \tag{23}$$

which is greater than the consumption response $\frac{1}{2\rho}$ under the flexible prices equilibrium as long as $\psi > \frac{1-\lambda}{\lambda}$. Since λ is a persistent parameter of productivity that is often deemed to be fairly big, this condition may not be too restrictive.

5 Optimal Interest Rate Rule and Welfare Analysis

We assume that the home central bank maximizes the home representative agent utility by choosing policy parameters α's given ψ. That is, the home central bank maximizes the following.

$$E_t\left[\frac{C_{t+1}^{1-\rho}}{1-\rho} - \kappa L_{t+1}\right] \tag{24}$$

The foreign central bank also solves a similar problem.

It is possible to formally derive the optimal response functions to country-specific real shocks (see Appendix). However, a careful inspection of (21) shows that the central banks are able to mimic optimal consumption responses by choosing,

$$\alpha_1 = \frac{1}{2}\left(1 - \frac{\psi(1+\lambda)}{1+\psi-\lambda}\right) = \alpha_2 \tag{25}$$
$$\alpha_1^* = \frac{1}{2}\left(1 - \frac{\psi(1+\lambda)}{1+\psi-\lambda}\right) = \alpha_2^*$$

Therefore, given $\psi > 0$, the optimal interest rate rules are,

$$\begin{aligned} i_t &= \iota + \psi p_t - \bar{\alpha}(\psi)(u_t + u_t^*) \\ i_t^* &= \iota + \psi p_t^* - \bar{\alpha}(\psi)(u_t + u_t^*), \end{aligned} \tag{26}$$

where $\bar{\alpha}(\psi) = \frac{1}{2}\left(1 - \frac{\psi(1+\lambda)}{1+\psi-\lambda}\right)$ is a constant given ψ. Note that the consumption innovations under the flexible prices equilibrium (17) are recovered with these rules.

One interesting feature of these results is the following. Unlike Devereux and Engel (2003) and Obstfeld (2006), central banks may implement contractionary monetary policy when there is a positive productivity shock. This case may arise when the technology diffusion effect is big enough. Recall that, observing a current shock u_t at time t, foreign producers will determine $p_{F,t+1}$ at a lower level due to technology diffusion that will occur at time $t+1$, and thus p_{t+1} will also decline . Assuming that central banks can commit the optimal policy rules, a strictly positive value of ψ implies lower nominal interest rates at time $t+1$. Furthermore, lower p_{t+1} will lead to higher expected inflation at time $t+1$. Hence, real interest rates at time $t+1$ will decrease in both countries. Therefore, expecting a positive consumption growth owing to lower p_{t+1} and lower real interest rates, agents will intend to increase c_t at time t. However, such a consumption innovation at time t is distortionary[9], and central banks wish to eliminate it. Note that the technology diffusion effect will be greater the bigger ψ is, since bigger ψ implies that real interest rates will decline more at time $t+1$[10].

In a nutshell, if central banks commit fairly aggressive responses to prices with $\psi > \frac{1-\lambda}{\lambda}$, markets may overreact, and the central banks may wish to respond to it by implementing contractionary monetary policies. This result is new[11], and I believe this new feature may be consistent with empirical evidence of rising nominal interest rates during economic boom.

6 Conclusion

In this paper, I develop a sticky-price, local-currency pricing model that features technology diffusion. This model produces quite interesting results. When a central bank commits a fairly aggressive response to a price level, a favorable country-specific shock may generate market overreaction, which requires the central bank to implement contractionary monetary policy instead of expansionary policy as Devereux and Engel (2003) and many others predict. My prediction, however, seems to be consistent with empirical evidence of rising nominal interest rates during economic boom.

[9]Because technology diffusion will occur at time $t+1$.

[10]Higher ψ will also reduce the sticky-price effect. However, it is easy to show that ψ alone cannot completely remove the sticky-price effect.

[11]Under LCP, models by Devereux and Engel (2003), Duarte and Obstfeld (2007), and Obstfeld (2006) predict that central banks implement expansionary monetary policies. It is easy to see that the sticky price effect alone cannot generate market overreaction.

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