Exchange Rates, Monetary Policies, and Macroeconomic Stability: Case of Korea

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Three aggregated stochastic models are developed which incorporate the major features of small open economy with structural changes in different stages of economic development. For Model 1 and 2, both analytic and empirical studies are made. The optimal policy mix between exchange rate and monetary policies for achieving economic stability is analyzed when the economy faces unexpected shocks on demand and supply. Empirical studies of Korea concludes that it is not optimal to absorb the external shocks through full accommodation of exchange rates. Since Model 3 assumes rigid price and capital mobility, exchange rates are no longer policy variables and determined within the system. The optimal monetary policies under those conditions are analytically derived but empirical studies are postponed since capital flows are under strict control in Korea.

I. Introduction

In the past, Korea's exchange rate policies have focused on maintaining price competitiveness in the world commodity market. Therefore the major concern of exchange rate policies has been how to maintain real effective exchange rates stable at a desirable level. Recently, with the help of favorable external economic environments, however, Korea has become confident about keeping long run balance of payments equilibrium. With less concern about balance of payments problems, it is quite natural that the focus of exchange rate policies has shifted to achieving economic stability.

This paper attempts to analyze the optimal policy mix between exchange rate and monetary policies for achieving economic stability. Economic stability is defined as a weighted sum of price and output variability. After a brief introduction, in Section II, three aggregated stochastic models are developed which incorporate the major features of small open economies with structural change in different stages of economic development. Model 1 is a simple wage contract model in which exchange rate policies affect a trade-off between output and price stability. This trade-off occurs since exchange rate policy to maintain real exchange rates constant stabilizes the demand but also disturbs price stability through its impact on aggregate supply. Model 2 reproduces the long term overlapping wage contract model of Dornbusch (1982) with a minor change of adding random terms on the aggregate demand side. The model is reintroduced for the purpose of empirical study, as the current labor market situation and the process of wage contracts are similar to those described in the overlapping wage contract model. Model 3 assumes perfect capital mobility. In this model, the exchange rate is no longer a policy variable since the exchange rate is determined by the interest parity theorem. Therefore, the optimal policy is no longer a policy mix between exchange rate and monetary policies but is now defined as the degree of flexibility of monetary targets in response to movements in real exchange rates.

In Section III, empirical studies of the first two models are carried out. Since capital flows are still controlled in Korea, an empirical study of Model 3 is not relevant to the case of Korea at this moment. For the empirical analysis, first, the parameters of each equation which typify the Korean economy are estimated. Second, variances of price and output are calculated as a function of the shock variances. Third, the loss function which is a weighted sum of output and price variances is defined. Finally the optimal policy mix is calculated to minimize the loss function.

In Section IV, there is a brief conclusion.

II. Models

The models are stated in terms of the deviations of variables from their given trends. All variables are expressed in logs with the exception of interest rates in Model 3.

Model 1: Simple Rigid Wage Contract Model

$$y = a(m - p) + b(e - p) + v_t \tag{1}$$

$$m = \alpha p, \qquad 0 < \alpha \leq 1 \tag{2}$$

$$e = \beta p, \qquad 0 < \beta \leq 1 \tag{3}$$

$$p = \phi w + (1 - \phi) e \tag{4}$$

$$w = \gamma p_{t-1} + \Phi \tilde{y}_t + u_t \tag{5}$$

Model 1 consists of five equations. Equaton (1) is a reduced form of the aggregate demand function. The level of real output is a function of the real money supply $(m-p)$, real exchange rate $(e-p)$, and a stochastic shock v_t, which captures the effect of change in external economic environments. A rise in the real money supply stimulates demand, as does a depreciation of the real exchange rate. Equaton (2) shows the rule by which the authorities operate monetary policies. The coefficient α measures the extent to which monetary policies are accomdating. A unit value for α means that monetary policies are fully accommodating. Exchange rate policies are specified by rules in equation (3). The coefficient β meausres the degree to which exchange rate policies are accommodating. A unit value for β implies that real exchange rates are maintained constant and purchasing power parity rules are followed. Unit values for α and β imply that output is maintained constant. Prices are determined as a weighted average of wage costs and costs of imported intermediate goods in equation (4). Here, fluctuations of imported goods depend upon the movements of exchange rates. The terms ϕ and $(1-\phi)$ represent the cost shares of wages and intermeidate goods. The model is completed with equation (5) which specifies wage formation. The current wage, w, is set by reference to the price of the previous period, p_{t-1}, and the anticipated current income $\tilde{y}$. In equation (5), u_t is a white noise error term which represents an unexpected shock in the labor market. Through the paper, a tilde denotes an expectation and we assume rational expectaions.

In order to obtain variances of output and price, it is necessary to derive output and price with their own lagged and random terms. Therefore, as a first step, output is expressed in terms of price and random term v_t by substituting equation (2) and (3) into equation (1):

$$y = - Hp + v_t \tag{6}$$

where $H = a(1-\alpha) + b(1-\beta)$

Next, we incorparate rational expectations into equation (6) and then substitute it into equation (5). Then, the newly obtained equation (5) and equation (3) are substituted into equation (4). By rearranging and assuming it stable, price is expressed in terms of its lagged value, p_{t-1}, and error term as follow:

$$p = \rho p_{t-1} + \delta u_t \tag{7}$$

where $\rho = \dfrac{\phi\gamma}{1-(1-\phi)\beta + \phi\Phi H}$

$\delta = \dfrac{\phi}{1-(1-\phi)\beta}$

With price and output in this model following first-order autoregression, variance of price is calculated from equation (7):

$$\sigma_p^2 = \mathrm{E}p^2 = \frac{\delta^2}{1-\rho^2}\,\sigma_u^2 \tag{8}$$

With equation (6) and (8), variance of output is obtained as follow:

$$\sigma_y^2 = \mathrm{E}y^2 = \frac{H^2\delta^2}{1-\rho^2}\,\sigma_u^2 + \sigma_v^2 \tag{9}$$

If we define the loss function as a weighted average of output and price variances, we can estimate the optimal combination of monetary and exchange rate policies which minimizes the loss function.

Model 2: Overlapping Wage Contract Model

$$y = a(m-p) + b(e-p) + v_t \tag{1}$$

$$m = \alpha p, \qquad 0 < \alpha \leq 1 \tag{2}$$

$$e = \beta p, \qquad 0 < \beta \leq 1 \tag{3}$$

$$p = (\phi/2)\cdot(x + x_{t-1}) + (1-\phi)e \tag*{(4)$'$}$$

$$x = \Phi x_{t-1} + (1-\Phi)\tilde{x}_{t+1} + \gamma[\Phi\tilde{y} + (1-\Phi)\tilde{y}_{t+1}] + u_t \tag*{(5)$'$}$$

Model 2 is identical with the model of Dornbusch (1982) except for the error term, v_t, in equation (1) which specifies random shocks on aggregate demand. Major differences between Model 1 and Model 2 lie in the aggregate supply side. In equation (4)$'$, wage costs are taken as the average of two contracts, with x as the current wage in the first period of a two-period contract made this period and x_{t-1} as the current wage in the second period of a two-period contract made last period. Following Taylor (1979), equation (5)$'$ states that current wage contracts depend upon three factors: the contract wage set in the previous period, the contract wage expected to be set in the next period, and the anticipated outputs of the current and next period. Here, a random term, u_t, signifies random shocks in the wage contracts.

This overlapping wage contract model is quite relevant to the current situation in Korea on the ground that wage contracts for civil servants are made in the fall while those for workers in the spring. In this case, the current wage is set in reference to the wage contract for the previous period as well as that expected in the next period.

Substituting equation (2) and (3) into (1), output is expressed as a function of demand prices:

$$y = -Hp + v_t \tag{6$'$}$$

where $H = a(1-\alpha) + b(1-\beta)$

Substituting equation (3) into (4)$'$, the price equation can be written as:

$$p = k(x + x_{t-1}) \tag{7$'$}$$

where $k = \dfrac{\phi/2}{1 - \beta(1-\phi)}$

If we substitute (7)$'$ into (6)$'$, output is also expressed as a function of wages. Then, substituting the above outcome into equation (5)$'$ and incorporating rational expectations, we have the following wage equation:

$$cx = \Phi\tilde{x}_{t-1} + (1-\Phi)\tilde{x}_{t+1} \tag{8}$$

where $c = \dfrac{1 + \gamma Hk}{1 - \gamma Hk}$

If we assume that the solution is stable:

$$x = \rho x_{t-1} + u_t \tag{9$'$}$$

where $\rho = \dfrac{c - [c^2 - 4\Phi(1-\Phi)]^{1/2}}{2(1-\Phi)}$

Using equation (9)$'$ and (7)$'$, we have the price equation and variance of prices as follows:

$$p = \rho p_{t-1} + k(u+u_{t-1}) \tag{10$'$}$$

$$\sigma_p^2 = \mathrm{E}p^2 = k^2 \frac{2}{1-\rho} \sigma_u^2 \tag{11}$$

Finally, variance of output is derived from equation (11)′ and (6)′:

$$\sigma_y^2 = \mathrm{E}y^2 = \frac{H^2k^2 \cdot 2}{1-\rho} \sigma_u^2 + \sigma_v^2 \tag{12)'$$

With the variances of output and prices, we can discuss the optimal combination of monetary and exchange rate policies for macroeconomic stability.

Model 3: Model of Wage Rigidity and Perfect Capital Mobility

$$y = a(m_s - p) + b(e-p) + v_t \tag{1}$$

$$m_s = \theta(e-p) \tag{2}$$

$$m_d = p - g(\tilde{e}_{t+1} - e) \tag{3}$$

$$p = \phi w + (1-\phi)e \tag{4}$$

$$w = \gamma p_{t-1} + \Phi \tilde{y}_t + u_t \tag{5}$$

$$m_s = m_d \tag{6}$$

In this model, we assume perfect capital mobility thus ensuring the interest parity theorem. Under the interest parity theorem, the domestic interest rate, i, is equal to the world interest rate, i^*, plus the expected rate of change in foreign exchange rates; $i = i^* + (\tilde{e}_{t+1} - e)$ where $\tilde{e}_{t+1}$ is the expected exchange rate at time $t+1$. If the world interest rate is assumed constant, the domestic interest rate is a function of the expected rate of change in exchange rates, $(\tilde{e}_{t+1} - e)$. Provided that demand for money, m_d, is a function of interest rates, the money demand function is written as the above equation (3)″. Money supply, m_s, which is the only policy variable in this model, is defined in equation (2)″. Monetary policies in this model, therefore, are specified as the degree of monetary accomodation with respect to the real exchange rate movements. Since foreign exchange rates are assumed to promptly adjust to reflect the difference in interest rates between two countries, foreign exchange rates are no longer policy variables. Equation (6) shows the equilibrium in the money market, equating money demand with money supply.

To derive the variances in prices and output, let us rearrange the output as a function of wages and foreign exchange rates, substituting equation (2)″ and (4) into equation (1):

$$y = \{a\theta + b - (1-\phi)\,[a(1+\theta) + b]\}e \qquad (7)''$$
$$- \phi[a(1+\theta) + b]\,w + v_t$$

Equating equation (2)″ with equation (3)″ and lagging one period backward, we will have the following equation:

$$\tilde{e} = H_0 e_{t-1} + H_1 w_{t-1} \qquad (8)''$$

$$\text{where } H_0 = \frac{g - \theta + (1+\theta)(1-\phi)}{g}$$
$$H_1 = \frac{(1+\theta)\phi}{g}$$

If we assume that charateristic roots exist and the stability condition is satisfied, the expected foreign exchange rate of the current period is related to the exchange rate of the previous period as follows:

$$E_{t-1}e_t = b_1 e_0 \mu^t,\ \tilde{e}_t = \mu e_{t-1} \qquad (9)''$$

In the same way, wages are related as follows:

$$E_{t-1}w_t = b_2 w_0 \mu^t,\ \tilde{w}_t = \mu w_{t-1} \qquad (10)''$$

where μ is a characteristic root which is solved analytically in this model.

Incorporating rational expectations in equation (7)″ and substituting it into equation (5), and also lagging one period backward of equation (4) and putting it into equation (5), we have:

$$w_t = \frac{\gamma\phi + \Phi(\tau_1 - a)\,H_1}{1 + \Phi\,\tau_1}\,w_{t-1} \qquad (11)''$$
$$+ \frac{\Phi(\tau_1 - a)\,H_0 + \gamma(1-\phi)}{1 + \Phi\,\tau_1}\,e_{t-1} + u_t$$

where $\tau_0 = a\theta + b,\ \tau_1 = \phi(\tau_0 + a)$

Putting equation (9)″ into equation (8)″, the relationship between exchange rates and wages is written as follows:

$$e_{t-1} = \frac{H_1}{\mu - H_0}\,w_{t-1} \qquad (12)''$$

Substituting equation (12)″ into (11)″, the current wages are expressed only as a function of their own one-period lagged terms

$$w_t = \mu w_{t-1} + u_t \tag{13}$$

where $\mu = 1/2\Big\{H_0 + \frac{1}{1+\Phi\tau_1}[\gamma\phi + \Phi(\tau_1 - a)H_1]$

$$-\sqrt{H_0 + \frac{1}{1+\Phi\tau_1}[\gamma\phi + \Phi(\tau_1 - a)H_1]^2 - \frac{4}{1+\Phi\tau_1}\cdot\frac{\gamma\phi(g-\theta)}{g}}\Big\}$$

From equation (13)″, variances of wages are calculated:

$$\sigma_w^2 = \frac{1}{1-\mu^2}\sigma_u^2 \tag{14″}$$

With equation (12)″ and (14)″, variances of exchange rates are derived as:

$$\sigma_e^2 = \frac{q^2}{1-\mu^2}\sigma_u^2 \tag{15″}$$

where $q = \dfrac{H_1}{\mu - H_0}$

Using equation (4), (12)″, and (15)″, variances of prices are determined as:

$$\sigma_p^2 = \frac{[\phi + (1-\phi)q]^2}{1-\mu^2}\sigma_u^2 \tag{16″}$$

In the same way, using equation (7)″, (12)″ and (15)″, variances of output are estimated as follows:

$$\sigma_y^2 = \frac{[(\tau_1 - a)q - \tau_1]^2}{1-\mu^2}\sigma_u^2 + \sigma_v^2 \tag{17″}$$

With the variances of output and prices calculated, the optimal monetary policy which minimizes the loss function is defined under capital mobility.

III. Empirical Analysis: Case of Korea

In this section, we conduct an empirical study of Korea using

Model 1 and 2. We estimate coefficients of each equation with regression analysis and then on the basis of our estimated values, seek the optimal values of α and β which minimize the loss function.

From a theoretical point of view, the coefficients should be simultaneously estimated since those of each equation are closely interrelated. Given the lack of consistency in data, however, we estimated each equation separately with annual time series data from 1960 to 1987 as in Penati (1985).

Model 1: Simple Rigid Wage Contract Model

For the values of coefficients for Korea, some were estimated and others were taken from existing empirical studies. To avoid the multicollinearity problem, coefficent 'a' and 'b' in equation (1) were estimated separately. To obtain the value of 'a', we regressed GNP at constant prices on the real money stock. The estimated regression is as follows:

$$\begin{aligned} ln\ y = \ & 0.54 + 0.6577\ ln(M/P) \\ & (26.81) \quad (17.97) \end{aligned}$$

$R^2 = 0.93$, $S.E. = 0.52$, ( ): $T-$statistic

where Y: GNP (1985 = 100)
M: M_2
P: GNP Deflator

where Y is GNP at constant prices, M is the stock of money M_2, and P is the GNP deflator. However, since the above estimated value of 'a' contained indirectly the impact of real exchange rate movements on output, we assign the 20% deflated value of 0.5 for 'a'. For the parameter 'b' which measures the impact of real exchange rates on output, we used the sum of import and export elasticities weighted by the ratio of imports plus exports to GNP. According to the World Bank study from 1974 to 1984, the price elasticity of imports ranged from 0.4 to 0.6 while that of exports from 1.4 to 1.7. We assigned 1.64 for 'b', which is the 20% deflated value of the sum of import and export price elasticities.

For the parameter ϕ in equation (4), we relied on the empirical study of Corbo and Nam (1986). The result of their empirical study is as follows:

$$\begin{aligned} P = \ & -0.04 + 0.545\ ULCM + 0.455\ PMR + 0.042\ ESM \\ & (-3.350) \quad (0.897) \qquad\qquad (7.503) \end{aligned}$$

$$R^2 = 0.795, \ D.W. = 2.28$$

where P: Manufacturing component of WPI excluding energy products
$ULCM$: Unit labor cost in manufacturing
PMR: Price of imported materials in domestic currency
ESM: Excess supply of money

We regarded 0.545 and 0.455 as the estimated share of wage and imported intermediate goods in the price determination, respectively. As shown, these estimates satisfy the homogeneity test.

In order to obtain parameters for γ and Φ, we regressed wages on prices of the previous period and output. The estimated regression using the Cochrane-Orcutt procedure is as follows:

$$\underset{}{w_t} = \underset{(6.94)}{0.96}\ p_{t-1} + \underset{(3.75)}{0.31}\ y_t$$

$$R^2 = 0.997, \ S.E. = 0.095$$

where w: Unit labor cost in manufacturing
p: Whole sales price index
y: GNP (1985=100)

Finally, we defined the loss function as a sum of variances of output and prices with different relative weights, and then estimated the optimal policy mixes for different loss functions. For the shock variances, we assume that $\sigma_u^2 = \sigma_v^2 = 1$, in order to give equal weight to each shock.

Using our estimated values, we simulated three different loss functions for $0.5 \leq \alpha \leq 1$, and $0 < \beta \leq 1$, with an interval of 0.1. When three different weights 1:1, 3:2, and 7:3 were assigned to output and prices, as shown in Table 1, the optimal value for β was 0.4, 0.5, and 0.6, respectively. In contrast the optimal value for α which minimizes the loss function was 1, regardless of different weights. This is partly due to the fact that we put the upper bound of α at 1. From our simulation, the optimal monetary policy holds the real money balance constant, while the optimal foreign exchange rate policy does not fully accomodate changes in price.

Model 2: Overlapping Wage Contract Model

In this model, we used the same estimated values as in Model 1 for parameters 'a' and 'b', in equation (1), and 'ϕ' in equation (4).

For the estimation of parameter 'γ' in equation (5)', we assume

TABLE 1

a	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
b	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64
α	1	1	1	1	1	1	1	1	1	1
β	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
ϕ	0.545	0.545	0.545	0.545	0.545	0.545	0.545	0.545	0.545	0.545
$1-\phi$	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455
γ	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Φ	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
H	0.164	0.328	0.492	0.656	0.82	0.984	1.148	1.312	1.476	1.64
ρ	0.846317	0.756708	0.684258	0.624469	0.574289	0.531573	0.494773	0.462737	0.434598	0.409685
δ	0.922946	0.856918	0.799706	0.749656	0.705501	0.666259	0.631152	0.599559	0.570979	0.545
price-var	3.002078	1.718114	1.202598	0.921228	0.742671	0.618738	0.527480	0.457417	0.401933	0.356933
y-var	1.080743	1.184841	1.291105	1.396437	1.499372	1.599097	1.695168	1.787372	1.875641	1.960008
LOSS-FTN (1:1)	2.041411	1.451477	1.246852	1.158833	1.120122	1.108918	1.111324	1.122394	1.138787	1.158470
LOSS-FTN (3:2)	1.849277	1.398150	1.255703	1.206354	1.196692	1.206954	1.228093	1.255390	1.286158	1.318778
LOSS-FTN (7:3)	1.657144	1.344823	1.264553	1.253875	1.272362	1.304990	1.344862	1.388385	1.433529	1.479085

Note: 1. monetary accommodation = 1.0

TABLE 2

a	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
b	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64
α	1	1	1	1	1	1	1	1	1	1
β	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
ϕ	0.545	0.545	0.545	0.545	0.545	0.545	0.545	0.545	0.545	0.545
$1-\phi$	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455
Φ	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
γ	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
k	0.5	0.461473	0.428459	0.399853	0.374828	0.352750	0.333129	0.315576	0.299779	0.285489
H	0	0.164	0.328	0.492	0.656	0.82	0.984	1.148	1.312	1.476
c	1	1.049638	1.094177	1.134364	1.170807	1.204006	1.234376	1.262264	1.287962	1.311717
ρ	0.923076	0.700165	0.623346	0.574376	0.539009	0.511796	0.490010	0.472076	0.457003	0.444127
price-var	6.5	1.420499	0.974780	0.751286	0.609539	0.509759	0.435205	0.377282	0.331007	0.293248
y-var	1	1.038205	1.104870	1.181859	1.262306	1.342762	1.421390	1.497222	1.569778	1.638863
LOSS-FTN (1:1)	3.75	1.229352	1.039825	0.966573	0.935923	0.926260	0.928298	0.937252	0.950393	0.966056
LOSS-FTN (3:2)	3.2	1.191123	1.052834	1.009630	1.001199	1.009561	1.026916	1.049246	1.074270	1.100617
LOSS-FTN (7:3)	2.65	1.152893	1.065843	1.052687	1.066476	1.092861	1.125535	1.161240	1.198147	1.235179

Note: 1. monetary accommodation = 1.0

that the relative impacts of prices (here, wages) and output on the determination of the current wage in Model 2 is the same as those of Model 1. Therefore, we assigned the value of 0.32 for 'γ' in equation (5)'. We regarded the estimated parameter of $ln\,x$, 0.48, as the relevant value for Φ, using the following equation:

$$ln\,x = c + \Phi ln\, x_{t-1} + (1-\Phi)\, ln\, x_{t+1} + \gamma [\Phi y + (1-\Phi)\, y_{t+1}] + u_t$$

$$R^2 = 0.99 \quad S.E. = 0.365 \quad D.W. = 3.16$$

With these estimated values, we repeated the same analysis conducted in Model 1. Even in the case of Model 2, the optimal value for α was 1, regardless of the different weights assigned to output and prices. The responsiveness of foreign exchange rate policy, however, was slightly higher in Model 2 than in Model 1. When three different weights 7:3, 3:2, and 1:1 were assigned to output and prices, the optimal values for β, were 0.7, 0.6, 0.5, respectively as shown in Table 2. This means that an exchange rate policy aiming at purchasing power parity is not the optimal policy when the objective is to stabilize the economy.

IV. Conclusion

This paper attempts to determine the optimal exchange rate and monetary policies when the economy faces unexpected shocks on demand and supply. Since the responsiveness of exchange rate policies determines the level of price fluctuations, exchange rate policies which maintain the purchasing power parity are no longer optimal when we take into account the impact of exchange rates fluctuations on supply. Our analysis concludes that it is not optimal to fully absorb the external shocks through exchange rate fluctuations when the objective of economic policies is to maintain economic stability.

When capital is perfectly mobile internationally, exchange rates are no longer policy variables since they are determined endogenously within the system. In this paper, we also set up a model of rigid price and capital mobility and analytically derived the optimal monetary policy under those conditions. Since capital flows are still strictly controlled in Korea, an empirical study on Korea is not feasible at its current stage of economic development.

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