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# **50 years of capital mobility in the Eurozone: breaking the Feldstein-Horioka Puzzle**

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# 50 years of capital mobility in the Eurozone: breaking the Feldstein-Horioka Puzzle\*

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## Abstract

This paper assesses capital mobility for the Eurozone countries by studying the long-run relationship between domestic investment and savings for the period 1970-2019. Our main goal is to analyze the impact of economic events on capital mobility during this period. We apply the cointegration methodology in a setting that allows us to identify endogenous breaks in the long-run saving-investment relationship. Specifically, the breaks coincide with relevant economic events. We find a downward trend in the saving-investment retention since the 70s for the so-called “core countries”, whereas this trend is not so clear in the peripheral, where the financial and sovereign crises have had a more substantial impact. Our analysis captures other economic events: the Exchange Rate Mechanism (ERM) crisis, the German reunification, the European financial assistance program, and the post-crisis period. Our results also indicate that the original euro design had some caveats that remain unsolved.

*Keywords:* Capital mobility; Feldstein-Horioka puzzle; Multiple Structural Breaks; Cointegration, unit roots.  
*JEL classification:* F36; F45; O16.

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## 1 Introduction

The free movement of capital in the European Union (EU) is one of the fundamental economic freedoms established in the founding treaties. However, the level of restrictions in this field has long been considered secondary in European construction. Until the mid-1980s, the regime for the liberalization of intra-Community capital movements had its origin in the 1960s and was limited to those capital operations most closely linked to compliance with the other fundamental freedoms of the Treaty of Rome. Obviously, the integration of the EU capital markets is a long-term structural endeavour and much effort has been devoted over the years. During the 60s, apart from two directives adopted in 1960 and 1962, other initiatives to facilitate the harmonization or convergence of national regulations were paralyzed; moreover, due to the instability of the financial markets in the 70s and the crisis of the European Monetary System (EMS) at the beginning of the 80s, some Member States (i. ex. France, Italy, Ireland, Denmark, and Greece) called in for safeguard clauses to stop and reverse the process of financial integration.

The relaunch of EU initiatives on the liberalization of capital movements took place in the early 1980s, parallel with the globalization process at the world level. In this environment, many of the EU Member States considered it necessary to open up and modernize their financial structures, giving them a Community dimension to improve their competitiveness levels: the Single Market project in the 1980s, with the liberalisation of capital movements and the creation of the European passport for financial services; the Financial Services Action Plan starting in 1999, the Lamfalussy process starting in 2001, and the Larosière Report in 2009 (Larosiere, 2009), which enshrined the vision of a single rulebook and resulted in the creation of the European supervisory authorities.

Since the Great Recession in 2007-2008, financial markets have experienced a striking dichotomy regarding the on-going process of globalization. In the specific case of Europe, there has been a remarkable process of fragmentation since the beginning of the crisis and the EU is now fostering financial integration through the creation of a banking and capital markets union (CMU hereafter). The Commission adopted the first CMU action plan in 2015. Since then, the EU has made significant progress on putting the building blocks in place towards increasing financial integration<sup>1</sup>. Therefore, the analysis of the evolution of the degree of financial integration in the EU has regained momentum.

Capital mobility can be considered a key issue in international macroeconomics. Baele et al. (2004) outline three widely accepted interrelated benefits of financial integration: higher efficiency, better opportunities for risk sharing, and more potential for growth. Financial liberalization allows capital to be reallocated where it is more efficient and eventually, this process improves welfare and growth. Moreover, integrated banking and capital mobility do provide broader protection from shocks in a single currency area and enhance “cross-country risk-sharing”, that is, it helps to decouple con-

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<sup>1</sup>The rationale behind this process is that the CMU can speed up the EU recovery from the COVID-19 pandemic. It can also provide the funding needed to deliver on the European Green Deal, make Europe fit for the digital age, and address its social challenges

sumption and output dynamics when an asymmetric shock occurs (Kalemli-Ozcan et al., 2003).<sup>2</sup> In order to take advantage of these positive effects, barriers to capital mobility started to be removed by the 1970s in the US and the UK, followed by other developed countries during the 1980s<sup>3</sup>. In the EU, this liberalization process also started in the 1980s and the beginning of the 1990s following the Single Market initiative, that implied full capital mobility by 1992 after the Maastricht Treaty (OECD, 2011).

However, despite the welfare improvement caused by capital mobility across countries, since the 1990s, there has been a side non-desired effect in terms of increasing and persistent external disequilibria in current account terms and its financial counterpart. That process is not constrained to the Euro area (EA); on the contrary, it has occurred parallel with a process of globalization characterized by the removal of capital barriers around the globe. Different hypotheses have come forward, trying to explain such external disequilibria; one of the most popular is the “savings glut” hypothesis, formulated by Bernanke (2005) and extended in Horioka et al. (2015). According to it, external disequilibria are caused by macroeconomic imbalances between savings and investment ( $S$  and  $I$ , respectively, hereafter) in a context of financial liberalization rather than by industrial, commercial, or exchange rate policies. Persistent imbalances between national  $S$  and  $I$  would be at odds with the existence of a Feldstein-Horioka puzzle and would lead to the creation of increasing external disequilibria in the following way: large surplus countries, where  $S > I$ , contribute to the world-saving pool; such excess of saving causes the real interest rate to decrease, which allow the access of deficit countries to new credit, pumping larger external disequilibria. However, this process sharply ended with the 2007 financial crisis and the subsequent adjustment that took place afterward. This re-balancing procedure can be especially costly within a monetary union, as the EA. The financial sudden stop inside the EA created an asymmetric shock, as countries were affected differently depending on their relative degree of external disequilibrium<sup>4</sup> At the core of the problem lies an issue of balance of payments adjustment within a monetary union<sup>5</sup>. Unwinding these imbalances led to sharp increases in sovereign debt and induced a sovereign-bank feedback loop. It also created spillover effects across the Member States that endangered the stability of the EA as a whole and marked a period of economic and financial divergence among the Member States. As a consequence of the limited cross-border financial integration in banking and capital markets, significant differences in financing conditions between EU countries arose during the crisis, slowing the recovery and undermining economic convergence. European capital markets should be as integrated and developed as possible, as in the context of a monetary union, the failure to achieve it may have serious consequences. First, if private risk-sharing is grossly insufficient it can limit the

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<sup>2</sup>Banking Union and capital markets integration have complementary stability implications for the risk absorption capacity of the Euro Area. While banking integration strengthens the intertemporal risk-sharing channel, which is very effective against temporary shocks, capitals market integration, instead, facilitates the absorption of structural shocks that affect permanent income via risk dispersion and diversification from cross-border holding of assets.

<sup>3</sup>For more information, see Pagoulatos (1999) and Wyplosz (1999).

<sup>4</sup>See Baldwin and Giavazzi (2016).

<sup>5</sup>As peripheral EA countries had fixed their exchange rates with core countries, the needed real exchange rate adjustments could not occur through nominal exchange rate appreciation but took place instead through domestic prices in the periphery.

resilience of euro area Member States, measured as the capacity to absorb and recover from adverse shocks. Second, capital mobility may also strengthen the effectiveness of the single monetary policy as fragmentation and frictions may prevent the pass-through of the policy interest rate to market interest rates. Therefore, the assessment of capital mobility in the EU deserves further attention.

According to Meyermans et al. (2018), the three main structural barriers that hamper the development of a well-functioning financial architecture in the EA are (i) the fragmented regulatory and institutional frameworks; (ii) the corporate sector's over-reliance on bank financing<sup>6</sup> and, finally, (iii) the strong "home bias" of credit and capital markets. Home bias, measured as the holding of domestic assets versus their optimal intra-EU allocation, relates to the quantity approach to financial integration (Feldstein and Horioka, 1980). This should be closely monitored, as a high home bias may amplify output shocks during the financial crisis. (Furceri and Zdzienicka, 2013).

In this paper we evaluate capital mobility using the Feldstein-Horioka (FH hereafter) regression and complement its interpretation by examining the time-series properties of the individual series involved as well as the stability of the long-run relationship linking domestic saving and investment. We take advantage of a natural experiment, the monetary and financial integration process in Europe, to test whether the beginning of the European single market in 1993 and the introduction of the euro in 1999 coincided with a structural break in the *savings – investment* relationship in the European countries. Another salient feature of this paper is that there is, to the best of our knowledge, little empirical literature on the Feldstein-Horioka puzzle covering financial integration from the very beginning of the monetary integration process, the only exceptions to the best of our knowledge being Katsimi and Zoega (2016), ECB (2018) and Camarero et al. (2020), although they cover a shorter span.

Bearing in mind all the arguments stated above, in this paper we seek to measure capital mobility over the period 1970-2019, accounting for the different stages of the EU financial integration: the initial process of financial integration since the 70s (more intense after the Maastricht Treaty signature in 1992), the creation of the Euro and the subsequent large capital imbalances along 2000-2007, the global financial crisis and the post-crisis period. The econometric methodology is based on tests recently proposed by Kejriwal and Perron (2010) that allows us to identify if there is a long-term relationship between domestic savings and investment as well as its stability, by the endogenous identification of potential breaks. Moreover, we test for cointegration using tests allowing for multiple structural breaks in the coefficients as proposed by Arai and Kurozumi (2007) and Kejriwal (2008). Finally, for the cases where we find cointegration between the two variables, we estimate the model including the breaks to assess if the relationship between domestic investment and saving (the slope parameter  $\beta$ ) has changed over time.

Our contributions are the following: first, we reassess the FH puzzle for the Eurozone countries

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<sup>6</sup>Indeed, with bank lending curtailed after the financial crisis, viable enterprises, and particularly SMEs had difficulties accessing alternative funding sources, especially in vulnerable Member States where alternative channels via capital markets remain under-developed.

with updated data; second, for this purpose, we take into account the non-stationarity properties of the variables; third, we relate our econometric methodology, that accounts for structural changes (breaks) in the long-run relationship, with the changes in the degree of financial integration and capital mobility as measured by the coefficient of savings in the FH equation; finally, our results have relevant economic policy implications.

This paper is organized as follows: in Section 2, we present the theoretical background on how capital mobility is measured using the FH approach; in Section 3, we review the empirical literature on the subject. Section 4 summarizes the econometric methodology and discusses the empirical results. Finally, Section 5 concludes.

## 2 Theoretical background

### 2.1 Capital mobility: some definitions

The measurement of the degree of capital mobility is not an easy task. Although the literature provides several alternative definitions, financial market integration is closely related to the law of one price. The law of one price states that if assets have identical risks and returns, then they should be priced identically regardless of where they are transacted. However, to get this result, different conditions should be met, and the literature has traditionally considered three approaches<sup>7</sup>. While the first one is known as the *price approach* and focuses on the co-movements between domestic and foreign rates linked by the exchange rate, the second approach - also known as the *quantity approach* - studies the co-movement of the variables that directly materialize capital mobility, that is, investment and savings. More recently, alternative measures, investigating the impact of common shocks on prices (*news-based measures*) have been added as a useful complement to the traditional price-based measures.

Concerning the price-approach<sup>8</sup>, there are three accumulative criteria that have been posited in the literature. The first criterion is the “covered nominal interest rate parity” or CIP. If the CIP is fulfilled, there would be no country premium. If  $i$  and  $i^*$  stand for nominal domestic and foreign interest rates and  $F$  and  $E$  are, respectively, the forward and spot exchange rates, the expression  $i_t - i_t^* - (F_t^{t+j} - E_t) = 0$ , means that the nominal interest rate differential should be compensated by an equal gap between forward and spot nominal exchange rate. In this case, there is perfect capital mobility of type I.

The second criterion is the “uncovered nominal interest parity” or UIP. It implies the fulfilment of type I mobility plus zero exchange risk premium. If this criterion holds, both country premium and exchange risk premium are zero,  $(F_t^{t+j} - E_t) - (E_{t+j}^* - E_t) = 0$ , and therefore, perfect capital mobility of type II holds.

<sup>7</sup>We follow Dooley et al. (1987) and Lemmen and Eijffinger (1993, 1995) in this Section.

<sup>8</sup>For an in-depth analysis, see Frankel (1988).

The third criterion is the “real interest parity” or RIP. This is the most restrictive definition of capital mobility as it requires criterion I and II to hold plus zero expected real depreciation. If this criterion is satisfied, it implies perfect financial and non-financial capital mobility, i.e. zero country premium, zero exchange risk premium plus zero expected real exchange rate change  $E_{t+k}^e - E_t = \pi_t^e - \pi_t^{*e}$ . Therefore, domestic and foreign real interest rate are equalized  $r_{t+j}^e - r_{t+j}^{*e} = 0$ .

Finally, according to this taxonomy, the strongest and more complete definition of capital mobility is given by the quantity-based approach, that is, the Feldstein-Horioka condition: it requires criteria I, II and III to hold, implying zero correlation between domestic investment and saving. This means that an exogenous change in the national saving rate should have no effect on the domestic investment rate.

## 2.2 FH condition for financial integration

Feldstein and Horioka (1980) estimated using OLS the relationship between the ratios of saving and investment over GDP for the period 1960-1974, as well as for three subperiods (1960-1964, 1965-1969 and 1970-1974). In particular, they estimate the following equation:

$$\left(\frac{I_i}{Y_i}\right) = \alpha + \beta\left(\frac{S_i}{Y_i}\right) \quad (1)$$

Where  $(I_i/Y_i)$  is the ratio of gross domestic investment to GDP and  $(S_i/Y_i)$  is the ratio of gross domestic saving to GDP. The  $\beta$  coefficient is called the saving-retention coefficient that measures how changes in the national investment ratio are explained by exogenous changes in the domestic saving ratio.

The authors argue that in a world with perfect capital mobility,  $\beta$  should be zero for small countries, whereas it would represent their share of the world capital stock for large countries. The reason for  $\beta$  to be zero is that in a world with fully integrated capital markets, any exogenous variation in domestic savings should not affect domestic investment, arguing that capital would move to the countries with the highest return. In contrast, in a closed economy, the saving-retention coefficient should be 1 because the domestic savings accommodate all variations in domestic investment.

Feldstein and Horioka (1980) found a  $\beta$  coefficient of 0.88. They argued that this coefficient implied that international capital mobility and the degree of integration of the international capital markets were low. The FH result has been tested in many papers. However, their result has remained robust in the cross-section analysis. This result confronts what international macroeconomics predicts in a process of globalization. This is why the FH result has given rise to the “Feldstein-Horioka puzzle”(Feldstein and Horioka, 1980).

### 2.3 Assumptions behind the FH regression

From a theoretical point of view, for the FH regression to be valid some assumptions should be satisfied. The FH condition for capital mobility is the strongest one, and it requires the other three criteria plus three strong assumptions:

*First:*

$$\left(\frac{I_i}{Y_i}\right) = \beta_0 - \beta_1 r_i + u_i \quad (2)$$

where (2) implies that the investment rate depends on the real interest rate and an unknown error term (that is, other factors that affect the investment rate different from the domestic real interest rate).

*Second:*

$$\text{Cov}\left(u_i, \frac{S_i}{Y_i}\right) = 0 \quad (3)$$

(3) implies that for the saving-retention coefficient to be unbiased, none of the determinants of the investment rate must be correlated with the saving ratio in country  $i$ . If this strong assumption does not hold, it would give rise to endogeneity problems. In fact, it is sensible to think that both rates are affected by population or productivity shocks.

*Third:*

$$r_i = r^* \quad (4)$$

Assuming that the real interest parity holds, then (4) implies that the country is unable to affect the world real interest rate, that is,  $r^*$  is exogenous.

Therefore to get a zero saving-retention coefficient in equation (2) we need the world interest rate  $r^*$  to be exogenous as well as the error term in equation (3) not to be correlated with the saving rate.

### 2.4 Assessment of capital mobility: still a debate

After the findings of Feldstein and Horioka (1980), many papers have attempted to find factors impeding capital mobility; Niehans (1986) argues that the removal of barriers to capital transfers does not ensure its mobility across countries. In the same vein, Obstfeld and Rogoff (2000) developed a model with transaction costs for international trade in goods finding that the sole existence of frictions in the good markets might prevent capital mobility across countries. More recently, Ford and Horioka (2017) maintain that financial markets integration is not a sufficient condition to achieve capital mobility, i.e. they state that FH's results can be due to the absence of globally integrated goods markets, and hence, both financial and goods markets integration are needed for capital mobility to exist.

In this sense, our EU sample is a natural test for capital mobility because there are no barriers neither to capital nor to goods mobility. In case capital mobility remains persistently low, we should conclude that there are other reasons for this result, probably the so-called "home bias". Following Ford and Horioka (2017), we study whether the process of economic integration in Europe has



encouraged capital mobility.

In contrast, other authors such as Sinn (1992), Jansen (1997), Jansen (1998), Jansen (2000), Obstfeld and Rogoff (1995), Coakley et al. (1996), and Shibata and Shintani (1998) think that the natural explanation for the existence of a long-run relationship (cointegration) between domestic saving and investment is simply the fulfilment of the long-run solvency condition of the economy and disagree with the conventional FH interpretation. However, this statement seems somehow at odds with the empirical evidence showing persistent long-run trend swings in the FH coefficient in parallel with periods of changes in financial openness.

### 3 Survey on the main empirical literature

Obstfeld and Rogoff (2000) refer to the FH puzzle as “the mother of all puzzles” as the seminal paper of Feldstein and Horioka (1980) has given rise to an extensive literature trying to solve it. This literature can be classified into three categories<sup>9</sup>.

The first one seeks to reconcile the large correlation found between domestic saving and investment with the existence of a high capital mobility constructing new theoretical models. One strand of the literature highlights the role of the intertemporal budget constraint for the explanation of the FH puzzle (Sinn, 1992; Jansen, 1997, 1998, 2000; Obstfeld and Rogoff, 1995; Coakley et al., 1996; Shibata and Shintani, 1998). An extension of that argument is related to the government interventions to offset private net capital flows (Fieleke, 1982; Feldstein, 1983; Westphal, 1983; Summers, 1988).

A second line of research includes those papers that do not agree with Feldstein and Horioka (1980) results. One of the most important criticisms has to do with the choice of the countries included in their paper as this could be a source of a sample selection problem: as FH only include large developed countries (LDC), this may cause an upward bias on the saving-retention coefficient. Savings shocks that hit large economies are expected to affect the world interest rate and hence their domestic investment. Therefore, we may expect a higher saving-investment correlation for large economies. In contrast, smaller economies cannot affect the world interest rate and hence it would be reasonable to find a lower saving-investment relationship. Harberger (1980), using a group of small and large countries finds that the former have experienced stronger capital inflows and outflows than large economies. Those results were also supported by Sachs (1983) and Murphy (1984). Later, Tesar (1991) excluded Luxembourg from her sample and found that the saving-retention coefficient changes from 0.35 to 0.84, concluding that there is a problem of sample selection bias.

Feldstein (1983) argues that the FH regression suffers from endogeneity problems that should be properly addressed<sup>10</sup>. Later studies have supported his view, such as Dooley et al. (1987), Bayoumi

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<sup>9</sup>As the literature is very large, we only refer to the most important papers. For a more exhaustive review, see Apergis and Tsoumas (2009) and Coakley et al. (1998).

<sup>10</sup>This problem may arise if both variables react to population or productivity shocks or to a government response to correct a current account imbalance.

(1990), Tesar (1991) and Kasuga (2004). Another source of criticism is related to the non-stationary properties of the variables. Jansen and Schulze (1993) and Coiteux and Olivier (2000) argue that if the variables are  $I(1)$  and they are in levels the result may not be valid. To solve this problem, Bayoumi (1990) introduces the variables in first differences. Finally, Obstfeld and Rogoff (1995) and Ho (2000) argue that time-averaged data in cross section studies tends to overestimate or underestimate the value of the saving-retention coefficient.

Relying on the previous objections, the third strand of literature focuses on improving the econometric techniques. We classify the papers according to the statistical methods used: cross-section, time series, and panel data methodologies.

Concerning cross section data, Murphy (1984) estimated the saving-investment relationship for a group of 17 countries finding that the correlation was higher for large countries and relating the FH results to country size instead of capital immobility. Feldstein (1982) updated FH paper by extending the sample from 1960-1979 with no change in the results. Later, Feldstein and Bacchetta (1991) using a sample of 23 OECD countries found that the saving-retention coefficient had marginally declined over time. Other studies have used different samples and time periods but in the cross-sectional analysis the FH result has been robust.

In time series studies, Feldstein and Horioka (1980) also ran the FH regression using annual data for 21 countries finding an average saving-retention coefficient of 0.64. Obstfeld (1986) obtained a saving-retention coefficient from 0.13 to 0.91. Tesar (1991) and Frankel (1991) also used time series and the latter showed that the saving-investment correlation had fallen from the 1980s in the US. Also in this literature, Miller (1988) studies the existence of cointegration between saving and investment over the period 1946-1987 finding that there only was cointegration under a fixed exchange rate regime. Gulley (1992) did not find any cointegrating relationship between the variables in any exchange rate regime. This result was confirmed by Sarno and Taylor (1998). Leachman (1991) and Sinha (2002) did not find cointegration using a sample of 23 OECD economies, probably due to the low power of the Engle-Granger two-step procedure. To overcome this problem other authors such as Jansen and Schulze (1993) used an error correction model to verify the existence of a long-run relationship and found more evidence in favour of cointegration.

The analysis implemented in Kejriwal (2008) deserves a special attention, as it revisits the FH puzzle for 21 OECD countries with data ending in 2000. He finds evidence from 1 to 3 regime changes and considers that part of the evidence in favour of the puzzle may be due to non-accounting for the non-stationarity of the variables and the existence of structural breaks. Ketenci (2012) applies the same econometric methodology than Kejriwal (2008) and estimates the  $\beta$  coefficients determined by the breaks. Her findings do not support FH's result for the EU countries.

Concerning panel techniques, Coakley et al. (2004), Krol (1996), Coakley and Kulasi (1997), Corbin (2001), Narayan (2005) and Kim (2001) are examples of applied papers testing the FH relationship with similar results than those recently found using time-series. Other authors criticize the panel

methodology, as the results would not be valid if no regime change is allowed for. Westerlund (2006) finds more evidence of cointegration between saving and investment once he accounts for structural breaks in the panel. However, there is not much literature on the FH puzzle allowing for structural breaks. An prominent example is Ho (2000), who includes structural changes in the cointegrated relationship as well, arguing that the saving-investment relationship may be subject to regime changes. Also, Telatar et al. (2007), Mastroiannis (2007) and Özmen and Parmaksiz (2003) allow for structural breaks. The last two papers found that when a regime shift is allowed there is no evidence in favour of the puzzle. Finally, Camarero et al. (2020) developed a time-varying parameters state-space model applied to panel data covering the EU countries.

Focusing on the European case, Drakos et al. (2018) assessed the correlation between domestic saving and investment for 14 EU countries employing panel data techniques for the period 1970-2015, finding that there is weak evidence in favour of the FH and that the long-run solvency condition is achieved. But and Morley (2017), applying panel techniques for a sample of OECD countries (in which some Eurozone countries are included), found that the correlation between domestic saving/investment dropped to record levels right before the 2008 financial crisis, and the puzzle returns afterwards. Their results also suggest that the puzzle for net capital-importing and capital-exporting countries differs. In this line, Ketenci (2018) using GMM techniques analyzed the impact of the 2008 financial crisis on the level of capital mobility, finding an insignificant impact.

Finally, the ECB performs periodical studies on the degree of financial integration in the Eurozone. In ECB (2018) and ECB (2020) it analyzes how financial integration has evolved in the Eurozone<sup>11</sup> concluding that it increased after the creation of the euro with a reversion of the trend after the 2007 financial crisis that stopped after the introduction of the Outright Monetary Transactions (OMT) programme and the banking union announcement. To assess the degree of financial integration the ECB uses two approaches. First, in ECB (2018), following the two seminal papers of Lewis (1995) and Asdrubali et al. (1996), the ECB examines the evolution of cross-country risk-sharing in the Eurozone and finds that risk-sharing is still low and unstable, with an increase in the correlation between consumption and output dynamics after the financial and sovereign crisis. Second, in ECB (2018) appears an analysis of the degree of financial integration in the Eurozone and the fulfilment of the FH puzzle. The approach followed was to augment the usual FH equation with country-specific variables to account for global shocks affecting those economies. However, the report highlights that the estimation is highly volatile being the interpretation of the results difficult, which calls for further research in the area.

#### **4 Econometric analysis: Unit roots, cointegration and stability**

In this section we examine the link between domestic investment and saving using cointegration techniques that allow for multiple structural breaks. Although we closely follow the empirical

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<sup>11</sup>The ECB measures financial integration using the price-based and the quantity-based approaches.

strategy developed by Kejriwal (2008), we first apply Perron and Yabu (2009) stability test, and only then, depending on whether the individual series are found to be stable, we use the proper specification of the unit root tests. Sequentially, the econometric procedure is as follows. First, we apply Perron and Yabu (2009) pre-test to assess the stability of each individual saving and investment series. Next, to determine the order of integration of the variables, if the series were found stable (that is, when we cannot reject the null hypothesis of stability in the Perron-Yabu test) we use the unit root test proposed by Ng and Perron (2001). For the non-stable series, we apply the unit root tests with breaks by Carrion-i Silvestre et al. (2009) and Harvey et al. (2013). In a third step, we test for the stability of the domestic saving-investment relationship (and select the number of breaks) using the test proposed by Kejriwal and Perron (2010). After that, we verify that the variables are cointegrated with tests allowing for multiple structural breaks in the coefficients as proposed by Arai and Kurozumi (2007) and Kejriwal (2008). Finally, for the cases where we find cointegration between the two variables, we estimate the model including the breaks to assess if the relationship between domestic investment and saving (the slope parameter  $\beta$ ) has changed over time.

As our interest is focused on the evolution of the savings-investment relationship in the EU and the role of the economic-integration related events<sup>12</sup> on this relationship, we have tried to obtain as much information as possible from the data. Annual data is only available for some of the countries: Austria (Aus), Belgium (Bel), Finland (Fin), Germany (Ger), Ireland (Ire), Italy (Ita), Luxembourg (Lux), Portugal (Por) and Spain (Spa) for the period 1970-2019. In the case of Cyprus (Cyp), it starts in 1975, Greece (Gre) and France (Fra) in 1960, and the Netherlands (Net) in 1969. The source is the World Bank (WB) database. Quarterly data was available for all the EU countries, for most of them starting in 1995 and has been obtained from the International Financial Statistics (IFS) of the IMF. Estonia, Latvia, Lithuania, Malta, Slovak Republic, and Slovenia have been only included in the quarterly analysis<sup>13</sup>. The reason for the combination of annual and quarterly data is that annual data is generally available for a longer sample period, usually, from 1970, whereas quarterly data is only available from 1995. We are applying the analysis to the data in the two frequencies. First, to include as many EU countries as possible, but also, and more importantly, because the techniques used to endogeneously detect the instabilities let out observations from the beginning and the end of the sample due to the trimming. Therefore, to capture potential structural breaks at the end of the sample (after the 2007 financial crisis) quarterly data is necessary<sup>14</sup>.

The variable used to measure investment is gross fixed capital formation, whereas, for saving, we

<sup>12</sup>Specifically, first, the political and economic integration brought by the monetary integration process; second, German Reunification; third, the 2007 financial crisis; fourth, the sovereign debt crisis.

<sup>13</sup>In the case of quarterly data, the availability is as follows: Austria (Aus) from Q1 1996 to Q1 2020, Belgium (Bel), Cyprus (Cyp), Greece (Gre), Ireland (Ire), Italy (Ita), Latvia (Lat), Lithuania (Lit), Luxembourg (Lux), Portugal (Por), Slovak Republic (Slovk) and Slovenia (Slo) from Q1 2015 to Q4 2019, Estonia (Est), The Netherlands (Net) and Spain (Spa) from Q1 1995 to Q1 2020, Finland (Fin) from Q1 1990 to Q4 2019, France (Fra) Q1 1980 to Q1 2020, Germany (Ger) from Q1 1991 to Q1 2020 and Malta (Mal) from Q1 2000 to Q4 2019.

<sup>14</sup>Moreover, in the annual analysis, if the number of observations in-between breaks is too short, the estimation of the coefficients for the sub-periods becomes unfeasible. In addition, due to the lack of degrees of freedom, the annual analysis tends to detect a smaller number of breaks.

use “basic saving”, as recommended by Baxter and Crucini (1993). This variable is defined as GDP minus total consumption (both public and private); both variables are expressed as a percentage of GDP. Quarterly data has been seasonally adjusted (except for the case of the Slovak Republic, for which data was not available).

#### 4.1 Stability. Perron and Yabu (2009) tests and preliminary analysis of the data

As a pre-test we start by applying the Perron and Yabu (2009) test for structural changes in the deterministic components of a univariate time series when it is a priori unknown whether the series is stationary –  $I(0)$  case – or contains an autoregressive unit root –  $I(1)$  case. The Perron-Yabu test statistic, called  $EXP - Wfs$ , is based on a quasi-Feasible Generalized Least Squares (FGLS) approach using an autoregression for the noise component, with a truncation to 1 when the sum of the autoregressive coefficients is in some neighborhood of 1, along with a bias correction. For given break dates, Perron and Yabu (2009) propose an F-test for the null hypothesis of no structural change in the deterministic components using the  $Exp$  function.

Table 1 shows the Perron and Yabu (2009) stability test. Model I, II, and III have been included since there is no common pattern in the series to choose only one model (level change, trend change or both). For annual data, the results of the  $Exp - WRQF$  test show stronger evidence in favor of structural breaks in the time series, rejecting the null hypothesis of absence of structural breaks for 15 out of 26 cases. In line with the annual data analysis, the quarterly results show stronger evidence in favor of structural breaks, rejecting the null hypothesis for 24 out of 38 time series.

In the case of quarterly data there is a different pattern for the two variables: investment is found to be unstable for most of the countries (except for 4 out of 19); for savings, in contrast, there is stronger evidence in favor of stability. This may be due to the higher volatility of investment, as it depends on the economic cycle, while savings are more stable. The savings rate may be explained by long-term factors that change more slowly, such as demography or the cultural propensity to save.

In order to complement the assessment of the stability of the variables, we present in Appendix A the graphs of the variables, both annual and quarterly, as well as some descriptive statistics in Tables 16 and 17 of Appendix C, with pre-crisis and post-crisis information.

Looking at the graphs and the tables, some patterns become apparent: the first one is that the saving rate is, in general, above the average for the EU countries with larger per capita income (Luxembourg, Ireland, The Netherlands, Austria, Finland, Belgium and Germany), both before and after the 2007 financial crisis. Regarding the investment rate, during the pre-crisis period countries with relatively low GDP per capita had higher investment rates than the average (Spain, Slovenia, Portugal, Estonia, Slovak Republic, Latvia); however, after the crisis no clear pattern is found.

These two facts taken together allow us to confirm that since the launching of the euro, and before

the crisis (2000-2007), the pool of saving generated by the richest countries of the EA may have flown (at least partially) into the less developed country members. After the crisis, foreign inflows into these countries suddenly stopped. The standard deviation of domestic investment also captures this effect: those Eurozone countries whose GDP per capita is below average have standard deviations above the average (Latvia, Greece, Slovak Republic, Cyprus, Estonia, Portugal, Spain, Slovenia, and Lithuania, an exception being Ireland). This may be explained by the large foreign capital inflows in the pre-crisis period and the sudden stop after it. These patterns are in line with the results of other studies, as in Baldwin and Giavazzi (2016).

#### 4.2 Order of integration

Once stability has been assessed, we apply the unit root tests proposed by Ng and Perron (2001) to the stable series, whereas for the unstable ones (the cases in which we could reject the null of stability), we have applied the GLS-based unit root tests with multiple structural breaks –both under the null and the alternative hypotheses– proposed in Carrion-i Silvestre et al. (2009). Previous unit root tests with a structural change in an unknown break date, such as Zivot and Andrews (1992) or Perron (1997), assumed that if a break occurs it does so only under the alternative hypothesis of stationarity.

Carrion-i Silvestre et al. (2009) propose a class of modified tests, called  $M^{GLS}$ , as  $M$  tests<sup>15</sup>, that use GLS detrending of the data as proposed in Elliott et al. (1996), and the Modified Akaike Information Criterion (*MAIC*) to select the order of the autoregression. We use Model III and II (structural breaks with trend and constant change and structural break with trend change, respectively) allowing for up to three breaks.

For comparability, we also apply the Harvey et al. (2013) unit root test with breaks to the unstable series. These authors show that the fixed magnitude trend break asymptotic theory of Carrion-i Silvestre et al. (2009) does not predict well the finite sample power functions of the  $M$  tests, and its power can be very low for the magnitudes of trend breaks typically observed in practice. In response to this problem Harvey et al. (2013) propose a unit root test that allows for multiple breaks in trend both under the null and the alternative hypotheses, obtained by taking the infimum of the sequence (across all candidate break points in a trimmed range) of local GLS detrended augmented Dickey-Fuller-type statistics,  $MDF_m$ . They show that this procedure is robust to the magnitude of any trend breaks, thereby retaining good finite sample power in the presence of plausibly-sized breaks. They also demonstrate that, unlike the OLS detrended infimum tests of Zivot and Andrews (1992), these tests display no tendency to spuriously reject in the limit when fixed magnitude trend breaks occur under the unit root null.

Table 2 shows the Ng and Perron (2001) unit root test for the stable variables. For both, annual and quarterly time series, with the exception of Germany (annual data) the null of a unit root cannot be

<sup>15</sup>These tests are  $MZ_{\alpha}^{GLS}$ ,  $MSB^{GLS}$ ,  $MZ_t^{GLS}$  and  $MP_T^{GLS}$ .

rejected at the 1% level of significance (although Luxembourg (investment) and Portugal is rejected at the 5% of significance).

Concerning the variables that are considered unstable, Tables 3, 4 and 5 show the unit root tests results proposed by Carrion-i Silvestre et al. (2009) for annual and quarterly data, whereas the results of the test by Harvey et al. (2013) are in Table 6. For annual data, Carrion-i Silvestre et al. (2009) test allowing up to 3 breaks shows that all the time series contain a unit root; similar conclusions are obtained with the Harvey et al. (2013) test up to 2 breaks, with a few exceptions<sup>16</sup>. For quarterly data, evidence in favor of a unit root in the time series is generally found, except for some cases in the Carrión-i-Silvestre et al. test<sup>17</sup>.

### 4.3 Cointegration and Structural Breaks Tests

As the results of subsection 4.1 point to instabilities in many variables across countries, in this subsection we test for cointegration accounting for potential structural breaks. We follow mostly the proposals of Kejriwal (2008) and Kejriwal and Perron (2010), as they allow for both  $I(1)$  and  $I(0)$  regressors and multiple breaks. However, we also apply Gregory and Hansen (1996) test for non-cointegration with one break, as well as Arai and Kurozumi (2007) test of the null of cointegration against the alternative of non-cointegration.

Kejriwal and Perron (2010) consider a sequential test of the null hypothesis of  $k$  breaks versus the alternative of  $k + 1$  breaks. As a complementary procedure to select the number of breaks we use the Bayesian Information Criterion (BIC) proposed by Yao (1988) and the LWZ criterion proposed by Liu et al. (1997). Kejriwal (2008) and Kejriwal and Perron (2010) show that the structural change tests can suffer from important lack of power against spurious regression (i.e., no cointegration). This means that these tests could reject the null of stability when the regression is really a spurious one. In this sense, tests for breaks in the long run relationship are used in conjunction with tests for the presence or absence of cointegration allowing for structural changes in the coefficients. This is the way we proceed in this subsection.

First, we test for structural change in the relationship between saving and investment. In Table 7, we report the stability tests and the number of breaks selected using the sequential procedure (S) and the two information criteria, the BIC (B) and LWZ (L). Given the span of data, we allow for up to three breaks<sup>18</sup> in both the annual and quarterly analysis.

Based on the recommendation of Bai and Perron (2003), we rely on the BIC and the Sequential criterion<sup>19</sup>. Using annual data (section A of Table 7), we find between one and three breaks, with the

<sup>16</sup>Austria (saving) using the  $MDF_1$  test; Germany (saving) with both the  $MDF_1$  and  $MDF_2$  tests.

<sup>17</sup>Austria (investment), Greece (saving), Ireland (investment), Latvia (savings), Malta (investment), The Netherlands (investment) and some exception of the rejection of the null for the Harvey et al. test: Greece (saving), Latvia (saving) and Malta (investment).

<sup>18</sup>Up to one break for Cyprus, due to the fact that the two breaks found were 1985 and 1993 (for any trimming used). For this country there are not enough observations to estimate the models using DOLS. By setting up to one break, it is found in 1985, that does not alter the results significantly.

<sup>19</sup>In case of contradictory outcomes, the graph can help with the identification.

exception of Belgium, Greece, the Netherlands, Portugal and Spain that, according to the sequential method have no break. Concerning the quarterly data, in section B, the majority of the countries have two or three breaks. Latvia, Luxembourg, Malta and the Netherlands have just one, whereas Finland, France and Italy have none.

The previous stability tests may also reject the null of coefficient stability when both variables are not cointegrated. Thus, we need to test for cointegration, used as confirmatory test.

We consider three different tests. First, the traditional Phillips-Perron and ADF tests for the null hypothesis of no cointegration without breaks<sup>20</sup>. The second and third cointegration tests take into account possible breaks in the cointegrated relationship. Whereas Gregory and Hansen (1996) tests for the null hypothesis of no cointegration with a structural break, Arai and Kurozumi (2007) allows up to three structural breaks. The cointegration test used will depend on the number of breaks selected by the sequential procedure and the BIC and LWZ criteria.

For the relationships that were found to be stable, we report in Table 8 the traditional Phillips-Perron and ADF tests. For annual data, in section A of the table, the null of non-cointegration is rejected for Greece and the Netherlands. However, for quarterly data, the null hypothesis of non-cointegration is rejected for Finland, Ireland, Luxembourg and the Netherlands.

Next, we use the Gregory and Hansen (1996) test for cointegration for those countries where at least one of the three procedures to select the number of breaks chose a single break. The test allows for regime shift under the null of no cointegration against the alternative of cointegration in the presence of a possible regime shift. The test statistics  $ADF^*$ ,  $Z_\alpha^*$  and  $Z_t^*$  are computed as the minimal values of the statistics over all possible breakpoint. We present our results in Table 9. For annual data, the null hypothesis of non-cointegration is rejected for Cyprus, Finland, Ireland, Luxembourg and the Netherlands. For quarterly data, the null hypothesis is rejected for all the countries considered.

However, the limitations of the Gregory and Hansen (1996) test is that the break date associated with the minimal value of a given statistic is not a consistent estimate of the break date. Given that the Gregory and Hansen (1996) test is designed to have power against the alternative of a single break, it may have low power when the alternative involves more than one break as it may be our case. In order to overcome such problem, we use the residual-based test of the null of cointegration with an unknown single break against the alternative of no cointegration proposed in Arai and Kurozumi (2007). They propose a LM test based on partial sums of residuals where the break point is obtained by minimizing the sum of squared residuals and consider three models: i) Model I, level shift; ii) Model II, level shift with trend; iii) and Model III, regime shift.

For our analysis and given what economic theory suggests, we only consider model III, that can be

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<sup>20</sup>As there is no clear trend among the variables, we perform the test with no time trend in the cointegrating regression.



written as follows:

$$y_t = c_i + z'_t \beta_i + u_t \quad \text{if } (T_{i-1} < t \leq T_i) \quad (5)$$

To correct for potential endogeneity of the regressors, equation (5) is augmented with leads and lags of the first differences of the I(1) regressors, such as:

$$y_t = c_i + z'_t \beta_i + \sum_{j=-l_T}^{l_T} \Delta Z'_{t-j} \Pi_j + u_t^* \quad \text{if } T_{i-1} < t \leq T_i \quad (6)$$

The LM test statistic (for one break),  $\tilde{V}_1(\hat{\lambda})$ , is given by:

$$\tilde{V}_1(\hat{\lambda}) = (T^{-2} \sum_{t=1}^T S_t(\hat{\lambda})^2) / \hat{\Omega}_{11} \quad (7)$$

where  $\hat{\Omega}_{11}$  is a consistent estimate of the long run variance of  $u_t^*$  in (10), the date of break  $\hat{\lambda} = (\hat{T}_1/T, \dots, \hat{T}_k/T)$  and  $(\hat{T}_1, \dots, \hat{T}_k)$  are obtained using the dynamic algorithm proposed in Bai and Perron (2003).

Concerning the results, Tables 10 and 11 show the Arai and Kurozumi (2007) cointegration test up to three breaks. In the analysis, using annual data, with the exception of Spain, we cannot reject the null of cointegration for any country, whereas for the quarterly data the null is rejected for the case of one break for Cyprus, as well as of two breaks for Belgium, The Netherlands and the Slovak Republic (sequential criteria). Finally, when three breaks are considered, the null is rejected for Austria (Sequential, BIC and LWZ criteria), France, Greece, Italy and Portugal (sequential criteria).

The Arai and Kurozumi (2007) test is more restrictive, as only a single structural break is considered under the null hypothesis. Hence, the test may tend to reject the null of cointegration when the true data generating process exhibits cointegration with multiple breaks. To avoid this problem, Kejriwal (2008) extended its test by incorporating multiple breaks under the null hypothesis of cointegration. The Kejriwal (2008) test of the null of cointegration with multiple structural changes is denoted with  $k$  breaks as  $\tilde{V}_k(\hat{\lambda})$ .

## 5 A linear cointegrated regression model with multiple structural changes

Accounting for parameter shifts is crucial in cointegration analysis since it normally involves long spans of data which are more likely to be affected by structural breaks. In particular, Kejriwal (2008) and Kejriwal and Perron (2010) provide a comprehensive treatment of the problem of testing for multiple structural changes in cointegrated systems. More specifically, they consider a linear model with  $m$  structural changes (i.e.,  $m + 1$  regimes) such as:

$$y_t = c_t + z'_{ft} \delta_f + z'_{bt} \delta_{bj} + x'_{ft} \beta_f + x'_{bt} \beta_{bj} + u_t \quad (t = T_{j-1} + 1, \dots, T_j) \quad (8)$$

for  $j = 1, \dots, m + 1$ , where  $T_0 = 0$ ,  $T_{m+1} = T$  and  $T$  is the sample size. In this model,  $y_t$  is a scalar dependent  $I(1)$  variable,  $x_{ft}(p_f \times 1)$  and  $x_{bt}(p_b \times 1)$  are vectors of  $I(0)$  variables while  $z_{ft}(q_f \times 1)$  and  $z_{bt}(q_b \times 1)$  are vectors of  $I(1)$  variables<sup>21</sup>. The break points  $(T_1, \dots, T_m)$  are treated as unknown.

The general model (8) is a partial structural change model in which the coefficients of only a subset of the regressors are subject to change. In our case, we assume that  $p_f = p_b = q_f = 0$ , and the estimated model is a pure structural change model with all coefficients of the  $I(1)$  regressors and deterministic components are allowed to change across regimes:

$$y_t = c_j + z'_{bt}\delta_{bj} + u_t \quad (t = T_{j-1} + 1, \dots, T_j) \quad (9)$$

Generally, the assumption of strict exogeneity is too restrictive and the test statistics for testing multiple breaks are not robust to the problem of endogenous regressors. To deal with the possibility of endogenous  $I(1)$  regressors, Kejriwal (2008) and Kejriwal and Perron (2010) propose to use the so-called dynamic OLS regression (DOLS)<sup>22</sup> where leads and lags of the first-differences of the  $I(1)$  variables are added as regressors, as suggested Saikkonen (1991) and Stock and Watson (1993):

$$y_t = c_i + z'_{bt}\delta_{bj} + \sum_{j=-l_T}^{l_T} \Delta z'_{bt-j}\Pi_{bj} + u_t^* \quad \text{if } T_{i-1} < t \leq T_i \quad (10)$$

for  $i = 1, \dots, k + 1$ , where  $k$  is the number of breaks,  $T_0 = 0$  and  $T_{k+1} = T$ .

In order to test the relationship between domestic investment and domestic saving, the empirical studies commonly used a linear regression model such as:

$$I_t = \alpha + \beta S_t + \varepsilon_t \quad (11)$$

As it has been explained in section 4, and because there are only two variables in the estimated long-run relationship, when there is no structural break we will simply estimate the model by OLS (Table 12). When there are instabilities in the relationship, we estimate by DOLS and the results are presented in Tables 13, 14 and 15). Thus, if we find no evidence of cointegration for a given country (for any number of breaks), we will conclude that there is no long-run relationship between domestic saving and domestic investment. Therefore, this would be interpreted as “perfect capital mobility” (as is the case using quarterly data for Austria or Belgium).

## 5.1 Individual regression results including the structural breaks

We should emphasize that we have analyzed two different time periods: 1970<sup>23</sup>-2019 using annual data and 1995-2019 with quarterly data. We have estimated country-by-country equations, allowing

<sup>21</sup>The subscript  $b$  stands for “break” and the subscript  $f$  stands for “fixed”(across regimes).

<sup>22</sup>Following Kejriwal (2008) a maximum of 2 (1 for annual data) lags and 2 (1 for annual data) leads are used. In contrast to Kejriwal (2008) in which 2 lags and 2 leads are set fixed, we used the BIC criteria for selecting the lags and leads.

<sup>23</sup>In some cases earlier.

for structural breaks and trying to use as much information as possible about each of the countries in the sample. Therefore, early stages of monetary integration may be captured with the annual sample, whereas the effects of deeper monetary integration are more likely to be detected in the quarterly data sample.

In table 12, we present the results for the OLS regression. However, the OLS results are only interpretable in the case that 0 breaks have been identified with the Sequential, BIC and LWZ procedure, and the null hypothesis of non-cointegration is rejected for the ADF-PP Cointegration test (table 8). Therefore, for the annual data, we can interpret the cases of Greece and the Netherlands, whereas, for the quarterly data, we can interpret the OLS regression for Finland, Ireland, Luxembourg and Netherlands. The OLS results show a high degree of capital mobility with the exception of Greece (annual data) and Ireland (quarterly data), which show a relatively larger coefficient. Next, we report the results of the regression with breaks, in which we would be able to analyze how capital mobility has changed over time.

We start by interpreting the annual data covering the different integration steps. The first salient feature of the results summarized in Table 13 is that most of the breaks are found in the 80s and 90s. However, in some cases, as in Ireland, Italy and Luxembourg, the last break is found in 2010. To ease the interpretation of the results, we split the sample into three country groups: the first group includes the “core countries”: Austria, Belgium, France, Germany, Luxembourg and the Netherlands. There is clear evidence of a decrease in the value of the saving-retention coefficient over time that generally becomes statistically indistinguishable from zero (or negative, that will be taken as evidence of perfect capital mobility). Austria, Belgium, France and Germany achieved perfect capital mobility in the 1990s (with the start of the Single Market) before the euro; in the case of Germany later in the 1990s due to the German reunification. In the case of France, annual data shows that capital mobility was very limited from 1960 until 1992, with perfect capital mobility afterwards. Some facts should be brought to attention: the period from mid-eighties until the EMS crisis (1992-1993) is one of financial turmoil; our analysis is able to capture this effect, as the evidence of capital mobility is very limited. Finally, in both Austria and Belgium the third break occurs in 2007 and 2008, respectively. The parameter obtained for the last sample period increases for Austria (reaching a value between 0.55 and 0.62) with a decrease in capital mobility after the crisis, and around 1 for Belgium.<sup>24</sup>

The second group of countries includes the periphery<sup>25</sup> (Cyprus, Greece, Ireland, Portugal and Spain). They share a similar pattern: large coefficients up to the mid-nineties (related to the Maastricht Treaty and the road to EMU), mostly coming from core countries (for which their coefficient shows capital mobility), attracted by the periphery’s higher rate of return. The size of Greece’s parameter as well as those of Ireland and Portugal were high before Maastricht (showing low capital mobility); however, such tendency was totally reverted after the 1990s with the full removal of cap-

<sup>24</sup>However, we should take into account that the number of observations after the breaks is too low, so that the result should be interpreted with caution, as the value of the parameter is biased upwards.

<sup>25</sup>These countries were later bailed-out by the ESM.

ital controls. The rest of the countries (i.e., Finland and Italy) show different patterns; for instance, Italy would have high capital mobility before the crisis and a large parameter (probably upwards biased) after the 2007 financial crisis. In Finland, the evidence in favour of capital mobility is found for the period 1979 to 1992; however, the coefficient increases after 1992, probably after being hit by the crash of the Soviet Union.

Having assessed capital mobility with annual data, we move to the quarterly analysis (tables 14 and 15), starting in 1995 but extending our analysis for the period of the euro setup until the 2007 financial crisis and the subsequent events. We first find that, indeed, the annual data regression provides similar results as the quarterly analysis for the shared period but, as the number of observations is considerably larger, the algorithm allows for more structural breaks to be found and richer results. As an illustration we can take the case of Finland. Using annual data, we find a structural break in 1980 and a second one in 1992: the effects of a shock had relatively long-lasting effects, as the USSR crash was captured in 1992; however, for the quarterly analysis, the first structural break is found in 1994. In both cases, the conclusion is, nonetheless, the same: the USSR crash causes the saving-retention coefficient to increase. However, the second break in Finland using quarterly data is found in 2001 and confirms the maintenance of free capital mobility in the country after joining the euro.

As in the case of annual data, we classify the countries into groups. Concerning the core countries (Austria, Belgium, Finland, France, Germany, Luxembourg and The Netherlands), we also obtain in this case that their degree of capital mobility is high (in the cases Austria, Belgium and France, this fact stems from the non-cointegrated relationship) and was achieved before the inception of the euro, or immediately afterwards (as in Finland, Germany<sup>26</sup> or Luxembourg); moreover, the core countries do not seem to have suffered any impact from the crisis in terms of capital mobility. The case of the Netherlands is an outlier in this group since it is still displaying a relatively high coefficient. However, it should be pointed out that the Netherlands has a saving rate higher than the domestic investment rate and the “saving glut” is invested abroad; therefore, the coefficient should not be interpreted as a limited capital mobility.

The second set of countries are Central and Eastern countries, that joined the EU and the euro later. Those countries received a large amount of capital inflows leading to increasing external disequilibria until the financial crisis in 2007. However, in terms of capital mobility, they show different behavior; Estonia (as Spain before) has received an increasing amount of capital inflows (until 2007) with an important part invested in the non-tradable sector (housing). This fact is captured by a large coefficient explained by improved investment opportunities: domestic savings keep being invested at home. In 2009, when the housing bubble burst, it caused a large external disequilibrium and a dramatic fall in the level of capital mobility. Latvia’s (3 breaks)<sup>27</sup> shows a

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<sup>26</sup>In the case of Germany, the German reunification in the early 1990s caused a decrease in capital mobility that was reverted before the start of the euro.

<sup>27</sup>The (B, L) regression is used for the interpretation of the results since the (S) regression is less informative for the period Q1:1995 to Q1:2009. However, the (B, L) regression presents three breaks and, therefore, more detailed information.

relatively low coefficient before the crisis; however, capital mobility started decreasing during the crisis as well as in the aftermath. In the case of Lithuania case (3 breaks)<sup>28</sup> the situation is quite similar to Latvia's, showing a "crisis effect" on capital mobility. However, in this case, the reason behind the reduction in capital mobility is explained by the housing bubble. The Slovak Republic displays, in turn, a high level of capital mobility since the first quarter of 2000, and the crisis seems not to have affected capital mobility (mainly because credit lending did not result in a large external disequilibrium). Concerning Slovenia, it had at the beginning of the sample high capital mobility, but was altered by the crisis (a decrease in capital mobility). However, after 2010 the previous capital mobility levels have been restored (with a slight decrease in capital mobility after 2016 according to the (S) regression).

The third set of countries are Cyprus, Greece, Ireland, Portugal, and Spain. All of them were bailed out through 2010 to 2015, and their financial stability programs are captured by our analysis. In the case of Cyprus (BIC regression)<sup>29</sup> shows no capital mobility until Q2 2012 (when it requested assistance from the euro area and the IMF). Afterwards, it shows an increase in capital mobility; the other break (Q2 2016) closely coincides with the Cyprus exit of the bailout program; in this case, high capital mobility remains. The case of Greece is similar to the one of Cyprus as it showed a low level of capital mobility before Q3 2010 when the first bailout occurred (May 2010). After the bailout, the retention coefficient would be compatible with capital mobility. As Greece's exit of the financial assistance program took place in the third quarter of 2018, we cannot capture it. Ireland (sequential procedure)<sup>30</sup> shows limited capital mobility (more restricted during the crisis period); however, the trend reverts during the period of the financial assistance program (displaying perfect capital mobility) and, again, returns to high capital mobility after the end of the program. We have obtained a large coefficient in both Portugal and Spain before the ESM programs (S)<sup>31</sup>, decreasing afterwards (perfect capital mobility for the case of Portugal and a slight improvement for Spain).

The remaining two countries are Malta and Italy, for which we conclude that there has been perfect capital mobility during the whole period.

## 6 Conclusions

In this paper, we have studied the evolution of capital mobility for the 19 countries of the Eurozone during the period 1970-2019 using both annual and quarterly data. While most of the earlier literature tends to focus on the price approach, we adopt the quantity one. This can be especially suited to assess the evolution of capital mobility within a monetary union where external imbalances have

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<sup>28</sup>As in the case of Latvia, the BIC regression with 3 breaks gives more detailed information. Therefore, the (B) regression is preferred to the LWZ, as it was already explained in section 5.3.

<sup>29</sup>In this case, while the Sequential and BIC criteria show the same number of breaks, their chronology is different. The graph for Cyprus shows that the BIC criteria are more suitable than the sequential breaks since the breaks are confined to happen in 2005, 2012 and 2016.

<sup>30</sup>In this case, the sequential procedure gives more complete information than the BIC, as there is much more volatility in the last part of the sample (2015-2019). Therefore, the BIC ends up selecting lesser complex models (as it was explained in section 5.3).

<sup>31</sup>Both BIC and Sequential criteria display similar results.

been persistently growing up to the Great Recession. From an econometric approach standpoint, we base our analysis on the state of the art cointegration econometrics of individual time series, allowing for discontinuities. One of the main benefits of the econometric methodology is that we are not imposing exogenously the breaks (that could bias the analysis), as they have been obtained endogenously as a result of the econometric analysis instead.

The main contributions of our analysis are, first, to identify different stages in the EU financial integration process up to the creation of the EMU; second, we analyze the evolution of the degree of capital mobility from the first years of the euro until the 2007 financial crisis distinguishing between core, peripheral and Central Eastern European countries; third, we can obtain a measure of the consequences of the financial crisis and the subsequent sovereign crisis on capital mobility; fourth, we have an appraisal of how the financial assistance programs affected the countries that were bailed out, and, finally, we can assess whether capital mobility increased after the European sovereign crisis.

Regarding our first question, our results confirm that the value saving-retention coefficient has, in general, been decreasing overtime. This implies that the degree of capital mobility has been increasing during the 1990s after the Maastricht Treaty was signed, only to be affected by three critical events: the EMS crisis, the German reunification, and the USSR downfall.

Concerning the second question, our results confirm that European economic integration encouraged capital flows from the core countries to the periphery (Ireland, Greece, Portugal, and Spain). Our results also show a larger beta coefficient in these countries, meaning that a high domestic saving rate is invested domestically. Moreover, as a large proportion of foreign saving was invested in non-tradable sectors, such investment flows caused a boom and later created credit shortage after the 2007 financial crisis, ending up with the sovereign crisis. As for the CEE countries, in general, they have relatively low saving-retention coefficients after or even before their euro membership. Here, it is important to highlight two opposite cases: first, in Estonia (as in Spain), large capital inflows were invested in the non-tradable market (housing), causing a sizeable external disequilibrium. When the real state bubble burst, capital mobility decreased dramatically. Second, in the Slovak Republic, capital mobility was achieved after its EU membership, and despite the other CEE countries, the financial crisis seems to have had no impact on capital mobility (such conclusion is in line with the quick recovery of the Slovak's economy).

As for the impact of the financial (2007) and sovereign crises (2010-2015) on capital mobility, we find heterogenous effects depending on the type of country. The effect can be summarized as follows: while core countries show no impact of the crisis on capital mobility, with some exceptions, in the periphery capital mobility has decreased. Moreover, some countries' capital mobility has not returned to its previous levels after the two crises.

Concerning the effects of the financial assistance programs on capital mobility, we find breaks in the series coinciding with the different financial assistance dates. More specifically, the period of

financial assistance through the EFSM and ESM programs goes in parallel with an improvement in capital mobility. However, after the program, some countries such as Cyprus and Ireland have returned to their previous levels of high capital mobility, whereas others (Portugal and Spain are prominent examples) have never recovered them.

Finally, in the period 2015 – 2019, after the global financial and European sovereign crisis, capital mobility shows a signal of recovery for the majority of the Eurozone countries. This is the case for the core countries, Italy, Malta, Ireland, Latvia, Slovak Republic and Slovenia. However, it should be pointed out that the FH puzzle remains for Estonia, Lithuania, Portugal, and Spain. The likely explanation is that these countries were heavily affected by the boom and bust period (real state bubble)<sup>32</sup>, which has harmed capital mobility, above all, after the bubble busted.

In terms of the FH puzzle, we have found that the correlation between domestic saving and investment has been mostly dropping since the 1970s along with the integration process until the creation of the euro. The first countries achieving a high degree of capital mobility have been the core ones. Driven by the financial crisis and market mistrust in the global financial and European sovereign crises, the puzzle returned for many peripheral countries, being more present in the countries with the highest external disequilibria.

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<sup>32</sup>Excepting for Ireland and Greece, where the reason may has been that the timing does not allow us to catch the after ESM financial program effect.

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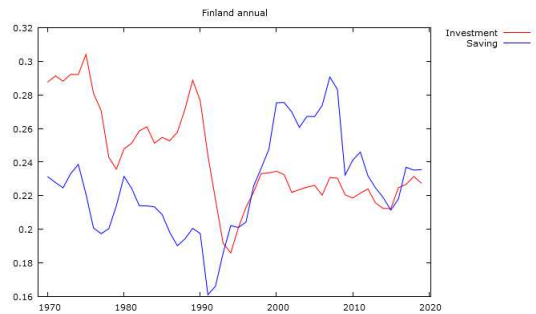
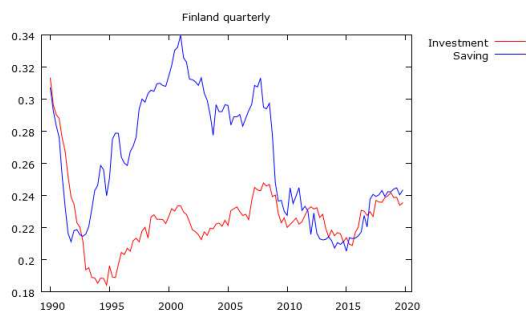
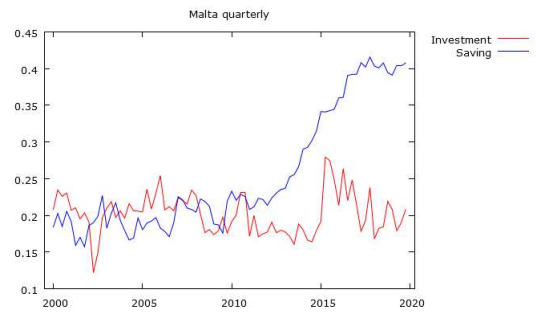
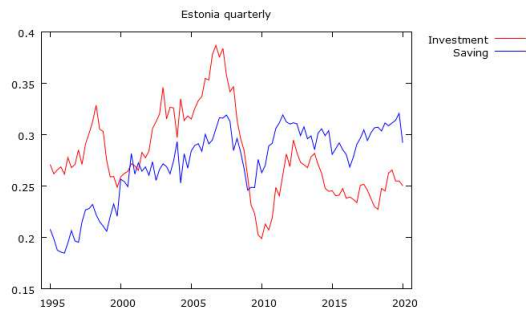
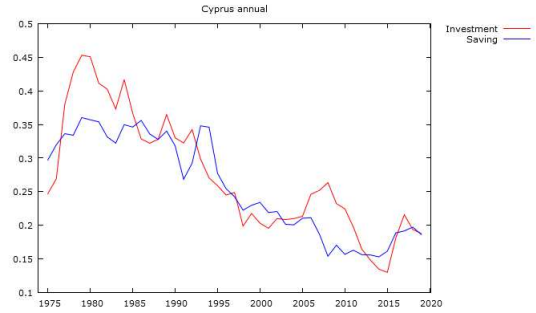
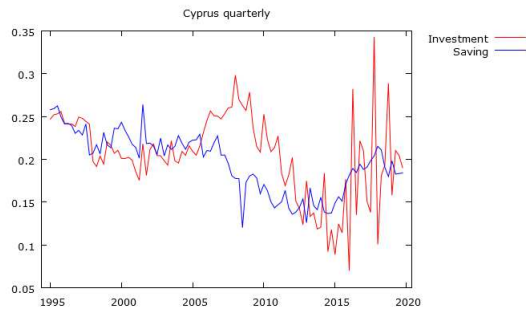
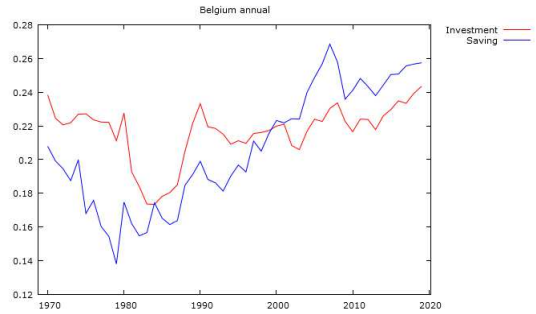
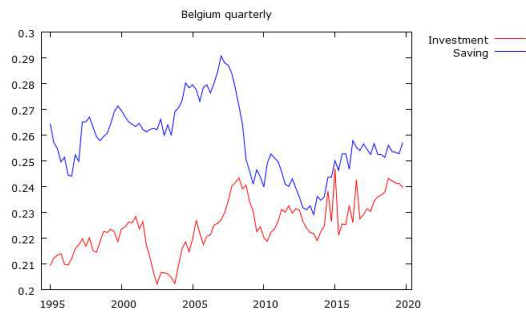
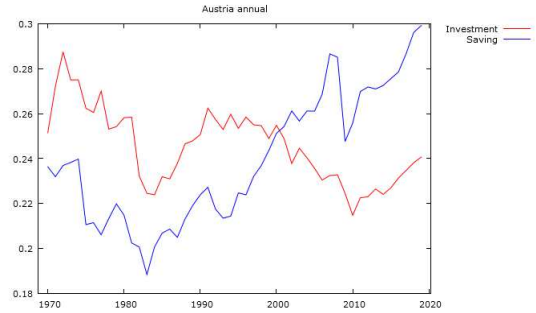
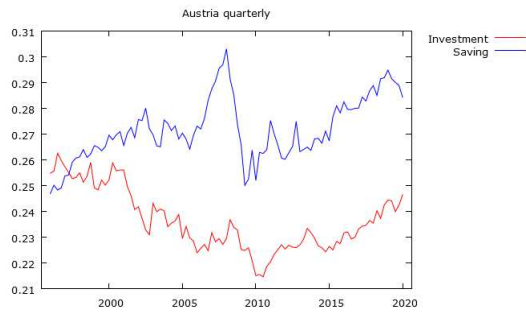
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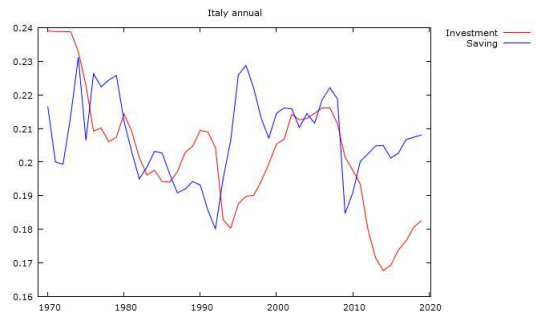
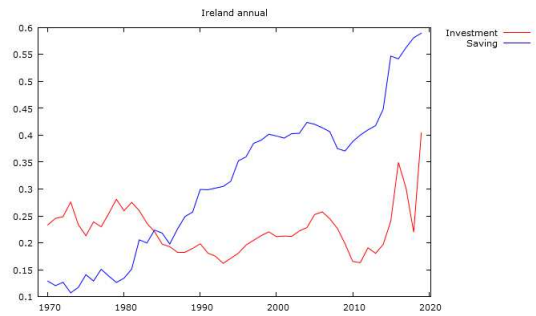
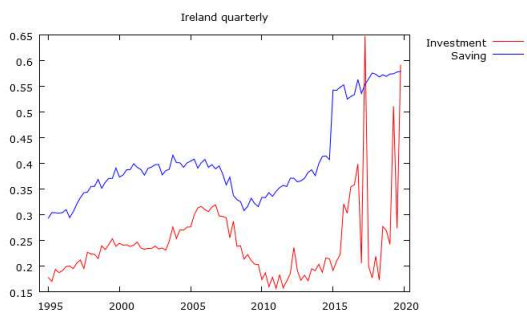
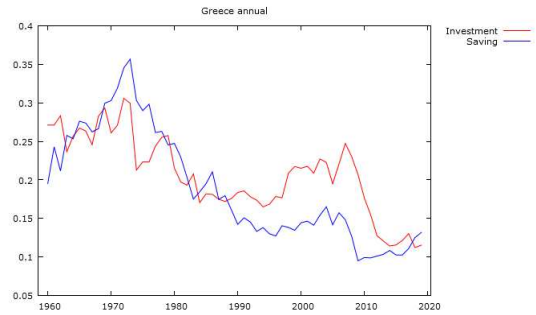
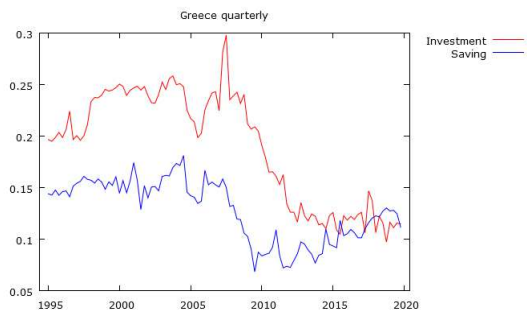
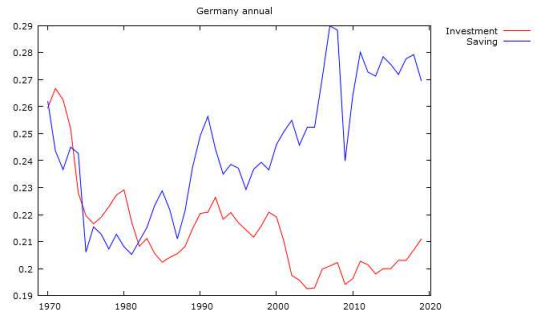
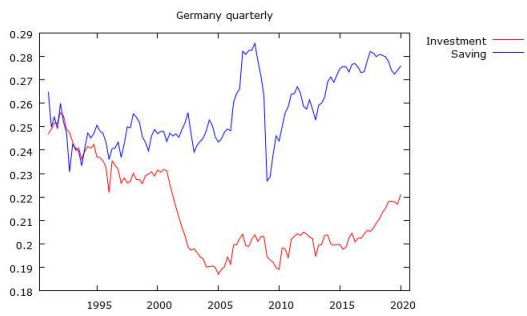
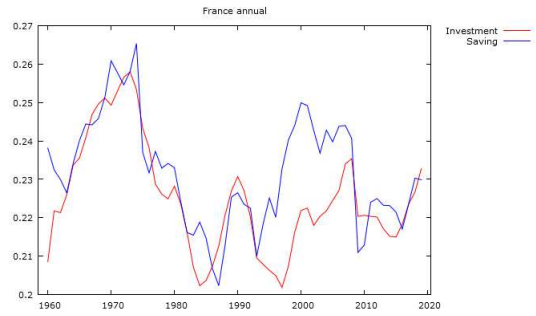
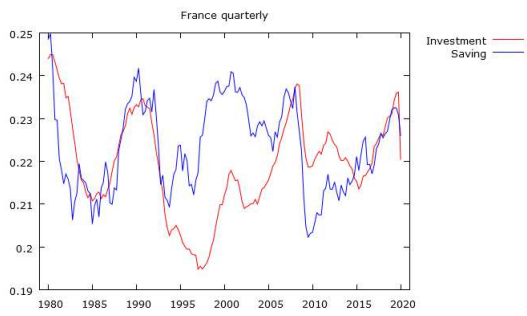
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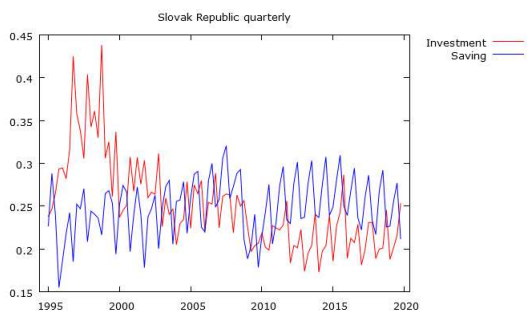
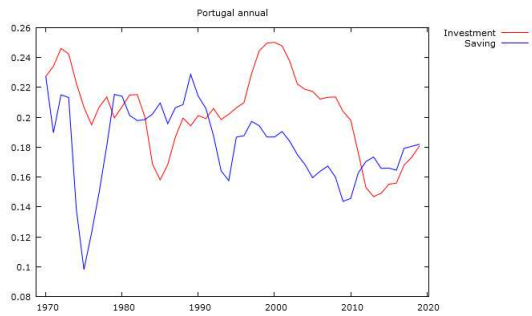
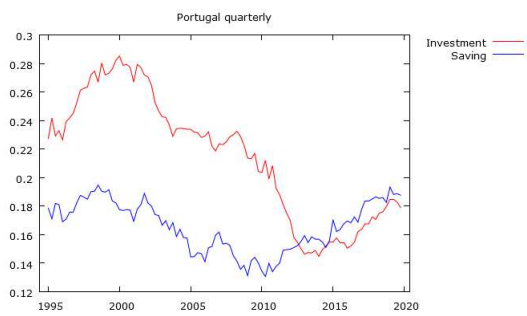
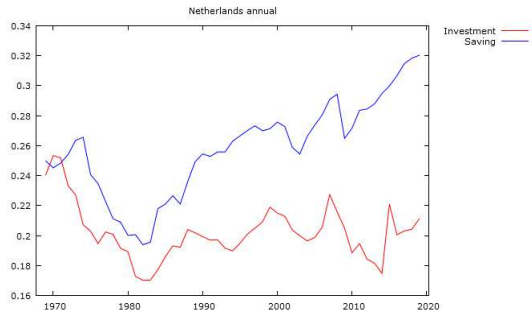
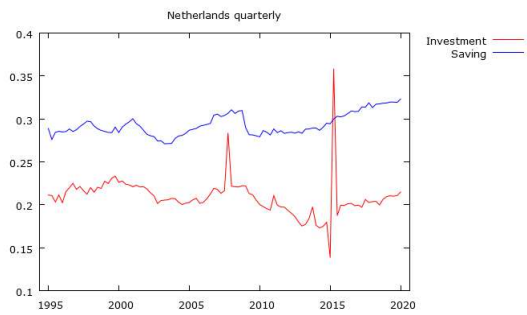
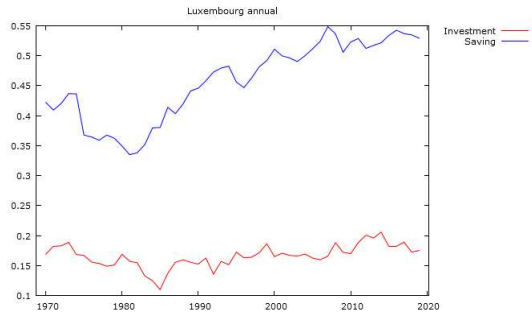
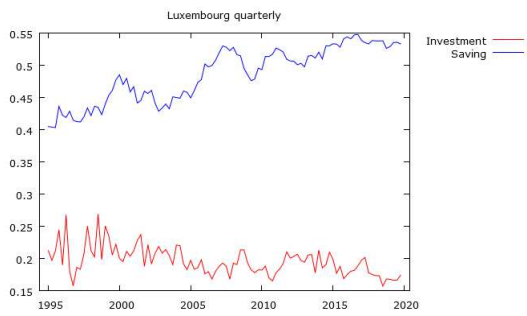
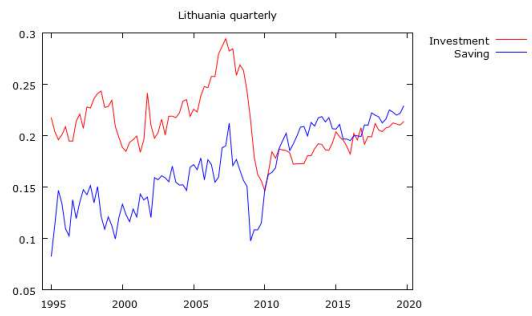
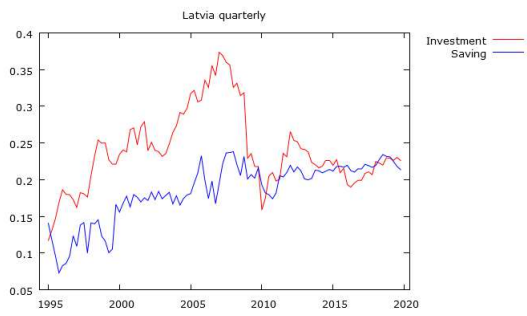
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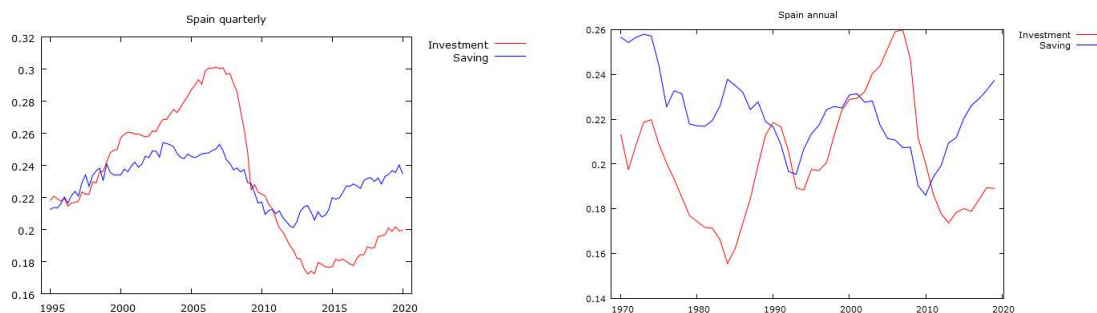
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## Appendix A Figures









## Appendix B Tables

**Table 1:** Perron and Yabu (2009) tests for structural changes in the deterministic component

Annual data				Quarterly Data			
Country	Model I	Model II	Model III	Country	Model I	Model II	Model III
Aus I	2.82**	-0.16	2.85	Aus I	2.08**	0.54	2.90
Aus S	9.70***	8.73***	11.39***	Aus S	8.37***	-0.13	8.52***
Bel I	0.34	1.46	1.98	Bel I	3.74***	-0.22	3.94**
Bel S	0.20	0.33	0.86	Bel S	1.10	-0.01	1.21
Cyp I	0.01	-0.03	0.52	Cyp I	4.63***	1.32	5.40***
Cyp S	3.05**	0.10	3.79**	Cyp S	4.49***	0.15	4.96***
Est I	-	-	-	Est I	1.04	-0.12	1.79
Est S	-	-	-	Est S	1.30	0.07	1.74
Fin I	0.81	-0.16	0.86	Fin I	0.63	14.61***	17.12***
Fin S	6.16***	0.02	6.20***	Fin S	1.49	-0.01	2.03
Fra I	3.45***	-0.04	3.68***	Fra I	0.80	-0.08	0.87
Fra S	5.92***	0.14	6.40***	Fra S	0.59	0.16	1.21
Ger I	0.09	0.19	0.72	Ger I	4.68***	1.51	5.87***
Ger S	7.19***	5.02***	12.55***	Ger S	21.56***	-0.13	22.69***
Gre I	7.20***	-0.09	7.61***	Gre I	4.92***	0.83	7.62***
Gre S	1.10	1.77**	6.57***	Gre S	2.43**	-0.16	16.63***
Ire I	0.06	6.33***	7.80***	Ire I	-0.01	1.42	15.08***
Ire S	0.33	0.49	1.35	Ire S	60.58***	0.37	60.61***
Ita I	4.86***	-0.14	5.68***	Ita I	1.52	1.12	3.06
Ita S	3.40***	-0.19	4.37**	Ita S	0.98	0.52	1.60
Lat I	-	-	-	Lat I	12.63***	0.80	25.41***
Lat S	-	-	-	Lat S	7.09***	3.65***	11.94***
Lit I	-	-	-	Lit I	3.48***	-0.14	3.50**
Lit S	-	-	-	Lit S	3.31***	-0.27	3.54**
Lux I	0.58	-0.13	2.76	Lux I	0.91	-0.19	2.23
Lux S	0.28	0.46	0.98	Lux S	0.68	-0.13	0.89
Mal I	-	-	-	Mal I	2.13**	-0.28	4.61**
Mal S	-	-	-	Mal S	0.68	0.30	2.01
Net I	0.12	0.26	0.71	Net I	3.05**	0.54	4.54***
Net S	4.00***	1.55	5.81***	Net S	11.33***	0.31	11.51***
Por I	0.66	-0.21	0.83	Por I	0.71	1.67**	2.83
Por S	-0.10	-0.25	-0.02	Por S	0.98	0.64	1.93
Slovk I	-	-	-	Slovk I	5.25***	3.36***	5.64***
Slovk S	-	-	-	Slovk S	0.99	-0.15	1.32
Slo I	-	-	-	Slo I	10.02***	0.55	14.32***
Slo S	-	-	-	Slo S	10.57***	0.27	11.29***
Spa I	3.56***	-0.13	2.91	Spa I	5.38***	0.31	7.28***
Spa S	0.66	0.82	3.32**	Spa S	0.75	0.57	1.75

Note:

(a): \*\* and \*\*\* denote the rejection of the null of no structural change (stability) at the 5% and 1% levels, respectively. The critical values are taken from (Perron and Yabu (2009), Table 2.a, Table 2.b and 2.c.



**Table 2: Ng and Perron (2001) unit root test (stable series)**

Annual Data					Quarterly Data				
Country	$Mz_{\alpha}^{GLS}$	$Mz_t^{GLS}$	$MSB^{GLS}$	$MP_t^{GLS}$	Country	$Mz_{\alpha}^{GLS}$	$Mz_t^{GLS}$	$MSB^{GLS}$	$MP_t^{GLS}$
Bel I	-4.50	-1.45	0.32	5.55	Bel S	-4.64	-1.51	0.33	5.30
Bel S	-1.78	-0.77	0.43	11.45	Est I	-5.52	-1.64	0.30	4.50
Cyp I	-2.36	-1.02	0.43	9.99	Est S	-0.08	-0.49	0.59	19.79
Fin I	-1.90	-0.87	0.46	11.67	Fin S	-1.53	-0.76	0.49	13.69
Ger I	-1.00	-0.60	0.60	1.64***	Fra I	-4.56	-1.46	0.32	5.47
Ire S	2.07	1.71	0.82	60.07	Fra S	-4.39	-1.44	0.33	5.66
Lux I	-8.24**	-2.02**	0.25*	3.01**	Ita I	-1.44	-0.79	0.55	15.71
Lux S	-0.88	-0.47	0.54	17.69	Ita S	-1.36	-0.76	0.56	16.43
Net I	-4.45	-1.48	0.33	5.53	Lux I	-0.35	-0.23	0.64	25.17
Por I	-12.47**	-2.44**	0.20**	2.20**	Lux S	0.05	0.03	0.68	30.23
Por S	-11.31**	-2.36**	0.21**	2.24**	Mal S	1.03	0.64	0.62	31.50
-	-	-	-	-	Por S	-2.20	-1.00	0.46	10.77
-	-	-	-	-	Slovk S	-2.93	-1.18	0.40	8.27
-	-	-	-	-	Spa S	-1.81	-0.86	0.48	12.42

Notes:

(a): \*, \*\* and \*\*\* denote the rejection of the null of a unit root at the 10%, 5% and 1% levels, respectively.

(b): The non-rejection of the null implies that the series is I(1).

(c): The critical values are taken from ((Ng and Perron, 2001), Table I.

**Table 3:** Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series).

		Annual data							
Country	m	Model II				Model III			
		$MP_t^{GLS}$	$Mz_\alpha^{GLS}$	$MSB^{GLS}$	$MZ_t^{GLS}$	$MP_t^{GLS}$	$Mz_\alpha^{GLS}$	$MSB^{GLS}$	$MZ_t^{GLS}$
Aus I	1	17.30	-9.52	0.23	-2.15	14.79	-11.25	0.21	-2.32
	2	20.84	-10.69	0.21	-2.21	17.48	-12.95	0.19	-2.44
	3	17.50	-16.19	0.18	-2.84	14.77	-19.25	0.16	-3.09
Aus S	1	12.16	-10.69	0.21	-2.26	11.11	-11.76	0.20	-2.38
	2	11.80	-18.68	0.16	-3.04	14.67	-19.94	0.16	-3.12
	3	14.67	-19.94	0.16	-3.12	13.50	-21.35	0.15	-3.27
Cyp S	1	19.82	-8.26	0.23	-1.86	18.86	-8.79	0.22	-1.93
	2	15.63	-13.23	0.19	-2.53	16.17	-16.75	0.17	-2.89
	3	16.17	-16.75	0.17	-2.89	14.67	-18.48	0.16	-3.04
Fin S	1	23.83	-6.53	0.28	-1.80	14.14	-11.04	0.21	-2.35
	2	14.03	-15.66	0.18	-2.77	16.81	-12.99	0.19	-2.53
	3	16.77	-16.22	0.17	-2.79	16.01	-16.77	0.17	-2.88
Fra I	1	11.45	-14.54	0.18	-2.61	24.95	-6.17	0.27	-1.64
	2	30.31	-7.76	0.25	-1.96	24.52	-9.60	0.23	-2.17
	3	25.07	-11.89	0.20	-2.38	22.89	-13.07	0.19	-2.52
Fra S	1	17.59	-9.19	0.23	-2.13	14.70	-10.99	0.21	-2.35
	2	21.19	-9.71	0.23	-2.20	21.20	-9.92	0.22	-2.23
	3	22.19	-12.91	0.20	-2.54	14.79	-19.38	0.16	-3.11
Ger S	1	6.24	-20.72	0.15	-3.19	21.64	-5.72	0.29	-1.66
	2	9.39	-20.89	0.15	-3.23	13.47	-21.25	0.15	-3.25
	3	13.47	-21.25	0.15	-3.25	16.38	-17.77	0.16	-2.92
Gre I	1	14.22	-11.26	0.21	-2.36	16.98	-9.44	0.22	-2.12
	2	19.26	-12.24	0.20	-2.47	15.03	-15.68	0.18	-2.80
	3	11.95	-21.96	0.15	-3.27	13.70	-18.92	0.16	-3.05
Gre S	1	23.96	-6.34	0.25	-1.61	17.79	-9.04	0.22	-1.96
	2	11.31	-20.87	0.15	-3.14	12.44	-19.22	0.16	-3.00
	3	13.47	-22.00	0.15	-3.28	12.37	-23.94	0.14	-3.43
Ire I	1	19.40	-6.24	0.26	-1.60	24.11	-4.87	0.29	-1.43
	2	33.55	-5.90	0.26	-1.51	37.40	-6.54	0.24	-1.59
	3	37.40	-6.54	0.24	-4.15	12.08	-24.24	0.14	-3.36
Ita I	1	8.94	-16.99	0.17	-2.91	22.30	-6.80	0.27	-1.84
	2	27.47	-7.79	0.25	-1.92	31.36	-6.59	0.26	-1.69
	3	29.96	-9.85	0.22	-2.15	29.23	-9.99	0.21	-2.09
Ita S	1	9.75	-13.16	0.19	-2.56	11.08	-11.55	0.21	-2.40
	2	16.51	-13.96	0.19	-2.64	11.21	-20.62	0.16	-3.21
	3	20.43	-14.51	0.19	-2.69	13.64	-21.78	0.15	-3.29
Net S	1	17.16	-9.56	0.23	-2.18	14.78	-11.16	0.21	-2.34
	2	26.43	-8.26	0.25	-2.03	21.87	-9.99	0.22	-2.23
	3	17.02	-15.57	0.18	-2.73	24.53	-10.63	0.22	-2.30
Spa I	1	8.32	-16.49	0.17	-2.85	11.86	-11.82	0.20	-2.42
	2	33.69	-6.27	0.26	-1.64	21.75	-10.29	0.22	-2.22
	3	38.87	-7.16	0.26	-1.85	21.33	-13.34	0.19	-2.52
Spa S	1	18.39	-6.79	0.27	-1.84	18.18	-6.87	0.27	-1.85
	2	24.45	-8.65	0.24	-2.08	21.32	-9.92	0.22	-2.23
	3	31.43	-9.40	0.23	-2.16	22.93	-12.89	0.20	-2.54

Notes:

(a): \*\* denotes rejection the null at the 5% level.

(b): m= number of breaks.

**Table 4:** Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Quarterly data.

		Quarterly data							
Country	m	Model II				Model III			
		$MP_T^{GLS}$	$MZ_\alpha^{GLS}$	$MSB^{GLS}$	$MZ_T^{GLS}$	$MP_T^{GLS}$	$MZ_\alpha^{GLS}$	$MSB^{GLS}$	$MZ_T^{GLS}$
Aus I	1	6.89**	-23.26**	0.15	-3.39**	7.32	-22.02	0.15	-3.29
	2	-8.95	-26.28	0.14	-3.61	16.04	-14.90	0.18	-2.63
	3	10.41	-28.11	0.13	-3.75	9.77	-30.25	0.13	-3.88
Aus S	1	12.00	-13.24	0.19	-2.57	9.64	-16.46	0.17	-2.87
	2	9.49	-22.51	0.15	-3.32	22.50	-9.25	0.23	-2.15
	3	11.29	-22.81	0.15	-3.34	11.50	-22.36	0.15	-3.31
Bel I	1	10.73	-11.30	0.21	-2.38	12.32	-9.85	0.22	-2.21
	2	19.21	-12.39	0.20	-2.47	13.37	-17.83	0.17	-2.98
	3	23.48	-12.34	0.20	-2.46	14.18	-20.41	0.16	-3.19
Cyp I	1	25.19	-4.51	0.32	-1.45	30.14	-3.85	0.36	-1.38
	2	37.31	-4.27	0.33	-1.41	9.84	-16.80	0.17	-2.89
	3	30.82	-6.53	0.27	-1.75	8.32	-24.80	0.14	-3.52
Cyp S	1	20.47	-7.52	0.26	-1.94	14.82	-10.45	0.22	-2.26
	2	18.48	-11.06	0.21	-2.35	7.81	-26.36	0.14	-3.62
	3	11.86	-26.01	0.14	-3.55	12.45	-24.03	0.14	-3.45
Fin I	1	27.89	-5.26	0.31	-1.62	18.54	-7.94	0.25	-1.99
	2	17.18	-11.05	0.21	-2.35	10.05	-18.89	0.16	-3.07
	3	20.59	-13.71	0.19	-2.60	12.44	-22.85	0.15	-3.36
Ger I	1	28.61	-5.40	0.27	-1.48	14.98	-11.34	0.20	-2.30
	2	11.08	-19.41	0.16	-3.04	14.95	-14.04	0.18	-2.58
	3	14.99	-20.00	0.15	-3.08	18.69	-15.62	0.18	-2.75
Ger S	1	9.68	-15.15	0.18	-2.74	10.17	-14.35	0.19	-2.67
	2	10.62	-18.92	0.16	-3.07	9.57	-20.98	0.15	-3.24
	3	13.04	-19.08	0.16	-3.07	10.82	-22.87	0.15	-3.38
Gre I	1	21.12	-4.98	0.29	-1.46	16.09	-6.83	0.27	-1.85
	2	15.35	-12.19	0.20	-2.47	16.31	-11.47	0.21	-2.39
	3	20.86	-14.24	0.19	-2.67	32.42	9.15	0.23	-2.13
Gre S	1	19.28	-7.75	0.25	-1.95	24.58	-6.07	0.29	-1.73
	2	7.52**	-29.47**	0.13**	-3.82**	8.24	-26.61	0.14	-3.64
	3	7.65**	-35.83**	0.12**	-4.18**	8.38	-32.42	0.12	-3.98
Irel I	1	23.03	-4.79	0.32	-1.53	3.68**	-31.44**	0.13**	-3.94**
	2	17.76	-10.55	0.21	-2.27	16.68	-11.68	0.19	-2.21
	3	18.38	-12.64	0.19	-2.46	18.90	-12.46	0.19	-2.35
Irel S	1	23.83	-5.07	0.31	-1.56	36.30	-3.37	0.39	-1.30
	2	27.44	-7.30	0.25	-1.85	17.44	-11.66	0.21	-2.41
	3	15.11	-19.59	0.16	-3.07	16.76	-17.24	0.17	-2.94

Notes:

(a): \*\* denotes rejection the null at the 5% level.

(b): m= number of breaks.

**Table 5:** Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Quarterly data. Continued.

		Quarterly data							
Country	m	Model II				Model III			
		$MP_T^{GLS}$	$MZ_\alpha^{GLS}$	$MSB^{GLS}$	$MZ_T^{GLS}$	$MP_T^{GLS}$	$MZ_\alpha^{GLS}$	$MSB^{GLS}$	$MZ_T^{GLS}$
Lat I	1	15.16	-10.01	0.22	-2.24	15.05	-10.16	0.22	-2.22
	2	14.79	-14.08	0.19	-2.65	14.05	-14.86	0.18	-2.72
	3	13.51	-20.82	0.15	-3.23	12.52	-22.57	0.15	-3.35
Lat S	1	32.07	-4.09	0.35	-1.43	5.20**	-25.50**	0.14**	-3.56**
	2	8.91	-24.69	0.14	-3.51	7.89	-28.00	0.13	-3.74
	3	10.94	-27.25	0.14	-3.68	14.18	-20.92	0.15	-3.23
Lit I	1	16.49	-9.36	0.23	-2.14	10.93	-14.18	0.19	-2.65
	2	24.63	-9.57	0.23	-2.16	13.55	-17.55	0.17	-2.95
	3	11.33	-25.29	0.14	-3.55	9.94	-28.80	0.13	-3.79
Lit S	1	7.78	-19.53	0.16	-3.12	7.59	-20.00	0.16	-3.16
	2	11.71	-20.23	0.16	-3.18	11.22	-21.15	0.15	-3.25
	3	13.79	-19.47	0.16	-3.12	12.67	-21.22	0.15	-3.25
Mal I	1	7.51	-17.60	0.17	-2.97	4.41**	-29.95**	0.13**	-3.87**
	2	13.47	-15.07	0.18	-2.73	6.32**	-32.00**	0.12**	-4.00**
	3	7.04	-31.03	0.13	-3.94	7.16	-30.68	0.13	-3.91
Net I	1	16.64	-7.34	0.26	-1.91	7.32	-17.15	0.17	-2.90
	2	23.47	-8.74	0.24	-2.08	7.86	-26.99	0.13	-3.64
	3	24.68	-8.74	0.24	-2.08	6.96**	-31.01**	0.13**	-3.94**
Net S	1	12.77	-11.95	0.20	-2.44	14.56	-10.48	0.22	-2.29
	2	19.64	-12.05	0.20	-2.45	24.75	-9.54	0.23	-2.17
	3	23.17	-11.66	-0.21	-2.41	26.17	-10.30	0.22	-2.24
Por I	1	10.79	-14.03	0.18	-2.55	38.27	-2.97	0.34	-1.00
	2	15.22	-14.90	0.18	-2.69	38.87	-5.64	0.29	-1.64
	3	17.17	-15.64	0.18	-2.79	15.11	-17.79	0.17	-2.98
Slovk I	1	32.52	-2.85	0.34	-0.96	32.27	-3.62	0.37	-1.34
	2	48.70	-3.91	0.35	-1.38	31.65	-6.11	0.28	-1.74
	3	61.03	-3.82	0.34	-1.28	41.47	-6.14	0.28	-1.74
Slo I	1	29.34	-4.99	0.30	-1.49	23.04	-6.54	0.27	-1.75
	2	35.31	-6.47	0.27	-1.77	28.72	-7.94	0.24	-1.93
	3	26.87	-10.42	0.22	-2.25	25.47	-11.07	0.21	-2.30
Slo S	1	14.87	-10.28	0.22	-2.23	22.49	-6.73	0.27	-1.82
	2	20.07	-11.74	0.20	-2.40	28.57	-8.19	0.24	-2.00
	3	33.22	-7.81	0.25	-1.94	30.41	-8.57	0.24	-2.05
Spa I	1	18.77	-8.21	0.23	-1.89	61.11	-1.80	0.42	-0.75
	2	17.72	-11.68	0.21	-2.41	16.26	-12.73	0.20	-2.52
	3	12.78	-19.53	0.16	-3.12	14.12	-17.68	0.17	-2.97

Notes

(a): \*\* denotes rejection the null at the 5% level.

(b): m= number of breaks.

**Table 6:** Harvey et al. (2013) unit root test with breaks (unstable series)

Annual data			Quarterly data		
Country	$MDF_1$	$MDF_2$	Country	$MDF_1$	$MDF_2$
Aus I	-2.55	-3.34	Aus I	-3.67	-4.23
Aus S	-4.03**	-4.21	Aus S	-2.71	-3.77
Cyp S	-2.02	-4.25	Bel I	-2.55	-2.68
Fin S	1.94	-3.93	Cyp I	-1.60	-2.38
Fra I	-2.48	-3.38	Cyp S	-2.56	-4.31
Fra S	-2.46	-3.06	Fin I	-1.70	-2.69
Ger S	-4.93**	-5.12**	Ger I	-2.71	-3.13
Gre I	-2.85	-4.13	Ger S	-3.47	-3.53
Gre S	-2.17	-4.50	Gre I	-2.34	-2.99
Ire I	-1.93	-2.01	Gre S	-2.26	-6.0**
Ita I	-2.96	-3.32	Ire I	-1.29	-3.34
Ita S	-3.21	-3.99	Ire S	-1.95	-3.25
Net S	-2.55	-3.08	Lat I	-2.52	-3.16
Spa I	-3.00	-4.09	Lat S	-4.44**	-4.84**
Spa S	-2.13	-2.38	Lit I	-2.24	-3.18
-	-	-	Lit S	-3.21	-3.41
-	-	-	Mal I	-3.13	-5.33**
-	-	-	Net I	-2.82	-3.43
-	-	-	Net S	-2.64	-2.83
-	-	-	Por I	-1.93	-2.61
-	-	-	Slovk I	-2.58	-3.13
-	-	-	Slo I	-1.89	-2.94
-	-	-	Slo S	-1.77	-3.11
-	-	-	Spa I	-2.09	-3.13

Notes:

(a): \*\* denotes rejection of the null of a unit root at the 5% level.

(b): The critical values for  $MDF_1$  and  $MDF_2$  are taken from Harvey et al. (2013), Table 1.

**Table 7: Tests for the number of structural breaks (A-B)**

(A): (Annual data)	Aus	Bel	Cyp	Fin	Fra	Ger	Gre	Ire	Ita	Lux	Net	Por	Spa
S	3	0	1	1	1	2	2	2	1	1	0	0	0
BIC	3	3	1	2	1	2	2	2	3	2	2	2	3
LWZ	3	2	1	1	1	2	0	1	3	1	1	1	3
(B): (Quarterly data)	Aus	Bel	Cyp	Est	Fin	Fra	Ger	Gre	Ire	Ita	Lat	Lit	
S	3	2	3	2	0	0	2	3	3	0	1	3	
BIC	3	2	3	2	2	3	3	3	1	3	3	3	
LWZ	3	2	1	2	2	3	2	2	0	3	3	2	
(B cont): (Quarterly data)	Lux	Mal	Net	Por	Slovk	Slo	Spa						
S	1	1	1	3	2	2	3						
BIC	1	1	2	3	2	3	3						
LWZ	0	1	0	3	2	3	3						

Notes:

(a): S, B and L refer to the sequential procedure, the BIC procedure and the LWZ procedure, respectively.

(b): a HAC estimator using a quadratic spectral Kernel with Andrews Automatics in the bandwidth calculation and an AR(1) in the lag specification are used to correct for autocorrelation.

(c): For quarterly data a 15% of trimming is used for all the countries. For annual data, a 15% of trimming is used for Belgium (S), France (S), Germany (B,L), Ireland (B,L) Portugal (S) and Spain (S,B,L), a 20% and 25% of trimming has been used for some countries, due to that DOLS procedure requires a minimum span of time to be performed (for the lags and leads).

**Table 8: ADF and PP cointegration test without breaks (A-B)**

(A) Annual data	Bel (S)	Gre (L)	Net (S)	Por (S)	Spa (S)	
$Z_t$	-2.65	-2.84**	-3.00**	-1.82	-2.06	
$Z_\alpha$	-12.02	-14.01	-11.46	-6.62	-8.34	
$ADF_t$	-2.39	-2.89**	-3.12**	-2.04	-2.65	
(B) Quarterly data	Fin (S)	Fra (S)	Ire (L)	Ita (S)	Lux (L)	Net (L)
$Z_t$	-4.55***	-2.22	-7.58***	-0.84	-8.28***	-9.11***
$Z_\alpha$	-12.83	-8.38	-76.20***	-1.54	-80.17***	-90.41***
$ADF_t$	-4.65***	-2.44	-1.23	-0.83	-2.54	-2.04

Notes:

(a) Where  $Z_t$  and  $Z_\alpha$  stand for Phillips and Ouliaris (1990) test statistics for non-cointegration and  $ADF_t$  is the ADF version.

(b) \*\* and \*\*\* denotes the rejection of the null hypothesis of no cointegration at the 5% and 1% levels. The critical values can be found in Phillips and Ouliaris (1990) tables I-a and II-a.

**Table 9:** Gregory and Hansen cointegration test with one break (A-B)

(A) Annual data	Cyp (S,B,L)	Fin (S,L)	Fra (S,B,L)	Ire (L)	Ita (S)	Lux (S,L)	Net (L)	Por (L)
$Z_t^*$	-4.18	-3.32	-4.60	-5.42***	-2.69	-5.00**	-3.85	-3.30
$Z_\alpha^*$	-22.72	-20.03	-29.09	-42.30	-11.92	-33.79	-22.53	-19.71
$ADF_t^*$	-4.69**	-4.72**	-4.42	-3.85	-3.75	-4.89**	-5.52***	-4.59

(B) Quarterly data	Cyp (L)	Ire (B)	Lat (S)	Lux (S,B)	Mal (S,B,L)	Nel (S)
$Z_t$	-10.14***	-9.12***	-5.36***	-9.15***	-6.42***	-11.79***
$Z_\alpha^*$	-101.73***	-101.49***	-38.93	-91.40***	-54.97***	-117.46***
$ADF_t^*$	-2.67	-4.14	-5.28***	-8.94***	-6.38***	-11.73***

Notes:

(a) \*\* and \*\*\* denotes the rejection of the null hypothesis of no cointegration at the 5% and 1% levels. The critical values can be found in Gregory and Hansen (1996).

**Table 10:** Arai and Kurozumi cointegration test: (1-2 breaks)

**1 Break**

(A.1) Annual data	Cyp (S,B,L)	Fin (S,L)	Fra (S,B,L)	Ire (L)	Ita (S)	Lux (S,L)	Net (L)	Por (L)
$V1(\hat{\lambda})$	0.08	0.08	0.08	0.05	0.19	0.06	0.07	0.14
Break fraction	0.23	0.44	0.45	0.47	0.20	0.24	0.28	0.80
Break date	1986	1992	1987	1993	1981	1983	1984	2008

(A.2) Quarterly data	Cyp (L)	Ire (B)	Lat (S)	Lux (S,B)	Mal (S,B,L)	Net (S)
$V1(\hat{\lambda})$	0.15**	0.08	0.07	0.09	0.11	0.14
Break fraction	0.66	0.61	0.57	0.17	0.79	0.61
Break date	Q2 2011	Q1 2010	Q1 2009	Q3 1999	Q2 2015	Q2 2010

**2 Breaks**

(B.1) Annual data	Bel (L)	Fin (B)	Ger (S,B,L)	Gre (S,B)	Ire (S,B)	Lux (B)	Net (B)	Por (B)
$V2(\hat{\lambda})$	0.06	0.07	0.06	0.07	0.05	0.05	0.03	0.06
Break fraction 1	0.20	0.18	0.22	0.22	0.47	0.24	0.22	0.53
Break fraction 2	0.49	0.44	0.67	0.65	0.84	0.84	0.85	0.80
Break date 1	1981	1980	1982	1974	1993	1983	1981	1996
Break date 2	1994	1992	2002	1998	2010	2010	2010	2008

(B.2) Quarterly data	Bel (S,B,L)	Est (S,B,L)	Fin (B,L)	Ger (S)	Ger (L)	Gre (L)
$V2(\hat{\lambda})$	0.14***	0.07	0.10	0.10	0.11	0.06
Break fraction 1	0.28	0.28	0.14	0.13	0.13	0.14
Break fraction 2	0.52	0.57	0.51	0.36	0.37	0.63
Break date 1	Q2 2002	Q2 2002	Q3 1994	Q2 1995	Q2 1995	Q4 1998
Break date 2	Q4 2007	Q2 2009	Q2 2005	Q3 2001	Q4 2001	Q3 2010

(B.2 cont) Quarterly data	Lit (L)	Net (B)	Slovk (S)	Slovk (B,L)	Slo (S)
$V2(\hat{\lambda})$	0.08	0.24**	0.10**	0.04	0.09
Break fraction 1	0.42	0.66	0.32	0.19	0.61
Break fraction 2	0.58	0.82	0.57	0.57	0.86
Break date 1	Q3 2005	Q2 2011	Q1 2003	Q1 2000	Q1 2010
Break date 2	Q2 2009	Q2 2015	Q1 2009	Q1 2009	Q1 2016

Notes:

(a) \*\*, \*\*\* denote the rejection of the null of cointegration at 5% and 1% levels, respectively.

(b) critical values are obtained by simulation using 500 steps and 2000 replications.

**Table 11: Arai and Kurozumi cointegration test: (3 breaks)**

**3 Breaks**

(A.1) Annual data	Aus (S)	Aus (B,L)	Bel (B)	Ita (B,L)	Spa (B,L)
$V_3(\lambda)$	0.04	0.06	0.04	0.07	0.04
Break fraction 1	0.22	0.22	0.20	0.20	0.36
Break fraction 2	0.56	0.44	0.47	0.62	0.60
Break fraction 3	0.78	0.76	0.80	0.84	0.82
Break date 1	1982	1982	1981	1981	1988
Break date 2	1997	1992	1993	2000	1999
Break date 3	2007	2006	2008	2010	2009

(A.2) Quarterly data	Aus (S)	Aus (B,L)	Cyp (S)	Cyp (B)	Fra (B,L)	Ger (B)	Gre (S,B)
$V_3(\lambda)$	0.10**	0.12***	0.05	0.06	0.10***	0.07	0.07**
Break fraction 1	0.22	0.23	0.14	0.43	0.33	0.13	0.14
Break fraction 2	0.37	0.39	0.43	0.71	0.48	0.37	0.49
Break fraction 3	0.85	0.85	0.66	0.87	0.65	0.88	0.65
Break date 1	Q3 2001	Q4 2001	Q4 1998	Q4 2005	Q2 1993	Q2 1995	Q4 1998
Break date 2	Q1 2005	Q3 2005	Q4 2005	Q2 2012	Q2 1999	Q4 2001	Q2 2007
Break date 3	Q1 2016	Q1 2016	Q2 2011	Q2 2016	Q1 2006	Q1 2016	Q1 2011

(A.2 cont) Quarterly data	Ire (S)	Ita (B,L)	Lat (B,L)	Lit (S)	Lit (B)	Por (S)
$V_3(\lambda)$	0.02	0.11**	0.07	0.05	0.05	0.12**
Break fraction 1	0.41	0.19	0.14	0.43	0.42	0.14
Break fraction 2	0.61	0.69	0.37	0.59	0.58	0.29
Break fraction 3	0.85	0.86	0.57	0.81	0.81	0.67
Break date 1	Q2 2005	Q1 2000	Q4 1998	Q4 2005	Q3 2005	Q4 1998
Break date 2	Q1 2010	Q1 2012	Q2 2004	Q3 2009	Q2 2009	Q3 2002
Break date 3	Q4 2015	Q1 2016	Q1 2009	Q4 2014	Q4 2014	Q3 2011

(A.2 cont) Quarterly data	Por (B,L)	Slo (B,L)	Spa (S)	Spa (B,L)
$V_3(\lambda)$	0.06	0.07	0.05	0.04
Break fraction 1	0.14	0.14	0.37	0.16
Break fraction 2	0.60	0.29	0.72	0.37
Break fraction 3	0.82	0.63	0.88	0.72
Break date 1	Q4 1998	Q4 1998	Q2 2004	Q2 1999
Break date 2	Q4 2009	Q3 2002	Q3 2012	Q2 2004
Break date 3	Q1 2015	Q3 2010	Q3 2016	Q3 2012

Notes:

(a) \*\*, \*\*\* denote the rejection of the null of cointegration at 5% and 1% levels, respectively.

(b) critical values are obtained by simulation using 500 steps and 2000 replications.



**Table 12: The individual OLS regression**

<u>Annual regression</u>								
Parameter	Aus	Bel	Cyp	Fin	Fra	Ger	Gre	Ire
$\alpha$	0.30***	0.16**	0.01	0.27***	0.06	0.26***	0.10*	0.21***
(s.e)	(0.06)	(0.07)	(0.06)	(0.10)	(0.05)	(0.03)	(0.05)	(0.04)
$\beta$	-0.22	0.28	1.04***	-0.15	0.72***	-0.20**	0.55***	0.04
(s.e)	(0.25)	(0.28)	(0.25)	(0.36)	(0.23)	(0.09)	(0.20)	(0.13)

Parameter	Ita	Lux	Net	Por	Spa
$\alpha$	0.14***	0.09***	0.16***	0.18***	0.21
(s.e)	(0.04)	(0.03)	(0.04)	(0.05)	(0.15)
$\beta$	0.29	0.16**	0.18	0.15	-0.04
(s.e)	(0.21)	(0.07)	(0.15)	(0.20)	(0.58)

<u>Quarterly Regression</u>							
Parameter	Aus	Bel	Cyp	Est	Fin	Fra	Ger
$\alpha$	0.29***	0.24***	0.09**	0.26***	0.20***	0.16*	0.31***
(s.e)	(0.09)	(0.05)	(0.04)	(0.09)	(0.03)	(0.08)	(0.11)
$\beta$	-0.21	-0.08	0.57***	0.06	0.09	0.27	-0.39
(s.e)	(0.30)	(0.20)	(0.20)	(0.40)	(0.09)	(0.38)	(0.39)

Parameter	Gre	Ire	Ita	Lat	Lit	Lux	Mal
$\alpha$	0.02	0.06	0.13	0.15***	0.22	0.32	0.19***
(s.e)	(0.05)	(0.05)	(0.14)	(0.05)	(0.02)	(0.03)	(0.02)
$\beta$	1.33***	0.44***	0.32	0.51	-0.06	-0.27***	0.03
(s.e)	(0.32)	(0.13)	(0.59)	(0.33)	(0.16)	(0.06)	(0.06)

Parameter	Net	Por	Slovk	Slo	Spa
$\alpha$	0.15	0.09	0.36***	0.16	-0.29**
(s.e)	(0.06)	(0.44)	(0.05)	(1.27)	(0.12)
$\beta$	0.21	0.73	-0.42**	0.28	2.24***
(s.e)	(0.21)	(3.20)	(0.18)	(5.22)	(0.52)

Notes:

(a): \*, \*\* and \*\*\* denotes statistical significance at the 10%, 5% and 1%, respectively.

(b): a HAC estimator using a quadratic spectral Kernel with Andrews Automatics in the bandwidth calculation and an AR(1) in the lag specification are used to correct for autocorrelation.

**Table 13: Estimated regression with breaks (annual data)**

Annual data	Aus S	Aus B,L	Bel B	Bel L	Cyp S,B,L	Fin S,L	Fin B	Fra S,B,L	Ger S,B,L	Gre S,B
C <sub>1</sub>	0.12*** (s.e) (0.03)	0.12*** (0.03)	0.21*** (0.00)	0.20*** (0.00)	-1.07*** (0.19)	0.13 (0.08)	-0.04* (0.01)	-0.05** (0.02)	0.00 (0.11)	0.21*** (0.01)
C <sub>2</sub>	-0.07 (s.e) (0.04)	-0.07 (0.04)	-0.13*** (0.02)	-0.13*** (0.20)	0.05 (0.06)	0.15*** (0.02)	0.36*** (0.06)	0.20*** (0.04)	0.07*** (0.02)	0.11*** (0.02)
C <sub>3</sub>	0.44*** (s.e) (0.05)	0.32*** (0.00)	0.18*** (0.01)	0.14 (0.34)	- -	- -	0.15*** (0.02)	- -	0.12*** (0.03)	-0.08* (0.04)
C <sub>4</sub>	0.07*** (s.e) (0.00)	0.06*** (0.00)	-0.04* (0.01)	- -	- -	- -	- -	- -	- -	- -
$\beta_1$	0.65*** (s.e) (0.16)	0.65*** (0.16)	0.10*** (0.02)	0.10*** (0.02)	4.33*** (0.58)	0.66 (0.38)	1.45*** (0.05)	1.21*** (0.08)	1.04* (0.46)	0.19*** (0.05)
$\beta_2$	1.49*** (s.e) (0.19)	1.16*** (0.24)	1.89*** (0.11)	1.88*** (0.11)	0.80*** (0.22)	0.31*** (0.08)	-0.47 (0.26)	0.10 (0.18)	0.62*** (0.08)	0.46*** (0.13)
$\beta_3$	-0.76*** (s.e) (0.18)	-0.30*** (0.01)	0.15*** (0.04)	0.37 (1.52)	- -	- -	0.31*** (0.06)	- -	0.29** (0.13)	1.99*** (0.28)
$\beta_4$	0.55*** (s.e) (0.01)	0.62*** (0.02)	1.06*** (0.06)	- -	- -	- -	- -	- -	- -	- -
T1	1982	1982	1981	1981	1986	1992	1980	1987	1982	1974
T2	1997	1992	1993	1994	-	-	1992	-	2002	1998
T3	2007	2006	2008	-	-	-	-	-	-	-

Annual data	Ire S,B	Ire L	Ita S	Ita B,L	Lux S,L	Lux B	Net B	Net L	Por L	Por B	Spa B,L
C <sub>1</sub>	0.31*** (s.e) (0.02)	0.31*** (0.02)	0.69*** (0.02)	0.69*** (0.02)	0.03 (0.05)	0.03 (0.05)	0.10*** (0.02)	0.02 (0.70)	0.23*** (0.03)	0.22*** (0.02)	-0.11** (0.05)
C <sub>2</sub>	0.02 (s.e) (0.03)	-0.04 (0.04)	0.16 (0.11)	0.29*** (0.02)	0.02 (0.03)	0.04 (0.04)	0.09*** (0.02)	0.16*** (0.02)	0.32 (0.83)	0.01 (0.02)	0.13*** (0.02)
C <sub>3</sub>	-0.14 (s.e) (0.10)	- -	- -	0.18*** (0.00)	- -	0.86*** (0.12)	-0.18 (0.07)	- -	- -	0.32 (0.83)	0.56*** (0.01)
C <sub>4</sub>	- (s.e) -	- -	- -	-0.15 (0.07)	- -	- -	- -	- -	- -	- -	0.17*** (0.00)
$\beta_1$	-0.45*** (s.e) (0.10)	-0.45*** (0.10)	-2.12*** (0.08)	-2.12*** (0.08)	0.37** (0.13)	0.37** (0.13)	0.53*** (0.12)	0.85 (2.68)	-1.12 (0.21)	-0.10 (0.13)	1.26*** (0.21)
$\beta_2$	0.52*** (s.e) (0.10)	0.64*** (0.10)	0.18 (0.54)	-0.46*** (0.11)	0.31*** (0.07)	0.26*** (0.08)	0.44*** (0.06)	0.14* (0.07)	-0.87 (5.60)	1.24*** (0.12)	0.34*** (0.07)
$\beta_3$	0.80** (s.e) (0.22)	- -	- -	0.15** (0.02)	- -	-1.27*** (0.23)	1.13** (0.19)	- -	- -	-0.87 (5.60)	-1.42*** (0.06)
$\beta_4$	- (s.e) -	- -	- -	1.59** (0.33)	- -	- -	- -	- -	- -	- -	0.13** (0.03)
T1	1993	1993	1981	1981	1983	1983	1981	1984	2008	1996	1988
T2	2010	-	-	2000	-	2010	2010	-	-	2008	1999
T3	-	-	-	2010	-	-	-	-	-	-	2009

Notes:

(a): \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels.

(b): A HAC estimator using a quadratic spectral Kernel with Andrews Automatics in the bandwidth calculation and an AR(1) in the lag specification are used to correct for autocorrelation.

**Table 14:** estimated regression with breaks (quarterly data)

Quarterly data	Cyp S	Cyp B	Cyp L	Est S,B,L	Fin B,L	Ger S	Ger B	Ger L	Gre L	Ire S	Ire B	Lat S	Lat B,L
C <sub>1</sub>	-0.03	0.06	0.26***	0.29***	0.22***	0.06***	0.06***	0.06***	-0.04	-0.01	-0.05	0.02	0.11
(s.e)	(0.04)	(0.06)	(0.06)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.06)	(0.04)	(0.44)
C <sub>2</sub>	0.19***	0.09	-0.01	-0.05	0.06**	0.25***	0.26***	0.26***	0.15***	-0.21***	-0.06	0.12***	0.19***
(s.e)	(0.06)	(0.07)	(0.05)	(0.06)	(0.02)	(0.03)	(0.06)	(0.06)	(0.02)	(0.01)	(0.06)	(0.04)	(0.02)
C <sub>3</sub>	0.20***	0.19	-	-0.06	0.18***	0.10	0.13***	0.09	0.16***	0.10***	-	-	0.16**
(s.e)	(0.06)	(0.11)	-	(0.06)	(0.02)	(0.33)	(0.02)	(0.34)	(0.02)	(0.02)	-	-	(0.07)
C <sub>4</sub>	-0.01	0.13	-	-	-	-	0.19	-	-	0.40	-	-	0.12***
(s.e)	(0.05)	(0.21)	-	-	-	-	(0.23)	-	-	(0.85)	-	-	(0.04)
$\beta_1$	1.11***	1.21***	-0.17	-0.05	-0.03	0.76***	0.76***	0.76***	1.66***	0.65***	0.82***	1.43***	0.67
(s.e)	(0.17)	(0.29)	(0.26)	(0.12)	(0.11)	(0.03)	(0.03)	(0.03)	(0.17)	(0.09)	(0.18)	(0.31)	(0.51)
$\beta_2$	0.06	0.82**	1.04***	1.34***	0.54***	-0.10	-0.12	-0.12	0.60***	1.32***	0.69***	0.46**	0.33**
(s.e)	(0.27)	(0.38)	(0.31)	(0.20)	(0.07)	(0.13)	(0.24)	(0.24)	(0.15)	(0.04)	(0.15)	(0.21)	(0.11)
$\beta_3$	0.26	-0.42	-	1.06***	0.22***	0.39	0.28***	0.40	-0.33**	0.23***	-	-	0.81**
(s.e)	(0.30)	(0.73)	-	(0.20)	(0.07)	(1.34)	(0.07)	(1.36)	(0.14)	(0.06)	-	-	(0.31)
$\beta_4$	1.04***	0.34	-	-	-	-	0.06	-	-	-0.14	-	-	0.46**
(s.e)	(0.31)	(1.09)	-	-	-	-	(0.81)	-	-	(1.55)	-	-	(0.21)
T1	Q4 1998	Q4 2005	Q2 2011	Q2 2002	Q3 1994	Q2 1995	Q2 1995	Q2 1995	Q4 1998	Q2 2005	Q1 2010	Q1 2009	Q4 1998
T2	Q4 2005	Q2 2012	-	Q2 2009	Q2 2005	Q3 2001	Q4 2001	Q4 2001	Q3 2010	Q1 2010	-	-	Q2 2004
T3	Q2 2011	Q2 2016	-	-	-	-	Q1 2016	-	-	Q4 2015	-	-	Q1 2009

Notes:

(a): \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels.

(b): A HAC estimator using a quadratic spectral Kernel with Andrews Automatics in the bandwidth calculation and an AR(1) in the lag specification are used to correct for autocorrelation. For the case of Latvia (BIC and LWZ) an AR(1) gave an unexpected high standard error, therefore, according to the Partial Autocorrelation Function an AR(0) has been set.

**Table 15: estimated regression with breaks (quarterly data continued)**

Quarterly data	Lit S	Lit B	Lit L	Lux S,B	Mal S,B,L	Net S	Por B,L	Slovk B,L	Slo S	Slo B,L	Spa S	Spa B,L
C <sub>1</sub>	0.15***	0.16***	0.16***	-0.19	0.25***	0.04	-0.17***	-0.13	0.13***	-0.07	-0.14***	0.03
(s.e)	(0.03)	(0.03)	(0.03)	(0.19)	(0.03)	(0.06)	(0.02)	(0.10)	(0.03)	(0.10)	(0.03)	(0.06)
C <sub>2</sub>	0.15***	0.13**	0.13**	0.34***	0.60***	0.05	0.01	0.37***	0.26***	0.54***	-0.29***	0.06
(s.e)	(0.01)	(0.05)	(0.05)	(0.03)	(0.08)	(0.05)	(0.05)	(0.06)	(0.03)	(0.09)	(0.03)	(0.06)
C <sub>3</sub>	0.13***	0.13***	0.11***	-	-	-	0.59***	0.18***	0.10**	0.09***	0.06**	-0.29***
(s.e)	(0.01)	(0.01)	(0.01)	-	-	-	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)
C <sub>4</sub>	0.06**	0.06**	-	-	-	-	-0.09***	-	-	0.22***	-0.49***	0.01
(s.e)	(0.02)	(0.02)	-	-	-	-	(0.01)	-	-	(0.02)	(0.02)	(0.05)
$\beta_1$	0.44**	0.41*	0.41*	0.95*	-0.24*	0.62***	2.32***	2.03***	0.49***	1.28**	1.66***	0.88***
(s.e)	(0.20)	(0.22)	(0.22)	(0.44)	(0.13)	(0.19)	(0.10)	(0.42)	(0.13)	(0.41)	(0.10)	(0.27)
$\beta_2$	0.73***	0.79**	0.79**	-0.29***	-0.99***	0.48***	1.41***	-0.45**	-0.25**	-1.10**	2.39***	0.84***
(s.e)	(0.07)	(0.32)	(0.32)	(0.06)	(0.19)	(0.17)	(0.32)	(0.21)	(0.11)	(0.37)	(0.16)	(0.25)
$\beta_3$	0.27***	0.25***	0.43***	-	-	-	-2.85***	0.12	0.33**	0.64***	0.53***	2.39***
(s.e)	(0.07)	(0.05)	(0.09)	-	-	-	(0.17)	(0.17)	(0.11)	(0.09)	(0.10)	(0.16)
$\beta_4$	0.68***	0.68***	-	-	-	-	1.43***	-	-	-0.12	2.94***	0.79***
(s.e)	(0.11)	(0.11)	-	-	-	-	(0.07)	-	-	(0.11)	(0.08)	(0.23)
T1	Q4 2005	Q3 2005	Q3 2005	Q3 1999	Q2 2015	Q2 2010	Q4 1998	Q1 2000	Q1 2010	Q4 1998	Q2 2004	Q2 1999
T2	Q3 2009	Q2 2009	Q2 2009	-	-	-	Q4 2009	Q1 2009	Q1 2016	Q3 2002	Q3 2012	Q2 2004
T3	Q4 2014	Q4 2014	-	-	-	-	Q1 2015	-	-	Q3 2010	Q3 2016	Q3 2012

Notes:

(a): \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels.

(b): A HAC estimator using a quadratic spectral Kernel with Andrews Automatics in the bandwidth calculation and an AR(1) in the lag specification are used to correct for autocorrelation. For the case of Slovenia (BIC and LWZ) an AR(1) gave an unexpected high standard error, therefore, according to the Partial Autocorrelation Function an AR(0) has been set.

## Appendix C Additional information

**Table 16:** Investment-Saving average (1995-2019)

Variable	Aus	Bel	Cyp	Est	Fin	Fra	Ger	Gre	Ire	Ita
Investment	24%	22%	20%	28%	23%	22%	21%	19%	24%	19%
Saving	27%	26%	20%	27%	26%	22%	26%	13%	40%	21%
Stard dev I	2%	2%	5%	5%	2%	1%	2%	6%	9%	2%
Strd dev S	1%	1%	6%	5%	4%	1%	2%	4%	9%	2%
Variable	Lat	Lit	Lux	Mal	Net	Por	Slovk	Slo	Spa	Avrge
Investment	24%	21%	20%	20%	21%	21%	25%	23%	23%	22%
Saving	18%	17%	49%	25%	29%	17%	25%	26%	23%	25%
Stard dev I	6%	3%	2%	3%	2%	4%	5%	4%	4%	3,7%
Strd dev S	5%	5%	4%	9%	2%	2%	3%	3%	1%	3,6%

**Table 17:** Investment-Saving average split into pre-crisis period (1995-2006) and post-crisis period (2007-2019)

Variable	Aus	Bel	Cyp	Est	Fin	Fra	Ger	Gre	Ire	Ita
Investment PC	24%	22%	22%	30%	22%	22%	22%	23%	24%	20%
Investment PstC	23%	23%	19%	26%	23%	22%	20%	15%	25%	19%
Saving PC	27%	27%	23%	25%	28%	23%	25%	15%	37%	22%
Saving PstC	28%	25%	17%	30%	24%	22%	27%	10%	44%	20%
Variable	Lat	Lit	Lux	Mal	Net	Por	Slvak	Slo	Spa	Avrge
Investment PC	24%	22%	21%	21%	21%	25%	29%	26%	25%	23%
Investment PstC	24%	20%	19%	20%	20%	18%	22%	21%	21%	21%
Saving PC	15%	14%	45%	19%	29%	17%	24%	26%	24%	24%
Saving PstC	21%	19%	52%	29%	30%	16%	25%	27%	22%	26%

**Table A: Timeline of the European sovereign crisis**

- 2008: Property bubble burst / Irish government provided guarantee for Irish Banks.
- 2009: Market mistrust began.
- 2010: Greek government reports a corrected budget with higher disequilibrium / Greek cost reached unsustainable levels/ First approval of 3-year joint financial assistance for Greece and Ireland (EFSM and IMF) / Financial assistance approved for Ireland/ Bank restructuring started in Spain.
- 2011: Approved of 3-year and first loan disbursement for Portugal (EFSM) / First loan disbursement to Ireland
- 2012: 2nd financial assistance programme for Greece was approved (EFSM and IMF) / Greece’s haircut on private debt / Cyprus asked for financial assistance / Recapitalise bank programme approved for Spain (ESM) and first loan disbursement.
- 2013: Financial assistance programme accepted for Cyprus (ESM) and first disbursement along with capital controls / Portugal is able to return to bond market / Ireland formally leave the EFSF programme. Bank restructuring is completed for Spain.
- 2014: Greece issued bonds after 4 years / Cyprus is able to return to bond markets / Portugal formally concluded the EFSM programme / Spain disbursed an early repayment increasing investors trust.
- 2015: Greece failed to repay IMF loan / ESM financial programme approved for Greece and first loan disbursement / ESM provides a loan for Greece’s bank recapitalisation / Transitional capital controls are removed in Cyprus.
- 2016: Cyprus successfully left the ESM programme.
- 2018: Greece successfully left the ESM programme.

**Table B: Overview of the financial assistance programme**

<b>Program</b>		<b>ESM loans along with macroeconomic adjustment programme</b>
Which countries	Ireland, Portugal, Greece and Cyprus	
Objective	To help countries which are lost market access and then in need of financing	
Requirements	Loans are encompassing with macroeconomic loans prepared by the European Commission and the ECB (and the IFM if the lead charge was shared)	
<b>Program</b>		<b>Loans for bank recapitalisation</b>
Which countries	Spain	
Objective	To preserve the financial stability, in case that private sector cannot solve capital shortfalls itself.	
Requirements	No other relevant requirements a part from the financial supervision and eligibility requirements for the recapitalisation	