The Relationship between the Exchange Rate and Domestic Prices in Korea*

I. Introduction

In line with the opening and internationalization of its economy, Korea has been pressing ahead with capital market liberalization, allowing foreign investors to invest directly in the domestic stock market. At the same time, it has been pursuing foreign exchange liberalization, moving toward implementing a freely fluctuating exchange rate system in the near future by expanding the daily fluctuation band of the exchange rate and thereby enhancing the role of the price mechanism in the foreign exchange market. But the liberalization of capital and foreign exchange markets can bring with it short-run overshooting of the exchange rate, increased volatility and sustained misalignment. Therefore, a main issue will be to minimize negative side effects on the domestic economy, such as inflation, caused by exchange rate instability in the process of liberalizing these markets.

Exchange rate movements affect the domestic price level through changes in prices of imported goods and through changes in the pattern of domestic aggregate demand induced by the effect of substitution between domestic and foreign goods. On the other hand, changes in domestic prices can lead to exchange rate movements through changes in the trade balance and expected inflation. Along these lines, it can be argued that exchange rate fluctuations cause changes in domestic prices that induce further exchange rate changes, which implies a vicious circle of exchange rates and prices. The actual relationship between these two variables, however, can differ depending upon policy responses and the structure of the economy. In this respect, a systematic analysis should be made of the interrelationship to facilitate the effective drawing-up and implementation of economic policies, where countries are carrying out capital market opening and foreign exchange liberalization.

This paper sets out to evaluate the relationship between exchange rates and domestic

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prices in Korea, and seeks to draw some policy implications for the achievement of the price stability, should exchange rate volatility increase during the process of capital market opening and foreign exchange liberalization. Chapter II briefly summarizes the theoretical relationship between the exchange rate and domestic prices. Chapter III analyzes the causal relationship between these two variables after outlining the pattern of changes in exchange rate and domestic prices since 1980, and in Chapter IV the inflationary impact of exchange rate changes is estimated. Finally, Chapter V concludes the paper by suggesting some policy implications on the basis of the empirical findings.

II. Exchange Rate and Prices in an Open Economy

Under an open economy with wide freedom for international trade and capital flows, the exchange rate and prices move together in close interaction. In this chapter, the relationship between exchange rate and prices is theoretically outlined in the following three aspects : the influence of exchange rate movements upon domestic price level ; the impact of domestic price changes on the exchange rate ; and the feedback relationship between the exchange rate and domestic prices.

First, exogenous changes in exchange rate affect the domestic price level through various channels, as shown in Figure 1.

Exchange rate movements *can* directly affect domestic consumer prices through changes in the prices of imported consumer goods, and indirectly affect domestic producer and consumer prices by causing changes in the costs of production through the prices of imported inputs.'' Also exchange rate movements induce relative price changes that work to shift demand away from foreign goods(domestic goods) towards domestic goods(foreign goods), and these demand shifts affect domestic prices. In this *case,* the change in real net exports influences domestic prices through the change in aggregate demand, putting upward or downward pressure on domestic capacity utilization and demand for labor. Meanwhile, wages are influenced by consumer prices on the labor supply side as workers seek to maintain real wages. The initial change in prices following exchange rate movements will be augmented as these wage-price dynamics

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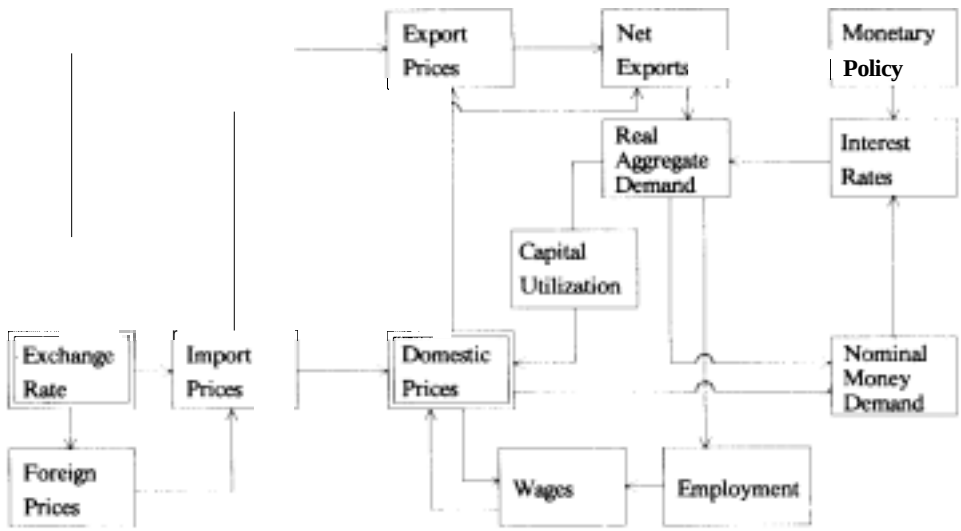
Note : 1) The extend to which changes in the exchange rate are passed through to domestic prices depends upon the structure of the domestic market and the shape of supply and demand curves. That is, when the domestic market for imported goods is imperfectly competitive or monopolistic, the pass-through of exchange rate changes to domestic prices *can* be low, as domestic importers absorb the exchange rate changes through adjustment of their profit margins in order to retain market share. Meanwhile, the pas-through will be greater the more elastic the supply curve and the more inelastic the demand curve. See Mann(1986), Dornbusch(1987), Froot and Klemperen(1989), among others.

are worked through.

The change in the value of the domestic currency also affects foreign prices. When the domestic currency declines in value, foreign currencies rise in value and the pattern of adjustments described above operates in the opposite direction on foreign prices. The pressure of exchange rate changes on foreign prices tends over time to moderate the change in domestic prices.

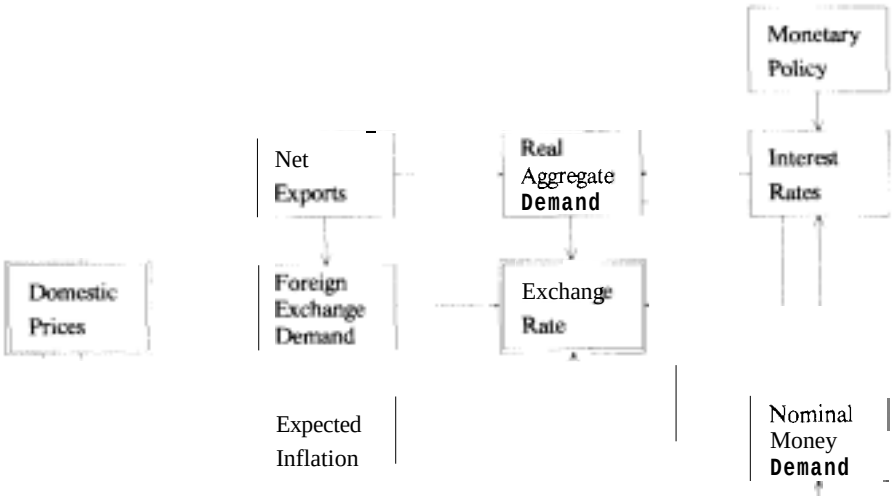
[Figure 1] Channels through which the Exchange Rate Influences Domestic Prices



The influence of the exchange rate on domestic prices mentioned above depends upon the response of the policy authorities. For example, the upward pressure of domestic currency depreciation on domestic prices and real aggregate demand raises demand for nominal money balances. If the money supply is held constant by the monetary authority, interest rates will rise to choke off the increased money demand The rise in interest rates will also depress real aggregate demand and reduce the initial inflationary impact of depreciation. On the other hand, if interest rates are pegged by the monetary authority, aggregate demand will rise, allowing the domestic inflationary effects of depreciation to work through.

Second, exogenous changes in domestic prices affect the exchange rate through the channels of relative price changes between domestic and foreign goods and changes in expected inflation, as shown in Figure 2.

[Figure **21** Channels through which Domestic Prices Influence the Exchange Rate



Changes in domestic prices induce a variation in the relative prices of domestic and foreign goods that works to change the trade balance. The resulting change in the demand for foreign exchange puts upward or downward pressure on the value of the domestic currency, causing exchange rate changes. In this case, economic news regarding the trade balance can be considered to magnify the initial change in exchange rate, as the news provides market participants with a signal of the credibility of the domestic economy. Also the change in the domestic price level induces a variation of expected inflation which, in turn, affects the exchange rate through the substitution effect between domestic and foreign financial assets caused by the change in expected real returns.

The impact of domestic prices on the exchange rate described above depends on the stance of economic policies. Suppose the monetary authority reduces the money supply in the presence of domestic inflation. Then interest rates will rise to mitigate the initial depreciation effects of domestic inflation, as the rise in interest rates works to appreciate the value of the domestic currency. On the other hand, suppose the monetary authority holds the existing money supply rule in order to boost the economic activity, which is depressed by the decrease in real net exports resulting from domestic inflation. Then the initial depreciation effects of domestic inflation remain as they are, because there is no upward pressure on the value of the domestic currency with interest rates held constant.

Third, when both the exchange rate and domestic prices are endogenously determined under the market price mechanism, these two variables have a feedback relationship which implies that exchange rate movements initiate change in domestic prices that feeds back to the exchange rate itself. An example of the factor causing this feedback relationship is an exogenous change in money supply.

Domestic monetary expansion will lower domestic interest rates through the liquidity effect and increase domestic real aggregate demand In this case, domestic prices rise as domestic aggregate demand increases and the value of the domestic currency declines as the fall in domestic interest rates shifts asset demand from domestic currency-denominated assets to foreign currency-denominated assets. Also the increase in domestic aggregate demand and the rise in domestic prices induced by the domestic monetary expansion increase domestic imports. The resulting deterioration of the trade balance augments the initial depreciation, thereby creating an additional source of inflationary pressure. This cumulative interaction between depreciation and inflation is termed the vicious circle of exchange rate and prices.

Meanwhile, a foreign monetary contraction will raise foreign interest rates and reduce foreign real aggregate demand The increase in foreign interest rates will shift asset demand from domestic currency-denominated assets to foreign currency-denominated assets and the reduction in foreign aggregate demand will worsen the domestic trade balance. Both of these shifts will cause the domestic currency to depreciate and import prices and domestic prices to rise. At the same time, however, the reduction in foreign aggregate demand will depress foreign prices as well as domestic net exports. The reduction in foreign prices from what they otherwise would have been reduces domestic import prices and at least partly offsets the domestic price effect of depreciation. The reduction in domestic net exports also has offsetting deflationary effects through its impact on domestic aggregate demand In this scenario, the feedback relationship between the exchange rate and domestic prices would be weakened

III. Causal Relationship between the Exchange Rate and Domestic Prices

In this chapter, we undertake a broad overview of the relation between the exchange rate and domestic prices by tracing the historical movements of these two variables, and then test the causality between them using more rigorous analysis.

1. Movements in the Exchange Rate and Domestic Prices since 1980

Though a great change took place in the system of exchange rate determination with the shift from a multiple-basket pegged system to a market-average exchange rate system in March 1990, the long-run exchange rate movements of the Korean won since 1980 had not deviated widely from changes in such economic fundamentals as the current account balance.

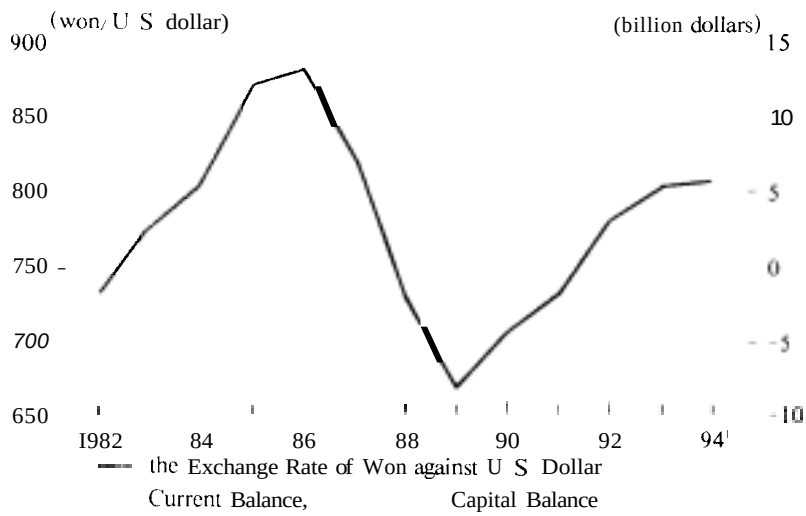
The overall price level, however, fluctuated within a wide range due to the combined effects of cost factors such as changes in wages or raw material prices demand factors, such as money supply and the increase in the demand for services induced by higher incomes and various other factors including the state of the harvest and the level of real estate prices.

The period since 1980 can be conveniently divided into four sub-periods and a description of exchange rate and domestic price developments for each of these is given below.

First, during the period of 1982 to 1986, the exchange rate of the won against the U.S. dollar showed a continued upward trend due to the dollar's strength in international foreign exchange markets as well as the monetary authorities' stance of encouraging a readjustment of the value of the Korean won to a more realistic level with the swelling of the accumulated current account deficit. On the other hand, the inflation rate

2)

The Exchange Rate and Balance of Payments in Korea
(1982~1994)



Note : 1) During the period of January to August in 1994.
Source : The Bank of Korea, Monthly Bulletin, various issues.

during this period stayed at an unprecedented low level for Korea, with the annual rates of increase in producer prices and consumer prices averaging 1.0 percent and *3.6* percent, respectively. The stability of prices during this period is attributable not simply to the fall in international interest rates and the lower unit value of imports caused by a drop in raw material prices particularly for oil. It also reflects the lower rate of wage rises and the slow growth rate of M2 at a time when the government was intent on stabilizing the economy.

During the period of 1987 to 1989, though, the exchange rate fell back relatively fast. This was mainly due to the weakness of the **U.S.** dollar in international foreign exchange markets after the Plaza Agreement of 1985. Also it was partly due to the Korean monetary authorities' willingness to see an appreciation of the Korean won, as

[Table 11 Main Economic Indicators')in Korea
(1982—1994)

Unit : Annual Average, %

	1982—86	87—89	90—91	92	93	Jan.—Aug. 94
Rates of Increase in the Exchange Rate(₩/$)	5.3	-8.7	4.5	6.4	2.8	1.0
Current Balance(billion U.S. dollars)	-1.9	29.1	-10.9	-4.5	0.4	-3.9
Overall Balance(billion U.S. dollars)	-3.6	19.8	-4.0	4.9	6.5	0.6
Rates of increase in CPI	3.6	5.3	8.9	6.2	4.8	6.5
Rates of Increase in PPI	1.0	1.5	4.4	2.2	1.5	2.3
Rates of Increase in Import Unit Value(measured in U. S. dollars)	-4.2	7.5	0.8	-1.6	-3.8	-0.7
Rates of Increase in M2[2]	17.4	18.7	19.9	18.4	18.6	15.7
Growth Rates of GNP	9.8	10.4	9.4	5.0	5.6	8.5"
Rates of Increase in Nominal Wages"	10.9	18.8	18.5	15.7	10.9	14.4"'
Growth of Labor Productivity[4]	7.2	8.4	12.1	10.0	8.7	8.5[5]

Notes : 1) Figures in current balance and overall balance are the sum of the values during the period. Other figures are rates of increase compared with the previous year.
2) Average of daily figures.
3) In manufacturing industries.
4) Based on the value-added productivity(at constant prices) index released by Korea Productivity Center.
5) During the Period of January to June in 1994.

Sources : The Bank of Korea, Monthly Bulletin, various issues.
Ministry of Labor, Report of Monthly Labor Survey, various issues.

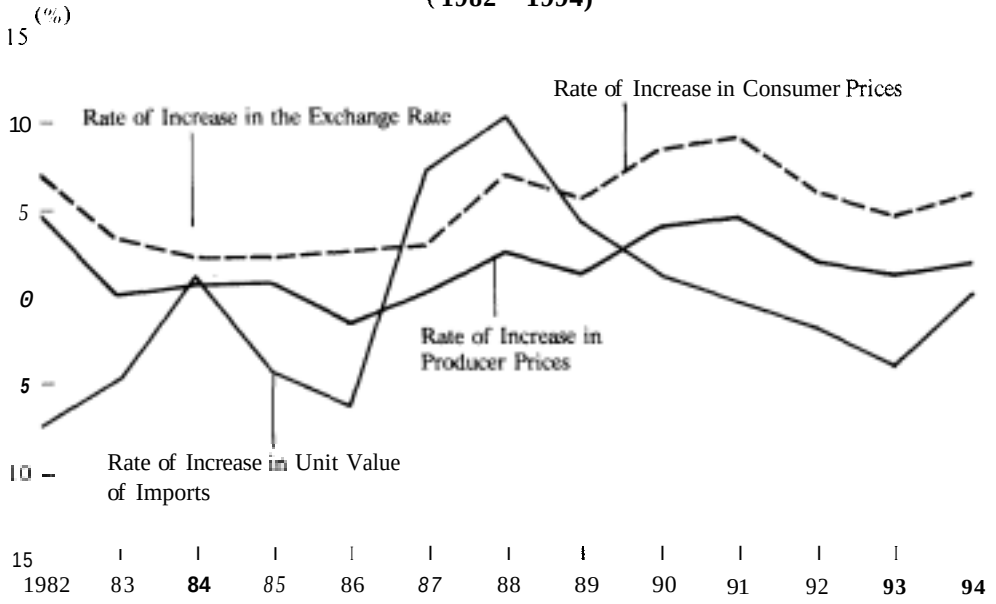
the current account balance shifted to a large surplus and the rigid operation of exchange rate policy became a major point of dispute in the trade friction between Korea and the U.S. In contrast, the prices rose sharply, responding both to supply side factors such as wage increases that outpaced the growth of labor productivity and rises in raw material prices, and those on the demand side, including the liquidity expansion through the foreign sector caused by sustained current account surpluses and the increase in aggregate demand as high GNP growth rates continued. Moreover, the increase in wealth during this period which was brought about by a sharp rise in the prices of stocks and real estate initiated an expansion in consumption and, consequently, reinforced the upward trend of prices.

In the two years of 1990 and 1991, the won-U.S. dollar exchange rate shifted to an upward trend again as the current account balance slid back deeply into deficit and the role of the exchange rate as a price variable became enhanced with the introduction of a market-average system in the foreign exchange market. Despite the fall in raw material prices which accompanied the worldwide stagnation, domestic prices rose even faster than before as the expansion of consumption and investment pushed up aggregate demand while there was no narrowing of the gap between the pace of wage increases and the improvement of labor productivity. In addition, a shortage of aggregate supply during this period caused by poor harvests and fishing catches acted as another factor pulling up prices.

Lastly, during the fourth sub-period, the exchange rate rose rapidly in 1992 as the current account deficit widened, but from early 1993, it showed relatively steady movements influenced by the inflow of external funds for investment in domestic stocks, following the opening of the stock market to foreign investors in January 1992. The pace of price rises during 1992, though, slowed down remarkably compared to the preceding years as the government carried out strong economic stabilization policies while the prices of raw materials and real estate showed a stable range of movements. But from 1994, international raw material prices, notably for petroleum, began to rise with the recovery of the world economy. Domestic demand, too, started to expand as domestic business picked up. Reflecting these developments on both the supply and demand sides, prices showed rather unstable movement.

Considering this pattern of exchange rate and price movements in Korea since 1980, one may reasonably conclude that there is a clear linkage running between the two variables. As can be seen in Figure 3, apart from the period of 1987 to 1989 when import prices (measured in U.S. dollars) soared due to sharp rises in raw material prices, there is a close relationship between changes in the exchange rate and those in prices.

[Figure 31 The Exchange Rate and Domestic Prices in Korea (1982 - 1994)



Source : The Bank of Korea, Monthly Bulletin, various issues.

2. Test of Causality between the Exchange Rate and Prices

The exchange rate and domestic prices seem to fluctuate in a close relationship, as described above, but, since the response of a variable to a change in another variable can be altered by preemptive measure by the monetary authority such as money supply management carried out by the central bank, the final causality between these variables needs to be tested systematically using empirical methods of analysis. Notably, the analysis of the causality between exchange rate and domestic prices has important implications for monetary policy because the optimal policy to deal with in either of these variables will differ according to whether there exists a uni directional causality or a feedback relation, implying that both variables initiate changes in each other. For example, if the exchange rate and prices have a feedback relation, an intentional depreciation of the domestic currency in order to improve the current account balance will instead initiate continuous inflation and thus, prove counter productive. Therefore, systematic analysis of the relation between these two variables is important for setting

up and carrying out an efficient economic stabilization policy.

To analyze the causal relationship between the exchange rate and prices, a two variable vector autoregressive(VAR) model based on that defined by Granger(1969) was built **as** below, assuming that the information **set** required for explaining and forecasting the movement of the exchange rate and prices is composed of the past serial **data** of these two variables.[3]

$$\ln P_t = c + \sum_{i=1}^{m} \alpha_i \cdot \ln P_{t-i} + \sum_{i=1}^{n} \beta_i \cdot \ln S_{t-i} + U_{1t} \quad \cdots\cdots (1)$$

$$\ln S_t = d + \sum_{i=1}^{p} \theta_i \cdot \ln S_{t-i} + \sum_{i=1}^{q} \lambda_i \cdot \ln P_{t-i} + U_{2t} \quad \cdots\cdots (2)$$

where P : domestic prices, S : spot exchange rate
c, d, α, β, θ, λ : coefficients
U_1, U_2 : error term
In : natural logarithm

The way of testing Granger causality from the model specified above is to judge whether the prediction of a variable has been improved by putting past values of another variable in the regression equation in addition to its own past **values.**[4]

3) There are four **types** of Granger–causality that *can* be derived from the **VAR** model which consists of equations (1) and (2).

1 If the prediction of prices is improved by adding the lagged values of the exchange rate **as** an explanatory variable in equation (1), but the prediction of the exchange rate is not improved by adding the lagged values of prices in equation (2), then there exists a uni-directional causation from the exchange rate to prices.

2 If the prediction of prices is not improved by adding the lagged values of the exchange rate in equation (1), but the prediction of the exchange rate is improved by adding the lagged values of prices in equation (2), then there exists a uni directional causation from prices to the exchange rate.

3 If the prediction of prices is improved by adding the lagged values of the exchange rate in equation (1) and the prediction of the exchange rate is **also** improved by adding the lagged values of prices in equation (2), then there exists a feedback relationship between the exchange rate and prices.

4 If the prediction of prices **is** not improved by adding the lagged values **of** the exchange rate in equation (1) and the prediction of exchange rate is not improved by adding the lagged values of prices in equation (2), either, then the exchange rate and prices are mutually independent.

4) There are two methods of deciding whether the explanatory **or** predictive power has been improved **or** not. First, it *can* be judged by testing whether the coefficients of the explanatory variable that has **been** added to the equation are significant or not using F-statistics(Granger(1969), Sims(1972)). **Second,** it *can* be judged by the **final** prediction error(FPE) criterion(Akaike(1970), Hsiao(1981)), that is, by examining if the prediction error has been reduced by adding an explanatory variable other than the past values of the dependent variable. **In this paper** both methods were used, **since** the empirical results of the two tests may differ in **certain** cases.

The data used in this empirical analysis are monthly data for the period of January 1982 to June 1994 and all data were seasonally adjusted by the X-11 ARIMA method. The monthly average spot exchange rate of the Korean won against the U.S. dollar was used for the exchange rate variable and the producer price index and the consumer price index were used for the domestic price variable.

According to the empirical results that are summarized in Table 2[5], when the past values of the exchange rate were added to equation (1) – the price equation – as an explanatory variable, the final prediction error(FPE) of both producer prices and consumer prices decreased and the F-statistics for the past values of the exchange rate turned out to be significant. This result shows that the predictability was improved by adding the exchange rate to the equation. On the other hand, in equation (2) – the exchange rate equation – the conclusions derived from the FPE criterion and the F-statistics were different. In the case of producer prices, the existence of a causality running from domestic prices to the exchange rate could only be found in the FPE test, and for consumer prices, both tests showed that the causality from domestic prices to the exchange rate was not significant.

5) The ordinary least squares(OLS) method was used in estimating the VAR model. In a VAR model, deciding the appropriate lag length in each equation is important, since lag structure may change the result of the test. In this paper, the minimum final prediction error criterion proposed by Akaike(1970) and Hsiao(1981) was used to decide the optimal lag length.

[Table 2] Granger Causality between the Exchange Rate and Domestic Prices

Equation (1) : Exchange Rate(S) → Domestic Prices(P)[1]

	Optimal Lag P	Optimal Lag S	FPE(P) × 10⁻⁵ (A)	FPE(P, S) × 10⁻⁵ (B)	F-statistics
PPI	2	1	1.338	1.314*	F(1, 134) = 4.445(0.04)**
CPI	1	1	1.663	1.580*	F(1, 135) = 9.082(0.00)***

Equation (2) : Domestic Prices(P) → Exchange Rate(S)[2]

	Optimal Lag P	Optimal Lag S	FPE(P) × 10⁻⁵ (A)	FPE(P, S) × 10⁻⁵ (B)	F-statistics
PPI	9	3	1.630	1.628*	F(3, 125) = 1.934(0.13)
CPI	9	1	1.630	1.643*	F(1, 127) = 0.946(0.33)

Notes: 1) $FEP(P) = \{(t+\hat{m}+1)/(t-\hat{m}-1)\} \cdot \{SSR(\hat{m}, 0)/t\}$

$FPE(P, S) = \{(t+\hat{m}+\hat{n}+1)/(t-\hat{m}-\hat{n}-1)\} \cdot \{SSR(\hat{m}, \hat{n})/t\}$

where t is the number of observation ; $\hat{m}$ is the optimal order of lags of P_t in regression I decided by the minimum final prediction error criterion ; $SSR(\hat{m}, 0)$ is the sum of squared residuals of regression II ($P_t = c + \sum_{i=1}^{m} \alpha_i \cdot P_{t-i} + U_t$) ; $\hat{n}$ is the optimal order of lags of S_t ; and $SSR(\hat{m}, \hat{n})$ is the sum of squared residuals of regression III ($P_t = c + \sum_{i=1}^{m} \alpha_i \cdot P_{t-i} + \sum_{i=1}^{n} \beta_i \cdot S_{t-i} + U_t$).

F-statistics : F-distribution statistics to test the null hypothesis of $\beta_i = 0 (i = 1, \cdots, \hat{n})$ in regression II.

2) $FPE(S) = \{(t+\hat{p}+1)/(t-\hat{p}-1)\} \cdot \{SSR(\hat{p}, 0)/t\}$

$FPE(S, P) = \{(t+\hat{p}+\hat{q}+1)/(t-\hat{p}-\hat{q}-1)\} \cdot \{SSR(\hat{p}, \hat{q})/t\}$

where $\hat{p}$ is the optimal order of lags of S_t in regression III decided by the minimum final prediction error criterion ; $SSR(\hat{p}, 0)$ is the sum of squared residuals of regression III ($S_t = d + \sum_{i=1}^{p} \theta_i \cdot S_{t-i} + U_t$) ; $\hat{q}$ is the optimal order of lags of P_t ; and $SSR(\hat{p}, \hat{q})$ is the sum of squared residuals of regression IV ($S_t = d + \sum_{i=1}^{p} \theta_i \cdot S_{t-i} + \sum_{i=1}^{q} A_i \cdot P_{t-i} + U_t$)

F-statistics : F-distribution statistics to test the null hypothesis of $\lambda_i = 0 (i = 1, \cdots, \hat{q})$ in regression IV.

3) Figures in parentheses show the degree of freedom and the level of significance.

4) * indicates that the final prediction error of B is smaller than that of A, which implies that the predictability of the equation is improved by including the lagged values of the other variable in the regression equation in addition to the lagged values of the dependent variable. ** and *** indicates that the F-statistics are significant at the upper 5% level and 1% level, respectively.

Putting these results together, it can be concluded that in Korea, generally, there exists a uni directional causality from the exchange rate to prices. In the case of producer prices, there is a weak feedback relationship between the exchange rate and prices.

The causality analysis between the exchange rate and prices may be affected by a third variable which has influence on both the exchange rate and domestic prices. For example, even though the exchange rate and prices are mutually independent, if there exists another variable which affects both variables with different time' lags, it may bring about spurious causality on these two variables. Therefore, to find out if the relation between these two variables remains stable even when a third variable which affects both of them is counted in, it is necessary to undertake an analysis which includes this third variable.

In this paper, the monetary stock is chosen as a third variable which might have an influence on the relation between the exchange rate and domestic prices. This is not only because money supply is an important policy variable that has influence on both variables but also because the speed of adjustment of the exchange rate and prices to changes in the monetary stock could differ, and thus it might bias the revealed causality which is defined in the sense of predictability or precedence."'

Hence, to test the stability of the relation between the exchange rate and domestic prices, incorporating the fact that the monetary stock influences both variables, a three variable **VAR** model including the monetary stock is specified.

$$\ln P_t = c + \sum_{i=1}^{m} \alpha_i \cdot \ln P_{t-i} + \sum_{i=1}^{r} \gamma_i \cdot \ln M_{t-i} + \sum_{i=1}^{n} \beta_i \cdot \ln S_{t-i} + U_{1t} \quad \cdots\cdots(3)$$

$$\ln S_t = d + \sum_{i=1}^{p} \theta_i \cdot \ln S_{t-i} + \sum_{i=1}^{s} \delta_i \cdot \ln M_{t-i} + \sum_{i=1}^{q} \lambda_i \cdot \ln P_{t-i} + U_{2t} \quad \cdots\cdots(4)$$

$$\ln M_t = e + \sum_{i=1}^{f} \mu_i \cdot \ln M_{t-i} + \sum_{i=1}^{h} \nu_i \cdot \ln S_{t-i} + \sum_{i=1}^{g} \rho_i \cdot \ln P_{t-i} + U_{3t} \quad \cdots\cdots(5)$$

where P : domestic prices, M : monetary stock, S : the exchange rate
c, d, e, α, γ, β, θ, λ, μ, ν, ρ : coefficients
U_1, U_2, U_3 : error terms

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6) In the asset market approach to exchange rate determination which considers changes in the monetary stock as an important factor in explaining exchange rate movements, mention is made in explaining the overshooting of exchange rate that the *speed* of adjustment to changes in the monetary stock is different for the exchange rate and prices. Due to rigidities in production capacity, consumers' habits in buying commodities, and the limitation of information in the commodity market, the *speed* of adjustment of prices in the commodity market(domestic price level) is slower than that of prices in the asset market(exchange rate), which, in turn, causes overshooting of the exchange rate(Dornbusch(1976), etc).

The empirical results using the reserve base, M1, and M2[7] as the measures of the monetary stock are presented in Table 3. Similar to the results derived from the model excluding the monetary stock, the results in Table 3 show that, in general, there exists a uni directional causality running from the exchange rate to domestic prices, even when the monetary stock is counted in the model. Hence, the causal relation shown above can be considered "stable".

More specifically, the test results using F-statistics show that a uni directional causality running from the exchange rate to domestic prices *can* be detected in all other cases, except when the producer price index is used as the price variable and the reserve base is used as the monetary stock. The results derived from the FPE criterion, however, differ depending on the variable used as the monetary stock. When M1 is used as the monetary stock, there appears to be a uni directional causality from the exchange rate to domestic prices, but when M2 takes its place, the exchange rate seems to have a feedback relationship with producer prices as well as consumer prices.

Summing up the empirical results, the relationship between the exchange rate and domestic prices, in Korea, turns out to be a stable uni directional causal relation with the direction running from exchange rates to domestic prices. This shows that a depreciation of the domestic currency would function as a cost-push factor, and thus move up domestic prices.

The feedback relationship between the exchange rate and domestic prices does not Seem to be strong. This means the vicious circle of exchange rate and prices – in which changes of domestic prices induced by exchange rate fluctuations cause further changes in the exchange rate – did not occur in Korea during the period under review. This may be explained by the fact that, since the capital market and foreign exchange market were not liberalized fully, the exchange rate functioned as an exogenous policy variable rather than an endogenous variable that reflected market fundamentals. But as foreign exchange liberalization and the opening of the capital market proceed, the price mechanism in the foreign exchange market will be enhanced and the endogeneity of the exchange rate will then be strengthened. Under this scenario, there is a greater probability of a feedback relationship between the exchange rate and domestic prices developing in the Korean economy, leading to the feared vicious circle.

7) The data on the reserve base, M1, and M2 used in this model are monthly average balances and all of them were seasonally adjusted by the X-11 ARIMA method.

[Table 31 Granger Causality between the Exchange Rate and Domestic Prices (considering the influence of monetary stock)

Equation (3) : Exchange Rate(S) → Domestic Prices(P)[1]

	Optimal Lag			FPE(P,M) × 10^{-5} (A)	FPE(P,M,S) × 10^{-5} (B)	F-statistics
	P	M	S			
RB,PPI	2	12	1	1.190	1.206	F(1, 122) = 0.232(0.63)
RB,CPI	1	2	1	1.478	1.458'	F(1, 133)=3.842(0.05)**
M1,PPI	6	4	3	1.288	1.235'	F(3, 124) = 3.720(0.01)**
M1,CPI	1	0	1	1.663	1.580*	F(1, 135) = 9.082(0.00)***
M2,PPI	2	8	2	1.251	1.220*	F(2, 125) = 3.492(0.03)**
M2,CPI	1	1	3	1.533	1.467*	F(3, 132) = 4.018(0.01)***

Equation (4) : Domestic Prices(P) → Exchange Rate(S)[2]

	Optimal Lag			FPE(S,M) × 10^{-5} (A)	FPE(S,M,P) × 10^{-5} (B)	F-statistics
	P	M	S			
RB,PPI	9	0	3	1.630	1.628*	F(3, 125) = 1.934(0.13)
RB,CPI	9	0	1	1.630	1.643	F(1, 127) = 0.946(0.33)
M1,PPI	9	2	3	1.620	1.621	F(3, 123) = 1.819(0.15)
M1,CPI	9	2	1	1.620	1.643	F(1, 125) = 0.053(0.82)
M2,PPI	9	2	3	1.551	1.540*	F(3, 123) = 2.141(0.10)
M2,CPI	9	2	2	1.551	1.532*	F(2, 124) = 2.624(0.08)

Note : 1) $FPE(P, M) = \{(t+\hat{m}+\hat{r}+1)/(t-\hat{m}-\hat{r}-1)\} \cdot \{SSR(\hat{m}, \hat{r}, 0)/t\}$
$FPE(P, M, S) = \{(t+\hat{m}+\hat{r}+\hat{n}+1)/(t-\hat{m}-\hat{r}-\hat{n}-1)\} \cdot \{SSR(\hat{m}, \hat{r}, \hat{n})/t\}$
where t is the number of observations ; $\hat{m}$ and $\hat{r}$ are the optimal order of lags of P_t and M_t in regression I decided by the minimum final prediction error criterion ; $SSR(\hat{m}, \hat{r}, 0)$ is the sum of squared residuals in regression I ($P_t = c + \sum_{i=1}^{\hat{m}} \alpha_i \cdot P_{t-i} + \sum_{i=1}^{\hat{r}} \gamma_i \cdot M_{t-i} + U_t$) ; $\hat{n}$ is the optimal order of lags of S_t in regression II ; and $SSR(\hat{m}, \hat{r}, \hat{n})$ is the sum of squared residuals in regression II ($P_t = c + \sum_{i=1}^{\hat{m}} a_i \cdot P_{t-i} + \sum_{i=1}^{\hat{r}} \gamma_i \cdot M_{t-i} + \sum_{i=1}^{\hat{n}} \beta_i \cdot S_{t-i} + U_t$).
F-statistics: F-distribution statistics to test the null hypothesis of $\beta_i = 0$ ($i = 1, \cdots, \hat{n}$) in regression II.

2) $FPE(S, M) = \{(t+\hat{p}+\hat{s}+1)/(t-\hat{p}-\hat{s}-1)\} \cdot \{SSR(\hat{p}, \hat{s}, 0)/t\}$
$FPE(S, M, P) = \{(t+\hat{p}+\hat{s}+\hat{q}+1)/(t-\hat{p}-\hat{s}-\hat{q}-1)\} \cdot \{SSR(\hat{p}, \hat{s}, \hat{q})/t\}$
where $\hat{p}$ and $\hat{s}$ are the optimal orders of lags of S_t and M_t in regression III decided by the minimum final prediction error criterion ; $SSR(\hat{p}, \hat{s}, 0)$ is the sum of squared residuals in regression III ($S_t = d + \sum_{i=1}^{\hat{p}} \theta_i \cdot S_{t-i} + \sum_{i=1}^{\hat{s}} \delta_i \cdot M_{t-i} + U_t$) ; $\hat{q}$ is the optimal order of lags of P_t in regression IV ; and $SSR(\hat{p}, \hat{s}, \hat{q})$ is the sum of squared residuals in regression IV ($S_t = d + \sum_{i=1}^{\hat{p}} \theta_i \cdot S_{t-i} + \sum_{i=1}^{\hat{s}} \delta_i \cdot M_{t-i} + \sum_{i=1}^{\hat{q}} \lambda_i \cdot P_{t-i} + U_t$)
F-statistics: F-distribution statistics to test the null hypothesis of $\lambda_i = 0$ ($i = 1, \cdots, \hat{q}$) in regression II.

3) Figures in parentheses show the degree of freedom and the level of significance.

4) * indicates that the final prediction error of B is smaller than that of A, which implies that the predictability of the equation is improved by including the lagged values of the other variables in the regression equation in addition to the lagged values of the dependent variable and the monetary variable. ** and *** indicates that the F statistics are significant at the upper 5% level and 1% level. respectively

Ⅳ. The Inflationary Effects of Exchange Rate Changes

According to the results of the Granger causality test described above, it is shown that the direction of causality is from the exchange rate to domestic prices. In what follows, we analyze the actual effects of exchange rate changes on domestic prices using both a VAR model and a structural model.

1. Analysis Using a **VAR** Model

The final effects of exchange rate changes on the domestic price level may vary in magnitude, depending on the pattern of policy response. Especially, under a flexible exchange rate regime in which exchange rate is endogenously determined by demand and supply in the foreign exchange market, the effects of exchange rate changes on the domestic price level depend on the policy response to the changes in aggregate demand

Here we specify a four variable VAR model, which includes money supply, exchange rate, prices, and industrial production index. In this *case,* the dynamic response of domestic prices to exchange rate changes is analyzed using the impulse response function and the variance decomposition technique in which the variables are ordered with money supply, exchange rate, industrial production index and prices in sequence[8], with the lag length of *6* months."'

$$\ln X_t = C + A_1 \ln X_{t-1} + A_2 \ln X_{t-2} + \cdots + A_6 \ln X_{t-6} + U_t$$

where X_t = money supply, exchange rate, industrial production index, prices

C : constant vector
A_i : coefficient matrix
U_t : disturbance vector

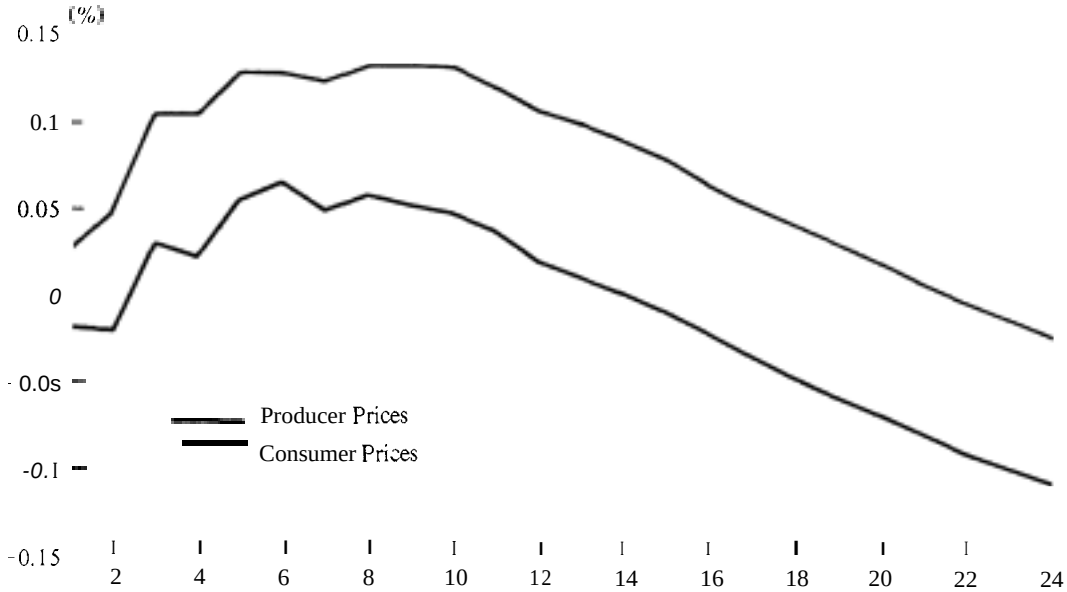
8) In the VAR Model, it is required to set the ordering of variables according to the **degree** of exogeneity. In our cases, the order used is money supply, exchange rate, industrial production index, and prices, based on the fact that money supply is a policy variable, and that exchange rate changes **cause** domestic price changes.

9) The lag length was chosen after performing likelihood ratio tests. The test statistic is $(T-C)$ **[log** $(\det\Sigma_r) - \log(\det\Sigma_u)$] where $det\Sigma_r$ and $det\Sigma_u$ are the restricted and **unrestricted** covariance matrices, and T is the **number** of observations. This is asymptotically distributed **as** a $x2$ with **degrees** of freedom **equal** to the **number** of restrictions. C is a correction to improve small sample properties.

The results of impulse response function analysis are described in Figure 4[10], from which it may be seen that producer prices respond immediately, rising to the first 10 months after depreciation shocks to domestic currency. For the consumer prices, the inflationary effects of exchange rate depreciation shock appear from the first 2 months to 6 months and dwindle away gradually thereafter.

From this result, it may be inferred that the inflationary effects of exchange rate changes are larger and longer lasting in producer prices than in consumer prices. This may imply that .exchange rate changes affect domestic prices through changes in the costs of production due to price changes in imported intermediate goods, rather than through price changes in imported consumer goods. It may also reflect the fact that services, which are generally nontraded and less directly affected by the exchange rate than goods, are included in the consumer prices.

[Figure 4] The Inflationary Effects of Depreciation Shocks' to Domestic Currency



Note : 1) The size of shock is given by one standard deviation shock to the domestic currency.

10) As data on money supply and exchange rate variable, M2(monthly average balances) and the exchange rate against the U.S. dollar are used, respectively. And as a price variable, producer price index and consumer price index are used

The results of variance decomposition, which shows the contribution of innovations in the explanatory variables to the variability of domestic prices are presented in Table 4. After the first 15 months, 16 percent of the forecast error variance in producer prices is accounted for by exchange rate changes, considerably higher than by money supply changes. It implies that the explanatory power of the exchange rate exceeds that of money supply. In contrast, the contribution of money supply changes to the variance of consumer prices is as high as 30 percent after the first 24 months, much larger than that of exchange rate changes.

Therefore, it may be concluded that the exchange rate changes affect domestic prices through changes in production costs due to price changes in imported intermediate goods, rather than through price changes in imported consumer goods. The results of impulse response function analysis discussed above also support this conclusion.

A further implication is that inflation may accelerate in certain circumstances where there is excessive money supply, because monetary expansion may fuel inflation not only by increasing aggregate demand but also by causing the depreciation of domestic currency by way of deterioration of the trade balance following increased import demand.

[Table 41 Percentage of Forecast Error Variance Explanied by Innovations in the Explanatory Variables

A. Producer Prices

Unit : %

Explanatory Variables	Months								
	1	3	6	9	12	15	18	21	24
Money Supply	0.1	1.7	3.0	2.8	2.4	2.2	2.1	2.0	2.0
Exchange Rate	0.8	4.3	9.3	12.8	15.0	15.8	15.5	14.9	14.4
Industrial Production Index	0.1	1.2	0.8	0.8	1.0	1.2	1.2	1.1	1.1
Prices	99.0	92.8	86.9	83.6	81.6	80.8	81.2	82.0	82.5

B. Consumer Prices

Unit : %

Explanatory Variables	Months								
	1	3	6	9	12	15	18	21	24
Money Supply	2.0	1.7	4.2	8.8	13.5	17.9	22.2	26.1	29.8
Exchange Rate	0.4	0.6	1.7	2.2	2.1	1.9	1.9	2.7	4.1
Industrial Production Index	0.6	1.2	1.1	0.8	0.8	0.7	0.7	0.8	1.1
Prices	97.0	96.5	93.0	88.2	83.6	79.5	75.2	70.4	65.0

2. Analysis Using a Structural Model

In this section, we analyze the inflationary effects of exchange rate changes using a structural model which has constraints on the form of equation.[11] Assuming that the price level is determined by the factors, such as unit labor costs, import prices, the exchange rate, interest rate, money supply and exchange rate volatility, we construct the long-run and short-run price equations.[12]

$$\ln P_t = \alpha_0 + \alpha_1 \ln M_t + \alpha_2 \ln S_t + \alpha_3 \ln PM_t + \alpha_4 \ln ULC_t + EC_t \quad \cdots\cdots (1)$$

$$\Delta \ln P_t = \beta_0 + \sum_{i=1}^{l} \beta_{1i} \Delta \ln P_{t-i} + \sum_{i=0}^{m} \beta_{2i} \Delta \ln M_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta \ln S_{t-i} + \sum_{i=0}^{p} \beta_{4i} \Delta \ln PM_{t-i} + \sum_{i=0}^{q} \beta_{5i} \Delta \ln ULC_{t-i} + \sum_{i=0}^{r} \beta_{6i} \Delta Z_{t-i} + \beta_7 EC_{t-1} \quad \cdots\cdots (2)$$

where P : price level, M : money supply, S : exchange rate
PM : import prices(measured in U.S. dollars)
ULC : unit labor costs, EC : error correction term
Z : the vector of other variables that are not included in equation (1)
Δ : first differencing

Equation (1) represents the equilibrium or long-run relationship between the variables in level form. On the other hand, equation (2) represents the short-run equation using the error correction model suggested by Engle and Granger(1987).[13] The explanatory

11) Dornbusch and Fischer(1981), among others, presents a structural model which includes unit labor costs, import prices, exchange rates, and money supply as factors of domestic price changes.

12) Unit labor costs are constructed dividing wages by physical labor productivity. Monthly average yields on corporate bonds of 3 year maturity are used as interest rates. All data were seasonally adjusted by the X-11 ARIMA method.

13) The validity of traditional econometric analysis is dependent upon the assumption of stationarity. It is well known that, when non-stationary variables are included in a regression, it is likely to cause a spurious regression problem. In other words, the high correlation found among those variables may not represent the true economic relationship but only common trends in the variables. Therefore, it is asserted that individual time series must be converted to stationary series by filtering the data with seasonal adjustment, differencing or elimination of deterministic trend. But one drawback of the procedure of differencing is that it may result in a loss of valuable long-run information which the original data series have. Recently the concept of cointegration has been developed by researchers including Granger, Engle, and Johansen as a solution to this problem. According to their studies, if the error term from the regression between non-stationary variables is stationary, there exists a cointegration relation between them and, in this case, there is a way to solve the spurious regression problem. Notably, Engle and Granger(1987) show that if a set of non-stationary variables is cointegrated, then an error correction model in which the spurious regression problem is avoided can be built.

variables of the short-run equation includes the first differenced variables with or without lags and the error correction term derived from the long-run equation.

In order to specify the long—run and short—run price equation, it is necessary to perform unit root tests which evaluate the stationarity of variables. When the variables are proven to be non-stationary, cointegration tests should be made in order to examine the stationarity of a linear combination of the variables in level form.

According to the results of the unit roots and cointegration test, it is shown that all the variables are non-stationary, and that there exists a cointegration relation between domestic prices and other variables which include money supply, exchange rate, import prices, and unit labor costs.[14] Therefore, the stationarity is achieved by taking a linear combination of the variables in level form, implying that there is an equilibrium or long-run relationship between these variables.

Based on these results, the inflationary effects of exchange rate changes can be analyzed using the short run and long-run equation.

First of all, the estimation results for the short-run price equation, in which explanatory variables include the lagged first differences of the variables in the long run equation, the exchange rate volatility[15] as a proxy for the uncertainty of foreign

14) Augmented Dickey-Fuller(ADF) unit root test statistics are -0.86 for producer prices, 0.96 for consumer prices, -1.43 for money supply, -1.64 for exchange rate, -2.45 for import prices, -3.25 for unit labor costs -2.79 for yields on corporate bonds. None of the variables can reject the null hypothesis of unit roots at the significance level of 5 percent, which implies that they are non-stationary. Also the ADF test statistics for the cointegration between prices and other variables are -4.23 and -4.62 for producer prices and consumer prices, respectively. So the null hypothesis of no cointegration can be rejected for the two sets of linear combination of the variables in level form at the significance level of 5 percent, implying that there is an equilibrium or long run relationship among these variables. The critical value for the significance level of 5 percent is -4.15 (Engle and Yoo(1987)).

15) The conditional variance is used as a proxy for the exchange rate volatility. It is estimated by the ARCH(autoregressive conditional heteroscedasticity) model suggested by Engle(1982), which is parameterized as the linear function of past squared residuals in order to take account of the conditional heteroscedasticity. ARCH model estimated in this paper is as follows, with t values in parentheses below the coefficient estimates. The results show that ARCH model is statistically appropriate.

$$\Delta \ln S_t = 0.001 + 0.689 \cdot \Delta \ln S_{t-1} + 0.116 \cdot \Delta \ln S_{t-2} + \varepsilon_t$$
$$(0.55)\ (8.60) \qquad (1.46)$$
$$\sigma^2_t = 0.002 + 0.249\ \varepsilon^2_{t-1}$$
$$(5.37)\ (3.19)$$
$$R^2 = 0.62,\ D\ W = 2.0,\ ARCH(1) = 9.66(0.00)$$

where σ^2 is the conditional variance, and ARCH(1) is the Lagrange Multiplier(LM) test statistic for testing the appropriateness of ARCH Model, which is distributed as a $\chi 2$ with the degree of freedom of 1, with the marginal significance level in parentheses.

excnange markets, and an error correction term, are as follows.[16] The reason for including the exchange rate the volatility as an explanatory variable is that the price level may change as uncertainty in the economy increases due to the greater volatility of the exchange rate.

(Producer Prices)

$$\Delta \ln P_t = -0.001 + 0.224 \cdot \Delta \ln P_{t-3} + 0.072 \cdot \Delta \ln M_{t-3} + 0.154 \cdot \Delta \ln S_{t-1}$$
$$(0.45)\quad (2.99)\quad (2.25)\quad (3.46)$$
$$+ 0.111 \cdot \Delta \ln PM_t + 0.011 \cdot \Delta \ln ULC_t + 0.124 \cdot \Delta \ln R_{t-2}$$
$$(5.01)\quad (1.79)\quad (1.82)$$
$$+ 0.002 \cdot \Delta \ln VOL_{t-1} - 0.039 \cdot EC_{t-1}$$
$$(2.05)\quad (-2.19)$$

$R^2 = 0.31$, D-W = 1.87 (D-h = 1.15)

where R : Interest rates

VOL: the exchange rate volatility

numbers in parentheses are t values

(Consumer Prices)

$$\Delta \ln P_t = 0.002 + 0.155 \cdot \Delta \ln P_{t-1} + 0.102 \cdot \Delta \ln M_{t-1} + 0.095 \cdot \Delta \ln S_{t-2}$$
$$(3.04)\quad (1.95)\quad (2.70)\quad (1.85)$$
$$+ 0.063 \cdot \Delta \ln PM_t + 0.014 \cdot \Delta \ln ULC_t + 0.155 \cdot \Delta \ln R_{t-1}$$
$$(2.28)\quad (2.05)\quad (1.94)$$
$$+ 0.001 \cdot \Delta \ln VOL_{t-1} - 0.028 \cdot EC_t$$
$$(1.26)\quad (-1.88)$$

$R^2 = 0.22$, D-W = 1.92 (D-h = 1.01)

where numbers in parentheses are t values

It is found that most of the variables are estimated to be statistically significant with the anticipated sign. But the estimation of equation using different measures of the price level allows us to discriminate among the effects of cost and demand factors on domestic prices. While cost factors, such as the exchange rate and import prices, primarily affect the producer prices, demand factors including money supply primarily influence the consumer prices. Also the empirical results shows that an increase in the exchange rate volatility induces domestic prices to rise.

16) Here the 'general-to-specific' approach proposed by Hendry(1989) has been used to determine the structure of dynamics, until reaching the meaningful parsimonious model. The model was estimated using the two step estimation procedure suggested by Engle and Granger(1987).

The result that the effects of the exchange rate and import prices on domestic prices are stronger for the producer prices than for the consumer prices may indicate that the inflationary effects through changes in the costs of production due to price changes in imported intermediate goods are most important. It may also, however, reflect the fact that services, which are generally nontraded and thus less directly affected by the exchange rate and import prices than goods have much less weight in the producer prices than in the consumer prices.

The estimated coefficient of the error correction term which represents the extent to which actual price level diverges from its long-run equilibrium level indicates that 4 percent(3 percent) of the previous deviation of the actual value from the equilibrium is reflected in current producer prices(consumer prices).[17] Therefore, we may conclude that domestic price level is fairly sticky because of the widespread expectations of inflation developed by the continued high inflation over many years.

On the other hand, the estimation results of the long-run price equation which is a linear combination of cointegrated variables in level form, using the dynamic OLS suggested by Stock and Watson(1989) are as follows:

(Producer Prices)

$$\ln R = -0.584 + 0.064 \cdot \ln M_t + 0.243 \cdot \ln S_t + 0.265 \cdot \ln PM_t + 0.110 \cdot \ln ULC_t$$
$$(1.26)\quad (4.28)\quad (5.93)\quad (5.68)\quad (2.13)$$
$$R^2 = 0.94$$

where numbers in parentheses are t values

(Consumer Prices)

$$\ln P_t = -0.790 + 0.266 \cdot \ln M_t + 0.144 \cdot \ln S_t + 0.177 \cdot \ln PM_t + 0.155 \cdot \ln ULC_t$$
$$(-1.29)\quad (13.56)\quad (2.68)\quad (2.90)\quad (2.28)$$
$$R^2 = 0.98$$

where numbers in parentheses are t values

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17) Suppose α represents the speed of adjustment. Then the actual value of P at time t depends on the linear combination of the realized value of P at time $t-1$ and its long-run equilibrium value denoted by $\bar{P}$.

$$\Delta P_t = \alpha(\bar{P} - P_{t-1})$$
$$P_t = (1-\alpha)P_{t-1} + \alpha\bar{P}$$
where $0 \le \alpha \le 1$

In this case, as the value of α becomes smaller, the variable P becomes less flexible because of the increasing dependence upon its past value.

All variables included in producer prices and consumer prices are estimated to be statistically significant and to have the anticipated sign. Based on these results, it is concluded that the long-run inflationary effects of cost factors, such as the exchange rate and import prices, are larger in producer prices than in consumer prices, whereas those of demand factors including money supply are larger in consumer prices than in producer prices. This finding coincides with the estimation results for the short-run equation using an error correction model.

Computing the long-run inflationary effects of exchange rate changes, it is found that in the case of the depreciation of 1 percent, producer prices and consumer prices rise by 0.24 percent and 0.14 percent, respectively, whereas, in the case of a money supply increase of 1 percent, producer prices and consumer prices rise by 0.06 percent and 0.27 percent, respectively.

V. Conclusions

As discussed in the above chapters, exchange rate movements are closely correlated with domestic price changes in Korea, and the causation runs from the exchange rate to domestic prices, not vice versa.

As the exchange rate has uni-directional causation to domestic prices, depreciation of the domestic currency may result in domestic inflation. However, no feedback relationship is detected, and so depreciation and domestic price changes are not expected to cause further inflation and depreciation. In other words, a vicious circle of the exchange rate and domestic prices does not yet exist in Korea. These findings imply that, in contrast to the converse situation, domestic prices seem to have limited effects on the exchange rate and this is ascribable to the imperfect capital and foreign exchange liberalization and the exogeneity of the exchange rate as a policy variable. But the deepening of the openness and liberalization of the economy will enhance the functioning of the price mechanism and strengthen the endogeneity of the exchange rate, which may generate a feedback relationship.

On the other hand, empirical results derived from the use of various models indicate that exchange rate changes affect domestic prices through changes in the costs of production due to price changes in imported intermediate goods rather than through price changes in imported consumer goods. Also, the increase in exchange rate variability, a measure of uncertainty in the foreign exchange markets, may cause inflation. By stimulating aggregate demand, an increase in domestic money supply induces inflationary pressures, while by enhancing import demand and worsening the trade balance, it results in the depreciation of the domestic currency, further fuelling inflation.

As the liberalization of the capital and foreign exchange markets is expanded, capital mobility is expected to increase. This may work as a source of disturbance to macroeconomic variables such as money supply and the exchange rate, thus bringing about the negative phenomenon of price instability. The policy implications for economic stabilization derived from the analysis presented in this paper are set out below.

First, as depreciation may cause inflation, it is better to narrow the current account imbalance by improving the competitiveness of exports through technical development and upgrading of product quality, rather than by engineering depreciation.

Second, the endogeneity of the exchange rate, which is reinforced in the process of opening and liberalization of the economy, may cause a vicious circle of the exchange rate and domestic prices. Therefore, the monetary authorities should make constant efforts to maintain price stability.

Finally, the exchange rate volatility associated with the improved functioning of the price mechanism may result in price instability, and so all possible measures should be taken to stabilize the range of exchange rate movements.

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