

Friedman Redux: Restricting Monetary Policy Rules to Support Flexible Exchange Rates*

Michael B. Devereux

Department of Economics, University of British Columbia and CEPR

Kang Shi

Department of Economics, University of British Columbia

Juanyi Xu[†]

Department of Economics, Simon Fraser University, 8888 University Drive, Burnaby, BC, Canada V5A 1S6

First draft: February 2004

This draft: January 2005

Keywords: Flexible Exchange Rates; Monetary Policy; Endogenous Currency of Pricing

JEL Classification: F0; F4

Abstract When the currency of export pricing is endogenous, there is a social benefit to exchange rate volatility that may be ignored by monetary authorities. As a result there is a welfare inferior equilibrium with zero exchange rate pass-through, and fixed exchange rates. This paper shows that there is a simple method of ruling out this equilibrium; restrict monetary authorities to respond only to domestic economic conditions.

*Devereux thanks SSHRC, the Royal Bank, and the Bank of Canada for financial support. This research was undertaken as part of University of British Columbia's TARGET research network. All authors thank TARGET for financial support.

[†]Corresponding author. Tel.: +1 604 291 5427; fax: +1 604 291 5944. *E-mail* Address : devm@interchange.ubc.ca (M. B. Devereux), kangshi@interchange.ubc.ca (K. Shi), jennyx@sfu.ca (J. Xu).

1 Introduction

The debate on fixed versus flexible exchange rates has been at the heart of international monetary economics for many years. Friedman (1953) and later Mundell (1961) made the case for flexible exchange rates as an efficient mechanism for dealing with country-specific shocks when domestic price levels cannot change quickly enough. But recent studies of monetary policy in utility-based open economy models have reached varying conclusions about the desirability of flexible exchange rates. One important distinction is the currency in which exporting firms set their prices. Devereux and Engel (2003) show that when export goods prices are set in the currency of the producer (PCP, or producer's currency pricing), implying full pass-through of exchange rate changes into consumer goods prices, then the equilibrium of a monetary policy game between countries involves flexible exchange rates. The key feature of this equilibrium is that there is full international consumption risk sharing, as well as efficient adjustment of international relative prices. In fact, monetary policy replicates the flexible price world equilibrium.

But when exporting firms follow local currency pricing (LCP), there is no short run impact of currency depreciation on domestic imported goods prices. Then an optimal monetary policy involves a fixed exchange rate, even in an environment with country-specific shocks. This monetary policy ensures efficient international consumption risk sharing, but does not sustain efficient international relative price adjustment.

When the currency of price setting is itself endogenous, Corsetti and Pesenti (2002) show that there can be multiple equilibria. In one equilibrium, firms will set prices using PCP, and an optimal monetary policy maintains a flexible exchange rate, while in another equilibrium, firms set prices using LCP, and in the equilibrium the exchange rate is fixed. In welfare terms however, the equilibrium with PCP is better. Since it ensures that relative prices change efficiently, it sustains the outcome of the flexible price economy.

This short paper investigates how optimal monetary policy should be designed in a world where the currency of price setting is endogenous. We focus on ways in which the welfare inferior equilibrium with LCP may be eliminated. Our central result is that if monetary authorities are restricted to react *only to domestic shocks*, and ignore shocks to the foreign economy, then there is a unique equilibrium where firms in all countries follow PCP, exchange rates are flexible, and the flexible price allocation of the world economy is sustained. The key insight is that there is a social benefit of exchange rate volatility that is not necessarily internalized in the policy makers' decision, when the currency of pricing is taken as given. By restricting monetary policy rules to focus only on domestic economic conditions, the policy makers are forced to follow rules that lead to volatile exchange rates. Given this exchange rate volatility, price setting rules adjust to ensure efficient exchange rate pass-through.

2 The model

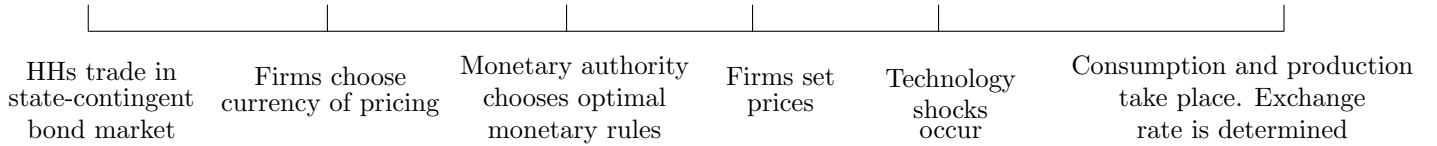
The world economy consists of two countries, labelled as home and foreign. Each country is populated by a large number of atomistic households, a continuum of firms that choose the currency of pricing and set prices in advance, and a monetary authority which chooses optimal money rules to maximize the

representative household's expected utility. Both countries specialize in the production of a composite traded good. From now on, variables in the foreign country are denoted by an asterisk.

2.1 Timing

All events take place within a single period.¹ As described in Figure 1, at the beginning of the period, households trade in a world market in state-contingent nominal bonds. Following this, firms choose the currency in which to set their export good prices (sales to domestic consumers are all set in local currency). Then monetary authorities choose optimal monetary rules, taking into account the way in which firms set their prices (but taking the currency of price-setting as given). After that, firms choose prices to maximize expected discounted profits, based on their stochastic discount factors, and anticipated demand and marginal cost conditions. Finally, at the end of the period, technology shocks (the only source of uncertainty in the model) occur, households work and choose their optimal consumption baskets, production and consumption take place, and the exchange rate is determined.

Figure 1: Timing of Model



Since the mathematical derivation of this model has been extensively presented in other papers, we will only discuss the main results in intuitive form.² In addition, except where necessary, we present only the home country side of the model. In all cases, the foreign country conditions are defined in an analogous manner.

2.2 Households and Firms

The representative household in the home country maximizes the following expected utility function :

$$U = E\left(\frac{C^{1-\rho}}{1-\rho} + \chi \ln \frac{M}{P} - \eta L\right) \quad (2.1)$$

where $C = \frac{C_h^n C_f^{1-n}}{n^n (1-n)^{1-n}}$ is an aggregate of home and foreign composite goods, $C_h = [n^{-\frac{1}{\lambda}} \int_0^n C_h(i)^{\frac{\lambda-1}{\lambda}} di]^{\frac{\lambda}{\lambda-1}}$ is the composite home goods aggregated over a continuum of home goods indexed by $[0, n]$; C_f , the composite foreign goods are analogously defined, but over a range of goods indexed by $[n, 1]$. $\frac{M}{P}$ denotes real money balances, and L is labor supply. We assume that $\rho \geq 1$, $\lambda > 1$, and η and χ are positive

¹Because we are considering a complete markets environment, and there are no predetermined state variables, an infinite horizon model would have *identical* results to those below.

²The detailed derivations are contained in an appendix available at <http://www.sfu.ca/~jennyx/DSXtechappendix.pdf>

Table 1 The optimality conditions for home households and firms

Money demand	$M = \chi PC^\rho$	Pricing schedules	
Labor supply	$W = \eta PC^\rho$	Goods sold in Home	$P_{hh} = \frac{\lambda}{\lambda-1} \frac{E[\frac{WC^{1-\rho}}{\theta}]}{E[C^{1-\rho}]}$
Risk-sharing condition	$\frac{C^{-\rho}}{P} = \Gamma \frac{C^{*- \rho}}{SP^*}$	Export Goods (PCP)	$P_{hf}^{*,PCP} = \frac{P_{hh}}{S}$
Risk-sharing parameter	$\Gamma = \frac{EC^{1-\rho}}{EC^{*1-\rho}}$	Export Goods (LCP)	$P_{hf}^{*,LCP} = \frac{\lambda}{\lambda-1} \frac{E[\frac{WC^{*1-\rho}S^{-1}}{\theta}]}{E[C^{*1-\rho}]}$
Nominal exchange rate	$S = \Gamma \frac{M}{M^*}$		

constant parameters. From the consumption structure, the CPI price index is $P = P_h^n P_f^{1-n}$ where P_h and P_f represent the prices for the home and foreign composite goods in the home country respectively. The optimal conditions for choosing the state-contingent nominal bond, real balances and labor supply are given in Table 1. These conditions are quite standard in the literature.³

Firms produce output using labor. Output of home producer i is $Y(i) = \theta L(i)$ where θ is the home country specific technology shock, which follows a log-normal distribution such that $\theta = \exp(u)$ and $u \sim N(0, \sigma_u^2)$. Each firm sets its price to exploit its monopoly power over the sale of its own good. Arbitrage costs for consumers allow monopolists to price discriminate across countries. Firms also choose the currency in which to set prices for exporting abroad. The firm follows PCP (LCP) if it sets its export price in the domestic currency (currency of the buyer). Whatever currency it chooses, the firm must set its export price (as well as the price for sales to the domestic consumer) before the state of the world is realized.

Following Devereux, Engel and Storgaard (2003), a home firm i will set its export price in home currency if and only if the following condition holds:

$$\frac{1}{2}\sigma_s^2 - cov(mc, s) > 0 \quad (2.2)$$

where $s = \ln(S)$ and is the log nominal exchange rate, $mc = \ln(\frac{W}{\theta})$ is the log marginal cost for the firm. If (2.2) is negative, then the firm will set its export price in foreign currency, whereas if (2.2) is zero, the firm is indifferent between setting prices in the home and foreign currency.⁴ The equivalent condition for the foreign firm is $\frac{1}{2}\sigma_s^2 + cov(mc^*, s) > 0$.

Since both the exchange rate and marginal cost are affected by the monetary policy rules, we can express the above conditions as functions of the underlying monetary policy parameters. Given the choice of currency in which to set prices, firms in each country will then set their prices for the home and foreign markets. Table 1 lists the optimal pricing policies for the home firm, in the case of PCP

³The only unusual feature of Table 1 is the endogenous risk-sharing parameter Γ . As shown in Devereux and Engel (2003), this reflects the fact that anticipated differences in wealth levels across countries can give rise to asymmetries in country income shares in a risk-sharing equilibrium.

⁴The intuition behind (2.2) is as follows. When the firm sets price in its own currency (the foreign currency), revenue is convex (linear) in the exchange rate. Hence exchange rate volatility leads the firm to favor its own currency more. On the other hand, if marginal cost co-varies positively with the exchange rate, the firm's expected costs tend to be higher when setting its price in its own currency. Condition (2.2) represents the trade-off between these two effects.

and LCP.

2.3 Monetary authorities

We assume that the monetary authority in each country is concerned with the expected utility of consumption and the disutility of labor effort, but ignores the utility of real money balances.⁵

Monetary policy responds to the realized values of technology shocks. Optimal monetary rules take account of the way in which prices are set. The general form of monetary policy rules are

$$m = a_1 u + a_2 u^* \quad m^* = b_1 u + b_2 u^* \quad (2.3)$$

The monetary authorities choose the coefficients $\{a_i\}$ and $\{b_i\}$ to maximize welfare.⁶ These rules are *unrestricted* in that they allow the monetary authority to respond freely to both home and foreign shocks. In principle it would seem undesirable to restrict monetary authorities from taking into account all shocks. However, in the presence of coordination externalities in price-setting, this conclusion may no longer hold. Hence we also define a *restricted* monetary policy rule, as follows:

$$m = au \quad m^* = bu^* \quad (2.4)$$

Under these rules, monetary policy can respond only to domestic shocks.

The policy feedback rule parameter vector $\{a, b\}$ in both cases are determined by the following international monetary Nash game

$$\max_a EU(a, b^n) \quad \max_b EU^*(a^n, b) \quad (2.5)$$

where expected utility for each monetary authority is constructed by solving the full equilibrium of the model, as described below.

2.4 Equilibrium

Given the stochastic process $\{\theta, \theta^*\}$, a symmetric equilibrium has the properties that; a) households choose consumption, labor supply, money holdings, and state-contingent bond holdings to maximize expected utility subject to budget constraints, b) the firms' currency of pricing decision is optimal, c) for

⁵Obstfeld and Rogoff (2002) and Devereux and Engel (2003) employ this assumption. This allows us to separate the role of monetary policy in eliminating the distortions due to sticky prices from that of providing an optimal liquidity value of money. The justification for this assumption is that expenditure on money services is small relative to that on other goods, so the money-services component of utility is small empirically. Since both Obstfeld and Rogoff (2002), Devereux and Engel (2003), and Corsetti and Pesenti (2001) abstract away from welfare issues related to the liquidity value of money in their evaluation of monetary policy, and since our paper represents a direct extension of their results, we follow this assumption here in order to make our results strictly comparable to theirs. In fact, the assumption is equivalent to focusing on the limiting case $\chi \rightarrow 0$ in (2.1). Moreover, when $\rho = 1$, the welfare results remain exactly the same when the utility of money is included, for *any positive* χ . When $\rho = 1$, from Table 1, in equilibrium real money balances are proportional to consumption $\frac{M}{P} = \chi C$. Thus we can replace the term $\log(C) + \chi \log(\frac{M}{P})$ by $(1 + \chi) \log C$ in evaluating individual utility.

⁶Since the model solution is log-linear and shocks log-normal, these rules are quite general representations of the choices available to monetary authorities.

given currency of pricing, firms set prices to maximize expected discounted profits, d) monetary policy rules are chosen in a Nash game between monetary authorities to maximize representative household's expected utility, given home and foreign firms' currency of pricing decision, and taking account of price setting decisions, and e) labor, goods, and money markets clear.

3 Multiple equilibria under unrestricted monetary policy rules

Monetary policy can be used to improve welfare if it can eliminate the inefficiencies coming from price stickiness. But the optimal monetary rule will depend upon the currency of export price setting. An equilibrium of the model must involve firms choosing the currency in which to set export prices, conditional on the behavior of the exchange rate and marginal cost, which in turn depends on the monetary policy rules. In order to ensure that any given set of optimal policy rules represent an equilibrium, they must be consistent with the currency of pricing decisions made by firms.

Under unrestricted monetary policy rules, there are multiple equilibria of the policy game⁷. To see this, first assume all firms follow PCP. In this case, the technical appendix shows that the optimal monetary rules in the Nash game between monetary authorities are

$$a_1 = 1, \quad a_2 = 0; \quad b_1 = 0, \quad b_2 = 1 \quad (3.1)$$

Each country responds only to its domestic shock. The exchange rate then becomes $\hat{s} = m - m^* = u - u^*$, where we use the notation $\hat{x} = x - E(x)$. By focusing on the domestic shock alone, each monetary authority ensures that consumption responds to the technology shock as in the flexible price equilibrium. In addition, because PCP ensures that there is full pass-through of exchange rate changes into relative prices, the movement in the exchange rate causes the terms of trade and national output levels to replicate the flexible price equilibrium.

But this is only an equilibrium if firms actually do choose PCP. It is easy to check that this is the case. From (3.1), the variance of the exchange rate is $\sigma_u^2 + \sigma_u^{*2}$. However, since marginal cost is $\hat{m}c = \hat{w} - u = m - u = 0$, the covariance of marginal cost and the exchange rate is zero. Hence, from (2.2), the home firm will always follow PCP. A similar argument holds for the foreign firm. This establishes the existence of an equilibrium with PCP and monetary rules given by (3.1).

Alternatively, assume that all firms follow LCP. Then the equilibrium of the Nash monetary game with unrestricted monetary policy rules is:

$$a_1 = n, \quad a_2 = 1 - n \quad b_1 = n, \quad b_2 = 1 - n. \quad (3.2)$$

Since both monetary authorities follow an identical monetary rule, the exchange rate is constant. Because of this, we can immediately see from (2.2) that the gain to PCP pricing, relative to LCP, is zero. Hence LCP is also an equilibrium of the pricing choice for home and foreign firms with monetary policy determined in response to this pricing.

⁷This was first shown for a similar model in Corsetti and Pesenti (2002). In their model, firms choose the rate of exchange rate pass-through in price setting, while here, each firm chooses whether to pass-through or not. Separately, Devereux and Engel (2003) compute the monetary rules given by (3.1) and (3.2) for given pass-through assumptions.

The monetary policy game under LCP does not sustain the flexible price equilibrium. Since there is no exchange rate pass-through, monetary authorities cannot change relative prices facing consumers. The best that they can do is to ensure consumption responds as in the flexible price equilibrium. To do this, it is necessary for each authority to respond to both shocks. While consumption in both countries responds as in the flexible price equilibrium, relative prices do not change, and hence the terms of trade and output does not respond as in the flexible price economy. As a result, welfare is below that of the PCP equilibrium.

Hence there are two equilibria to the monetary policy game with endogenous currency of pricing. The welfare inferior equilibrium occurs because of coordination failure in the game between monetary authorities and price setters. Monetary authorities may fail to take account of the social benefit implied by exchange rate adjustment, in the sense that movements in exchange rates encourage PCP price setting, which in turn allows for exchange rate pass-through and efficient relative price adjustment.

4 Sustaining the flexible price equilibrium with restricted monetary policy rules

How can a monetary policy be designed to ensure that home and foreign firms follow PCP pricing rules, and the flexible price equilibrium of the world economy is attained? One possibility would be to have the monetary authorities move ‘first’ in the game. If monetary policy rules were set *before* the firms make their currency of pricing decision, reversing the sequence of actions described in Figure 1, then (see the technical appendix) there is a *unique* equilibrium to the policy game, characterized by PCP, and flexible exchange rates, which coincides with the flexible price world equilibrium.

However, this equilibrium requires that monetary policy take account of the structural determination of pricing. To the extent that our model captures a pricing decision that may evolve more slowly over time than we actually allow for in the simple timing structure here, it may be unrealistic to assume that monetary policy can have the degree of commitment and far-sightedness necessary to sustain such a rule. Real world monetary policy making does not usually consider product market structure to be within its influence. For these reasons, it may be that the timing sequence of Figure 1 is the most relevant way to describe monetary policy making.

As an alternative, we consider placing restrictions on the monetary policy rule itself in order to select the PCP pricing equilibrium of the monetary policy game. Assume that monetary authorities are restricted to follow rules that focus only on domestic productivity shocks, as described by (2.4). What will be the outcome in this case? We present the analysis as follows. First, assume a given currency of pricing. Then derive the outcome of an international monetary Nash game, where monetary authorities take the currency of pricing as given. Finally, use the solution of the monetary game to check whether or not the given currency of pricing configuration is consistent with the optimal strategies of home and foreign firms.

4.1 Case 1: All firms follow PCP

When all firms follow PCP, the technical appendix shows that the equilibrium of a Nash game between monetary authorities using restricted monetary rules is given as:

$$a = 1, \quad b = 1 \quad (4.1)$$

This is in fact equivalent to (3.1). Since, in the case of unrestricted monetary policy, in a Nash equilibrium with PCP, monetary authorities choose to respond to the domestic shock alone, then the restriction on the form of monetary rules is irrelevant.

We can use the same logic as above to show that the monetary rules given by (4.1) are consistent with PCP pricing behavior on the part of firms. Let Ω and Ω^* be the expected profit differential between PCP and LCP (see (2.2)), given (4.1), the technical appendix shows that $\Omega = \Omega^* = \frac{1}{2}(\sigma_u^2 + \sigma_{u^*}^2) > 0$, so both home and foreign firms will choose PCP. Hence $\{\text{PCP}, \text{PCP}\}$ is an equilibrium of the game with restricted monetary rules.

4.2 Case 2: All firms follow LCP

What happens if all firms in both countries follow LCP? The appendix shows that in this case, the restricted optimal monetary rules are

$$a = n, \quad b = 1 - n \quad (4.2)$$

In this instance, the optimal monetary rules differ from the unrestricted rules under LCP. Monetary authorities offset their own national shock, in proportion to their country weight. But as described in (3.2) above, they would strictly prefer to offset the foreign shock as well, since in the absence of exchange rate pass-through, they would wish to use monetary policy to replicate the flexible price response of consumption.

What does this monetary rule imply for the currency of pricing decision? Note that unlike the economy with LCP and unrestricted setting of monetary policy, where the exchange rate is fixed in equilibrium, under the restricted money rule, there is inevitably fluctuation in exchange rate, since by design monetary authorities cannot respond to shocks in the same way. But the presence of exchange rate volatility will encourage firms to follow PCP pricing rules. Again, using (2.2), we may establish that $\Omega = \frac{n(2-n)}{2}\sigma_u^2 + \frac{(1-n)^2}{2}\sigma_{u^*}^2 > 0$ and $\Omega^* = \frac{n^2}{2}\sigma_u^2 + \frac{(1-n)(1+n)}{2}\sigma_{u^*}^2 > 0$. This implies that all firms in both countries will choose PCP. Thus $\{\text{LCP}, \text{LCP}\}$ is not an equilibrium when monetary authorities can only use the restricted money rules.

From the analysis of the above two cases ⁸, we may state the following proposition.

⁸We have not allowed for the possibility of asymmetric pricing equilibria, where one country follows LCP and another country follows PCP. In the technical appendix to this paper however, it is shown that such an asymmetric outcome cannot be an equilibrium. The reason is that if one country follows a PCP rule, then the monetary policy game will imply sufficient exchange rate flexibility that firms in *both* countries will choose PCP. Hence the asymmetric outcome is ruled out for the same reasons as in Case 2.

Proposition 1 *The $\{PCP, PCP\}$ configuration, and flexible exchange rates represent the unique equilibrium of the international monetary Nash game, where the currency of pricing is endogenous, and monetary are restricted as in (2.4).*

Corollary 1 *The full flexible price equilibrium can be sustained by the restricted monetary rules.⁹*

5 Discussion and Conclusions

When monetary policy is chosen conditional on the currency of pricing, and monetary policy rules are unrestricted, then there are two Pareto ranked equilibria, as shown by Corsetti and Pesenti (2002). Due to the problem of coordinating expectations of price setters and the actions of monetary authorities, the economy can be stuck in an equilibrium with low pass-through, fixed exchange rates, and social welfare lower than the flexible price equilibrium. One way to eliminate this bad equilibrium is to assume that monetary policy can take account of the currency of pricing decision. Nevertheless, we have argued that this may not be a realistic description of monetary policy, since product market structure is normally thought to be outside the purview of monetary policy. An alternative however is to restrict the form of monetary rules itself. If monetary authorities are precluded from reacting to foreign productivity shocks, then their optimal policies will rule out the equilibrium with LCP. In this sense, restricting the form of the monetary policy rule acts as an equilibrium selection mechanism.

The key effect of the restrictions on monetary rules is that they ensure exchange rate adjustment. Without any restrictions, there is an equilibrium where the monetary authorities find it optimal to eliminate exchange rate adjustment. Given LCP pricing decisions, exchange rate volatility hinders cross country consumption risk-sharing, while at the same time, has no benefit in terms of relative price adjustment (because there is no pass-through to domestic prices). By ensuring that monetary policy cannot deliver absolute exchange rate stability, the restricted rules cause all firms to follow PCP pricing decisions, leading to full exchange rate pass-through. The ensuing optimal monetary policy then brings *both* efficient international consumption risk-sharing, and efficient relative price adjustment.

References

- [1] Corsetti, Giancarlo, and Paolo Pesenti (2001). “International Dimensions of Optimal Monetary Policy,” *Federal Reserve Bank of New York Staff Report* 124.
- [2] Corsetti, Giancarlo, and Paolo Pesenti (2002). “Self-Validating Optimal Monetary Currency Areas,” *NBER Working Paper*, No. 8783.
- [3] Devereux, Michael B., and Charles Engel (2003). “Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility,” *Review of Economic Studies*, 70, 765-84.

⁹It can be shown that to sustain the full flexible price equilibrium, we only need one monetary authority to use the restricted monetary rules. In other words, as long as one country promises to restrict itself and only respond to domestic shocks, Friedman’s argument for flexible exchange rate can be upheld.

- [4] Devereux, Michael B., Charles Engel, and Peter Storgaard (2003). "Endogenous Exchange Rate Pass-through when Nominal Prices are Set in Advance," *Journal of International Economics*, forthcoming.
- [5] Friedman, Milton (1953). "The Case for Flexible Exchange Rates", in *Essays in Positive Economics*, Chicago University Press, Chicago.
- [6] Mundell, Robert A. (1961). "A Theory of Optimum Currency Areas", *American Economic Review*, 51, 657-665.
- [7] Obstfeld, Maurice, and Kenneth Rogoff (2002). "Global Implication of Self-Oriented National Monetary Rules," *Quarterly Journal of Economics*, v. 117(2), 503-35.