Quantifyng capital mobility in OECD and EU areas

Par:

Sanda Petruta LORINT

Département des Sciences Economiques
Faculté des Arts et des Sciences

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Section I - Introduction

Under perfect capital mobility, the investment of a country should not be linked to the size of its saving pool. Despite widespread belief that international financial markets are highly integrated, Feldstein and Horioka (1980) showed that a country's ratio of investment to GDP is highly related to its ratio for saving to GDP. Using a regression of average investment on average saving ratios for industrialized countries, they found a coefficient of 0.89 instead of the expected coefficient close to zero.

The object of this study is to provide a quantitative measure of the evolution of international capital mobility throughout the OECD-minus (i.e. all OECD countries except Mexico, Turkey, Korea, Central European countries) and EU areas.

More specifically, the correlation between OECD minus and EU investment and saving rates from 1975 to 2003 will be analyzed in a context a panel data to get an indication of how capital mobility has developed.

We will analyze the evolution of the capital mobility coefficient in a context of inter-temporal optimization models of current account dynamics where the budget constraint will induce high degrees of positive co-movement in the levels of saving and investment.

Inspired by the work of Pedroni, the FMOLS approach will enable us to get appropriate estimates in a context of cointegration relationship which exist between investment and saving rates in both areas.

Intuitively, we would expect that in special in EU area to find well integrated capital markets and gradually, increasing capital mobility.

Our investigation throughout the OECD-minus and EU areas provides indicators which confirm that the coefficient diminishes in time and we find capital mobility to be relatively high in special during 1990-2003 and we could conclude that the Feldstein-Horioka Puzzle is not as bad as we think.

The paper is structured as follows: Section II provides an overview of the importance of capital mobility in economic theory, as well an exposition of the Feldstein-Horioka Puzzle. Section III evaluates previous work on the issue of capital mobility. Section IV presents data. Section V presents the methodology and the econometric results of our tests, followed by some concluding remarks in Section VI.

Section II - The importance of capital mobility and the Feldstein-Horioka Puzzle

The importance of capital mobility in international macroeconomics cannot be underestimated. According to neoclassical theory, the marginal productivity of capital is inversely related to the scarcity of this factor of productivity, making the most profitable areas for investment those regions where capital is relatively rare. Under the condition of perfect capital mobility, capital is allocated to the various region of the world in such a manner as to have an equalization of returns of investment.

The hypothesis of perfect capital mobility forms the basis of most theoretical work and modeling in particular the standard neo-classic intertemporal current account model.

International consumption smoothing adequately explains temporary changes in a country's current account only if perfect capital mobility is assumed. The degree of international capital mobility plays an essential role in standard Keynesian Theory (for example, in the open economy Mundell-Fleming model) as well as in neo-keynesian developments (in overshooting model, for instance).

Interest in the quantification of capital mobility began with the seminal article by Feldstein and Horioka (1980) which was the first analysis of the correlation between the gross national saving rate and the domestic investment rate. The authors proposed that perfect capital mobility implied a zero correlation between investment and saving rates. Such a correlation would indicate that domestic investment no longer had to depend on national pool of capital. Likewise, a zero correlation meant that national savings was no longer limited by domestic investment opportunities and could be placed in international markets.

Economists have long been interested in empirical tests of international capital mobility (also referred to as the degree of international financial integration). The issue whether actual or incipient flows of private capital can effectively perform arbitrage functions between domestic and foreign financial assets has significant implications for policy making in developing and developed countries.

Effectiveness of various stabilization policies such as the effects of devaluation on output and prices; the outcome of monetary policy in influencing aggregate demand and prices; and the extent to which expansionary fiscal policy can crowd out private investment depend on the relationship between domestic and international financial markets. The

general belief is that capital mobility has increased in recent years on account of widespread financial sector reforms and the opening up of the capital account to private capital inflows.

The evaluation of the degree of capital mobility is broadly classifiable into two categories - the quantity approach and the price approach.

The quantity approach literature questions whether shocks to investment are constrained by local supply of capital, or whether they are met by the global supply of capital. The degree of capital mobility can be assessed by analyzing saving-investment correlation.

Another variant of the quantity approach, is the consumption-smoothing approach, which examines whether shocks to income are adequately smoothed away i.e., whether international risk-sharing works.

The other alternative is to use the price approach, which examines whether rates of return are equalized between countries as a measure of capital mobility.

In this paper, capital mobility is evaluated using the quantity criteria pertaining to the relationship between savings and investment. The analysis is based on a procedure in Feldstein and Horioka (1980).

In 1980, Feldstein and Horioka published a work named "Domestic saving and international capital flows". Using data from 1960-1974 for the OECD's countries and regressing savings rates and investment rates they "find" that all of incremental saving remains in the country of origin. Feldstein and Horioka are using an average for each country and no a panel.

They run the following regression:

$$\left(I/Y\right)_{it} = \alpha + \beta \left(S/Y\right)_{it} + \varepsilon_{it}$$

$\left(I/Y\right)_{it}$ and $\left(S/Y\right)_{it}$ are ratios of investment and saving to GDP in country i and year t.

It is important to note that throughout our investigation, investment and saving will always be expressed as percentage of GDP. Thus, economic growth is incorporated into our analysis and we avoid the ludicrous situation of having to assume that long run absolute values of I, S and GDP are constant in the long-run.

The β used here is the "between" estimator which permit to capture the relation of long term between saving and investment.
The value of β closed to zero implied perfect world capital mobility. In contrast, estimates of β close to one would indicate that most of the incremental saving in each country has remained there.

The coefficient β of the F-H regression was 0.89.

They interpret as incompatible with the assumption of complete arbitrage in a perfect world capital market.

They sustained their point by three conclusions:

- First, the uncertainties and risks associated with foreign investment restricted the investment to the domestic country
- Second, the full mobility of capital would be impeded by official restrictions on the export of capital
- Third, important institutional rigidities tend to keep a large segment of domestic saving at home

Section III - The review of the literature

O. Blanchard and F. Giavazzi (2002) in their paper "Current Account Deficits in the Euro Area. The End of the Feldstein-Horioka Puzzle?" show that the correlation saving-investment declined over time, especially within Euro area.

Taking in consideration the case of Portugal and Greece, two of the poorest members of EMU, these countries run large current account deficits.

First, they run the Feldstein-Horioka original regression (a cross-section regression at each period) for the period 1975-2001. Their result for OECD as whole is 0.58 with no evidence of a decline in the coefficient over time.

In a second time, they ran the following regression using time-varying parameters:

$$\left(I/Y\right)_{it} = \alpha_t + \beta_t \left(S/Y\right)_{it} + \varepsilon_{it}$$

allowing for both years effects and year-specific coefficients on saving.

They also ran the same regression for the EURO (the countries which have been adopted EURO as common currency), EURO-minus (the EURO area without Portugal and Greece) and also for the Union European (EU in short) area.

The estimated coefficients are close to zero or are negative at the end of 1990's.

The follow graphs are a reproduction after Blanchard's and Giavazzi' work. The graphs plot the time series for estimated β_t for the EU, EURO and EURO-minus area.

Graph 1 - Estimated Feldstein Horioka coefficients for EU, 1975 - 2001
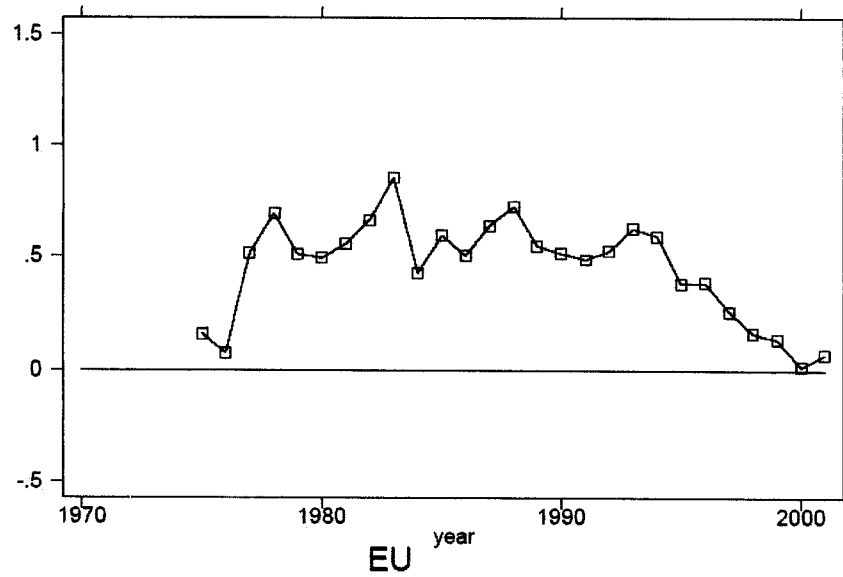
Graph 2 - Estimated Feldstein Horioka coefficients for EURO, 1975 - 2001

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Graph 3 - Estimated Feldstein Horioka coefficients for EURO-minus, 1975 - 2001

The coefficients for the EU area show an inverse U shape, with the coefficient initially increasing from a value close to zero in 1975 to a higher value, and then steadily declining from the late 1980's.

The third graph, which shows the coefficient for EURO-minus, does not exhibit the low value of the coefficient at the start, and so 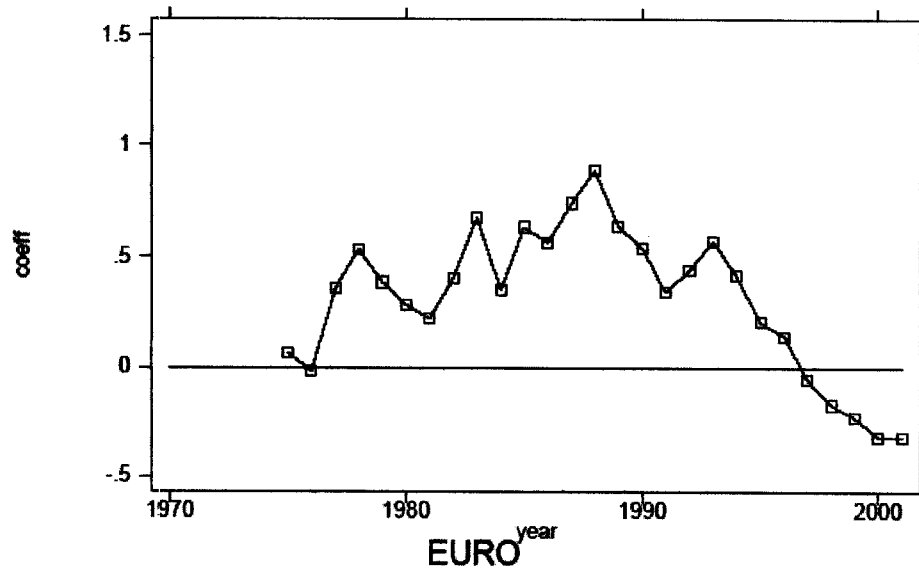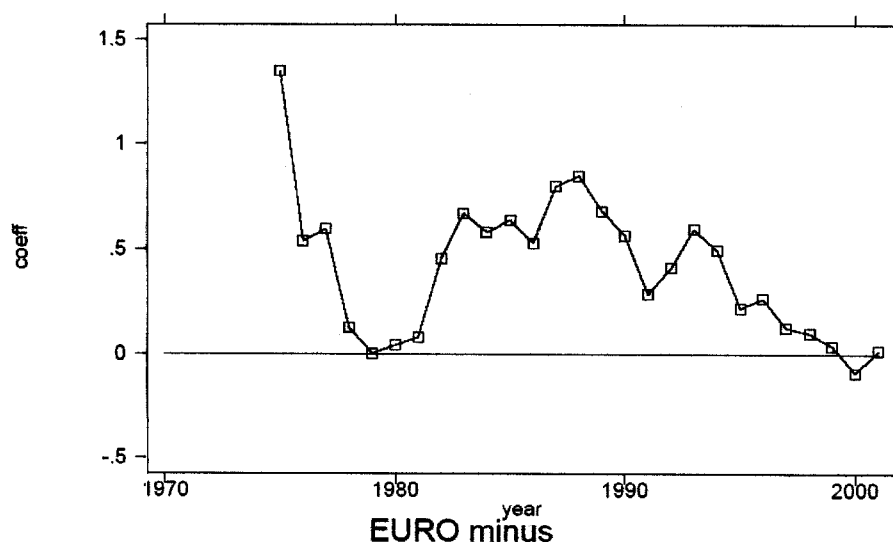indicates that the low initial value in the other panels comes again from the experience of Portugal and Greece in the late 1970's and early 1980's.

In short, for the countries of the European Union there is no longer appears to be a Feldstein-Horioka Puzzle.

Based on the fact that the error term ε_{it} contains the common factors and that is correlated with the regressors, D.Gianone and M.Lenza (2002) controlling for co-movements generated by global factors in the savings-investment regressions find that the F-H Puzzle is to be de-emphasized as the saving-retention coefficient considerably decreases in a panel regression for OECD countries and the saving-retention coefficient seems to decline over time becoming not significant in the 1990's.
Co-movement can be measured as the variance of the panel explained by some aggregates. They interpret this finding as a consequence of increased integration in OECD countries.

Several studies have highlighted the presence of endogenous macroeconomic factors which produce co-movements in saving and investment. Among the varying explanations for the observed correlation, the most significant include current account targeting, offsetting capital flows and common productivity shocks.

There would be a high correlation between saving and investment even in the presence of international capital mobility if any of the above plausible macroeconomic factors held. Current account targeting, if successful, would produce a strong saving-investment relationship even with a high degree of capital mobility.

Obstfeld and Rogoff (1995) have pointed out possible mechanisms to explain the co-movement of savings and investment.
Since both investment and savings are functions of the state of the business cycle there is a reason to believe that temporary real shocks such as total productivity shocks that are sufficiently persistent can cause a high saving-investment correlation.

Further support for the current account targeting argument comes from Sachs (1981, 1983). Feldstein-Horioka type analysis is justified on the basis of the argument that a transitory increase in savings is likely to stay at home since it is not worth incurring the costs of analyzing foreign investment opportunities or evading foreign exchange controls. On the other hand, a permanent increase in saving is more likely to flow abroad. The Feldstein-Horioka result suggests the opposite and is often stressed as support for the current account targeting explanation of the Feldstein-Horioka Puzzle.

In inter-temporal optimization model of current account dynamics, the budget constraint will induce high degrees of positive co-movement in the level of savings and investment and the two variables are likely to be co-integrated.

Given the generally assumption of perfect capital mobility, several economists have questioned the interpretation of Feldstein's and Horioka's empirical results and highlighted several econometric problems with their model. Murphy (1994) suggests that Feldstein and Horioka appear to have confused two assumptions commonly used together in international macroeconomic modeling: the assumption of capital mobility and that of a small country.
He concludes that the correlation is related to the size of the country, large countries show higher correlations than small countries.

Baxter & Crucini (1993) constructed a general equilibrium model where they related the size of the country, domestic saving, investment and an adjustment cost to avoid great oscillations in the national capital stock.
First, they found positive correlations between savings and investment which become higher for larger countries.
Second, they explored the links between output, investment and current account. They consider that Feldstein-Horioka Puzzle is not a puzzle at all.

Other recent researches tried to put in evidence the importance of heterogeneity on panel data. S.Maveyraud-Tricoire (2003) carries out a selection of the Feldstein-Horioka estimators on panel-data. He finds that the European countries are heterogeneous because the levels of development are different. But the mobility of the capital and the goods is strong because we observe a catch-up of the countries the least developed zone (Greece, Portugal) towards the most developed countries.

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In another study J.Coakley, A.Fuertes and F.Spagnolo (2001) employ the Pesaran and Smith (1995) MG (Mean Group) approach to reassess the long-run saving-investment association in a panel framework which accommodates both permanent current account shocks and heterogeneity across countries.

The MG slope estimator provides a measure of the average long-run saving-investment association in the Feldstein-Horioka framework.

They found that the MG estimator yields a slope consistent with the long-run capital mobility overturning the evidence from the between estimator. This supports the hypothesis of long-run capital mobility.

Several studies based on time series and using other econometric techniques like ECM (Error Correction Model) tried to make a separation between the short-run and the long-run dynamics of the saving investment relationship.

The short-run and long-run dynamics of the saving investment relationship are estimated in an error correction model because the procedure enables us to capture the dynamics of the saving-investment relationship and the current account.

A.M.Taylor (2000) in his paper "A Century of Current Account Dynamics" examines capital mobility using time-series analysis of current-account dynamics for fifteen countries since 1850.

He develops an applied LRBC (Long-Run Budget Constraint) framework for studying current account dynamics as a tool for assessing capital mobility in a comparative historical setting. He uses an econometric estimation and simulation exercises applied to an ECM model:

$$\Delta\left(\frac{I}{Y}\right)_t = a_t^{ECM} + b_t^{ECM}\,\Delta\left(\frac{S}{Y}\right)_t + c_t^{ECM}\left[\left(\frac{S}{Y}\right)_{t-1} - \left(\frac{I}{Y}\right)_{t-1}\right] + \varepsilon_t$$

He suggests interpreting the coefficient b^{ECM} as a measure of short run capital mobility and c^{ECM} as a measure of long run capital mobility. Relate to b^{ECM} and c^{ECM}, he finds that the underlying dynamics of saving and investment in his historical sample tend to generate a strong relationship between current account persistence parameters, shock variances, and the estimated Feldstein-Horioka coefficient.

Section IV - Data

My data base is organized as follows:

- "OECD-minus", i.e. all OECD countries except Mexico, Turkey, Korea, Central European countries (The Czech Republic, Slovakia, Hungary, and Poland), and Luxembourg, 22 countries in all. The countries taken into consideration are France, Italy, Germany, New Zeeland, Iceland, Spain, Greece, Portugal, Belgium, Denmark, Ireland, Netherlands, Austria, Finland, Sweden, United Kingdom, USA, Japan, Canada, Switzerland, Norway and Australia. The reasons for removing those countries vary. The mechanisms behind the evolution of current account deficits in Mexico, Turkey, and Korea, three much poorer countries, are likely to be different from those in the richer OECD countries. Data for Central European countries only exist from 1990 on, so the countries cannot be used when constructing a balanced panel. And the economy of Luxembourg is highly idiosyncratic (Luxembourg reports consistent current account surpluses of the order of 30% of GDP). This selection comes from Blanchard's and Giavazzi's work

- "European Union" or EU for short, the group of European Union countries, again excluding Luxembourg, so 14 countries in all. The rationale for looking at this subgroup of OECD countries is obvious. If integration is the basic force behind the widening of current account balances, one would expect the effect of the Single Market to be much stronger for EU countries than for OECD countries in general. We are following the same choice like Blanchard and Giavazzi in their paper "Current Account Deficits in the Euro Area. The End of the Feldstein-Horioka Puzzle?"

- "EURO area", the countries which have been adopted EURO as common currency or Euro for short, the countries now in the Euro area, minus Luxembourg, so 11 countries in all. (Greece, which joined in 2001, is included throughout). The rationale for looking at this group is equally obvious. With the fixing of parities in 1999, and the shift to the Euro at the end of the 1990s, one would again expect the degree of integration to be stronger for Euro countries than for EU or a fortiori OECD country in general.

We use data from the European Commission database, called AMECO (which stands for "Annual Macroeconomic Database "). These are based on national income accounts and, post 1995, on the ESA95 EU accounting system.The annual data are taken for the period 1975-2003.

Section V - The methodology and the results

The findings are obviously closely related to the research triggered by the Feldstein-Horioka Puzzle - the high correlation between investment and saving rates, both across time and across countries. The findings of an increasing positive dependence of saving on income per capital and a negative dependence of investment on income per capital raise the possibility that this correlation has decreased through time.

With this in mind, we explore the relation between investment and saving across countries and time. We do so by running two sets of regressions.

First, we are running conventional Feldstein-Horioka regressions of investment on saving in levels, over different time periods.

Table 1 shows the estimated values for β, first from estimation over the whole period 1975-2003, then over two sub-periods 1975-1990 and 1991-2003.

Table 1 - Feldstein-Horioka coefficients, 1975-2003 and sub-periods

Period	OECD minus	EU	EURO
1975-2003	0.45924	0.43313	0.3624
1975-1990	0.55913	0.48061	0.4011
1991-2003	0.26485	0.33857	0.1325

Table 1 suggests like main conclusions:
- The coefficient of the original Feldstein-Horioka regression, run on a sample of 16 OECD countries over the period 1960-1974, was 0.89; the results, for the OECD-minus, give a coefficient of 0.46, with a small evidence of a decline in the coefficient over time. The decline is more evident if we compare the results across the period, from 0.56 (period 1975-1990) to 0.26 (period 1991-2003).

- As we move from OECD-minus to EU zone the decline presents less difference; but when we are running the same regression for EURO area we obtain 0.13 for the period 1991-2003; the coefficient declines, suggesting steadily higher degrees of integration

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To look at the evolution of the relation between investment and saving more closely, then we run the regression where we allow for both year effects and year-specific coefficients on saving.

The results are presented in the Graphs 4 and 5 (included on page 16) for EU and OECD-minus.

The coefficient for OECD-minus shows more of a steady decline over the 1990's; the coefficient at the end of the period is close to zero (and also negative).

For the EU area, the estimated coefficient is close to zero or negative at the end of the 1990's.

Graph 4 - Evolution of β_t for EU, 1975-2003

Years
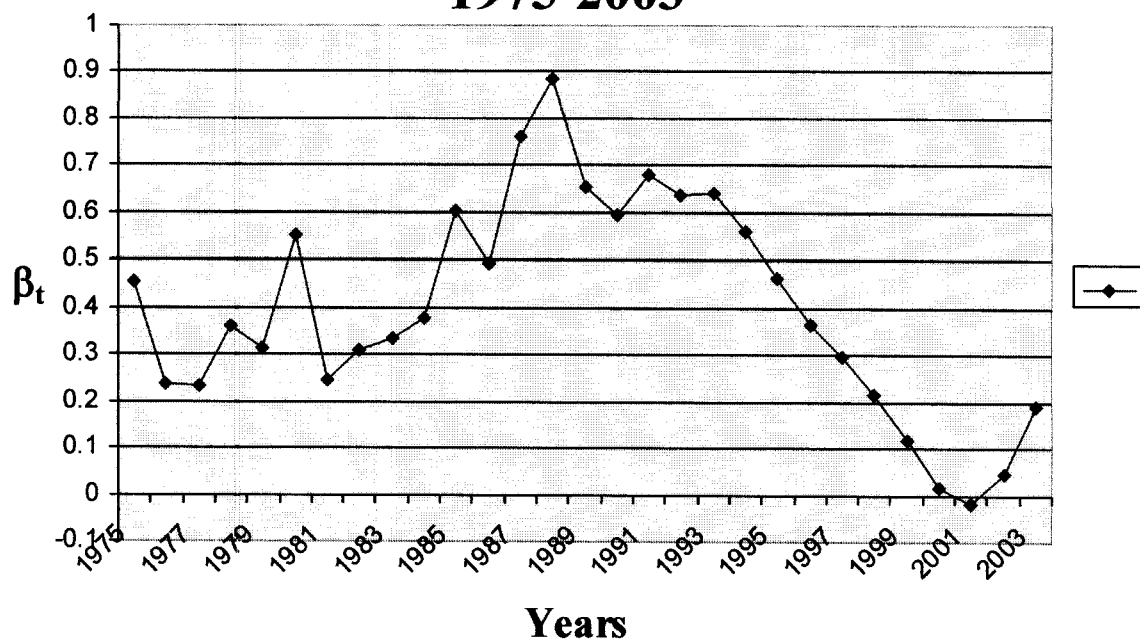
Graph 5 - Evolution of β_t for OECD-minus, 1975-2003

Years
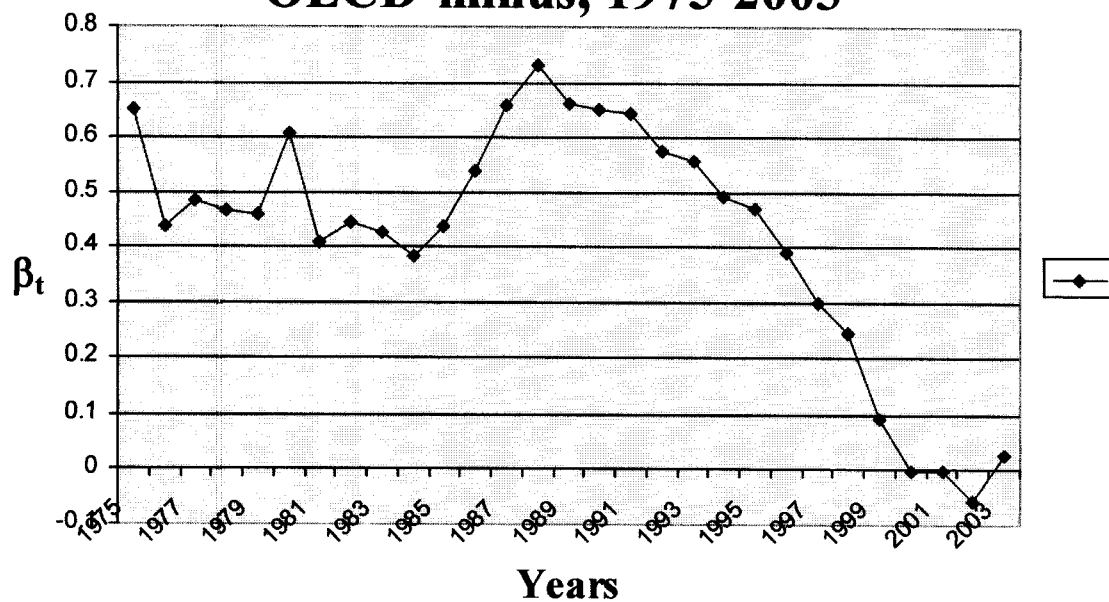
V.1. - Testing for Unit Roots in Time Series

The investigation of stationarity (or non-stationarity) in a time series is closely related to the tests for unit roots. Existence of unit roots in a series denotes non-stationarity. Numbers of alternative tests are available for testing whether a series is stationary.

First, we will consider the presence of panel data. The logic behind the use of a panel unit root test is to combine the information from time series with the information from cross-sectional units. The addition of cross-sectional variation to time series variation improves estimation efficiency, leading to smaller standard errors and, consequently, to higher t-ratios.

Second, we will treat each country individually, trying to detect the presence of unit root in each series I and S and to eliminate the countries which are stationary in panel data.(if the tests in panel data confirm at least that some countries are stationary).

We are interested in detecting the presence of unit root using recent advances in the econometrics of non-stationary dynamic panel methods.
We apply panel cointegration tests to guard against the spurious regression problem and to detect long-run relationship.

Evidence of long-run relationship is found for some countries, thus the problem of spurious regressions is ruled out allowing us to offer rigorous inference on the estimation of our variables.
The econometric methodology rests upon the panel data integration tests proposed by Im, Pesaran and Shin (IPS, 1997) and Levin, Lin and Chu (LLC, 1993).
Both tests rely on the augmented Dickey-Fuller (ADF-) principle.

$$\Delta x_{it} = (\varphi_i - 1)x_{it-1} + \mu_i + \beta_i t + \varepsilon_{it}$$

Where:

x_{it} - is the variable considered

ε_{it} - is a white noise process

The Levin-Lin-Chu approach (LLC test) absorbs the heterogeneity by the deterministic component and the dynamic. It is assumed that all panel elements have the same autoregressive parameter.

The most general specification, is designed to discriminate between a set of I (1) processes with drift under the null and a set of trend-stationary processes under the alternative.

The cross-section average at t is subtracted from the data, which is equivalent to the introduction of time specific dummy variables. The reason is to eliminate the cross sectional dependence.

The cross-sectional independence assumption was a key assumption for the asymptotic normality of the unit root tests statistics studied till now. Other approaches have been developed. **The second generation panel unit root** tests relax the cross-sectional independence assumption. The results must be carefully interpreted. The results strongly depend on the specification of the model and the method used to eliminate the cross-sectional correlations.

A recent research (2004) made by A. Banerjee and P. Zanghieri in the same field (Feldstein-Horioka Puzzle) using the method of principal components (Bai and Ng 2004) support the idea that the series for the ratio of investment and the ratio of saving are I(1) for OECD et EU.

Under the null-hypothesis the regression t-statistic t_δ, properly centered and resealed is asymptotically normal, so that, in general:

$$t_\delta^* = \frac{t_\delta - N\overline{T}\hat{S}_N \hat{\sigma}_\varepsilon^{-2} SE\left(\hat{\delta}\right)\mu_{mT}^*}{\sigma_{mT}^*} \rightarrow N(0,1) \text{ under } H_o^{(m)}$$

Where the standard error of $SE\left(\hat{\delta}\right)$ is $\hat{\delta}$, the standard error of the regression (3) is $\hat{\sigma}_\varepsilon$; μ_{mT}^* and σ_{mT}^* are necessary adjustments for the mean and the standard deviation which depend on the included deterministic components and t.
And also $m = 1$ or 2 which represent the model chosen.

If the joint null-hypothesis $\delta_1 = \ldots\ldots = \delta_N$ is rejected, usually it is concluded that all elements are stationary.
However, the test is consistent even if only some series are stationary.
The test's null-hypothesis should be carefully considered. It will be violated if even one of the series in the panel is stationary. A rejection should thus not be taken to indicate that each of the series is stationary.
The results obtained are presented in the Tables 2 and 3 (table 3 included on the page 18). The critical value at 5% level is -1.65.

Table 2 - Results of LLC test for OECD-minus

t-star	trend	no-trend
I/Y	-3.59112	-4.16053
S/Y	-2.51749	-2.76092

Table 3 - Results of LLC test for EU

t-star	trend	no-trend
I/Y	-2.10443	-2.71024
S/Y	-2.57299	-2.48015

We strongly reject the presence of common unit root at 5% level. We could conclude that at least some from the series are stationary.

The Im-Pesaran-Shin (IPS henceforth) test allows an individual dynamic structure in the test regressions. The IPS tests extended the LLC framework by allowing for a mixture of stationary and non-stationary series under the alternative hypothesis.

The test is defined for models 1 and 2 (like LLC) and the alternative is modified to:

$$H_1^{(IPS)} = \rho_i < 0; \ \forall i = 1,2,......N_1$$

$$\rho_i = 0, \ \forall i = N_1 + 1,.........,N$$

IPS suggests a group mean Lagrange Multiplier (LM) test based on the individual ADF t-values. The test statistic is the average of the individual ADF test statistics, which has to be normalized.

These normalizations values are determined by stochastic simulations. The normalized test statistics of both approaches converge to standard normal distribution, if the panel elements are independent. In simulation done by authors the t- test outperforms the LM test slightly. According to the ADF lag order chosen in each section and the length T, adjustments are necessary to the mean and variance.

The number of lags is chosen using Akaike Information Criterion (AIC) and also Schwartz Information Criterion (SIC).

The test statistics becomes:

$$\Psi_t = \frac{\sqrt{N\left\{\bar{t}_{N,T} - \frac{1}{N}\sum_{i=1}^{N} E\left[t_{i,T}(L_i,0)|\rho_i = 0\right]\right\}}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} Var\left[t_{i,T}(L_i,0)|\rho_i = 0\right]}} \approx N(0,1) \text{ under } H_o^{(IPS)}$$

The alternative hypothesis of the test approach is that at least one panel element is stationary.
The adjustments $E[....]$ and $Var[.....]$ are tabulated in the paper.

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The expression $\bar{t}_{N,T} = \frac{1}{N}\sum_{i=1}^{N} t_{i,T}(L_i, \theta_i)$ is the mean of the actual ADF test statistics.

IPS also suggests the inclusion of time specific effects in the regression or, alternatively, the demeaning of the panel at each t. Note, however, that in contrast to LLC, the IPS-test uses an average of t-statistics and not a single estimated t-value from the pooled series. The test proposed by Im, Pesaran and Shin permits to solve Levin's and Lin's serial correlation problem in assuming heterogeneity between units in a dynamic panel framework.

The test's null-hypothesis should be carefully considered. It will be violated if even one of the series in the panel is stationary. A rejection should thus not be taken to indicate that each of the series is stationary.

IPS (1997) showed that their test has a higher power than the Levin-Lin-Chu method. The results obtained are presented in the Tables 4 and 5. The critical value at 5% level is -1.65.

Table 4 - Results of IPS test for OECD-minus

t-star	trend	no-trend
I/Y	-2.755	-2.407
S/Y	-2.506	-2.153

Table 5 - Results of IPS test for EU

t-star	trend	no-trend
I/Y	-2.749	-2.503
S/Y	-2.645	-2.251

In both cases, we reject the presence of unit root at 5% level. We could conclude that at least some from the series are stationary.
The existing panel procedures, LLC and IPS, are, in general, based on the assumption that the series that make up the panel are independent of each other, which, of course, is hardly a realistic assumption to make where investment and saving ratios are concerned.

In panel data, Taylor and Sarno (1998) use the Two-Step Estimated GLS (EGLS) procedure to estimate the system of equations are I(1) and test the joint null hypothesis using the Wald-Statistic, which they call the Multivariate ADF (MADF) statistic.
Mad-Fuller performs the multivariate augmented Dickey-Fuller panel unit root test on a variable that contains both cross-section and time-series components.

The test applies Zellner's seemingly unrelated equation estimator to N equations, defined for the N units of the panel. Each equation is specified as a k-th order auto regression. The test involves testing the hypothesis, for each equation, that the sum of the coefficients of the autoregressive polynomial is unity.

The null-hypothesis consists of the joint test that this condition is satisfied over the N equations. Under the null-hypothesis, all of the series under consideration are realizations of I(1), or non-stationary, stochastic processes.

The test's null-hypothesis should be carefully considered. It will be violated if even one of the series in the panel is stationary. A rejection should thus not be taken to indicate that each of the series is stationary.

The Table 6 presents the results for OECD-Minus and EU.

Table 6 - Results of MADF tests

	I/Y	S/Y
OECD minus	302.093	491.515
EU	109.198	96.638

The critical value at 5% level derived by Taylor and Sarno from Monte Carlo simulation is 28.150. We could conclude that at least one from the series is stationary.

Secondly, because the tests in panel data confirm that at least one from the series is stationary, we will treat each country individually, trying to detect the presence of unit root in each series I and S and to eliminate the countries which are stationary in panel data.

Our database includes 22 countries.

We used the Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) to choose the number of lag.

We are applying the two tests: one of Phillips-Perron and also the Augmented Dickey-Fueller for 44 variables. The approach of Phillips-Perron is primarily based on Phillip's Z-tests. The latter test involves transforming the test statistic to eliminate any autocorrelation in the model.

These Z-statistic based tests are non-parametric in nature because no parametric specification of the error process is involved in designing the tests.
Given the overwhelming evidence of heteroskedasticity and non-normality in the raw time-series data, Phillips-Perron tests have gained significant popularity among modern scholars in the literature.

The results are present in the Table 7 (page 21) (no time trend).

Table 7 – Results of Phillips - Perron test on individual data

Countries	I/Y	S/Y
Greece	-2.935***	-3.327***
Portugal	-3.278***	-3.820***
Belgium	-2.124	-0.892
Denmark	-3.202***	-1.846
Germany	-1.871	-1.507
Spain	-3.284***	-2.164
France	-2.237	-3.032***
Ireland	-1.729	-1.471
Italy	-1.665	-1.792
Netherlands	-2.676***	-2.149
Austria	-2.265	-1.619
Finland	-1.514	-2.578
Sweden	-2.601	-3.462***
UK	-3.650***	-1.746
USA	-2.259	-0.812
Japan	-1.388	-0.721
Canada	-2.212	-2.139
Switzerland	-2.161	-1.994
Norway	-2.509	-2.374
Iceland	-2.196	-2.394
Australia	-2.529	-2.760***
New Zeeland	-2.725***	-2.861***

Note:

- the critical value at 10% level is -2.628
- in case of ***, we reject the presence of unit root at 10 % level

We fail to reject the presence of the unit root for the ratio of investment in case of 15 variables and for the ratio of saving in case of 16 variables at 10% level.

We reject the presence of the unit root in case of 7 variables at 10% level (for the ratio of investment) and for 6 variables at 10% level in case of the ratio of saving.

The approach of Augmented Dickey-Fuller tests the null-hypothesis of a unit root running the regression:

$$\Delta y_t \text{ on } y_{t-1}, \Delta y_{t-1}, \ldots, \Delta y_{t-p}$$

The inclusion of the lagged changes is intended to clean up any serial correlation in Δy_{t-p}.

The results are presented in the Table 8 (no time trend).

Table 8 – Results of ADF test on individual data

Countries	I/Y	S/Y
Greece	-2.338	-2.176
Portugal	-2.143	-2.776[***]
Belgium	-1.851	-0.954
Denmark	-2.240	-1.244
Germany	-1.423	-1.456
Spain	-2.663[***]	-3.017[***]
France	-1.421	-1.950
Ireland	-1.454	-1.344
Italy	-1.042	-0.859
Netherlands	-2.816[***]	-1.887
Austria	-2.162	-1.604
Finland	-2.335	-2.048
Sweden	-2.293	-2.645[***]
UK	-2.035	-1.239
USA	-2.371	-0.593
Japan	-0.835	-0.236
Canada	-2.372	-1.745
Switzerland	-1.501	-3.015[***]
Norway	-1.802	-2.153
Iceland	-3.409[***]	-1.674
Australia	-2.490	-2.513
New Zeeland	-2.458	-2.204

Note:

- the critical value at 10% level is -2.626
- in case of [***] , we reject the presence of unit root at 10% level.

We fail to reject the presence of the unit root for the ratio of investment in case of 19 variables and for the ratio of saving in case of 18 variables at 10% level.
We reject the presence of the unit root in case of 3 variables at 10% level (for the ratio of investment) and for 4 variables at 10% level in case of the ratio of saving.

Taking in consideration the tables 7 and 8 and trying to corroborate the results, arbitrarily we choose to eliminate the countries where the ratio of saving and the ratio of investment are stationary following the rule:' If at least two tests reject and the others two statistics are around the significance level of rejection, we consider the series like stationary and

we exclude the countries'. Based on this rule we eliminate the following countries: Spain and Portugal.

V.2. - Testing for Cointegration

V.2.1. - The Concept of Cointegration

The concept of cointegration, first introduced into the literature by Granger (1981), is relevant to the problem of the determination of long-run or "equilibrium" relationships in economics. Cointegration is the statistical implication of the existence of a long-run relationship between economic variables.

In other words, from a statistical point of view, a long-term relationship means that the variables move together over time so that short-term disturbances from the long-term trend will be corrected.

A lack of cointegration suggests that such variables have no long-run relationship: in principal the variables they can wander arbitrarily far away from each other.

V.2.2 - The Cointegration Test

The concept of cointegration is based on the idea that, although economic time series exhibit non-stationary behavior, an appropriate linear combination between trending variables could remove the trend component and, hence, time-series could be cointegrated.

Cointegration is relevant to the problem of determination of a long-run or a steady state equilibrium economic relationship, where economic forces are in balance and there is no tendency to change.

The importance of cointegration lies in the fact that it allows us to seek the existence of an equilibrium relationship among two or more time series, each series is individually non-stationary.
Upon being detected, the long-run relationship can be tested for its validity.

We are using the Engle and Granger procedure in individual data which consist in 2 stages:

In **the first stage**, we estimate the regression by OLS:

$$y_t = \alpha + \beta x_t + \varepsilon_t$$

In **the second stage**, we regress the errors ε_t on ε_{t-1} and we are using DF test to conclude if the variables y_t and x_t are I(1) (there is no cointegration) or the variables are I(0) (there is cointegration and there is long-run relationship between y and x).

We are running 20 regressions. The results from the test of cointegration on individual data are reported in the Table 9.

Table 9 - Results for the test of cointegration

Countries	DF Test for co-integration
Greece	-2.01
Belgium	-1.72
Denmark	-2.02
Germany	-1.26
France	-1.11
Ireland	-1.25
Italy	-2.27
Netherlands	-2.89
Austria	-2.63
Finland	-1.76
Sweden	-1.61
UK	-2.00
USA	-2.63
Japan	-2.21
Canada	-2.27
Switzerland	-1.30
Norway	-1.95
Iceland	-4.57^{***}
Australia	-3.17^{***}
New Zeeland	-3.36^{***}

Note:

- the critical value of MacKinon at 10 % level is -3.04
- in case of ***, we reject the presence of no cointegration

We fail to reject the null-hypothesis of no cointegration for 17 from 20 regressions at 10% level.
And we reject the null-hypothesis of no cointegration for three regressions at 10% level (it's the case of Iceland, New Zeeland and Australia).

In the empirical application for the panel data we shall apply Pedroni's cointegration test methodology (1995, 1997 and 1999).

Pedroni (2001) showed that testing for cointegration in panel data is not so straightforward. The only case in which raw data and residuals have equivalent distribution is when the regressors are strictly exogenous and when the pooled OLS slope is constrained to be homogeneous.

This is due to the fact that in this case, the OLS estimator converges to a non-random value. For these reasons; he developed few statistics to test the null of no cointegration for the case of heterogeneous panels and derived their asymptotic distributions.

The tests allow for considerable heterogeneity among individual members of the panel, including heterogeneity in both the long-run cointegrating vectors as well as heterogeneity in the dynamics associated with short-run deviations from these cointegrating vectors.

He derived the asymptotic distributions and explored the small sample performances of seven different statistics to test panel data cointegration.Of these seven statistics, four are based on pooling, which is often referred to as the within dimension (called "panel" after), and the last three are based on the between dimension (called "group" after).
However for smaller samples (T inferior to 30) the Group ADF-Statistic (non-parametric) is the most powerful, followed by the Panel V-Statistic and the Panel RHO-Statistic.

For this reason, only the group ADF-statistic will be considered in our study for panel cointegration testing.

Our first step is to compute the regression residuals from the hypothesized cointegrating regression.
In the most general case, this may take the form:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \ldots\ldots\ldots + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad (1)$$

Where T refers to the number of observations over time, N refers to the number of individual members in the panel, and M refers to the number of regression variables. Notice that the slope coefficients $\beta_{1i}, \beta_{2i}, \beta_{Mi}$ are permitted to vary across individual members of the panel.

For the between-dimension statistics the null of no cointegration is implemented as a residual-based test of the null-hypothesis H_o: $\gamma_i = 1$ for all i, versus the alternative hypothesis H_1: $\gamma_i < 1$, where:

$$\hat{e}_{i,t} = \hat{\gamma}_i \hat{e}_{i,t-1} + \sum_{k=1}^{K_i} \hat{\gamma}_{i,k} \Delta \hat{e}_{i,t-k} + \hat{u}_{i,t}^*$$

We can compute the group **ADF-statistic** by performing the following steps:

Step 1:

Estimate the panel cointegration regression (1), making sure to include any desired intercepts, time trends or common time dummies in the regression and collect the residuals $\hat{e}_{i,t}$ for later use.

Step 2:

Using the residuals $\hat{e}_{i,t}$ of the original cointegrating regression, estimate the appropriate auto-regression, for the parametric statistics estimate and compute the simple variance of $\hat{u}_{i,t}^*$ denoted $\hat{s}_i^{*2}$.

Step 3:

Using each of these parts, we construct any of the seven statistics, and then we apply the appropriate mean and variance adjustment terms reported into the tables proposed by Pedroni.

The results which include also the time dummies are presented in the Table 10.
The critical value at 5% level is -1.65.

The OECD-minus contains 20 countries (the data base is described into the **Section IV Data** but we eliminate Spain and Portugal because the countries are stationary) The EU contains 12 countries (the countries excluded: Luxembourg, Spain and Portugal).

Table 10 shows the estimated values, first from estimation over the whole period 1975-2003, then over two sub-periods 1975-1990 and 1991-2003.

Table 10 - Results for Group-ADF-Statistics

Period	OECD minus	EU
1975-2003	-2.4503	-1.7912
1975-1990	-2.1032	-1.7071
1991-2003	-1.9451	-1.6921

For the OECD-minus we reject the null of no cointegration. Also for EU we reject the null of no cointegration. Both panels provide evidence of cointegration to support the long-run relationship among variables.

In order to get appropriate estimates of the cointegration relationship, efficient estimation techniques are employed. Problems arising from the endogeneity of the regressors and serial correlation in the error term are avoided.
Due to the corrections, the estimators are asymptotically unbiased. Especially, fully modified (FMOLS) technique is applied.

Pedroni (2000) proposes the group mean panel FMOLS estimator which provides a consistent test of a common value for the cointegrating vector under the null hypothesis against values of the cointegrating vector that need not be common under the alternative hypothesis.

Pedroni address **two key** sources of cross member heterogeneity that are particularly important. **One such source of heterogeneity** manifests itself in the familiar fixed effects form. These reflect differences in mean levels among the variables of different individual members of the panel and we model these by including individual specific intercepts.

The second key source of heterogeneity in such panels comes from differences in the way that individuals respond to short-run deviations from equilibrium cointegrating vectors that develop in response to stochastic disturbances. He models this form of heterogeneity by allowing the associated serial correlation properties of the error processes to vary across individual members of the panel.

Asymptotic Distribution of the Panel FMOLS Group Mean t-statistic:

$$t_{\hat{\beta}_{NT}^*} = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \hat{L}_{11i}^{-1} \left(\sum_{t=1}^{T} (x_{it} - \bar{x}_i)^2 \right)^{-\frac{1}{2}} \left(\sum_{t=1}^{T} (x_{it} - \bar{x}_i) y_{it}^* - T\hat{\gamma}_i \right) \Rightarrow N(0,1)$$

Where: $y_{it}^* = (y_{it} - \bar{y}_i) - \dfrac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta x_{it}$

And: $\hat{\gamma}_i = \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^o - \dfrac{\hat{L}_{21i}}{\hat{L}_{22i}} (\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^o)$

$\hat{L}_i$ is a lower triangular decomposition of $\hat{\Omega}_i$ as defined whose elements are related as follows:

$$L_{11i} = \left(\Omega_{11i} - \frac{\Omega_{21i}^2}{\Omega_{22i}} \right)^{\frac{1}{2}}; \quad L_{12i} = 0; \quad L_{21i} = \frac{\Omega_{21i}}{\Omega_{22i}^{\frac{1}{2}}} \text{ and } L_{22i} = \Omega_{22i}^{\frac{1}{2}}$$

For the cross sectional dimension, Pedroni will employ the standard panel data assumption of independence.

The implementation of the feasible form of the between dimension group mean estimator also has advantages over the other estimators in the presence of heterogeneity of the residual dynamics around the cointegrating vector.

The results of running the FMOLS proposed by Pedroni are reported into the Table 11.

Table 11 - Results of FMOLS

Period	OECD minus	EU
1975-2003	0.39 (t-statistic=-16.20)	0.38 (t-statistic=-14.02)
1975-1990	0.50 (t-statistic=-17.24)	0.44 (t-statistic=-15.28)
1991-2003	0.29 (t-statistic=-14.59)	0.30 (t-statistic=-13.01)

We observed a decline in the coefficients from 0.50 to 0.29 for OECD-minus and from 0.44 to 0.30 for EU which confirms in fact that the capital mobility increased over time. The decreasing is more pronounced for OECD-minus .We could conclude that the Feldstein-Horioka Puzzle is not as bad as we think.

Section VI - Conclusions

The results of this analysis suggest that capital mobility increased over time. The coefficient of Feldstein-Horioka regression decreased at 0.46 for OECD-minus and 0.43 for the EU throughout the period 1975-2003. If we take into consideration just the last decade (1990-2003) the decrease is very pronounced in special for OECD-minus at 0.26.

For the EU the decrease of the coefficient for the period (1991-2003) was less pronounced from 0.43 to 0.33. But the EU area is much more homogenous than OECD-minus. For the EU and the Euro area, the estimated coefficient is close to zero or negative at the end of the 1990s. To the extent that investment and saving depend with opposite signs on income per capita, and to the extent that integration reinforces these two effects, the estimated coefficient in a regression of investment and saving may well be negative, and this may be what we are observing at the end of the period.
The product market, the integration of financial markets within the European Union and the monetary union leads to this homogeneity.

We try to detect the presence of the unit root, using tests which are based on the cross-sectional independence assumption, LLC and IPS; we strongly reject the presence of common unit root in both cases. At least one from the series is stationary .The results are ambiguous because the both tests suppose the cross-sectional independence, hypothesis which is violated.

The univariate tests Phillips-Perrons and Augmented Dickey-Fueller also confirm that some series are stationary.Based on these results we eliminate from our data base Spain and Portugal.

Testing for cointegration on individual data meant that the ratio of saving and the ratio of investment are I(1) so there is no long-run relationship between investment and saving.

But the pure time series don't take in consideration the fact that there are relations across time and across countries in organizations like OECD and EU. They treat each country individually.

We have been applied also the Pedroni's cointegration test methodology.
The results obtained reject the null of no cointegration for OECD-minus and also for EU. Both panels provide evidence of cointegration to support the long-run relationship among variables.

The next step was to get appropriate estimates of the cointegration relationship, so fully modified (FMOLS) technique is applied.

When we control for the presence of endogeneity, the results obtained by fully modified OLS confirm in fact that the capital mobility increased (the coefficient β passed after running the conventional Feldstein-Horioka regression from 0.50 (1975-1990) to 0.29 (1991-2003) for OECD-minus and from 0.44 (1975-1990) to 0.30 (1991-2003) for EU).

We also highlighted the importance of controlling for cross-sectional dependence when testing for a unit root in panels of saving and investment. The second generation panel unit root tests relax this assumption.

The panel cointegration models are directed at studying questions that surround long-run economic relationship. Such a long-run relationship is often predicted by economic theory and it is then of central interest to estimate the regression coefficients and test whether they satisfy theoretical restrictions.

The fully modified OLS proposed by Pedroni or a panel dynamic least squares (DOLS) estimator proposed by Kao and Chiang (2000) may be very promising in cointegrated panel regressions. In case of FMOLS the biggest problem is the assumption of the cross-sectional independence.

In many cases, common time dummies may not be sufficient, particularly when the cross sectional dependence is not limited to contemporaneous effects and is dynamic in nature.

Also recent researches support the idea may be better to look at the evidence from country-by-country and sub-group analysis. The reason behind this story is the presence of cross-country cointegration. It's interesting (and sometimes very difficult) to reconcile the evidence from the country-by-country tests and the panel analysis.

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