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Monetary Policy and the Determination of the Interest Rate and Exchange Rate in a Small Open Economy with Increasing Capital Mobility

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MONETARY POLICY AND THE DETERMINATION OF THE INTEREST RATE AND EXCHANGE RATE IN A SMALL OPEN ECONOMY WITH INCREASING CAPITAL MOBILITY

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ABSTRACT

This paper presents a general model of the determination of the interest rate and the exchange rate which is relevant for a small economy with any degree of capital mobility. The model is tested by using the quarterly data of Korea and Singapore. The emperical results show that in the Korean case changes in money supply affect the interest rate, but do not affect the exchange rate, while in the case of Singapore the domestic interest rate is determined by the foreign interest rate and the expected change in the exchange rate, as well as by changes in the money supply; changes in the money supply also influence the exchange rate. The results imply that the progress of capital liberalization in a small country will alter the transmission mechanism from reliance on the interest rate channel alone to effects arising through both the interest rate and the exchange rate.

KEYWORDS: Capital movement, foreign exchange rates, interest rates, monetary policy

JEL CLASSIFICATION: E43,E52,F32

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1. Introduction

Edwards(1985), and Edwards and Khan(1985) proposed a general model of interest rate determination that is applicable to a small country with any degree of capital mobility. Their model contributes to the understanding of the determinants of interest rates. In particular, it develops the roles of the domestic money supply and the foreign interest rate in the determination of the domestic interest rate and how they are altered by increasing capital mobility. This paper extends their interest rate analysis to include the exchange rate.

After the collapse of the Bretton Wood System in early 1970s, most countries moved to flexible exchange rate regimes, although many countries maintained some degree of international capital controls. Recently, some countries, especially developing countries like Korea, have been pursuing financial internationalization, including the liberalization of capital mobility, in response to domestic and foreign pressures to open their capital markets. These pressures, reenforced by the Uruguay Round agreement, are expected to accelerate the liberalization of capital mobility in developing countries in the near future. These changes in the financial environments of developing countries have raised questions about how the transmission mechanism of monetary policy will be altered and about how the determination of interest rates and exchange rates will be changed.

Existing theories say that in a small open economy with flexible exchange rates and a nominal wage rate that is sticky in the short run, monetary policy has strong effects on real output, regardless of the degree of capital mobility, but that the transmission mechanism of monetary policy and the determination of the interest rate and the exchange rate are fundamentally different, depending on the degree of capital mobility. There are two extreme short-run models: one is the model without capital mobility, and the other is the model with perfect capital mobility pioneered by Mundell(1963) and Fleming(1962). In the first model, the interest rate plays a unique role in the transmission mechanism of monetary policy and the interest rate is determined by the equilibrium condition of domestic money market as in a closed economy. In this case, the exchange rate varies to maintain the balance of trade account and insulates the domestic economy from foreign disturbances. In contrast, in the Mundell-Fleming model, the exchange rate is the critical channel for the influence of monetary policy on real output. In this model, changes in the money supply play an important role in the determination of exchange rate, but not the interest rate. Instead, the interest rate is closely linked to world interest rate and, if the expectations of the exchange rate are not static, to the expected change of exchange rate.

These two extreme models imply that in a small economy with increasing capital mobility, the exchange rate no longer insulates the domestic economy from foreign shocks, and it becomes an important channel of monetary policy; simultaneously, the interest rate becomes a less important channel of monetary policy. Most countries, especially developing countries, are in a situation where capital is not perfectly mobile; controls on capital movements or, in the absence of legal regulations on capital mobility, uncertain real returns limit capital mobility. The analysis of the channels of monetary policy in such a small economy requires an investigation of the role of money in the determination of both the interest rate and the exchange rate.

The purpose of this paper is to develop a general model of the determination of the interest rate and the exchange rate which is relevant for a small economy with any degree of capital mobility, to test the model and to explain its implications for interest rates and exchange rates. In section 2, I will briefly describe the transmission mechanism of monetary policy and the determination of interest rate and exchange rate in small economies without capital mobility and with capital mobility. The model for the interest rate and the exchange rate then is found by combining models without capital mobility and with perfect capital mobility. The general model is useful for determining the effects of changes in monetary policy on the interest rate and the exchange rate, and for organizing the investigation of which factors, especially domestic or foreign, play relatively greater roles in the determination of the interest rate and of the exchange rate. In section 3, I will test the model by using quarterly data of Korea and Singapore over 1980. II - 1993. IV and 1979. II - 1993. IV, respectively. These two countries are good examples for the tests of the model, because they differ significantly in the degree of capital mobility. The Korean economy has a relatively closed capital market, while the Singaporean economy's capital market is relatively open. In addition, both economies have been widely acknowledged as typical, so-called Newly Industrialized Countries that have accomplished the most successful economic development among the developing countries after World War II. In final section, I will provide summary and concluding remarks.

2. Monetary Policy and the Determination of the Interest Rate and Exchange Rate in a Small Open Economy

2.1 The Model without Capital Mobility

Until Mundell(1963) and Fleming(1962) introduced the assumption of perfect capital mobility into macroeconomic models, analysis of the effects of monetary policy in a small open economy[1] largely was conducted ignoring international capital mobility.[2] Such an analysis indicates that, under a flexible exchange rate regime, the exchange rate completely insulates the domestic economy from foreign disturbances, such as changes in foreign expenditures, and thus monetary policy has real effects similar to those in a closed economy. The model without capital mobility is characterized by the following typical assumptions: (1) nominal wages are fixed in the short run; (2) unemployed resources exist; (3) international capital mobility is not allowed at all; (4) the external account is always balanced, and thus the money stock is fully under control of the monetary authorities; (5) exchange rate expectations are ignored.

In such a model, an increase in the nominal money stock leads to a reduction in the rate of interest through a liquidity effect.[3] The lower interest rate results in an increase of output through the expansion of private expenditure on investment and consumption. The balance of trade account(or current account) is deteriorated due to the expansion of private expenditure, depreciating the exchange rate of the home currency. It is because the balance of payments consists of only the trade account when there is complete capital immobility and

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[1] A small open economy, where domestic monetary policy does not affect foreign variables such as the price of foreign output, foreign income or the level of foreign interest rate, is assumed throughout this paper. Open refers to being open to foreign trade, unless otherwise indicated.

[2] See Marston(1985), especially pp. 861-866 for references to and discussions of such model.

[3] The existence of a liquidity effect is due to the assumption of fixed nominal wages and prices in the short run. In an economy where inflationary expectations are high, an increase in the money stock can raise the expectations and the nominal interest rate. In this case, the Fisher effect or inflationary expectation effect will be more dominant rather than liquidity effect. As a result, an increase of nominal money stock can lead to the increase of nominal interest rate than its decrease. See Friedman and Schwartz(1982), Mehra(1985), and so on.

thus the exchange rate adjusts to maintain the equilibrium of trade balance. Therefore, monetary policy has real effects on output only through the interest rate channel as in a closed economy.

In this model, the nominal interest rate is determined by the equilibrium condition for the domestic money market where the demand for real money is assumed to be a function of real income and nominal rate of interest, and the supply of money is exogeneously given. The exchange rate is determined by the balance of current account. Accordingly, the reduced-form equations for the interest rate and the exchange rate, assuming a lagged-adjustment process for both, can be written as:

$$(1)\quad I_t = a_1 + a_2 M_t + a_3 Y_t + a_4 I_{t-1} + v_{1t} \qquad a_2 < 0, \quad a_3, a_4 > 0$$

$$(2)\quad E_t = b_1 + b_2 CA_t + b_3 E_{t-1} + v_{2t} \qquad b_2 < 0, \quad b_3 > 0$$

where I is the nominal rate of interest, M is the log of the supply of real money, Y is the log of the real output, E is the log of the exchange rate, expressed as the home currency price of a unit of foreign currency, implying that the rise of E means the depreciation of home currency, and CA is the balance of current account. The v_1 and v_2 are random error terms with zero mean and constant variance, respectively.

2.2 The Model with Perfect Capital Mobility

The Mundell-Fleming Model demonstrates that monetary policy has short-run real effects, not through changes in interest rates, but through changes in exchange rates. Retaining the assumptions of fixed money wages, unemployed resources and ignorance of expectations about the exchange rate, the model assumes that capital is fully mobile internationally, and domestic and foreign financial assets have perfect substitutability. Accordingly, the domestic interest rate is always fixed at the level of foreign interest rate.

In the model, an expansion of the nominal money supply puts downward pressure on the rate of interest and, in turn, creates an incipient outflow of capital. Since the capital flow is infinitely elastic with respect to the rate of interest, the exchange rate depreciates to raise the trade surplus enough to offset the net capital outflows. At the new balance of payments equilibrium, the interest rate is unchanged, but output is higher and the value of domestic currency is lower. Thus, the exchange rate is a unique channel for monetary policy to affect real output; the interest rate plays no role because it does not change.

The results of Mundell-Fleming were also found in an extended model of Dornbusch(1976) that introduced the assumption of rational expectations for the exchange rate and a slow adjustment of the goods market relative to exchange rates and asset prices. In the extended Mundell-Fleming model, nominal interest rates are no longer equalized across countries, but the domestic interest rate adjusted for the expected rate of depreciation of its own currency is equal to foreign interest rate.[4]

In this Mundell-Flemming model there are no impediments to capital flows, the determination of the interest rate and the exchange rate differs from that of an economy without capital mobility. Domestic and foreign interest rates are closely linked through the uncovered interest parity condition. In the world with no transaction costs and risk-neutral agents, the domestic interest rate

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[4] See Dornbusch(1976) pp. 1172 - 73.

should be always to the foreign rate plus the expected rate of depreciation of exchange rate at the equilibrium status.[5] The reduced-form equation for the interest rate and exchange rate can be specified, again assuming a lagged-adjustment process for both, as;

(3) $I_t = c_1(I^*{}_t+\dot{E}_t) + c_2\ I_{t-1} + v_{3t}$ $\qquad c_1 > 0,\ c_2 > 0$

(4) $E_t = d_1 + d_2\ M_t + d_3\ Y_t + d_4\ E_{t-1} + v_{4t}$ $\qquad d_2,\ d_4 > 0,\ d_3 < 0$

where I^* is the world interest rate for a financial asset of the same characteristics as the domestic asset, and $\dot{E}_t$ is the expected rate of depreciation of home currency between period t and period t+1 corresponding to the maturity of the financial asset. The v_3 and v_4 are random error terms with zero mean and constant variance, respectively.

2.3 The General Model

Most macroeconomic models that analyse the real effects of monetary policy and its transmission channels make extreme assumptions regarding the degree of capital mobility; in particular, capital is either completely immobile or perfectly mobile. In reality, however, many countries, especially developing countries, are in a situation where capital mobility is imperfect due to some controls to capital movements or because of transaction costs or uncertain real returns even in no legal limitations to capital mobility. The two extreme models described above imply that in an economy with imperfect capital mobility,

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[5] If we expect that the forward rate is a reflection of the market's expectation about the future spot exchange rate, the forward rate can be replaced by the expected spot rate. If agents are assumed to be risk-averse, however, the expected rate of depreciation of exchange rate should be replaced by the forward premium; alternatively, a risk-premium term should be added to the equation.

monetary policy has short-run real effects through channels of both interest rate and exchange rate.[6]

In such an economy, an increase in the money stock leads to a reduction in the rate of interest which stimulates an increase in private expenditure. The rise in expenditure results in an increase of income and a deterioration in the trade balance. The rise in income and the following increase of the demand for money moderate the fall in the rate of interest, but do not return it to the original level because income expansion is not as large as in the model with perfect capital mobility. As a result, the balance of capital account still deteriorates and the trade balance improves, but by less than that in the case with perfect capital mobility. An adverse shift in the balance of payments causes a depreciation of the exchange rate to whatever extent may be necessary to produce a net improvement in the trade balance equal to the deterioration in the capital balance and thus to maintain external transactions as a whole in balance. In addition to the rise in income led by the fall of interest rate, the expansion of exports caused by the depreciation also acts as a stimulus to income, raising it above the level of income in the model with capital immobility. In general, the greater the capital mobility, the larger the real effect of monetary policy.

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[6] A portfolio balance model also assumes that with the fixed nominal wage, capital mobility and the substitutability between domestic and foreign assets are imperfect due to exchange risk or other factors. In the model, relative supplies of domestic and foreign assets, along with the nominal money stock, affect interest rate and exchange rate, and the current account affects the exchange rate by influencing portfolio composition as well as wealth. The model modifies the money demand function and the expenditure function to incorporate the effects of wealth, which is defined as the sum of money, domestic bonds and foreign bonds held by the domestic private sector. Empirical tests of the model, however, have not been greatly successful, because of two important methodological problems, the data requirement and the specification of stable asset demand functions. See Dornbusch(1980, 1987), Obstfeld(1985), Shafer and Loopesko(1983), Pigott and Rude(1990).

In addition, the greater the responsiveness of the international capital flow to movements in the rate of interest, the larger the effects of the changes in money supply on the exchange rate, and the greater the role of exchange rate in the process that monetary policy produces real effect, and vice versa.[7]

The general model of the determination of the interest rate and the exchange rate that is of relevance for a small economy with any degree of capital mobility can be set up by combining the models for the two extreme cases. This kind of modeling work is done for the interest rate in Edwards(1985), and Edwards and Khan(1985). But their model is a partial one in the sense that it did not present any role of money in a fully opened economy. The general model set up in this paper is useful for determining the effects that changes in monetary policy have on both the interest rate and on the exchange rate, and for investigating which factors play relatively greater roles in the determination of the interest rate and exchange rate in line with the progress of capital liberalization. The general model of determination of interest rate and exchange rate is follows;

$$\begin{aligned}(5)\quad I_t &= A_1(a_1 + a_2 M_t + a_3 Y_t + a_4 I_{t-1} + v_{1t}) + A_2(c_1 [I^*_t + \dot{E}_t] + c_2 I_{t-1} + v_{3t}) \\ &= \alpha_1 + \alpha_2 M_t + \alpha_3 Y_t + \alpha_4 I_{t-1} + \alpha_5 [I^*_t + \dot{E}_t] + u_{1t} \quad \alpha_2 \leq 0,\ \alpha_3,\ \alpha_5 \geq 0,\ \alpha_4 > 0\end{aligned}$$

$$\begin{aligned}(6)\quad E_t &= A_1[b_1 + b_2 CA_t + b_3 E_{t-1} + v_{2t}] + A_2[d_1 + d_2 M_t + d_3 Y_t + d_4 E_{t-1} + v_{4t}] \\ &= \beta_1 + \beta_2 CA_t + \beta_3 M_t + \beta_4 Y_t + \beta_5 E_{t-1} + u_{2t} \qquad \beta_2,\ \beta_4 \leq 0,\ \beta_3 \geq 0,\ \beta_5 > 0\end{aligned}$$

where the u_1 and u_2 are random error terms with zero and constant variance, respectively. The A_2 is the openness parameter of the capital market, which represents the degree of capital mobility, and the sum of A_1 and A_2 is assumed to be equal to one. Thus, if the capital mobility of the economy under study is

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[7] See Fleming(1962) pp. 373 - 74.

perfect, it would be expected that A2 is equal to one and A1 is equal to zero. If the economy, on the other hand, is completely closed to the rest of the world, it would be expected that A2 is equal to zero and A1 is equal to one. In the case of a semi-open economy with imperfect capital mobility, however, it would be expected that A2 would be between zero and one. In general, it would be expected that the greater the degree of capital mobility, the closer A2 is to one and the closer A1 is to zero.

3. Empirical Tests of the General Model

3.1 The Degree of Capital Mobility of Korea and Singapore

The Korean and Singaporean economies are regarded as a highly open one for trade flows. The Korean capital market, however, is relatively less open, especially compared with the Singaporean economy. Since 1980, the Korean capital market has been opened step-by-step, in accordance with the government's long-term plan. There has been a major expansion of indirect opportunities for foreigners to make portfolio investment in the Korean securities market. Since 1992, foreign investors have been allowed to invest in up to 10 percent of total stocks of each company listed in the Korea Stock Exchange. Even though there have been gradual relaxations on capital controls, however, some restrictions on capital mobility still exist. The Korean currency, won, was floated beginning in January of 1980 when the fixed exchange rate system were replaced by a Multi-Currency Basket Peg(MCBP) system. In March of 1990, the exchange rate regime was shifted to a Market Average Rate(MAR) system under which the daily basic won rate against dollar is determined by the weighted average of interbank exchange rates applied in the spot transactions on the previous business day.

On the other hand, the Singaporean economy is a highly open one, with no legal restrictions on trade and capital flows except for capital transactions made with the Singapore dollar. The last elements of capital controls were completely lifted in June 1978. From June of 1973, the exchange rate regime changed from a fixed one to a floating one.[8]

3.2 Data

The data used in this paper are quarterly. For Korea, the nominal money stock is a quarterly average of M2(in billion won), broad money[9], which consists of currency in circulation, demand deposits, and time and savings deposits of the Deposit Money Banks. The real money stock is obtained from dividing the nominal money stock by the consumer price index(1990 = 100). Output is the value of real Gross National Product in 1990 Korean currency(in billion won). The interest rate is the yield per annum on corporate bonds with 3-year maturity traded in the secondary market.[10] The expected rates of depreciation of exchange rates between periods t and t+1, E_t, are replaced by the actual rates of depreciation with the assumption of perfect foresight. The exchange rate is the rate of Korean currency, won, against U.S. dollar.[11] The current account balance is denominated

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[8] For the internal purpose, however, the monetary authorities of Singapore, is known to have used a trade-weighted basket of the currencies of major trading partners of Singapore.

[9] Instead of M_1, narrow money, M_2 is selected because it has served as the principal target of monetary control since 1979.

[10] In Korea, the trading yield of 3-year corporate bond has been regarded as a typical market interest rate because the money market is relatively less developed.

[11] For the analysis of the exchange rate determination, the nominal effective exchange rate seems to be more relevant than the U.S. dollar spot rate. But, for the empirical test for Korea, the spot rate against the U.S. dollar is used because the data of effective exchange rate is not officially compiled.

in billions of U.S. dollars. All Korean Data are obtained from the monthly Bulletin of the Bank of Korea. The sample period runs from the second quarter of 1980 through the fourth quarter of 1993. The beginning quarter is chosen because the exchange rate was floated on January of 1980.

In the case of Singapore, the nominal money stock is an outstanding balance of M1(in million Singapore dollars) at the end of each quarter, which consists of currency and demand deposits. The price level is the consumer price index (September 1987 - August 1988 = 100). Output is the value of real Gross Domestic Product in 1985 Singaporean prices(in million Singapore dollars). The interest rate is the 3-month interbank rate per annum. In the estimation of the interest rate equation, the forward premium is used to proxy the expected exchange rate, since forward rates of the Singapore dollar against the U.S. dollar are available. The exchange rate is the index of nominal effective exchange rate(1985 = 100) compiled by International Monetary Fund.[12] The trade account balance[13] is denominated in billions of U.S. dollars. All Singaporean data except the nominal effective exchange rate are obtained from the monetary authorities of Singapore. The nominal effective exchange rate is obtained from the International Financial Statistics of International Monenatary Fund. The data for Singapore are for the period of the second quarter of 1979 through the fourth quarter of 1993. The initial quarter is chosen based on the availability of data on the nominal effective exchange rate.

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[12] In the estimation of the interest rate equation for Singapore, the expected rate of depreciation of the Singaporean dollar against U.S. dollar instead of the nominal effective exchange rate is employed, because the 3-month U.S. Treasury bill rate is used to measure the rate of world interest(I^*), instead of the weighted average of interest rates of major trading parters of Singapore.

[13] Instead of current account, trade account is used for the empirical analysis for Singapore, because the quarterly data of current account are available from the first quarter of 1986.

3.3 Estimation and Testing

The interest rate and exchange rate equations for Korea and Singapore are estimated using the general model (5) and (6) developed in section 2.2. Ordinary Least-Squares method is employed for the estimation of the equations, then if the estimated results had first-order autocorrelation in the residuals, the equations were reestimated by Cochrane-Orcutt method in order to correct the problem.

Equations (1.1) and (1.2) of table 1 show the results that estimate the interest rate equations of Korea with the OLS method. Equation (1.1) illustrates that the coefficients of all variables except those of constant term and the sum $(I^u_t+\dot{E}^k_t)$ of the Treasury bill rate of U.S.(I^u_t) and the expected rate of depreciation$(\dot{E}^k_t)$ are statistically significant at the 5 percent level and have the expected signs. The estimated coefficient of $(I^u_t+\dot{E}^k_t)$ variable, even though it has the expected sign for an open capital market, is statistically insignificant at the 5 percent level and the value of that coefficient, 0.018, is close to zero. This implies that the openness parameter of the capital market, A2, that represents the degree of capital mobility, is not different from zero. The interest rate equation which drops $(I^u_t+\dot{E}^k_t)$ variable from the equation (1.1) is reestimated by OLS, and the results are shown in equation(1.2). The Durbin-h statistic of the equation (1.2), which is more appropriate than Durbin-Watson statistics in a model with lagged dependent variable, is 1.53, and falls below the critical value of 1.645 at the 5 percent level. Thus the null hypothesis of the absence of first-order autocorrelation in the residuals is not rejected. The explanatory power of equation (1.2), $\bar{R}^2 = 0.913$, is almost the same as that of equation (1.1), and all coefficients of equation (1.2) except that of constant term are statistically significant. In particular, money stock is negatively related to the interest rate with semi-elasticity of -0.046, implying that an 1 percent increase of money stock results in the 0.046 percentage point fall of interest rate during the same period, whereas real income is positively related to the interest rate with semi-elasticity of 0.056.

The estimated exchange rate equations of Korea are reported in equations (2.1), (2.2) and (2.3) of table 2. The equation (2.1) estimated by the OLS shows that the coefficients of the current account variable($CA^k{}_t$) and the log of lagged exchange rate($E^k{}_{t-1}$) are statistically significant at the 5 percent level and have expected signs. But the coefficients of the log of real money($M^k{}_t$) and the log of real GNP($Y^k{}_t$) are statistically insignificant at the 5 percent level and do not have the expected signs, and their values, -0.014 and 0.006, respectively, are very small, implying that the domestic money stock does not affect exchange rate determination. This again confirms that the openness parameter of capital market, A2, is not different from zero, as expected. The equation (2.1) might be serially correlated, because the Durbin-h statistic, 3.04, is greater than critical value. The equation (2.2) estimated by the Cochrane-Orcutt method shows similar results to the equation (2.1). Thus, the exchange rate equation with the exclusion of $M^k{}_t$ and $Y^k{}_t$ is reestimated by using the Cochrane-Orcutt method, and the results are shown in equation (2.3). In the equation (2.3), the explanatory power($\bar{R}^2$ = 0.982) is the same as those of equation (2.2), and all coefficients are statistically significant. The coefficient on $CA^k{}_t$, - 0.0028, means that the 1 billion U.S. dollar surplus(deficit) of current account leads to the 0.28 percent appreciation(depreciation) of Korean currency during the same period.

These results suggest that the interest rate is determined by the domestic money stock and the lagged rate of domestic interest, but is not affected by the foreign interest rate and the expected rate of depreciation, and that the exchange rate is determined by current account and the lagged rate of exchange, but is not affected by the condition of domestic money market. These results are predicted by the model without capital mobility(A_2 equals zero). The liberalization of capital mobility in Korea has been limited, partly allowed for the stock market.[14] Therefore, these results imply that during the 1980. II - 1993. IV, the interest channel is important in producing the effects of monetary policy on real output, but the exchange rate does not play any role.

The results for Singapore are significantly different from those for Korea. The equations (1.3) and (1.4) of table 1 show the estimated results for the interest rate equation of Singapore. The equation (1.3) illustrates that the coefficients of the log of real money($M^s{}_t$) and the log of real GDP($Y^s{}_t$) are statistically insignificant at the 5 percent level due to possible multicollinearity between them. Thus the interest rate equation which excludes $Y^s{}_t$ from the equation (1.3) is reestimated, and the results are reported in equation (1.4). The equation (1.4) is free from first-order autocorrelation, and all coefficients are significant at the 5 percent level. The value of coefficient of $(I^u{}_t+\dot{E}^s{}_t)$, 0.249, means that the 1 percent increase(decrease) of U.S. Treasury bill rate or the 1 percent depreciation(appreciation) of Singaporean currency leads to the 0.249 percent rise(fall) of domestic interest rate, while the value of coefficient of $M^s{}_t$, -0.018, means that the 1 percent increase of money stock results in the 0.018 percentage point fall of interest rate. These results imply

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[14] During two years after the opening of stock market in 1992, net foreign capital of 7,772 million U.S. dollars inflowed into the Korean stock market. But the inflow of foreign capital were mainly affected by the condition of stock market and other factors including economic fundamentals rather than by the differentials between domestic interest rate and foreign interest rate.

that both $(I^u_t+\dot{E}^s_t)$ and M^s_t play important roles in the determination of interest rate, and M^s_t, even though the role of money stock is relatively minor, cannot be excluded in the determination of interest rate.[15]

The equations (2.4), (2.5) and (2.6) of table 2 show the estimated exchange rate equations for Singapore. Equation (2.4) illustrates that coefficients of M^s_t, Y^s_t, and E^s_{t-1} are significant at the 5 percent level and have the expected signs, but the coefficient of the trade account(TB^s_t) has an unexpected sign and the equation has first-order autocorrelation. After the correction of the autocorrelation by Cochrane-Orcutt, the coefficient of TB^s_t still has an unexpected sign[16](See the equation (2.5)). Thus the exchange rate equations which

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[15] These results are quite different from those of Edwards and Khan(1985). They estimated the interest rate equation for Singapore over the period of 1976.III -1983.IV, then concluded that the foreign interest rate and the expected changes of exchange rate play dominant roles in the determination of interest rate, but that domestic monetary developments and the lagged rate of interest play no direct roles. Thus, the interest rate equation is reestimated by using the model presented in this paper for the same period as that of Edwards and Khan, and the estimated results support the conclusion of this paper. The OLS estimates of the model of this paper and the model of Edwards and Khan, (1) and (2), respectively, are as follows;

$$(1)\quad \underset{}{I^s_t} = \underset{(1.32)}{0.281} - \underset{(-1.94)}{0.144\, M^s_t} + \underset{(1.94)}{0.114\, Y^s_t} + \underset{(2.56)}{0.304\, (I^u_t+\dot{E}^s_t)} + \underset{(2.77)}{0.425\, I^s_{t-1}}$$

$$\bar{R}^2 = 0.746 \qquad \text{M.S.E.} = 0.027 \quad \text{D-h} = 1.00$$

$$(2)\quad I^s_t = -\underset{(0.20)}{0.200} + \underset{(0.24)}{0.052\, (Y^s_t-M^s_{t-1})} + \underset{(23.68)}{0.922\, (I^u_t+\dot{E}^s_t)} + \underset{(0.02)}{0.001\, I^s_{t-1}} + \underset{(1.40)}{0.026\, \dot{P}^s_t}$$

$$\bar{R}^2 = 0.991 \qquad \text{D-h} = 0.39$$

* The values in parentheses are t-ratios. $\dot{P}^s$ is the expected rate of inflation for Singapore.

[16] The negative coefficient of TB^s_t variable, apart from the expectation of model (6) implies that the trade account variable may not substitute for the current account variable. This occurs because the two balances showed different movements. The trade account registered chronic deficits for the entire period of 1979. II - 1993 IV, but the current account was in surplus

exclude the TB^s_t variable from equation (2.5) and replace Y^s_t by Y^s_{t-1}[17] are reestimated by the Cochrane-Orcutt method, and the results are shown in equation (2.6). The M^s_t coefficient of -0.084 indicates that the 1 percent increase of money stock decreases(depreciates) the nominal effective exchange rate by 0.084 percent. These results imply that the exchange rate is determined by changes in the money stock in addition to the lagged rate of exchange.

The estimated results for Singapore demonstrate that changes in money supply affect the determination of both interest rate and exchange rate. The results are not compatible with the model for perfect capital mobility, but are consistent with the model for imperfect capital mobility. The openness parameter of capital market for Singapore, A2 is expected to be between zero and one. This implies that even though the legal limitations on capital movements are completely lifted, capital, in reality, may be not perfectly mobile due to the constraints such as transaction costs and uncertain real returns. Therefore, we can conclude that in a small economy with imperfect capital mobility, the interest rate as

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for most of the period, 1986. I - 1993. IV. The exchange rate equation with current account variable is estimated by OLS for the period of 1986.I - 1993.IV. The results show that the exchange rate is affected by the current account variable with a lag of a quarter. The estimated results are as follows;

$$E^s_t = \underset{(1.74)}{0.0044\ CA^s_{t-1}} - \underset{(-1.69)}{0.093\ M^s_t} + \underset{(3.69)}{0.221\ Y^s_{t-1}} + \underset{(14.14)}{0.732\ E^s_{t-1}}$$

$\bar{R}^2 = 0.976$ M.S.E. = 0.085 D-h = 0.67

* The values in parentheses are t-ratios.

[17] The estimated result for the exchange rate equation with Y^s_t shows that the coefficient of Y^s_t is insignificant at the 5 percent level.

well as the exchange rate act as important channels in having the effects of monetary policy on real output.[18]

4. Summary and Concluding Remarks

In this paper, the general model for the determination of the interest rate and the exchange rate, which is applicable to small countries with the differing degree of capital mobility, is presented. The model is tested by using the quarterly data of 1980. II - 1993. IV and 1979. II - 1993. IV for Korea and Singapore, respectively.

The empirical results for Korea and Singapore are found to support the model. In the Korean case, which is in the early stage of capital liberalization, the estimated results show that changes in money supply affect the interest rate, but do not affect the exchange rate. These results imply that the interest rate channel has been important for monetary policy, but not that the exchange rate. In the case for Singapore, where despite the abolition of the legal limitations on capital movements, capital, in reality, is considered to be not perfectly mobile due to the constraints such as uncertain real return, the empirical results show that the domestic interest rate is determined, with a lagged adjustment process, by the foreign interest rate and the expected change in the

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[18] We test for heteroskedasticity for all equations of tables 1 and 2 using the Breusch-Pagan test and Arch test developed by Breusch and Pagan(1979) and Engle(1982), respectively. The null hypothesis is that the variances of residuals from a regression are the same over the different sample periods, against the alternative that they are different. The test results show that the null hypothesis for all equations cannot be rejected at the significance level of 5 percent. In addition, tests for unit roots and cointegration are performed in order to investigate the specification of the estimated equations. The finding of cointegration in the equations means that the equations are stationary even though all variables included in the equations are not stationary individually. See appendix for the tests for unit roots and cointegration.

exchange rate, as well as by changes in the money supply; changes in the money supply also influence the exchange rate. Thus, both the interest rate and the exchange rate channels are important for the transmission of monetary policy.

There are some implications for the conduct of monetary policy from the empirical results. First, the progress of capital liberalization in a small country will alter the transmission mechanism from reliance on the interest rate channel alone to effects arising through both the interest rate and the exchange rate. Therefore, in the conduct of monetary policy and its assessment in a small open economy, both interest rate and exchange rate movements must be taken into consideration. Second, to the extent that regulations on capital mobility are going to be gradually relaxed, the domestic interest rate will be more greatly affected by foreign interest rate and the expected rate of changes in the exchange rate. Thus, it will be more difficult to use interest rates rather than monetary aggregates as an intermediate target of monetary policy. Finally, in determining the target rate of monetary aggregates, monetary authorities should keep in mind to avoid excessive money supply that exceeds the potential growth rate of real GNP. It is because in an economy where high inflation is sustained or inflationary expectation is high, Fisher effect or expectation effect may be more dominant than the liquid effect, and thus monetary expansion may result in the acceleration of inflation and the increase of the interest rate rather than the positive effects on real output.

[Table 1] Interest Rate Equations of Korea and Singapore

	Constant	M_t	Y_t	I_{t-1}	$I^u_t+\dot{E}_t$	$\bar{R}^2$	MSE	D-W	D-h
Korea									
Equation (1.1;OLS)	-0.085 (0.077)	-0.045 (0.015)	0.057 (0.016)	0.870 (0.055)	0.018 (0.087)	0.911	0.046	1.55	1.82
Equation (1.2;OLS)	-0.065 (0.058)	-0.046 (0.014)	0.056 (0.016)	0.875 (0.044)	-	0.913	0.046	1.61	1.53
Singapore									
Equation (1.3;OLS)	0.175 (0.079)	-0.037 (0.030)	0.020 (0.028)	0.501 (0.102)	0.253 (0.074)	0.836	0.028	1.97	0.16
Equation (1.4;OLS)	0.176 (0.079)	-0.018 (0.008)	-	0.513 (0.100)	0.249 (0.073)	0.838	0.028	2.07	-0.40

Note: The values in parentheses are standard errors.

Definitions of variables

Korea;

M = the log of real money stock M2(in billion won)
Y = the log of real GNP(in billion won)
I = the yield of 3-year corporate bond divided by 100
$I^u+\dot{E}$ = the sum of 3-month Treasury bill rate of U.S. and the expected rate of depreciation of Korean exchange rate divided by 100

Singapore;

M = the log of real money M1(in million Singapore dollar)
Y = the log of real GDP(in million Singapore dollar)
I = the 3-month interbank interest rate divided by 100
$I^u+\dot{E}$ = the sum of 3-month Treasury bill rate of U. S. and the expected rate of depreciation of the spot exchange rate of Singapore divided by 100

[Table 2] **Exchange Rate Equations of Korea and Singapore**

	Constant	$CA_t(TB_t)$	M_t	Y_t	E_{t-1}	$\bar{R}^2$	MSE	D-W (D-h)	ρ
Korea									
Equation	0.272	-0.008	-0.014	0.006	0.974	0.981	0.097	1.29	-
(2.1;OLS)	(0.133)	(0.001)	(0.014)	(0.017)	(0.020)			(3.04)	
Equation	0.538	-0.004	-0.011	0.004	0.932	0.982	0.092	1.99	0.59
(2.2;C-O*)	(0.313)	(0.002)	(0.013)	(0.012)	(0.046)			(-)	
Equation	0.644	-0.0028	-	-	0.904	0.982	0.092	2.05	0.68
(2.3;C-O*)	(0.369)	(0.0016)			(0.056)			(-)	
Singapore									
Equation	0.604	-0.022	-0.134	0.131	0.864	0.969	0.084	1.26	-
(2.4;OLS)	(0.131)	(0.004)	(0.041)	(0.043)	(0.033)			(2.92)	
Equation	0.598	-0.021	-0.101	0.102	0.858	0.971	0.082	1.94	0.40
(2.5;C-O*)	(0.185)	(0.005)	(0.043)	(0.045)	(0.045)			(-)	
Equation	-	-	-0.084	0.136**	0.895	0.965	0.082	2.02	0.64
(2.6;C-O*)			(0.043)	(0.049)	(0.045)			(-)	

Note: (*) indicates the estimation by the Cochrane-Orcutt method. (**) indicates the values of coefficients on Y^s_{t-1}. The values in parentheses are standard errors.

Definitions of variables

Korea;

E = the log of exchange rate of Korean currency against U.S. dollar(won)
* The increase of E indicates the depreciation.
CA = the current account(in billion U.S. dollar)

Singapore;

E = the log of nominal effective exchange rate(1985 = 100)
* The increase of E indicates the appreciation.
TB = the trade balance(in billion U.S. dollar)

[Appendix] **Tests for Unit Roots and Cointegration**

Tests for unit roots and cointegration are performed for the interest rate equations of Korea and Singapore, (1.2) and (1.4), and the exchange rate equations, (2.3) and (2.6), respectively.

Tests for Unit Root

For testing for unit roots, we use the augmented Dickey-Fuller(ADF) method to control for possible autocorrelation in individual variables. Each test consists of regressing the first-difference of a variable under consideration on its own lagged level, an appropriate number of lagged first-difference, and a constant. The test statistic is the t-statistic on the estimated coefficient of the lagged level. Critical values for this test statistics are tabulated in Fuller(1976). The null hypothesis is that the estimated coefficient of the lagged level is zero, implying that the variable under investigation has a unit root or is nonstationary, whereas the alternative hypothesis is that it is not.

Table A1 reports the test results for the level of the variables included in the equations of interest rate and exchange rate. The results indicate that the nonstationarity of the level of the variables under considerations cannot be rejected with the exception for the interest rate of Korea.

Cointegration Tests

Tests for cointegration are performed using the methodology proposed by Phillips, Ouliaris and Hansen. It is a more suitable test because the dependent variable is determined in advance and the lagged dependent variable is included in the right-hand side of the equation, and because it is also applicable to the small sample.[1] The procedure is to estimate the equations with OLS and then construct one of the standard unit root tests on the estimated residuals, such as the augmented Dickey-Fuller t test or the Phillips Z_t test. The null hypothesis is that the equation under consideration is not cointegrated, against the alternative hypothesis that it is cointegrated. Critical values for small sample are tabulated by Engle and Yoo(1987). Table A2 reports the results for cointegration tests for the equations of interest rate and exchange rate. The equations of interest rate and exchange rate for Korea and Singapore and the exchange rate equation for Korea turn out to be cointegrated at the significance of 5 percent level. The exchange rate equation for Singapore is cointegrated at the significance of 10 percent level. The Johansen test by the full-information maximum likelihood estimation that is widely used in the empirical literature cannot be applied to our original equations, because the equations have the lagged dependent variables. Thus, the Johansen tests for the equations that drop the lagged dependent variable from the original equations are performed. The test results reported in table A3 show that there is at least one cointegration vector in the interest rate equations for Korea and Singapore and in the exchange rate equation for Korea at the 5 percent level, and in the exchange rate equation for Singapore at the 10 percent level. On the other hand, as we described in the text, since the OLS estimation of the exchnage rate equations for Korea and Singapore had first-order serial correlation, they were reestimated by the Cochrane-Orcutt method. The Cochrane-Orcutt estimations have advantages that they can avoid spurious regressions, as well as misspecified regression which differencing the original data can result in.[2]

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[1] See Hamilton(1994) pp. 591 - 96.

[2] See Hamilton(1994) pp. 557 - 62.

[Table A1] ADF Unit Root Tests For the Levels of Variables

Country	I	E	M	Y	$I^u+\dot{E}$	CA(TB)
Korea	-2.96*	-2.39	-0.80	-1.88	-1.90	-1.93
	(2)	(1)	(4)	(4)	(2)	(4)
Singapore	-1.69	-1.47	1.14	0.42	-1.94	-0.69
	(0)	(1)	(4)	(4)	(2)	(1)

Note: (*) indicates the statistical significance at the 5 percent level. Critical values for the 50 sample size taken from Fuller(1976) are -2.93 and -3.50, respectively. The figures in parentheses indicate the lag length of first-difference of each variable, which is chosen as the smallest value of significant coefficient in the following general form;

$$\Delta X_t = c + a\, X_{t-1} + \sum_{i=1}^{i=4} b_i\, \Delta X_{t-i} + u_t$$

where ΔX is the first-difference of each variable, c is a constant term, and u is a random error term.

[Table A2] Phillips-Ouliaris-Hansen Tests For Cointegration

	Interest rate equation	Exchange rate equation
Korea	-6.86*(4)	-4.78*(3)
Singapore	-7.82*(4)	-4.16**(4)

Note: (*) indicates the significance at the 5 percent level. (**) indicates the significance at the 10 percent level. The figures in parentheses indicate the number of variables included in the equations for cointegration tests.

Critical values for 50 observations taken from Engle and Yoo(1987).

	3 variables	4 variables
5 percent	4.11	4.35
10 percent	3.73	4.02

[Table A3] **Johansen Test**

	Trace			Max. Eigenvalue		
	k = 0	k ≤ 1	K ≤ 2	k = 0	k = 1	k = 2
Interest rate equation						
Korea(3)	41.8*	14.7	1.6	24.7*	11.8	1.5
Singapore(3)	34.9*	12.1	0.5	20.9**	10.7	0.4
Exchange rate equation						
Korea(2)	27.4*	11.1*	-	14.8*	10.1*	-
Singapore(3)	44.0*	5.0	0.6	35.7*	4.1	0.5

Note: (*) indicates the significance at the 5 percent level. (**) indicates the significance at the 10 percent level. The figures in parentheses indicate the number of variables.

Critical values at the 5 percent level tabulated by Johansen and Juselius(1990).

	Trace			Max. Eigenvalue		
g = n-h	k = 0	k ≤ 1	K ≤ 2	k = 0	k = 1	k = 2
2	17.8	8.1	-	14.6	8.1	-
3	31.3	17.8	8.1	21.3	14.6	8.1

g = the number of random walks under the null hypothesis.
n = the number of variables.
h = the number of cointegrations under the null of hypothesis.

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