

Measurement and Prevention the Risk of Exchange Rate of The central bank

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Abstract—since the 1970's, Developing countries have begun to introduce structural economic liberalization and stable macroeconomic plan, but these attempts do not achieve the expected effects in the short term. While the external environment is becoming increasingly complex, fixed exchange rate system began to appear collapse and Monetary crisis has appeared. Especially since the 1980's, the international financial crisis began frequently. The traditional monetary crisis model has general lack of quantitative analysis of the monetary system and real-time evaluation. Thus, apply the VaR method to exchange rate risk assessment has stronger reality, it can make scientific quantitative analysis of the exchange rate risk, then make the central bank's supervision more effective.

Keywords- Vulnerabilit; The risk of exchange rat; The Central Banks; VaR model

I. INTRODUCTION

The risk of exchange rate means fluctuations of a country's real exchange rate and may bring huge currency crisis. [1] The exchange rate seems unchanged in the country which takes a fixed exchange rate or pegged exchange rate system, but the potential value asymmetry of the different currency is objective existence. At this time, the risk of exchange rate performs as the vulnerability of the central bank. Previous currency crisis model find the causes mainly from the economic theory, but lack of quantitative measurement and real-time evaluation of the monetary system. Such as famous Economists Dornbusch (1998) point out: The focus of research on the financial crisis is gradually from estimate system stability to estimate of the vulnerability. Whether the nations will lose confidence after exchange market has been attacked by speculators mainly depends on the ability of the central Banks so a nation is likely to become the object of speculative attacks when monetary system vulnerability increase, Speculative attack led to the collapse of the monetary system and then cause the currency crisis [2].

This kind of exchange rate risk specific performance in two aspects: First, the vulnerability of The central bank will led nation's currency become the object to foreign speculators; On the other hand Once the participants in the financial market think country's ability to defense against external attack has been reduced they will lose confidence and buy foreign currency When speculators attack to the country's Nominal Exchange Rate, the country's financial system is easy to collapse and lead currency tumbled.

This paper aims at introducing a new research method: VaR (Value-at-Risk), to explore the influence and the deciding factors to the payment ability of the central bank. The main idea of VaR methods is to compare the losses of potential risks with the current assets and evaluate the central bank's payment capacity. To be specific if the potential risk loss was more than the hold assets in normal conditions it means the central bank's payment ability

reduced and the risk of default increased, it also means the vulnerability enhanced and the depreciation pressure of currency has increased.

II. SECURITIZATION OF ASSETS AND LIABILITIES OF THE CENTRAL BANK

To estimate the potential risk loss of the central bank, we can presume that all the assets and liabilities as the bull or bear of securities, Therefore we suppose all the assets and liabilities of the business as a securities portfolio [3] , and suppose the central bank as an ordinary investors in the global market. The value of this securities portfolio will change for basic market factors, such as interest rate and exchange rate. According to this method, Mario I.Blejer & Lillian Schumacher (1998) constructed a currency crisis model to evaluate the vulnerability of the central bank by using VaR method[3,5].A typical central bank's assets and liabilities business can divided into the following three aspects :

1) *assets*

Foreign exchange reserve can be regarded as a fixed interest securities bull which is denominated in foreign currency; Claims on Government, Claims on Other Depository Corporations, Claims on Other Financial Corporations, Claims on Non-financial Sector can be regarded as a assets bull position denominated in domestic currency.

2) *liabilities*

Reserve Money Sight can be regarded as short position; foreign liabilities can be regarded as all the countries' foreign debt

3) *off-balance-sheet business*

The guarantee of financial institutions can be regarded as a Bearish options short position which the central bank sold to financial institutions.

To sum up, according to the basic idea of BS model, With reference to the main projects of the Balance sheet from the central bank quarterly report, This paper uses the conception of securities, make assets and liabilities as securities[4], as table 1

TABLE I. Securitization of assets and liabilities

Assets and liabilities business	Positions part after securitization	Basic market factor
(1) Foreign Assets	fixed interest rate bull position denominated in foreign currency assets bull position denominated in domestic currency	1.interest rates in the international market
(2) Holdings of treasury bond		2.Exchange rate
(3) Claims on Government		3.Domestic interest rates
(4) Claims on Other Financial Corporations		4.interest rate to government
(5) Claims on Non-financial Sector		5.interest rate to Non-financial institutions
(6) Reserve Money	Sight short position fixed interest rate short position denominated in foreign currency	1.Foreign interest rates
(7) Foreign Liabilities		2.Exchange rate
(8) guarantee on financial institutions	Bearish options short position	1.Institutions leverage 2.interest rates 3.volatility of the assets

Source: IMF 《Monetary and Financial Statistics Manual》

III. MODEL

In order to simplify the model, we presume that the period of assets and liabilities has same time length. Also assuming that the time value factors of Domestic and foreign asset position are Domestic interest rates i and foreign interest rates i^* . Then the value model of the central bank securities portfolio can be expressed as:

$$V = \bar{R}\delta^*S + \bar{D}\delta + \phi\bar{G}\delta - H - \bar{B}\delta^*S - P(\delta, L/A, \sigma_A^2) \quad (1)$$

V = Value of the central bank Securities portfolio;

$\bar{R}$ = Total stock of the Foreign Assets; Item 1 in table;

δ^* = Reserves of the foreign currency, decided by foreign currency interest rates i^* ;

S = Spot exchange rate;

$\bar{D}$ = Net value of holdings of Treasury bond, Claims on Other Financial Corporations, Claims on Non-financial Sector; Items 2, 4, 5 in table;

δ = Price of Local currency bonds, decided by Local currency interest rates i ;

ϕ = The government's repayment rate, $0 < \phi < 1$;

$\bar{G}$ = Claims on Government, Item 3 in table;

H = Reserve Money, Item 6 in table;

$\bar{B}$ = Foreign Liabilities, Item 7 in table;

P = Potential market value of guarantee on financial institutions, Item 8 in table;

For reaction how different variables' change can influence the value V , The formula derivation is:

$$dV = [\bar{R}\delta^*dS + \bar{R}Sd\delta^* + S\delta^*d\bar{R}] + [d\bar{D}\delta + \bar{D}d\delta] + \phi[\bar{G}d\delta + \delta d\bar{G}] - [\bar{B}\delta^*dS + \bar{B}Sd\delta^* + \delta^*Sd\bar{B}] - dH_s - (\partial P/\partial\delta)d\delta \quad (2)$$

Under the open economy condition, basic currency issue include domestic credit amount and foreign exchange reserves, domestic credit amount divided into claims on government(G) and claims on domestic institutions (D), Considering the changes in the exchange rate and assuming:

$$dH = dG + SdR + RdS + dD \quad (3)$$

Considering the time value of money, then assuming that investment and distribution of new foreign assets, Claims on Government and institutions are both based on face value, we can get the following equations:

$$dG = \delta d\bar{G} \quad (4)$$

$$SdR = S\delta^*d\bar{R} \quad (5)$$

$$dD = \delta d\bar{D} \quad (6)$$

Bring them into the formula (3), we will have:

$$dH = \delta d\bar{G} + \delta^*Sd\bar{R} + \delta^*\bar{R}dS + \delta d\bar{D} \quad (7)$$

Bring (7) into the formula (2), we get:

$$dV = \bar{R}\delta^*dS + \bar{R}Sd\delta^* + S\delta^*d\bar{R} + d\bar{D}\delta + \bar{D}d\delta + \phi\bar{G}d\delta + \delta d\bar{G} - \delta d\bar{G} - \delta^*Sd\bar{R} - \delta^*\bar{R}dS - \delta d\bar{D} - \bar{B}\delta^*dS - \bar{B}Sd\delta^* - \delta^*Sd\bar{B} - (\partial P/\partial\delta)d\delta \quad (8)$$

After simplification, we get :

$$dV = d\delta^*(\bar{R}S - \bar{B}S) + d\delta\left[\bar{D} + \phi\bar{G} - \frac{\partial P}{\partial\delta}\right] + d\bar{G}(\phi - 1)\delta - \bar{B}\delta^*dS - s\delta^*d\bar{B} \quad (9)$$

So the variance of the central bank Securities portfolio can be expressed as :

$$\sigma_v^2 = \begin{bmatrix} \sigma_{\delta^*}^2 (\overline{RS} - \overline{BS})^2 + \sigma_{\delta}^2 (\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta})^2 \\ + \sigma_G^2 [(\phi - 1)\overline{G}]^2 + \sigma_S^2 (S\delta^*)^2 + \sigma_{\overline{B}}^2 (S\delta^*)^2 \\ + \text{covariance} \end{bmatrix} \quad (10)$$

Assuming k is the believe coefficient which is decided the confidence levels. According to calculation formula based on Delta-Normal Method, we can get the securities portfolio *VaR* model of the central bank [6]:

$$\text{Var} = k \left[\sigma_{\delta^*}^2 (\overline{RS} - \overline{BS})^2 + \sigma_{\delta}^2 (\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta})^2 \right]^{\frac{1}{2}} + \sigma_G^2 [(\phi - 1)\overline{G}]^2 + \sigma_S^2 (S\delta^*)^2 + \sigma_{\overline{B}}^2 (S\delta^*)^2 + \text{covariance} \quad (11)$$

In order to make the expression of the formula more direct and make some of these variables have more intuitive economic meaning. We can get the relationship between the price of securities and interest rates by using negotiable card coupons formula:

$$\delta^* = e^{-i^*} \quad (12)$$

$$\delta = e^{-i} \quad (13)$$

Because the domestic interest rate and international interest rates has the following relations:

$$i = i^* + E(ds) + a \quad (14)$$

According to formula (12), (13), (14); we can get:

$$d\delta^* = e^{-i^*} (-di^*)$$

$$d\delta = e^{-i} (-di)$$

$$di = di^* + dE(ds) + da$$

$$d\delta = -e^{-i} [di^* + dE(ds) + da]$$

Bring them into formula (9), we get:

$$\begin{aligned} dV = di^* & \left[(\overline{BS} - \overline{RS})e^{-i} - (\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta})e^{-i} \right] \\ & - e^{-(i^* + E(ds) + a)} \left[\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right] dE(ds) - \\ & e^{-(i^* + E(ds) + a)} \left[\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right] da + d\overline{G}(\phi - 1)\delta \\ & - \overline{B}\delta^* dS - S\delta^* d\overline{B} \end{aligned} \quad (15)$$

According to the similar derived, use Delta-Normal methods, According to the formula of the *VaR* :

$$\text{Var} = k \left[\sigma_{i^*}^2 \left[(\overline{RS} - \overline{BS})e^{-i^*} + \left(\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right) e^{-i} \right]^2 + \sigma_{Eds}^2 \left[e^{-(i^* + E(ds) + a)} \left(\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right) \right]^2 + \sigma_a^2 \left[e^{-(i^* + E(ds) + a)} \left(\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right) \right]^2 + \sigma_G^2 [(\phi - 1)\overline{G}]^2 + \sigma_S^2 (Se^{-i^*})^2 + \sigma_{\overline{B}}^2 (Se^{-i^*})^2 + \text{covariance} \right]^{\frac{1}{2}} \quad (16)$$

In order to write conveniently, we use E_i to represent the coefficient of each risk factor σ_i . That is the size of the sensitivity:

$$E_{i^*} = (\overline{RS} - \overline{BS})e^{-i^*} + \left(\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right) e^{-i}$$

$$E_{Eds} = e^{-(i^* + E(ds) + a)} \left(\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right)$$

$$E_a = e^{-(i^* + E(ds) + a)} \left(\overline{D} + \phi \overline{G} - \frac{\partial P}{\partial \delta} \right)$$

$$E_{\overline{G}} = (1 - \phi)\overline{G}$$

$$E_S = \overline{B}e^{-i^*}$$

$$E_{\overline{B}} = Se^{-i^*}$$

Use the formula above, formula (16) can be expressed as a matrix:

$$\text{VaR} = k \left\{ \begin{bmatrix} \sigma_{i^*} \cdot E_{i^*} \\ \sigma_{Eds} E_{Eds} \\ \sigma_a \cdot E_a \\ \sigma_{\overline{G}} E_{\overline{G}} \\ \sigma_S E_S \\ \sigma_{\overline{B}} E_{\overline{B}} \end{bmatrix} \begin{bmatrix} \text{correlation} \\ \text{matrix} \end{bmatrix} \begin{bmatrix} \sigma_{i^*} \cdot E_{i^*} \\ \sigma_{Eds} E_{Eds} \\ \sigma_a \cdot E_a \\ \sigma_{\overline{G}} E_{\overline{G}} \\ \sigma_S E_S \\ \sigma_{\overline{B}} E_{\overline{B}} \end{bmatrix} \right\}^{\frac{1}{2}} \quad (17)$$

So we get the relation between the central bank's *VaR* and values of each card coupons. When the value of *VaR* Close to, or greater than the net value of V , it means that the central bank's payment ability reduce and default risk increase. When the economic subject in the market loss confidence to the country's payment ability, it is easy to cause the collapse of the monetary system and

the currency crisis. From formula (17), we can know different risk sources of the value of VaR and measure the size of them, so that the central bank can manage and monitor to the related projects timely. Through the brief analysis of the model we can get four points:

- 1) When the volatility of foreign exchange rate, interest rate, expected exchange rate and country risk coefficient increase, the risk loss of the central bank will increase at the same time. This foreign exchange risk is because the financial market is not stable. In this case, often the correlation between the variables has also increase, then leading the value of increase. This time the central bank can consider taking some control to the projects of the capital account.
- 2) Even if the exchange rate volatility was limited to a certain extent, the expect of devaluation of the currency increase can also make the vulnerability of the central bank increase, With the integration of the global financial markets and wide use of derivatives tools. This effect will also cause more and more influence [7].
- 3) The point of view that reduce the coefficient of all risk factors to reduce the value of VaR . Through analyze all kinds of risk factors sensitivity, we get that how the central bank can reduce its potential value loss may take these measures: Maintain foreign reserves and external debt to a rough balance, Keep balance of Claims on Corporations and guarantee on domestic institutions, improve the government's repayment rate ϕ and keep the right scale of external debts.
- 4) The country's economic conditions affect the national security coefficient, assets and liabilities status of financial institutions and fiscal policy will also make the central bank's VaR change. Therefore, the value of VaR is the indicator of macroeconomic and financial system, it also play a guiding role to the national macroeconomic regulation and control.

IV. CONCLUSION

This paper introduces the mainstream international risk management methods in current time and applies it to the supervision of the central bank. As the new method to maintain monetary system stable, it has several obvious advantages: comprehensive, quantitative, clear. Of course, there still have some problems in the concrete application of the model. The model is more complex, and data processing workload is very great; and the model demand further improved accounting system and more transparent accounting information disclosure. Generally speaking, this model can evaluate the central bank's payment ability and vulnerability based on measuring the central bank default risk. Although it needs to be further improved in practical application, but it provides a new method to the central bank of maintaining financial stability and preventing currency crisis, it is also a supplement to the traditional method.

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