The Feldstein –Horioka Puzzle and structural breaks: evidence from EU members.

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Abstract

The purpose of this paper is to investigate the level of capital mobility in European Union members using the Feldstein-Horioka puzzle proposed by Feldstein and Horioka (1980) in order to investigate relations between saving and investment flows. In this paper, data for 27 European countries were used over the period of 1995-2009 on the quarterly basis. Data were extracted from the official statistical site of the European Union, Eurostat. Firstly, unit root tests were applied to the series in order to estimate the stationarity of the model variables. Two different tests were used, which are the Ng and Perron (2001) unit root test procedure and approach proposed by Zivot and Andrews (1992) for unit root test allowing for a structural shift. Then the Bai and Perron (1998) structural break test was applied to determine the presence of structural breaks in series. In most countries except Belgium and Finland UDmax and WD max tests rejected the hypothesis of no breaks. Moreover, structural break locations for every series were selected by sequentially procedure, BIC and LWZ. Finally, the cointegration relationships between investment and saving flows of European Union members were tested. Three different cointegration techniques were applied to the data. Firstly, the Johansen (1988) cointegration approach was used for the case of no cointegration shifts, then the Gregory and Hansen (1996) cointegration test was applied, which allows for one structural shift. Finally, again the Johansen' cointegration approach was used; however, this time with the inclusion of dummy variables related to earlier selected structural break locations.

The empirical results provided stronger evidence of cointegration between investment and saving variables in the case of structural break accommodation compared to the case where the presence of structural breaks was ignored. In most cases of estimations saving-investment correlation has a tendency to increase with regime changes. However, the estimated saving retention coefficient in the presence of structural breaks using the Bai and Perron (1998) approach appeared relatively low in many cases, illustrating by this the openness of estimated countries. In general, world and European countries with time have a tendency to a higher level of their capital market openness. According to Feldstein and Horioka (1980), a higher saving-investment correlation is related to lower capital mobility. Therefore, the contradicting results between saving retention coefficient estimates and cointegration tests illustrate that cointegration indicates a rather current account solvency condition than capital mobility. Estimations of a saving retention coefficient in the presence of structural changes do not support the existence of the Feldstein-Horioka Puzzle in the considered EU countries.

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Key Words: Feldstein-Horioka puzzle, saving-investment association, capital mobility, cointegration, structural breaks, EU.

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1. Introduction

For the last several decades the issue of high correlation between investment and saving ratio has been discussed widely in the literature. The high correlation between the variables can be explained by the low capital mobility. However, Feldstein and Horioka (1980) in their seminal work found that the investment and saving ratios for 16 OECD member countries over the period 1960-1974 are highly correlated. These findings contradict international capital mobility in open developed economies. This phenomenon is known as the Feldstein-Horioka Puzzle (FHP). In the literature a great deal of attention has been given to the FHP (see, for example, literature surveys by Frankel [1992], Coakley et al. [1998], and Apergis and Tsoumas [2009]).

In looking for support or for contradictory evidence of Feldstein-Horioka (1980)'s findings ample empirical studies were done on FHP for OECD countries for different periods (see, for example, Murphy [1984], Golub [1990], Leachman [1990], Sinn [1992], Coakley et al. [1996], Ozkan [2009], Fouquau et al. [2008]). The European Union and its individual countries were studied for the FHP as well (see, for example, Armstrong et al. [1996], Bajo-Rubio [1998], Pelagidis and Mastoyiannis [2003], Banerjee and Zanghieri [2003], Kollias et al. [2008]).

Studies on FHP differ in terms of methodology and in terms of different econometric techniques as well, where cross-sectional data (see Feldstein-Horioka [1980], Murphy [1984], Penati and Dooley [1984], Dooley et al. [1987], Coakley et al. [1988], Herwartz and Xu [2010]), time-series (see Miller [1988], Argimon and Roldan [1994], Jansen [1996], Coakley and Kulasi [1997], Caporale et al. [2005]) as well as panel data (see Corbin [2001], Ho [2002], Fouquau et al. [2008], Kollias et al. [2008], Vasudeva Murthy [2009]) were employed.

In terms of research, empirical studies on FHP are divided in different directions. Some authors attempt to explain the results of Feldstein-Horioka (1980) with additional exogenous factors. For example, Fouquau et al. (2008) in their study on OECD countries employed a panel smooth threshold regression approach proposed by Gonzalez et al. (2005) and Dijk et al. (2005), which can capture heterogeneity across countries and the time variability of the saving retention coefficient. The author estimates Feldstein-Horioka coefficients including in the analysis 5 threshold variables which are used in literature as mostly possible explanations of countries' heterogeneity. The threshold variables considered in the study by Fouquau et al. (2008) are economic growth of considered countries, demography, degree of openness, country size and current account balance. The author found that the highest impacts on the international capital mobility have degree of openness, country size and the current account balance. It was found that countries in the sample have heterogeneous degree of international capital mobility and that the estimated saving retention coefficients have a tendency to decline in the considered period between 1960 and 1990, which is in line with the literature on FHP in developed countries. Ho (2003), for example, employed only a country-size threshold variable for measuring its impact on the saving retention coefficient. The study was conducted for the panel of 23 OECD countries covering a period from 1961 to 1997. The author provided substantial evidence of the threshold effects of the country size variable on the saving retention coefficient, which can be a partial explanation of FHP. For another example, see Herwartx and Xu (2010).

Another direction is related to attempts to provide evidence that the results of Feldstein-Horioka (1980) do not measure the degree of international capital mobility. For example, Coacley et al. (1996) suggest an alternative explanation of high saving retention coefficient in FHP. The authors provide evidence that investment and savings are cointegrated irrespective of the capital mobility level. The high level of correlation between investment and savings in FHP indicates rather the conditions for the long-run solvency of the current account than measure of the capital mobility. Sachsida et al. (2000) in their study employing equations of external and domestic substitutability provided evidence that the savings retention coefficient in Feldstein-Horioka (1980) presents substitutability relations between external and internal savings, and can not explain capital mobility. For another example, see Nell and Santos (2008).

Another part of the studies used econometric techniques different from those of Feldstein-Horioka (1980) in order to examine international capital mobility in the considered countries. Hussein (1998), for example, using dynamic OLS analysis examined the capital mobility across 23 OECD countries for the period 1960-1993 and took the endogeneity of savings into account. His results illustrated high levels of capital mobility in the cases of 18 countries and only in the cases of 5 countries was the hypothesis of capital immobility not rejected. Sinha and Sinha (2004), for example, used the error correction model to measure the long-run relationship between saving and investment rates across 123 country. The authors found evidence for capital mobility for only 16 countries, most of which are developing countries, concluding that the error correction model approach is not a good measure for the capital mobility in developed countries. For another example, see Ho (2002).

In the FHP studies for EU countries the findings are as different as the findings for OECD countries. For example, Kollias et al. (2007) in their studies on FHP across EU members, using the ARDL bounds approach and panel data illustrated that the savings-retention coefficient for EU15 is 0.148 and that this coefficient increases to 0.157 when Luxemburg is excluded from the panel. Therefore, the estimations of this study provided evidence of high capital mobility in the considered group of EU members, which contradicts the findings of Feldstein-Horioka (1980) for OECD countries. However, Pelagidis and Mastroyiannis (2003), in their study on capital mobility for Greece, found that the saving-retention coefficient is 0.91, rejecting the hypothesis of high capital mobility, which confirms the results of Feldstein and Horioka (1980). Nonetheless, this study found evidence of a slight increase in the level of capital mobility after 1981.

The degree of capital mobility between European Union countries has to be above the capital mobility between OECD countries due to the presence of homogenous institutions, the degree of financial openness and regulations in the European Union. This hypothesis was supported as well as rejected in the literature. Apergis and Tsoulfidis (1997), using credit as a proxy for investment in their study of 14 EU members, found that capital mobility degree does not significantly effect investments, which mainly are affected by domestic savings. The author with this finding rejected the hypothesis of high capital mobility inside of the EU. From another side, Feldstein and Bachetta (1991) and Artis and Byoumi (1991) compared EU and OECD countries in their studies on savings-investment relations and on financial integration. In both studies results were in favor of the higher degree of the capital mobility inside the EU than between OECD members. Buch (1999) for example, in her study on the transition economies of the EU, found evidence of a similar degree of capital mobility in the transition economies of the EU compared to that of OECD countries and that less developed transition members of the EU have a higher level of correlation between investment and savings than more advanced transition economies. Heterogeneity between samples of countries, considered periods and employed econometric techniques bring contradictory results which continue to span debates on FHP.

Considering international capital mobility for the long term, it has to be accepted that investment and saving flows are exposed to various changes in domestic as well as in world economies. However, only a few studies on FHP have taken into account the presence of structural breaks or regime shifts using different econometric techniques. See, for example, Telatar et al. (2007), Mastroyiannis (2007), Kejriwal (2008), Ozmen and Parmaksiz (2003). Ozmen and Parmaksiz (2003) and Mastroyiannis (2007) in their capital mobility analysis of

UK and Greece did not find evidence supporting FHP in the presence of structural breaks. Telatar et al. (2007) employed the Markov-switching model to examine the behavior of saving retention coefficients in the presence of regime change. Authors in their study for several European countries found evidence of increasing capital mobility in Belgium, Denmark, Finland, France, Italy and Sweden after the regime change in 1994, which was the establishment of the EU. They confirmed that the saving retention coefficient declined after taking into account the regime change. Kejriwal (2008) as well as the above-mentioned authors did not find the evidence of FHP existence in European countries in the presence of structural breaks. However, the author argues that the reason for the overstated saving retention coefficients in the literature can be in the misspecification of regression models.

The purpose of this article is to make a contribution to the literature on the Feldstein-Horioka puzzle analysis for European Union countries using cross-section cointegration tests that accommodate structural breaks. The data sample of this study includes EU27 member countries except Greece, Ireland, Malta and Romania for the reason of the lack of homogenous data for these countries for the full considered period in the used source. The data for selected countries are extracted from the official statistical site of the EU, Eurostat. The quarterly data are used in this research and cover the period from 1995 to the second quarter of 2009.

The rest of the paper is organized as follows. In the next section the applied methodological approach is presented. In section 3 obtained empirical results are reported and finally, the last section concludes.

2. Methodology

This study investigates the degree of capital mobility in EU members in the presence of structural breaks. In order to examine the level of capital mobility in OECD countries Feldstein and Horioka (1980) estimated the following equation:

$$\left(\frac{I}{Y}\right)_i = \alpha + \beta\left(\frac{S}{Y}\right)_i + e_i \qquad (1)$$

Where I is gross domestic investment, S is gross domestic savings and Y is gross domestic product of considered country i. Coefficient β which is known as saving retention coefficient measures the degree of capital mobility. If a country possesses perfect international capital mobility, the value of β has to be close to 0. If value of β is close to 1, it would indicate the capital immobility of the country. The results of Feldstein Horioka (1980) showed that the value of β for 21 open OECD economies changes between 0.871 and 0.909, illustrating by this international capital immobility in considered countries. These controversial results gave start to widespread debates in the economic literature. Numerous studies have provided evidence supporting these results, at the same time different results exist in the literature with a wide array of interpretations. Therefore, the findings of Feldstein Horioka (1980), which are contrary to economic theory, started to be referred to as "the mother of all puzzles" (Obstfeld and Rogoff, 2000, p.9).

In the long run macroeconomic series including investment and savings may contain a variety of structural changes within a country or at the international level. Therefore in order to examine the regression model (1) in the presence of multiple structural breaks, Bai and Perron (1998) methodology was employed in this study. The methodology considers the multiple linear regression in the presence of *m* breaks, which means *m+1* regimes.

$$y_t = x_t'\beta + z_t'\delta_j + e_t \qquad (2)$$

where $t = T_{j-1} + 1, \ldots, T_j$ is the time period with $j = 1, \ldots, m+1$ regimes. y_t is dependent variable of the regression, x_t and z_t are vectors of covariates with sizes of ($px1$) and ($qx1$), respectively, β and δ_j are vectors of coefficients, where the parameter vector β is not subject to change, while δ_j is changing across regimes. Finally, e_t is the disturbance term of the regression. The purpose of this methodology is to estimate the unknown coefficients of the regression together with treated as unknown *m* number of break points. For every *m* partition ($T_1, \ldots, T_m$), estimates of coefficients β and δ_j are generated by minimizing the sum of squared residuals which is represented by the following equation:

$$S_T(T_1, \ldots, T_m) = \sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} \left[y_t - x_t'\beta - z_t'\delta_t \right]^2 \qquad (3)$$

Substituting estimates $\hat{\beta}(\{T_j\})$ and $\hat{\delta}(\{T_j\})$ into equation (3) the estimators of break locations will be obtained, which are the global minimum of the sum of squared residuals objective function, and can be expressed by the following equation:

$$(\hat{T}_1, \ldots, \hat{T}_m) = \arg\min_{T_1, \ldots, T_m} S_T(T_1, \ldots, T_m) \qquad (4)$$

The minimization of the sum of squared residuals is obtained in all partitions ($T_1, \ldots, T_m$), that $T_i - T_{i-1} \geq q$. The estimates of regression parameters are least-squares estimates associated with *m*-partition $\{\hat{T}_j\}$, i.e. $\hat{\beta} = \hat{\beta}(\{T_j\})$ and $\hat{\delta} = \hat{\delta}(\{T_j\})$. Bai and Perron (2003) proposed the efficient algorithm of obtaining the locations of break points, which is based on the principle of dynamic programming.

The procedure for the specification of the number of breaks proposed by Bai and Perron (1998) is as follows. Firstly, the statistics for *UD*max and *WD*max tests have to be calculated. *UD*max and *WD*max tests are double maximum tests that examine for the hypothesis of no structural break against an unknown number of breaks with the given upper bound of breaks *M*, and can be calculated by the following formulas:

$$UD\max F_T(M,q) = \max_{1\le m\le M} \sup_{(\lambda_1,\ldots,\lambda_m)\in\Lambda_\varepsilon} F_T(\lambda_1,\ldots,\lambda_m;q). \quad (5)$$

where $F_T(\lambda_1,\ldots,\lambda_m;q)$ is the sum of *m* dependent chi-square random variables, each one divided by *m*, with *q* as degree of freedom.

$$WD\max F_T(M,q) = \max_{1\le m\le M} \frac{c(q,\alpha,1)}{c(q,\alpha,m)} x \sup_{(\lambda_1,\ldots,\lambda_m)\in\Delta_\varepsilon} F_T(\lambda_1,\ldots,\lambda_m;q). \quad (6)$$

where $c(q,\ \alpha,\ m)$ is the asymptotic critical value of the individual tests with α as significance level.

Next, Wald type tests have to be applied, where the sup F(0|1) test examines for the hypothesis of no breaks against 1 break existence. If the statistics of this test reject the hypothesis of no breaks, the sup F(*l+1*| *l*) has to be applied to specify the number of breaks in series. The number of breaks in series can be chosen as well on the basis of the Bayesian Information Criteria (BIC), and the modified version of BIC proposed by Liu et al. (1997) (LWZ).

Before proceeding to cointegration tests, the stationarity of employed variables has to be examined. In order to test integration, the properties of variables two different unit root tests were applied. The first test is the unit root test proposed by Ng and Perron (2001), which has maximum power against *I*(0) alternatives. In order to generate efficient versions of the modified tests of Perron and Ng (1996), Ng and Perron (2001) employed the generalized lest squares detrending procedure proposed by Elliot, Rothenberg and Stock (1996). Ng and Peron stressed that the choice of the lag length of a regression is extremely important for the good size and power properties of an efficient unit root test. Therefore, Ng and Perron proposed modified AIC and recommended the use of a minimized value of modified Akaike information criterion (AIC) for selecting the regression's lag length.

An additional unit root test employed in this study is a test proposed by Zivot and Andrews (1992), which is the sequential break point selection test with the null hypothesis of unit root without structural break against the alternative that series are trend-stationary with one break point. Zivot and Andrews considered three different models: model A allows for a break in the intercept; model B allows for a break in the slope; and model C allows for a single break in the intercept and in the slope of the function. In this study, model C was employed.

Finally, in order to test for cointegration characteristics between variables under the consideration of a structural break presence, the Gregory and Hansen (1996) test was employed for countries where 1 structural shift was detected. For comparison purposes and for cases where no structural breaks were detected, the Johansen (1988) cointegration test was employed as well, and for cases where more than one structural break was detected, the Johansen cointegration test was employed with a dummy addition to account for structural break points.

3. Empirical results

Table 1 presents the results of the Ng and Perron (2001) unit root tests. All tests in Table 1 are consistent with each other. The null hypothesis of the unit root was not rejected for any of the series (savings or investment) by any of Ng and Perron tests in the cases of Austria, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, Luxemburg, the Netherlands, Portugal, Slovenia, Spain and Sweden. However, the non-stationarity of investment series was rejected by all four tests in the cases of Belgium and Poland, while the non-stationarity of the saving series was rejected in the cases of Bulgaria, Cyprus, Check Republic, Hungary, Italy, Slovakia and the UK.

However, when the Zivot and Andrews (1992) unit root test was applied, Table 2, which allows for the structural break allocation, only a few of the countries exhibited the absence of unit root in their series. Table 2 displays the *t* statistics of the test and possible break locations. Thus, the unit root hypothesis was rejected for investment series only in the cases of France, Luxemburg and Slovakia. In the cases of France and Spain the hypothesis is rejected only at a 5% significance level, while for Luxemburg it is rejected at a 1% significance level. On the other hand, saving series displayed the stationarity only in the case of Bulgaria.

Having verified the non-stationarity of the series under observation, structural change presence and cointegration tests were conducted. Table 3 reports the results of the Bai and Perron (1998) tests for detecting structural changes. Sup F(*k*) tests are significant for at least one value of *k* in all cases except Belgium and Finland. On the other hand, the last two columns of the table present statistics for *UD*max and *WD*max tests. Once more, only in cases of Belgium and Finland did both tests reject the null hypothesis of no structural breaks, while in all other cases the null was rejected by both tests. Combining the results of tests presented in Table 3, it can be concluded that there is strong evidence of structural change in the employed series except for in the cases of Belgium and Finland.

Table 4 reports the results for the sequential test of *l* versus *l+1* structural changes proposed by Bai and Perron (1998). Column S reports the number of breaks detected by the sequential test. At the same time, BIC and LWZ can be used for the detection of the number of breaks, which are presented in last two columns. Only in the case of Luxemburg did none of criterion detect any structural breaks while in the cases of the other countries at least one break was detected by one of employed information criterion with an upper bound of 5 breaks.

Table 5 reports the results of the parameters estimations of regression (2) in the presence of structural breaks, where dependent variable y_t is the ratio of gross domestic investments to the gross domestic product, while covariate x_t is the ratio of gross domestic savings to the gross domestic product. Estimates of break locations are given in the last four columns $\{\hat{T}_j\}$ of the table based on a 95% confidential level. Estimates of the coefficient $\hat{\beta}$ are given in the second column, which can be interpreted as the saving retention coefficient corrected for the presence of structural breaks. In most of cases these coefficients were found significant except in the cases of Austria, Bulgaria, France, Germany, Latvia and Lithuania. The highest estimate of the coefficient was found in Poland, 1.04, where four breaks were detected by sequential procedure and by BIC; in Belgium, the saving retention coefficient is 0.91, where one break was detected by BIC and LWZ and no breaks were detected by sequential procedure; and in Portugal, the estimate of the coefficient was found at the level 0.67, where one break was detected by sequential procedure and four breaks were detected by BIC and LWZ. In other observed countries, the saving retention coefficient in the presence of structural breaks was found in the interval between 0.05 and 0.54 which tend to be close to zero than to one. The results of regression estimates in the presence of structural shifts provide evidence of rather moderate and high mobility of capital in members of the EU. Therefore, the allocation of structural breaks in the model may correct estimated parameters for the provision of better capital mobility illustration. Thus, the results of regression estimates with structural breaks allocation provide rather weak evidence of FHP presence in EU countries in the observable period.

Cointegration

In the recent literature with the improvement of econometric techniques, cointegration techniques are widely applied to evaluate FHP (see for example Coacley et al., 1996; Hussein, 1998; Ozmen and Parmaksiz, 2003; Kollias et al., 2008; Vasudeva Murthy, 2009). Table 6 presents the results of the Gregory and Hansen (1996) cointegration test applied to countries where at least one of the information criterion for model selection - sequential procedure, BIC or LWZ - detected one structural break. Three different models were applied in running the cointegration test, (I) a structural shift in the intercept, (II) a structural shift in the slope, and (III) a structural shift in both intercept and slope of the regression. The results of the cointegration test statistics of ADF*, Z_t* and Z_α*, provide no evidence of cointegration in the cases of Estonia and Portugal, while for the rest of the countries, Austria, Belgium, Czech Republic, Finland, France, Hungary, Italy, Slovenia, Slovakia and Sweden, at least one of test statistics of the Gregory and Hansen cointegration test suggest the existence of cointegration relations between investment and savings variables. The choice of model C, C/T or C/S does not significantly affect the results of the cointegration test. Therefore following the interpretation of Feldstein Horioka (1980), countries where savings investments relations were found stationary, maintain FHP.

Next, for comparison reasons the Johansen cointegration test was conducted. In order to determine the rank of cointegration space the test presents two statistics, Trace and Max-Eigenvalue statistics (Table 7). In most cases, the results of the trace likelihood ratio test statistic and of the Max-Eigenvalue likelihood ratio test statistic are consistent with each other. The results of the tests indicated at least one cointegration relationship between saving investment variables in most of the cases. However, the null of no cointegration could not be rejected by any of the statistics in the cases of Denmark, France and Italy. The results of Table 7 indicate the existence of long run relationships between chosen variables in most of the cases when structural breaks are not taken into account.

Furthermore, the Johansen cointegration test was applied to the data with dummies introduction, at structural break locations (Table 8). In the country column, under the country title the number in parenthesis specifies number of structural break location chosen by indicated criteria from the Bai and Perron (1998) test. The location of dummies used for every country in the Johansen cointegration test of Table 8, corresponds to the location of the detected structural breaks and reported in the Table 5. The results of Table 8 provide significant evidence of cointegration existence in all countries under the condition of structural breaks existence at the known points. Therefore, the results illustrate high cointegration between savings investment variables in EU members, supporting by this the

FHP existence. However, in the literature the cointegration presence between savings and investment at the same time is interpreted as the long-run solvency condition, implying effective realization of government policies targeting a sustainable current account (Coakley et al., 1996; De Vita and Abbott, 2002; Abbott and De Vita, 2003; Vasudeva Murthy, 2009).

4. Conclusion

In the literature a great deal of attention is paid to one of the important puzzles in economics, FHP. Following Feldstein and Horioka (1980), numerous studies employed samples of OECD countries in order to contribute to findings in the FHP (see, for example, Murphy, 1984; Coakley et al., 1996; Nell and Santos, 2008). On the other hand, many studies have attempted to solve FHP employing samples of countries different from those of the OECD (see, for example, Armstrong et al., 1996; Pelagidis and Mastoyiannis, 2003; Vasudeva Murthy, 2009). A few recent studies have devoted their attention to the issue of FHP in the presence of structural shifts (for example, Ozmen and Parmaksiz, 2003; Telatar et al., 2007; Kejriwal, 2008). In general, studies which counted for the structural break presence in series have not found strong evidence of FHP existence in the considered samples.

The purpose of this study is to make a contribution to the literature on FHP in EU members with the inclusion of structural breaks. Using the Bai and Perron (1998) approach, the presence of structural breaks was confirmed in all EU considered members except Luxemburg, where none of the information criterion detected structural shifts. The estimated saving retention coefficient in the presence of structural shifts was found close to unity in cases of Poland, Belgium and Portugal at levels 1.04, 0.91 and 0.67, respectively, while for the other 19 countries the saving retention coefficient was found in the interval between 0.05 and 0.54 indicating the high and moderate level of capital mobility in these countries.

The Gregory and Hansen (1996) cointegration test in the presence of one structural break applied to samples of at least one of S, BIC or LWZ criterion detected the presence of only one structural shift. The results of this test provided evidence of cointegration in all cases except for those of Estonia and Portugal. Furthermore, the Johansen cointegration test with dummy variables was employed to test for stationarity of the saving investment relationship in the presence of multiple structural breaks. The results of the Johansen cointegration test with dummy variables located at known points for structural dates indicated a high level of cointegration in all considered EU members except Luxemburg, which was not included in the last test.

The low level saving retention coefficient estimated in this empirical research in the presence of structural breaks indicates high capital mobility in most of considered countries, providing evidence by this against FHP in the considered sample. These results are consistent with the literature reporting that the introduction of structural breaks in OECD sample significantly decreases the saving retention coefficient value (see Kumar and Bhaskara, 2009). However, the results of cointegration tests in the presence of structural breaks provided strong evidence of cointegration presence in all of the considered EU members. Therefore, the outcome of this empirical research supports the hypothesis suggested in previous studies (for example, Coakley et al., 1996) that cointegration between investment and saving series exist irrespective of level of capital mobility, which is the indication of current account solvency. In conclusion, it can be suggested that the saving retention coefficient in Feldstein and Horioka (1980) can be overestimated due to the ignorance regarding the existence of the structural breaks.

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Table 1. Unit Root Tests Ng and Perron (2001)

Country	MZ_α^{GLS}	MZ_t^{GLS}	MSB^{GLS}	MP_T^{GLS}	MZ_α^{GLS}	MZ_t^{GLS}	MSB^{GLS}	MP_T^{GLS}
	Investments				***Savings***			
Austria	1.63	2.03	1.25	117.61	0.93	0.59	0.63	31.72
Belgium	-22.19**	-3.18**	0.14**	1.61**	1.01	0.68	0.67	34.77
Bulgaria	2.87	9.00	3.13	875.26	-75.13**	-6.04**	0.08**	0.51**
Cyprus	-0.63	-0.26	0.42	13.94	-22.37**	-3.22**	0.14**	1.52**
Check Republic	-0.34	-0.16	0.46	16.39	-43.57**	-4.55**	0.11**	0.87**
Denmark	1.08	0.74	0.69	36.95	-0.50	-0.23	0.45	15.43
Estonia	-0.28	-0.12	0.44	15.69	1.95	3.15	1.61	204.43
Finland	1.37	1.16	0.85	55.59	1.45	1.29	0.89	60.91
France	1.72	1.87	1.09	93.07	-0.69	-0.30	0.43	14.29
Germany	-7.84	-1.77	0.23	3.89	0.45	0.24	0.54	22.96
Hungary	1.89	3.24	1.71	226.04	-3355.99**	-40.95**	0.01**	0.01**
Italy	1.73	2.08	1.19	111.49	-4116.17**	-4115.81**	-45.354**	0.01**
Latvia	1.97	2.21	1.12	102.61	-0.65	-0.29	0.44	14.49
Lithuania	-2.14	-0.72	0.34	9.09	0.82	0.58	0.72	37.68
Luxemburg	-0.14	-0.07	0.47	17.47	-6.17	-1.51	0.25	4.73
Netherland	-5.53	-1.423	0.26	5.09	-0.51	-0.22	0.44	14.99
Poland	-19.88**	-3.00**	0.15**	1.77**	1.43	1.18	0.83	53.73
Portugal	-6.61	-1.60	0.24	4.42	-2.94	0.95	0.32	7.77
Slovenia	0.99	0.66	0.66	34.29	1.63	1.47	0.89	64.44
Slovakia	1.65	2.08	1.26	121.12	-79.27**	-6.21**	0.08**	0.49**
Spain	-4.23	-1.19	0.28	6.16	-3.73	-1.11	0.29	6.68
Sweden	0.79	0.48	0.61	28.92	1.59	1.42	0.89	63.57
UK	-1.05	-0.42	0.39	12.37	-133.91**	-8.12**	0.06**	0.28**

Notes: MZ_α^{GLS} is the modified Phillip-Perron test MZ_α; MZ_t^{GLS} is the modified Phillip-Perron MZ_t test; MSB^{GLS} is the modified Sargan-Bhargava test; MP_T^{GLS} is the modified point optimal test, for details see Ng and Perron (2001). The order of lag to compute the test has been chosen using the modified AIC (MAIC) suggested by Ng and Perron (2001). * and ** denote the rejection of the null hypothesis at the 5% and 1% respectively. The critical values for the above tests have been taken from Ng and Perron (2001).

Table 2. Unit Root Tests Zivot and Andrews

Country	k	t statistics	break	k	t statistics	break
	Investment			**Savings**		
Austria	4	-4.259	2002:1	4	-3.092	2002:3
Belgium	4	-4.434	2002:1	4	-3.289	2007:1
Bulgaria	4	-3.712	2004:2	3	-9.552**	1999:1
Cyprus	4	-3.916	1999:3	3	-3.465	2006:4
Check Republic	4	-4.808	2001:2	4	-2.962	1998:4
Denmark	4	-3.109	2006:2	4	-4.045	1999:2
Estonia	4	-2.465	2006:3	4	-4.197	2000:4
Finland	4	-3.657	2001:4	4	-2.597	1999:4
France	4	-5.459*	2004:1	4	-3.400	2001:1
Germany	4	-3.520	2001:3	4	-3.659	2000:2
Hungary	4	-3.339	2004:1	4	-3.720	2002:1
Italy	4	-2.067	2002:3	4	-3.544	1998:1
Latvia	4	-2.789	2006:3	4	-3.604	2004:3
Lithuania	4	-2.628	1998:4	4	-3.311	2002:2
Luxemburg	2	-6.448**	2004:3	4	-2.889	2007:1
Netherland	4	-3.272	2002:2	4	-4.096	2000:1
Poland	4	-3.795	2001:3	4	-3.541	2001:4
Portugal	4	-4.381	2002:1	4	-3.278	2002:3
Slovenia	4	-3.058	2000:4	4	-2.901	2001:2
Slovakia	4	-5.307*	1999:1	4	-3.727	2000:4
Spain	4	-2.162	2007:2	3	-2.373	2003:4
Sweden	4	-2.917	2001:1	4	-2.254	2007:2
UK	4	-3.277	2001:3	4	-3.003	2001:2

Notes: The critical values for Zivot and Andrews test are -5.57, -5.08 and -4.82 at 1 %, 5 % and 10% levels of significance respectively.
* denotes statistical significance at 5% level. ** denotes statistical significance at 1% level.

Table 3. Structural Break Tests of Bai and Perron (1998).

Country	Sup F(1)	Sup F(2)	Sup F(3)	Sup F(4)	Sup F(5)	UDmax	WDmax
Austria	20.18**	0.95	4.33	2.45	1.03	20.18**	20.18**
Belgium	0.01	0.02	1.64	5.39*	4.41	5.39	8.15
Bulgaria	45.87**	143.29**	144.89**	128.03**	125.93**	144.89**	213.41**
Cyprus	14.01**	34.57**	40.03**	161.83**	165.62**	165.62**	280.66**
Check Republic	13.04**	57.16**	15.16**	15.79**	163.07**	163.07**	276.34**
Denmark	0.29	104.61**	705.16**	48.57**	136.69**	705.16**	938.15**
Estonia	17.22**	0.73	708357.13**	73303.76**	14150.03**	708357.13**	942404.96**
Finland	0.02	1.68	0.85	1.02	2.24	2.24	3.79
France	143.89**	193.70**	178.18**	86.42**	219.39**	219.39**	371.79**
Germany	0.48	225.99**	14.61**	21.91**	22.85**	225.99**	259.66**
Hungary	77.96**	102.59**	79.16**	50.69**	74.67**	102.59**	126.54**
Italy	0.57	0.33	0.28	25.85**	276.28**	276.28**	468.18**
Latvia	22.29**	386.49**	54.56**	85.65**	75.18**	386.49**	444.07**
Lithuania	64.77**	48.44**	38.99**	134.98**	53.60**	134.98**	203.70**
Luxemburg	1.24	2.42	5.42	965.69**	18335.08**	18335.08**	31070.62**
Netherland	3.36	56.23**	49.12**	748.17**	441.32**	748.17**	1129.08**
Poland	9.42**	41.47**	77.64**	115.24**	77.48**	115.24**	173.91**
Portugal	13.09**	17.23**	502.03**	51.69**	456.17**	502.03**	773.03**
Slovenia	9.84**	10.84**	11.89**	11.38**	10.42**	11.89**	17.66**
Slovakia	287.63**	21.07**	389.88**	145.83**	1503.35**	1503.35**	2547.56**
Spain	0.14	65.16**	56.15**	45.18**	50.59**	65.16**	85.74**
Sweden	8.92	53.45**	162.52**	251.70**	498.38**	498.38**	844.56**
UK	1.05	18.44**	21.26**	66.33**	314.03**	314.03**	532.15**

Notes: * denotes statistical significance at 5% level. ** denotes statistical significance at 1% level.

Table 4 Sequential test of *l* versus *l+1* structural changes Bai and Perron (1998).

Country	Sup F(2|1)	Sup F(3|2)	Sup F(4|3)	Sup F(5|4)	S	BIC	LWZ
Austria	0.11	0.08	0.08	0.07	1	1	1
Belgium	1.69	1.69	0.34	0.34	0	1	1
Bulgaria	88.64**	74.41**	94.92**	10.19	4	3	3
Cyprus	20.87**	13.21**	13.42**	13.42**	2	5	3
Check Republic	12.07**	0.15	0.15	1.71	4	1	0
Denmark	0.06	4.36	4.36	0.09	0	2	2
Estonia	45.07**	45.07**	45.07**	0.72	2	4	1
Finland	4.47	0.01	0.02	0.99	0	1	0
France	2.88	1.83	0.001	0.01	1	3	3
Germany	0.27	0.02	0.10	0.36	0	2	0
Hungary	8.59	28.53**	3.93	3.93	1	2	1
Italy	0.02	9.24	9.24	0.41	0	2	1
Latvia	37.45**	8.91	8.91	8.91	2	2	2
Lithuania	70.86**	7.81	2.71	2.71	2	2	2
Luxemburg	8.38	8.38	8.38	0.01	0	0	0
Netherland	161.55**	1.14	1.84	1.14	0	2	2
Poland	259.17**	30.61**	25.73**	114.37**	4	4	2
Portugal	1.45	0.05	0.25	0.25	1	4	4
Slovenia	0.01	0.37	0.01	0.42	1	1	1
Slovakia	3.38	24.89**	4.97	4.97	1	2	2
Spain	0.87	9.24	1.52	1.11	0	4	2
Sweden	0.01	0.01	0.001	0.001	1	1	1
UK	0.19	0.48	0.81	0.81	0	3	3

Notes: S - sequential procedure, BIC - Bayesian Information Criteria, LWZ - the modified version of BIC proposed by Liu et al. (1997), are used for the selection of breaks number.

Table 5 Estimated regression parameters under breaks.

Country	$\hat{\beta}$	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	$\hat{\delta}_5$	$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$
Austria **(S, BIC, LWZ)**	0.15 (0.13)	20.11** (3.33)	17.64** (3.78)	-	-	-	2001:Q4 (‘00:Q4- ‘02:Q4	-	-	-
Belgium **(BIC, LWZ)**	0.91** (0.10)	-2.08 (2.59)	-3.76 (2.85)	-	-	-	2001:Q4 (‘98:Q1- ‘04:Q1	-	-	-
Bulgaria **(BIC, LWZ)**	-0.05 (0.04)	12.25** (1.13)	18.65** (0.99)	24.89** (1.16)	34.11** (1.22)	-	1999:Q2 (’98:Q4- ’99:Q4)	2003:Q3 (’02:Q4- ’04:Q1)	2006:Q3 (’06:Q1- ’06:Q4)	-
Cyprus **(S)**	-0.05** (0.01)	18.91** (0.27)	21.32** (0.36)	23.04** (0.37)	-	-	2005:Q4 (’04:Q2- ’07:Q3)	2007:Q4 (’07:Q3- ’09:Q2)	-	-
Check Republic **(S)**	-0.22** (0.05)	35.76** (1.37)	34.61** (1.26)	33.33** (1.25)	35.56** (1.26)	34.39** (1.35)	1996:Q4 (’96:Q3- ’03:Q1)	1998:Q4 (’97:Q1- ’99:Q2)	2001:Q1 (’00:Q4- ’01:Q04)	2002:Q4 (’99:Q4- ’03:Q1)
Denmark **(BIC, LWZ)**	0.21* (0.09)	12.40** (2.17)	14.34** (2.30)	16.94** (2.13)	-	-	1997:Q2 (’96:Q4- ’98:Q1)	2005:Q3 (’05:Q1- ’06:Q1)	-	-
Estonia **(S)**	0.26* (0.12)	15.32** (2.47)	19.65** (2.80)	27.09** (3.24)	-	-	1996:Q1 (’95:Q1- ’96:Q2)	2002:Q2 (’98:Q4- ’02:Q4)	-	-
Finland **(BIC)**	0.52** (0.06)	3.90* (1.67)	2.76 (1.94)	-	-	-	1999:Q3 (’96:Q2- ’00:Q2)	-	-	-
France **(S)**	-0.17 (0.08)	21.31** (1.71)	23.51** (1.74)	-	-	-	1999:Q1 (’97:Q4- ’99:Q1)	-	-	-
Germany **(BIC)**	-0.12 (0.11)	23.62** (2.52)	21.73** (2.66)	23.39** (2.95)	-	-	2001:Q4 (’01:Q1- ’03:Q1)	2006:Q1 (’04:Q4- ’07:Q1)	-	-
Hungary **(S, LWZ)**	0.37** (0.03)	12.44** (0.62)	10.65** (0.65)	-	-	-	1996:Q3 (’95:Q4- ’97:Q3)	-	-	-
Italy **(BIC)**	0.22* (2.31)	13.93** (2.16)	15.41** (2.08)	16.36** (2.03)	-	-	1998:Q3 (’97:Q3- ’99:Q3)	2001:Q4 (’00:Q2- ’04:Q2)	-	-
Latvia **(S, BIC, LWZ)**	0.30 (0.18)	11.32** (2.48)	20.03** (3.22)	28.59** (3.15)	-	-	1997:Q4 (’96:Q4- ’98:Q2)	2004:Q1 (’02:Q2- ’05:Q1)	-	-
Lithuania **(S, BIC, LWZ)**	0.15 (0.09)	13.56** (1.56)	18.56** (1.53)	24.25** (1.30)	-	-	1996:Q3 (’95:Q4- ’96:Q4)	2005:Q1 (’03:Q1- 05:Q3)	-	-
Luxemburg **(S, BIC, LWZ)**	-	-	-	-	-	-	-	-	-	-
Netherland **(BIC, LWZ)**	0.40** (0.08)	8.53** (2.14)	10.49** (2.21)	8.85** (2.25)	-	-	1996:Q1 (’95:Q3- ’96:Q2)	2002:Q2 (’01:Q3- ’03:Q1)	-	-
Poland **(S, BIC)**	1.04** (0.04)	-1.06 (0.79)	4.03** (0.68)	1.38* (0.79)	-0.36 (0.74)	2.39* (0.91)	1996:Q3 (’95:Q4- ’96:Q4)	2001:Q1 (’00:Q4- ’03:Q2)	2003:Q1 (’01:Q4- ’04:Q2)	2008:Q1 (’07:Q2- ’08:Q3)
Portugal **(S)**	0.67** (0.09)	10.39** (1.77)	13.28** (1.54)	-	-	-	1997:Q3 (’96:Q1- ’98:Q2)	-	-	-
Slovenia **(S, BIC, LWZ)**	0.36** (0.07)	13.03** (1.49)	16.73** (1.78)	-	-	-	1997:Q1 (’96:Q2- ’97:Q3)	-	-	-
Slovakia **(BIC, LWZ)**	-0.18* (0.10)	29.45** (2.92)	39.03** (2.75)	31.59** (2.76)	-	-	1996:Q3 (’96:Q1- ’97:Q2)	1998:Q4 (’98:Q3- ’99:Q2)	-	-
Spain	0.54**	9.65**	12.84**	15.07**	17.52**	15.38**	1998:Q1	2003:Q1	2005:Q1	2008:Q1

(BIC)	(0.09)	(2.27)	(2.29)	(2.21)	(2.09)	(2.14)	('97:Q3-'98:Q2)	('02:Q2-'03:Q4)	('04:Q1-'05:Q4)	('03:Q4-'08:Q4)
Sweden **(S, BIC, LWZ)**	0.15* (0.06)	12.97** (1.53)	14.67** (1.83)	-	-	-	2006:Q1 ('05:Q3-'07:Q1)	-	-	-
UK **(BIC, LWZ)**	0.48** (0.05)	6.22** (0.97)	8.43** (0.93)	9.65** (0.82)	10.39** (0.85)	-	1997:Q4 ('97:Q3-'98:Q2)	2001:Q4 ('01:Q2-'02:Q1)	2006:Q3 ('04:Q1-'07:Q3)	-

Notes: The parentheses under the break points are 95% confidence intervals for the break dates.
**, * Denote statistical significance at the 1 and 5% level respectively.

Table 6. Cointegration test with a structural break Gregory and Hansen

Country	Model	ADF*	Z_t^*	Z_α^*	S	BIC	LWZ
Austria	C	-3.31	-9.36**	-67.75*	1	1	1
	C/T	-4.19	-11.22**	-73.77**			
	C/S	-3.39	-9.28**	-67.76*			
Belgium	C	-4.13	-6.81**	-51.97	0	1	1
	C/T	-4.49	-6.18**	-47.96			
	C/S	-4.18	-6.81**	-51.99			
Check Republic	C	-4.80	-5.74*	-39.35	4	1	0
	C/T	-5.19	-6.32**	-44.46			
	C/S	-4.98	-5.82*	-41.87			
Estonia	C	-3.91	-4.15	-31.65	2	4	1
	C/T	-3.14	-3.77	-29.84			
	C/S	-3.94	-4.15	-31.13			
Finland	C	-3.24	-6.74**	-53.26*	0	1	0
	C/T	-3.87	-6.96**	-54.33*			
	C/S	-3.26	-7.15**	-55.85*			
France	C	-3.43	-4.73	-28.14	1	3	3
	C/T	-5.46*	-6.34**	-48.08			
	C/S	-4.58	-4.83	-30.56			
Hungary	C	-2.57	-7.72**	-59.56*	1	2	1
	C/T	-3.31	-8.30**	-63.39*			
	C/S	-2.57	-7.88**	-60.66*			
Italy	C	-2.83	-8.32**	-63.68*	0	2	1
	C/T	-3.15	-8.27**	-63.59*			
	C/S	-3.42	-8.88**	-66.89*			
Portugal	C	-3.34	-4.71	-33.42	1	4	4
	C/T	-4.92	-4.71	-33.92			
	C/S	-3.45	-4.75	-34.14			
Slovenia	C	-4.24	-6.82**	-49.07	1	1	1
	C/T	-3.90	-6.36**	-46.09			
	C/S	-4.19	-6.93**	-48.58			
Slovakia	C	-3.66	-7.42**	-49.99	1	2	2
	C/T	-3.86	-7.63**	-53.71*			
	C/S	-3.97	-7.44**	-49.59			
Sweden	C	-3.43	-9.86**	-72.23**	1	1	1
	C/T	-3.75	-9.79**	-72.02**			
	C/S	-3.45	-9.87**	-72.29**			

Notes: * denotes statistical significance at 5% level. ** denotes statistical significance at 1% level. Last three columns S, BIC and LWZ (sequential procedure, Bayesian Information Criteria, and the modified version of BIC Respectively) indicate by which if these procedures presence of one break was selected in the application of Bai and Perron (1998) approach, see Table 4.

Table 7. Standard Cointegration test Johansen

Country	Trace statistics		Max-Eigen Statistics	
	r = 0	r ≤ 1	r = 0	r ≤ 1
Austria	28.36**	3.71	24.64**	3.71
Belgium	19.47*	3.41	16.06*	3.41
Bulgaria	44.21**	0.45	43.76**	0.45
Cyprus	33.43**	0.07	33.36**	0.07
Check Republic	17.58*	0.64	16.93*	0.64
Denmark	8.32	0.12	8.19	0.12
Estonia	16.19*	4.99	11.19	4.99
Finland	19.33*	4.02*	15.31*	4.02*
France	8.01	0.83	7.18	0.83
Germany	16.52*	3.57	12.95	3.57
Hungary	24.02**	3.41	20.61**	3.41
Italy	12.08	3.11	8.97	3.11
Latvia	17.81*	3.24	14.57*	3.24
Lithuania	20.16**	3.03	17.13*	3.03
Luxemburg	26.95**	2.09	24.86**	2.09
Netherland	21.89**	2.87	19.02**	2.87
Poland	55.35**	4.34*	51.01**	4.34*
Portugal	25.14**	0.39	24.75**	0.39
Slovenia	20.37**	7.33**	13.03	7.33**
Slovakia	20.29**	7.64**	12.66	7.64**
Spain	21.94**	8.92**	13.01	8.92*
Sweden	18.82*	3.30	15.51*	3.30
UK	15.73*	3.50	12.22	3.51

Notes: * denotes statistical significance at 5% level. ** denotes statistical significance at 1% level.

Table 8. Cointegration test with multiple structural breaks Johansen

Country	Trace statistics						Max-Eigen Statistics					
	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r ≤ 4	r ≤ 5	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r ≤ 4	r ≤ 5
Austria **(1, S, BIC, LWZ)**	45.55**	19.10*	1.92				26.45**	17.18*	1.92			
Belgium **(1, BIC, LWZ)**	44.51**	8.83	3.64				35.68**	5.20	3.64			
Bulgaria **(3, BIC, LWZ)**	87.59**	47.08	30.35*	14.25	0.29		40.51**	16.72	16.11	13.96	0.29	
Cyprus **(2, S)**	76.92**	38.04**	10.72	2.63			38.87**	27.33**	8.09	2.63		
Check Republic **(4, S)**	135.24**	76.92**	37.20	19.05	8.64	2.79	58.32**	39.72**	18.15	10.41	5.85	2.79
Denmark **(2, BIC, LWZ)**	56.68**	23.61	5.71	0.001			33.08**	17.89	5.71	0.001		
Estonia **(1, S)**	78.38**	25.53	7.08	1.51			52.85**	18.45	5.57	1.51		
Finland **(1, BIC)**	45.37**	18.51*	4.82*				26.85**	13.69	4.82*			
France **(1, S)**	41.93**	11.31	0.11				30.61**	11.21	0.11			
Germany **(1, BIC)**	78.83**	28.28	8.68	1.44			50.55**	19.59	7.24	1.44		
Hungary **(1, S, LWZ)**	59.59**	28.27**	3.98*				31.32**	24.29**	3.98*			
Italy **(1, BIC)**	76.60**	31.31*	8.78	3.81*			45.29**	22.52*	4.98	3.81*		
Latvia **(2, S, BIC, LWZ)**	77.12**	28.25	11.13	2.44			48.86**	17.18	8.69	2.44		
Lithuania **(2, S, BIC, LWZ)**	86.60**	34.89*	16.30*	5.20*			51.71**	18.59	11.10	5.20*		
Luxemburg	-	-	-	-	-	-	-	-	-	-	-	-
Netherland **(2, BIC, LWZ)**	54.93**	29.01	7.74	1.85			25.92	21.27*	5.89	1.85		
Poland **(4, S, BIC)**	155.88**	77.84**	51.61*	32.37*	15.95*	4.36*	78.04**	26.23	19.24	16.42	11.59	4.36*
Portugal **(1, S)**	44.72**	16.42*	0.19				28.30**	16.23*	0.19			
Slovenia **(1, S, BIC, LWZ)**	37.59**	18.69*	6.92**				18.91	11.76	6.92**			
Slovakia **(1, BIC, LWZ)**	72.87**	32.34*	3.64	0.14			40.54**	28.69**	3.50	0.14		
Spain **(1, BIC)**	153.78**	84.68**	49.98*	30.15*	15.95*	3.37	69.09**	34.70*	19.83	14.20	12.58	3.37
Sweden **(1, S, BIC, LWZ)**	38.39**	17.49*	3.07				20.91	14.42*	3.07			
UK **(3, BIC, LWZ)**	115.04**	62.41**	29.03	11.09	4.92*		52.64**	33.38**	17.94	6.17	4.92*	

Notes: * denotes statistical significance at 5% level. ** denotes statistical significance at 1% level.