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THE MEASUREMENT OF INTERNATIONAL CAPITAL MOBILITY BY USING ERROR CORRECTION MODEL IN KOREA

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This study aims at measuring the international capital mobility in Korea, taking into consideration short run and long run relationship between savings and investment. Whereas the long run relationship between saving and investment implies intertemporal budget constraint, short run relationship may measure the degree of international capital mobility. Many other specification equations which have been used to gauge correlation of investment and saving, are one of constrained error correction model. The result of estimation by using error correction model shows that the traditional equations estimated by many other authors have specification error and there doesn't exist Feldstein and Horioka's puzzle and international capital mobility has increased rapidly since 1980s in Korea.

JEL Classification: E0, F2, C1
Keywords: Capital Mobility, Error Correction Model

I. INTRODUCTION

The degree of capital mobility is an important topic to international economists and policy makers. Capital mobility enhances the efficiency of the resource allocation which leads to positive growth. When capital is mobile, the ability to smooth consumption against temporary shock can be enhanced through external borrowing and lending. But side effects of capital mobility cannot be neglected. When capital is mobile, the speculative capital movement could exert serious negative influences on the economy.

There are two well known principal methods to measure the international

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capital mobility. One is to compare the rates of return on capital across countries. When capital is fully mobile, capital moves to the countries with higher rate of return, which leads to the equalization of rates of return. The equilibrium condition under which rates of return on capital are equalized is called interest parity condition. The other is to look at actual international capital flows. The latter approach is to examine the relationship between investment and saving, which was initiated by the Feldstein and Horioka(1980). I will adopt this method and discuss the degree of international capital mobility based on relationship between investment and savings.

The effect of international capital mobility on the relationship between saving and investment has been subject to considerable debates. Feldstein and Horioka(1980) stated that in the world of perfect capital mobility, there should be no relationship between saving and investment. Average investment was regressed on average saving across the countries. It was found that saving and investment are highly correlated in OECD countries. Furthermore the correlation between saving and investment didn't decline over time. It was interpreted that such a high correlation between saving and investment means no capital mobility. Subsequent empirical works have confirmed Feldstein and Horioka's finding.[1)]

The interpretation of high correlation between saving and investment as low capital mobility has been challenged by many authors. The research on the explanation of high correlation between saving and investment proceeds in the following two ways. Some authors set up the model in which they show that investment is highly correlated with savings even though capital is perfectly mobile. Saving and investment are correlated because of the nature of the disturbances affecting the economy. Obstfeld(1986) shows that a positive domestic productivity shock will increase investment and saving, even though capital is perfectly mobile. A persistent productivity shock would raise saving as the wage are temporarily high, and also increase investment because capital is more productive. Therefore the economies with productivity shock will exhibit a positive relationship between saving and investment. Some other models with nontraded goods and immobile factors predict that domestic investments are limited by domestic savings even when capital is mobile. Tesar(1990) incorporates the nontradable investment goods in the infinite horizon model. She shows that both demand shock and supply shock in nontradable goods lead to the comovement of investment and saving. Thus the high correlation of saving and investment does not provide the evidence of low capital mobility. Some other authors have pointed out that government targets the current account through various policy measures.[2)] The current account can be expressed as national saving minus national investment. If the government is to manage the

[1] Refer to the survey paper by Tesar(1991).

[2] The examples are Summers(1985) and Bayoumi(1990).

current account balance at some target level, the net change in the private saving and investment is matched by offsetting change in government saving, which leads to high correlation of investment and saving.

Recent empirical researchers have used cointegration techniques to measure international capital mobility using the Feldstein and Horioka method. Many researches study the relationship between saving and investment using cointegration analysis. The cointegration of the saving and investment implies long run relationship between savings and investment, which means domestic investment is restricted to domestic savings and the vice versa is also true. If savings and investment are not cointegrated, investment is not restricted to savings and savings is not restricted to domestic investment. Therefore, according to Feldstein and Horioka's interpretation, long run relationship between savings and investment means capital immobility and no existence of long run relationship means capital mobility. Miller(1988), Leachman(1991), de Haan and Siermann(1994), Argimon and Roldan(1994), Lemmen and Eijffinger(1995), and Kim and Oh(1996) investigated cointegration of saving and investment based on this interpretation.

Some authors argue that the existence of the cointegration of savings and investment is due to solvency constraint, not to capital immobility.[3] The current account which is equal to saving minus investment, should be in equilibrium in the long run due to intertemporal budget constraint. The very fact that the current account is in equilibrium in the long run implies that the current account is stationary and also savings and investment are cointegrated. Therefore the cointegration of saving and investment reflects solvency restriction, not the capital mobility. This paper investigates international capital mobility using the relationship between savings and investment in Korea, taking into consideration the long run equality of the investment and saving as in Jansen and Schulze(1996) and Taylor(1996). The paper is ordered as follows. Section II explains the error correction model which incorporates the short run as well as long run relationship between saving and investment. Also a comparison will be made with other specification equations. The empirical work on Korean international capital mobility will be done in section III. In section IV, a conclusion will be made

II. THE MODEL

In an infinitely-lived representative agent model(Blanchard and Fisher(1989)), the agent maximizes the life time utility subject to intertemporal budget constraint. Capital is perfectly mobile. Agents use international capital market to smooth consumption. In the steady state in which the current account is

[3] Talor(1996), Jansen and Schulze (1996) Coakley and Kulasi and Smith(1996), Coakley and Kulasi(1997) are suggested.

constant, saving and investment have one to one relationship. The equality of investment and saving implies that sustained current account surplus and deficit are ruled out.

However in the short run, a shock to the economy may push the economy out of the steady state and cause saving and investment to diverge temporarily from the steady state value. Investment boom in the short run produces the current account deficit as investment is financed by foreign capital to smooth consumption. That is, when capital is mobile, investment can increase without an increase in saving in the short run. When capital is perfectly immobile, an increase in investment can be realized only by an increase in saving since financing from international financial market is ruled out. Therefore the short run relationship between saving and investment can be used to measure the degree of international capital mobility.

Jansen and Schulze(1996) notes that imperfect capital mobility is a sufficient, not a necessary condition for high positive correlation. Even though correlation of saving and investment is high, it cannot be concluded that it is due to low capital mobility without additional information. On the other hand, very low saving and investment correlation could be generated only when capital is highly mobile.

It is desirable to consider both the long run and short run relationship between investment and saving. It is well known that error correction models incorporate both the long run and short run movement of the variables. Therefore an error correction model is a good candidate for measuring capital mobility.

Engle and Granger(1987) shows that when nonstationary variables are cointegrated, an error correction representation exists. The two step procedure reveals error correction model. First a cointegration regression equation is set up and estimated. Here the concerned cointegration equation is specified as equation (1) which exhibits the relationship between investment and saving as follows:

$$(I/Y)_t = a + b(S/Y)_t + \varepsilon_t \tag{1}$$

The simplest error correction model is the first order error correction model as in equation (2) where $[(I/Y)_{t-1} - a - b(S/Y)_{t-1}]$ is the error correction term which is equal to the residual of estimated equation (1).

$$\triangle(I/Y)_t = a + \beta\triangle(S/Y)_t + \gamma[(I/Y)_{t-1} - a - b(S/Y)_{t-1}] + \eta_t \tag{2}$$

Equation (2) can be rewritten as equation (3) which incorporates the gap between saving and investment explicitly:

$$\triangle(I/Y)_t = a + \beta\triangle(S/Y)_t + \gamma(S/Y - I/Y)_{t-1} + \delta(S/Y)_{t-1} + \varepsilon_t \tag{3}$$

Jansen and Schulze(1996) and Taylor(1996) estimated the relationship between saving and investment using equation (3). Equation (3) is very convenient for this study as it can implement a well specified test of saving and investment correlation.

First, consider the long run equilibrium relationship between saving and investment. In the steady state, $\Delta(I/Y)_t = \Delta(S/Y)_t = 0$. The implied long run relationship is given by $\alpha + \gamma((S/Y)^* - (I/Y)^*) + \delta(S/Y)^* = 0$. (* denotes the long run steady state values.) Parameter restrictions may be used to test various hypotheses regarding the long run relationship. If $\delta = 0$, the long run current account which is defined by the gap between saving and investment, equals a constant. Furthermore when both the constant and coefficient of savings rate are zero, current account is in equilibrium. In both case, in the long run, one-to-one relationship between savings and investment is compatible with the perfect capital mobility.

Given the long run relationship between saving and investment, the coefficient β measures the short run response of the investment to shocks to savings. If the coefficient β is close to 1, the short run shock to savings passes to the investment fully. In contrast, the coefficient β is close to 0, the short run shock to savings doesn't pass to investment. In this case the investment can be financed from international financial market. Therefore the coefficient β can be interpreted as the degree of international capital mobility which is called the short run saving retention coefficient.

The coefficient γ measures the speed of a convergence of the system to the long run equilibrium. Also, the coefficient γ is used for the cointegration. When γ is significantly different from zero, the concerned variables are cointegrated. In contrast when γ equals zero, the variables are not cointegrated as there is no moving force toward the long run equilibrium. Whether the variables are cointegrated can be tested by checking the zero or non zero of γ.

A lot of empirical researches have been done with respect to the saving and investment relationship. The original study regarding saving and investment relationship by Feldstein and Horioka(1980) was based on the above equation(1). Since the equation(1) ignores the dynamic adjustment process, it cannot adequately capture the saving and investment dynamics. The equation(1) assumes no cointegration of the saving and investment and also correspond to the restraint of $\beta - \delta = 1$ and $\gamma = 1$ of the equation(3).

Feldstein(1983), Feldstein and Bacchetta(1991), and Bayoumi(1990) estimate the saving and investment relationship in first differences. Their specification measures short run correlation. It has no static equilibrium solution in the sense that informations are excluded regarding the relationship of the levels of saving and investment in the steady state. This specification corresponds to the restriction $\gamma = \delta = 0$ in equation (3) and is written in equation (4).

$$\Delta(I/Y)_t = a + b\Delta(S/Y)_t + \varepsilon_t \tag{4}$$

An alternative specification used by Feldstein and Bacchetta(1991), is the partial adjustment form like equation (5). It is based on the assumption that investment reacts to the gap between saving and investment in the previous period.

$$(I/Y)_t = a + b((S/Y)_{t-1} - (I/Y)_{t-1}) + u_t \tag{5}$$

This equation imposes the restriction that the short run correlation between saving and investment is zero. It puts the constraint on dynamic structure. Equation (5) corresponds to the case of $\beta = \delta = 0$ in equation (3).

Equations (1), (4), (5) are nested in forms of equation (3) which is general specification as explained above. Therefore equation (3) is a natural starting point for the investigation of the relationship between saving and investment.

Capital mobility may change with capital liberalization policies and technological progress over time. In the 1970s and 1980s, worldwide capital mobility has increased rapidly as the result of Euromarket development, shifts in the exchange rate regime and capital account liberalization measures. Structural changes in capital mobility may take place as capital movement relating environments change. Structural break can be seen in the change of the short run saving retention, coefficient β, and the speed of convergence, coefficient γ, in equation (3).[4] Structural change can be tested using dummy variable such like equation (6).

$$\Delta(I/Y)_t = a + (\beta_1 D_1 + \beta_2 D_2)\Delta(S/Y)_t + \gamma(S/Y - I/Y)_{t-1} + \delta(S/Y)_{t-1} + \varepsilon_t \tag{6}$$

where D_t denotes dummies that are one during subscript i and zero otherwise.

When there is a long run relationship between saving and investment, it is interesting to check the direction of causality. When two variables are cointegrated, there exists a causality at least in one direction. The direction of long run causality is investigated using ECM representation. Equation for causality test can be set up as follows:

$$\Delta(I/Y)_t = a + \Sigma\beta_i\Delta(I/Y)_{t-i} + \Sigma\gamma_i(S/Y)_{t-i} + \delta(I/Y - S/Y)_{t-1} + \varepsilon_t \tag{7}$$

When (S/Y) does not Granger cause (I/Y), then both γ and δ must be equal to zero.

[4] As I am interested in the degree of capital mobility, only the structural break in β is concerned.

Ⅲ. THE EMPIRICAL RESULTS FOR KOREAN CAPITAL MOBILITY

This study focuses on the Korean economy's capital mobility. The annual data are collected from CD Rom version of International Financial statistics from 1955 to 1995. National investment is the sum of private investment, government investment and changes in stock. The national saving is defined as gross national product minus the sum of private consumption and government consumption. Saving and investment ratio of GNP are used in this study. The direct tax and wage income which are used for exogeneity test, are taken from Economic Statistic Yearbook(Bank of Korea). The defence spending and dependency ratio are collected from World Development Indicators 1997(The World Bank).

Cointegration in the saving and investment context deals with the long run relationship. Application of cointegration between saving rate and investment rate requires saving and investment rate to be integrated of order one. Augmented Dickey Fuller method and Phillips and Perron method are used to test the unit roots for saving rate and investment rate. Phillips and Peron method can be used to test for unit root when disturbance terms are serially correlated and possibly heteroskedastic as well. If the coefficient of time trend variable is not significantly different from zero, we perform ADF and Phillips and Perron test without a trend.

Table 1 shows the outcome of the unit root test. Explanation of the results of unit root test is in order. The null hypothesis that national saving rate has a unit root cannot be rejected at 5 % significance level except the case of Phillips

[Table 1] Unit Root Test on Saving and Investment

variables	ADF (with no trend)	ADF (with trend)	P-P (with no trend)	P-P (with trend)
national saving rate (S/Y)	-0.56(2)*	-3.34(1)	-0.59(2)	-4.23(1)
differenced national saving rate $(\triangle (S/Y))$	-5.17(2)	-5.28(1)	-7.86(2)	-7.71(1)
national investment rate (I/Y)	-0.86(2)	-3.01(1)	-1.13(2)	-3.12(1)
differenced investment rate $(\triangle (I/Y))$	-4.57(2)	-5.85(1)	-6.98(2)	-6.90(1)
critical value**	-2.93:	-3.50	-2.93	-3.50

* ( ) denotes the numbers of time lags. The number of lags are chosen on the Akaike and Schwartz criterion.

** at 5% significance level

Perron with trend.[5] In the case of national investment, the null hypothesis of unit root cannot be rejected by any method at 5 % significance level. The current account has an unit root with some marginal result when ADF with trend is used. Unit root test results indicate that the variables of interest in this study have a unit root at 5 % significance level. At the same time Table 1 shows unambiguously that the first differenced variables are stationary. These results warrant use of cointegration test of the saving rate and investment rate.

Next I will check whether savings and investment rate are cointegrated. First we use Engle-Granger two-step method. Saving rate is regressed on investment rate by which residuals are obtained. The residuals are subjected to unit root test. If the residual doesn't have unit root, the investment rate and savings rate are found to be cointegrated. Table 2 shows results of cointegration of saving rate and investment rate. The estimated coefficient of time trend appears not significantly different from zero, and Augmented Dickey Fuller and Phillips Perron tests without time trend were performed. Table 2 indicates that investment and saving rates are cointegrated not only for sub-period but also for all period. The fact that saving and investment are cointegrated implies that in the long run saving and investment are moving with a specific relationship and error correction model can be used for measuring international capital mobility in Korea.

Test results of cointegration between saving and investment by using error correction model are reported in Table 3. Before looking into the estimation results of error correction model(equation (3)), it is necessary to check its diagnostic tests. First of all, the exogeneity test for differenced savings rate should be done. The Hausman test shows that $\Delta(S/Y)$ can be treated as exogenous variable.[6] I performed the tests for serial correlation and heteroschedasticity of the disturbance term. All diagnostic tests including ARCH are

[Table 2] Cointegration Test of Savings and Investment Rate by Two Step Method

period	ADF test (no trend)	Phillips-Perron (without trend)
all period 1955-1995	−3.40	−3.16
structural break=1980	−5.97	−5.79
structural break=1985	−6.31	−6.05

[5] Other many studies show that saving rate is nonstationary. And result of ADF test shows that savings rate is nonstationary. So I treat it as nonstationary.

[6] The direct tax, wage income, defence spending and dependency ratio are used in the Hausman test

passed. So OLS method is used for estimation of error correction equation(3).

The estimated coefficient of gap between saving and investment is significantly different from zero regardless of the presence of structural break. The results confirm the savings rate and investment rate are cointegrated. This finding is consistent with theoretical prediction that there is one for one relationship between savings and investment because of the equilibrium condition of the current account balance in the long run.

Now I look closely into implications of the estimated long run model. Equation 3 implies an explicit long run relationship between saving and investment. The steady state in which $\Delta(S/Y)_t = \Delta(I/Y)_t = 0$, implies that $a + \gamma(S/Y - I/Y)^* + \delta(S/Y)^* = 0$. In equation (3), the estimated coefficient of gap between saving rate and investment rate in Table (3) is significantly different from zero. This result does not satisfy the usual transversality condition that national net asset holdings should be zero in the long run. In addition the hypothesis that $a = \delta = 0$ or saving equals investment in the long run is rejected at 5% significant level (F(2,36) statistic yields 4.69). This is surprising result since solvency restriction requires that investment be equal to saving in the long run. However it is understood that this result is not inconsistent with the fact that Korean economy has maintained current account deficit for a long period except for late 1980s.

[Table 3] Saving-Investment Relations, Equation (3)

	equation (3) * no structural break	equation (7) structural break(1980)	equation (7) structural break(1985)
constant	0.04(2.68)*	0.05(3.23)	0.05(3.21)
$\Delta(S/Y)_t$	0.454(3.84)		
$D_{(55-80)}\Delta(S/Y)_t$ $D_{(81-95)}\Delta(S/Y)_t$		0.56(4.49) -0.05(-0.19)	
$D_{(55-84)}\Delta(S/Y)_t$ $D_{(85-95)}\Delta(S/Y)_t$			0.57(4.52) -0.35(-0.99)
$(S/Y - I/Y)_{t-1}$	0.35(3.08)	0.42(3.54)	0.39(3.60)
$(S/Y)_{t-1}$	-0.11(2.22)	-0.15(2.84)	-0.105(-2.32)
DW	1.68	1.85	1.82
$\overline{R^2}$	0.36	0.41	0.43
ARCH(1)	1.24	10.78	1.17
Hausman ($\Delta(S/Y)$**	1.26	1.25	0.88

* ( )=t value, D means dummy and the sub number denote period.

** As instrument variables, I used wage, direct tax, defence spending and dependency ratio. These data are available from 1972. So I performed Hausman test for these available time periods.

Table 3 shows the estimates for the short run coefficient β. I will examine the case of test results of no structural break.[7] The coefficient β is significantly different from zero at any reasonable significant level for the whole period(equation (3)). It cannot be claimed that a nonzero coefficient indicates that capital has been immobile during past forty years. However it can be argued that non zero estimate of the short run coefficient implies less than perfect capital mobility, given long history of strict capital control in Korea.

The degree of international capital mobility critically varies with the technological innovation and financial market liberalization measures. Korean economy is reasonably evaluated to have structural break in 1980 or 1985[8]. The hypothesis that the short run coefficient stays constant is rejected at 5 % significance level. F statistic is 4.37 when it is contended there was a structural break in 1980. F statistic is 6.23 when it is assumed that the structural break took place in 1985. The fitting is also improved with the structural break. This finding suggests that Korea has gone through structural break.

Given these results, the short run coefficient is appropriately estimated by using the model with a structural break. The short run coefficients have declined substantially from 0.56 to -0.05 in the 1980 break or 0.57 to -0.39 in the 1985 break. This implies that international capital mobility in Korea has rapidly risen in the 1980s. These empirical finding is consistent with the fact that significant measures have been taken in the 1980s to open the capital market.

Jansen and Schulze(1996) showed that many other econometric specifications used in saving investment regression is the special cases of an error correction model equation (3). The error correction model encompasses static equation (1), differenced form equation (4) and partial adjustment equation (5). These alternative models can be tested against error correction model. Here Korean data are used to illustrate their assertion. Table 4 clearly shows three alternative specifications are all rejected in favor of error correction model. This means that static specification, difference equation and partial adjustment model have specification error. Therefore error correction model seems to be most suitable equation for discussing the saving and investment correlation in Korea.

[Table 4] Test of Alternative Specification against Error Correction Model

	no structural break	structural break(1980)	structural break(1985)
static model	15.57(2,36)	14.99(2,35)	14.25(2,35)
difference equation	4.76(2,36)	6.52(2,35)	7.60(2,35)
partial adjustment	10.88(2,36)	9.39(2,35)	10.03(2,35)

* The numbers of ( ) denote numerator and denominator of F statistic.

[7] As explained in next paragraph, it is desirable to take into consideration the structural break. But here I tried to explain the empirical results over the whole period.

[8] Korean economy suffered from political turmoil and second oil shock in 1980.

The results for Korean economy reported in this study confirm that saving and investment are cointegrated. The existence of cointegration means that there is a long run causality relationship between variables. It is worthwhile to check for the direction of causality because the direction of causality gives the information about constraint factor. The causality from saving to investment means that saving acted as constraints on investment. In contrast, the causality from investment to saving means that investment playes a role in constraining saving. The null hypothesis that there is no causality from saving to investment is rejected at significance level of 95%($F(2,36)=5.24$). However the null hypothesis that there is no causality from investment to saving cannot be rejected($F(2,36)=2.58$). Therefore there is one-side causality from saving to investment in the past 40 years.[9] Given that the Korean economy has had shortage of the credit availability during the period of economic growth, it is safely argued that saving acted as constraint on investment. Also the data and test results support this view.

Ⅳ. CONCLUSION

This study investigates the degree of international capital mobility in Korea by looking at the long run and short run relationship of saving and investment. Many empirical results show that investment is highly correlated with saving, which induces many authors to study the reason. One direction of such researches is to try to consider intertemporal budget constraint. Due to intertemporal budget constraint, there is one to one relationship between saving and investment in the long run when capital is mobile. But in the short run, the economy may be away from the steady state. This means that short run correlation between saving and investment is high, while long run relationship is high.

This study checks the degree of international capital mobility in Korea by using error correction model which incorporates short run as well as long run relationship between saving and investment. According to the test, the degree of international capital mobility in Korea has risen rapidly since the 1980s. This result is in accordance with the fact that Korean economy has adopted many important measures related with capital account opening since in the early of 1980s. In this sense, there doesn't exist Feldstein-Horioka puzzle in Korea. It should be also noted that in Korea the condition that saving should be equal to

[9] When causality test is performed using the model which incorporates structural break, the results are a little different. In the case of structural break in 1980, the null hypothesis that there is no causality from saving to investment is rejected at any reasonable significance level($F(3, 34)=10.21$). The null hypothesis that there is no causality from investment to saving is also rejected($F(3,34)=4.62$). That means saving and investment are constraints on each other. In the case of 1985 structural break, saving causes investment, but the converse is not true. This result leads to the conclusion that saving is constraint on investment.

investment in the long run does not hold. However, this finding is consistent with the fact that Korean current account has been in deficit. Given that sustained borrowing is not feasible, the finding that transversality condition does not hold in Korea is rather interesting. Causality test shows that in Korea savings have played important role in constraining investment over long time, not vice versa. This result reflects the fact that credit was in severe shortage during past development period of Korean economy.

As future research, whether the transversality condition is related with currency crisis will be investigated. This research may give the answer to the question if the true cause of currency crisis is higher capital mobility or unsustainable current account deficit. Also the estimation of capital mobility by using error correction model in East Asian countries will be pursued to check whether error correction model is suitable alternative to solving Feldstein and Horioka's puzzle.

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