Using a panel structure to discuss the Feldstein-Horioka puzzle in developing countries

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Resumo : O objetivo desse artigo é testar as implicações da solvência da conta corrente sobre a correlação poupança-investimento em países em desenvolvimento. Uma vez que solvência é um fenômeno de longo prazo e, dado que o poder dos testes padrão de raiz unitária e cointegração é baixo, exploramos a estrutura de painel da amostra de 29 países em desenvolvimento. Achamos evidência de que poupança e investimento são cointegrados e que a conta corrente é estacionária. Portanto, as correlações de Feldstein-Horioka não constituem um "puzzle" no sentido de que elas refletem a restrição orçamentária intertemporal. Os mesmos resultados são obtidos para diferentes sub-amostras (Africa, Ásia e América Latina) e para diferentes períodos de tempo (1960-74 e 1975-96). Sugerimos, então, que um modelo de correção de erros poderia distinguir entre a correlação de longo prazo, que reflete a condição de solvência, e a correlação de curto prazo, que poderia medir mobilidade de capital.

Abstract : The purpose of this paper is to test the implications of current account solvency for the saving-investment correlation in developing countries. Since solvency is a long-run phenomenon, and given that the power of the standard unit root and cointegration tests is low, we exploit the panel structure of the sample of 29 developing countries. We find evidence that saving and investment are cointegrated and that the current account is stationary. Therefore, the Feldstein-Horioka correlations are not a puzzle in the sense they reflect the intertemporal budget constraint. The same results are obtained for different subsamples (Africa, Asia, and Latin America) and for different periods of time (1960-74 and 1975-96). We, then, suggest that an error correction model should distinguish between the long-run correlation, which reflects the solvency condition, and the short-run correlation, which could measure capital mobility.

Keywords : Capital mobility, panel unit roots, panel cointegration, developing countries.

JEL : F32, F41.

Using a panel structure to discuss the Feldstein-Horioka puzzle in developing countries

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The purpose of this paper is to test the implications of current account solvency for the saving-investment correlation in developing countries. Since solvency is a long-run phenomenon, and given that the power of the standard unit root and cointegration tests is low, we exploit the panel structure of the sample of 29 developing countries. We find evidence that saving and investment are cointegrated and that the current account is stationary. Therefore, the Feldstein-Horioka correlations are not a puzzle in the sense they reflect the intertemporal budget constraint. The same results are obtained for different subsamples (Africa, Asia, and Latin America) and for different periods of time (1960-74 and 1975-96). We, then, suggest that an error correction model should distinguish between the long-run correlation, which reflects the solvency condition, and the short-run correlation, which could measure capital mobility.

1. Introduction

Feldstein and Horioka (1980) propose assessing the degree of capital mobility by measuring the correlation between saving and investment. Using a sample of sixteen OECD countries they find that saving and investment are highly correlated, concluding for a low degree of capital mobility among industrial countries, in contradiction with the belief that the industrial countries had few barriers to capital movements. Feldstein and Horioka's results were also obtained by other researchers using different samples and different empirical techniques More surprisingly, the estimated saving-investment correlation was not only high but also stable despite the held perception that capital became more mobile in the second half of the 70s.Murphy (1984), Obstfeld (1986), Dooley et a. (1987), and Wong (1990) also find a close association between saving and investment for smaller industrialized and developing countries, although the estimated correlations are lower on average. The correlations are, however, still smaller before mid 70s than after that. [1]The regularity of the results made the Feldstein and Horioka correlation one of the most important puzzles in international finance (Obstfeld and Rogoff, 2000).

Despite the robust empirical regularity, several critiques of the correlation between saving and investment as an indicator of capital mobility have emerged. The first one is the endogeneity of saving, implying that other factors could produce a correlation between saving and investment even if capital is mobile. Examples of these exogenous factors are: the procyclicality of saving and investment, population growth (Summers (1988),Obstfeld (1986)), productivity and other shocks (Obstfeld (1986)), and the presence of a non-traded consumption good (Murphy(1986) and Wong(1990)), and the government's reaction to current account imbalances (Summers (1988), Wong (1990)). In order to deal with this endogeneity problem Feldstein and Horioka (1980), Feldstein (1983), Tesar (1991), and others worked with time average data to wash out business cycle, Summers (1988) and Feldstein and Bacchetta (1991) added the variable to the regression, and Feldstein and Horioka (1980), Frankel (1986,1991), and Dooley et al. (1987) used instrument variables. The results, however, did not change substantially. The second one is a country size effect. If a country is large enough to affect the world interest rate, an increase in national saving would reduce the world interest rate, and therefore, increase domestic investment (Murphy, 1984). Besides, larger countries are more diversified and do not need to borrow abroad in the event of shock declines (Harberger (1980)). [2]

An alternative explanation for the high cross-section association between saving and investment is given by the current account solvency condition. The solvency constraint requires that the current account as a share of GDP be stationary since the external debt can not grow forever. Given that the current account balances add up to zero in the long run, so must the difference between saving and investment given that by definition the current account balance is equal to the difference between investment and saving. In other terms, saving and investment are cointegrated with a unit coefficient. The Feldstein-Horioka coefficient, therefore, is not a puzzle at all . Since the cross-section regressions measure the average long-run coefficient they, in fact, capture the unit coefficient implied by the solvency constraint and not the degree of capital mobility ((Sinn, (1992), Coakley et al. (1996)).

We believe the solvency constraint argument is really strong. There is a huge unrelated literature that argues that the present value external constraint implies that saving

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[1] The estimated saving-investment correlations based on annual data are considerably lower and variable (Sinn, 1992).

[2] Frankel (1986) shows that the large country effect can not be found responsible for the high correlation in the United States. Dooley et a. (1987), on the other hand, argue that "Harberger's argument only predicts that the ratio of the current account balance to GNP should be smaller for larger countries (as indeed it is), but not

and investment rates should be cointegrated or equivalently, that the current account should be stationary (Husted (1992), Sawada (1994), Ahmed and Rogers (1995)). The purpose of this paper is to present some additional empirical evidence on the correlation between saving and investment in order to determine if the Feldstein-Horioka results constitue a puzzle or not. Is it the long-run solvency condition rather than some measure of capital mobility that the Feldstein-Horioka cross-section regression captures? In order to avoid the sample-bias problem usually observed in cross-section regressions, we assess the saving-investment correlation using time-series techniques. Also to increase the power of these tests we exploit the panel structure of the sample of 29 developing countries over the period 1960-1996[3]. We choose to work with developing countries because the evidence regarding these countries is much smaller than the one available for developed countries.

The paper is organized as follows. The second section discusses the different approaches used to estimate the saving-investment correlation. The third section presents an intertemporal equilibrium model and shows that the intertemporal budget constraint implies that saving and investment are cointegrated. Therefore, since the Feldstein and Horioka regression is a long run equilibrium equation it captures the solvency constraint and not the degree of capital mobility. The fourth section presents the empirical results. The fifth section discusses an alternative to estimate the degree of capital mobility in developing countries and points out its limitations. The sixth section contains the conclusions and suggestions for future research.

2. Saving-investment correlation : comparing the different econometric specifications

Feldstein and Horioka (1980) propose assessing the degree of capital mobility by measuring the correlation between saving and investment. They estimate the following cross-section regression :

$$(I/Y)_i = a + b(S/Y)_i + u_i \qquad (2.1)$$

that a regression coefficient for saving and investment shares should be smaller for a sample of large countries".

[3] Panel data estimations have been used successfully by microeconomists who, in general, work with a large number of units (large N) and a small number of temporal observations (small T). Macroeconomists, however, use a reasonable number of temporal observations (large T). For these cases, the study of the

where (I/Y) is the ratio of gross domestic investment to gross national product (GNP) and (S/Y) is the ratio of national saving to GNP. i is a country index, a and b represent parameters to be estimated and u is the error term. For small countries, b should be close to zero under the null hypothesis of perfect capital mobility. When b equals zero there is no relationship between domestic saving and investment. On the other hand, if b is large, capital is considered immobile. If b equals 1, for example, then all additional saving goes to finance domestic investment. Usually regressions based on equation (1) have used long-term averages of saving and investment ratios from a cross-section of countries. The idea is, as observed by Bayoumi (1990), try to eliminate the effects of the business cycles. Given that I/Y and S/Y are prociclycal the use of annual data imparts an upward bias to the b coefficient.

Using a sample of OECD countries Feldstein and Horioka (1980) find an estimate of b equal to 0.89 for the entire sample (1960-74). This result implies a low degree of capital mobility among industrial countries, in contradiction with the belief that capital was highly mobile among industrial countries.

Equation (1) was also estimated using time series. In this case the saving and investment rates for each country for a particular year were used as observations.

Frankel (1986,1991), Tesar (1991), Sinn (1992) consider the variables in levels:

$$(I/Y)_t = a + b(S/Y)_t + u_t \qquad (2.2)$$

Feldstein (1983), Feldstein and Bachetta (1991)[4], and Bayoumi (1990) estimate the saving-investment in first differences.

$$\mathrm{D}(I/Y)_t = a + b\mathrm{D}(S/Y)_t + u_t \qquad (2.3)$$

stationarity of the series is an important issue. It was not until recently that panel data techniques and time series techniques were joined, allowing Macroeconomists to work more comfortably with panels.

4 Feldstein and Bachetta (1991) also used a different specification in which the ratio investment/GDP reacts to the gap between the ratio investment/GDP and the ratio saving/GDP in the previous period. As observed by Jansen (1996b) "This specification restricts the short-run correlation between the saving rate and the investment rate to be zero and thus imposes limitations on the dynamic structure. Since it seems rather dubious that the data justify this restriction, their equation is also misspecificied (p. 121)".

Bayoumi (1990) takes the first difference of the series in order to make them stationary. However, unless there is a long run relationship between saving and investment the equation in differences is misspecified (it is overdifferenced).

This brings in two advantages with respect to the usual cross-section estimations:

1) it avoids the sample selection bias typical of cross-section studies (Wong, 1990).
2) As observed by Sinn (1992) the use of an intertemporal framework calls attention for a new empirical problem. The intertemporal external budget constraint implies that a country can not borrow or lend indefinitely, or current account surpluses (deficits) should be followed by current account deficits (surpluses). By definition, the current account balance of a country in any period is equal to the difference between investment and saving. Given that the current account balances add up to zero in the long run, so must the difference between saving and investment. Since saving and investment shares are approximately equal if they are averaged over time, the use of averaged data would introduce a correlation between these two variables . Therefore, cross-sectional investment-saving regressions using time-averaged data will incorrectly signal a low degree of international capital mobility. The use of time-series regressions therefore avoids the bias against capital mobility of cross-section studies. In his empirical analysis (1992) Sinn finds lower and more variable correlations for OECD countries when annual data is used.

More recently, the time series saving-investment regressions started to be estimated using unit root and cointegration techniques. The time series approach to equation (1) consists basically of two tests:

1) With time-series data it is initially necessary to verify if I/Y and S/Y are non-stationary. If they are, regression (1) is spurious and the significance tests are no longer valid. The usual t and F tests will "overstate the significance of b, biasing the results toward the null of no capital mobility". It is still important to remember that the null hypothesis of perfect saving-investment correlation is Ho (a,b) = (0,1). Therefore, if I/Y and S/Y are I(1), Feldstein and Horioka's capital mobility test imply that S/Y and I/Y are cointegrated with cointegrating vector (1,-1)' (Gundlach and Sinn, 1992). For developed countries cointegration tests were implemented in Miller (1988), Leachman (1991), De Haan and

Siermann (1994), and Argimón and Roldán (1994). Argimón and Roldán perform Johansen cointegration tests and the remaining papers perform Engle-Granger cointegration tests for different countries. Leachman (1991) observes that saving and investment are not cointegrated for none of the 23 OECD countries. Haan and Siermann (1994) argue that this result is due to the small sample size (only 25 years). When longer series are used cointegration is found in 4 out of 7 OCDE countries. Argimón and Roldán (1994) analyse 8 European countries and conclude that saving and investment are cointegrated for 5 countries, and that the direction of long-run causality is from saving to investment. The amount of saving was the constraint on investment.

Studies for developing countries, as far as we know, do not take cointegration into account. Mamingi (1993) and Montiel (1994) work with changes in saving and investment ratios, but assume that saving and investment ratios are cointegrated, given that solvency does not allow saving and investment to deviate permanently. [5] Mamingi (1993) adopts the "fully modified OLS" estimator (Phillips and Hansen, 1990). Montiel (1994) estimates an error-correction version of the Feldstein-Horioka regression. A simple especification is chosen, given the small number of observations : the change in the investment ratio is regressed on a constant, the lagged residual from the cointegration regression, and the change in the saving ratio. Ordinary least-squares and instrumental variables regressions are performed.

3) As observed before, Feldstein and Horioka's perfect correlation hypothesis can be restated as the hypothesis that S/Y and I/Y are cointegrated with cointegrating vector (1,-1), or that the linear combination S/Y-I/Y is I(0). Given that by definition the current account is equal to the difference between saving and investment, if it is not possible to reject the hypothesis of non-stationarity of the current account it can be concluded that the perfect correlation hypothesis is rejected, and then capital is mobile. Bagnai and Manzocchi (1996) try to avoid imposing the cointegration assumption. They argue that if the saving and investment ratios are I(1), the Feldstein and Horioka hypothesis of perfect capital mobility corresponds to the hypothesis that $(S/Y)_i$ - $(I/Y)_i$ is I(0), and investigate if the current account in

[5] In fact, Montiel (1994) is aware that the null hypothesis of no cointegration could be rejected only for few countries but argues, using the solvency argument, that the failure to reject cointegration is due to the small sample size used.

developing countries is stationary or not. The results indicate that in 14 out of 37 developing countries, although capital is far from perfectly mobile, there is some degree of mobility.

The results based on time series indicate that capital mobility in developing countries is higher than expected, although there is no consensus regarding the extent of capital mobility in each individual country (Table 1). As we can see only 2 out of the 25 countries (Israel and Korea) are equally classified by Mamingi (1993), Montiel (1994), and Bagnai and Manzocchi (1996). On the other hand, 9 countries have their degrees of capital mobility classified differently by the three tests (Ecuador, El Salvador, Guatemala, India, Malawi, Malaysia, Senegal, and Thailand).

Table 1

Capital mobility in developing countries : some previous results

Countries	Mamingi 1970-1991	Montiel Several intervals	Bagnai/Manzocchi Several intervals
Argentina		Inconclusive	Immobility
Brazil	Intermediate	Mobility	Mobility
Chile	Intermediate	Immobility	Immobility
Colombia	Mobility	Mobility	Immobility
Ecuador	Intermediate	Mobility	Immobility
El Salvador	Intermediate	Mobility	Immobility
Guatemala	Immobility	Inconclusive	Mobility
Honduras	Immobility	Inconclusive	Immobility
India	Intermediate	Inconclusive	Mobility
Indonesia		Inconclusive	Immobility
Israel	Mobility	Mobility	Mobility
Jamaica	Immobility	Mobility	Immobility
Korea	Mobility	Mobility	Mobility
Malawi	Immobility	Inconclusive	Mobility
Malaysia	Inconclusive	Mobility	Immobility
Mexico	Mobility	Mobility	Immobility
Morocco	Inconclusive	Mobility	Mobility
Nigeria	Intermediate	Immobility	Immobility
Paraguay	Mobility	Mobility	Mobility
Phillipines	Immobility	Intermediate	Immobility
Senegal	Intermediate	Mobility	Immobility
Thailand	Intermediate	Inconclusive	Mobility
Venezuela	Mobility	Immobility	Immobility

Notes : Previous results are showed only for countries considered later in this paper. Mamingi, 1993, tab.6. Montiel, 1994, tab. 2 (instrumental variables results). Bagnai and Manzocchi, 1996, tab.2.
"Intermediate" means that both the perfect capital mobility and the capital immobility hypothesis were rejected; "mobility" means that only the hypothesis of perfect capital mobility was not rejected; "immobility" means that only the hypothesis of no capital mobility was not rejected; "inconclusive" means that it was not possible to discriminate among mobility and immobility.

3.Saving-investment correlation and current account solvency

Suppose an infinite horizon small open economy that consumes a single good.

The representative agent maximizes:

$$U_t = \lim_{t \to \infty} [u(C_t) + \beta u(C_{t+1}) + \beta^2 u(C_{t+2}) + \ldots] = \sum_{s=t}^{\infty} \beta^{s-t} u(C_s) \qquad (3.1)$$

In order to simplify we assume that the world interest rate r is constant over time. Output on any date s is determined by the production function $Y = AF(K)$, where $F(K)$ has the usual properties. The economy starts out on date t with stocks of capital K_t and net foreign assets B_t accumulated in the past.

The current account identity (again assuming a constant interest rate) states that :

$$CA_t = B_{t+1} - B_t = Y_t + rB_t - C_t - G_t - I_t \qquad (3.2)$$

where $I_t = K_{t+1} - K_t$. Rearranging terms we have :

$$(1+r)B_t = C_t + G_t + I_t - Y_t + B_{t+1} \qquad (3.3)$$

Iterative forward substitution of (3.3) gives :

$$\sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t}(C_s + I_s) + \left(\frac{1}{1+r}\right)^{T} B_{t+T+1} = (1+r)B_t + \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t}(Y_s - G_s) \qquad (3.4)$$

In order to find the necessary conditions for maximizing U_t in equation (1) we simply substitute for the consumption levels in (1) using the current account identity and obtain :

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} u[(1+r)B_s - B_{s+1} + A_s F(K_s) - (K_{s+1} - K_s) - G_s] \qquad (3.5)$$

Maximization with respect to B_{s+1} and K_{s+1} yields :

$$u'(C_s) = (1+r)\beta u'(C_{s+1}), \qquad (3.6)$$

$$A_{s+1}F'(K_{s+1}) = r \qquad (3.7)$$

Condition (3.6) is the consumption Euler equation and condition (3.7) is the equality between the marginal product of capital and the world interest rate.

The terminal condition

$$\lim_{T \to \infty} \left(\frac{1}{1+r}\right)^T B_{t+T+1} = 0 \qquad (3.8)$$

must always hold for a maximizing individual. Condition (3.8) is the transversality condition and it is equivalent to :

$$\sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (C_s + I_s) = (1+r)B_t + \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (Y_s - G_s) \qquad (3.9)$$

or

$$-B_t = \sum_{s=t}^{\infty} (1+r)^{-(s-t)-1} (Y_s - G_s - C_s - I_s) \qquad (3.10)$$

If the term in the limit in (3.8) was negative, the economy would be consuming and investing more than the present value of its output by an amount that never converges to zero. The economy is constantly issuing new debt to pay the old debt rather than transferring real resources to its creditors by making C+I smaller than Y-G. But foreigners will never allow such a Ponzi scheme. If the term in the limit in (3.8), on the other hand, was positive the present value of the resources of the economy is smaller than the present value of its output. The domestic consumers could raise their lifetime utility by consuming more. Only when the limit term is exactly equal to zero the economy, asymptotically, is using exactly the resources its budget constraint allows.

A useful way to interpret equation (3.10) is to to make $Y_s - C_s - G_s = S_s$. Since in an economy with investment $CA_s = S_s - I_s$ (national saving in excess of domestic capital formation flows into net foreign asset accumulation) equation (3.10) then becomes :

$$-B_t = \sum_{s=t}^{\infty} (1+r)^{-(s-t)-1} (S_s - I_s) \qquad (3.11)$$

or

$$-B_t = \sum_{s=t}^{\infty} (1+r)^{-(s-t)-1}(CA_s) \qquad (3.12)$$

From the expressions before, we know that a country can not borrow or lend indefinitely, or current account surpluses (deficits) should be followed by current account deficits (surpluses). The current account balances should then add up to zero in the long run, and so, by definition, must the difference between saving and investment. Therefore, the solvency constraint requires that the current account be a stationary variable and implies that saving and investment cointegrate with a coefficient of one. In fact, the solvency constraint will produce coefficients close to one whether capital is mobile or not.[6]

4. Empirical tests

The purpose of this section is to determine if the Feldstein and Horioka estimations are really a puzzle or they are only capturing the long run relationship between saving and investment implied by the intertemporal macro models. In order to do so we test for cointegration between saving and investment. First, we test for cointegration between saving and investment. If saving and investment are cointegrated we need to investigate the magnitude of the cointegrating vector. If the cointegrating vector is (1,-1)' the current account is stationary, and we can not say anything about the degree of capital mobility. This is the standard long-run relation implied by the intertemporal open-economy models. If saving and investment are cointegrated with vector different from (1,-1)' the current account is non-stationary and we can conclude that there is capital mobility.

A set of annual observations of investment and saving ratios from 1960 to 1996 is used for 29 developing countries : Argentina, Botswana, Brazil, Chile, Colombia, Ecuador, Egypt, El Salvador, Ghana, Guatemala, Honduras, Hong Kong, India, Indonesia, Israel, Jamaica, Korea, Malawi, Malaysia, Mexico, Morocco, Nigeria, Pakistan, Paraguay, Phillipines, Senegal, Singapore, Thailand, and Venezuela is considered. The data are from the World Bank. Domestic investment corresponds to the private sector's and government

[6] Husted (1992) finds no cointegration for the United States for the whole sample (1960-1989). An analysis of subsamples, however, supports cointegration if a structural break in 1983 is allowed. Ahmed and Rogers (1995) find strong evidence of the external present value constraint being satisfied for the United States and the United Kingdom. Sawada (1994) studies 13 heavily indebted countries and concludes that most of them do not feasible current account deficits.

sector's gross investment and saving is the sum of private and government saving. Both saving and investment are divided by the gross domestic product (GDP) in order to be converted in rates.

We exploit the panel structure of the data and look at the cointegration and unit root tests jointly to increase the power of the tests.

At the beginning of the 90s, based on the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests for time series, emerged the first works on a unit root test for panel data by Levin and Lin (1992,1993) and Quah (1993,1994). Im, Pesaran, and Shin (1997) (IPS) proposed an alternative test based on the average of the statistics of the individual unit root tests. Their test has a better performance than Quah's test since it allows for heterogeneity among groups, such as specific individual effects and different patterns of serial correlation. More specifically we use the t-bar statistic based on the average ADF, proposed by IPS. Under the null hypothesis of a unit root this statistics has a standard normal distribution for N, the number of countries, and T the number of time periods, sufficiently large and for N/T going to zero. Under the alternative hypothesis of stationarity the statistic diverges to negative infinity[7].

Initially we discuss the stationarity of the series of saving and investment ratios for the set of countries. From Table 2 we can see, for each series, that the joint unit root test fails to reject the null in levels.

Table 2
Unit root tests for saving and investment : levels

Panel (test in level)	Test statistic
Saving	-3.17
Investment	-3.19

* means that the null hypothesis is rejected at the level of 1% significance.

Since investment and saving are both I(1), the next step is to verify if both are cointegrated. There are two different approaches for the cointegration tests for panel data. The first one, developed by Pedroni (1995,1999), considers as a null hypothesis the non-cointegration between the series and uses the residuals of the panel to build the test, in analogy to Engle and Granger (1987). The second one, proposed by McCoskey and Kao (1998), takes cointegration between the series as the null hypothesis[8].

Once the panel cointegration tests in Pedroni (1995,1999) allow cointegrating vectors to be heteregeneous accross different members of the panel, we exploit this approach to verify if investment and saving cointegrate. The method uses the residuals, generated by ordinary least square (OLS), of the cointegration equation given by (4), the more general case, and creates statistics to test the null hypothesis of non-cointegration.

$$y_{it} = \alpha_i + \delta_i t + X'_{it}\beta_i + \varepsilon_{it}, \qquad i = 1, ..., N, \; t = 1, ..., T \tag{4.1}$$

where $\beta_i = (\beta_{1i}, \beta_{2i}, ..., \beta_{Mi})'$, $X_{it} = (x_{1it}, x_{2it}, ..., x_{Mit})'$ and ε_{it} are the residuals.

This set up allows a high degree of heterogeneity in the panel, that is, different slope coefficients (β_i), fixed effects (α_i), and deterministic trends (δ_i) for each country .

Pedroni (1999) constructs 7 statistics of panel cointegration: panel v, panel rho, panel pp, panel adf, group rho, group pp, group adf. The first four are denominated "within dimension" statistics and the last three "between-dimension" statistics[9]. Pedroni refers to the "within dimension" statistics as panel cointegration statistics, and the "between dimension" statsitics as group mean panel cointegration statistics[10].

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[7] The expected values and variances of the ADF statistic are in IPS (1997). They show that this test has substantially more power than the usual ADF tests.

[8] The objective of the cointegration test proposed by Pedroni (1995,1999) is simply to verify whether a set of variables cointegrate or not. Though aware that the cointegration vector may not be unique, the issue of how many cointegration relationships exist is not answered. The researcher must have in mind a particular normalization among the variables and then test whether there is cointegration among the variables.

[9] The "within dimension" statistics are constructed by summing separately the terms of the numerator and the denominator over N dimension, whereas the between-dimension statistics are constructed by first dividing the numerator by the denominator before summing over N dimension. Hence, the first category of statistics is based on estimators that effectively pool the auto-regressive coefficient across the different countries, while the second category is based simply on the average of the coefficients estimated for each country i.

[10] If we denote by ρ_i the auto-regressive coefficient of the residuals for the i-nth country ($\varepsilon_{it} = \rho_i \, \varepsilon_{it-1} + \mu_{it}$), then the first category of tests considers the following specification for the null and alternative hypotheses:

Ho : $\rho_i = 1$, for all i,

Ha: $\rho_i = \rho < 1$ for all i, that is, we presume a common value ρ for ρ_i.

The second category of tests considers:

The first three of the 4 *panel cointegration statistics* are versions for a panel of non-parametric statistics analogous to the non-parametric corrections of the Phillips-Perron test. The fourth is a parametric statistic analogous to the t statistic of the ADF test.

The first and the second statistics of *group mean panel cointegration statistics* are analogous to the rho and t statistics of Phillips-Perron. The third is analogous to the t statistic of the ADF test[11].

In order to test the cointegration between saving and investment, the seven panel statistics in Pedroni (1999) were calculated. All of them lead to the rejection at the level of 1% (Table 3) of the null hypothesis of non-cointegration.

Table 3
Cointegration tests between saving and investment – full panel

Panel cointegration statistics
Panel v = 93.324*
Panel rho = -70.767*
Panel pp = -15.118*
Adf Panel = -16.361*
Group mean Panel cointegration statistics
Rho Group = -80.019*
pp Group = -17.676*
Adf Group = -17.676*

* means that the null hypothesis is rejected at the level of significance of 1%.

The values of the statistics above are not adjusted by the mean and variance tabulated by Pedroni (1999). Under the alternative hypothesis, the right tail of the normal distribution is used to reject the null hypothesis for the v statistic, i.e., large and positive values for the v statistic lead to the rejection of the null hypothesis. For the other six statistics the inverse

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Ho : ρ_i =1, for all i,
Ha: ρ_i <1 for all i

[11] The finite sample distributions from the Monte Carlo simulations are in Pedroni (1999). Pedroni (1999) also shows that the size distortion of the tests is small with large temporal observations, as long as the moving average coefficients are positive. He also shows the high power of the tests in particular when there are more than 100 time observations.

occurs. Hence, very large negative values for the rho statistic and relative large negative values for the pp and adf statistics (in general the critical value at the level of 10% remains around –10) lead to the rejection of the null hypothesis of non-cointegration.

Since the hypothesis of non-cointegration between saving and investment has been rejected the next step is to check if the cointegrating vector is (1,-1)'.

A short-cut can be used to check if the cointegrating vector between saving and investment ratios is (1,-1)'. As observed before, if S/Y and I/Y are cointegrated with cointegrating vector (1,-1), the linear combination S/Y-I/Y will be I(0). Since the current account is by definition equal to the difference between saving and investment we can simply verify its stationarity in order to conclude that the cointegrating vector is (1,-1)'. Table 4 provides the results for the panel using this approach.

Table 4

Unit root tests for the current account balance – full panel

Panel (test in level)	Test statistic
Current Account	-8.51*

* means that the null hypothesis is rejected at the level of 1% significance.

Therefore, the test rejects the non-stationary for the current account, which means that saving and investment are cointegrated with vector (1,-1)'. This is the long-run solvency condition implied by the intertemporal models, and do not constitute evidence with respect to capital mobility. When developing countries are considered the Feldstein and Horioka regression captures only the behavior of the intertemporal budget constraint and is unable to measure capital mobility.

We repeated the same procedure above with different subsamples of countries to study if regional economic policies would change the empirical results we obtained for the whole sample.

Tables 5 summarizes that as in the whole sample, in Asia, Africa and Latin America, the test fails to reject the evidence of a unit root for both series in levels. Besides, as shown in the table 6, the null hypothesis of non-cointegration between saving and investment is also rejected for each of the subsamples. Finally, table 7 presents the unit root tests for the current account balance of the different regions. Unit root test rejects that the current account is a non-stationary variable for Asia, Africa, and Latin America. This is the long-run relation implied by the intertemporal models which assume perfect capital mobility.

Table 5

Unit root tests for saving and investment - different continents

Panel (test in level)	Asia	Africa	Latin America
Saving	-1.52	-2.29	-1.76
Investment	-1.76	-0.74	-2.80

* and ** means that the null hypothesis is rejected at the level of 1% and 5% significance.

Table 6

Cointegration tests between saving and investment – different continents

	Asia	Africa	Latin America
Panel cointegration statistics			
Panel v	50.300*	46.167*	66.422*
Panel rho	-43.591*	-32.075*	-45.543*
Panel pp	-9.083*	-7.240*	-9.655*
Adf panel	-9.986*	-8.101*	-10.165*
Group mean panel cointegration statistics			
Rho group	-45.112*	-37.804**	-54.311*
Pp Group	-9.147*	-7.814**	-10.487*
Adf Group	-9.639*	-9.586*	-11.357*

* and ** means that the null hypothesis is rejected at the level of significance of 1% and 5%, respectively.

Table 7

Unit root tests for the current account balance – different continents

Panel (test in level)	Test statistic
Asia	-8.70*
Africa	-4.06*
Latin America	-7.11*

* means that the null hypothesis is rejected at the level of 1% significance

Finally, in order to verify if the movement to more flexible exchange rates and the general liberalization of financial markets in the middle of the 70s affected capital mobility, we run separate regressions for the 1960-74 and 1975-96 periods. The integrated order of both series based on the results of the unit root tests in level and in first difference are presented in Table 8.

Table 8

Unit root tests for saving and investment – 1960-74 and 1975-96

		1960-74	1975-96
Asia	Saving	I(1)	I(0)
	Investment	I(1)	I(0)
Africa	Saving	I(1)	I(1)
	Investment	I(1)	I(1)
Latin America	Saving	I(1)	I(0)
	Investment	I(1)	I(0)
Full sample	Saving	I(1)	I(0)
	Investment	I(1)	I(0)

We observe that for the first part of the sample, investment and saving, for each of the continents and as well as for the full sample, appear to have one unit root and are of integrated order one I(1). For the second part of the sample the results are mixed. In the case where saving and investment are stationary, we can conclude that the current account, their difference, is stationary. In the cases where saving and investment are integrated of order one I(1) we proceed by doing the cointegration tests. As it can be observed in table 9, except for Asia and Africa during 1960-74, the results indicate that it is the long-run relation implied by the intertemporal models which is being captured.

Table 9

Results for the subsamples

	1960-74	1975-96
Asia	S and I do not cointegrate	CA is stationary
Africa	S and I do not cointegrate	S and I cointegrate
Latin America	S and I cointegrate	CA is stationary
Full sample	S and I cointegrate	CA is stationary

5. Measuring capital mobility

As observed before, given that saving and investment ratios are connected by the intertemporal budget constraint, in steady-state, I/Y-S/Y or the current account balance is in long-run equilibrium. Consequently, the dynamics of saving and investment are only temporary. Therefore, an error correction model would be the best way to treat the Feldstein and Horioka equation since it is a dynamic equation with a steady-state solution compatible with equilibrium (Jansen (1996), Jansen and Schulze(1996b)). Suppose the following specification established by Jansen:

$$\Delta(I/Y)_t = \alpha + \beta\Delta(S/Y)_t + \gamma[(S/Y)_{t-1} - (I/Y)_{t-1}] + \delta(S/Y)_{t-1} + \varepsilon_t \qquad (5.1)$$

where ε is a well-behaved error term.

The error correction term $(S/Y)_{t-1} - (I/Y)_{t-1}$ captures the long-run relationship. If $\gamma \neq 0$ saving and investment are cointegrated and the cointegrating (long-run) relationship is given by :

$$\alpha + \gamma[(\overline{S/Y}) - (\overline{I/Y})] + \delta(\overline{S/Y}) = 0 \qquad (5.2)$$

The cointegrating vector is $(1+\delta/\gamma, -1)'$.

If $\delta = 0$, the current account balance (equal to saving minus investment) is a stationary variable around $-\alpha/\gamma$. The current account fluctuates around zero if $\alpha = \delta = 0$.[12]

The relevant saving-investment correlation is the short-run correlation. It is defined between the changes of saving and investment rations, and it is measured by β.[13]

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[12] Equation (2.2) can be obtained from equation (4.1) if $\beta - \delta = 1$ and $\gamma = 1$. As observed before it is, however, a static equation and it can not capture the saving-investment dynamics properly since it does not take into account the dynamic adjustment process. Equation (2.3) can be obtained from equation (4.2) if $\gamma = \delta = 0$. As also pointed out before it is correctly specified only if saving and investment are not cointegrated. Equation (4.1) also takes into account the long-run relationship between saving and investment captured by the cointegration tests of capital mobility. It is in this sense that Jansen (1996) and Jansen and Schulze (1996) claim that the error correction model can be seen as a synthesis of the different approaches used in the literature. We, on the other hand, follow the literature on external solvency and take the stationarity of the current account as evidence of intertemporal balance. Therefore, only when saving and investment are not cointegrated with vector (1,-1)' there is evidence in favor of capital mobility.

[13] Jansen (1996) and Jansen and Schulze (1996) suggests the following steps to detect capital mobility using an error correction model :

1) non-rejection of $\gamma = 0$ implies that saving and investment are not cointegrated. This constitutes evidence of capital mobility according to the Feldstein and Horioka criterion since saving and investment are not correlated. If γ is actually equal to zero it is not necessary to learn about β and δ.
2) Rejection of $\gamma = 0$ implies that there is a long-run relationship between saving and investment. The estimate of δ will determine the type of this relationship. If $\delta = 0$, the current account (saving minus investment) is a constant in the long-run ($-\alpha/\gamma$), or in other terms, the current account is stationary, evolving around $-\alpha/\gamma$." This result is implied by intertemporal general equilibrium models which explicitly assume perfect international capital mobility". Therefore this results does not allow any conclusion with respect the degree of capital mobility. If $\delta \neq 0$, saving and investment are not cointegrated with vector (1,-1)' but with vector $(1+\delta/\gamma, -1)'$. The current account balance, therefore, is a non- stationary variable and there is evidence in favor of capital mobility.
3) If there is cointegration ($\gamma \neq 0$) and $\delta = 0$ the next step is to estimate the short run correlation , β.This is the parameter that has traditionally been estimated in the literature.

As pointed out by Jansen and Schulze (1996), although an error correction model is able to distinguish between the long run correlation which reflects the intertemporal budget constraint , and the short run correlation , which serve as an indicator of capital mobility, sometimes it can not give a definite answer. As discussed before, high positive correlations between saving and investment can be observed even if capital is fully mobile. Therefore, without additional information, it is not possible to establish with certainty if a high correlation is due to low capital mobility, business cycles, imperfectly integrated good markets, etc… On the other hand, small positive, zero, and negative correlations indicate unambiguously that there is capital mobility. “Without additional information, the saving-investment can only be used to reject the hypothesis of capital immobility. When the saving-investment correlation is high, meaningful conjectures about capital mobility can be derived only by consulting further sources of information. For instance, zero return differentials and the absence of institutional rigidities point to substantial capital mobility. Strict capital controls lead to the reasonable suspicion of restricted capital mobility: still we do not know to what extent the low degree of capital mobility is responsible for the high correlation” (p.123).

6. Conclusions

Feldstein and Horioka (1980) used the saving-investment correlation to evaluate the degree of capital mobility. In the original data sample they examined cross-section regressions of investment on saving yielded slope coefficients near unity, indicating that capital mobility was low in OECD countries. Coefficients close to unity were found for other samples and periods of time. A high coefficient, although smaller than the one found for developed countries, was also systematically found for developing countries.

We, however, believe that the cross-section regression in fact measures the average long-run coefficient and, therefore, it is capturing the unit coefficient implied by the solvency/sustainability transversality condition. We share, then, the points of view of Sinn (1992) and Coakley et al. (1996). If we turn to the theoretical intertemporal models, we will see that they all require a solvency constraint and as the same time they assume perfect capital mobility. If we turn to the empirical literature on tests of external sustentability we see that the solvency constraint requires that the current account be stationary since the country can not play a Ponzi game with its debt. Since the current account equals saving minus investment, saving and investment rates should cointegrate with a unit coefficient.

In order to increase the power of the standard unit roots and cointegration tests we exploit the panel structure of the sample of 29 developing countries over the period 1960-96. Saving and investment ratios appear to be I(1), and cointegrate with a unity coefficient. The current account is, therefore, I(0). It is the long-run solvency rather than the degree of capital mobility that the Feldstein and Horioka cross-section regression is, in fact, measuring. We also use the data to evaluate if the results are sensitive to the sample. We work, then with two samples (1960-74 and 1975-96), given the belief that after the mid 70s the degree of capital mobility increased. The results, in general, are the same. It is not possible to reject that the current account is a non-stationary variable. This, again, is the long-run relation implied by the intertemporal models. Finally, the results are robust to different samples of country. For Latin American, African, and Asian countries all the results are the same.

As observed by Jansen (1996) and Jansen and Schulze (1996), an error correction model is the natural specification to measure capital mobility since both long run (solvency) and short run (mobility) dynamics are simultaneously estimated. So far we have showed that the Feldstein and Horioka regression captures the long-run solvency condition and not some measure of capital mobility. The next step would be to verify what can be said about capital mobility in developing countries when the solvency constraint is taken explicitly into account.

7. References

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Appendix :

As can be seen in Table A.1 25 countries out of the 36 in the sample the gap between saving and investment ratios is less than 5% of GNP. A good example to illustrate this point is Chile. An huge rise in the current deficit in 1981 was observed, followed by an even faster decline of the deficit in 1983. In fact, within two years from a deficit of 10% of GNP the current account balance moves to a surplus of almost 3% of GDP. From Table A.1, however, it can be observed that the gap between saving and investment rates when averaged data is considered is only 0.2%.

Table A.1

Time-averaged saving and investment ratios

Countries	S/Y	I/Y	Difference
Argentina	21.7	22.8	1.1
Botswana	27.1	24.9	2.2
Brazil	21.0	21.4	0.4
Chile	19.8	19.6	0.2
Colombia	18.8	19.2	0.4
Ecuador	20.0	19.1	0.9
Egypt	21.8	13.0	8.8
El Salvador	15.9	10.2	5.7
Ghana	12.4	8.00	4.4
Guatemala	14.2	11.0	3.2
Honduras	20.6	16.4	4.2
Hong Kong	23.9	28.4	4.5
India	20.5	18.7	1.8
Indonesia	21.4	23.3	1.9
Israel	23.1	13.1	10
Jamaica	27.2	21.8	5.4
Korea	27.6	23.3	4.3
Malawi	18.9	7.50	11.4
Malaysia	27.3	30.3	3
Mexico	21.0	20.5	0.5
Morocco	19.9	13.9	6
Nigeria	17.8	17.6	0.2

Pakistan	17.7	10.5	5.2
Paraguay	20.7	16.9	3.8
Phillipines	22.9	20.5	2.4
Senegal	13.6	6.5	7.1
Singapore	34.3	26.9	7.4
Thailand	28.3	24.9	3.4
Venezuela	24.8	30.9	6.1