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The Feldstein-Horioka Model Re-Visited for African Countries

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THE FELDSTEIN-HORIOKA MODEL RE-VISITED FOR AFRICAN COUNTRIES

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Abstract:

We study the relationship between the saving and investment rates for 20 African countries using a long period of data. A high correlation between saving and investment is often taken as evidence of capital immobility. We use the new Ng-Perron unit root tests to examine the stationarity of saving and investment rates. Both Johansen cointegration tests and fractional cointegration tests are used. The results are mixed. The Johansen cointegration tests show that the saving and investment rates are cointegrated only for Rwanda and South Africa. This implies that for the other 18 countries, there is evidence of capital mobility. The fractional cointegration test results are different. The two rates are found to be fractionally cointegrated for the following 12 countries: Algeria, Burundi, Egypt, Morocco, Niger, Rwanda, Senegal, South Africa, Swaziland, Tunisia, Tanzania and Zimbabwe. For Cote d'Ivoire, Kenya, Lesotho and Sierra Leone there is some evidence of capital mobility while the results for Ethiopia, Malawi, Mauritius and Nigeria are mixed.

JEL categories: C22, E21, O11

I. Introduction

Since the publication of the Feldstein-Horioka (1980) paper, economists have been studying the saving-investment relationship intensively. Most studies have examined this relationship for the industrialized countries. Although studies have explored the savings-investment relation for developing countries, very few studies have been undertaken for African countries. Studies that have tested the Feldstein-Horioka model for the African countries include Sinha and Sinha (2004), Agbetsiafa (2002), Isaksson (2001) and Mamingi (1997). Mamingi studies the saving-investment relationship for 58 developing countries using the Phillips-Hansen fully modified OLS. Mamingi's sample includes a number of African countries. He tests for unit roots in the data before estimation. However, the time period of his dataset is limited to 1970-90 – hardly enough to study the long run relationship. Sinha and Sinha (2004) and Agbetsiafa (2002) use an error correction framework to test the Feldstein-Horioka model. While Sinha and Sinha (2004) find that capital is more mobile in the African countries with a lower per capita income, Agbetsiafa (2002) finds that capital is not mobile internationally in the six African countries under study. Isaksson (2001) examines the Feldstein-Horioka model for 90 developing countries that include countries in Africa, Asia, Latin America and the Middle East. He uses cross-section data and panel data. He finds that except for the countries in the Middle East, capital mobility is low. However, capital mobility is higher during the post-liberalization period.

There are a number of distinguishing features of the present study. First, the data spans a much longer time period for most countries than any previous studies. This is important for studying the long-run relationship between saving and investment. Second, we use a new unit root test, the Ng-Perron (2001) test, which has not been used to study the saving and investment relationship. Third, apart from the conventional Johansen (1988) cointegration test, we also apply fractional cointegration tests.

The rest of the paper is structured as follows. Part 2 reviews the previous studies. Part 3 discusses the data, methodology and the results of the Ng-Perron unit root tests and the Johansen cointegration tests. Part 4 discusses the methodology and the results of the fractional cointegration tests. Part 5 has some concluding remarks.

II. Previous Studies

The literature on the saving-investment relationship has burgeoned since the publication of Feldstein and Horioka's pioneering article which upset conventional wisdom by finding that capital is not very mobile internationally among the developed countries. As pointed out by Blecker (1997), the literature on saving-investment relations has taken three basic strands: Feldstein-Horioka and later empirical tests, analyses of financial capital mobility and endogenous policy responses. We will pay more attention to the first strand since the present work belongs to the same genre.

Feldstein and Horioka (1980) fit the following regression

$$IR_i = \alpha + \beta\ SR_i \quad (1)$$

where i stands for the country subscript, IR is the investment rate and SR is the national savings rate. IR is defined as investment divided by GDP and SR is defined as national saving divided by GDP. A sample of 16 countries and average rates for 1960-74 are used by Feldstein and Horioka. Other specifications are also used. OLS results for equation (1) yielded a very high degree of correlation between the two rates, prompting the authors to conclude that capital was not very mobile among the major OECD countries.

In another part of the paper, Feldstein and Horioka also regress the investment rate on three different types of saving rates, namely, household saving rate, corporate saving rate and the government saving rate. When the dependent variable used is either total investment rate or the private investment rate, then there are no significant differences in the coefficients on the three different types of saving rates. However, when the dependent variable is corporate investment rate, then the coefficient on the corporate saving rate is found to be much more significant than the coefficients of either the household saving rate or the government saving rate. Most subsequent studies, however, do not distinguish between these three different types of saving.

Numerous subsequent studies have followed the Feldstein-Horioka line. Sachs (1981) uses cross section data to regress the change in current account balance rate (defined as the ratio of current account balance to GNP) on the change in the investment rate. The equation can be expressed as follows:

$$\Delta(CA/Y)i = \delta + \gamma\Delta(I/Y) \quad (2)$$

where CA stands for the current account balance, Y is GNP and I is investment. γ (negative) measures the proportion of changes in domestic investment that is financed by capital inflows. Sachs uses average data for 15 industrialized countries for 1968-73 and 1974-79 to calculate the changes in the two variables. He finds that γ is –0.65 and is statistically significant. This prompts him to conclude that 65% of the change in investment during the period was financed by capital inflows than rather than by saving. Thus, he finds evidence of high capital mobility among the industrialized countries. A later study by Penati and Dooley (1984) finds that the results obtained by Sachs are very sensitive to the period under study. Also, the results depend upon a few outliers. Penati and Dooley also re-estimate Feldstein and Horioka's equation and find support for their findings. Dooley, Frankel and Mathieson (1987) study the relationships between saving and investment for developing and developed countries (using cross section data) to find that capital is more mobile for developing countries than for developed countries. A number of recent studies have used an error correction model to study the saving-investment relationship. Among the recent studies, Jansen (1996) finds that the saving and the investment rates have a long run relationship (i.e., they are cointegrated) for most of the OECD countries. He uses a error-correction model of the following form:

$$\Delta IR_t = \alpha + \beta\Delta SR_t + \gamma(SR_{t-1} - IR_{t-1}) + \delta SR_{t-1} + \varepsilon_t \qquad (3)$$

where SR and IR are saving and investment rates respectively and Δ stands for the first difference. If the error-correction term (γ) is statistically significant, it implies a long run relationship (i.e., cointegration) between the saving and investment rates. δ measures capital mobility. If δ is statistically significant, it shows that capital is mobile. Davidson et al (1978) were the first to use this type of error-correction model. However, the origin of such error correction models go back to Sargan (1964). Sinha and Sinha (2004) use the model to study the saving-investment relationship for 123 countries and Agbetsiafa (2002) for 6 countries.

The second strand of studies looks at international capital mobility by examining the rates of return data rather than using the methodology of Feldstein-Horioka. Obstfeld (1986) uses this methodology. His finding is that the rate of return had been rising and thus capital mobility had been rising.

The third strand is related to examining endogenous policy responses. The basic identity is that the current account balance is nothing but saving minus investment. Even if capital is very mobile internationally, policies that keep the current account in almost balance will also keep saving and investment almost equal (Summers (1985)). Summers' empirical tests find support for the hypothesis that fiscal policy endogeneity is, to a large extent, responsible for the high correlation between saving and investment.

III. Data, Methodology and the Results of Ng-Perron Unit Root Tests and Johansen Cointegration Tests

This study uses annual data as follows for the following 20 countries: Algeria (1950-2003), Burundi (1965-2003), Cote d'Ivoire (1960-2002), Egypt (1952-2004), Ethiopia (1961-2001), Kenya (1964-2003), Lesotho (1964-2002), Malawi (1954-2000), Mauritius (1952-2004), Morocco (1952-2003), Nigeria (1951-2003), Niger (1963-2002), Rwanda (1968-2003), Senegal (1960-2001), Sierra Leone (1964-2003), South Africa (1948-2003), Swaziland (1967-2003), Tanzania (1960-2003), Tunisia (1960-2003) and Zimbabwe (1963-2000). Our source of data is the *International Financial Statistics* (2005) of the IMF. Following many previous studies, we define saving as GDP minus private and government consumption. Also, a number of studies use gross fixed capital formation as a measure of investment. We do the same in this paper.

If we examine the data on saving and investment rates in Africa, what is striking (but not very surprising) are the low levels of the two rates in many of the African countries. For the period chosen, a number of countries had negative rates of saving for a number of years. Correspondingly, investment rates are also low. This contrasts with the experience of most of the Asian countries.

As noted earlier, this study is in the tradition of Feldstein-Horioka. It has now become standard to study the unit root properties of the data in time series analysis. We use the Ng-Perron (2001) unit root test. The advantages of the Ng-Perron tests are that the tests have good size and power. The tests are particularly suitable for small samples. To describe the Ng-Perron test, we start with the augmented Dickey-Fuller test (ADF) (Dickey and Fuller, 1979, 1981)

$$\Delta y_t = \alpha y_{t-1} + x_t^{/}\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots\ldots\ldots \beta_p \Delta y_{t-p} + v_t \qquad (4)$$

The null hypothesis of a unit root involves testing $\alpha = 0$ against the alternative hypothesis $\alpha < 1$ using the conventional *t*-test. Since the statistic does not follow the conventional Student's t-distribution, Dickey and Fuller (1979) and Mackinnon (1996), among others, simulate the critical values. The ADF tests, can include a constant and/or a linear time trend. Elliot, Rothemberg and Stock (ERS hereinafter) (1996) modify the ADF tests for two cases – one with a constant and the other with a constant and a trend, as follows. First, a quasi-difference of y_t is defined. The quasi-difference of y_t depends on the value of a representing the specific point against which the null hypothesis below is tested:

$$d(y_t|a) = y_t \text{ if } t = 1 \text{ and } d(y_t|a) = y_t - ay_t \text{ if } t > 1$$

Second, quasi-differenced data $d(y_t|a)$ is regressed on quasi-differenced $d(x_t|a)$ as follows:

$$d(y_t|a) = d(x_t|a)' \, \delta(a) + \eta_t \qquad (5)$$

where x_t contains a constant or a constant and a trend. Let $\hat{\delta}(a)$ be the OLS estimate of $\delta(a)$

For a, ERS recommend using $a = \bar{a}$ where $\bar{a} = 1 - 7/T$ if $x_t = \{1\}$ and $\bar{a} = 1 - 13.5/T$ if $x_t = \{1, t\}$. GLS detrended data, y^d_t are defined as follows. $y^d_t \equiv y_t - x_t'$. In the ERS, GLS detrended y^d_t is substituted for y_t.

$$\Delta y^d_t = \alpha \, \Delta y^d_{t-1} + \beta_1 \Delta y^d_{t-2} \, \Delta y_{t-1} + \ldots\ldots\ldots + \beta_p \Delta y^d_{t-p} + v_t \qquad (6)$$

As in the ADF test, the GLS unit root test involves the test on the coefficient α. The ERS Point Optimal test is as follows. Let the residuals from equation (2) be $\hat{\eta}_t(a) = d(y_t|a) = d(x_t|a)' \hat{\delta}(\bar{a})$ and let the sum of squared residuals, $SSR(a) = \hat{\eta}_t^{\,2}(a)$. The null hypothesis for the point optimal test is $\alpha = 1$ and the alternative hypothesis is $\alpha = \bar{a}$. The test statistic is $P_T = (SSR(\bar{a}) - SSR(1))/f_0$ where f_0 is an estimator of the residual spectrum at frequency zero.

The four tests of Ng-Perron involve modifications of the following four unit root tests: Phillips-Perron Z_α and Z_t, Bhargava R_1 and ERS Optimal Point tests. The tests are based on GLS detrended data, Δy^d_t. First, let us define $\kappa = \sum_{t-2}^{T} (y^d_{t-1})^2 / T^2$

The four statistics are listed below.

$$MZ^d_\alpha = (T^{-1} y^d_T)^2 - f_0) / 2\kappa \qquad (7)$$

$$MZ^d_t = MZ_\alpha \text{ x } MSB \qquad (8)$$

$$MSB^d = (\kappa / f_0)^{1/2} \qquad (9)$$

$MP^d_T = (\bar{c}^2 \kappa - \bar{c} T^1)(y^d T)^2)/ f_0$ if $x_t = \{1\}$ and $MP^d_T = (\bar{c}^2 \kappa + (1 - \bar{c})T^1(y^d T)^2)/ f_0$ if $x_t = \{1, t\}$

where $\bar{c} = -7$ if $x_t = \{1\}$ and $\bar{c} = -13.5$ if $x_t = \{1, t\}$ (10)

As with most other tests, the null hypothesis of unit root cannot be rejected if the test statistic is higher than the critical value. We use the 5% level of significance for all tests. The results of the Ng-Perron unit root test for the levels of the SR and IR are in Table 1 and those for the first differences of the SR and IR (denoted by ΔSR and ΔIR) are in Table 2. For Algeria, Burundi, Cote d'Ivoire, Ethiopia, Lesotho, Nigeria, Niger, Rwanda, Senegal, South Africa, Swaziland, Tanzania and Zimbabwe, both the SR and IR are found to be I(1). Except for two exceptions, the results are the same irrespective of the four different Ng-Perron tests that are used. Two exceptions are as follows. For Senegal, the MZ^d_α, MZ^d_t and MSB^d tests show that IR is I(1) but according to the MP^d_T test, IR is I(0). But, we take IR to be I(0) since 3 out of 4 tests find IR to be I(0). Similarly, for Swaziland, according to the MZ^d_t, MSB^d and MP^d_T tests, IR is I(1) but according the MZ^d_α test, IR is I(0). Using similar logic, we take IR to be I(1).

[Tables 1-2, about here]

Since both the SR and IR are I(1) for Algeria, Burundi, Cote d'Ivoire, Ethiopia, Lesotho, Nigeria, Niger, Rwanda, Senegal, South Africa, Swaziland, Tanzania and Zimbabwe, we proceed with the Johansen (1991) framework of cointegration tests (see Pesaran and Smith (1998) for details) for these countries. The general form of the vector error correction model is given by:

$$\Delta y_t = a_{oy} + a_{1y}\, t - \Pi_y\, z_{t-1} + \sum_{i=1}^{p-1} \Gamma_{iy}\Delta z_{t-i} + \Psi_y w_t + e_t,\ t=1,2,.......n \qquad (11)$$

where $z_t = (y'_t, x_t')'$, y_t is an m_y x 1 vector of endogenous variables I(1) variables, x_t is an m_x x 1 vector of exogenous I(1) variables

$$\Delta x_t = a_{ox} + \sum_{i=1}^{p-1} \Gamma_{ix}\Delta z_{t-i} + \Psi_x w_t + v_t \qquad (12)$$

and w_t is a q x 1 vector of exogenous/deterministic variables I(0) variables.

In this model, the disturbance vectors of e_t and w_t satisfy the assumptions (a) and (b) below:

$$(a)\ u_t = (e_t\ w_t)' \sim iid\ (0, \Sigma) \qquad (13)$$

where Σ is a symmetric positive-definite matrix.

(b) u_t (the disturbances in the combined model) are distributed independently of w_t i.e.,

$$E(u_t\ |w_t) = 0 \qquad (14)$$

a_{0y} and a_{1y} (the intercept and the trend coefficients respectively) are m_y x 1 vectors; Π_y is the long run multiplier matrix of order m_y + m, where m = m_x +m_y; Γ_{1y}, Γ_{2y},…….$\Gamma_{p-1,y}$ coefficient matrices capture the short run dynamic effects and are of order m_y x m; and Ψ_y is the my x m matrix of coefficients on the I(0) exogenous variables.

[Tables 3-4, about here]

The results of the maximal eigenvalue and trace tests are given in tables 3 and 4 respectively. In all cases, the number of lags for the cointegration tests were determined by the Schwarz Bayesian Criterion (SBC). The maximal eigenvalue tests show that the variables are cointegrated for Rwanda and South Africa while the trace tests show that the IR and SR are cointegrated for Rwanda only. In both cases, the number of cointegrating vectors is equal to one. Thus, in these two cases, we can use the Phillips-Hansen (1990) fully modified OLS procedure. The model is given by

$$y_t = \beta_0 + \beta_1' x_t + u_t,\ t= 1, 2, ...n \qquad (15)$$

where y_t is an I(1) variable, and x_t is a k x 1 vector of I(1) regressors which are not cointegrated among themselves. It is also assumed that x_t has the first difference stationary process $\Delta x_t = \mu + v_t$, t= 2, 3, ...n where μ is a k x 1 vector of drift parameters, v_t is a k x1 vector of I(0) variables and that $\xi_t = (u_t, v_t')'$ is strictly stationary with zero mean and a finite positive definite covariance matrix, Σ. This procedure has a number of advantages: it corrects for endogeneity and serial correlation effects; it also asymptotically eliminates the sample bias. This procedure is applicable only where there is only one cointegrating vector. Also, the Phillips-Hansen procedure is valid only when the independent variables are not cointegrated among themselves. However, in our case, this problem does not arise since we have only two variables.

The Phillips-Hansen fully modified estimates for equation (1) for Rwanda and South Africa are given in table 5. For South Africa, the investment and saving rates are positively related as expected. However, for Rwanda, they are found to be negatively related. Next, in order to test the null hypothesis that capital is perfectly immobile for South Africa a Wald test was carried out on the restriction that $\beta = 1$. The $\chi_1^2 = 5.8642$ (0.015) where 1 is the degree of freedom and the p-value of the test statistic is reported in parenthesis. Thus, we reject the null hypothesis that $\beta = 1$ for South Africa.

[Table 5, about here]

For each of the remaining 18 countries, we estimate equation (1). For the countries in which both SR and IR are integrated of order 1 but the variables are not cointegrated, we estimate the relationships in the first differences of the variables. There are 11 countries in this category. The countries for which, either one of the two series is stationary and the other is first difference stationary, we estimate equation (1) in first differences as well. There are 7 countries in this category. The Breusch-Godfrey test for serial correlation does not indicate the presence of serial correlation in any of the cases. Thus, OLS is used for estimation. The results are in table 6. The results indicate that the overall fit of the equation is not very high in most cases. β is significant at the 5% level (and positive) for only three countries: Ethiopia, Nigeria and Senegal. For Cote d'Ivoire, Kenya, Malawi, Mauritius, Morocco, Nigeria and

Tunisia, β is negative showing a negative relationship between the two variables. However, β is not significant in any of the cases. Since the results are not conclusive under the Johansen cointegration test, we now turn to the fractional cointegration tests.

[Table 6, about here]

IV. Methodology and Results of Fractional Cointegration

In this section, we examine the relation between saving and investment rates using fractional cointegration. If there is evidence of fractional cointegration, then, mean reversion does take place. The cointegration relationship possesses long memory. The error correction term responds slowly to shocks. In other words, deviations from the equilibrium are long-lived.

The semi-parametric test of Geweke and Porter-Hudak (1983) (GPH hereinafter) is employed to test for fractional cointegration. The GPH test is carried out on the first differences of the series to ensure that stationarity and invertibility are achieved. GPH show that the differencing parameter, *d*, which is also called a long memory parameter, can be estimated consistently from the least squares regression:

$$\ln(I(\omega_j)) = \theta + \lambda \ln(4\sin^2(\omega_j / 2)) + \upsilon_j\, ;\ j = 1,....J \qquad (16)$$

where θ is a constant, $\omega_j = 2\pi j / T(j = 1,....T-1)$, $J = f(T^{\mu})$ where $\mu = 0.5$ and $\mu = 0.6$. J is an increasing function of T where T are the number of observations and $0 < \mu < 1$. $I(\omega_j)$ is the periodogram of the time series at frequency ω_j. The existence of a fractional order of integration can be tested by examining the statistical significance of the differencing parameter, d. The estimated d values can be interpreted as follows: the process is mean reverting if $d < 1$ and exhibits long memory if $0 < d < 1$. If $d \geq 0.5$ the process is non-stationary and exhibits long memory; if $0 < d < 0.5$ the process is stationary and exhibits long memory. The process is stationary and has short memory if ½ $< d < 0$.[1] Table 7 reports the $\tilde{d}$ estimates for $J = T^{0.5}, T^{0.6}$ for the first difference of the saving rate, the first difference of the investment rate and the error correction term, E, obtained through a least squares estimation of the cointegrating regression equation (1). Different values of μ are used in order to check the sensitivity of the results to changes in μ.

[Table 7, about here]

The results appear to be fairly consistent to the different choices of μ. The fractionally differencing parameter for the first difference of the saving rate and investment rate are $0 < d < 1$, for Algeria, Tanzania, Tunisia and Zimbabwe. For Cote d'Ivoire, Egypt, Ethiopia, Kenya, Lesotho, Nigeria, Niger, Sierra Leone, the coefficient on the investment rate is greater than 1, while for Malawi, Senegal, and Swaziland the coefficient on saving rate is greater than 1. However, the differencing parameter for the residual series obtained from the cointegrating regressions are between 0 and 1 for Algeria, Burundi, Egypt, Morocco, Niger, Rwanda, Senegal, South Africa, Swaziland, Tanzania, Tunisia and Zimbabwe suggesting that although the individual series wander, the equilibrium error terms follow a fractionally cointegrated process and consequently have long memory. It is observed that the E_t process is $0.5 < d < 1$ for Algeria, Burundi, Morocco, Niger, Senegal, Swaziland, Tanzania suggesting that the series are non-stationary and exhibit long memory. The E_t process for Egypt and Rwanda are $0 < d < 0.5$ implying that the series are stationary and exhibit long memory. The results for Malawi, South Africa, Tunisia and Zimbabwe are not consistent across $\mu = 0.5$ and μ=0.6. While for South Africa, Tunisia and Zimbabwe the series show

[1] See Granger and Joyeux (1980) and Hosking (1981) for a detailed discussion.

evidence of long memory with $0 < d < 1$; for Malawi E_t shows evidence of short memory with $\mu = 0.5$.

The results indicate that although the saving rate and investment rates are both non-stationary, the two rates are fractionally cointegrated for Algeria, Burundi, Egypt, Morocco, Niger, Rwanda, Senegal, South Africa, Swaziland, Tanzania, Tunisia and Zimbabwe. A common set of fundamentals combine the saving and investment rates together suggesting that they are interdependent. The fact that domestic investment and domestic saving rates are interdependent implies the lack of perfect capital market integration. For Cote d'Ivoire, Kenya, Lesotho and Sierra Leone, the null hypothesis that d =1 cannot be rejected suggesting that the error correction term does not return to long run equilibrium. This suggests that the domestic savings rate and investment rate are not driven by a common set of fundamentals in these countries. This shows capital mobility with domestic investment being financed by foreign saving rather than domestic saving. The results for Ethiopia, Malawi, Mauritius and Nigeria are mixed.

V. Conclusion

In our study of 20 African countries, the Johansen cointegration tests show that saving and investment rates have a long run relationship in only two countries, Rwanda and South Africa. However, for Rwanda, the two rates have a negative relationship. For the other 18 African countries, there is no long run relationship between saving and investment rates. The regression results show that except for Ethiopia, Niger and Senegal, the bulk of the investment is not being financed by domestic saving but by foreign saving. The low correlation between the saving and investment rates implies that domestic investment is not constrained by low domestic saving rate. However, as shown by Coakley, Kulasi and Smith (1996), the lack of a long-run relationship between saving and investment may cause macroeconomic instability in these countries. However, the fractional cointegration tests indicate that the saving and investment rates are fractionally cointegrated for Algeria, Burundi, Egypt, Morocco, Niger, Rwanda, Senegal, South Africa, Swaziland, Tanzania, Tunisia and Zimbabwe.

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Table 1. Ng-Perron Unit Root Tests for Saving Rates and Investment Rates

	SR				IR			
	MZ^d_α	MZ^d_t	MSB^d	MP^d_T	MZ^d_α	MZ^d_t	MSB^d	MP^d_T
Algeria	-10.67* (-17.30)	-2.22* (-2.91)	0.221* (0.168)	9.14* (5.48)	-5.72 (-8.10)	-1.68 (-1.98)	0.29 (0.23)	4.32 (3.17)
Burundi	-12.80* (-17.30)	-2.47* (-2.91)	0.19* (0.168)	7.43* (5.48)	-4.56 (-8.10)	-1.50 (-1.98)	0.33 (0.23)	5.40 (3.17)
d'Ivoire	-15.06* (-17.30)	-2.73* (-2.91)	0.18* (0.168)	6.11* (5.48)	-3.33* (-17.3)	-1.28* (-2.91)	0.38* (0.168)	27.02* (5.48)
Egypt	-9.88 (8.10)	-2.20 (-1.98)	0.22 (0.23)	2.56 (3.17)	-4.56* (-17.3)	-1.41* (-2.91)	0.12* (0.23)	19.25* (5.48)
Ethiopia	-18.88* (-17.30)	-3.06* (-2.91)	0.16* (0.168)	4.89* (5.48)	-13.85* (-17.3)	-2.63* (-2.91)	0.19* (0.168)	6.61* (5.48)
Kenya	-10.20 (-8.10)	-2.21 (-1.98)	0.22 (0.23)	2.58 (3.17)	-2.38 (-8.10)	-1.03 (-1.98)	0.43 (0.23)	9.89 (3.17)
Lesotho	-2.73 (-8.10)	-1.06 (-1.98)	0.39 (0.23)	8.60 (3.17)	-7.14* (-17.3)	-1.68* (-2.91)	0.24* (0.168)	13.05* (5.48)
Malawi	-5.10 (-8.10)	-1.59 (-1.98)	0.31 (0.23)	4.82 (3.17)	-11.31 (-8.10)	-2.38 (-1.98)	0.21 (0.23)	2.17 (3.17)
Mauritius	-589.28* (-17.3)	-17.17* (-2.91)	0.03* (0.168)	0.15* (5.48)	-14.32* (-17.3)	-2.64* (-2.91)	0.18* (0.168)	6.55* (5.48)
Morocco	-21.95* (-17.3)	-3.30* (-2.91)	0.15* (0.168)	4.25* (5.48)	-12.07* (-17.3)	-2.46* (-2.91)	0.20* (0.168)	7.55* (5.48)
Nigeria	-12.34* (-17.3)	-2.45* (-2.91)	0.20* (0.168)	7.55* (5.48)	-4.06 (-8.10)	-1.42 (-1.98)	0.35 (0.23)	6.05 (3.17)
Niger	-7.60 (-8.10)	-1.94 (-1.98)	0.26 (0.23)	3.25 (3.17)	-5.42 (-8.10)	-1.65 (-1.98)	0.30 (0.23)	4.52 (3.17)
Rwanda	-12.80* (-17.3)	-2.48* (-2.91)	0.19* (0.168)	7.38* (5.48)	-8.17* (-17.3)	-2.02* (-2.91)	0.25* (0.168)	11.17* (5.48)
Senegal	-9.60 (-8.10)	-2.17 (-1.98)	0.226 (0.23)	2.61 (3.17)	-17.07* (-17.3)	-2.90* (-2.91)	0.17* (0.168)	5.46* (5.48)
Sierra Leone	-11.84 (-8.10)	-2.33 (-1.98)	0.20 (0.23)	2.48 (3.17)	-15.49* (-17.3)	-2.60* (-2.91)	0.168* (0.168)	6.92* (5.48)
South Africa	-4.23* (-17.3)	-1.38* (-2.91)	0.33* (0.168)	20.79* (5.48)	-4.32* (-17.3)	-1.45* (-2.91)	0.33* (0.168)	20.89* (5.48)
Swaziland	-7.06* (-17.3)	-1.77* (-2.91)	0.25* (0.168)	13.05* (5.48)	-8.41 (-8.10)	-1.97 (-1.98)	0.234 (0.23)	3.19 (3.17)
Tanzania	-9.06* (-17.3)	-2.04* (-2.91)	0.23* (0.168)	10.40* (5.48)	-9.04* (-17.3)	-2.09* (-2.91)	0.23* (0.168)	10.22* (5.48)
Tunisia	-8.58* (-17.3)	-1.98* (-2.91)	0.23* (0.168)	10.93* (5.48)	-8.12 (-8.10)	-2.01 (-1.98)	0.25 (0.23)	3.04 (3.17)
Zimbabwe	16.74* (-17.3)	-2.88* (-2.91)	0.17* (0.168)	5.52* (5.48)	-8.82* (-17.3)	-1.94* (-2.91)	0.22* (0.168)	10.89* (5.48)

*Indicates trend.

Note: Lags were determined using Schwarz Information Criterion (SIC). The critical values are for 5% level.

Table 2. Ng-Perron Unit Root Tests for First Differences of Saving Rates and Investment Rates

	ΔSR				ΔIR			
	MZ^d_α	MZ^d_t	MSB^d	MP^d_T	MZ^d_α	MZ^d_t	MSB^d	MP^d_T
Algeria	-16.33 (8.10)	-2.81 (-1.98)	0.17 (0.23)	1.68 (3.17)	-26.5 (-8.10)	-3.64 (-1.98)	0.14 (0.23)	0.93 (3.17)
Burundi	-15.99 (-8.10)	-2.73 (-1.98)	0.17 (0.23)	1.87 (3.17)	-32.35 (-8.10)	-4.02 (-1.98)	0.12 (0.23)	0.77 (3.17)
Cote d'Ivoire	-20.80 (-8.10)	-3.22 (-1.98)	0.15 (0.23)	1.18 (3.17)	-17.90 (-8.10)	-2.99 (-1.98)	0.17 (0.23)	1.37 (3.17)
Egypt	NA	NA	NA	NA	-26.10 (-8.10)	-3.61 (-1.98)	0.14 (0.23)	0.94 (3.17)
Ethiopia	-15.31 (-8.10)	-2.75 (-1.98)	0.18 (0.23)	1.66 (3.17)	-17.56 (-8.10)	-2.96 (-1.98)	0.17 (0.23)	1.41 (3.17)
Kenya	NA	NA	NA	NA	-19.32 (17.3)	-3.11 (-2.91)	0.16 (0.168)	4.73 (5.48)
Lesotho	-21.16 (-8.10)	-3.25 (-1.98)	0.15 (0.23)	1.18 (3.17)	-19.00 (-8.10)	-3.08 (-1.98)	0.16 (0.23)	1.30 (3.17)
Malawi	-24.67 (-8.10)	-3.45 (-1.98)	0.14 (0.23)	1.21 (3.17)	NA	NA	NA	NA
Mauritius	NA	NA	NA	NA	-25.78 (-8.10)	-3.59 (-1.98)	0.14 (0.23)	0.95 (3.17)
Morocco	NA	NA	NA	NA	-22.62 (-8.10)	-3.35 (-1.98)	0.15 (0.23)	1.13 (3.17)
Nigeria	-26.14 (-8.10)	-3.61 (-1.98)	0.14 (0.23)	0.94 (3.17)	-24.34 (-8.10)	-3.49 (-1.98)	0.14 (0.23)	1.02 (3.17)
Niger	-20.27 (-8.10)	-3.18 (-1.98)	0.16 (0.23)	1.23 (3.17)	-10.37 (-8.10)	-2.25 (-1.98)	0.22 (0.23)	2.46 (3.17)
Rwanda	-15.63 (-8.10)	-2.79 (-1.98)	0.18 (0.23)	1.57 (3.17)	-32.48 (-8.10)	-4.03 (-1.98)	0.12 (0.23)	0.77 (3.17)
Senegal	-11.14 (-8.10)	-2.27 (-1.98)	0.20 (0.23)	2.54 (3.17)	-23.12 (-8.10)	-3.40 (-1.98)	0.15 (0.23)	1.10 (3.17)
Sierra Leone	NA	NA	NA	NA	-20.57 (-8.10)	-2.99 (-1.98)	0.15 (0.23)	1.91 (3.17)
South Africa	-31.18 (-8.10)	-3.90 (-1.98)	0.13 (0.23)	0.92 (3.17)	-42.38 (-8.10)	-4.60 (-1.98)	0.11 (0.23)	0.59 (3.17)
Swaziland	-18.74 (-8.10)	-3.03 (-1.98)	0.16 (0.23)	1.42 (3.17)	-18.45 (-8.10)	-3.00 (-1.98)	0.16 (0.23)	1.48 (3.17)
Tanzania	-18.50 (-8.10)	-3.04 (-1.98)	0.16 (0.23)	1.33 (3.17)	-22.88 (-8.10)	-3.38 (-1.98)	0.15 (0.23)	1.10 (3.17)
Tunisia	-25.81 (-8.10)	-3.60 (-1.98)	0.14 (0.23)	0.95 (3.17)	NA	NA	NA	NA
Zimbabwe	-17.82 (-8.10)	-2.92 (-1.98)	0.16 (0.23)	1.60 (3.17)	-17.15 (-8.10)	-2.92 (-1.98)	0.17 (0.23)	1.46 (3.17)

*Indicates trend.

Note: Lags were determined using Schwarz Information Criterion (SIC). The critical values are for 5% level. NA means not applicable, i.e., the variable is stationary in its level.

Table 3. Maximal Eigenvalue Tests for Cointegration Between Saving and Investment Rates

	Null: r = 0	Null: r ≤ 1
	Test Statistic	Test Statistic
Algeria	6.5153	1.9252
Burundi	4.4398	3.6573
Cote d'Ivoire	13.5802	1.4373
Ethiopia	14.7658	2.8539
Lesotho	5.6381	3.2119
Nigeria	11.5351	3.7623
Niger	15.8343	3.4340
Rwanda	19.1945*	5.0512
Senegal	6.8295	2.6982
South Africa	16.8041*	0.4158
Swaziland	11.6842	4.9691
Tanzania	9.8115	4.6021
Zimbabwe	12.3548	6.3726

Note: The critical values for null hypotheses r=0 and r≤1 are 15.8700 and 9.1600 respectively at the 95% percentile. The corresponding alternative hypotheses are r=1 and r=2.
*Significant at the 5% level.

Table 4. Trace Tests for Cointegration Between Saving and Investment Rates

	Null: r = 0	Null: r ≤ 1
	Test Statistic	Test Statistic
Algeria	8.4404	1.9252
Burundi	8.0971	3.6573
Cote d'Ivoire	15.0175	1.4373
Ethiopia	17.6197	2.8539
Lesotho	8.8500	3.2119
Nigeria	15.2974	3.7623
Niger	19.2684	3.4340
Rwanda	24.2456*	5.0512
Senegal	9.5277	2.6982
South Africa	17.2199	0.4158
Swaziland	16.6533	4.9691
Tanzania	14.4136	4.6021
Zimbabwe	18.7310	6.3726

Note: The critical values for null hypotheses r=0 and r≤1 are 20.1800 and 9.1600 respectively at the 95% percentile. The corresponding alternative hypotheses are r≥1 and r=2.
*Significant at the 5% level.

Table 5. Phillips-Hansen Fully Modified OLS Estimates

	β Estimate	T-ratio
Rwanda	-0.1941	-6.7505**
South Africa	0.7420	6.9632**

**Significant at the 1% level.

Table 6. OLS Estimates of β in Equation (1)

	β Estimate (t-ratio)	R^2	Breusch-Godfrey Statistic (p-value)
Algeria	-0.0894 (-1.0036)	.02	0.9879 (0.61)
Burundi	0.1119 (0.9939)	.03	3.9829 (0.14)
Cote d'Ivoire	-0.0563 (-1.4949)	.02	2.3450 (0.31)
Egypt	0.1004 (0.6700)	.01	0.0830 (0.96)
Ethiopia	0.3936 (4.4028*)	.34	4.5332 (0.10)
Kenya	-0.1262 (-2.2322)	.12	2.3077 (0.32)
Lesotho	0.0353 (0.3412)	.003	3.0056 (0.77)
Malawi	-0.6697 (-0.3886)	.003	4.4465 (0.11)
Mauritius	-0.0249 (-1.0990)	.02	2.9243 (0.23)
Morocco	-0.1074 (-0.9326)	.02	3.1858 (0.20)
Nigeria	-0.0658 (-1.3582)	.04	9.3251 (0.85)
Niger	0.4176 (4.6522*)	.37	0.5706 (0.77)
Senegal	0.2000 (3.6408*)	.25	2.6705 (0.26)
Sierra Leone	0.1291 (1.4526)	.05	4.7425 (0.09)
Swaziland	0.0191 (0.1433)	.001	1.9238 (0.38)
Tanzania	0.0868 (0.7481)	.01	2.6246 (0.27)
Tunisia	-0.1495 (-1.0785)	.03	4.0281 (0.13)
Zimbabwe	0.1090 (1.1982)	.04	0.0507 (0.97)

Note: The model is estimated in the first differences of the variables.
*Significant at the 5% level.

Table 7. Results of the Geweke and Porter-Hudak Test for Fractional Cointegration

	d = .5	d = .6
Algeria	0.84	0.78
ΔSR	(0.39)	(0.29)
	(0.16)	(0.14)
ΔIR	0.73	0.96
	(0.39)	(0.30)
	(0.14)	(0.13)
E	0.73	0.61
	(0.38)	(0.29)
	(0.31)	(0.19)
Burundi	0.78	1.05
ΔSR	(0.44)	(0.32)
	(0.47)	(0.33)
ΔIR	0.98	0.83
	(0.44)	(0.32)
	(0.35)	(0.27)
E	0.92	0.80
	(0.44)	(0.32)
	(0.39)	(0.27)
Cote d'Ivoire	0.57	0.64
ΔSR	(0.44)	(0.32)
	(0.31)	(0.19)
ΔIR	1.59	1.63
	(0.43)	(0.33)
	(0.47)	(0.34)
E	1.04	1.24
	(0.43)	(0.32)
	(0.32)	(0.34)
Egypt	0.85	0.66
ΔSR	(0.39)	(0.30)
	(0.24)	(0.19)
ΔIR	1.27	1.40
	(0.39)	(0.30)
	(0.22)	(0.20)
E	0.36	0.35
	(0.38)	(0.29)
	(0.46)	(0.28)
Ethiopia	0.51	0.79
ΔSR	(0.44)	(0.33)
	(0.34)	(0.30)
ΔIR	0.39	1.02
	(0.44)	(0.33)
	(0.39)	(0.45)
E	0.38	1.01
	(0.44)	(0.32)
	(0.38)	(0.45)

Table 7. (Continued)

	$d = .5$	$d = .6$
Kenya ΔSR	0.34 (0.44) (0.56)	0.57 (0.38) (0.32)
ΔIR	1.25 (0.44) (0.22)	1.30 (0.33) (0.23)
E	1.15 (0.44) (0.21)	1.08 (0.32) (0.19)
Lesotho ΔSR	0.68 (0.44) (0.76)	0.80 (0.33) (0.45)
ΔIR	1.44 (0.44) (0.46)	1.01 (0.33) (0.34)
E	1.43 (0.44) (0.49)	1.01 (0.32) (0.35)
Malawi ΔSR	1.43 (0.43) (0.16)	1.27 (0.30) (0.13)
ΔIR	0.61 (0.43) (0.15)	1.03 (0.30) (0.50)
E	-0.03 (0.43) (0.26)	0.50 (0.30) (0.46)
Mauritius ΔSR	0.20 (0.38) (0.20)	0.22 (0.29) (0.13)
ΔIR	0.83 (0.38) (0.35)	1.09 (0.29) (0.26)
E	0.59 (0.38) (0.30)	1.16 (0.29) (0.42)
Morocco ΔSR	0.61 (0.38) (0.17)	0.70 (0.30) (0.22)
ΔIR	1.08 (0.38) (0.41)	0.89 (0.30) (0.26)
E	0.99 (0.38) (0.41)	0.70 (0.29) (0.28)

Table 7. (Continued)

	$d = .5$	$d = .6$
Nigeria	0.48	0.82
ΔSR	(0.39)	(0.29)
	(0.12)	(0.41)
ΔIR	1.13	1.31
	(0.39)	(0.30)
	(0.29)	(0.31)
E	0.89	1.17
	(0.38)	(0.29)
	(0.24)	(0.33)
Niger	0.62	0.62
ΔSR	(0.44)	(0.32)
	(0.50)	(0.32)
ΔIR	1.04	1.28
	(0.44)	(0.32)
	(0.22)	(0.16)
E	0.65	0.62
	(0.44)	(0.32)
	(0.38)	(0.21)
Rwanda	0.89	0.94
ΔSR	(0.44)	(0.35)
	(0.22)	(0.28)
ΔIR	1.20	0.97
	(0.44)	(0.35)
	(0.37)	(0.27)
E	0.04	0.19
	(0.44)	(0.35)
	(0.21)	(0.17)
Senegal	1.21	1.03
ΔSR	(0.44)	(0.32)
	(0.41)	(0.24)
ΔIR	1.06	0.97
	(0.44)	(0.32)
	(0.20)	(0.16)
E	0.92	0.89
	(0.44)	(0.32)
	(0.10)	(0.08)
Sierra Leone	0.46	0.35
ΔSR	(0.44)	(0.32)
	(0.93)	(0.55)
ΔIR	1.09	1.17
	(0.44)	(0.32)
	(0.27)	(0.36)
E	1.06	1.05
	(0.44)	(0.32)
	(0.29)	(0.31)
South Africa	1.42	0.73
ΔSR	(0.38)	(0.27)
	(0.17)	(0.25)

Table 7. (Continued)

	d = .5	d = .6
ΔIR	1.57 (0.38) (0.71)	0.96 (0.27) (0.45)
E	0.58 (0.38) (0.45)	0.40 (0.27) (0.39)
Swaziland ΔSR	1.02 (0.44) (0.24)	1.40 (0.35) (0.36)
ΔIR	0.87 (0.44) (0.21)	0.53 (0.35) (0.24)
E	0.95 (0.44) (0.19)	0.54 (0.35) (0.27)
Tanzania ΔSR	0.69 (0.43) (0.33)	0.98 (0.32) (0.38)
ΔIR	0.69 (0.43) (0.33)	0.73 (0.32) (0.23)
E	0.59 (0.43) (0.42)	0.53 (0.32) (0.26)
Tunisia ΔSR	0.91 (0.43) (0.26)	0.91 (0.32) (0.23)
ΔIR	0.49 (0.43) (0.37)	0.91 (0.32) (0.31)
E	0.30 (0.43) (0.71)	0.60 (0.32) (0.45)
Zimbabwe ΔSR	0.28 (0.44) (0.17)	0.63 (0.35) (0.38)
ΔIR	0.22 (0.44) (0.31)	0.74 (0.35) (0.35)
E	0.19 (0.44) (0.32)	0.73 (0.35) (0.36)

Note: $\tilde{d}$ =0.25, $\tilde{d}$ =0.5 and $\tilde{d}$ = 0.6 give the $\tilde{d}$ estimates corresponding to the GPH spectral regression of sample size J = $T^{0.25}$, J = $T^{0.5}$, J = $T^{0.6}$. The standard errors are reported in parenthesis. The first term in parenthesis is the asymptotic standard error and the second term is the OLS standard error.

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