Foreign Exchange Reserves and Inflation: An Empirical Study of Five East Asian Economies

Mei-Yin Lin*
Department of Economics, Shih Hsin University, Taiwan

Jue-Shyan Wang
Department of Public Finance, National Chengchi University, Taiwan

Abstract: This study extends the time consistency model developed by Kydland and Prescott (1977) to incorporate exchange rate stability in the policymaker's objectives. We find that when the foreign exchange reserves increases, the inflation rate rises while the exchange rate effect is strong. Conversely, the inflation rate reduces when the monetary surprise effect is more powerful and the weight placed on output stability is not large. Our empirical study uses the data for five East Asian economies to make this argument more clear.

Keywords: Foreign Exchange Reserves, Inflation, Time Consistency Model

JEL Classification Number: E61; F31

1. Introduction

The literature on institutional arrangements for central banks has been developed over the past several years. The most cited paper is perhaps the Kydland and Prescott (1977) which has been a stepping-stone for the subsequent works. In the previous literature, it is standard to assume that the central bank's objective function involves employment (or output) and inflation within the context of a closed economy. Our study will extend into an open-economy model and highlight the role of foreign exchange in monetary policy. First, the exchange rate will enter the objective function, as do output and inflation. This modification intends to describe the fact that many small or developing countries, like Argentina or Mexico, have made exchange-rate stability the centerpiece of their inflation stabilization attempts. Today even the European Monetary System (EMS) considers fixed exchange rate as an advantage to force governments to pursue more conservative inflation policies. Therefore incorporating exchange-rate stability into the objective function is sensible. And the similar setting can be seen in Obstfeld (1996) and Vitale (2003). Furthermore, because the central bank uses foreign exchange reserves as an instrument to sterilize the exchange rate, we will specify an equation to represent the link between exchange rate and foreign exchange reserves. Therefore the change in foreign exchange reserves will affect the inflation in the model. Our empirical study uses the data for five East Asian economies to make this argument more clear.

* Corresponding author. Email address: mylin@cc.shu.edu.tw.
2. Theoretical Framework

We specify the Lucas-type aggregate supply function with the consideration of the effect of net exports. The form is:

$$
\Delta y_t = \alpha (\pi_t - \pi_t^e) + \beta (\Delta S_t + \pi_t^f - \pi_t) + \epsilon_t, \quad \alpha > 0, \beta > 0
$$

(1)

where $\Delta y_t$ is the growth rate of aggregate output, $\pi_t$ is inflation rate, $\pi_t^e$ is expected inflation rate, $\pi_t^f$ is inflation rate of foreign country, $\Delta S_t$ is the change rate of exchange rate, and $\epsilon_t$ is the shock to aggregate output. The individual have rational expectations and set $\pi_t^e$ prior to the realization of the output shock.

In equation (1), two factors contribute to the growth of output. The first term, called monetary surprise effect, depicts that the aggregate output is a function of inflation surprise. If the actual inflation rate exceeds the expected inflation rate, realized real wage will be less than the level expected and the employment (output) will be rising.

The second term, called exchange rate effect, describes the impact of exchange rate on labor market and output. Several empirical studies have found statistically significant effects of exchange rate for employment. In theory, an appreciation of domestic currency will result in lower prices of foreign goods. It reduces the demand for domestic goods and in turn leads to lower domestic output and lower employment. On the other hand, Goldberg and Tracy (1999) suggest that in an export-oriented industry, an appreciation of domestic currency directly reduces the competitiveness of its products and leads to the decline in labor demand. Therefore the effect of an appreciation has on employment is indeterminable. As shown by these theories and empirical results, the sign of $\beta$ in equation (1) is ambiguous.

The central bank tends to influence the exchange rate by exchange market operations. The intervention strategy is described as:

$$
\Delta S_t = k \cdot \Delta FR_t, \quad k > 0
$$

(2)

where $\Delta FR_t$ is the change in foreign exchange reserves. The central bank should purchase foreign currency to let foreign currency appreciate; that is $k > 0$.

---

1 The exchange rate is defined as the domestic currency price of a unit of the foreign currency.
3 See the same setting in Kohli (2003).
The loss function of the central bank is given in the following quadratic form:

\[ L(\pi_t, \Delta y_t, \Delta S_t) = \frac{1}{2} \pi_t^2 + \frac{\gamma_1}{2} (\Delta y_t - \Delta \bar{y})^2 + \frac{\gamma_2}{2} \Delta S_t^2 \quad \gamma_1 > 0, \gamma_2 > 0, \]  

(3)

where \( \Delta \bar{y} \) is the targeted growth rate of output. The parameter \( \gamma_1 \) and \( \gamma_2 \) measure the importance of stability on output growth and exchange rate relative to inflation. Substituting equation (1) and equation (2) into equation (3), the policymaker's optimization problem is to choose the inflation rate that minimizes the loss function. By the first order condition, we obtain:

\[ \pi_i = \frac{\gamma_1 (\alpha - \beta) [\alpha \pi^e_t + \Delta \bar{y} - \beta (k \Delta FR + \pi^f_t)] - \epsilon_t}{1 + \gamma_1 (\alpha - \beta)^2} \]  

(4)

By the assumption of rational expectations, the equilibrium inflation expectation \( \pi^e_t = E_{t-1} \pi_t \) and \( E_{t-1} \epsilon_t = 0 \) yield:

\[ \pi_i = \frac{\gamma_1 (\alpha - \beta) [\Delta \bar{y} - \beta (k \Delta FR + \pi^f_t)]}{1 - \beta \gamma_1 (\alpha - \beta)} - \gamma_1 (\alpha - \beta) \frac{\epsilon_t}{1 + \gamma_1 (\alpha - \beta)^2} \]  

(5)

Differentiation of equation (5) shows that:

\[ \frac{\partial \pi_i}{\partial \Delta FR_t} = -\frac{(\alpha - \beta) \beta \gamma_1 k}{1 - \beta \gamma_1 (\alpha - \beta)} \]  

(6)

The sign of the differentiation represented in equation (6) is indeterminable because the sign of \( \alpha - \beta \) is ambiguous. We still try to interpret it by simple economic intuition. The depreciation of domestic currency directly increases output growth. Then the output volatility could be offset by the inflation effect indirectly. When \( \alpha = \beta \), equation (6) is zero. It means that the exchange rate effect is equivalent to the monetary surprise effect. And it is ineffective for the central bank to lower the output growth by altering the inflation rate. When \( \alpha < \beta \), the sign of equation (6) is positive. It implies that the exchange rate effect dominates the monetary surprise effect and the central bank will increase the inflation rate to lower the output growth indirectly. When \( \alpha > \beta \), the sign of equation (6) will depend on the degree of \( \gamma_1 \). Equation (6) will be negative when \( \gamma_1 < \frac{1}{\beta (\alpha - \beta)} \). If the weight placed on output stability objectives \( \gamma_1 \) is not large, the central bank should lower the inflation rate to reduce the output growth. Namely, the central bank would rather substitute the monetary surprise effect for the exchange rate effect. However, if the weight placed on output stability objectives is large enough, the inflation rate should be rising to
lower the output growth as the case of $\alpha < \beta$

3. Empirical Framework

3.1. The Data and Econometric Methodology

The study consists of five East Asian economies: Japan (JPN) and four "Tigers" (Hong Kong (HK), Korea (KOR), Singapore (SNG) and Taiwan (TWN)). The inflation rate is measured as the annual change in Consumer Price Index (CPI). The exchange rate is defined as the domestic currency price of a unit of the U.S. dollar. The inflation rate of foreign country is the CPI inflation rate of U.S. All the data are quarterly and span from 1981Q1 to 2003Q4, except from 1994Q1 to 2003Q4 for Hong Kong. The data set is obtained from the International Monetary Fund’s International Financial Statistics (IFS). For Taiwan, the data is from Financial Statistics Monthly Taiwan District, the central Bank of China. For the first view of the data, we compute the correlation coefficient between inflation rate ($\pi$) and foreign exchange reserves: -0.4323 for Japan, 0.2216 for Hong Kong, -0.0500 for Korea, 0.1525 for Singapore, and 0.3352 for Taiwan.

We suggest a regression model motivated by equation (5) as the following form:

$$\pi_i = \beta_0 + \beta_1 \text{Trend}_i + \beta_2 \Delta FR_i + \beta_3 \pi'_i + e_i$$

(7)

where $\text{Trend}_i$ is time trend, $e_i$ is the disturbance term. $\Delta FR_i$ is the change rate of foreign exchange reserves. The sign of estimated coefficient $\beta_2$ can tell us the relation between inflation rate and the foreign exchange reserves.

The regression can be estimated for each economy respectively or as a system of separate equations for the individual economy. We assume the disturbances are independent across equations when the regressions are estimated by the first method. However, the second method known as seeming unrelated regressions (SUR) is allowing the disturbances across equations to be freely correlated.

3.2. Empirical Results

First, we estimate equation (7) for each economy respectively and this regression is named for Case 1. The empirical results are reported in Table 1. The inflation rate in Japan has significantly negative trend and the trend terms in other four economies are not obvious. The inflation rate of U.S. is positively related to the domestic inflation rate in each economy.

The coefficient on $\Delta FR_i$ is different among these five economies. For Japan, on an average a 1% rise in foreign exchange reserves leads to a 0.0034% fall in inflation rate. However, on an average a 1% rise in foreign exchange reserves results in a 0.0043% rise in
inflation rate of Korea and a 0.0090% rise in inflation rate of Taiwan. This relation is significant for Japan, Korea and Taiwan. Similarly, on an average a 1% rise in foreign exchange reserves invokes an inflation response of approximately 0.0033% for Hong Kong, -0.0053% for Singapore. This relation is insignificant in these two economies.

Table 1: Estimated Results of Equation (7) in each Economy Respectively (Case 1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>JPN</th>
<th>HK</th>
<th>KOR</th>
<th>SNG</th>
<th>TWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.3924**</td>
<td>23.4924</td>
<td>0.8002</td>
<td>-0.4333</td>
<td>0.0257</td>
</tr>
<tr>
<td>Trend_t</td>
<td>-0.0209*</td>
<td>-0.2894</td>
<td>0.0282</td>
<td>-0.0062</td>
<td>0.0111</td>
</tr>
<tr>
<td>ΔFR_t</td>
<td>-0.0034**</td>
<td>0.0033</td>
<td>0.0043*</td>
<td>-0.0053</td>
<td>0.009**</td>
</tr>
<tr>
<td>π^f t</td>
<td>0.2128*</td>
<td>0.2368</td>
<td>0.5782*</td>
<td>0.7825*</td>
<td>0.2658</td>
</tr>
<tr>
<td>ρ</td>
<td>0.7842*</td>
<td>0.9118*</td>
<td>0.7982*</td>
<td>0.7819*</td>
<td>0.8179*</td>
</tr>
<tr>
<td>¯R²</td>
<td>0.87</td>
<td>0.9419</td>
<td>0.8498</td>
<td>0.8605</td>
<td>0.8529</td>
</tr>
<tr>
<td>Observations</td>
<td>92</td>
<td>40</td>
<td>92</td>
<td>92</td>
<td>92</td>
</tr>
</tbody>
</table>

Note: The regressions are estimated with a correction for serial correlation by Cochrane-Orcutt method. *(***) indicates significant at 5%(10%).

Equation (7) can also be estimated as a system of separate equations for the individual economy. We use generalized least squares (GLS) to estimate this system. The standard errors are computed from heteroscedastic-consistent matrix developed by White. Because the sample period for Hong Kong is not as long as other four economies, we estimate this system by two periods of analysis: Case 2 is from 1981Q1 to 2003Q4 for four economies excluding Hong Kong, and Case 3 is from 1994Q1 to 2003Q4 for all five economies. The results are presented in Table 2 and Table 3 respectively.

Table 2 shows that the sign of coefficient on ΔFR_t is negative for Japan and is positive for Korea. Both are significantly different from zero. The result of Case 2 is exactly the same as Case 1. However, the coefficient on ΔFR_t is not significant in Singapore and Taiwan.

Finding of Table 3 indicates that the sign of coefficient on ΔFR_t is significantly positive for Korea and Taiwan which is similar to the result in Case 1. For Japan, Hong Kong and Korea, the coefficient is insignificant, nevertheless.

To sum up, the coefficient on ΔFR_t is significantly positive for Korea in three cases. And the value of the coefficient reveals that on an average a 1% rise in foreign exchange reserves invokes an inflation response of approximately 0.0043% to 0.0102%. The sign is significantly negative for Japan and the significance is weak in Case 3. For those
significant cases, an average a 1% rise in foreign exchange reserves leads to about 0.0034% to 0.0130% fall in inflation rate. For Taiwan, an average a 1% rise in foreign exchange reserves results in about 0.0090% to 0.0163% rise and this positive relation disappears in Case 2. And this relation is not evident in Hong Kong and Singapore.

Table 2: Estimated Results of Equation (8) by SUR: 1981Q1 to 2003Q4 (Case 2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>JPN</th>
<th>KOR</th>
<th>SNG</th>
<th>TWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.2844*</td>
<td>-4.6297*</td>
<td>-2.2327*</td>
<td>-3.8883*</td>
</tr>
<tr>
<td>Trend,</td>
<td>-0.0225*</td>
<td>0.0382*</td>
<td>0.0109*</td>
<td>0.0183</td>
</tr>
<tr>
<td>ΔFR,</td>
<td>-0.0130*</td>
<td>0.0102*</td>
<td>0.0012</td>
<td>-0.0018</td>
</tr>
<tr>
<td>π,</td>
<td>0.3499*</td>
<td>2.2775*</td>
<td>0.9877*</td>
<td>1.6257*</td>
</tr>
<tr>
<td>R²</td>
<td>0.7115</td>
<td>0.6484</td>
<td>0.6549</td>
<td>0.5511</td>
</tr>
<tr>
<td>Observations</td>
<td>92</td>
<td>92</td>
<td>92</td>
<td>92</td>
</tr>
</tbody>
</table>

Note: *(**) indicates significant at 5%(10%).

The significance and magnitude of the coefficient on ΔFR, are not robust to the sample period or the estimation method. The main conclusion is that the monetary surprise effect is strong in Japan. And the exchange rate effect may be powerful in Korea and Taiwan probably. These two effects are approximately equivalent in Hong Kong and Singapore.

Table 3: Estimated Results of Equation (8) by SUR: 1994Q1 to 2003Q4 (Case 3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>JPN</th>
<th>HK</th>
<th>KOR</th>
<th>SNG</th>
<th>TWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.9990*</td>
<td>33.1612*</td>
<td>11.5162*</td>
<td>3.1571*</td>
<td>10.2683*</td>
</tr>
<tr>
<td>Trend,</td>
<td>-0.0406*</td>
<td>-0.3900*</td>
<td>-0.0849*</td>
<td>-0.0557*</td>
<td>-0.1328*</td>
</tr>
<tr>
<td>ΔFR,</td>
<td>-0.0065</td>
<td>0.0111</td>
<td>0.0091*</td>
<td>0.0014</td>
<td>0.0163*</td>
</tr>
<tr>
<td>π,</td>
<td>-0.2973**</td>
<td>-0.6723</td>
<td>-0.4543</td>
<td>0.8911*</td>
<td>0.2658*</td>
</tr>
<tr>
<td>R²</td>
<td>0.3545</td>
<td>0.7720</td>
<td>0.2773</td>
<td>0.5768</td>
<td>0.7769</td>
</tr>
<tr>
<td>Observations</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

Note: *(**) indicates significant at 5%(10%).

The results could be interpreted by the structure of each economy. For the period 1986 to 2003, the average trade dependency ratio is 16.51% for Japan, 55.91% for Korea, 81.83%

4 The ratio is measured as the rate of sum of export and import to GDP.
for Taiwan, 286.08% for Singapore, and 231.02% for Hong Kong. We argue in Japan the impact of international trade on output may not be as strong as the domestic monetary effect. However, Korea and Taiwan are both small open economies where the international trade will play very important role in economic growth. Thus the exchange rate effect should dominate the domestic monetary surprise effect. By the empirical result, we conclude these two forces are approximately balanced in Hong Kong and Singapore.

4. Conclusion

This study is an extension of the time consistency model. Through the operations in the foreign exchange market by central bank, we are then able to analyze the relation between foreign exchange reserves and inflation rate. The conclusion is that when the foreign exchange reserves increases, the inflation rises while the exchange rate effect is stronger than monetary surprise effect. And the inflation rate reduces when the monetary surprise effect is powerful if the weight placed on output stability is not large.

We use the data for five East Asian economies to make our argument more clear. The empirical result shows that the relation between the change in foreign exchange reserves and inflation rate is negative for Japan and is positive for Korea and Taiwan. And this relation is insignificant for Hong Kong and Singapore. We conclude that the monetary surprise effect is strong in Japan and the exchange rate effect is powerful in Korea and Taiwan. These two effects are approximately equivalent in Hong Kong and Singapore.

Reference


