THE PHILIPPINE REVIEW OF ECONOMICS
VOL. XLIV NO. 2 DECEMBER 2007 P. 99-110

Savings and investment in developing countries: Granger causality test

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Additional evidence on savings and investment relationship in developing countries has been provided using conventional and time-series econometrics techniques. This paper finds no long-run relationship between savings and investment in seven countries of the sample, which implies increased degree of capital mobility and weakening of savings and investment relationship since early 1970s. There is bidirectional causality between savings and investment in South Africa, while there is unidirectional causality from savings to investment in Pakistan and Sri Lanka. There is no causality in India, Philippines, Malaysia, and Iran. This divergence might be due to country-specific policies and economic conditions. Strong correlation between savings and investment does not rule out capital mobility across countries.

JEL classification: C23, F 31, F21, F30
Keywords: Savings, investment, capital mobility, causality

1. Introduction

Savings and investment are two crucial macroeconomic variables that are decidedly desirable for achieving rapid economic growth, which is the major economic objective of any development plan in a developing country. It is difficult to find any country that managed a high growth rate for a long period without experiencing high rates of capital formation and/or high rates of savings. Empirical studies in the developed and less developed countries (LDCs) have reported high positive correlation between savings and investment both in time-series and cross-sectional studies (Feldstein and Horioka [1980]; Frankel, Dooley, and Mathieson [1986]; Arginon and Roldan [1994]; Bayoumi [1990]; Apergis and Tsoulfidis [1997]; Sinha [2002]).

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The purpose of this paper is to examine the issue of capital mobility and savings-investment relationship in developing countries. We use the time-series techniques of cointegration and Granger causality to examine the savings-investment relationship for ten developing countries: Pakistan, India, Iran, Philippines, Venezuela, Sri Lanka, South Africa, Malaysia, Thailand, and Nigeria.

2. Review of studies

Feldstein and Horioka [1980] have studied the relationship between savings and investment in 23 industrialized countries for the period 1960-1974. Their evidence showed high correlation between domestic savings and investment. Variation in the savings rate seemed to be associated with variation in investment, not in the external balance. Therefore, despite the possibility that savings and investment move independently, in practice they are highly correlated. This led Feldstein and Horioka to conclude that there was limited capital mobility between the industrialized countries. Most of the domestic savings were used for domestic capital formation, and policies were adopted to raise domestic savings that would also increase domestic investment. After Feldstein and Horioka [1980] a large number of studies[1] have examined this relationship offering alternative explanations of the savings-investment relationship. However, all the studies are not in complete agreement because of different approaches used to explain the said relationship.

Bayoumi [1990] maintains that a savings-investment correlation may indicate that the government uses monetary and fiscal policies to target the current account. Murphy [1984] argues that Feldstein and Horioka (FH) results reflect large country bias rather than low capital mobility. Cardia [1991] and Baxter and Crucini [1993] introduce productivity shocks in their general-equilibrium models and reconcile high international capital mobility with positive correlation between savings and investment. Miller [1988], using annual data for the United States for the period 1946-1987, finds cointegration between savings and investment before World War II and absence of cointegration after the war, suggesting increased capital mobility. Arginon and Roldan [1994] used the distinction of public and private sector and explored the correlation between domestic savings and investment in European Union countries for the period 1960-1988.

Apergis and Tsoulfidis [1997] used autoregressive distributive lag (ARDL) bounds testing procedure for 14 European Union countries and have concluded that savings and investment are cointegrated, implying that capital mobility was

[1]For a survey, see Taylor [1996] and Dooley, Frankel, and Mathieson [1987].

not high even after the move toward economic integration gained momentum in Europe. The study also finds that savings Granger-cause investment using vector error correction model (VECM). Krol [1996], using annual data (1962-1990) for 21 OECD (Organisation for Economic Co-operation and Development) countries, found that the estimated impact of savings on investment was considerably smaller than the estimates of the earlier studies that used averaged data. Jansen [1998] suggests that limited capital mobility, current account targeting by the government, and intertemporal budget constraint determine the long-run relationship between savings and investment while the short-run co-movements are due to capital mobility. The paper also reports that the short-run correlation seems to vary across countries and is determined by country-specific business cycles. Sinha and Sinha [2004], using an error correction framework, have estimated the short-run and long-run relationship between savings and investment rates. They have reported that capital is more mobile for high per capita income than for low-income countries.

Most of the studies have examined the savings-investment relationship and capital mobility for the developed countries. Similar studies on the developing countries are not many. Frankel, Dooley, and Mathieson [1986] used a sample of 64 countries (14 developed and 50 developing countries) to examine savings-investment relationship and found that except for a few less developed countries, savings and investment are highly correlated in the countries of the sample and shared a long-run equilibrium relationship.

Ghosh and Ostry [1995] used a current-account solvency model to explain the correlation of savings and investment co-movement in developed and developing economies. They considered demand-side factors. Coakley, Hasan, and Smith [1999] extended their study and have concluded that the correlation is low in LDCs, which could be attributed to country-specific macroeconomic policies and not to high capital mobility. Sinha [2002] finds that savings and investment rates are cointegrated for Myanmar and Thailand, showing that growth of savings rate causes the growth of investment rate. Reverse causality between savings rate and investment rate has been observed for Hong Kong, Malaysia, Myanmar, and Singapore.

3. Methodology and data

3.1. Unit root tests

Several tests of nonstationarity called "unit root tests" have been developed in the time-series econometrics literature. If the nonstationarity hypothesis is

rejected, then the traditional econometrics methods can be used. If not, the theory of cointegration may provide useful information about the relationship between the variables. The general requirement for applying the cointegration technique is to have variables of the same order of integration at hand. Before applying the cointegration technique, we need to determine the order of integration of each variable. The variables under consideration must be nonstationary and integrated of the same order. We use ADF (augmented Dickey-Fuller) test. This test is routinely computed by the econometrics softwares. Therefore, theory underlying the test is not discussed.

3.2. Johansen cointegration test

We use the maximum likelihood procedure of Johansen [1991, 1995] because it is based on well-established maximum likelihood procedure. The advantage of the Johansen's procedure is that several cointegration relationships can be estimated, and this is currently the most reliable test for cointegration and has better small sample properties. Johansen's method tests the restrictions imposed by cointegration on the unrestricted vector autoregression (VAR) involving the series. Consider a VAR of order p.

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} \ldots + A_p Y_{t-p} + BZ_t + \mu_t \tag{1}$$

where Y^t is a k-vector of nonstationary $I(1)$ variables, Z_t is a d-vector of deterministic variables, and μ_t is a vector of innovations. We can write the VAR as

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma i \Delta Y_{t-i} + BZ_t + \mu_t \tag{2}$$

$$\text{where } \Pi = \sum_{i=1}^{p} Ai - I \qquad i = 1 \ldots p \qquad \Gamma i = -\sum_{j=i+1}^{p} A_j \tag{3}$$

where Δ is difference operator and I is a $k \times k$ identity matrix. The rank of coefficient matrix Π determines the number of cointegrating vectors because the rank of Π is equal to the number of independent cointegrating vectors. Johansen's method uses two test statistics for the number of cointegrating vectors: the trace test (λ_{trace}) and maximum Eigenvalue $(\lambda_{\max})$ test. λ_{trace} statistic tests the null hypothesis (H_0) that the number of distinct cointegrating vectors is less than or equal to r against the alternative hypothesis of more than r cointegrating vectors and is given by:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{p} \ln[I - \lambda i] \tag{4}$$

where T is the number of useable observations and λ_i are the eigenvalues obtained from the estimated Π matrix in equation (5). The second statistic tests H_0 that the number of cointegrating vectors is r against the alternative of $r+1$ cointegrating vectors and is defined as

$$\lambda_{\max}(r, r+1) = -T \ln[I - \lambda i] \tag{5}$$

3.3. Granger causality

If the variables are not cointegrated, we can use standard Granger causality test. For performing this between Y_t and X_t series, the following equations are used:

$$Y_t = a_0 + \sum_{i=1}^{n} a_i Y_{t-i} + \sum_{j=1}^{m} b_j X_{t-j} + \varepsilon_t \tag{6}$$

$$X_t = b_0 + \sum_{i=1}^{n} c_i X_{t-i} + \sum_{j=1}^{m} d_j Y_{t-j} + \mu_t \tag{7}$$

where a_0 and b_0 are parameters representing intercept terms. ε_t and μ_t are uncorrelated white-noise series. One variable X Granger causes another variable Y, if Y can be explained adequately by using past values of Y and whether adding lagged values of X can improve the explanation. X Granger-causes Y does not imply that Y is the effect or the result of X. Using the above equations, three types of causal relationships can emerge. If b_j or d_j is statistically significant, there is unidirectional causality from X to Y or from Y to X. There is bidirectional causality if both b_j and d_j are statistically significant. X and Y do not cause each other if the coefficients of X in equation (6) and of Y in equation (7) are statistically insignificant.

The data on savings and investment were obtained from the International Monetary Fund (IMF) International Financial Statistics (various issues). While quarterly data were not available on the desired variables for sample countries, we used annual data from 1960 to 2006. Data on savings are not directly available in the referred source. We calculated the national savings from the gross domestic product identified as follows:

$$Y = C + I + X - M \tag{8}$$

where $Y = GDP$, C = consumption, I = Gross domestic investment, X = Exports, and M = imports.

Equation (8) can be written as:

$$I = S + F \tag{9}$$

where S is national savings defined by

$$S = I + X - M \tag{10}$$

4. Empirical results

We follow Bodman [1995] and use the following specification to see the degree of international capital mobility:

$$I_t = a_0 + a_1 S_t + \mu_t \tag{11}$$

where I_t is investment and S_t is savings for the ten developing countries mentioned earlier. The ordinary least square (OLS) estimates of the above equation are as follows:

Table 1. OLS regression results

Country	$\hat{a}_1$	*Standard error*	R^2	*DW*
India	1.05	0.005	0.99	1.06
Iran	0.91	0.010	0.99	1.65
Malaysia	0.59	0.040	0.84	0.43
Nigeria	0.83	0.020	0.96	1.22
Pakistan	1.01	0.020	0.98	0.61
Philippines	1.09	0.040	0.94	0.90
South Africa	0.89	0.016	0.98	0.73
Sri Lanka	1.43	0.021	0.99	1.44
Thailand	0.85	0.040	0.91	0.48
Venezuela	0.64	0.025	0.94	2.08

The OLS results indicate high correlations between savings and investment and, therefore, low capital mobility. However, there are problems in the above regression results from the point of view of standard econometric assumptions.

In regressing a time-series variable on another time-series variable, one can get a very high R^2 although there is no meaningful relationship between the two. This situation shows what Granger and Newbold [1974] call a spurious regression that arises in the presence of nonstationary variables. It is clear from Table 1 that R^2 exceeds 0.90 for all countries except Malaysia, and DW casts doubts on the reliability of results. It is unrealistic to assume that saving is orthogonal to the error term even asymptotically. Dooley, Frankel, and Mathieson [1987] have pointed out the measurement errors in national income accounts, and the potential endogeneity of savings and investment measures or the endogenous policy response by the government to current account disequilibrium. Therefore, savings coefficient estimates are not valid, and even under conditions of perfect capital mobility the coefficient estimates may be significant.

Another problem is that the error term may not be well-behaved. We are dealing with time-series data, and the above regression results do not take into consideration dynamic aspects and may result in serially correlated errors and the possible autoregressive conditional heteroskedasticity (ARCH). This aspect would make parameter estimates inconsistent and statistical inference invalid. We subjected the residuals of regression (11) to Q-statistic, Lagrange multiplier (LM) test for serial correlation and ARCH test. Q-statistic and LM test are significant for all countries except Iran, Venezuela, and Sri Lanka. ARCH test is not significant for Nigeria, South Africa, and Sri Lanka. Even after correcting for the above-mentioned problems, we found evidence of robust relationship between savings and investment (results not reported for space considerations but available upon request).

If the absolute value of the ADF statistic is less than the critical values, the time series is nonstationary, and if this value exceeds the critical values then we do not reject the hypothesis that the given time series is stationary. ADF results (Table 2) show that savings and investment are nonstationary for all countries. Similarly, variables are found to be first-difference stationary. Therefore, savings and investment are nonstationary and integrated of order 1.

We now proceed to test the variables for cointegration. It is clear from Table 3 that the hypothesis of no cointegration $(H_0 : r = 0)$ is rejected by the trace test for Thailand while λ_{max} for Nigeria and by both λ_{max} and trace test for Venezuela. For the other seven countries, savings and investment are not cointegrated, i.e., do not have long-run relationship. Therefore, the cointegration results do not provide evidence of a long-run relationship in the seven developing countries. These results are in agreement with Bodman [1995] and Miller [1988] who have provided similar evidence for OECD countries and the United States, respectively. These are in disagreement with Frankel, Dooley,

and Mathieson [1986] for developing countries. The result for Thailand is consistent with Sinha [2002]. Now we apply the Granger causality test.

Table 2. Unit root tests: investment and savings

Country	*ADF level with trend*		*ADF first difference with rend*	
	Investment	*Savings*	*Investment*	*Savings*
India	-3.70	-3.49	-8.05	-8.66
Iran	-2.95	-1.90	-5.02	-5.55
Malaysia	-1.11	-3.36	-5.36	-6.30
Nigeria	-1.91	-2.77	-6.59	-7.88
Pakistan	-2.39	-2.19	-5.70	-6.88
Philippines	-1.58	-1.84	-5.25	-8.07
South Africa	-2.86	-1.34	-6.59	-5.06
Sri Lanka	-2.60	-3.30	-4.90	-6.40
Thailand	-1.89	-0.55	-4.76	-6.19
Venezuela	-1.37	-0.90	-6.04	-5.85

Note: ADF test critical values for 1 percent, 5 percent, and 10 percent are -4.18, -3.51, and -3.18, respectively [Mackinnon 1996].

Table 3. Cointegration

	λ_{max}	95% CV	λ_{trace}	95% CV
H_0	$r=0$ $r\leq 1$	14.26	$r=0$ $r\leq 1$	15.49
H_1	$r=1$ $r=2$	3.84	$r\geq 1$ $r\geq 2$	3.84
India	8.34	0.00090	8.34	0.00090
Iran	8.27	0.00098	8.27	0.00098
Malaysia	11.46	0.69000	12.16	0.69000
Nigeria	14.54*	0.15000	14.69	0.15000
Pakistan	6.62	0.07000	6.69	0.07000
Philippines	6.64	3.65000	10.28	3.65000
South Africa	13.64	1.58000	15.23	1.58000
Sri Lanka	13.99	0.02000	14.01	0.02000
Thailand	13.52	2.46000	15.98*	2.46000
Venezuela	17.09*	2.23000	19.32*	2.23000

* Denotes rejection of the hypothesis at the 0.05 level based on Mackinnon, Haug, and Michelis [1999].

Optimal lag length is determined by LR (likelihood ratio statistic), FPE (final prediction error), AIC (Akaike information criterion), and SIC (Schwartz information criterion).

There is bidirectional causality between savings and investment in South Africa. We find that savings Granger-cause investment in Pakistan and Sri Lanka, while there is evidence of no-causality in India, Philippines, Malaysia, and Iran (Table 4). This divergence might be due to country-specific policies and economic conditions.

Table 4. Granger-causality

Country	*Null hypothesis*	*F-statistic*	*Probability*
India (1)	A[a]	1.22363	0.27510
	B[b]	0.04627	0.83075
Iran (1)	A	0.23243	0.63236
	B	2.98372	0.09182
Malaysia(2)	A	1.47924	0.24063
	B	2.30904	0.11314
Pakistan(1)	A	0.07507	0.78547
	B	5.95893*	0.01905
Philippines (2)	A	1.02868	0.36722
	B	0.78413	0.46376
South Africa(2)	A	4.22887*	0.02197
	B	3.08140*	0.05752
Sri Lanka (1)	A	0.10894	0.74307
	B	13.23520*	0.00078

Notes:

1. H_0: A[a] Inv does not Granger-cause S, B[b] S does not Granger-cause Inv.
2. Optimal lag length of VAR is determined by LR (likelihood ratio statistic), FPE (final prediction error), AIC (Akaike information criterion) and SC (Schwarz information criterion) and it is one for each country and * indicates significance at 5 percent.

Error-correction as well as lagged savings coefficient is significant, indicating long-run and short-run causality from savings to investment in Venezuela based on error-correction results. The Wald test is significant for both savings and investment, suggesting bidirectional causality between savings and investment. For Thailand, error-correction coefficient is significant, but the lagged savings coefficient is not significant. There is long-run relationship between savings

and investment whereas no short-run causality from savings to investment in Thailand. We got statistically unreliable results for error-correction for Nigeria (results available on request).

5. Conclusion

Savings and investment are considered absolutely desirable for achieving rapid economic growth. Capital formation has remained an inescapable phenomenon in economic development. A large literature in both developed and developing countries has been devoted to examining the savings-investment behavior. Though some studies cast doubt on the strong relationship, many empirical studies have reported high positive correlation between savings and investment both in time-series and cross-sectional context. In most of the countries, notably developing countries, savings have lagged behind investment demand needed for accelerating economic development. Capital mobility across countries has tended to fill the gap between savings and investment. Feldstein and Horioka's study on savings and investment in OECD countries concluded limited capital mobility between the industrialized countries. A large number of studies done after Feldstein and Horioka reestimated the relationship for developed and developing countries. These studies have offered alternative explanations regarding savings and investment behavior and capital mobility. Different methodologies have been used—emphasizing diverse aspects—and different results have been reported.

We have provided additional evidence on savings and investment relationship in developing countries using convential and time-series econometrics techniques. There exists a strong relationship between savings and investment even after correcting for time-series problems. This paper finds no long-run relationship between savings and investment in seven countries of the sample, which implies increased degree of capital mobility and weakening of savings and investment relationship that has emerged since the early 1970s because the developing countries faced severe balance-of-payments problems resulting from October 1973 oil-price shock. Moreover, massive public sector investment was undertaken in these countries, which were also instrumental in inviting foreign capital besides balance-of-payments needs. Error-correction model indicates long-run and short-run causality from savings to investment in Venezuela and long-run relationship in Nigeria and Thailand. Strong correlation between savings and investment has remained an empirical consistency, but this does not rule out the capital mobility across countries.

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