UNIVERSITAT ROVIRA I VIRGILI

WORKING PAPERS

Col·lecció "DOCUMENTS DE TREBALL DEL DEPARTAMENT D'ECONOMIA"

"Market Effects of Foreign Exchange Coordinated Intervention"

Montserrat Ferré Carracedo
Carolina Manzano Tovar

Document de treball nº -3- 2008

DEPARTAMENT D'ECONOMIA
Facultat de Ciències Econòmiques i Empresarials

Edita:

Departament d'Economia
http://www.fcee.urv.es/departaments/economia/public_html/index.html
Universitat Rovira i Virgili
Facultat de Ciències Econòmiques i Empresarials
Avgda. de la Universitat, 1
432004 Reus
Tel. +34 977 759 811
Fax +34 977 300 661

Dirigir comentaris al Departament d'Economia.

Dipòsit Legal: T-835-2008
ISSN 1988 - 0812

DEPARTAMENT D'ECONOMIA
Facultat de Ciències Econòmiques i Empresarials

Market Effects of Foreign Exchange Coordinated Intervention

Montserrat Ferré* and Carolina Manzano
Department of Economics, Universitat Rovira i Virgili,
Av. Universitat 1, 43204-Reus (Spain)
montserrat.ferre@urv.cat, carolina.manzano@urv.cat
*Corresponding author. Tel. +34-977-759852, Fax: +34-977-300661

Abstract

In this article we develop a theoretical microstructure model of coordinated central bank intervention based on asymmetric information. We study the economic implications of coordination on some measures of market quality and show that the model predicts higher volatility and more significant exchange rate changes when central banks coordinate compared to when they intervene unilaterally. Both these predictions are in line with empirical evidence.

Keywords: coordinated foreign exchange intervention, market microstructure.
JEL Classification: D82, E58, F31, G14

Financial support from projects SEJ2006-12392, SEJ2007-67580-C02-01/ECON and 2005SGR00949 is gratefully acknowledged.

1 Introduction

The effects of central bank intervention on the characteristics of the market have been thoroughly studied, empirically, for unilateral interventions. There are, however, fewer studies for coordinated intervention. Among these, Dominguez (2006) and Beine et al. (2003), find that coordinated interventions, like unilateral ones, have a positive effect on volatility. Further, Dominguez (2003) finds that coordinated interventions have the largest price impact and thus are more effective than unilateral ones.

In this article we develop a theoretical model of coordinated central bank intervention that matches these market characteristics. We use an asymmetric information microstructure model, as intervention in the foreign exchange (FX) market by central banks has recently been explained through such models.

In particular, Pasquariello (2007), analysing Swiss National Bank interventions, finds that the effectiveness is crucially related to their perceived information content, rather than to inventory considerations. Further, empirical evidence on FX intervention confirms the suitability of asymmetric information microstructure models, as evidence shows that the markets learn about central bank intervention through trading rather than public news, e.g. Reuters (see, for instance, Peiers (1997), Chang and Taylor (1998) and Dominguez (2003)). At the theoretical level, the study of central bank intervention has focused almost exclusively on unilateral intervention (see Vitale (1999)), but we develop here a model for coordinated intervention.

The structure of this article is as follows. Section 2 presents the theoretical model and the equilibrium conditions of coordinated and unilateral central bank intervention in the FX market. Section 3 presents the characteristics of the market resulting from coordinated central bank intervention, and finally Section 4 offers some conclusions.

2 The model and equilibrium conditions

The model considers an economy where a single foreign currency is traded at an exchange rate s. Let f represent its fundamental value. Three kinds of agents participate in this market: noise traders, central banks and market makers.

Noise traders demand a random, inelastic quantity, not based on maximizing behavior, denoted by ε.

We consider two possible scenarios for central bank behaviour: it either intervenes on its own (unilaterally) or with another central bank (coordinated). In either case, a central bank that intervenes in the market acts strategically, perfectly knows the value of f and has a target level for the exchange rate, denoted by t. We assume that when the two central banks intervene jointly they have a common target objective, in line with the studies of Dominguez and Frankel (1993), Goodhart and Hesse (1993) or Frenkel et al. (2003). They find evidence of the existence of an implicit target for the exchange rate. In particular, $t = f + \xi$, where ξ denotes a term not related to the fundamental.

Following the literature (see Vitale (1999), Ferré and Manzano (2008)), each central bank will choose its market order, x, in order to minimize the expected value of its loss function. This function includes a first term that reflects the speculative intervention, and a second term that reflects the stabilization of the exchange rate around the target, where the parameter q represents the weight given by the central bank to such stabilization:

$$L = (s - f)\, x + q\,(s - t)^2 \,.$$

Market makers observe the aggregate net order flow quantity w and set the exchange rate at which they trade the quantity necessary to clear the market. We assume that market makers are risk neutral. Competition among market makers forces them to choose the exchange rate such that they earn zero expected profits. Thus,

$$s = E(f|w). \tag{1}$$

All random variables are assumed to be normally distributed. More precisely, $f \sim N\left(s_0, \sigma_f^2\right)$, $\varepsilon \sim N\left(0, \sigma_\varepsilon^2\right)$ and $\xi \sim N\left(\xi_0, \sigma_\xi^2\right)$. Furthermore, it is supposed that these random variables are independent of each other. The joint distribution of all these random variables is common knowledge.

The equilibria are derived next. In particular, in the case where both central banks (i and j) coordinate, we obtain the following result:

Proposition 1: *If the intervention of the two central banks is simultaneous, then there exists a unique symmetric linear Nash equilibrium defined as follows:*

$$s = \mu + \lambda(x_i + x_j + \varepsilon)$$

and

$$x_k = \alpha + \beta f + \gamma t, \ k = i, j,$$

where λ *is the unique positive root of the following polynomial:*

$$P(\lambda) = 16\lambda^2 q^2 \sigma_\xi^2 + \lambda^2 \left(4q\lambda + 3\right)^2 \sigma_\varepsilon^2 - 2\left(2q\lambda + 1\right)\sigma_f^2,$$

and $\mu = s_0 - 4q\lambda\xi_0$, $\alpha = 2q\xi_0 - \beta s_0 - \gamma(s_0 + \xi_0)$, $\beta = \frac{1}{\lambda(4q\lambda+3)}$, *and* $\gamma = \frac{2q}{(4q\lambda+3)}$.

Proof: Suppose that the central bank i conjectures that central bank j's demand is given by

$$x_j = \alpha + \beta f + \gamma t \tag{2}$$

and that the pricing rule is

$$s = \mu + \lambda w, \tag{3}$$

where

$$w = \alpha + \beta f + \gamma t + x_i + \varepsilon.$$

Solving the central bank i optimization problem, its optimal market order is given by

$$x_i = \frac{(1 - \lambda\beta(2q\lambda + 1))f + \lambda(2q(1 - \lambda\gamma) - \gamma)t - (2q\lambda + 1)(\mu + \lambda\alpha)}{2\lambda(q\lambda + 1)}.$$

Equating coefficients according to (2), we have

$$\alpha = \frac{-\left(2q\lambda + 1\right)\mu}{\lambda\left(4q\lambda + 3\right)}, \tag{4}$$

$$\beta = \frac{1}{\lambda\left(4q\lambda + 3\right)} \text{ and} \tag{5}$$

$$\gamma = \frac{2q}{4q\lambda + 3}. \tag{6}$$

Looking at the market makers' problem, from (1) and the normality assumption, we get $s = s_0 + \frac{cov(f,w)}{var(w)}(w - E(w))$. Equating coefficients according to (3),

$$\mu = s_0 - \lambda(2\alpha + 2(\beta+\gamma)s_0 + 2\gamma\xi_0) \text{ and} \tag{7}$$

$$\lambda = \frac{2(\beta+\gamma)\sigma_f^2}{4(\beta+\gamma)^2\sigma_f^2 + 4\gamma^2\sigma_\xi^2 + \sigma_\varepsilon^2}. \tag{8}$$

(4)-(8) constitute a system of five equations and five unknowns. After direct computations, we obtain the desired expressions for the equilibrium coefficients and that λ is the unique positive root of $P(\lambda)$. ■

For the case where only one central bank (central bank i) intervenes in the foreign exchange market, we obtain the following proposition:

Proposition 2: *If the intervention of central bank i is unilateral, then there exists a unique linear Nash equilibrium defined as follows:*

$$s_1 = \mu_1 + \lambda_1(x_i + \varepsilon)$$

and

$$x_i = \alpha_1 + \beta_1 f + \gamma_1 t,$$

where λ_1 *is the unique positive root of the following polynomial:*

$$P_1(\lambda_1) = 4q^2\lambda_1^2\sigma_\xi^2 + 4\lambda_1^2(q\lambda_1+1)^2\sigma_\varepsilon^2 - \sigma_f^2(2\lambda_1 q + 1),$$

and $\mu_1 = s_0 - 2q\lambda_1\xi_0$, $\alpha_1 = 2q\xi_0 - \beta_1 s_0 - \gamma_1(s_0+\xi_0)$, $\beta_1 = \frac{1}{2\lambda_1(q\lambda_1+1)}$, *and* $\gamma_1 = \frac{q}{q\lambda_1+1}$.

Proof: This proof is omitted since is identical to the proof of Proposition 2 in Ferré and Manzano (2008). ■

3 Market characteristics of coordinated interventions

Next, we examine the economic implications of coordinated (versus unilateral) intervention comparing some measures of market quality, like liquidity and efficiency. We also study the consequences on volatility and the price change of the two types of intervention.

a) Market liquidity

Following Kyle (1985), market liquidity is measured by the inverse of the endogenous variable λ, as this inverse represents the order flow necessary to induce the exchange rate to rise or fall by one unit. Therefore, the higher the market liquidity, the lower the impact of the order of one particular agent on the price of the currency.

Pasquariello (2007) analyses the effects on liquidity of central bank intervention, showing that liquidity deteriorates with intervention. Whether the effect on liquidity is enhanced by unilateral or coordinated intervention has not been resolved empirically but our theoretical model has implications in this respect:

Corollary 1: *The FX market is more liquid when central banks coordinate their interventions.*

Proof: Recall that λ_1 is the unique positive root of $P_1(\lambda_1)$ and that $\underset{\lambda_1\to\infty}{lim} P_1(\lambda_1) = \infty$. Using $P(\lambda) = 0$, direct computations yield that $P_1(\lambda) < 0$, which tells us that $\lambda < \lambda_1$. ■

The intuition for this result is as follows. When two central banks intervene together the volume of intervention is more volatile than when there is only one central bank in the market. This higher volatility (or noise) implies that market makers rely less on the order flow when setting the exchange rate.

b) Market efficiency

A usual measure of the market efficiency is the inverse of the conditional variance of the fundamental value given the information set of market makers, that is, $var^{-1}(f|w)$.

Corollary 2: *The FX market is more efficient when central banks coordinate their interventions.*

Proof: We want to prove that

$$var(f|w) < var(f|w_1). \tag{9}$$

Using the normality assumption, we have $var(f|w_1) = \sigma_f^2 - \frac{cov^2(f,w_1)}{var(w_1)}$ and $var(f|w) = \sigma_f^2 - \frac{cov^2(f,w)}{var(w)}$. Thus, to prove (9), it suffices to show

$$\lambda cov(f,w) > \lambda_1 cov(f,w_1) \tag{10}$$

since

$$\lambda_1 = \frac{cov(f,w_1)}{var\,(w_1)} \text{ and } \lambda = \frac{cov(f,w)}{var\,(w)}. \tag{11}$$

Using the expressions of order flows and of equilibrium coefficients, and operating, we get $2q\,(2\lambda - \lambda_1) + 1 > 0$. This inequality is demonstrated if we prove $2\lambda > \lambda_1$, or, $P_1(2\lambda) > 0$. Using $P(\lambda) = 0$,

$$P_1(2\lambda) = \frac{h(q\lambda)}{(4q\lambda+3)^2},$$

with $h(z) = -768\sigma_\xi^2 z^4 - 64\left(10\sigma_\xi^2 - 3\sigma_f^2\right)z^3 - 16\left(7\sigma_\xi^2 - 17\sigma_f^2\right)z^2 + 132\sigma_f^2 z + 23\sigma_f^2$. Descartes' rule allows us to conclude that $h(z)$ has only one positive root. Applying the Implicit Function Theorem, we have that $q\lambda$ is increasing in q. Moreover, $\lim_{q\to 0}\lambda q = 0$ and $\lim_{q\to\infty}\lambda q = \frac{\sigma_f^2+\sqrt{\sigma_f^4+8\sigma_f^2\sigma_\xi^2}}{8\sigma_\xi^2}$. Therefore, $q\lambda \in$

$\left[0, \frac{\sigma_f^2+\sqrt{\sigma_f^4+8\sigma_f^2\sigma_\xi^2}}{8\sigma_\xi^2}\right)$. Direct computations yield that $h(0) > 0$ and $h\left(\frac{\sigma_f^2+\sqrt{\sigma_f^4+8\sigma_f^2\sigma_\xi^2}}{8\sigma_\xi^2}\right) > 0$. This implies that $h(q\lambda) > 0$, and hence, $P_1(2\lambda) > 0$. ■

When two central banks coordinate their intervention in the foreign exchange market, the correlation between f and w is higher. This effect increases efficiency, compensating the decrease in efficiency resulting from the higher volatility of the order flow.

c) Volatility and price changes

The empirical literature has considered volatility and price changes as measures of effectiveness Our model has the following implication for these measures:[1]

Corollary 3: *The FX market is more volatile when central banks coordinate their interventions. Also, the change in exchange rates is more significant when central banks coordinate.*

Proof: First, we want to prove that $var\,(s) > var\,(s_1)$. From Propositions 1 and 2, it is equivalent to $\lambda^2 var\,(w) > \lambda_1^2 var\,(w_1)$. Combining (10) and (11) we conclude that this inequality holds.

Finally, we compare $E(|s - s_0|)$ and $E(|s_1 - s_0|)$. To obtain these expressions we use the following result: if $x \sim N\left(0, \sigma_x^2\right)$, then $E(|x|) = \sqrt{\frac{2}{\pi}\sigma_x^2}$. In our case, $E(|s - s_0|) = \sqrt{\frac{2}{\pi} var\,(s - s_0)}$ and $E(|s_1 - s_0|) = \sqrt{\frac{2}{\pi} var\,(s_1 - s_0)}$. Since $var\,(s) > var\,(s_1)$, we conclude that $E(|s - s_0|) > E(|s_1 - s_0|)$. ■

The predictions we obtain are in line with empirical evidence. Dominguez (2003) finds that volatility surrounding intervention periods is substantially higher than during non-intervention periods. Further, empirical evidence shows that coordinated FX intervention operations have a larger impact on currency values (Vitale (2006)).

We argue that the higher effect of coordinated intervention on volatility is due to the higher volume associated with a coordinated intervention. As the aggregate size of intervention is larger when two banks, rather than one, intervene, this effect is what increases volatility and produces a higher price change. Empirically, larger intervention has been associated with a relatively larger exchange rate movement (see Fatum and Hutchinson (2003) and Chaboud and Humpage (2005)). Further, this possibility is acknowledged by Dominguez (2003), who finds evidence that coordinated G-3 interventions are more effective than unilateral ones, but admits that it is possible that the larger coordination effect results from the fact that the aggregate size of intervention tends to be higher when intervention is coordinated.

[1] Corollary 3 might appear counterintuitive, given that liquidity is higher when central banks coordinate. In fact, when central banks coordinate, liquidity is higher but at the same time, the order flow is more volatile. Corollary 3 shows that the latter effect dominates.

4 Conclusion

In this article we have developed a simple asymmetric information microstructure model of coordinated intervention and have shown that coordinated intervention is associated with higher liquidity and efficiency than unilateral intervention. These effects help to explain why central banks tend to intervene together in the FX market, as liquidity and efficiency are generally considered as desirable characteristics of any market.

Further, the model developed predicts higher volatility and more significant exchange rate changes when central banks coordinate than when they intervene unilaterally. Both these predictions are in line with empirical evidence, and we have argued that they arise as a consequence of the higher volume associated with coordinated intervention.

References

[1] Beine, M., S. Laurent and F. Palm, 2003, Central bank forex intervention assessed using realized moments, Maastricht University, Research Memorandum 03/043.

[2] Chaboud, A. and O. Humpage, 2005, An assessment of the impact of Japanese foreign exchange intervention: 1991-2004, International Finance Division Discussion Papers 824, Board of Governors of the federal Reserve System.

[3] Chang, Y. and S. Taylor, 1998, Intraday effects of foreign exchange intervention by the Bank of Japan, Journal of International Money and Finance 17, 191 – 210.

[4] Dominguez, K., 2006, When do central bank interventions influence intra-daily and longer-term exchange rate movements?, Journal of International Money and Finance 25, 1051-1071.

[5] Dominguez, K., 2003, The market microstructure of central bank intervention, Journal of International Economics 59, 25-45.

[6] Dominguez, K. and J. Frankel, 1993, Does foreign exchange intervention work?, Washington, D.C.: Institute for International Economics.

[7] Fatum, R. and M. Hutchinson, 2003, Is foreign exchange intervention effective after all? An event study approach, The Economic Journal 113, 390-411.

[8] Ferré, M. and C. Manzano, 2008, When do central banks prefer to intervene secretly?, International Journal of Finance and Economics, forthcoming.

[9] Frenkel, M., C. Pierdzioch and G. Stadtmann, 2003, Modeling coordinated foreign exchange market interventions: the case of the Japanese and U.S. interventions in the 1990s, Review of World Economics 139, 709-729.

[10] Goodhart, C. and T. Hesse, 1993, Central bank forex intervention assessed in continuous time, Journal of International Money and Finance 12, 368-389.

[11] Kyle, A. S., 1985, Continuous auctions and insider trading, Econometrica 53, 1315 – 1335.

[12] Pasquariello, P., 2007, Informative trading or just costly noise? An analysis of central bank interventions, Journal of Financial Markets 10, 107-143.

[13] Peiers, B., 1997, Informed traders, intervention, and price leadership: A deeper view of the microstructure of the foreign exchange market, The Journal of Finance 52, 1589 – 1614.

[14] Vitale, P., 2006, A critical appraisal of recent developments in the analysis of foreign exchange market intervention, CEPR Discussion Paper 5729.

[15] Vitale, P., 1999, Sterilised central bank intervention in the foreign exchange market. Journal of International Economics 49, 245 – 267.