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The relative effectiveness of sterilized and non sterilized foreign exchange market interventions

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Abstract

This paper examines the impact of non sterilized and sterilized foreign exchange market operations on both the exchange rate and domestic interest rate within the context of a rational expectations portfolio balance model. The results show that non sterilized intervention will be more effective than sterilized intervention in affecting both the exchange rate and domestic interest rate. Both types of operations affect a market risk premium that is shown to be a function of relative asset supplies in the hands of the private sector. When domestic and foreign bonds are perfect substitutes, the risk premium vanishes and so to does the effectiveness of sterilized foreign exchange market interventions.

JEL classification: F310

Keywords: Exchange market intervention; Sterilized intervention; Non sterilized intervention

1. Introduction

There is a considerable literature examining the impact of foreign exchange market interventions by central banks see, for example, Adams and Henderson (1983), Argy (1982), Fatum and Hutchison (2003), Genberg (1981), Kenen (1982, 1987) and the excellent survey by Taylor and Sarno (2001). This literature has tended to focus primarily upon the exchange rate effects of intervention, however, it is equally important to focus the interest rate effects

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of such operations. The impact on the domestic economy of foreign exchange market intervention is combination of these two effects. In this paper, we use a dynamic specification of the portfolio balance model to show how both the exchange rate effects and interest rate effects are linked to their impacts on a risk premium that is a function of relative asset supplies in the hands of private agents. The only other paper to examine the effects of exchange market intervention on the risk premium has been Dooley and Isard (1983) who used a static expectations model.

2. The model

The model we draw upon for analysing the effects of sterilized and non sterilized intervention in the foreign exchange market is a rational expectations version of the portfolio balance class of exchange rate models attributable to Branson (1976) and Kouri (1983). There are three assets that are held in the portfolios of the private agents and the authorities: Domestic monetary base, M; domestic bonds denominated only in the domestic currency, B^*; foreign bonds denominated only in the foreign currency, F^*. Domestic bonds may be held by either domestic agents or the authorities. The supply of domestic bonds is assumed to be fixed as:[1]

$$B^* = B + B_{\mathrm{a}} \tag{1}$$

where B^* is the fixed net supply of domestic bonds, B is the domestic bond holdings of private agents and B_{a} is the domestic bond holdings of the authorities. The country's net holding of foreign bonds is held by private agents and the authorities which we assume to be positive in both cases and equal to the summation of previous current account surpluses. The holdings of foreign assets may be increased or decreased over time via a current account surplus or deficit. Thus, we have:

$$F^* = F + R \tag{2}$$

where F^* is the net foreign bond holdings of the country, F is the foreign bond holdings of private agents and R is the stock of foreign bonds held by the authorities in their reserves valued in foreign currency. The domestic monetary base liability of the authorities is equivalent to the assets of the authorities[2] so that:

$$M = B_{\mathrm{a}} + SR \tag{3}$$

where S is the exchange rate defined as domestic currency units per unit of foreign currency. Total private sector financial wealth at any point in time is given by the identity:

$$W = M + B + SF \tag{4}$$

[1] In essence, this means we are considering balanced budgets.

[2] It is assumed that capital gains or losses to the authorities as a result of exchange rate changes do not affect the monetary base.

The demand to hold money by the private sector is inversely related to the domestic interest rate, inversely related to the expected rate of return on foreign bonds and positively to domestic income and wealth. This yields:

$$M = m(r,\ \dot{S},\ W),\quad \mathrm{mr} < 0,\ \ \mathrm{m\dot{s}} < 0,\ \text{and}\ \ \mathrm{mw} > 0 \tag{5}$$

where r is the domestic nominal interest rate, $\dot{S}$ is the expected rate of depreciation of the domestic currency. We invoke the assumption that foreign exchange market participants form their expectations rationally and possess perfect foresight[3] with respect to the exchange rate. The demand to hold domestic bonds as a proportion of private wealth is positively related to the domestic interest rate, inversely related to the expected rate of return on foreign assets and positively to wealth. This yields:

$$B = b(r,\ \dot{S},\ W),\quad \mathrm{br} > 0,\ \ \mathrm{b\dot{s}} < 0,\ \text{and}\ \ \mathrm{bw} > 0 \tag{6}$$

The demand to hold foreign bonds as a proportion of total wealth is inversely related to the domestic interest rate, positively related to the expected rate of return from holding foreign bonds and positively to wealth. This yields:

$$SF = f(r,\ \dot{S},\ W),\quad \mathrm{fr} < 0,\ \ \mathrm{f\dot{s}} > 0,\ \text{and}\ \ \mathrm{fw} > 0 \tag{7}$$

The current account balance (CA) is crucial to the dynamics of the system because the current account surplus gives the rate of accumulation of foreign assets. That is:

$$\mathrm{CA} = \frac{\mathrm{d}F}{\mathrm{d}t} = \dot{F} = T + r^{*}(F + R) \tag{8}$$

where CA is the current account surplus in foreign currency, T is the net exports measured in foreign currency, r^{*} is the fixed foreign interest rate. The current account is made up of two components: the revenue from net exports and interest rate receipts from net holdings of foreign assets. The trade balance is assumed to be a positive function of the real exchange rate.

$$T = T\left(\frac{S}{P}\right)\quad Ts > 0 \tag{9}$$

where P is the fixed domestic price level. The $\dot{S} = 0$ schedule is given by:

$$\dot{S} = \frac{\begin{array}{c}(-\mathrm{fr} + \mathrm{fr}\cdot\mathrm{mw} - \mathrm{mr}\cdot\mathrm{fw})\mathrm{d}M + (\mathrm{fr}\cdot\mathrm{mw} - \mathrm{mr}\cdot\mathrm{fw})\mathrm{d}B\\ +(\mathrm{fr}\cdot\mathrm{mw} + \mathrm{mr} - \mathrm{mr}\cdot\mathrm{fw})S\mathrm{d}F + (\mathrm{fr}\cdot\mathrm{mw} + \mathrm{mr} - \mathrm{mr}\cdot\mathrm{fw})F\mathrm{d}S\end{array}}{\mathrm{f\dot{s}}\cdot\mathrm{mr} - \mathrm{fr}\cdot\mathrm{m\dot{s}}} \tag{10}$$

The slope of the $\dot{S} = 0$ schedule is given by the expression:

$$\frac{\mathrm{d}S}{\mathrm{d}F}(\dot{S} = 0) = \frac{-S}{F} \tag{11}$$

[3] Nearly all modern asset market theories invoke the assumption of perfect foresight on the part of foreign exchange market participants.

The $\dot{F} = 0$ schedule is given by:

$$\dot{F} = Ts\,\mathrm{d}S + r^{*}\,\mathrm{d}F \tag{12}$$

Thus, the $\dot{F} = 0$ schedule has a negative slope given by:

$$\frac{\mathrm{d}S}{\mathrm{d}F}(\dot{F} = 0) = \frac{-r^{*}}{Ts} < 0 \tag{13}$$

The model is in equilibrium when the $\dot{F} = 0$ schedule intersects the $\dot{S} = 0$ schedule. The model is dynamically stable only when $\dot{F} = 0$ schedule is less steep than the $\dot{S} = 0$ schedule.

3. The exchange rate effects of sterlized and non sterilized foreign exchange interventions

With an expansionary FXO, the authorities purchase foreign bonds from the private sector with newly created monetary base. This means that there is an increase in the private sectors holdings of money and an equivalent fall in their holdings of foreign bonds ($\mathrm{d}M = -S\,\mathrm{d}F = S\,\mathrm{d}R$). There will be an upward shift of the $\dot{S} = 0$ schedule given by the expression:

$$\frac{\mathrm{d}S}{\mathrm{d}M}(\dot{S} = 0) = \frac{\mathrm{fr} + \mathrm{mr}}{(\mathrm{fr}\cdot\mathrm{mw} + \mathrm{mr} - \mathrm{mr}\cdot\mathrm{fw})F} \tag{14}$$

With a sterilized foreign exchange operation SFXO, there is also an upward shift of the $\dot{S}$ schedule. A sterilized intervention in the foreign exchange market leaves the domestic monetary base unchanged ($\mathrm{d}M = -S\,\mathrm{d}F$ and $-\mathrm{d}M = \mathrm{d}B$ so that $-S\,\mathrm{d}F = \mathrm{d}B$); effectively, the authorities are altering the currency composition of bonds held in private portfolios. In this case there is an upward shift of the $\dot{S} = 0$ schedule given by the expression:

$$\frac{\mathrm{d}S}{\mathrm{d}B}(\dot{S} = 0) = \frac{\mathrm{mr}}{(\mathrm{fr}\cdot\mathrm{mw} + \mathrm{mr} - \mathrm{mr}\cdot\mathrm{fw})F} \tag{15}$$

Both operations lead to a fall in the private sectors holdings of foreign assets and there is a jump depreciation of the exchange rate.[4] Both operations create an excess demand for foreign assets that can be satisfied in the short run only by a depreciation of the domestic currency. However, it is clear that a SFXO has a relatively weaker effect on the nominal exchange rate than a FXO because the shift of the $\dot{S}$ schedule is less than in the case of a FXO. This ensures that the new saddle path following a SFXO must lie below that of a FXO and consequently that jump depreciation of the exchange rate is less than following a FXO. As such, a SFXO is a relatively ineffective means of influencing the exchange rate as compared to a FXO. This is illustrated in Fig. 1.

With a SFXO the exchange rate jump depreciates from S_1 to S_2, while with a FXO the exchange rate jump depreciates from S_1 to S_3. One also needs to distinguish between the

[4] The initial jump in the exchange rate is greater, the smaller initial private holdings of foreign assets.

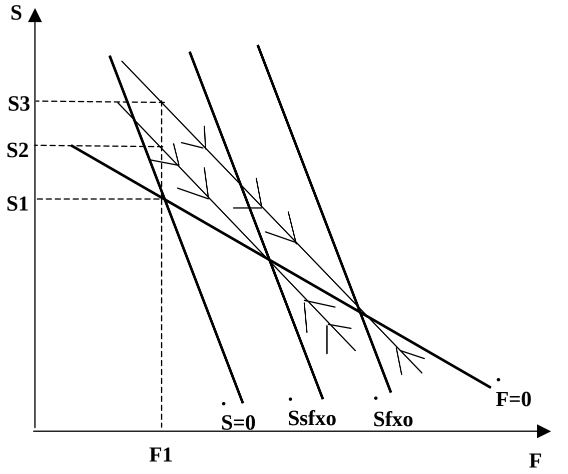

Fig. 1. The effects of sterilized and non sterilized foreign exchange operations.

short and long-term impacts of the operations; in both cases, the impact of a real depreciation is that the current account moves into surplus; this leads to increased private sector holdings of foreign assets which in turn results in an increased demand for domestic assets and a resulting appreciation of the domestic currency. The real exchange rate actually appreciates in the long run since a deterioration of the trade account is required to offset the increased interest rate receipts due to greater holdings of foreign assets by the country.[5] Hence, the long-term consequences of foreign exchange operations are actually the reverse of the initial impact effects.

4. The interest rate effects of sterilized and non sterilized foreign exchange interventions

The solution for the domestic interest rate is important as well as the exchange rate effects. For a FXO, the expression for the impact effect on the domestic interest rate is given by Eq. (16):

$$\mathrm{d}r = \frac{(-\mathrm{b\dot{s}})\mathrm{d}M + (-\mathrm{m\dot{s}}\cdot\mathrm{bw} + \mathrm{b\dot{s}}\cdot\mathrm{mw})F\mathrm{d}S}{\mathrm{m\dot{s}}\cdot\mathrm{br} - \mathrm{b\dot{s}}\cdot\mathrm{mr}} \tag{16}$$

A FXO leads to a fall in the domestic interest rate. This is not surprising as the operation increases both the monetary base and nominal wealth, which in turn raises the demand for domestic bonds. For a SFXO, the impact effect on the domestic interest rate is given by

[5] During the transition to long run equilibrium, the economy experiences a current account surplus and an appreciating currency; Kouri (1983) labels such a link between the current account and the exchange rate as the “acceleration hypothesis.”

Eq. (17):

$$\mathrm{d}r = \frac{(\dot{\mathrm{ms}})\mathrm{d}B + (-\dot{\mathrm{ms}} \cdot \mathrm{bw} + \dot{\mathrm{bs}} \cdot \mathrm{mw})F\mathrm{d}S}{\dot{\mathrm{ms}} \cdot \mathrm{br} - \dot{\mathrm{bs}} \cdot \mathrm{mr}} \tag{17}$$

Hence, a SFXO has an ambiguous effect on the domestic interest rate. The direct effect of increasing the supply of domestic bonds and decreasing the holdings of foreign bonds is to raise the domestic interest rate; this is opposite in sign to the direct effect of a FXO. The ambiguous effect of a SFXO on the domestic interest rate arises because the depreciation of the domestic currency leads to an increased wealth demand for domestic bonds, which depresses the domestic interest rate. Nevertheless, even if the wealth effect outweighs the direct effect of a SFXO, the fall in the domestic interest rate must be lower than in the case of a FXO because the direct effect raises the domestic interest rate in the case of a SFXO and the wealth effect must be smaller because the initial jump in the exchange rate is smaller. Hence, a SFXO has an ambiguous and more muted impact on the domestic interest rate compared to a FXO.

5. Analysing the effects on the risk premium

The portfolio balance model differs from the monetary models in that it breaks up the uncovered interest rate parity condition by introducing a risk premium as in Eq. (18):

$$r - r^* = E\dot{S} + \mathrm{RP} \tag{18}$$

where RP is the risk premium on domestic assets. It follows that under the assumption of perfect foresight ($E\dot{S} = \dot{S}$):

$$\mathrm{d}r - \mathrm{d}r^* = \mathrm{d}\dot{S} + \mathrm{dRP} \tag{19}$$

Since the foreign interest rate is assumed to be fixed, we can rearrange the above to yield:

$$\mathrm{dRP} = \mathrm{d}r - \mathrm{d}\dot{S} \tag{20}$$

Around the neighbourhood of the stationary equilibrium, $\mathrm{d}\dot{S} = \dot{S}$ and we know dr. This means that it is possible to derive from the structure of the portfolio balance model itself an expression for the change in the risk premium given by Eq. (21):

$$\mathrm{d}RP = \frac{\begin{array}{c}(-\dot{\mathrm{ms}} \cdot \mathrm{bw} - \dot{\mathrm{bs}} + \dot{\mathrm{bs}} \cdot \mathrm{mw})\mathrm{d}M + (\dot{\mathrm{ms}} - \dot{\mathrm{ms}} \cdot \mathrm{bw} + \dot{\mathrm{bs}} \cdot \mathrm{mw})\mathrm{d}B \\ +(-\dot{\mathrm{ms}} \cdot \mathrm{bw} + \dot{\mathrm{bs}} \cdot \mathrm{mw})S\mathrm{d}F + (-\dot{\mathrm{ms}} \cdot \mathrm{bw} + \dot{\mathrm{bs}} \cdot \mathrm{mw})F\mathrm{d}S\end{array}}{\dot{\mathrm{ms}} \cdot \mathrm{br} - \dot{\mathrm{bs}} \cdot \mathrm{mr}} + \frac{\begin{array}{c}(\mathrm{fr} - \mathrm{fr} \cdot \mathrm{mw} + \mathrm{mr} \cdot \mathrm{fw})\mathrm{d}M + (-\mathrm{fr} \cdot \mathrm{mw} + \mathrm{mr} \cdot \mathrm{fw})\mathrm{d}B \\ +(-\mathrm{fr} \cdot \mathrm{mw} - \mathrm{mr} + \mathrm{mr} \cdot \mathrm{fw})S\mathrm{d}F + (-\mathrm{fr} \cdot \mathrm{mw} - \mathrm{mw} + \mathrm{mr} \cdot \mathrm{fw})F\mathrm{d}S\end{array}}{\dot{\mathrm{fs}} \cdot \mathrm{mr} - \mathrm{fr} \cdot \dot{\mathrm{ms}}} \tag{21}$$

Following a FXO, the effect on the risk premium is given by Eq. (22):

$$\mathrm{d(RPfxo)} = \frac{(-\mathrm{b\dot{s}})\mathrm{d}M + (-\mathrm{m\dot{s}}\cdot\mathrm{bw} + \mathrm{b\dot{s}}\cdot\mathrm{mw})F\mathrm{d}S}{\mathrm{m\dot{s}}\cdot\mathrm{br} - \mathrm{b\dot{s}}\cdot\mathrm{mr}} + \frac{(\mathrm{fr}+\mathrm{mr})\mathrm{d}M + (-\mathrm{fr}\cdot\mathrm{mr} + \mathrm{mr}\cdot\mathrm{fw} - \mathrm{mr})F\mathrm{d}S}{\mathrm{f\dot{s}}\cdot\mathrm{mr} - \mathrm{fr}\cdot\mathrm{m\dot{s}}} \tag{22}$$

Following a SFXO the effect on the risk premium is given by Eq. (23):

$$\mathrm{d(RPsfxo)} = \frac{(\mathrm{m\dot{s}})\mathrm{d}B + (-\mathrm{m\dot{s}}\cdot\mathrm{bw} + \mathrm{b\dot{s}}\cdot\mathrm{mr})F\mathrm{d}S}{\mathrm{m\dot{s}}\cdot\mathrm{br} - \mathrm{b\dot{s}}\cdot\mathrm{mr}} + \frac{(\mathrm{mr})\mathrm{d}B + (-\mathrm{fr}\cdot\mathrm{mw} + \mathrm{mr}\cdot\mathrm{fw} - \mathrm{mr})F\mathrm{d}S}{\mathrm{f\dot{s}}\cdot\mathrm{mr} - \mathrm{fr}\cdot\mathrm{m\dot{s}}} \tag{23}$$

These results for the two operations are summarised in Table 1. In so doing, we distinguish between the direct effect of the operation on the risk premium and the indirect effect. The direct effect results from the change in relative asset supplies and the indirect effect results from the change in the exchange rate induced by the change in relative asset supplies. Both the change in the domestic interest rate and change in the expected depreciation of the currency may be divided up into direct and indirect effects.

An explanation of the results reported in Table 1 is necessary. In the case of a FXO, the direct effect of the increase in the money supply is to depress the domestic interest rate. In the case of a SFXO, however, the direct effect is to raise the domestic interest rate; this is because the operation increases private agents holdings of domestic bonds relative to the other two assets. However, in both cases the indirect effect on the domestic interest rate is negative as the depreciation increases private agents wealth leading to an increased demand for domestic bonds.

With regard to the exchange rate effect, the direct effect of the operations is to lead to an *expected appreciation* of the currency as the operations increase the relative holdings of domestic assets. The indirect effect of the initial depreciation, however, works in the opposite direction because the depreciation has the effect of increasing relative holdings of foreign assets requiring an *expected depreciation* of the domestic currency. We know, however, that if the economy jumps onto the unique stable saddle path the former effect outweighs the latter so that there is an *expected appreciation* of the domestic currency.

As we can see, unless we impose constraints upon the various parameters, it is not possible to evaluate the net effect on the risk premium of the various operations. The source of the

Table 1
Effects on the risk premium

Type of operation	dr			$-\mathrm{d}\dot{S}$			dRP		
	D	*I*	*N*	*D*	*I*	*N*	*D*	*I*	*N*
FXO d$M = -S$ dF	–	–	–	+	–	+	?	–	?
SFXO d$B = -S$ dF	+	–	?	+	–	+	+	–	?

D: direct effect (d*M*, d*B*, *S* d*F*), *I*: indirect effect (*F* d*S*), *N*: net effect (*D* + *I*).

ambiguity derives from the fact that the depreciation following an operation of whatever sort revalues private holdings of foreign bonds and with it raises domestic wealth leaving it unclear whether or not the stock of domestic bonds and money rise or fall as a proportion of wealth. That is:

$$\mathrm{RP} = \mathrm{RP}\left(\frac{B}{W}, \frac{M}{W}\right), \quad \mathrm{RP}_B > 0, \quad \mathrm{RP}_M > 0$$

With a FXO while the ratio B/W falls it is unclear whether the ratio M/W rises or falls; while in the case of a SFXO it is unclear whether the ratio B/W rises or falls while the M/W ratio falls. The difference between a FXO and SFXO depends crucially upon their different effects on the risk premium the existence of which is crucial for a SFXO to exert any effects.

6. Conclusions

This paper has investigated the relative effectiveness of non sterilized and sterilized interventions in the foreign exchange market. A non sterilized foreign exchange operation does not require a risk premium to have an effect on both the exchange rate and the domestic interest rate while a sterilized intervention exerts its effects by altering the risk premium. The portfolio balance model breaks up the uncovered interest rate parity condition by the introduction of a risk premium. We have derived from the model structure itself an equation for the change in the risk premium. The change in the risk premium is affected by changes in all the asset supplies depicted in the model including the domestic money supply, this suggests that existing research which typically analyses the risk premium in relation to only two assets, domestic and foreign bonds, needs to be extended to explicitly include changes in the money stock. It is clear that one cannot analyse the effectiveness of exchange market intervention without analysing the risk premium. How large a SFXO may be required to exert a significant exchange rate effect is basically an empirical question, see, for example, Fatum and Hutchison (2003). If it is the case that it requires a very large scale operation to have significant exchange rate effects the reserve changes implied may act as a constraint on the usage of this policy instrument or by adversely affecting private expectations even be counterproductive.

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References

Adams, D. B., & Henderson, D. W. (1983). *Definition and measurement of exchange market intervention*. Washington: Board of Governors of the Federal Reserve System, Staff Study No. 126.

Argy, V. (1982). *Exchange rate management in theory and practice*. Princeton Studies in International Finance No. 50.

Branson, W. H. (1976). *Asset markets and relative prices in exchange rate determination*. Stockholm: Institute for International Economic Studies, Seminar Paper No. 66.

Dooley, M., & Isard, P. (1983). The portfolio-balance model of exchange rates and some structural estimates of the risk premium. *IMF Staff Papers, 30*, 683–702.

Fatum, R., & Hutchison, M. (2003). Is sterilized foreign exchange intervention effective after all? An event study approach. *The Economic Journal*, *113*, 390–411.

Genberg, H. (1981). The effects of central bank intervention in the foreign exchange market. *IMF Staff Papers, 28*, 451–476.

Kenen, P. B. (1982). Effects of intervention and sterilization in the short run and the long run. In R. N. Cooper, P. B. Kenen, J. B. Macedo, & J. V. Ypersele (Eds.), *The international monetary system under flexible exchange rates*. Cambridge, MA: Ballinger.

Kenen, P. B. (1987). Exchange rate management: What role for intervention? *American Economic Review Papers and Proceedings*, 194–199.

Kouri, P. J. K. (1983). Balance of payments and the foreign exchange market: A dynamic partial equilibrium model. In J. S. Bhandari & B. H. Putnam (Eds.), *Economic interdependence and flexible exchange rates*. Cambridge, MA: MIT Press.

Taylor, M. P., & Sarno, L. (2001). Official intervention in the foreign exchange market: Is it effective and, if so, how does it work. *Journal of Economic Literature*, *39*, 839–868.