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Analysis of the Relationship between Saving and Investment in Korea: Influence of Foreign Exchange Crisis and Foreign Reserves*

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Feldstein and Horioka (1980) pointed out that even in the open economy; there is a high correlation between total saving and investment. This paper analyzes the relationship between saving and total investment from the first quarter of 1970 to the second quarter of 2018 in Korea. As a result of estimating the savings retention parameter, the correlation between total saving and total investment in Korea was high before the foreign exchange crisis but it was lowered after. The same conclusions were obtained when analyzed the correlation between investment rate and saving rate. The adjustment of foreign exchange reserves was not related to the fall in the savings retention parameter. The foreign exchange crisis has weakened the link between domestic savings and domestic investment, and securing foreign reserves is not the cause.

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1. INTRODUCTION

As for the relationship between savings and investment, many studies have emerged following Feldstein and Horioka (1980) which said that the savings retention coefficient of OECD countries is close to one. Many studies on this phenomenon, so-called Feldstein-Horioka puzzles, have been introduced in Apergis and Tsoumas (2009). According to the Solow growth model, investment is seen as the most fundamental determinant of economic growth. Based on data from 16 OECD countries, Kim (2005) analyzed whether international flows of capital are linked to improving national income. The relationship with savings as a determinant of investment is an important topic related to the economic growth. Hwang (2010) analyzed savings in Korea as an important determinant of economic growth as a determinant of investment. The reason for paying attention to the relationship between savings and investment is to understand the role of savings as a determinant of investment.

The relationship between savings and investment is related to the openness of financial markets, as Feldstein and Horioka (1980) have argued. Kim and Oh (1996) conclude that capital mobility is higher in developed countries after estimating the savings retention parameters of five developed countries and five Asian countries. In countries where international capital flows are free, domestic savings are only one of many factors that determine domestic investment. The relationship between the interest rate in the international financial market and the return rate of domestic investment, and the attitude toward risk in the financial market are more important variables than the savings as the factors that determine the investment. Therefore, estimates of savings retention parameter are likely to be low in countries with open financial markets.

The determinants of the saving retention parameter are not solely the openness of the financial markets. Krol (1996) argued that the saving retention parameter is estimated to be high due to the analytical techniques used. The nature of the panel data gathering the time series of the various countries influences the results of the analysis. As a result of the Fixed Effect analysis,

a lower saving retention parameter was estimated than that estimated by Feldstein and Horioka (1980). Ho (2002) estimates saving retention parameters by using FMOLS, DOLS, and other analytical techniques that take the non-stationarity of time series data into consideration. Similar to Krol (1996), Ho (2002) showed the lower estimates for the saving retention parameter than those of Feldstein and Horioka (1980). Corbin (2001) also found that the high saving retention parameter is due to the country specific effect. There are also studies that pay attention to the differences in the saving retention parameter by countries. Baxter and Crucini (1993) argued that the relationship between savings and investment is determined by the size of the national economy. Ho (2003) suggests that the larger the size of the national economy, the higher the correlation between savings and investment.

Based on previous studies, we can say that the correlation between saving and investment varies by countries and times. Cavallo and Pedemonte (2015) estimated saving retention parameters for Latin America and the Caribbean countries, and found that saving retention parameter are lowering over time and that larger countries are larger. In Jun and Song (2011), the convergence rate of savings and investment in Korea slowed after the foreign exchange crisis. In Jun (2012), the saving retention parameters of 28 Asian countries showed a decreasing tendency and structural changes at the Asian financial crisis. Jun (2010) argued that the fall in the saving retention parameter is related to the opening of the Asian financial market.

This paper analyzes the relationship between savings and investment in Korea through the saving retention parameter. Understanding the relationship between savings and investment is an important issue in economic growth. In previous studies (Baxter and Crucini, 1993; Corbin, 2001; Ho, 2003, etc.), the saving retention parameters differ widely among countries. In order to obtain policy implications for Korea's economic growth, there is a limit to applying the results of analyzing data from various countries. Therefore, this study analyzes only the data of Korea. In the study of estimates of saving retention parameter (Jun, 2010; Jun and Song, 2011; Jun, 2012, etc.), the saving retention parameters in Asia or Korea are reported to have structural changes

at the foreign exchange crisis. Therefore, this analysis also focuses on the change in the saving retention parameter after the foreign exchange crisis. In particular, we want to analyze whether the reason for the change in the saving retention parameter is due to the expansion of foreign reserves. Expansion of foreign reserves is an increase in overseas investment. The expansion of foreign reserves can reduce the saving retention parameter by directing domestic savings out of domestic investment.

As a result of the analysis, the saving retention parameter is lowered after the foreign exchange crisis, however the expansion of foreign reserves cannot be seen as a major cause. As in previous studies, the decline in Korea's saving retention parameter was observed at the foreign exchange crisis. The drop in the saving retention parameter was observed irrespective of the nature of the analysis method or data. Even when the net savings, which is total savings subtracted by increases of foreign reserves, were used in order to investigate the effect of the expansion of foreign reserves, the fall in saving retention parameter is still observed at the foreign exchange crisis.

Chapter 2 explains the data used and presents the trends of total savings, investments and foreign reserves. Chapter 3 reports the estimates of the saving retention parameter. We analyze whether the saving retention parameter changes at the foreign exchange crisis and analyze whether these changes in the saving retention parameter persists after adjusting the expansions of foreign reserves. Chapter 4 concludes.

2. DATA

All the data used in the analysis were obtained through the Economic Statistics System of the Bank of Korea. The sources and definitions for the variables used in the analysis are summarized in table 1. Total savings is the GDP minus the final consumption expenditure, including private consumption and government consumption. Total investment refers to the formation of total fixed capital in the data of the Bank of Korea. Both data are from the

Table 1 Definition and Source of Data in Analysis

Variables	Definition
sav	Total Savings (GDP-Private Consumption-Government Spending)
inv	Fixed Capital Formation
sav_reserve	Foreign Reserves Adjusted Total Savings
sav_rate	Total Savings / GDP
inv_rate	Fixed Capital Formation / GDP
sav_reserve_rate	sav_reserve/GDP

Notes: Data are seasonal adjusted. Unit is 1 billion won. Data are from 1970.1/4 to 2018.2/4 except *sav_reserve* and *sav_reserve_rate*. *save_reserve* and *save_reserve_rate* are from 1970.2/4 to 2018.2/4. Foreign reserve are in 1,000 dollar and are converted into KRW by quarterly average exchange rate.

Source: All data are from Bank of Korea (BOK) web site (http://ecos.bok.or.kr).

first quarter of 1970 to the second quarter of 2018. Seasonality may appear due to the nature of quarterly data. Therefore, we used seasonally adjusted data to rule out the effects of seasonality. We use foreign reserves to see how the expansion of foreign reserves affects savings and investment relationships. The foreign reserves provided by the Bank of Korea are in US dollars. However, the total savings and total investment included in the analysis are in Korean won. To consolidate monetary units, the net increase in foreign reserves was multiplied by the average exchange rate for that quarter. The reason for using the net increase of foreign reserves is that the total savings and the total investment are flow and foreign reserves are stocks, so the net increase of foreign reserve is used to make a flow variable. In order to analyze how the saving retention parameter changes due to foreign reserves, we subtracted the net increase in foreign reserves from savings. If foreign reserves increase, the domestic savings cannot be used for the domestic investment. Therefore, if the saving retention parameter changes due to foreign reserves, the estimates of saving retention parameter differ when we use the foreign reserve adjusted total savings.

The previous literature analyzing the relationship between savings and

Table 2 Descriptive Statistics of Variables

	sav	*Inv*	*sav_reserve*	*sav_rate*	*inv_rate*	*sav_reserve_rate*
Mean	47,627.15	43,711.78	46,546.25	0.3229	0.3243	0.3113
Median	33,210.60	32,499.80	34,645.04	0.3391	0.3217	0.3154
Std. Dev.	47,871.06	42,013.96	46,584.21	0.0624	0.0437	0.0677
Minimum	101.10	144.30	1.20	0.1355	0.2022	0.1395
Maximum	162,581.60	137,759.10	157,932.71	0.4284	0.4229	0.5275
N	194	194	189	194	194	189

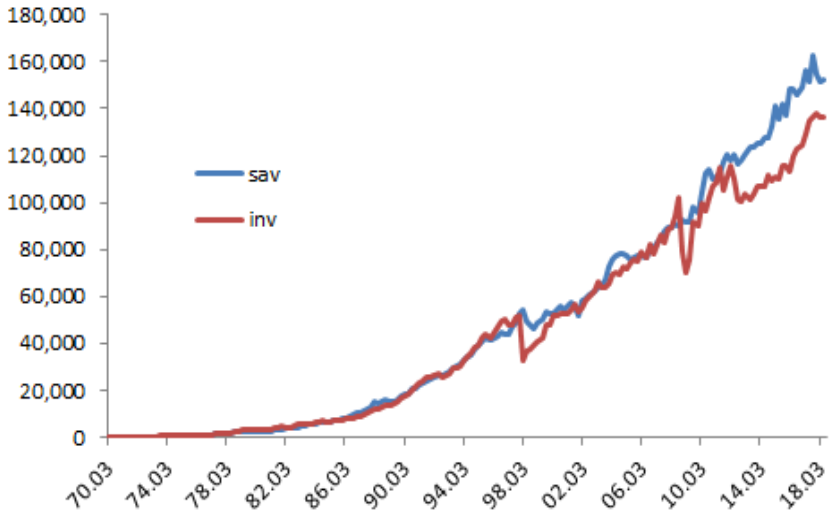
Note: Unit for *sav, inv sav_reserve* is 1 billion won.

investment mainly uses the savings rate and the investment rate to GDP. Therefore, in this study, we also use the savings rate, investment rate and foreign reserve adjusted savings rate to GDP. Foreign reserves data exist from the first quarter of 1971. Thus, the foreign reserve adjusted savings is available only from the second quarter of 1971.

Table 2 shows descriptive statistics for the data used in this analysis. The number of observations is 194 from the 1st quarter of 1970 to the 2nd quarter of 2018, but the number of observation is 189 for the saving rate and the foreign reserve adjusted saving rate which is from the 2nd quarter of 1971 to the 2nd quarter of 2018. The savings, investment and foreign reserve adjusted savings show very similar descriptive statistics. The mean of each variable is larger than the median, which means that the distribution has a long tail to the right. The variance is lowest in the investment and increases in order of foreign reserve adjusted savings and savings. But the differences are not great. By the descriptive statistics alone, we may say the relationship between foreign reserve adjusted savings and investment is tighter than that between savings and investment. This is because the means, variances, median, maximum and minimum values are more similar in the foreign reserve adjusted savings and investment than in savings and investment. However, the difference in the minimum value may be affected by the different observation periods of the data, the saving is from the 1st quarter of 1970, and the foreign reserve adjusted savings is from the 2nd quarter of 1971. In the

Figure 1 Savings and Investment

Unit: 1 billion won

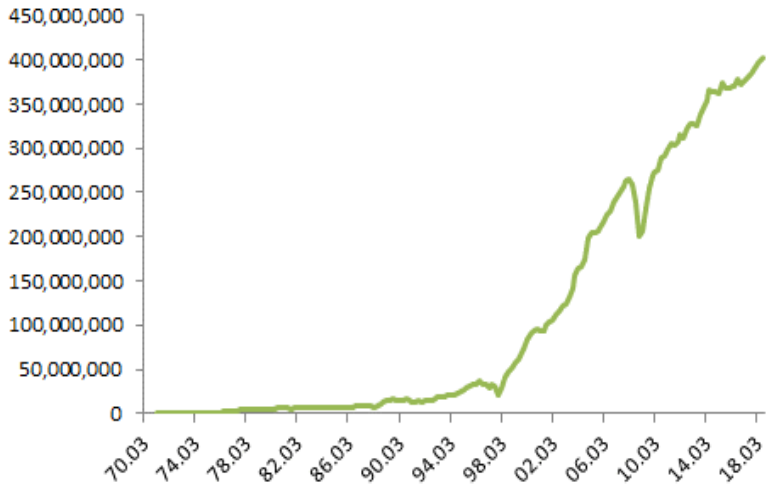


case of saving rate and investment rate, the descriptive statistics of saving rate and investment rate are more similar than those of foreign reserve adjusted saving rate and investment rate. The variance of foreign reserve adjusted saving rate is higher than that of the saving rate.

Figure 1 shows the trends in savings and investment. Up to the end of 1997, when the foreign exchange crisis broke out, there was little difference between savings and investment. After the outbreak of the foreign exchange crisis, the volatility of the investment has increased. The investment declines abruptly right after the outbreak of the foreign exchange crisis, but the total savings did not decrease as much. The same phenomenon was observed right after the global financial crisis. We also observed that the gap between saving and investment has increased after the global financial crisis. Previous studies have pointed out the misalignment of savings and investment in various countries. Cavallo and Pedemonte (2015) reports that the saving retention parameters of Latin America and the Caribbean countries are declining, and Song and Jun (2010), Jun (2011) and Jun (2012) report that there has been a

Figure 2 Foreign Reserve

Unit: 1 thousand USD



structural decrease in the saving retention parameters from the Asian financial crisis in Asian countries and Korea. As a result of observing the trends of saving and investment in Korea, we can see that the relationship between savings and investment is weakening over times as previous studies proclaim. In particular, the investment is less than the savings. Therefore, it can be guessed that some of the saving will not lead to domestic investment, which means that there is a leakage. By observing the trends of the savings and investment, we observed the weakening relationship between savings and investment over times because the savings does not lead to the investment.

Figure 2 shows the trend of foreign reserves in Korea. The foreign reserves of Korea did not accumulate significantly until the foreign exchange crisis. Up to the foreign exchange crisis, foreign reserves have increased at the much slower rate comparing the speed of foreign reserve increase after the crisis. Before the foreign exchange crisis, the most foreign reserves were $36.5 billion at the 2nd quarter of 1996. At the end of the 4th quarter of 1997 when the foreign exchange crisis broke out, foreign reserves were reduced to $20.4 billion. The government has adopted a free floating exchange rate system,

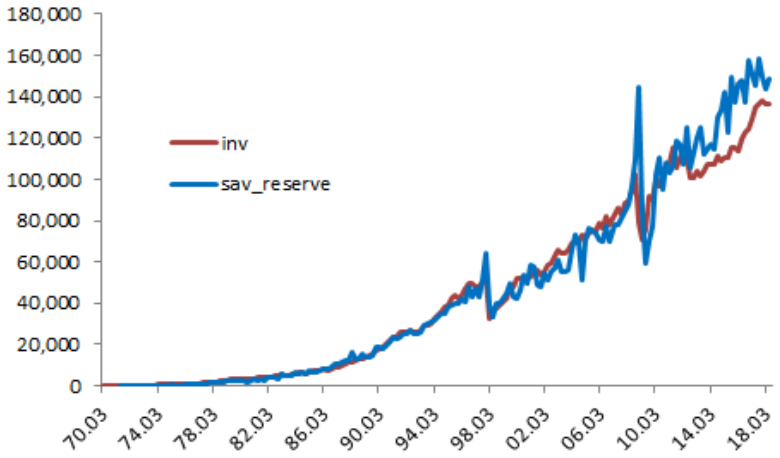
and has increased foreign reserves to prevent the recurrence of the foreign exchange crisis after the foreign exchange crisis. In the 1st quarter of 2008, foreign reserves amounted to $264.2 billion. Foreign reserves have been used to maintain the stability of the foreign exchange market during the global financial crisis. As the result, the foreign reserve has dropped to $201.2 billion at the 1st quarter of 2009. In spite of the fact that Korea's foreign reserves were sufficient compared to various standards, such as 3-month imports and total short-term debt, it was not enough to overcome liquidity concerns in the foreign exchange market during the global financial crisis. Therefore, the government and the central bank has increased the foreign reserve after the global financial crisis. At the 2nd quarter of 2018, foreign reserve has expanded to $403 billion. Before the global financial crisis, there were some concern to have too much foreign reserve, and there were the discussions on proper level of foreign reserves. However, the global financial crisis has shown that the Korean foreign exchange market is very vulnerable to external shocks. Therefore the government and the central bank has been accumulated a higher foreign currency reserves than the previously discussed appropriate level of foreign reserves.

The increase in foreign reserves is one reason why savings cannot be linked to investment. Foreign reserves consist of gold, special drawing rights from the IMF, and foreign bonds. Therefore, securing the assets for foreign reserves is to expand non-financial assets and/or purchase foreign financial assets. Therefore, assets that make up foreign reserves are not linked to domestic investment. Expanding foreign reserves can be one reason why savings leaking out of domestic investment. The purpose of foreign reserves is to protect the foreign exchange market from external shocks, but expansion of foreign exchange reserves causes domestic savings to flow abroad in turn hindering economic growth by reducing investment.

Figure 3 shows the foreign reserve adjusted savings and investment trends. The saving did not change much after the financial crisis and the global financial crisis in figure 1, but the foreign reserve adjusted savings fluctuated significantly right after the two crises. The changes in the foreign

Figure 3 Foreign Reserve Adjusted Saving and Investment

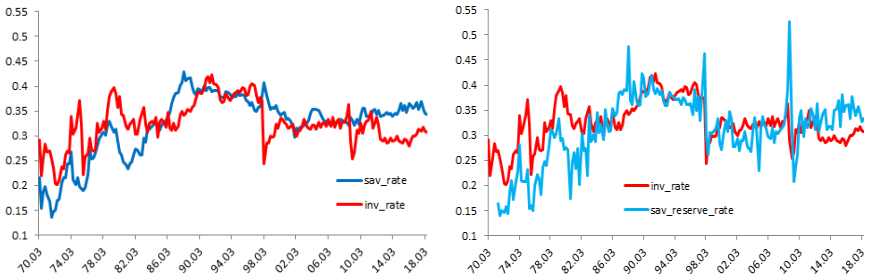
Unit: 1 billion won



reserve adjusted savings after the two crises are more consistent with changes in investment than those of savings. The investment has declined abruptly right after the crises, but the saving did not so. This can be explained to some degree by the expansion of foreign after the crises. On the other hand, the volatility of the foreign reserve adjusted savings is larger than that of investments, since the net increase in foreign reserves were huge right after the crises.

Figure 4 shows the trends in the saving rate and the investment rate and the foreign reserve adjusted saving rate to GDP. The saving and investment rates seem to be accompanied by a long-term trend, but we can observe many misalignments in a short-term. The saving and the investment in figure 1 and figure 3 moved very closely, and short-term fluctuations are emphasized by using the saving rate and investment rate because of the effect of eliminating trends when we are dividing saving and investment by GDP. Even with the saving rate and investment rate, we observed that the investment rates have fallen sharply right after two crises while the saving rates have not. On the other hand, the foreign reserve adjusted saving rates have fallen as the

Figure 4 Saving Rates and Investment Rate



investment rates have right after two crises. The saving rate fluctuated little after the global financial crisis, while the volatility of the foreign reserve adjusted saving rate seems to have increased after the global financial crisis.

We observed that the saving and foreign reserve adjusted saving move differently. Both the savings and the saving rates did not show a significant change after the two financial crises, while foreign reserve adjusted ones has fallen sharply when both crises broke out. It is possible that the relationship between saving and investment will change depending on the adjustment of foreign reserves. In the next chapter, we analyze whether the visual difference is confirmed through regression analysis.

3. REGRESSION RESULTS

In previous chapter, we observed the possibility that the relationship between the saving and the investment might be affected by the accumulation of foreign reserve. In order to verify this observation, we estimate the saving retention parameter in the following regression equation using OLS.

$$inv_t = \alpha + \beta sav_t + \varepsilon_t .$$

Table 3 Saving Retention Parameter's Estimates using OLS

Dependent Variable	*inv*	
Constant	2,228** (524.4)	3,695** (818.1)
sav	0.8710** (0.007776)	
sav_reserve		0.8845** (0.01244)
N	194	189
Adjusted R^2	0.9848	0.9641

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively.

β is the saving retention parameter in this regression equation. If we use *sav_reserve* instead of *sav*, we can get the saving retention parameter of foreign reserve adjusted saving.

Table 3 shows the estimates of the saving retention parameters using OLS. The saving retention parameter has been estimated assuming no structural breaks during the sample period. The estimate of saving retention parameter is 0.8710 without adjusting foreign reserve. This is large compared with previous literature's estimates. The estimate has increased to 0.8845 with foreign reserve adjustment. We can say that the foreign reserve adjustment makes the relation between saving and investment tighter. Even though we do not have the estimate of covariance of two saving retention parameters' estimates, the difference, 0.0135 might not be statistically significant conjectured by the estimates of standard errors of two estimates.

Table 3 does not allow any structural changes. Table 4 shows the estimates of saving retention parameters before and after the foreign exchange crisis. We set the pre-foreign exchange crisis from 1st quarter of 1970 to 3rd quarter of 1997 and rest periods are set to be post-foreign exchange crisis. As explained in 2nd chapter, the foreign reserve adjusted data only existed from 2nd quarter of 1971. Without foreign reserve adjustment, the estimates of saving retention parameter are 1.034 pre-crisis and 0.7956 post-crisis. To

Table 4 Saving Retention Parameter's Estimate before and after Foreign Exchange Crisis

Dependent Variable	*inv*			
	Before	After	Before	After
Constant	−168.5 (149.5)	9,907** (2229)	−81.46 (170.8)	2.058e+04** (2803)
Sav	1.034** (0.007970)	0.7956** (0.02211)		
sav_reserve			1.043** (0.009001)	0.7217** (0.02892)
N	111	83	106	83
Adjusted R^2	0.9935	0.9404	0.9922	0.8835

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively.

verify the statistical significance of a structural break, we did Chow-test and the F-test statistic is 28.26 which rejects the null hypothesis of there is no structural break. As we observed in figure 1, the regression estimates of saving retention parameters verify that the saving and investment relation in pre-crisis were tighter than that in post-crisis.

With the foreign reserve adjustment, the drop of saving retention parameters' estimates has been observed at the foreign exchange crisis. The visual observations of figure 1 and figure 3 has hinted us that the relationship between saving and investment is tighter with foreign reserve adjustment, but the estimates of saving retention parameters did not show that. The estimate of saving retention parameter in post-crisis with foreign reserve adjustment is lower than that without the adjustment. To verify the statistical significance of a structural break, we did Chow-test and the F-test statistic is 51.00 which rejects the null hypothesis of there is no structural break.

To sum up the results using OLS, the saving retention parameter has dropped after the foreign exchange crisis, which confirms the previous literatures' findings. The drop of saving retention parameter persists after the foreign reserve adjustment in savings. Therefore, we can conclude that the expansion of foreign reserves was not the reasons why the relations between saving and

Table 5 Non-stationarity Tests for Savings and Investment

Methods		*inv*	*sav*	*sav_reserve*
ADF	Test stat.	−1.55333	−0.710064	−0.154964
	P-value	0.8111	0.9716	0.994
KPSS	Test stat.	0.86766	0.917607	0.835427
	Critical value (5%)	0.148	0.148	0.148

Notes: Models include constant and time trend. ADF (augmented Dickey-Fuller)'s null hypothesis is "Unit root exists". KPSS's null hypothesis is "Unit root does not exist".

investments have been weakened.

The OLS regression show very high R^2. Therefore, we logically doubt that the data in analysis are non-stationary time series. If the saving and investment series are non-stationary the estimates of standard error of saving retention parameter does not converge to population standard deviations but to 0. We call this 'spurious regression'. To verify if the regressions suffer from 'spurious regression' problem, we test the non-stationarity of data. The non-stationarity test (unit-root test) reports in table 5. The ADF test does not reject the null hypothesis that the saving and the investment are non-stationary series. And the KPSS test rejects the null hypothesis that there is no unit-root (stationary series). Then, the estimates of standard errors in OLS regression converge to 0 and reports spuriously high significance of the saving retention parameters.

We can estimate the saving retention parameters using error correction model when the variables are non-stationary. The following vector regression equation can be used for estimating the error correction term.

$$\Delta Y_t = \rho\delta' Y_{t-1} + \sum_{i=1}^{p-1} A_i \Delta Y_{t-i} + \varepsilon_t .$$

$Y_t = \begin{pmatrix} inv_t \\ sav_t \end{pmatrix}$ or $Y_t = \begin{pmatrix} inv_t \\ sav\_reserve_t \end{pmatrix}$ in the above vector regression equation. We call δ error correction term. The error correction term

Table 6 Saving Retention Parameters' Estimates Via Error Correction Term.

Normalizing coefficient of *inv* as 1		
sav	0.78395** (0.035750)	
sav_reserve		0.91050** (0.031728)

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively. Estimates are from the error correction term of VECM(vector error correction model).

represents a linear combination of two non-stationary series in vector Y_t which makes a stationary series. We may say that this linear relation is a long-term relation of these two series. We can get the estimate of saving retention parameter by the estimated coefficient of sav_t or $sav\_reserve_t$ after normalizing the coefficient of inv_t to be 1. Table 6 and table 7 represents the estimates of saving retention parameters using error correction term.

The results in table 6 can be compared with those in table 3. The standard errors in table 6 are bigger than those in table 3. The standard errors estimates in OLS analysis are converging to 0 when data are non-stationary so they are smaller than estimates in error correction term. The estimates of saving retention parameters in table 6 show little differences with those in table 3. The saving retention parameter's estimate with foreign reserve adjusted savings is bigger than that without adjustment. However, we cannot test the statistical significance of this difference.

Table 7 presents the estimates of saving retention parameter using error correction term before and after the foreign exchange crisis. The saving retention parameters have decreased after the foreign exchange crisis as we already have seen in OLS analysis. The difference of saving retention parameters before and after the foreign exchange crisis is bigger than that in table 4 using OLS analysis. The drop of saving retention parameters persists after adjusting saving with foreign reserve, moreover the difference is bigger with foreign reserve adjusted saving.

Table 7 Saving Retention Parameters' Estimates Via Error Correction Term Before and After Foreign Exchange Crisis

Normalizing coefficient of *inv* as 1				
	Before	After	Before	After
sav	1.2509** (0.038747)	0.80425** (0.061716)		
sav_reserve			1.2682** (0.032925)	0.79514** (0.054814)

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively. Estimates are from the error correction term of VECM(vector error correction model).

Table 8 Saving Retention Parameter's Estimates Using OLS with Saving Rate and Investment Rate

Dependent Variable	*inv_rate*	
Constant	0.1903** (0.01340)	0.2065** (0.01176)
sav_rate	0.4152** (0.04076)	
sav_reserve_rate		0.3837** (0.03693)
N	194	189
Adjusted R^2	0.3475	0.3626

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively.

The analysis considering non-stationarity in data leads the same conclusion with the OLS estimation. Two analyses confirm that the saving retention parameters have fallen after the foreign exchange crisis. And the expanding foreign reserve is not a cause of this decrease of the saving retention parameter.

Table 8 presents the estimates of the saving retention parameter using saving ratio and investment ratio to GDP (saving rate, investment rate respectively hereafter). As seen in figure 4, the correlation between saving rate and investment rate is lower than that of saving and investment. This visual observation has confirmed by OLS analysis. I.e., the estimate of saving

Table 9 Saving Retention Parameter's Estimates Before and After Foreign Exchange Crisis with Saving Rates and Investment Rate

Dependent Variable	*inv_rate*			
	Before	After	Before	After
Constant	0.1689** (0.01253)	0.4411** (0.04472)	0.1866** (0.01207)	0.2972** (0.01735)
sav_rate	0.5368** (0.03943)	−0.3796** (0.1303)		
sav_reserve_rate			0.4968** (0.03836)	0.04307 (0.05365)
N	111	83	106	83
Adjusted R^2	0.6262	0.0836	0.6136	−0.0044

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively.

retention parameter is 0.4 which is lower than 0.88 in table 3. The saving retention parameters did not decrease with foreign reserve adjustment. So we can conclude that the expansion of foreign reserve does not affect the relation between saving rate and investment rate.

Table 9 presents the estimates of saving retention parameter before and after the foreign exchange crisis with saving rate and investment rate. The saving retention parameter is positive before the crisis and negative after without foreign reserve adjustment. This means that the increase of saving is leading the decrease of investment after the foreign exchange crisis. We can conjecture the reason why there is negative relation between saving and investment by observing figure 4. There are drops in investment after the foreign exchange crisis and global financial crisis but the savings persist or increase. After adjusting foreign reserve, the saving retention parameter is positive before the foreign exchange crisis and is not statistically different from 0 after.

In sum, the OLS results with saving rate and investment rate support the drop of saving retention parameter after the foreign exchange crisis. After the crisis, the saving and the investment move opposite directions after the

Table 10 Non-stationarity Tests for Saving Rates and Investment Rate

Methods		*inv_rate*	*sav_rate*	*sav_reserve_rate*
ADF	Test stat.	−3.66322	−1.9781	−2.99819
	P-value	0.005396	0.2964	0.03508
KPSS	Test stat.	0.576237	1.7948	1.31344
	Critical value (5%)	0.462	0.462	0.462

Notes: Models include constant and time trend. ADF (augmented Dickey-Fuller)'s null hypothesis is "Unit root exists". KPSS's null hypothesis is "Unit root does not exist".

Table 11 Non-stationarity Tests for Saving Rates and Investment Rate Before and After the Foreign Exchange Crisis

Methods		*inv_rate*		*sav_rate*		*sav_reserve_rate*	
		Before	After	Before	After	Before	After
ADF	Test stat.	−2.3141	−5.6540	−2.0609	−2.8198	−1.5549	−5.9403
	P-value	0.1694	0	0.2609	0.0598	0.5058	0
KPSS	Test stat.	1.6389	0.4123	1.9425	0.3450	1.8900	0.7020
	Critical value (5%)	0.462		0.462		0.462	

Notes: Models include constant and time trend. ADF (augmented Dickey-Fuller)'s null hypothesis is "Unit root exists". KPSS's null hypothesis is "Unit root does not exist".

crisis when we did not adjust saving rate with foreign reserve. With foreign reserve adjustment, the saving retention parameter is not statistically different from 0 after the crisis.

As previously explained, the standard errors of estimates will be affected by whether the data are stationary or not. Table 10 and table 11 present the test results of the data's stationarity. In table 10, there are the stationarity test results for the whole sample period. The ADF test rejects the null hypothesis that the foreign reserve adjusted saving rate and investment rate are non-stationary, while the KPSS test rejects the null hypothesis that all series are stationary.

Figure 4 shows that the volatility of the saving rates and the investment rate might differ from the foreign exchange crisis. In order to test whether the

non-stationarity tests in table 10 is affected by this visual observation; we perform the non-stationarity test before and after the crisis and report the results in table 11. Before the crisis, we could not reject that all three variables were non-stationary time series according to two test methods. However, after the crisis, it is difficult to argue that the three variables are non-stationary time series. The ADF test rejects the non-stationarity of investment rate while the KPSS rejects the stationarity of investment rate. The ADF test rejects the non-stationarity of saving rate at 5% significance level but does not at 10% significance level (*P*-value is 0.0598) and the KPSS test does not reject a stationarity of the saving rate. The ADF test rejects the non-stationarity of the foreign reserve adjusted saving rate, while the KPSS test reject the stationarity of it. As a result of tests, it can be assumed that all variables used in the analysis before the financial crisis are non-stationary, but we are not sure about the non-stationarity of them after the foreign exchange crisis. The non-stationarity tests results are consistent with the fact that R^2 is not close to 1 in the OLS results in table 8 and table 9, unlike the OLS results of saving and investment in table 3 and table 4. Because if all variables were non-stationary time series, R^2 would be close to 1 by the spurious regression.

Table 12 and table 13 present the estimates of saving retention parameter assuming the saving rates and investment rate are non-stationary. Table 12's estimate of saving retention parameter is 0.44 which is similar with the OLS

Table 12 Saving Retention Parameters' Estimates Via Error Correction Term with Saving Rates and Investment Rate

Normalizing coefficient of *inv_rate* as 1		
sav_rate	0.44119** (0.13445)	
sav_reserve_rate		0.12823 (0.15816)

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively. Estimates are from the error correction term of VECM (vector error correction model).

Table 13 Saving Retention Parameters' Estimates Via Error Correction Term with Saving Rates and Investment Rate Before and After the Foreign Exchange Crisis

Normalizing coefficient of *inv_rate* as 1				
	Before	After	Before	After
sav_rate	0.54988** (0.068269)	−0.44067* (0.23389)		
sav_reserve_rate			0.40230** (0.066972)	−0.60076** (0.14661)

Notes: Standard errors in parentheses. *, ** show significant estimates at 10%, 5% significance levels, respectively. Estimates are from the error correction term of VECM (vector error correction model).

estimate (0.42). The foreign reserve adjusted saving rate and investments rate does not have long-run relationship. In other words, they are not co-integrated. The foreign reserve adjusted saving rate can be a stationary time series according to ADF test. Therefore, we should be careful to interpret the estimates from error correction term as the saving retention parameter. If the investment rate is not non-stationary time series, the estimate from error correction term does not have any meaning.

Table 13 reports the estimates of saving retention parameter using error correction term before and after the foreign exchange crisis. Before the crisis, the saving retention parameter is estimated 0.55 without adjusting foreign reserve and 0.40 with adjustment. The adjustment of foreign reserve does not raise the estimate of saving retention parameter. We can conclude that the expansion of foreign reserve does not weaken the relation between saving and investment. Meanwhile we should be careful to interpret the results after the crisis, because the data in this analysis could be stationary after the crisis.

As we see the test result in table 11, if the data is non-stationary before the foreign exchange crisis and stationary after the crisis, the proper estimates for the saving retention parameter are ones using the error correction term as in table 13 for the pre-crisis and ones using OLS as in table 9 for post-crisis.

In sum the saving retention parameter has decreased after the foreign exchange crisis, the expansion of foreign reserve does not explain the decrease

of saving retention parameter. This result is supported regardless of selection of data or methods.

4. CONCLUSION

The relationship between saving and investment in Korea is analyzed through saving retention parameter. In the study of estimates of savings retention parameter (Jun and Song, 2011; Jun, 2010; Jun, 2012, etc.), the saving retention parameter in Asia or Korea are reported to have structural changes starting from the Asian financial crisis (which is foreign exchange crisis for Korea). As a result of the analysis, it was confirmed that the saving retention parameter of Korea declined after the foreign exchange crisis. Even when the analytical method considering the non-stationarity of the data is applied, we can observe the decline of saving retention parameter from the financial crisis. The fall in the saving retention parameter was also found in the analysis using the foreign reserve adjusted saving or saving rate. Therefore, the decline in the saving retention parameter from the foreign exchange crisis seems not to be due to expansion of foreign exchange reserves.

The analysis suggests that the opening of the financial market, which has been undergoing the foreign exchange crisis, has weakened the link between saving and investment, as claimed by Jun (2010). The crowding-out effect of the expansion foreign reserve from saving to investment seems not to be significant. Households might save more in order to absorb the persistent income shocks then the linkage between saving and investment would weaken. Another possibility is that the productivity shocks become less persistent so saving and investment do not move together as much. Therefore, it would be more desirable to attract foreign investment or provide policy support to investment drivers rather than to encourage saving in order to promote economic growth at this moment.

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