A Macroeconometric Dynamic Stochastic Keynesian Theory of Saving and Investment with Application for Latin American Economies

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Abstract

In the long run, the present value of current account balance would not get indefinitely large without precipitating in a macroeconomic crisis. This simple insight produces an econometrically testable relationship between saving and investment. We develop and test a variant of such a testable hypothesis using the recent cointegration methodology. We use data for ten Latin American countries. The results indicate that there exists a long run positive relationship between saving and investment in four out of the ten countries. However, the strict condition of saving and investment with a cointegrated vector of (1, -1) is rejected. For five other countries, the divergence between saving rate and investment rate may result in macroeconomic instability in the long run.

Introduction

In the past sixteen years, economists have been studying the relationship between saving and investment with renewed vigor. The biggest impetus comes from Feldstein and Horioka (1980). The main focus of the literature following Feldstein and Horioka is international capital mobility in the industrialized countries. With more sophisticated econometric methodology and more data availability for other countries, we are beginning to understand the relationship between saving and investment better. We are also recognizing the implications of the presence or absence of close relationships between saving and investment.

Sixty years ago, Keynes recognized the importance of the connection between saving and investment. In his classic, the *General Theory of Employment, Interest and Money* (1973) he writes:

"The prevalence of the idea that saving and investment, taken in their straightforward sense, can differ from one another, is to be explained, I think, by an optical illusion due to regarding an individual depositor's relation to his bank as being a one-sided transaction, instead of a two-sided transaction, which it actually is. ...But no one can save without acquiring an asset, whether it be cash or a debt or capital-goods; and no one can acquire an asset which he did not previously possesses, unless either an asset of equal value is newly produced or someone else parts with an asset of that value which he previously had. In the first alternative there is a corresponding new investment; in the second alternative someone else must be dissaving an equal sum. For his loss of wealth must be due to his consumption exceeding his income, and not to a loss on capital account through a change in the value of a capital asset, since it is not a case of his suffering a loss of value which his asset formerly had; he is duly receiving the current value of his asset and yet is not retaining this value in wealth in any form, ie., he must be spending it on current consumption in excess of current income." (pp. 81-82)

Keynes was clearly focused on an economy with individuals as the basic decision-making units. In this paper, we extend this Keynesian model to a dynamic stochastic multicountry environment with each country as the basic element of analysis. Our model produces a clearly econometrically testable hypothesis: saving and investment should be cointegrated. In the second part of the paper, we proceed to test this theory using Latin American data. Latin American countries provide an ideal dataset for testing macroeconomic time series over the past half a century because many of them have gone through clearly identifiable major macroeconomic crises over this period.

A Dynamic Stochastic Keynesian Model of Saving and Investment

We set out a time series model that relates saving and investment using the national income accounting identities that summarize Keynes' insight quoted above.

Suppose that there are n countries in the world each of them small enough not to affect the world interest rate (R) individually. We will use subscript t to denote time and subscript i to denote a country. We formulate a variant of the linearized version of the model proposed by Feldstein (1983) which is used by Coakley *et al* (1995):

$$S_{it} = a_k + S_{it-1} + b_k R_t + e_{kit} \quad (1)$$

Equation (1) summarizes the stylized facts that saving (S) is a process with unit root and that saving at time t for country i (S_{it}) depends positively on (real) world interest rate (R) at time t.

$$I_{it} = a_l + I_{it-1} - b_l R_t + e_{lit} \quad (2)$$

Equation (2) encapsulates the stylized facts that investment (I) is also a unit root process but has a negative relation with interest rate.

More generally,

$$I_{it} = a_l + I_{it-1} - b_l R_t + d(S_{it-1} - I_{it-1}) + e_{lit} \quad (2^{/})$$

The additional term $d(S_{it-1} - I_{it-1})$ is an error correction term to reflect a risk premium. The terms e_{kit} and e_{lit} are iid white noise processes and a_k, b_k, a_l, b_l and d are constants. Two equations (1) and ($2^{/}$) (or, (1) and (2) as ($2^{/}$) becomes identical to (2) if d = 0) can be used to solve for R_t:

Subtracting ($2^{/}$) from (1), we get

$$S_{it} - I_{it} = a_k - a_l + S_{it-1} - I_{it-1} + (b_k - b_l)R_t - d(S_{it-1} - I_{it-1}) + e_{kit} - e_{lit} \quad (3)$$

If it is a closed system with n countries, then total saving in each period must be equal to the total investment in that period. This means $\Sigma S_{it} = \Sigma I_{it}$ summing over i.

Summing over i in equation (3), we get,

$$0 = n(a_k - a_l) + n(b_k - b_l)R_t + \Sigma(e_{kit} - e_{lit}) \quad (4)$$

Thus, assuming $b_k \neq b_l$, we solve for R_t from (4) by noting that differences of independence white noise processes still produce white noise (say, z_t):

$$R_t = [a_l - a_k + \Sigma(e_{kit} - e_{lit})/n]/(b_k - b_l) = R^* + z_t \quad (5)$$

Let $C_{it} = S_{it} - I_{it}$. Then, from equation (3) we get by substituting the expression (5),

$$C_{it} = C_{it-1} - d(C_{it-1}) + (b_k + b_l)z_t + (e_{kit} - e_{lit}) \quad (6)$$

We can take expectations in (6) on both sides conditional on time t-1 to get

$$E_{t-1}(C_{it}) = C_{it-1} - d(C_{it-1}) \quad (7)$$

For a country i, the present value of the conditional expectations of C_{it} must be bounded above:

$$E_{t-1}(\Sigma\, C_{it} /(1 + R^*)^t) < \infty \quad (8)$$

Given (7), (8) follows provided (1-d)/(1+R*) < 1. In fact, we can show by simple algebra that

$$E_{t-1}(\Sigma\, C_{it} /(1 + R^*)^t) = C_{it-1}(1-d)(1+R^*)/(R^*+d) \quad (9)$$

provided (1-d)/(1+R*) < 1.

This solvency condition for the country shows that in the long run, the only credible path of saving and investment should be such that they are cointegrated. Otherwise (9) does not hold. Moreover, the cointegrating vector should be (1, -1) because $C_{it} = S_{it} - I_{it}$ by definition. Any other relation would not be viable in the long run. Thus, the model actually produces a testable hypothesis. However, since our model rests on a number of restrictive assumptions (such as a closed system assumption and a small country assumption), the empirical results may not exactly produce a cointegrating vector (1, -1).

The other implication of the model is the relation between import and export. If, the central bank activities are ignored (and in the long run, the central bank cannot continue to buy or sell securities without a credibility constraint), the capital account is the flip side of net export. Hence, in the long run, export and import should be cointegrated with a cointegrating vector of (1, -1) as well.

A Helicopter Tour of Ten Latin American Economies

The basic features of saving and investment for the ten economies studied are summarized in Figure 1-10 (for other countries in the region, long enough datasets to carry out time series analysis are not available).

[Figure 1-10, about here]

Colombia: The most striking feature for Colombia is the divergence of saving and investment in the 70s and again in the late 80s. The main reasons behind the divergence are political uncertainty and associated high rates of inflation. Recent surge of foreign investment is directly attributable to sweeping economic reform and the development of Cusiana oilfields.

Dominican Republic: Unlike Colombia, Dominican Republic has a long history of saving and investment following each other closely with the unusual feature of saving persistently lagging investment since the early 1960s.

Ecuador: Ecuador has two main cash “crops”: oil and banana. With the growth of oil price in the 1970s, saving received a boost in Ecuador. However, a relative drop in banana price in the following decades saw the saving fall somewhat.

El Salvador: The picture for El Salvador tells a remarkable sad story of the economic consequence of civil wars. In the 1980s, the economy was savaged by a decade long civil war that saw hundreds of thousands dead, others fleeing the country and a consequent drop in saving in the economy. But, with recent privatization efforts of the democratically elected government, investment has picked up since 1990.

Guatemala: Political uncertainty and the consequent economic fallout has played havoc with the economy resulting in a large exodus of Guatemalans into Mexico and the United States. This has led to a sharp drop in domestic saving. However, recent encouragement of foreign investment (mainly in agriculture) has led to a resurgence of investment especially with the emergence of democracy in the 1990s.

Honduras: One of the poorest countries in the Western Hemisphere (along with Nicaragua and Haiti), it is largely dependent on agriculture. The main cash crops are coffee and banana. In Honduras, saving tracked investment closely over the period under study except for the period 1975-85 when the political turmoil led investment to exceed saving.

Jamaica: Saving and investment followed each other quite closely in this small Caribbean country. However, foreign investment in bauxite mining and tourism has kept investment in Jamaica somewhat ahead of saving.

Mexico: Mexico was characterized by a steady simultaneous rise in saving and investment over 1950-1980 followed by divergence between the two with a severe contraction of investment in the 1980s. In the past five years, investment has been running ahead of saving culminating in the biggest currency crisis in history.

Panama: In the entire timeframe, investment and saving have followed each other closely. Panama is a very small economy with heavy dependence on offshore banking and flag of convenience facilities for ships. With the fall of General Noriega, the country went through a sharp drop in international confidence in the late 1980s. But, it seems to have recovered since then.

Venezuela: As the sole member of OPEC countries in the Western Hemisphere, Venezuela's fortune rises and falls with oil price. The sharp peak in saving in the early 1970s was a direct result of the rise in the price of oil. Investment peaked with a delayed effect. The most striking feature is the huge gap between saving and investment in Venezuela. A gap of this magnitude over such long periods does not exist anywhere else in Latin America.

What Can We Say About Cross Section Correlation Between Saving and Investment?

Feldstein and Horioka (1980) upset conventional wisdom by proclaiming that a high saving investment correlation in pooled cross section data of a number of (industrialized) countries imply capital immobility among them. This assertion holds under very restrictive theoretical conditions (see Frankel (1992)). Moreover, simulations with artificial economies have shown that high saving and investment correlation can persist even with perfect capital mobility (Baxter and Crucini (1993) and Finn (1991)). We deliberately refrain from drawing any conclusion based on pooled cross section analysis of our datasets for the following reason: All the basic series exhibit unit roots. Gonzalo (1994) has shown that in the presence of unit roots in the time series data, none of the usual test statistics for the ordinary least square regressions have standard distributions. Hence, any inference drawn from them are very likely to be erroneous even with very large samples. Therefore, applying their argument in these data series seem entirely inappropriate.

Data and Methodology

All data come from the *International Financial Statistics* (CDROM version, June 1996) of the International Monetary Fund. Annual data are used as follows: Colombia (1957-94), Dominican Republic (1950-95), Ecuador (1950-95), El Salvador (1951-95), Guatemala (1950-94), Honduras (1950-95), Jamaica (1950-93), Mexico (1950-94), Panama (1950-94) and Venezuela (1950-95). We follow the previous literature in defining gross domestic saving. Gross domestic saving is defined as gross domestic product minus total consumption (private plus government). This measure has been called "basic saving" by Baxter and Crucini (1993, p. 420). Gross fixed capital formation is taken as a measure of investment following earlier studies.

Bayoumi (1990) points out that there is a distinct advantage in using gross fixed capital formation as a measure of investment because it has a lesser tendency to behave procyclically since it excludes the highly procyclical inventories component. The two variables considered are gross domestic saving and investment as percentages of gross domestic product. We call these variables SR and IR respectively.

We use two types of unit root tests. The first is the Phillips-Perron (1988) test. The test is well suited for analyzing time series whose differences may follow mixed ARMA (p,q) processes of unknown order in that the test statistic incorporates a nonparametric allowance for serial correlation. Consider the following equation:

$$y_t = \tilde{c}_0 + \tilde{c}_1 y_{t-1} + \tilde{c}_2 (t - T/2) + \nu_t \qquad (10)$$

where $\{y_t\}$ is the relevant time series in equation (10), T is the number of observations and ν_t is the error term. The null hypothesis of a unit root is H_0: $\tilde{c}_1 = 1$. We can drop the trend term to test the stationarity of a variable without the trend.

The second test is an augmented Dickey-Fuller (ADF) test which is an extension of the Dickey-Fuller test (see Dickey and Fuller(1979) and (1981)). The ADF test entails estimating the following regression equation (with an autoregressive process):

$$\Delta y_t = c_1 + \omega y_{t-1} + c_2\, t + \sum_{i=1}^{r} d_i\, \Delta y_{t-i} + \nu_t \qquad (11)$$

In (11), $\{y_t\}$ is the relevant time series, Δ is a first-difference operator, t is a linear trend and ν_t is the error term. The above equation can also be estimated without including a trend term (by deleting the term $c_2\, t$ in the above equation). The null hypothesis of the existence of a unit root is H_0: $\omega = 0$.

The concept of cointegration is proposed by Granger (1981). Engle and Granger (1987) provide an axiomatic foundation of the methodology. Two (or more) I(1) variables are said to be cointegrated if there exists a linear combination of them that is stationary. Engle and Granger show that if the variables are cointegrated, then the OLS method gives super-consistent estimates. We use the Johansen-Juselius (see Johansen (1988) and Johansen and Juselius (1990) for details) tests for cointegration. The method can be shown to have the error correction representation of the VAR(p) model with Gaussian errors:

$$\Delta Z_t = a_0 + \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \ldots\ldots\ldots \Gamma_{p-1} \Delta Z_{t-p+1} + \Pi Z_{t-p} + BX_t + u_t \qquad (12)$$

where Z_t is a an mx1 vector of I(1) variables, X_t is an sx1 vector of I(0) variables, Γ_1, Γ_2, Γ_{p-1}, Π are mxm matrices of unknown parameters, B is an mxs matrix and $u_t \sim N(0, \Sigma)$. The maximum likelihood method is used to estimate (3) subject to the hypothesis that Π has a reduced rank, r < m. The hypothesis, therefore, is as follows:

$$H(r): \ \Pi = \alpha\beta^{/} \qquad (13)$$

where α and β are m x r matrices. If certain conditions are fulfilled, equation (13) implies that the process ΔZ_t is stationary, Z_t is non-stationary, and that βZ_t is stationary. βZ_t are known as the cointegrating relations and β the cointegrating vector. In our model C_t plays the role of Z_t in (12). If we find that SR and IR are cointegrated, the relevant hypothesis for the vector β to be tested is H_0: $\beta^{/} = (1, -1)$. Our results, however, have to be interpreted with caution. The unit root tests have low power (see Blough (1992)). The same goes for the Johansen-Juselius cointegration tests.

Results

The results of the Phillips-Perron unit root tests are in Table 1. The results indicate that both variables have unit roots for nine out of the ten countries. Only for Dominican Republic, both variables are stationary. Thus, we do not proceed to test for I(1) for Dominican Republic. For all other countries, both variables are found to be I(1). Although we do not report the results, the ADF tests also yield the same qualitative results. Thus, we proceed with the cointegration tests within the Johansen-Juselius framework for all these countries. We use the finite sample correction proposed by Reinsel and Ahn (1992). The trace statistic is multiplied by $T - pk / T$ where T is the number of observations, p is the number of variables and k is the lag order in the VAR system. The results are in Table 2. Although we do not report the results of the maximal eigenvalue tests, the results are the same with the maximal eigenvalue tests as well. Thus, our results are quite robust. The results indicate that for Ecuador, Honduras, Jamaica and Panama, SR and IR are cointegrated. In all four cases, the number of cointegrating vector is equal to one.

[Tables 1 and 2, about here]

For other five countries, the two variables are not cointegrated (recall that for Dominican Republic SR and IR are not integrated). Thus, in these five countries, the ratios may drift apart. This clearly violates equation (9). Therefore, our results indicate that Colombia, El Salvador, Guatemala, Mexico and Venezuela would be more prone to sudden crises of currency or balance of payment problems resulting in macroeconomic adjustment problems such as high real interest rate or high inflation or both. History of the past half a century tells us that these are precisely the countries where such problems did occur.

Table 3 gives the normalized long run cointegrating vectors for these four countries. In all five cases, the signs of the coefficients are as expected. The two variables have a long run equilibrium relationship. The magnitudes of the coefficients of the vectors are fairly close to (-1, 1).

[Tables 3, about here]

Next, we test the null hypothesis that β' is (1, -1). The test statistic (the likelihood ratio) has a χ^2 distribution with one degree of freedom. The test statistic, the critical value and the p-value are in Table 4. The results indicate that we reject the null hypothesis of the restriction. Thus, for all four countries the strict condition of cointegrated saving and investment with the cointegrating vector (1, -1) is rejected. Thus, the empirical results support only a part of our model that the SR and IR should be cointegrated.

[Table 4, about here]

Conclusions

In this paper, we develop and test a variant of the Feldstein-Horioka hypothesis of saving-investment equality using the cointegration methodology. First, we test for unit roots. We find that except for Dominican Republic, saving and investment ratios of other nine countries have unit roots. This gives us a high degree of confidence on the equations (1) and (2) that incorporate the stylized facts. Tests show that both variables are I(1) for these nine countries. We proceed with the cointegration tests using the Johansen-Juselius framework. We use the finite sample correction to adjust our test statistics. The results show that saving and investment ratios have a long run relationship for only four out of ten countries. For all four countries, we find that the number of cointegrating vectors is equal to one. The vectors show that there is a long run positive equilibrium relationship between the two variables. We normalize the vectors with respect to the saving rate and find that the magnitude of the investment coefficients are fairly close to one. However, our chi-square tests reject that the null hypothesis that the cointegrating vector is (1, -1) in all cases. For five other countries, the divergence between saving rate and investment rate may result in macroeconomic instability in the long run.

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Figure 1: Saving Rate (SR) and Investment Rate (IR) for Colombia

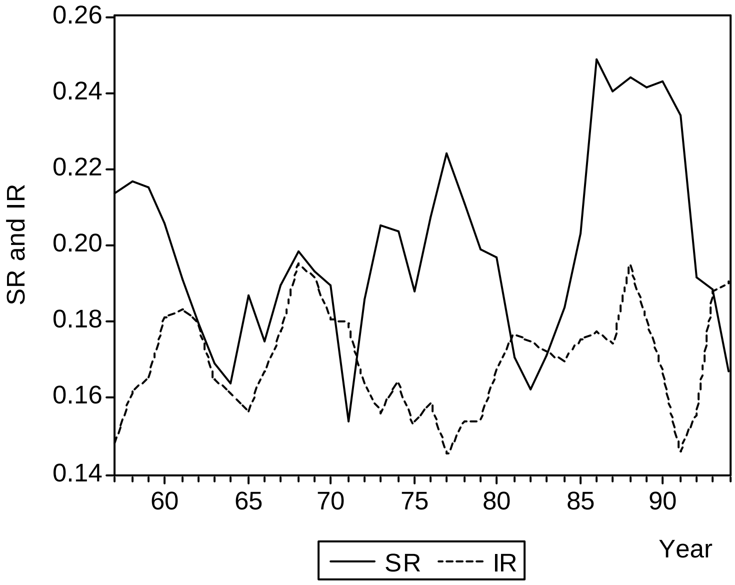

Figure 2: Saving Rate (SR) and Investment Rate (IR) for Dominican Republic

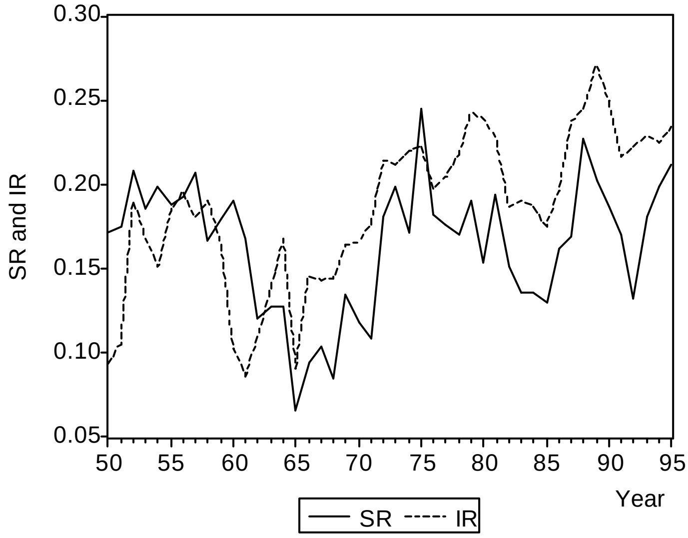

Figure 3: Saving Rate (SR) and Investment Rate (IR) for Ecuador

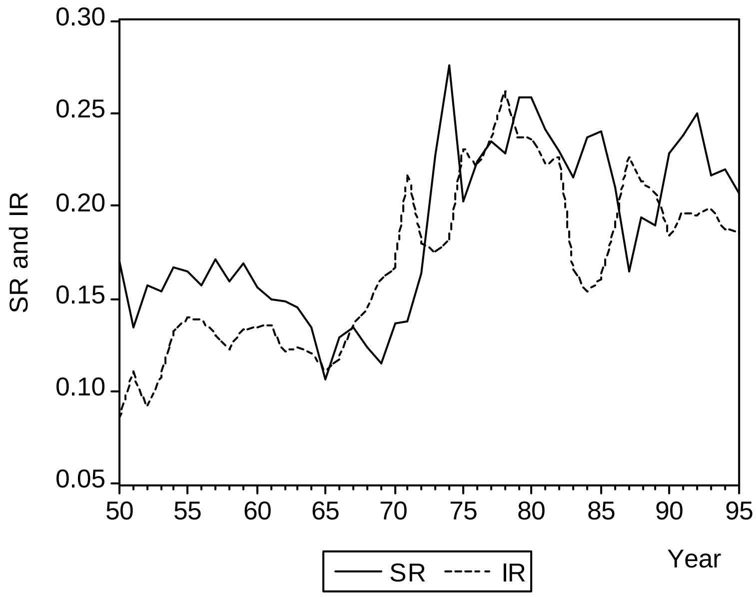

Figure 4: Saving Rate (SR) and Investment Rate (IR) for El Salvador

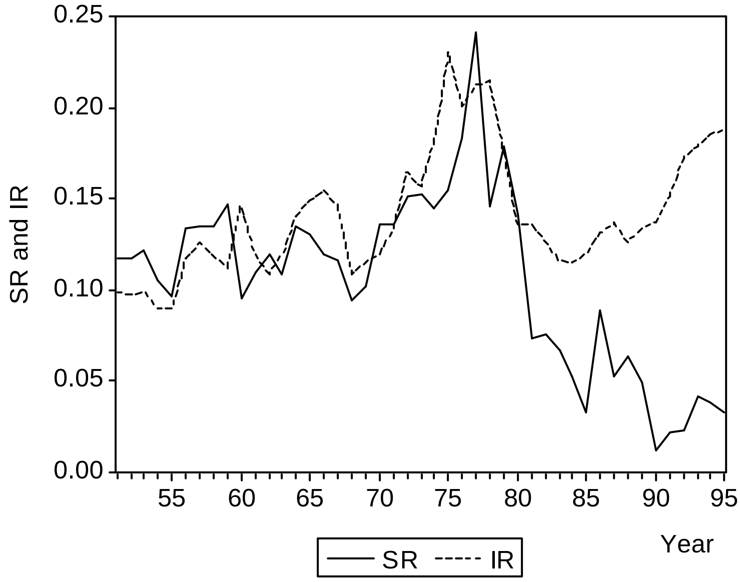

Figure 5: Saving Rate (SR) and Investment Rate (IR) for Guatemala

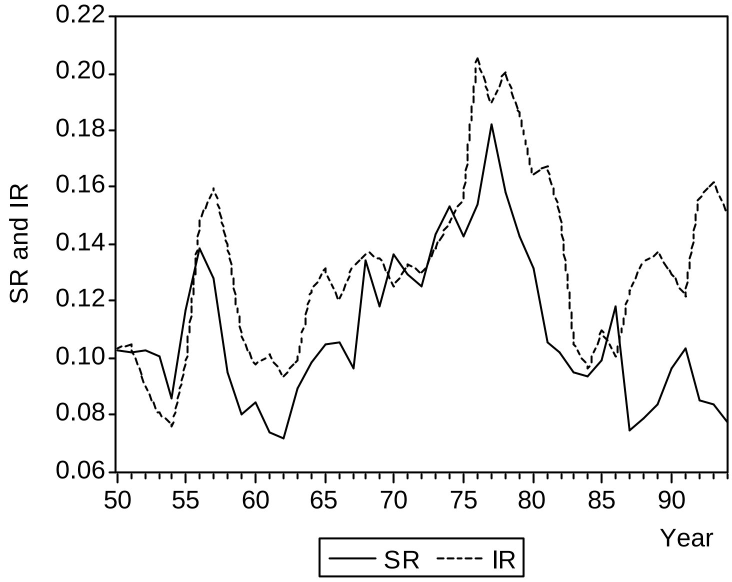

Figure 6: Saving Rate (SR) and Investment Rate (IR) for Honduras

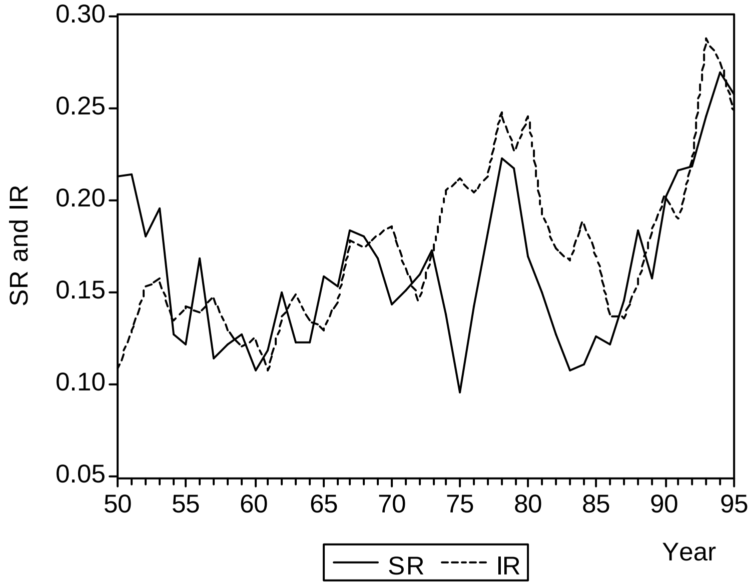

Figure 7: Saving Rate (SR) and Investment Rate (IR) for Jamaica

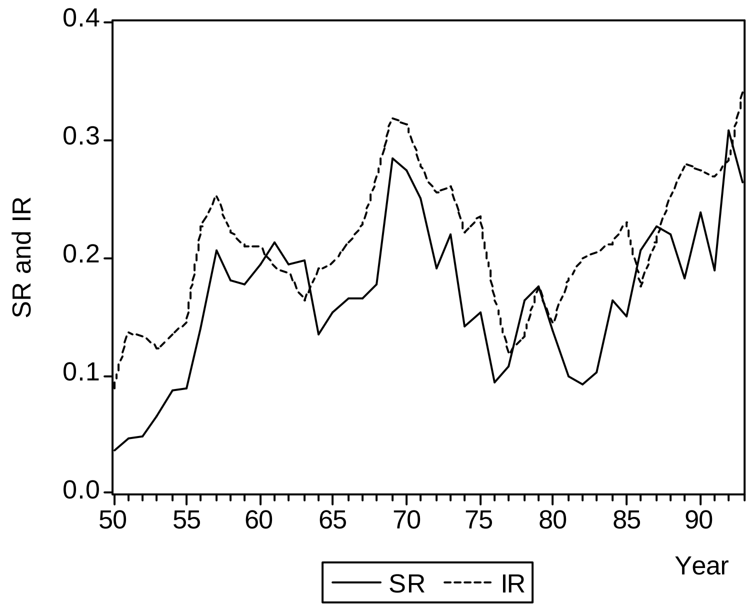

Figure 8: Saving Rate (SR) and Investment Rate (IR) for Mexico

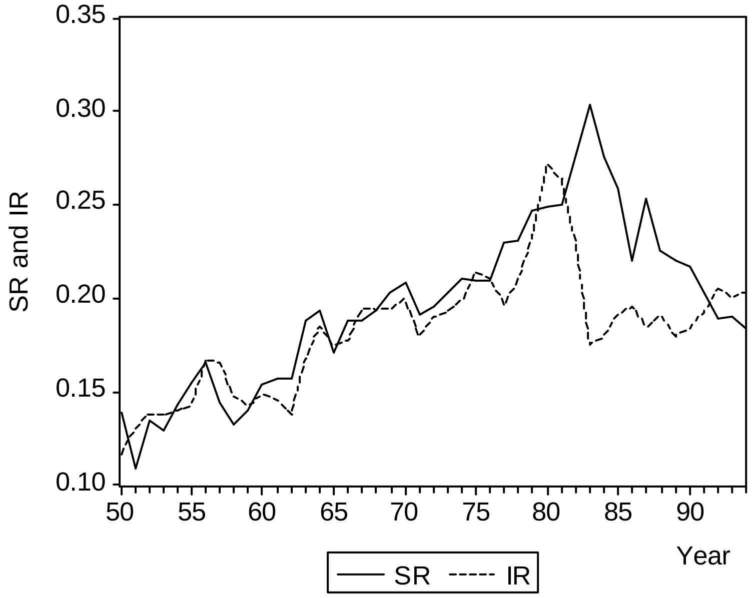

Figure 9: Saving Rate (SR) and Investment Rate (IR) for Panama

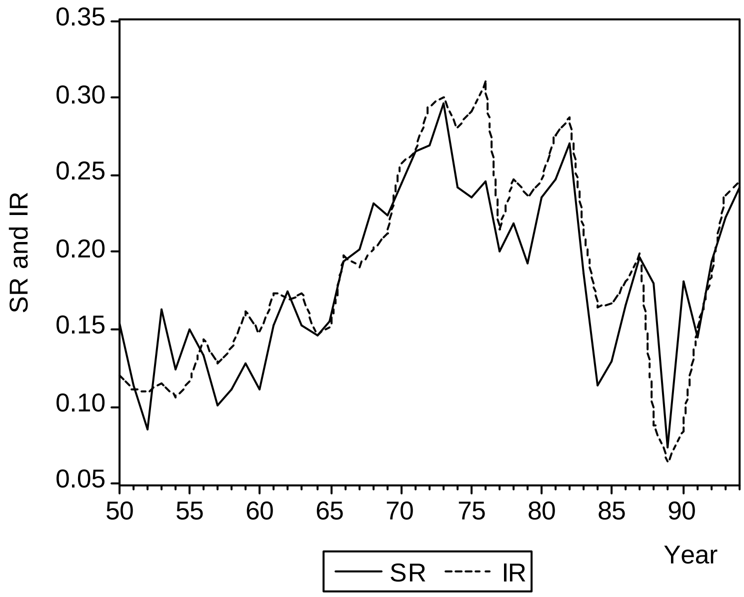

Figure 10: Saving Rate (SR) and Investment Rate (IR) for Venezuela

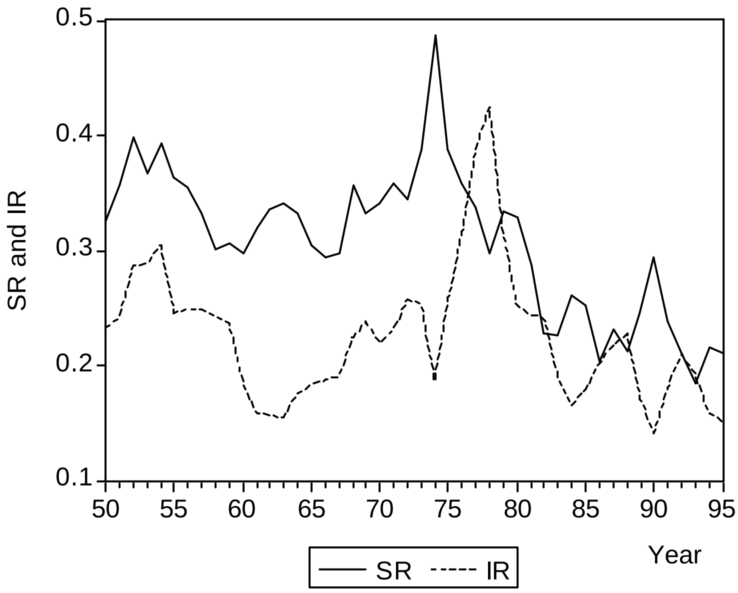

Table 1. Phillips-Perron Unit Root Tests for Savings Ratios and Investment Ratios

	SR		IR	
	Test Statistic	Critical Value	Test Statistic	Critical Value
Colombia	-2.5226[a]	-2.9422	-2.6720[a]	-2.9422
Dom. Rep.	-3.3548[a]	-2.9271	-3.4784	-3.5112
Ecuador	-2.5812	-3.5112	-2.0760	-3.5112
El Salvador	-2.6632	-3.5136	-2.6176	-3.5112
Guatemala	-1.9957[a]	-3.9286	-2.5126	-3.5136
Honduras	-2.3994	-2.9271	-2.4276	-3.5112
Jamaica	-2.5683	-3.5162	-2.2357	-3.5162
Mexico	-0.8907	-3.5136	-1.9976	-3.5136
Panama	-2.2039[a]	-2.9286	-1.7773[a]	-2.9286
Venezuela	-2.8861	-3.5112	-1.8292[a]	-2.9271

[a]Indicates no trend.

Note: The critical values at the 5% level are from Mackinnon (1991). The lag of 3 was determined using the Schwert (1989) Criterion.

Table 2. Trace Tests for Cointegration Between Saving and Investment

	Null: r=0		Null: r≤1	
	Test Statistic	Critical Value[*]	Test Statistic	Critical Value[*]
Colombia	12.1279	17.8520	4.29216	7.5250
Ecuador	17.6074[**]	15.6630	2.0219	6.5030
El Salvador	6.0971	15.6630	2.7686	6.5030
Guatemala	14.9376	17.8520	3.5778	7.5250
Honduras	17.9495[**]	17.8520	1.4158	7.5250
Jamaica	17.7299[**]	15.6630	4.2755	6.5030
Mexico	14.6246	15.6630	3.4936	6.5030
Panama	24.5464[**]	17.8520	3.2754	7.5250
Venezuela	13.9698	17.8520	1.3423	7.5250

[*]Critical values are for the 90% quantile. These are from Osterwald-Lenum (1992).
[**]Significant at the 10% level.

Table 3. Long Run Cointegrating Vector (β) Between Saving and Investment

	SR	IR
Ecuador	-1.000	1.0167
Honduras	-1.000	0.8468
Jamaica	-1.000	1.0886
Panama	-1.000	0.7667

Note: The coefficients are normalized on SR.

Table 4. Tests of Restrictions of (-1, 1) of the Cointegrating Vectors

	LR Test Statistic	Critical χ^2 Value
Ecuador	13.8556(.000)	2.71
Honduras	15.8032(.000)	2.71
Jamaica	9.6066(.002)	2.71
Panama	18.5661(.000)	2.71

Note: P-values of accepting the null hypotheses are in parentheses. The critical value is at the 10% level.