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ECONOMIC FUNDAMENTALS AND EXCHANGE RATES UNDER DIFFERENT EXCHANGE RATE REGIMES: KOREAN EXPERIENCE

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Korea provides a unique opportunity to study the different behaviors or roles, if any, of limited flexibility and free floating exchange rate regimes. Korea shifted from a limited flexibility to a free floating exchange rate regime after the 1997 economic crisis. It is well documented that the exchange rate is very difficult to predict using any theoretical models for exchange rate determination. Based on a simple monetary model, we find that the impact of economic fundamentals on the exchange rate is very similar under both exchange rate regimes according to OLS estimates, but the difference is statistically significant with GARCH(1,1) results. We also find that the size of the exchange rate shock is much bigger under the free floating regime than under the limited flexibility regime. VAR results show that the exchange rate shock impact on inflation is not statistically different under the two regimes. These findings are generally in line with Baxter and Stockman (1989) for regime neutrality.

JEL classification codes: F31, F43, C22
Key words: Korean exchange rate regimes, economic fundamentals, exchange rate pass-through

I. Introduction

After the recent Asian economic crisis of 1997, many Asian countries, including Thailand, Malaysia, Indonesia and Korea among others, were forced to devalue their local currencies and resorted to a free floating exchange rate system. It is widely believed that fixed or pegged exchange rate regimes are ultimately destined to collapse, thus resulting in an economic crisis. Obstfeld and Rogoff (1995) and Larrain and Velasco (2001) argue that the solution to economic crises lies in increased exchange rate flexibility in the long-run.

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Baxter and Stockman (1989) and Flood and Rose (1995) studied the relationship between exchange rate regimes and macroeconomic volatilities, and found that macroeconomic volatilities are not particularly dependent on exchange rate regimes. This paper follows a similar line of research focusing on a single country, Korea.

This paper investigates the macroeconomic structural differences of the Korean economy under the free floating exchange rate regime after the economic crisis compared to the limited flexible regime before the economic crisis. The contribution of this paper is two fold. First, this paper focuses on Korean exchange rate regimes. The Korean economy has grown so fast in the last 30 years, that Korea is the 12th largest economy in the world, joining the OECD in 1996, and becoming one of the key players in international trade. Even with these achievements, the Korean economy did not receive due attention in rigorous academic research. Second, Korean exchange rate regimes provide one of the unique opportunities to study different behaviors or roles, if any, of a limited flexible regime and a free floating regime in the same economy. Since the regime change has occurred in a relatively recent period, it provides a natural experiment to empirically verify the role of exchange rate regimes on macroeconomic variables. We will investigate the effect of exchange rate pass-through on domestic variables such as the inflation rate under the two different regimes. The results of this paper provide useful guidelines for emerging economies to properly set their exchange rate system for stable economic growth.

There is an increasing trend for many developing countries to adopt free floating exchange rate regimes after economic crises. In reality, however, the officially declared exchange rate regimes are not what they claim to be. This is the "fear of floating" by Calvo and Reinhart (2002). The advantages of a fixed regime, especially for developing countries, are well summarized in Frankel (2003). They are: providing a nominal anchor to monetary policy, encouraging trade and investment, precluding competitive depreciation and avoiding speculative bubbles. In short, fixed exchange regimes provide the stability that developing countries need to maintain their economic growth. However, as the countries manage to maintain a fixed exchange rate with occasional interventions, there are usually smaller exchange rate shocks, but there might be one huge shock that might force the country to abandon the peg. Under the free floating regime, exchange rates are allowed to move freely to adjust economics fundamentals, and there may be larger shocks, but there is no risk of a massive exchange rate shock. Frankel (2003) also provides four advantages of a free floating exchange rate regime: independent monetary policy, automatic adjustment to trade shocks, seigniorage and lender of last resort ability, and ability to avoid speculative attacks. However, as Frankel points out, it is not completely clear whether the majority of developing countries can, or are willing to take advantage of a free floating exchange rate regime.

The next section introduces a simple monetary model of exchange rate determination based on the purchasing power parity. Section III describes the data set and presents empirical results. Section IV concludes the paper with some suggestions on the future direction of the current study.

II. Theoretical framework of exchange rate determination

The theoretical framework of our model is based on the simple monetary model summarized in Obstfeld and Rogoff (1996). Exchange rate prediction is a notoriously difficult task, as already demonstrated by Meese and Rogoff (1983). MacDonald and Taylor (1994), and Mark (1995) use the monetary model to test the predictability of exchange rates. They claimed the modest success in predicting exchange rates for a longer horizon. Mark and Sul (2001) use the same model for panel data set of 19 industrialized countries, while Wu and Chen (2001) estimated equation (8) below using a nonlinear Kalman filter allowing for a time-varying nature of the slope parameter. The monetary model consists of four behavioral equilibrium equations: domestic and foreign (ROW) money market equilibrium, the purchasing power parity condition (PPP) and the uncovered interest parity condition (UIP),

$$m_t - p_t = \lambda y_t - \phi i_t, \tag{1}$$

$$m_t^* - p_t^* = \lambda y_t^* - \phi i_t^*, \tag{2}$$

$$s_t = p_t - p_t^*, \tag{3}$$

$$i_t - i_t^* = E_t s_{t+1} - s_t, \tag{4}$$

where
$m_t \left(m_t^*\right)$: domestic (foreign) money supply in natural log;
$p_t \left(p_t^*\right)$: domestic (foreign) price level in natural log;

$y_t\left(y_t^*\right)$: domestic (foreign) GDP in natural log;
$i_t\left(i_t^*\right)$: domestic (foreign) interest rate;
s_t : nominal exchange rate (local currency price of one foreign currency) in natural log;
$E_t s_{t+1}$: expectation of s_{t+1} at time *t;*
$0 < \lambda < 1$: income elasticity to money demand;
$\phi > 0$: interest semi-elasticity to money demand.

From equations (1) to (3), we have

$$s_t = m_t - m_t^* - \lambda\left(y_t - y_t^*\right) + \phi\left(i_t - i_t^*\right) = f_t + \phi\left(i_t - i_t^*\right), \tag{5}$$

where $f_t = m_t - m_t^* - \lambda\left(y_t - y_t^*\right)$ are economic fundamentals from domestic and foreign economies.

By substituting the UIP equation (4) into equation (5), the equilibrium condition is:

$$s_t - f_t = \phi\left(i_t - i_t^*\right) = \phi\left(E_t s_{t+1} - s_t\right). \tag{6}$$

Under the rational expectations hypothesis with no bubble solutions for the exchange rate process, we will have the fundamental solution for s_t as:

$$s_t = \frac{1}{1+\phi} E_t\left(\sum_{j=0}^{\infty}\left(\frac{\phi}{1+\phi}\right)^j f_{t+j}\right). \tag{7}$$

The exchange rate is expressed as the discounted value of the future economic fundamentals. This is a characteristic of the monetary model, viewing the exchange rate as the asset price of the future economic fundamentals. Assume that the economic fundamentals series $\{f_t\}$ follows a driftless random walk process, I(1). Then, $s_t \sim \mathrm{I}(1)$, $\Delta s_t \sim \mathrm{I}(0)$. Since $s_{t+1} = E_t s_{t+1} + v_t$, where v_t is a white noise forecasting error, nominal exchange rate and fundamentals, $\{s_t, f_t\}$ must be cointegrated by equation (6). Rearrange equation (6) to construct an econometric model of exchange rate changes and fundamentals such that:

$$\Delta s_{t+1} = \beta_0 + \beta_1 z_t + \varepsilon_t, \tag{8}$$

where $z_t = s_t - f_t = \phi(i_t - i_t^*)$ is the nominal exchange rate deviations from the economic fundamentals. We expect $\beta_1 < 0$ because when s_t is undervalued relative to the economic fundamentals ($(s_t - f_t)$ increases), nominal exchange rate should correct downward (appreciation: Δs_t decreases) to restore equilibrium.

This is the basic model used to perform exchange rate forecasting based on the monetary model. This paper extends the exchange rate predictions of the monetary model to different exchange rate regimes.

III. Evolution of Korean exchange rate controls

The Korean exchange rate system has gone through several fundamental changes in recent years. From 1974 to 1980, the government strictly regulated foreign exchange transactions, and the Korean *won* was pegged to the U.S. dollar. From February 27, 1980, the Korean *won* was officially pegged to a basket of currencies and SDR. The market average exchange rate (MAR) system was first adopted in March 1990 and maintained a pre-announced crawling peg to U.S. dollar with bandwidth ± 0.1 to 0.8 % in different periods until October 31, 1994. Starting November 1, 1994, this band expanded to ± 1.5 %, and December 1, 1995, this band again expanded to ± 2.25% until an economic crisis hit the country. In late 1997, the Korean economic crisis broke out and Korea turned to IMF for rescue. Taking advantage of the opportunities presented by the economic crisis, Korea has accelerated the speed of economic restructuring including capital account liberalization and lifting of exchange rate controls. Korea shifted to a free-floating exchange rate system on December 17, 1997. The ceiling on foreign investment in Korean equities was entirely abolished in May 1998, and the local bond markets and money markets were completely opened to foreign investors. In June 1998, the Korean government announced a plan to liberalize all foreign exchange transactions in two stages. The first stage of liberalization took effect on April 1, 1999 with the introduction of the new Foreign Exchange Transaction Act. The second stage of liberalization took effect on January 2001. The remaining ceilings on current account transactions by individuals have been eliminated.

During this period, exchange rate regime classifications have evolved through several stages. According to the official de jure IMF regime classification, Korea maintained a managed float throughout the 1980s and 1990s until the 1997 economic crisis and moved to a free float after the economic crisis and economic restructuring. However, there are several other classification schemes that do not agree with the official de jure classification. Reinhart and Rogoff (2004, RR hereafter) using parallel rates classify the Korean exchange rate regime as a crawling-peg during 80s and 90s and a free float after 1998. Levy-Yeyati and Sturzenegger (2003, 2005, LYS hereafter), using the volatilities of exchange rates and reserves, classify the Korean exchange rate regime for the crisis period as an intermediate (crawling peg) regime and the post-crisis period of 1999 and 2000 as a fixed regime. This classification does not reflect the true nature of Korean exchange rate regimes in recent years. Dubas, Lee and Mark (2005, DLM hereafter) use volatilities of effective exchange rates in addition to the official exchange rates and reserves to classify the Korean exchange rate regime as a limited flexibility regime (similar to crawling peg) with a few exceptional years for the 1980s and 1990s until the economic crisis, and independently floating (free float) after 1998. For the 1980s and 1990s before the economic crisis, IMF official de jure classification is more flexible than those of RR and DLM. This paper follows the generally agreed classifications of RR and DLM for the pre-crisis period as a limited flexibility regime and for the post-crisis period as a free float.

A. Data description

All our data comes from the IMF International Financial Statistics (IFS) CD-ROM. Data frequency is monthly except GDP and GDP deflator series, which are available only on a quarterly basis. We converted the quarterly series into monthly frequencies by linearly interpolating quarterly observations into monthly observations.

We used the bilateral nominal exchange rates per U.S. dollars for Australia, Japan and South Korea for the period of January 1980 to December 2003. These exchange rates are nominal domestic currency prices per US dollar at the end of each month. The Japanese yen and Australian dollar are introduced here as benchmarks for Korean exchange rate regimes. Japan is one of the largest trading partners of Korea, and Korea has sustained a chronic trade deficit with Japan. In addition to the close economic relationship between Korean and Japan, the Japanese yen has been freely floating after the collapse of the Bretton Woods

Accord. As Calvo and Reinhart (2002) observed, the Japanese yen serves as one of the reserve currencies of the world. Therefore, its characteristics of free floating regime may be different from those of small developing economies. In this regard, Australia is chosen because the Australian dollar is also freely floating, but because the Australian economy is much smaller than that of Japan, it more closely resembles typical small developing economies. As in the Calvo and Reinhart (2002) study, we use the Australian dollar as a benchmark currency for a free floating exchange rate regime of a small open economy.[1]

Other economic variables in our analysis are as follows: money supply: M2 measure of nominal money supply; interest rate: short term government bond rates for Australia and Japan, short term (90 day) deposit rate for Korea, and 3 month U.S. Treasury bill rate; general price level: manufacturing output prices for Australia, consumer price indices for Japan, Korea and the United States; reserves are measured as total reserves minus gold in U.S. dollar terms.

We divide our data into three periods according to the regime classifications of RR and DLM. The first period is from January 1980 to the beginning of the Korean economic crisis, September 1997 (period 1). During this period, Korean exchange rates were tightly managed and controlled by the Bank of Korea. Exchange rate changes are very limited during this period. The second period is the crisis period, October 1997 to September 1998, when the first round of financial restructuring was completed following the IMF recommendations to recover from economic crisis. During the crisis period, nominal exchange rates were unstable and fluctuating widely. Thus, we exclude this period from our analysis. The last period, starting October 1998 to the end of sample period, December 2003, is the post crisis free floating exchange rate regime (period 2). Korean exchange rates were allowed to move freely during this period with minimal market intervention.[2]

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[1] Calvo and Reinhart (2002) use the Australian dollar as a benchmark currency for the floating exchange rate regimes for small developing countries. Australia, with a credible commitment to floating, shares many characteristics of small developing countries, and the Australian dollar is not a world reserve currency. Calvo and Reinhart (2002) report that the probability the Australian dollar fluctuates within the prescribed 2.5% monthly band for a free floating regime is about 70% during the monthly period of January 1984 to November 1999. For U.S. dollar/ Deutsche mark, this probability is 59% and it is 61% for Japanese yen/U.S. dollar. The average of those countries declared as floating regimes in Calvo and Reinhart (2002) is over 79%.

[2] The definition of crisis period could be arbitrary. However, varying the crisis window did not qualitatively alter our results.

B. Exchange rates and economic fundamentals

First, we will examine the volatilities of two variables that are closely related to exchange rate regimes, the nominal exchange rate and foreign reserves. We compare the monthly rate of return volatilities measured as the standard deviation of the percentage change of the bilateral nominal exchange rates and foreign reserves ($\Delta s_t = s_t - s_{t-1}$, $\Delta r_t = r_t - r_{t-1}$), where s_t is the natural log of the nominal exchange rate S_t and r_t is the natural log of foreign reserves R_t. Table 1 compares the return volatilities of three exchange rates for two distinct periods, before the Korean economic crisis for the limited flexibility regime and after the economic crisis for the free floating regimes. Volatility is measured as the standard deviation of each variable. This table also provides test statistics to test the equality of the volatilities between two periods.

Table 1. Volatilities for nominal exchange rates and reserves for each period

	Limited flexibility regime, period 1 January 1980 – September 1997		Free floating regime, period 2 October 1998 – December 2003	
	Δs_t	Δr_t	Δs_t	Δr_t
Korea	0.869	7.505	2.629	1.663
Australia	2.854	9.477	3.204	7.334
Japan	3.387	3.459	3.481	2.442
	F-test statistics for $H_0 : \sigma_{i,1}^2 = \sigma_{i,2}^2$			
Korea	Δs_t	9.162 (0.000)	Δr_t	20.364 (0.000)
Australia	Δs_t	1.260 (0.308)	Δr_t	1.670 (0.011)
Japan	Δs_t	1.056 (0.830)	Δr_t	2.006 (0.001)

Note: Test statistics are for the null hypothesis that volatilities are the same between two periods; p-values are in parenthesis

Table 1 shows that the Korean won is much less volatile during the limited flexibility regime, and its volatility is much smaller than that of Australian dollar and Japanese yen. During the free float regime, the Korean won is still less volatile than those other exchange rates, but their difference is now statistically insignificant.[3] The Korean *won* fluctuates as freely as other floating exchange rate currencies after adopting the free floating regime in period 2. The Australian dollar and the Japanese yen show little change in volatility during these two periods even with the recent Asian economic crisis. Test statistics show little evidence of volatility changes of the two free floating currencies. The Korean *won*, on the other hand, shows strong evidence of volatility change during this period. Korean foreign reserve holdings are much more volatile under the limited flexibility regime than under the free floating period. This is expected since under limited flexibility reserves are often used to maintain stable nominal exchange rates (the interest rate is another policy tool to manage exchange rates). By comparing the reserve volatilities of two periods, we can observe that the reserve changes have become increasingly stabilized under the recent free floating exchange regime, especially for Korea.

Exchange rate volatilities can be best illustrated using the figures. To avoid cluttering the figures, Figure 1 plots the nominal exchange rate returns for two currencies, the Korean won (solid line) and the Japanese yen (broken line) against the U.S. dollar for the entire sample period. Australian dollar returns could also be plotted in the same figure, but this is not included in Figure 1 to simplify the presentation.

The Japanese yen is more volatile during period 1 when the Korean won was under a limited flexibility regime. During period 2 when the Korean won was freely floating, the two currency volatilities appear to be quite similar, and they are not statistically different.

Reserves are often used to control and manage nominal exchange rates under fixed and limited flexibility exchange rate regimes. Figure 2 plots the volatility of reserve changes for Korea (solid line) and Japan (broken line). It is clear that Korean reserves were much more volatile than those of Japan during the limited flexibility regime. Korean reserves are also more volatile under the limited flexibility regime than under the free floating regime. This presents the empirical evidence of exchange rate management schemes. While there are criticisms that Korean exchange rates are still managed and controlled during the free float period, reserve

[3] Levine's F-test statistic to test the equality of volatilities of three currencies is 1.410 with p-value of 0.247. Levine's test is based on the analysis of variance (ANOVA) of the absolute mean difference.

Figure 1. Monthly percentage changes of the Korean and Japanese nominal exchange rates per U.S. dollar

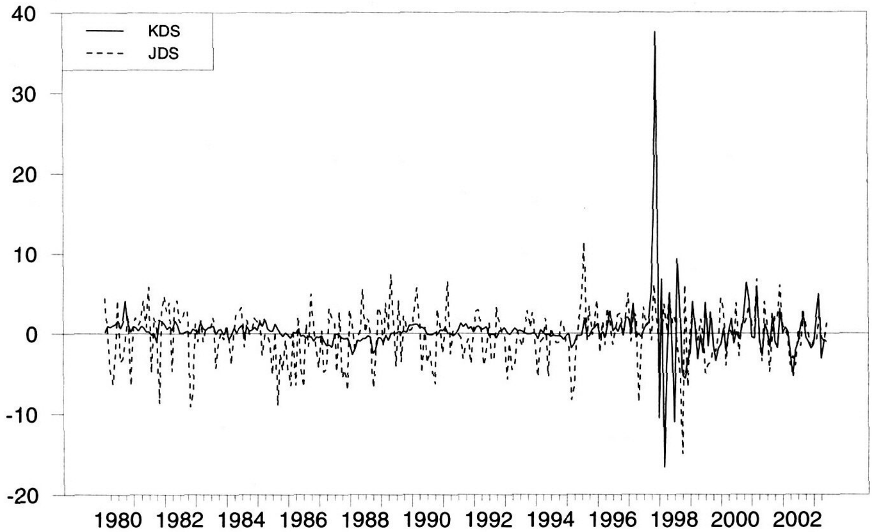
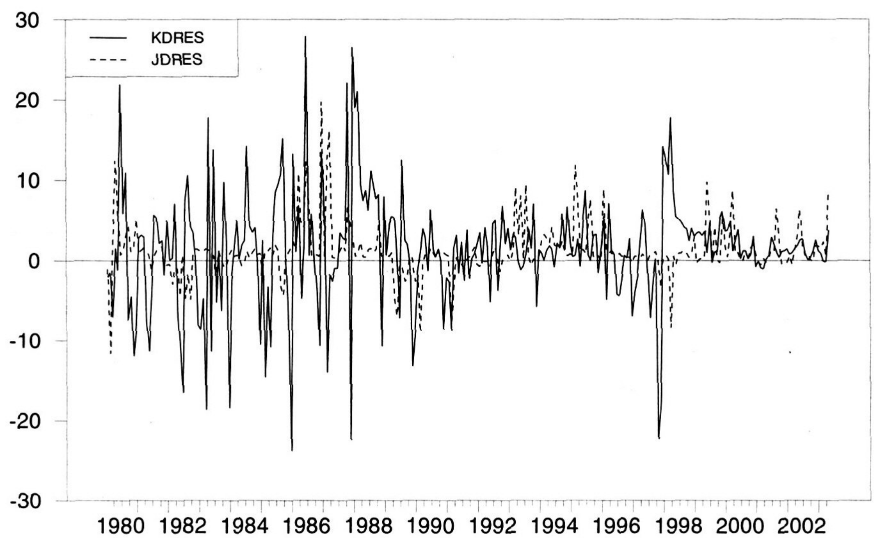


Figure 2. Monthly percentage changes of the reserves for Korea and Japan



volatility is relatively low. The recent volatility of the Korean nominal exchange rate exhibits characteristics similar to other free floating exchange rates. In fact, Korean reserves remain relatively stable and exchange rates are more volatile during the free floating period. Australia has relatively volatile reserve changes throughout the period. In fact, even with the free floating exchange rate regime, the probability reserve changes stay within the 2.5% band is only about 50% according to Calvo and Reinhart (2002).[4] Korean reserve levels were highly volatile during the limited flexibility regime, but her reserve volatility has decreased significantly under the free floating regime. Korean reserve volatility is even more stable than Japan's during period 2. From Table 1 statistics, we can see that reserve volatilities have fallen significantly in period 2 compared to period 1 for all three countries. Since Korea has changed her exchange regime from period 1 to period 2, the reserve volatility of Korea has been reduced dramatically.

Once we observed the visual pattern of exchange rates movements, we estimate equation (8) to examine the relationship between exchange rates and economic fundamentals. Exchange rates, like many other assets prices, often show the persistence of volatilities in their evolutions. Table 2 is a summary statistic for the ARCH residuals for the three currencies.

Table 2. Exchange rate behavior (Δs_t): ARCH(1) LM test

Country Period	Korea All	 Period 1	 Period 2	Australia All	Japan All
F-statistic	27.415	6.309	0.789	0.368	0.936
	(0.000)	(0.013)	(0.378)	(0.544)	(0.334)
Asymptotic χ^2	25.088	6.183	0.806	0.371	0.940
	(0.000)	(0.013)	(0.369)	(0.543)	(0.332)

Note: Null hypothesis is no ARCH residuals. ARCH(1) LM test is performed on the residuals of exchange rate changes fitted on the constant. Different lag lengths of ARCH model produce qualitatively similar results. p-values are in parenthesis.

The Korean won shows ARCH residuals for period 1 and for the entire period, while there is no evidence of ARCH residuals during free floating period 2. Even

[4] Japan has the highest probability of reserve changes within the 2.5% band, 74%, while the United States has a probability of 62%.

though the analysis periods exclude the crisis period, there are several episodes of ARCH residuals (persistent volatilities) under the limited flexibility regime during the late 1980s and the middle of 1990s leading to the economic crisis. The Australian dollar and Japanese yen do not show ARCH residuals either for the entire period or for two periods separately. It is interesting to observe that ARCH residuals appear only during the limited flexibility exchange rate regime.[5]

The following two figures, Figures 3 and 4, show that exchange rates are widely fluctuating around the deviations from economic fundamentals (z_t is standardized to have zero mean) for Korea and Japan, and it is not an easy task to predict exchange rates using economic fundamentals. The relationship between exchange rates and fundamentals for Australia show similar patterns to other countries, but it is not shown here to conserve space. Meese and Rogoff (1983) have shown that none of the theoretical exchange rate determination models outperform simple random walk model in the root mean square criteria. Our objective here is not to predict the exchange rate using the economic fundamentals, but to investigate the causal relationship between economic fundamentals and the nominal exchange rate focusing on the exchange rate regime shift of the Korean won, and to compare it to other flexible exchange rate regimes.

The basic econometric model to examine the relationship between exchange rates and economic fundamentals is equation (8) from the monetary model introduced in section II. Table 3 shows the OLS estimation results for three countries, using

$$\Delta s_{t+1} = \beta_0 + \beta_1 z_t + \varepsilon_t. \tag{9}$$

In Table 3 the Korean won shows ARCH(1) behavior, so in Table 4 we estimated equation (8) for Korea with a GARCH(1,1) model using

$$\Delta s_{t+1} = \beta_0 + \beta_1 z_t + \varepsilon_{t+1}, \tag{10}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 \sigma_{t-1}^2, \tag{11}$$

[5] Since the Japanese yen and Australian dollar, two free floating benchmark currencies, do not show the persistence of volatility during the sample period, the persistence of Korean *won* volatility during the limited flexibility regime may be attributed to a sub-optimal (relative to economic fundamentals) exchange rate policy.

Figure 3. Economic fundamentals and the nominal exchange rates for Korea

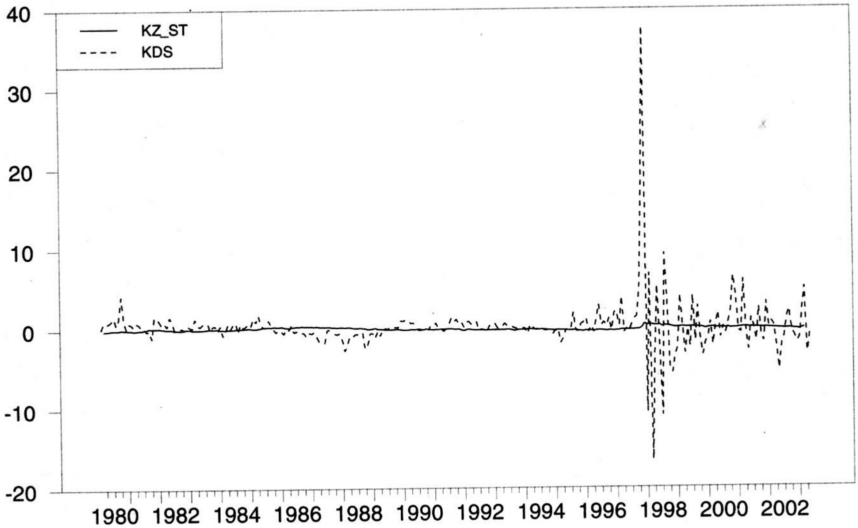
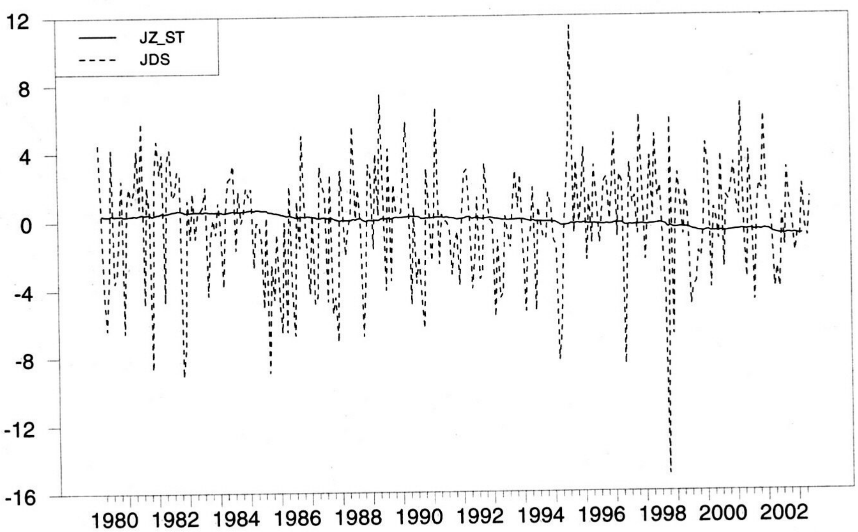


Figure 4. Economic fundamentals and the nominal exchange rates for Japan



where $\sigma_t^2 = Var(\varepsilon_{t+1}|\Omega_t)$ and Ω_t is an information set at time t.

OLS results show that the Korean won's fluctuation in response to the deviations from the economic fundamentals has increase from period 1 to period 2, but the difference is not statistically significant. This result is generally in line with Baxter and Stockman (1989) for the regime neutrality. However, by GARCH(1,1) estimation, it shows that exchange rate is more sensitive to the economic fundamentals, and the difference between two periods is statistically significant (-1.12 vs. -6.23). Since we have observed the ARCH(1) residuals from Table 2, GARCH estimation is more efficient than OLS results. Japan and Australia also show the increase of slope estimates between two periods, but their differences are not statistically significant either. While the difference of individual slope estimates is statistically insignificant, Chow test for the joint hypothesis of structural stability between two periods strongly rejected for all three countries.

Table 3. OLS estimation

		Korea	Australia	Japan
Period 1	β_0	7.637 (1.810)***	-4.825 (4.051)	20.309 (9.746)**
(210)	β_1	-1.215 (0.296)***	-0.674 (0.589)	-1.844 (0.870)**
	SSR	146.772	1706.178	2345.673
Period 2	β_0	37.326 (18.735)**	-12.802 (20.301)	55.649 (32.976)*
(55)	β_1	-6.215 (3.099)**	-1.604 (2.526)	-5.404 (3.189)*
	SSR	358.863	546.258	640.851
Both periods	β_0	8.882(2.911)***	-2.888 (2.272)	8.392 (5.376)
(265)	β_1	-1.438(0.477)***	-0.387 (0.318)	-0.790 (0.487)
	SSR	535.406	2258.068	3042.148
F-statistic		7.684 (0.001)	0.326 (0.722)	2.431 (0.090)

Note: Standard errors in parenthesis. *, **, *** indicate statistical significance at 10%, 5% and 1%, respectively. F-statistic tests the structural equivalence of the two periods, p-values are in parenthesis.

Table 4. GARCH(1,1) estimation for Korean *won*

	Period 1	Period 2	Both periods
β_0	7.109 (1.402)***	37.202(19.352)*	5.279 (1.314)***
β_0	-1.125 (0.229)***	-6.226 (2.194)*	-0.834 (0.215)***
α_0	0.124 (0.041)***	0.886 (0.357)**	0.085 (0.026)***
α_1	0.654 (0.152)***	-0.224 (0.083)***	0.923 (0.094)***
γ_1	0.341 (0.097)***	1.082 (0.102)***	0.400 (0.037)***

Note: Standard errors in parenthesis. *, **, *** indicate statistical significance at 10%, 5% and 1%, respectively.

C. Exchange rates and inflation

We are now ready to investigate the impact of exchange rate pass-through to domestic economic variables. From the purchasing power parity condition (PPP) of equation (3), there is a one-to-one relationship between the domestic inflation rate and the nominal exchange rate assuming constant foreign inflation. Therefore, we would like to see how the change of the nominal exchange rate affects domestic inflation rate. Our main focus is the effect of exchange rate regimes on the domestic inflation rate for the Korean economy. An important objective of a fixed exchange rate regime for a developing economy is to maintain stable price levels to help increase foreign trade trade. However, aggressive exchange rate defense may excessively drain foreign reserves, and it may bring further pressure for depreciation and domestic inflation. The vicious cycle may ultimately result in economic crisis. We will examine the macroeconomic relationship between inflation and the change of exchange rates since the 1990s. Figure 5 plots these two variables, inflation (solid line) and the return of the nominal exchange rate (broken line). Figure 6 is a scatter gram of these two variables for the two periods. The square symbol represents the limited flexibility exchange regime (1990:03-1997:09), while the triangle symbol represents the free floating regime (1998:10-2003:12).

Figure 5. Inflation and the changes of the Korean exchange rate

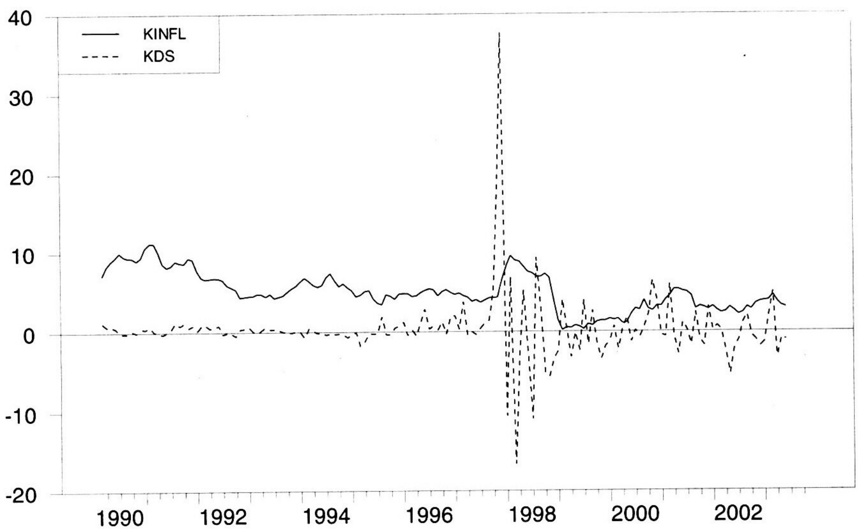
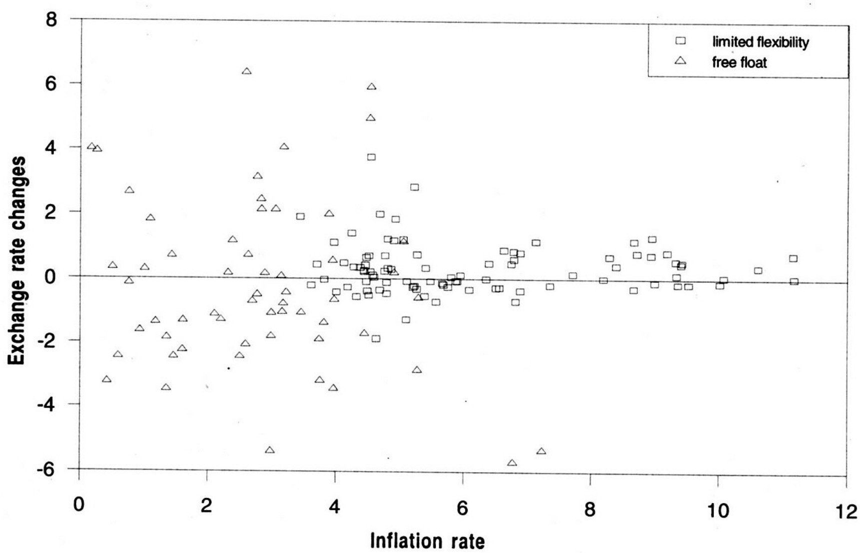


Figure 6. Scattergram of inflation and exchange rate changes



Exchange rates have become much more volatile while the inflation rate has become more stable under the free floating regime than under the limited flexibility regime. For the statistical regression analysis, I will limit my data to two distinctive periods of the exchange rate regimes, from March 1990 to September 1997 for the limited flexibility regime and from October 1998 to December 2003 for the free floating exchange rate.[6] Inflation and exchange rates are analyzed using a bivariate VAR model focusing on the purchasing power parity of equation (3). The additional exogenous variables are the percentage change of money supply (Δm_t), the real GDP growth rate ($\Delta rGDP_t$), and the Korean import price ($\Delta import\_pr_t$) as a proxy for the foreign prices.[7] Exogenous variables are included as one time-lagged values. The lag length for endogenous variables is two according to the Schwarz criteria. Other lag length selections were estimated also, but they did not change the qualitative relationship between these variables. The inflation rate

[6] The Korean won was pegged to the U.S. dollar until March 1990.

[7] The VAR model is estimated using monthly data. Since GDP data is available only on a quarterly frequency, real GDP is interpolated using quarterly nominal GDP and GDP deflators. All other variables, including the left-hand variables of inflation and exchange rate, are at monthly frequencies.

appears to show a strong time trend, but Dickey-Fuller tests with a time trend reject the unit root hypothesis for all periods. A bivariate VAR model may be too simple to analyze the complete exchange rate determination model introduced in section II, but the main objective of this analysis is to focus on the pass-through of the exchange rate to inflation contrasting two different exchange rate regimes. Therefore, the estimated bivariate VAR model is:

$$\Delta Y_t = B_0 + \Sigma_{j=1}^{2} B_j Y_{t-j} + \Gamma_j X_{t-1} + \varepsilon_t, \tag{12}$$

where $Y_t = (\Delta s_t, Infl_t)'$, $X_t = (\Delta m_t, \Delta rGDP_t, \Delta import\_pr_t)'$ and $\varepsilon_t = (\varepsilon_{1t}, \varepsilon l_{2t})'$ are uncorrelated white-noise random shocks. (B_0, B_j, Γ_j) are conformable parameters.

Equation (12) is estimated for the two periods separately, and both periods combined. The following table presents the estimation results.

Table 5.A shows that the exchange rate is largely unaffected by domestic inflation, but it is affected by money supply and real GDP growth in period 1. For period 2, money supply affects inflation significantly, but with the wrong sign. Table 5.B shows that the one period lagged exchange rate change has a significant impact on the domestic inflation rate for both periods, but money supply and real GDP growth do not appear to affect the inflation rate. Import price as a proxy for the foreign price is statistically significant under the free float regime, while insignificant under the limited flexibility regime.

The Granger causality test confirms the causal relationship between inflation and the exchange rate. Table 6 reports Granger causality test statistics with two lags for each period and the two periods combined. The exchange rate does cause inflation, but not vice versa. From the VAR estimates, we can infer that one percent depreciation of the one period lagged Korean won (Δs_{t-1}) increases the inflation rate 0.12% for the entire period. This could be a consequence of the small open economy which is heavily dependent on the intermediate goods imports to promote exports. Currency depreciation will boost exports, but it also causes worsening terms of trade, and higher import prices of intermediate goods trigger higher domestic inflation. It is evident that the export boosting policy during the limited flexibility exchange rate regime was pursued at the expense of domestic inflation. However, Table 5.B also shows that the impact of the exchange rate on inflation

Table 5. Bivariate VAR model

	Period 1	Period 2	Both periods
A. Exchange rate equation			
β_0	0.343 (0.288)	1.596 (1.104)	-0.017 (0.367)
$Infl_{t-1}$	0.038 (0.148)	-1.034 (0.756)	-0.001 (0.259)
$Infl_{t-2}$	-0.067 (0.148)	0.643 (0.619)	0.045 (0.254)
Δs_{t-1}	0.144 (0.103)	0.216 (0.144)	0.211 (0.087) **
Δs_{t-2}	0.179 (0.105) *	-0.104 (0.150)	-0.134 (0.088)
Δm_{t-1}	0.140 (0.056) **	-0.568 (0.298) *	-0.045 (0.107)
$\Delta rGDP_{t-1}$	-0.146 (0.070) **	0.145 (0.179)	-0.004 (0.094)
$\Delta import\_pr_{t-1}$	-0.022 (0.017)	0.032 (0.046)	-0.026 (0.019)
Adjusted R^2	0.167	0.037	0.029
B. Inflation equation			
β_0	0.364 (0.196) *	0.830 (0.245) ***	0.218 (0.115) *
$Infl_{t-1}$	1.309 (0.101) ***	0.894 (0.168) ***	1.281 (0.081) ***
$Infl_{t-2}$	- 0.361 (0.101) ***	- 0.150 (0.138)	- 0.329 (0.080) ***
Δs_{t-1}	0.118 (0.070) *	0.106 (0.032) ***	0.121 (0.027) ***
Δs_{t-2}	- 0.100 (0.071)	0.046 (0.033)	0.014 (0.027)
Δm_{t-1}	- 0.010 (0.038)	- 0.090 (0.066)	- 0.009 (0.033)
$\Delta rGDP_{t-1}$	- 0.023 (0.048)	- 0.008 (0.040)	- 0.021 (0.030)
$\Delta import\_pr_{t-1}$	- 0.015 (0.011)	0.020 (0.010) **	- 0.002 (0.006)
Adjusted R^2	0.940	0.883	0.952
D-F	-5.960 (0.000) ***	-3.625 (0.036) **	-3.839 (0.017) **

Note: Standard errors in parenthesis. *, **, *** indicate statistical significance at 10%, 5% and 1%, respectively. D-F is Dickey-Fuller statistics for the inflation rate. p-value is in parenthesis.

does not appear to be statistically different in the two periods. This result is in line with Baxter and Stockman (1989) that the exchange rate regime is largely neutral to macroeconomic variables.

Having established the causal relationship between the exchange rate and inflation, we would like to see the behavior of these variables in response to the external shocks. Figure 7 and 8 are impulse response functions (IRF) and accumulated response functions (ARF) for periods 1 and 2 using the Cholesky decomposition for two years (24 months). Since the Cholesky decomposition is

Table 6. Granger causality test statistics (F-statistics)

Null hypothesis	Period 1	Period 2	Both periods
Δs_t does not Grange cause $Infl_t$	2.537(0.085)	7.388(0.002)	11.704(0.000)
$Infl_t$ does not Grange cause Δs_t	0.226(0.799)	0.622(0.541)	0.156(0.856)

Note: Values in parenthesis are p-values for the F-statistic.

sensitive to the order of shocks to the VAR system, we produced two sets response functions by rotating shock orderings. However, different shock orderings produced remarkably similar responses to the point of being virtually identical. We only report the IRF and ARF of shock ordering of $(\Delta s_t, Infl_t)$.

Figures 7 and 8 are IRF (upper panel) and ARF (lower panel) for each period. The lower-left corner of IRF and ARF are responses of inflation to the one standard deviation shock of the nominal exchange rates. Under the limited flexibility regime (Figure 7), the impulse responses and accumulated responses are quite mild in magnitude, and they are statistically insignificant. Under the free-floating regime (Figure 8), the initial impact on inflation from the exchange rate shock is relatively large and statistically significant from two to five months. This shows that under the managed exchange rate regime, the exchange rate shock does not directly transmit to other macroeconomic variables, especially the inflation rate. Under the floating exchange rate regime, the nominal exchange rate depreciation directly passes through to the domestic price level. However, this difference is largely due to the different size of the shocks in the two periods.[8] Exchange rate shocks are much bigger under the free float regime than under limited flexibility. Under the limited flexibility regime, exchange rate policy effectively limited the size of the exchange rate shocks, and minimized the impact on domestic inflation. The accumulated impulses remain positive and statistically significant in the long-term under the free float regime.

The upper-right corner of IRF and ARF are the responses of the exchange rate to the shocks of inflation. As we demonstrated previously with VAR results and

[8] The upper-left corner graphs of IRFs from both figures show the size of the exchange rate shocks. Observe that two graphs show different scales reflecting the size of shocks for each period.

Figure 7. IRF and ARF (Period 1) to one standard deviations ± 2*(s.e.)

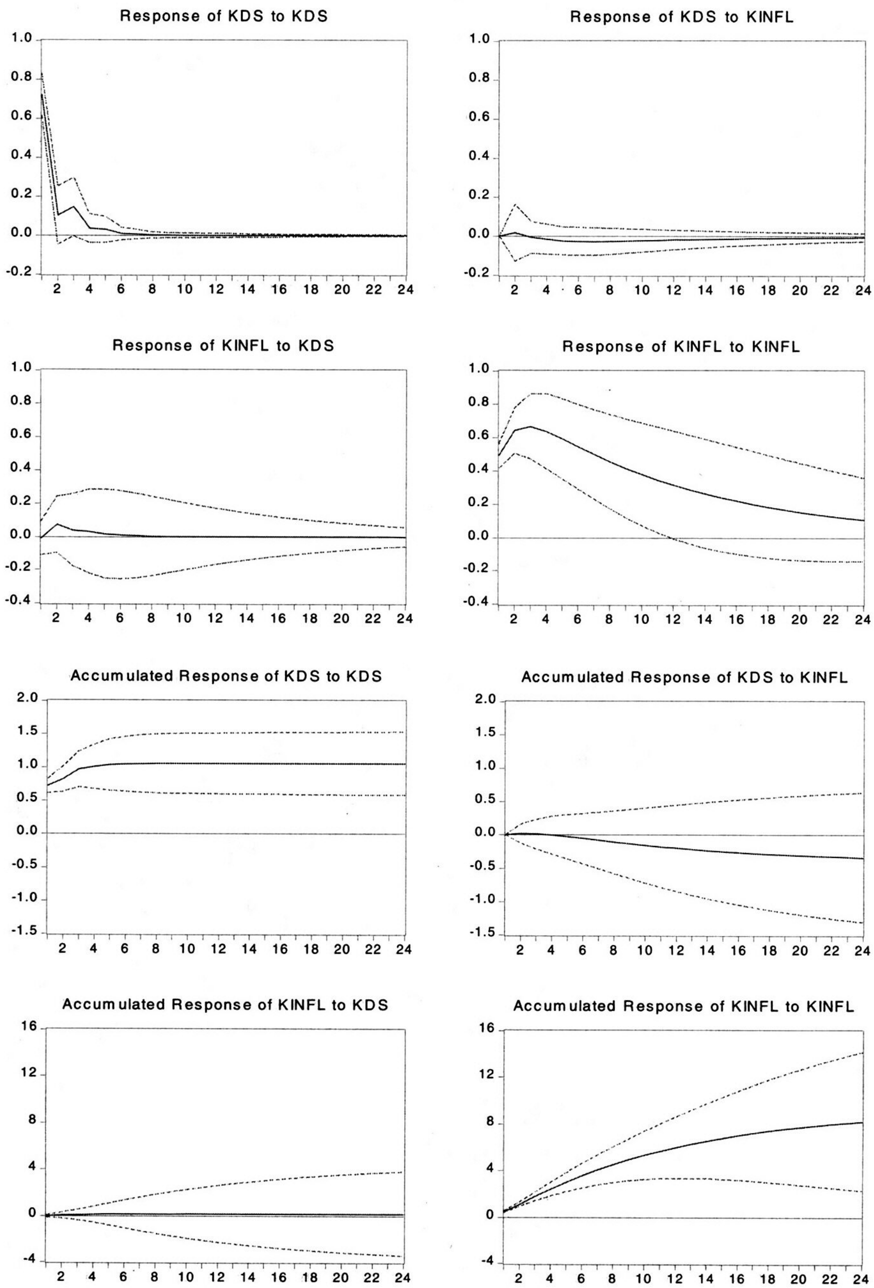
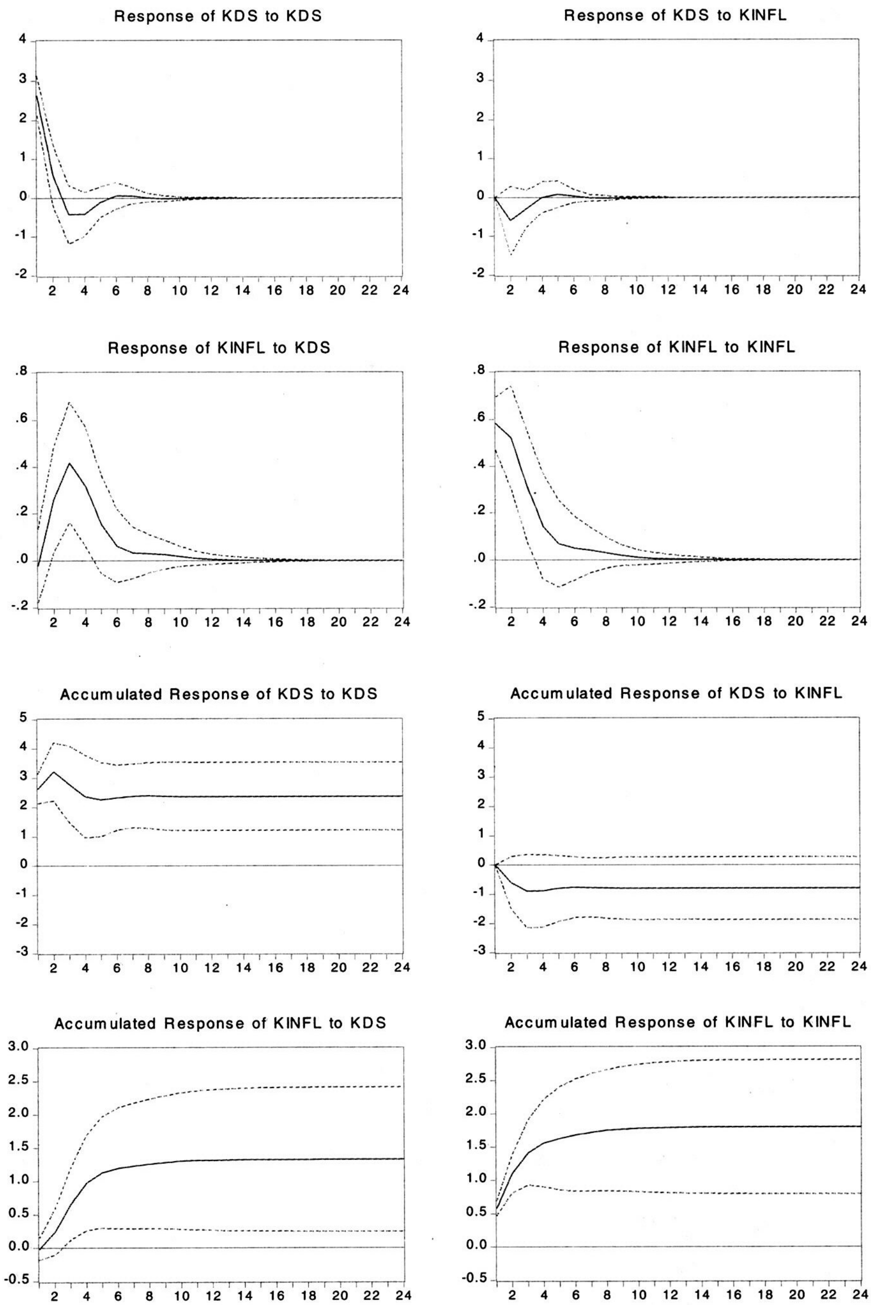


Figure 8. IRF and ARF (Period 2) to one standard deviations ± 2*(s.e.)



Granger causality tests, the impact of inflation shock on the exchange rates are statistically insignificant for both periods.

IV. Conclusion

This paper investigated the role of economic fundamentals in the determination of the exchange rate under different exchange rate regimes. Focusing on the Korean economy, this paper found that the impact of economic fundamentals on exchange rates has increased under the free float regime. However, the difference between the two periods is statistically significant only according to the GARCH(1,1) estimation, not to the OLS estimation. VAR estimation results show that the impact of exchange rates on domestic inflation is remarkably similar under the two different regimes. The major difference is that the size of exchange rate shocks has become much bigger under the free float regime. IRF and ARF show the lasting impact of the exchange rate shock on a domestic variable, the inflation rate. In short, under the free floating regime, exchange rates are allowed to move freely, thus reflecting the underlying economic fundamentals more accurately.

It is true that the exchange rate has become more volatile under the flexible exchange rate system than under the limited flexibility regime. To reduce short-run volatility of the flexible exchange rate system, the Korean government needs to pursue an exchange rate policy to reduce the short-run volatility of the flexible exchange rate system and promote stable economic growth.

It is still an open question regarding which exchange rate regime is better for economic growth in the long-run, especially for developing economies. My future research will expand the current topic to investigate the relationship between different exchange rate regimes and other macro economic performances, especially economic growth.

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