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An exchange rate determination model for central banks' interventions in financial markets*

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Abstract: We establish an exchange rate determination model for central banks' interventions in financial markets. The model shows that central banks can adjust exchange rate by several policy instruments and that different instruments may have different effects on exchange rate determination. It specifies potential policy instruments for central banks as well as their policy effects. Based on these effects，feasible matches of policy instruments in contingent intervention are put forth.

Key words: Intervention of exchange rate，Financial market，Exchange rate determination
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INTRODUCTION

Exchange rate intervention theories on financial markets evolve with the development of exchange rate determination theories（TERD）. Tsing Sho-chieh began to establish a theoretical framework for this field in 1959（Tsing，1959）. After the middle 1970s，Asset Market Approach theory was developed under the circumstance of frequent international capital flow. This theory argues that when disequilibrium occurs in one financial market，its recovery can be obtained not only through the adjustment of the domestic commodity markets，but also through adjustment of domestic and international financial markets（Sarker et al.，1984）. Portfolio Balance Model of Exchange Rate，a branch of this theory，advocates that disequilibrium in the exchange market will be cleared out by the adjustment of financial assets in financial markets（both domestic and international）in short term. The theory advocates the disequilibria effects on the exchange rate determined by risk-benefit analysis rather than by commodity arbitrage or interest rate arbitrage analysis. In this dynamic process，exchange rate is a key variable to keep the balance of assets supply and demand in financial markets（William，1977；Black，1968；Dornbusch，1989）.

We establish a model of exchange rate determination for central banks' interventions in this paper. We argue that central bank can adjust the exchange rate in financial markets based on this model；we also make an explanation for intervention policy instruments and provide feasible matches of them in contingent intervention.

MODEL

We have three assumptions. 1. Capital mobility is perfect（PCM）；2. Financial markets are highly developed；3. The country is a small one（by the effects of interest rate change and exchange rate change）and world interest rate is exogenous.

Rational investors will allocate their wealth to different kinds of alternative assets by benefit-cost analysis. Were capital mobility perfect，private sectors' wealth can be expressed by the following equation：

$$W = M + N + eF \qquad (1)$$

W is net wealth of private sectors，which includes domestic currency（M），domestic securities（N），foreign currencies and foreign securities（F）. e stands for exchange rate under direct quotation system.

The expected return on foreign asset is foreign interest rate（i_f）plus the expected change

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of exchange rate (π_e), while the expected return on domestic currency is zero and the expected return on domestic security is domestic interest rate (i). Proportion of each asset positively relate to its expected return and negatively relate to its substitutes. These processes can be described by Eq.(2) to Eq.(5).

$$W = M + N + eF \tag{2}$$

$$M = \alpha(i, i_f, e^e) \times W \tag{3}$$

$$\partial_M/\partial_i<0;\ \partial_M/\partial_{i_f}<0;\ \partial_M/\partial_{e^e}<0$$

$$N = \beta(i, i_f, e^e) \times W \tag{4}$$

$$\partial_N/\partial_i>0;\ \partial_N/\partial_{i_f}<0;\ \partial_N/\partial_{e^e}<0$$

$$eF = \gamma(i, i_f, e^e) \times W \tag{5}$$

$$\partial_F/\partial_i<0;\ \partial_F/\partial_{i_f}>0;\ \partial_F/\partial_{e^e}>0$$

$$\alpha + \beta + \gamma = 1$$

In this model, i is domestic interest rate; i_f is foreign interest rate; e^e is expected change of exchange rate. α, β, γ represent proportions that private sectors are willing to hold in domestic currency, domestic securities, and foreign assets separately. Since Eqs.(3), (4), (5) are not independent, we construct Eq.(6) to describe the determination of expected exchange rate.

$$e^e = e + \varepsilon \tag{6}$$

ε is noise. Short-term exchange rate can be determined by Eq.(6) and anyone of Eqs.(3), (4), (5). The mechanism is described in Fig.1.

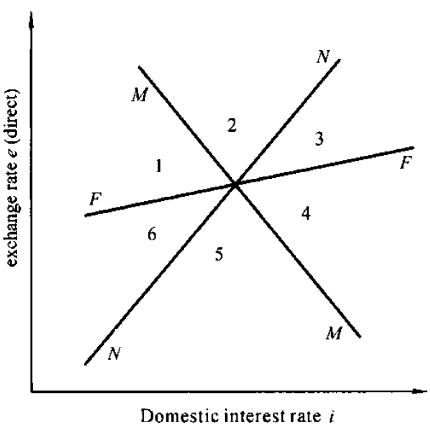

Fig.1 The relationship between domestic interest rate and exchange rate

MM: equilibrium line in domestic monetary market;
NN: equilibrium line in domestic securities market;
FF: equilibrium line in foreign assets market

In Fig.1, *NN* is much steeper than *FF*, because demand for foreign assets has higher elasticity to exchange rate change while domestic asset has higher elasticity to domestic interest rate change. Line *MM*, *NN*, *FF* cross in one spot, which represents the equilibrium point in the exchange rate and domestic interest rate in foreign assets market, in domestic monetary market and in domestic securities markets.

The outlined analysis is based on constant wealth distribution hypothesis. In fact, changes of wealth will affect current account balance through wealth effects and this will affect exchange rate. Now we model the economic behaviors of real sectors by:

$$y^T = y^T(q),\ y_q^T>0 \tag{7}$$

$$y^N = y^N(q),\ y_q^N<0 \tag{8}$$

$$c^T = c^T(q, W),\ c_q^T<0,\ c_W^T>0 \tag{9}$$

$$c^N = c^N(q, W),\ c_W^N>0,\ c_W^N>0 \tag{10}$$

$$y_D = y^T + y^N + (i_f + \pi_e)eF \tag{11}$$

$$c = c^T + c^N \tag{12}$$

The Eq.(7) to Eq.(12) describe consumption, investment, export and import of real sectors under open economy separately. y^T is total product of tradable commodity and y^N is total product of commodity that is not tradable. q refers to real exchange rate; c^T is consumption of tradable commodity while c^N stands for consumption commodity that is not tradable. The balance of current account can be expressed as

$$\Delta f = y^T(q) - c^T(q, W) + (i_f + \pi_e)eF \tag{13}$$

We hypothesize that depositing behavior is determined by real wealth and expected wealth ($\overline{W}$) difference, which can be expressed as

$$\alpha = \beta(\overline{W} - W),\ 0<\beta<1 \tag{14}$$

β stands for adjusting factor. Deposits can be described by

$$\alpha = (y^T - c^T) + (i_f + \pi_e)eF \tag{15}$$

Therefore, we get the relationship between change of current account and change of wealth.

$$\beta(\overline{W} - W) = (y^T - c^T) + (i_f + \pi_e)eF \tag{16}$$

Because wealth effects are slower than asset market adjustments, exchange rate determined by

wealth effects is long-term exchange rate.

DISCUSSION

We will demonstrate how central banks' open market operations affect the determination of exchange rate. We show the effects of purchasing bonds by Fig. 2.

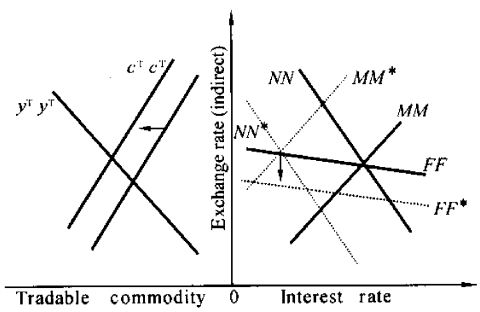

Fig. 2 Exchange rate determination mechanism of open market operation

$c^T c^T$: consumption curve of tradable commodity

$y^T y^T$: tradable commodity curve

In short term, purchasing bonds by central banks will break the equilibria of domestic monetary market and bond market, which will decrease interest rate and increase demand for foreign assets. Increase of such demand will lead to domestic currency depreciation. If elasticity conditions are proper, demand changes of foreign bonds will be greater than monetary supply change and will lead to exchange rate overshooting. The overshooting will cause both price bias and wealth effects. Therefore deposits will increase. From the analysis above, the increase of deposits will decrease the exchange rate. This process is shown by the movement of $c^T c^T$ in Fig. 2.

Besides open market operation, central banks can intervene with the exchange rate determination by other policy instruments, which include interest rate adjustment, purchase/sale of foreign asset and direct regulation on exchange rate. As shown in the models above, the relationships between exchange rate and other variables can be expressed as

$$e = \phi(\overset{+}{M},\ \overset{?}{N},\ \overset{-}{F},\ \overset{-}{i},\ \overset{+}{i_f},\ \overset{+}{e^e}) \qquad (17)$$

"+","?" and "−" represent the relationships between exchange rate and variables changes. "+" means change in the same direction, "?" means in uncertain direction and "−" means in opposite direction. Therefore, we can summarize the comparative static analysis by Table 1.

Table 1 The effects on exchange rate and interest rate of policy instruments

Variables	Changes of Domestic Interest Rate(i)	Changes of Exchange Rate(e)
Increase of Monetary Base	Decrease	Appreciation
Increase of Domestic Securities	Increase	Uncertain
Increase of Foreign Asset	Decrease	Depreciation
Increase of Domestic Interest Rate	Increase	Depreciation
Increase of Foreign Interest rate	Increase	Appreciation
Increase of Expected Exchange Rate Change	Increase	Appreciation

Intervention instruments will be adopted to deal with disequilibria of interest rate and exchange rate in open economy. Multiple goals of economic policies make it difficult to make intervention decisions. For example, in zone 3, where the interest rate and exchange rate are higher than equilibrium, central banks can't control the exchange rate only by adjusting interest rate or only by decreasing monetary base. The same problem happens in zone 6 too. Therefore, central banks need to match different policy instruments in interventions. Interest rate and exchange rate are different policy goals of intervention in financial markets. Central banks should consider these goals simultaneously because they have different effects on internal equilibrium, external equilibrium and stability of the financial system. Table 2 provides a feasible match of different instruments based on the analysis of this model.

Table 2 The feasible matches of different instruments

Zone	Disequilibrium types		Feasible intervention behavior of central banks			
	Interest rate	Exchange rate	Domestic currency market	Domestic securities market		Foreign assets market
1	Lower		Purchase M	Increase i	Sell N	
2		Higher	Purchase M		Alternative	Sell F
3	Higher	Higher		Decrease i	Purchase N	Sell F
4	Higher		Sell M	Decrease i	Issue N	Alternative
5		Lower	Purchase M			Purchase F
6	Lower	Lower		Increase i	Sell N	Purchase F

CONCLUSIONS

An exchange rate determination model is established to explain central banks' policy instruments in interventions. We show that some instruments have double effects on exchange rate determination. So the matches of policy instruments are needed in order to achieve good policy performance. Tinbergen argues that in order to achieve n kinds of policy goals, there should be at least n kinds of different independent policy instruments. Central banks' intervention activities should also obey these rules. In our study, we use open market operations and rediscount interest rate to deal with domestic interest rate goal, and we use transactions of foreign assets to deal with exchange rate goal.

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