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Capital mobility, financial integration and cross-border assets allocation in the European Union

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A mi familia, los que están y los que se fueron, pero que han dejado un recuerdo inquebrantable.

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Chapter 1

Introduction

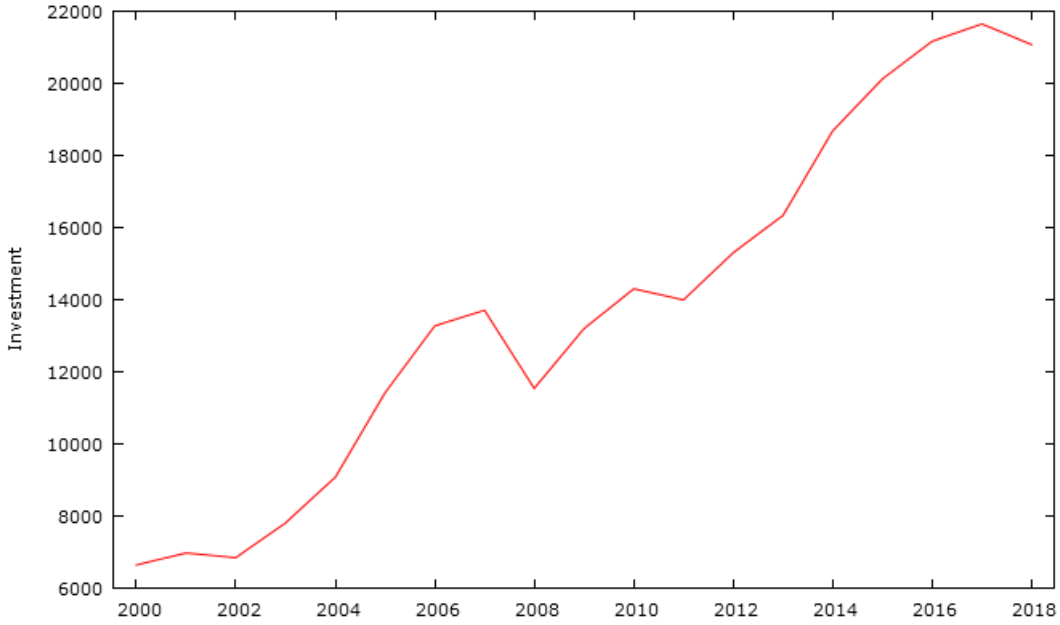
In this dissertation, we aim to contribute to three current debates. The first relates to analyzing the degree of capital mobility and financial integration in the EU financial markets. We pay special attention to how the different stages of the EU financial integration and the financial turmoil and crises have affected capital mobility. Second, we delve into the debate about the drivers of capital mobility, specifically portfolio investment, and address the problem of model specification of the gravity equation. Third, we focus on tax havens' role as critical intermediaries in the global financial system. Our sample of interest is the EU due to its weight in the global financial system but also because it is a natural experiment for capital mobility as there are no barriers to capital or goods mobility within the area.

Capital mobility and well-integrated financial markets are key elements in international macroeconomics. According to Baele et al. (2004), financial integration has three widely accepted interrelated benefits. Firstly, it facilitates sharing risks across borders, offering opportunities for individuals and institutions to diversify their investment portfolios and hedge against potential losses. Moreover, by breaking down barriers to trade and capital flows, financial integration enables market participants to allocate their funds toward the most profitable ventures, thereby maximizing returns on investment. Additionally, heightened levels of financial integration are closely linked with economic growth, as efficient capital allocation fosters innovation, productivity, and overall prosperity. Furthermore, financial integration is crucial for effective monetary policy transmission in monetary unions such as the euro area. This ensures that changes in interest rates and other policy measures are transmitted smoothly and uniformly across mem-

ber states, thereby contributing to macroeconomic stability and convergence. Thus, financial integration is a cornerstone for fostering resilience, prosperity, and stability in the global economy.

To harness the benefits of these positive effects, financial restrictions started to be removed in the United States and the United Kingdom in the early 1970s, followed by other developed countries. In the European Union (EU), the financial openness process was initiated during the 1980s and early 1990s with the Single Market initiative, followed by the complete removal of economic barriers in 1992 with the signature of the Maastricht Treaty. As shown in Figure 1.1, that shows the evolution of total portfolio stock for the EU 28, economic integration (real and financial) has boosted cross-border investment. For the capital of a country to be "perfectly mobile" across national borders would require no frictions not only in financial markets but also in goods markets (i.e., no transport costs, no tariffs, no non-tariff barriers, no costs of regulatory compliance, etc.).[1]

Figure 1.1: EU 28 Portfolio stock investment.

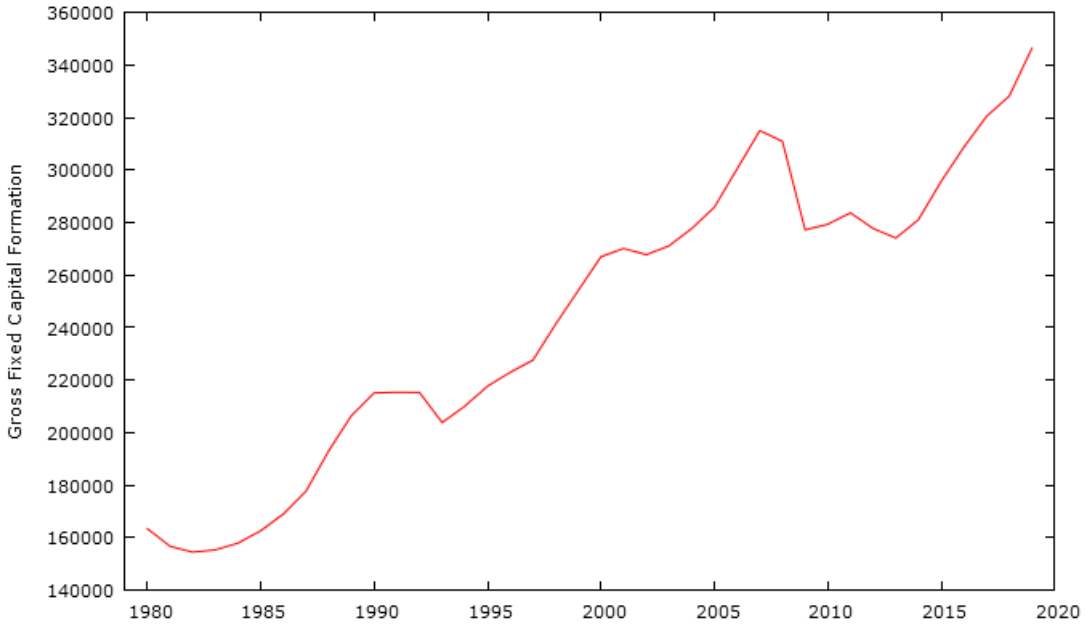


Notes: a) Source: FinFlows database. Unit: EUR divided by 1.000 millions.

[1]The importance of frictions in goods markets (also called "trade costs" or "trade frictions") as a possible explanation for the Feldstein–Horioka puzzle was first pointed out by Obstfeld and Rogoff (2001) and later developed in Ford and Horioka (2017) and Horioka (2024). For an empirical refutation of this hypothesis, see Johansen and Juselius (1992), Camarero and Tamarit (1996), and Eaton et al. (2016).

One of the key developments in the EU integration process has been the creation of the Eurozone. The adoption of the euro has accelerated financial integration between member states, eliminated currency exchange risks, and reduced transaction costs for cross-border investments. The increase in cross-border investment has positively affected gross fixed capital investment, as seen in Figure 1.2.

Figure 1.2: Gross fixed capital formation EU 15.

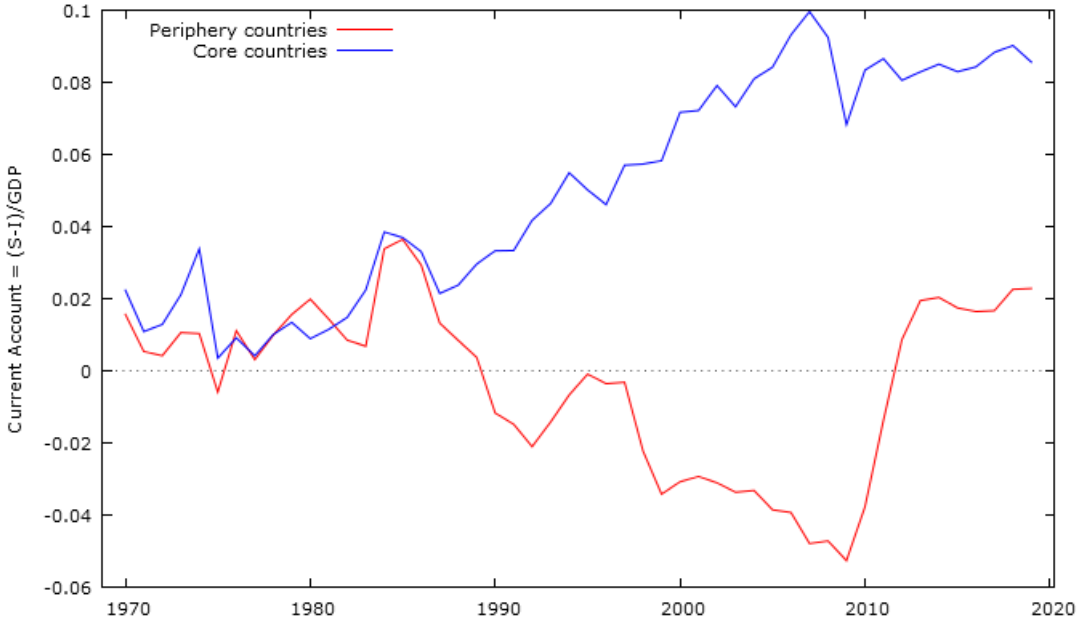


Notes: a) Source: World bank database. (constant 2015 USD). Amount divided by 10 Millions. b) EU 15 countries are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, UK and Sweden.

However, international capital mobility is not without its drawbacks. Firstly, it can lead certain countries to borrow from abroad excessively, potentially resulting in sovereign default and capital flight, thereby precipitating financial crises. Secondly, countries sacrifice their ability to pursue an independent monetary policy under a pegged exchange rate regime. Consequently, while international capital mobility offers benefits, it also presents significant challenges. Thus, assessing whether capital has become more mobile internationally over time and analyzing its implications for the global economy and specific countries or regions is imperative. In the case of the EU, progressive capital mobility and financial integration have had a non-desired effect on persistent and increasing external current account imbalances from 1990

up to the Great Recession. This fact has been even more remarkable in the euro area, where economic and financial integration has encouraged capital flows from the core countries to the periphery. Figure 1.3 shows the current account for the euro area core and peripheral countries[2].

Figure 1.3: Current Account.



Notes: a) Source: World Bank database. The current account is defined as domestic savings minus domestic investment. The current account is the average value of the group. b) Core countries are: Austria, Belgium, Finland, France, Germany, Luxembourg and Netherlands. Periphery: Greece, Italy, Portugal and Spain. Cyprus has been excluded from the annual figure since it started in 1975. Ireland's current account shows a large surplus for the period given the low tax regime (in line with Luxembourg and Netherlands), therefore it has not been included in the periphery group figures.

Given that external current account imbalances are not constrained in a monetary union, the figure shows that external imbalances within the euro area peaked between the euro's inception and right after the 2007-2008 financial crisis. The core and periphery country groups exhibit mirroring behavior. Due to the sudden stop of flows, this situation reversed during the 2010-2015 European sovereign debt crisis.

[2]In this figure, core countries are Austria, Belgium, Finland, France, Germany, Luxembourg, and Netherlands, while peripheral countries consist of Greece, Italy, Portugal, and Spain. Cyprus has been excluded from the figure since data availability only started in 1975. Finally, as Ireland's current account shows a large surplus for the period, given its low tax regime (in line with Luxembourg and The Netherlands), it has not been included among the periphery to avoid distortions.

In addition to this non-desirable side effect of capital mobility, the ongoing process of globalization has experienced a series of setbacks since the Great Recession of 2007-2008. In the euro area, the large external imbalances created an asymmetric shock, triggering a sovereign-bank feedback loop that had spillover effects across the core and periphery countries. This put more pressure on the financial fragmentation process. Moreover, the current post-Covid-19 crisis, characterized by high inflation, has complicated this scenario due to the increasing uncertainty affecting the external relations across countries. The ECB has been fighting[3] market fragmentation since the beginning of the successive shocks. However, the issue is far from being over.

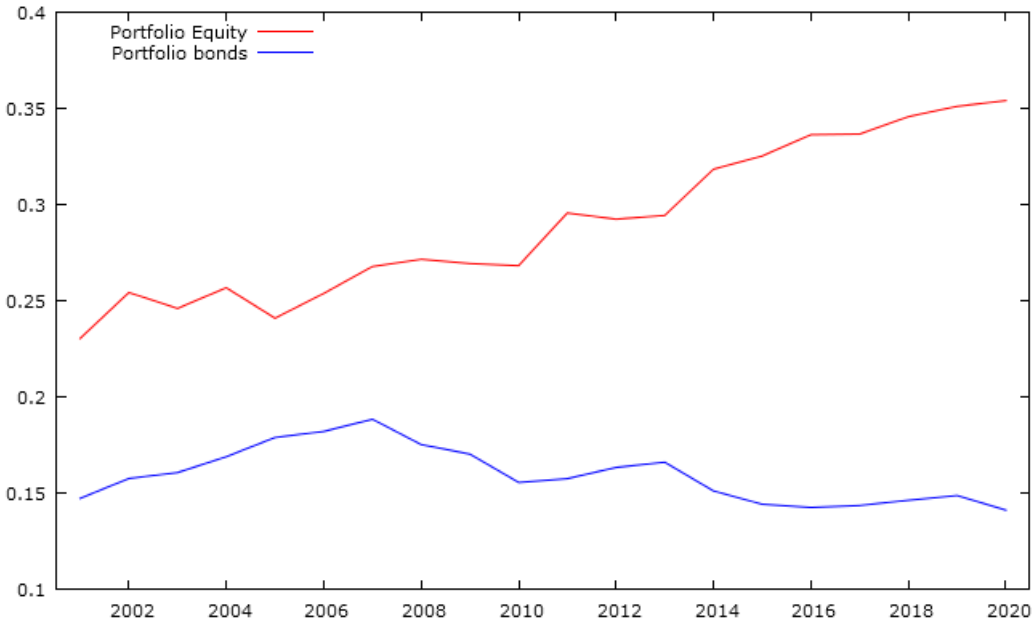
Given the benefits of capital mobility and the negative impact of the global situation after the 2007-2008 financial crisis, there has been a renewed interest in the economic literature to assess the degree of capital mobility for specific regions or groups of countries. Measuring the degree of capital mobility is complex and depends on the definition. The literature has considered two approaches: the price approach, which focuses on the co-movement between domestic and foreign rates linked by the exchange rate, and the quantity approach, which studies the co-movement of the variables that directly materialize capital mobility, that is, investment and saving. The seminal paper in this field was Feldstein and Horioka (1980) (FH, from now onwards). The authors estimated the relationship between saving and investment ratios and found a significant and large parameter linking the two variables for their 1960-1974 sample. The authors argued that the degree of international capital mobility and integration of the global capital markets was low. Obstfeld and Rogoff (2001) refers to the FH's conclusions as the mother of all puzzles. Consequently, these results have given rise to extensive literature. The FH approach has been tested using many estimation techniques with time series and panel data. However, some of the literature has not adequately considered the non-stationarity properties of the data. Moreover, economic events, as well as global and local shocks, also affect the degree of capital mobility, with the impact of structural breaks affecting capital mobility and financial integration usually neglected in the literature.

[3]For example, the Securities Market Programme (SMP) between 2010 and 2012, the Outright Monetary Transactions (OMT) from 2012 onward, and the Public Sector Purchase Programme (PSPP) since 2015. With the outbreak of the COVID-19 crisis, the ECB launched the Pandemic Emergency Purchase Programme (PEPP).

Similarly, countries and policymakers must understand the factors underlying investors' decisions when allocating cross-border investments. Traditionally, researchers have relied on the push-pull framework to explain capital flows based on limited factors such as interest rate differentials, economic growth differentials, and political factors. This approach, although informative, lacks a theoretical foundation and fails to capture the dynamics of investment decisions. Over time, the gravity model has emerged as an alternative to assess the drivers of portfolio investments, offering a more realistic representation of the interconnected global financial system. The gravitational perspective captures the forces that drive investors' behavior, acknowledging that bilateral cross-border investments between two countries are proportional to their economic sizes, inversely to distance, and subjected to frictions and resistance. Okawa and Van Wincoop (2012) established a theoretical foundation for the gravity model applied to asset trade. Although the theoretical model is well-defined, there is considerable uncertainty in its empirical application. In this respect, the gravity equation is often extended with push-pull factors.

In addition to the above-established gravity specification, tax havens' role as a critical player in the global financial system deserves special attention, especially since the 2007-2008 financial crisis. Figure 1.4 shows the percentage of portfolio equity and bonds stocks invested through tax havens. The figure highlights the undoubted relevance of their implication in the global financial markets as intermediaries between the actual source and the final destination. Traditionally, tax havens were attributed to wealthy households shielding assets from taxation. However, this role changed with the increasing activity of global firms issuing securities through cross-border affiliates in tax havens aiming to minimize taxes, access international financial markets, and avoid capital controls and other regulations. Despite its increasing relevance, the empirical literature accounting for tax havens is scarce. A potential reason is that traditional cross-border investment databases are built under the residency principle, which only identifies where the investor and issuer are. Commonly used databases using this principle are the IMF Coordinated Portfolio Investment Survey (CPIS) for portfolio Investment and FinFlows, which also covers other flows/stocks. However, to overcome this limitation, new databases are being developed: Damgaard et al. (2019) for the case of FDI and Coppola et al. (2021) and Beck et al. (2023) for the case of portfolio. These databases are built under the nationality principle that re-maps the stock/flows to the actual source and final destination and removes the effect of intermediaries.

Figure 1.4: Percentage of world tax havens for portfolio over total.



Notes: (a) Data obtained from the IMF (CPIS) database (residence principle); (b) Tax havens included in the graph are listed in table 4.C.

As previously indicated, this doctoral dissertation pursues three objectives. Firstly, to deepen the analysis of the level of capital mobility and financial integration in the markets of the EU. This objective is fundamental due to the prominent role played by the EU in the global financial landscape and its status as a conducive field for evaluating capital mobility in an environment without trade barriers or restrictions on fund mobility. Our target sample is the EU and its subsets (euro area 19[4], EU 15[5] and EU 28). Secondly, the aim is to contribute to the debate on the explanatory factors of capital mobility, focusing on the portfolio of investments in listed securities. The gravity model will be expanded and refined as an analytical tool to achieve this. Lastly, we seek to examine the growing role of tax havens as intermediaries in the global financial system, with particular emphasis on their relationship with the EU. This analysis is of utmost relevance given the significance of tax havens today and their impact on the stability and transparency of the international financial system.

[4]Croatia had not adopted the euro for the sample period of this dissertation.

[5]Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, UK and Sweden.

The thesis is divided into three chapters. After this introduction, in chapter 2, we assess capital mobility for the euro area countries by studying the long-run relationship between domestic investment and savings for 1970-2019.

We base our analysis on individual time series cointegration techniques, allowing for heterogeneous and endogenous structural breaks. In chapter 3, we assess capital mobility for a panel of 15 EU countries for the period 1970-2019 using Chudik and Pesaran (2015) Dynamic Common Correlated Effects (DCCE) that allow for one homogeneous break. Using the Cross-sectional Distributed lags (CS-DL) proposed in Chudik et al. (2016), we also consider the non-linear impacts of the risk and financial openness on capital mobility. Lastly, in chapter 4, we examine the determinants of portfolio equity and bond investment in the European Union. We estimate the impact of different drivers of the gravity model developed by Okawa and Van Wincoop (2012) in which bilateral and multilateral resistance are modeled as financial restrictions between the country pair and relative to the rest of the world. It is also important to clarify that capital mobility and financial integration concepts will be used interchangeably. However, they are not entirely the same; financial integration is the consequence of capital mobility; in this sense, we will refer to financial integration when capital mobility is high.

Fourth, unlike most previous studies, we use a recent database developed by Coppola et al. (2021) that takes into account the role of tax havens (chapter 4). The former is a relevant improvement compared to the traditional portfolio databases (for example, the IMF CPIS database). As we show in this dissertation, adequately addressing the role of tax havens is particularly relevant for portfolio equity, for which tax havens play a significant role. Fifth, given the risk of financial fragmentation within the EU and the euro area, the analysis of the evolution of the degree of financial integration in the EU has regained momentum (chapter 2 and 3). Moreover, the EU's excessive overreliance on the banking system has been a setback for growth performance, and it has held back recovery since the 2007-2008 financial and sovereign debt crises. Hence, understanding the drivers of portfolio investment (chapter 4) may help EU policymakers to put the blocks for a well-developed Capital Market Union (CMU) with the investment being channeled through a market-based financial system instead of a banking-based financial system.

Next, we describe the rationale behind the content of this dissertation. Following the introduction, chapter 2 focuses on the evolution of capital mobility for the 19 euro area countries from 1970 to 2019 using

the FH regression. The econometric methodology followed in this chapter allows us to identify heterogeneous structural breaks and relate them to the EU's integration process. To this end, the euro area countries are an interesting case of study because they have gone further in the EU financial integration progress with the euro's creation. Moreover, the time-series approach is suitable for addressing the heterogeneity of euro area countries regarding trade patterns, financial exposures, and net external position. In this chapter, we apply the analysis to the data in annual and quarterly frequencies. Annual data is available for a more extended period (usually starting in 1970), while quarterly is available from 1995. The reasons for using the two frequencies are to include as many euro area countries as possible and because the techniques used to detect the structural breaks endogenously leave out observations and reduce the length of the available sample. Therefore, quarterly data is necessary to capture structural breaks after the 2007 crisis. For our analysis, we used the definition of investment and saving recommended by Baxter and Crucini (1993). In particular, we use gross fixed capital formation for investment, whereas we use the definition of "basis saving" as GDP minus total consumption (public and private) for savings; both variables are expressed as a percentage of GDP. Our sources are the World Bank (WB) database for the annual data and the International Financial Statistics (IFS) of the IMF from the quarterly sample.

In this respect, the econometric procedure is based on Kejriwal (2008). However, we first apply the Perron and Yabu (2009) stability test to choose the most suitable specification for the unit root tests. Next, we test for the order of integration of the variables, considering the potential instabilities if they exist. In the third step, we test for the stability of the FH regression, select the number of breaks, and then test for cointegration. Finally, when we find cointegration, we estimate the model, including the breaks, and assess if the domestic investment-saving relationship has changed over time. Our results confirm that capital mobility has increased since the 70s, along with the integration process until the euro's creation. However, capital mobility has been negatively affected by several external events, such as the European Monetary System (EMS) crisis, the German reunification, the Union of Soviet Socialist Republics (USSR) downfall, and the global financial crisis (2007-2008) and European sovereign debt crisis (2012-2015). The core euro countries were the first countries to achieve a high degree of capital mobility. Subsequently, European integration encouraged capital flows from the core to the periphery. This former group was severely affected by the European sovereign crisis to such a degree that some peripheral countries have not yet returned to their previous levels of capital mobility.

In addition to the time-series approach, analyzing an economically integrated area can be improved using panel data since it allows the exploitation of the cross-section and time information included in large T panels. Thereby, chapter 3 analyses capital mobility for the EU-15 between 1970-2019 in the context of the Feldstein and Horioka (1980) puzzle. As in chapter 2, we allow structural breaks in the FH regression. However, in this case, given that our analysis is based on a panel approach, the endogenous break included is homogeneous to the whole group. This approach is advantageous in identifying which has been the most relevant common break affecting capital mobility. Our sample has been constrained by the period available for the rest of the EU sample[6]. However, the EU 15 sample gathers 87% of the total EU's GDP[7]. Hence, we include the largest EU countries (in terms of GDP). Our data has been obtained from the OECD database. Our empirical approach allows for a complete analysis of capital mobility, looking at four dimensions: first, long-run capital mobility; second, the path followed to return to the long-run equilibrium when a shock occurs; third, structural breaks that have affected the domestic investment-saving relationship and lastly, short-run capital mobility. The former capital mobility dimension has usually been neglected in the literature. To our knowledge, no studies have addressed all these elements in assessing capital mobility within the FH context.

To achieve the objectives of chapter 3, we follow an econometric strategy in two stages; first, we analyze the long-run and short-run links between domestic investment and saving using Chudik and Pesaran (2015) Dynamic Common Correlated Effects (DCCE hereafter) modeled as an error correction model that adds one common structural break. Second, we use the Cross-sectional Distributed lags (CS-DL hereafter) proposed by Chudik et al. (2016) to assess how long-term domestic investment and savings change when risk and economic openness reach a certain threshold. Our econometric strategy allows us to deal with some neglected econometric issues for panel data: common effects, cross-section dependence, parameter heterogeneity, and endogeneity. Sequentially, the chosen econometric procedure goes as follows: First, we test for cross-sectional dependence over the panel FH regression. Second, we determine the order of integration of the variables using the Bai and Carrion-i Silvestre (2009) test, that considers cross-sectional dependence and structural breaks. In the next step, we test for cointegration using the Banerjee and Carrion-i Silvestre (2015) test that, as in the case of the unit root test, structural

[6]Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

[7]GDP, PPP (current international $) calculated for the period 2000-2019. Source: World Bank (WB) database.

breaks and cross-sectional dependence are accounted for. In this step, we also identify the structural breaks that affect the investment-saving relationship. Finally, as we already described, we estimate the DCCE with one common structural break identified in the cointegration analysis and the CS-DL threshold model. Our results suggest that not correctly accounting for structural breaks underestimates the degree of capital mobility. One homogeneous structural break is found at the euro's inception when we include one in our analysis. When we include the euro launching in our estimation, the long-run saving retention drastically decreases, showing that capital mobility is higher. However, the results also suggest that financial integration is not complete, confirming the Ford and Horioka (2017) 's hypothesis for which fully goods markets are a needed condition to achieve financial integration. The speed of adjustment towards the long-run equilibrium also sheds some light on the large external imbalances found for the periphery countries with an average of twelve years; in contrast, core countries return in six years. Our threshold analysis also shows that periods of economic crisis and financial turmoil in the EU have negatively impacted capital mobility, while we find a positive effect on financial openness.

After assessing the degree of capital mobility and financial integration, chapter 4 analyzes the drivers behind the allocation of portfolio equity and bonds for the EU countries during 2007-2017. The 28 EU countries are a central pillar of our sample; therefore, we include all the bilateral portfolio stocks in which at least one EU country is involved, either on the investor or issuer side. To overcome the problem of model specification found in the literature, we follow the theoretical-based gravity model developed by Okawa and Van Wincoop (2012). The model is also extended to capture the potential effect of the quality of the government and financial market development. Additionally, one remarkable feature of chapter 4 is that resistance variables that are derived from the gravity equation are modeled through financial restrictions between the country pair (bilateral resistance) and relative to the rest of the world (multilateral resistance). Given the increasing relevance of tax havens since the 2007-2008 financial crisis outbreak, their role cannot be neglected in the capital mobility analysis. Therefore, we use the database developed by Coppola et al. (2021), which re-maps portfolio stock issued/invested through any tax havens to the actual source and destination countries. Moreover, as a comparison exercise, we perform the analysis using the IMF (CPIS) database built under the residence principle to show how relevant it is to adequately address the role of tax havens in the global financial system. The econometric methodology used is the Poisson Pseudo Maximum Likelihood (PPML) estimator developed by Santos Silva and Ten-

reyro (2006). The PPML is a superior estimator to the OLS (Ordinary Least Square) when dealing with heteroskedasticity and bilateral zero stocks/flows.

Once the role of tax havens is appropriately considered, our findings suggest that gravitational variables are significant for both portfolio equity and bonds. In particular, distance has a negative effect, as countries that are further away tend to invest less in each other. In contrast, economic size (mass) is positive, implying that large countries tend to invest more in each other. Regarding the resistance variables, bilateral financial restrictions harm bilateral investments, whereas increasing financial restrictions in the rest of the world relative to the bilateral restrictions have a positive effect on the more bilateral portfolio stocks between the country pair. Global risk's impact is negative, while historical links have a positive effect. The euro area pair variable is positive and significant, which confirms a euro bias in portfolio allocation. The last extension of our model shows that the quality of the government and financial development positively impact portfolio holding allocation.

The next step entails the examination of the differences and similarities of the drivers of portfolio equity and bonds. This a topic of interest given that they are different assets in nature and risk. Our results show some interesting differences; distance and the euro bias are more relevant for portfolio bonds as the EU debt tends to be invested in the EU. However, portfolio equity has more international mobility, a fact that makes portfolio equity more sensitive to financial restrictions with the rest of the world and global risk. Despite the differences, some similarities exist, such as the positive role of historical links, institutional quality, and financial development.

To show how relevant it is to address the role that tax havens have in the financial markets, we compare the results obtained when applying our analysis to Coppola et al. (2021) database built under the nationality principles with the ones obtained with the IMF (CPIS), a database built under the residence principle. In this comparability exercise, some differences become apparent; first, distance and economic size are less relevant under the residency principle. This difference is probably due to the intermediary role of tax havens. Regarding the resistance variables, bilateral financial restrictions have a similar impact; however, multilateral resistance with the rest of the world is much more limited under the residence principle. Some inconsistencies are also found in the case of global risk in portfolio bonds. All the differences observed point to the relevance of adequately addressing the role of tax havens.

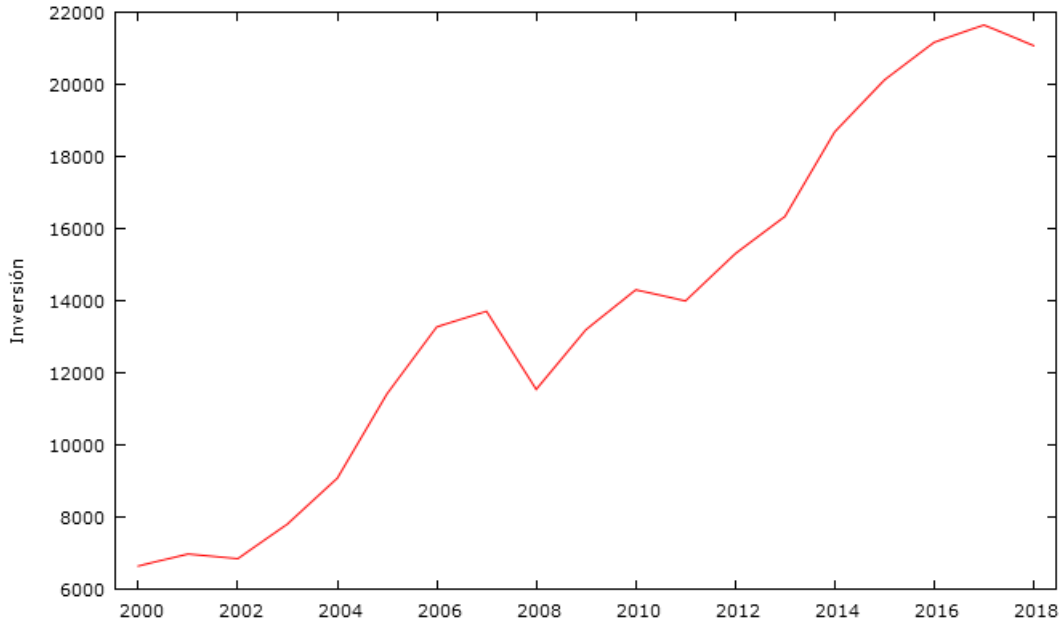
Introducción

Esta Tesis pretende contribuir en tres debates abiertos en la actualidad. El primero es el análisis del nivel de movilidad de capitales y del grado de integración en los mercados financieros de la UE. En concreto, se presta especial atención a cómo los diferentes escenarios de la integración financiera en la UE y los episodios de incertidumbre, turbulencias financieras y crisis han afectado a la movilidad de capital. Segundo, participa en el debate sobre cuáles son los factores explicativos de la movilidad de capital, especialmente, de inversiones en cartera de valores cotizados, estimando una especificación ampliada del modelo de gravedad. Tercero, se analiza el papel creciente que juegan los paraísos fiscales como intermediarios en el sistema financiero global. La UE es un caso de estudio con un interés particular debido a su peso en el sistema financiero mundial y porque constituye un test natural de la movilidad de capital y sus factores explicativos subyacentes, debido a que en ella se han eliminado las barreras comerciales y las restricciones a la movilidad de capital.

La movilidad de capitales y la integración de los mercados financieros son elementos clave de la macroeconomía internacional. De acuerdo con Baele et al. (2004), la integración financiera proporciona tres tipos de beneficios interconectados entre ellos y ampliamente aceptados. En primer lugar, facilita el reparto y la diversificación del riesgo a través de las fronteras nacionales, ofreciendo oportunidades a los individuos e instituciones para diversificar sus carteras de inversión y cubrirse contra pérdidas potenciales. En segundo lugar, al eliminar las barreras al comercio y a los flujos de capitales, la integración financiera permite asignar los recursos a los proyectos más rentables y, por tanto, maximizar el retorno de la inversión. Asimismo, elevados niveles de integración financiera están intrínsecamente unidos al crecimiento económico, ya que la asignación eficiente de capitales impulsa la innovación, la productividad y la prosperidad en general. En tercer lugar, la integración financiera es un elemento clave para la transmisión efectiva de la política monetaria en una unión monetaria, como es el caso de la zona euro. La integración financiera hace posible que cambios en los tipos de interés y otras políticas se transmitan de manera acompasada y uniforme entre los Estados miembros y, por ende, contribuye a la estabilidad macroeconómica y la convergencia. Por estos motivos, la integración financiera es la piedra angular para la promoción de prosperidad, resiliencia y estabilidad en la economía global.

Para aprovechar estos efectos positivos, las restricciones financieras empezaron a ser paulatinamente eliminadas en los Estados Unidos y el Reino Unido a comienzos de 1970, seguidos por otros países desarrollados. En la Unión Europea (UE) el proceso de liberalización financiera se inició durante los años 80 y principios de los 90 con la iniciativa del Mercado Único, seguida por la eliminación total de barreras económicas en 1992 tras la firma del Tratado de Maastricht. Como puede apreciarse en la Figura 1.5, que muestra la evolución del stock de valores cotizados (acciones y bonos) para los 28 países de la UE, la integración económica (real y financiera) ha incentivado las inversiones transfronterizas. Para que el capital sea "perfectamente móvil" a nivel internacional, se requiere que no existan fricciones, no sólo en los mercados financieros, sino también en el mercado de bienes (en otras palabras, que no existan costes de transporte, aranceles aduaneros y otras medidas equivalentes).[8]

Figure 1.5: Inversión en stock de cartera UE 28.

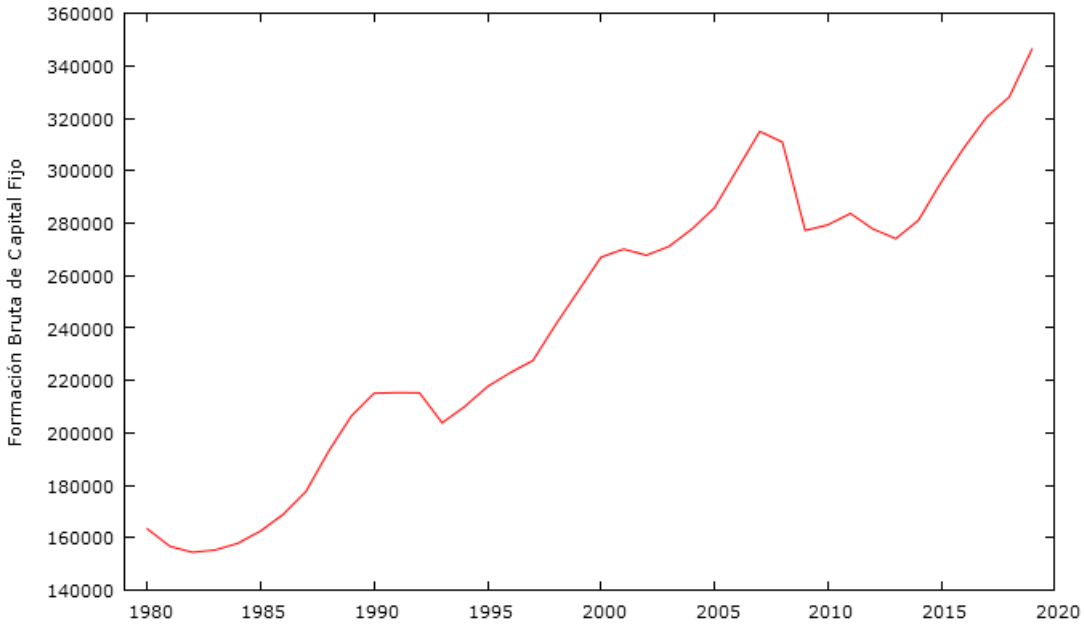


Notas: a) Fuente: base de datos de FinFlows. Unidad: EUR dividido por 1.000 millones.

[8]La importancia de las fricciones en el mercado de bienes (también llamadas "costes de comercio" o "fricciones comerciales") como una posible explicación a la paradoja de Feldstein-Horioka fue ya propuesta por Obstfeld and Rogoff (2001) y posteriormente desarrollada en Ford and Horioka (2017) y Horioka (2024). Para una refutación empírica de esta hipótesis, ver Johansen and Juselius (1992), Camarero and Tamarit (1996), y Eaton et al. (2016).

Uno de los desarrollos clave en el proceso de integración de la UE ha sido la creación de la zona euro. La adopción del euro ha acelerado la integración financiera entre los Estados miembros, eliminando el riesgo de variación del tipo de cambio y reduciendo los costes de transacción de las inversiones transfronterizas. El incremento de éstas ha afectado positivamente a la inversión en activos fijos, como puede verse en la Figura 1.6.

Figure 1.6: Formación Bruta de Capital Fijo UE 15.

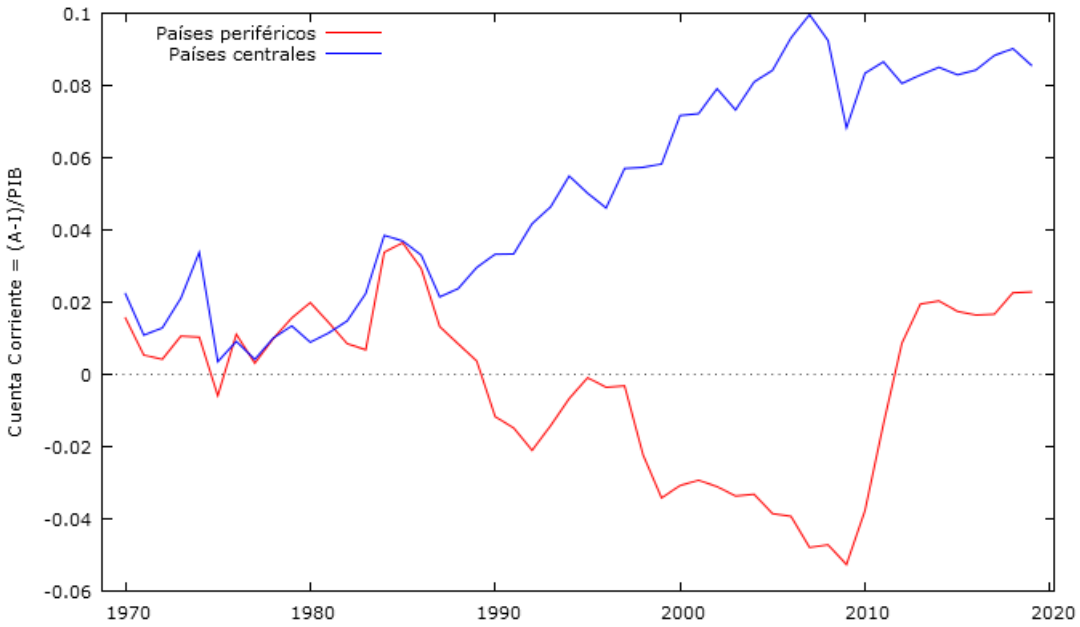


Notas: a) Fuente: Banco Mundial (USD constantes 2015). Importe dividido por 10 Millones. b) UE 15: Alemania, Austria, Bélgica, Dinamarca, España, Finlandia, Francia, Grecia, Irlanda, Italia, Luxemburgo, Países Bajos, Portugal, Reino Unido y Suecia.

Sin embargo, la movilidad internacional de capitales también presenta una serie de inconvenientes que requieren atención. En primer lugar, puede llevar a los países a un exceso de crédito, lo que potencialmente puede desencadenar quiebras de deuda soberana y huida de capitales y, en última instancia, una crisis financiera. En segundo lugar, los países sacrifican su independencia de política monetaria con tipos de cambio fijos. Por tanto, aunque la movilidad internacional de capitales ofrece beneficios, también plantea retos significativos. Por lo tanto, es relevante analizar la evolución del grado de la movilidad internacional de capitales a lo largo del tiempo, así como sus implicaciones para la economía global

y los diferentes grupos de países o regiones. En el caso de la UE, el aumento progresivo de la movilidad de capitales y la integración financiera han tenido un efecto adverso sobre el incremento persistente de desequilibrios externos desde 1990 hasta la Gran Recesión. Este fenómeno ha sido especialmente grave en la zona euro, donde la integración real y financiera había impulsado flujos de capital desde los países centrales hacia los periféricos. La Figura 1.7 muestra la evolución de la balanza por cuenta corriente en los países centrales y periféricos de la zona euro[9].

Figure 1.7: Cuenta Corriente.



Notas: a) La cuenta corriente se define como ahorro doméstico menos inversión doméstica dividida por el PIB. b) Los países centrales son: Alemania, Austria, Bélgica, Finlandia, Francia, Luxemburgo y Países Bajos. Países periféricos: España, Grecia, Italia, Portugal. Chipre ha sido excluido de la figura anual, ya que empieza en 1975. La cuenta corriente de Irlanda muestra un gran superávit para el periodo debido a su laxo régimen fiscal (en línea con Luxemburgo y Países Bajos), por lo tanto, se ha excluido de los países periféricos.

[9]En esta figura, los países centrales son: Alemania, Austria, Bélgica, Finlandia, Francia, Luxemburgo y Países Bajos, mientras que los países periféricos consisten en España, Grecia, Italia y Portugal. Chipre ha sido excluida de la figura, ya que la disponibilidad de sus datos empieza en 1975. Finalmente, como la cuenta corriente de Irlanda muestra un superávit para el periodo, debido a su laxo régimen fiscal (en línea con Luxemburgo y Países Bajos), dicho país no ha sido incluído entre los periféricos para evitar distorsiones.

Debido a que la restricción externa intertemporal es menor en una unión monetaria, la figura muestra que los desequilibrios externos por cuenta corriente dentro de la zona euro alcanzaron su máximo nivel entre la introducción del euro y justo después de la crisis financiera de 2007-2008. Los grupos de países centrales y periféricos exhiben una evolución opuesta. Debido a la parada repentina de flujos, esta situación se revirtió durante la crisis de deuda soberana europea ocurrida en el periodo 2010-2015.

Junto con los efectos no deseados de la movilidad de capitales mencionados antes, el proceso continuo de globalización se ha visto afectado por diversos shocks que han ocurrido con posterioridad a la Gran Recesión de 2007-2008. En la zona euro los graves desequilibrios externos hicieron que el choque fuera asimétrico, desencadenando una retroalimentación en cadena entre deuda bancaria y soberana cuyos efectos se expandieron hacia todos los países, tanto centrales como periféricos y aumentando la fragmentación financiera. Además, la actual crisis post-COVID-19, caracterizada por altas tasas de inflación, ha complicado este escenario debido al crecimiento de la incertidumbre y sus efectos sobre las relaciones externas entre países. El Banco Central Europeo (BCE) ha implementado políticas [10] para luchar contra la fragmentación desde el comienzo de los sucesivos choques. Sin embargo, esta situación está lejos de haber concluido.

Dados los beneficios de la movilidad de capitales y el impacto negativo de la crisis financiera de 2007-2008, ha habido un creciente interés en la literatura económica por evaluar el nivel de movilidad de capitales en ciertas regiones o grupos de países. La medición del nivel de la movilidad de capitales es compleja y depende de la propia definición que empleemos. La literatura ha considerado dos enfoques: el enfoque precio, que se centra en el análisis de las correlaciones entre los tipos de interés domésticos y extranjeros y sus efectos sobre el tipo de cambio, y el enfoque cuantitativo, que estudia las correlaciones de las variables que directamente materializan la movilidad de capitales, es decir, la inversión y el ahorro. En el artículo seminal en este campo Feldstein and Horioka (1980) (FH, de aquí en adelante), los autores estimaron la relación entre las ratios de ahorro e inversión, obtuviendo (en contra de lo esperado) un parámetro grande y significativo en la regresión entre las dos variables durante el período 1960-1974. Los autores concluyeron que el nivel internacional de movilidad de capitales y la integración de los mercados

[10] Por ejemplo, el Securities Market Programme (SMP), por sus siglas en inglés, entre 2010 y 2012, y el Outright Monetary Transactions (OMT) desde 2012 hacia delante, y el Public Sector Purchase Programme (PSPP) desde 2015. Con el estallido de la crisis del COVID-19, el BCE lanzó el Pandemic Emergency Purchase Programme (PEPP).

globales de capital era sorprendentemente bajo. Obstfeld and Rogoff (2001) se refieren a las concusiones de FH como la madre de todas las paradojas. Estos resultados han dado lugar a una extensa literatura intentando resolver la controversia. El enfoque de FH ha sido contrastado utilizando muchas técnicas de estimación tanto de series temporales como de datos de panel. Sin embargo, una parte de la literatura no ha teniendo en cuenta las propiedades no estacionarias de los datos. Además, los eventos económicos, así como las perturbaciones globales y locales, también afectan al nivel de movilidad de capitales. Sin embargo, estos cambios estructurales han sido tradicionalmente descuidados en la literatura.

De manera similar, países y reguladores deben entender los factores que se encuentran detrás de las decisiones de los inversores cuando éstos asignan sus inversiones a nivel internacional. Tradicionalmente, los investigadores han utilizado el marco de atracción y repulsión (push-pull models en inglés) para explicar los flujos de capitales, basándose en una serie de factores tales como los diferenciales de intereses, diferenciales de crecimiento económico y factores políticos. Este enfoque, aunque informativo, carece de fundamentos teóricos y falla al capturar la dinámica de las decisiones de inversión. A lo largo del tiempo, el modelo de gravedad ha emergido como una alternativa para analizar los factores detrás de las inversiones de cartera, ofreciendo una representación más realista de un sistema financiero global interconectado. La perspectiva gravitacional capta las fuerzas que empujan el comportamiento del inversor, señalando que las inversiones transfronterizas bilaterales entre dos países son proporcionales a los tamaños de sus economías, inversamente a la distancia, y sujetas a unas fricciones y resistencias. Okawa and Van Wincoop (2012) establecieron unos fundamentos teóricos sólidos del modelo de gravedad aplicado a las transacciones de activos. Aunque el modelo teórico está bien desarrollado, todavía existe incertidumbre sobre su aplicación empírica. De hecho, la ecuación de gravedad ha sido ampliada añadiendo factores de atracción y repulsión.

Junto con la especificación del modelo financiero de gravedad descrito en el párrafo anterior, el papel de los paraísos fiscales como actores fundamentales en el sistema financiero global requiere especial atención, sobre todo desde la crisis financiera de 2007-2008. La Figura 1.8 muestra el porcentaje del stock de cartera de acciones y bonos invertido a través de paraísos fiscales. La figura muestra su indudable relevancia en los mercados financieros globales como intermediarios entre el país de origen y de destino implicados en la transacción. Tradicionalmente, la existencia de los paraísos fiscales estaba

relacionada con hogares con un alto nivel patrimonial que tenía el objetivo de cubrirse de cargas fiscales. Sin embargo, este papel ha cambiado con la creciente actividad de compañías multinacionales, que emiten valores a través de filiales transnacionales localizas en los paraísos fiscales. Estas estrategias tienen varios objetivos, como acceder a los mercados financieros internacionales, evitar controles de capital y sortear otras regulaciones. A pesar de su creciente relevancia, la literatura empírica que tiene en cuenta los paraísos fiscales es más bien escasa. Uno de los posibles motivos es que las bases de datos tradicionales sobre inversiones transfronterizas se han construido bajo el principio de residencia, según el cual sólo se identifica la localización física del inversor y emisor de los activos. La bases de datos más comúnmente utilizadas bajo este principio son el Coordinated Portfolio Investment Survey (CPIS) del FMI para las inversiones de valores cotizados y el FinFlows, que también cubre otro tipo de flujos/stock. Sin embargo, para superar esta limitación se están desarrollando nuevas bases de datos: Damgaard et al. (2019) para el caso de Inversión Extranjera Directa (IED) y Coppola et al. (2021) y Beck et al. (2023) para el caso del stock de valores cotizados. Estas bases de datos se han construido bajo el principio de nacionalidad, de manera que re-mapea los flujos/stock a la fuente inicial y destino finales, eliminando el efecto de los intermediarios.

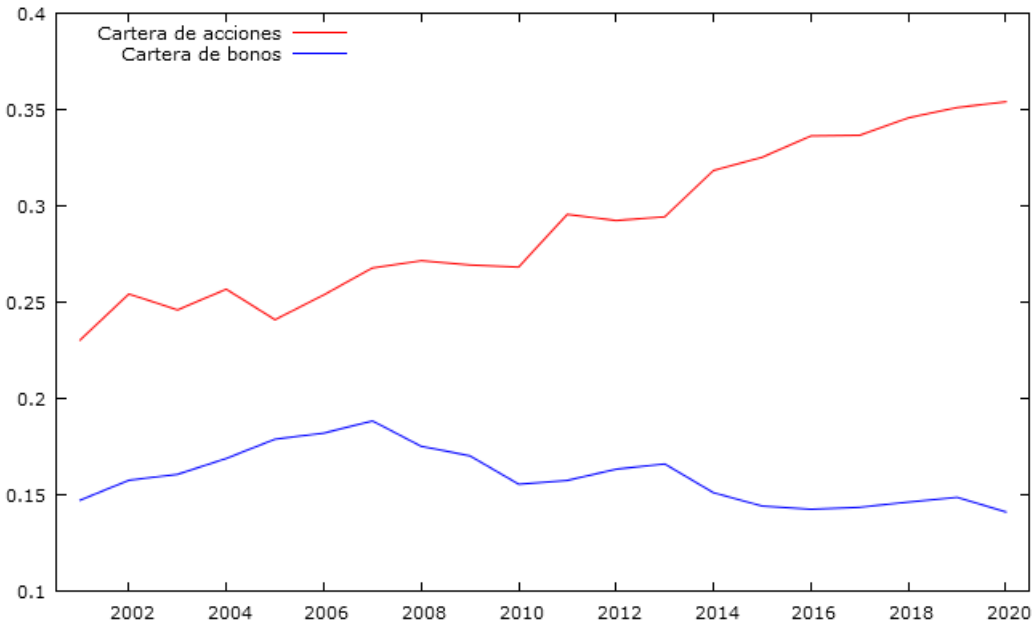
Como se ha indicado anterioremente, esta tesis doctoral persigue tres objetivos. En primer lugar, profundizar en el análisis del nivel de movilidad de capitales y la integración financiera en los mercados de la Unión Europea (UE). Este objetivo reviste particular importancia debido al papel destacado que desempeña la UE en el panorama financiero mundial y su condición de campo propicio para evaluar la movilidad de capitales en un entorno sin barreras comerciales ni restricciones a la movilidad de fondos. Nuestra muestra objetivo es la UE y sus submuestras (zona euro 19[11], UE 15[12] y la UE 28). En segundo término, se pretende contribuir al debate sobre los factores explicativos de la movilidad de capital, focalizándose especialmente en la cartera de inversiones en valores cotizados. Para ello, se ampliará y perfeccionará el modelo de gravedad como herramienta analítica. Por último, se busca examinar el creciente papel de los paraísos fiscales como intermediarios en el sistema financiero global, con especial énfasis en su relación con la UE. Este análisis es de suma relevancia, dada la trascendencia de los paraísos fiscales en la actualidad y su impacto en la estabilidad y transparencia del sistema financiero

[11] Croacia no había adoptado el euro durante el periodo de análisis examinado en esta disertación.

[12] Alemania, Austria, Bélgica, Dinamarca, España, Finlandia, Francia, Grecia, Irlanda, Italia, Luxemburgo, Países Bajos, Portugal, Reino Unido y Suecia.

internacional.

Figure 1.8: Porcentaje de paraísos fiscales en el mundo para la cartera de activos cotizados sobre el total.



Notas: (a) Datos obtenidos de la base de datos del FMI (CPIS) bajo el principio de residencia.; (b) La lista de paraísos fiscales se ha incluído en la tabla 4.C.

La tesis se divide en tres capítulos. Después de esta introducción, en el capítulo 2, evaluamos la movilidad de capitales para los países de la zona euro estudiando la relación de largo plazo entre el ahorro e inversión doméstica para el periodo 1970-2019.

El análisis empírico se realiza utilizando tanto series temporales como datos de panel y técnicas de cointegración, permitiendo cambios estructurales heterogéneos e identificados de manera endógena. En el capítulo 3, evaluamos la movilidad de capitales en un panel de quince países de la UE para el periodo 1970-2019 estimado aplicando Efectos Comunes Correlacionados Dinámicos (ECCD), en el que también se introduce un cambio estructural homogéneo(Chudik and Pesaran, 2015). Usando Retardos Distribuidos de Sección Cruzada (RDSC) propuestos en Chudik et al. (2016), también analizamos impactos no lineales del riesgo y la apertura financiera sobre la movilidad de capitales. Por último, en el capítulo 4, estudiamos los determinantes de la inversión en cartera de acciones y bonos en la Unión Europea. Estimamos el impacto de los diferentes factores a través del modelo de gravedad desarrollado por Okawa

and Van Wincoop (2012), en el cual la resistencia, tanto bilateral como multilateral, se introduce como restricciones financieras entre pares de países y en relación al resto del mundo. Es importante clarificar que en esta tesis, la movilidad de capitales y la integración financiera son conceptos que se utilizarán de manera intercambiable. Sin embargo, no son completamente lo mismo; la integración financiera es la consecuencia de la movilidad de capitales; en este sentido, nos referiremos a la integración financiera cuando la movilidad de capitales es alta.

Esta Tesis contribuye a la literatura en diferentes aspectos: primero, analizamos la movilidad de capitales en la Unión Europea y en la zona euro desde el inicio del proceso de integración financiera. Hasta donde alcanza nuestro conocimiento, no hay estudios comprables que cubran íntegramente este periodo y que conecten los cambios estructurales identificados con los cambios en el nivel de movilidad de capitales. Segundo, desde un punto de vista metodológico, basamos nuestro análisis en técnicas de cointegración econométricas vanguardistas (capítulos 2 y 3). Las no linealidades son introducidas con cambios estructurales (capítulos 2 y 3) y análisis basados en umbrales (capítulo 3). Además, seguimos una metodología econométrica que nos permite tratar efectos comunes correlacionados, dependencia de corte transversal, heterogeneidad de parámetros y endogeneidad siguiendo un enfoque de panel (capítulo 3). Tercero, otra característica destacable de esta Tesis, es que estimamos la ecuación de gravedad siguiendo el modelo teórico desarrollado por Okawa and Van Wincoop (2012) (capítulo 4). Sorprendentemente, existe muy poca literatura que estime la ecuación de gravedad siguiendo la especificación que se deriva de este modelo teórico. Una práctica común es introducir factores de "atracción y repulsión ad hoc", que carecen de una justificación teórica y producen estimadores sesgados. Cuarto, a diferencia de otros estudios previos, utilizamos una base de datos recientemente desarrollada por Coppola et al. (2021) que tiene en consideración el rol de los paraísos fiscales (capítulo 4). Esta última es una mejora sustancial en comparación con las bases de datos de activos del mercado de valores (por ejemplo, la base de datos del CPIS FMI). Como mostramos en esta Tesis, tener en cuenta los paraísos fiscales de una manera adecuada es particularmente relevante para el stock de acciones. Quinto, dado el riesgo de fragmentación financiera existente dentro de la UE y la zona euro, el análisis de la evolución de la integración financiera en la UE es un tema de especial actualidad en el debate académico y de política económica (capítulos 2 y 3). Además, la excesiva dependencia de los países de la UE del sistema bancario ha sido una limitación relevante para el crecimiento económico y ha ralentizado la recuperación desde la crisis financiera de

2007-2008 y la subsiguiente crisis soberana. Por lo tanto, la comprensión de los factores que explican la dinámica de inversión en los mercados de valores (capítulo 4) podría ayudar a los reguladores de la UE a poner las bases para un buen desarrollo de la Unión del Mercado de Capitales (UMC) que permita canalizar la inversión a través de un sistema financiero basado en mercados, en vez de uno altamente bancarizado.

En el siguiente párrafo describimos los fundamentos detrás del contenido de esta Tesis. Tras la introducción, el capítulo 2 se centra en la evolución de la movilidad de capitales para los 19 países de la zona euro desde 1970 a 2019, utilizando el enfoque de Feldstein-Horioka (FH). La metodología econométrica seguida en este capítulo nos permite identificar cambios estructurales heterogéneos y conectarlos con el proceso de integración de la UE. La zona euro es un caso interesante de estudio, ya que han ido más lejos en el proceso de integración financiera en la UE con la creación del euro. Además, el enfoque de series temporales es particularmente adecuado para adaptarse al nivel de heterogeneidad de los países de la zona euro en lo que respecta a los patrones de comercio, exposición financiera, y posición externa neta. En este capítulo, aplicamos el análisis a datos de frecuencia tanto anual como trimestral. La razón es que los datos anuales están disponibles para un periodo más extenso (en general, empezando en 1970), mientras que los trimestrales sólo están disponibles desde 1995. Usando las dos frecuencias se ha intentado incluir tantos países de la zona euro como sea posible y además, debido a que las técnicas usadas para detectar los cambios estructurales de manera endógena eliminan observaciones y reducen el tamaño temporal de la muestra, es conveniente disponer de un número importante de observaciones. Por lo tanto, los datos trimestrales son necesarios para captar cambios estructurales después de la crisis de 2007. En nuestro análisis hemos utilizado la definición de ahorro e inversión recomendada por Baxter and Crucini (1993). En concreto, usamos la formación bruta de capital fijo para la inversión, mientras que para el ahorro usamos la definición de "ahorro básico" como PIB menos el consumo total (público y privado); ambas variables están expresadas como porcentaje del PIB. Nuestras fuentes son la base de datos del Banco Mundial (BM) para los datos anuales y el International Financial Statistics (IFS) del FMI para los datos trimestrales.

En el análisis de series temporales, el procedimiento econométrico utilizado se basa en Kejriwal (2008). Sin embargo, primero aplicamos el test de estabilidad de Perron and Yabu (2009) para elegir la especi-

ficación más adecuada para el test de raíces unitarias. En el siguiente paso, contrastamos el orden de integración de las variables, considerando las inestabilidades potenciales en el caso de que existan. En el tercer paso, contrastamos la estabilidad de la regresión de FH, seleccionamos el número de cambios estructurales y contrastamos la existencia de cointegración. Finalmente, cuando hallamos evidencia de cointegración, estimamos el modelo incluyendo los cambios estructurales y evaluamos si la relación de inversión-ahorro doméstico ha cambiado a lo largo del tiempo. Nuestros resultados confirman que la movilidad de capitales ha aumentado desde la década de los 70, ligado al proceso de integración hasta la creación del euro. Sin embargo, la movilidad de capitales se ha visto afectada de manera negativa por ciertos eventos externos, tales como la crisis del Sistema Monetario Europeo (SME), la reunificación de Alemania, y la caída de la Unión de Repúblicas Socialistas Soviéticas (URSS), la crisis financiera global (2007-2008) y la crisis europea de deuda soberana (2012-2015). Los países centrales fueron los primeros en alcanzar un alto nivel de movilidad de capitales. Consiguientemente, la integración europea ha fomentado los flujos de capital desde los países centrales a los periféricos. Este último grupo fue gravemente afectado por la crisis europea de deuda soberana, hasta el punto de que algunos países periféricos no han retornado a sus niveles previos de movilidad de capitales.

Junto al enfoque de series temporales, el análisis de un área de integración económica puede ser completado con el uso de datos de panel, ya que permite explotar los datos de sección cruzada a la vez que la información temporal que se incluye en los grandes paneles. Por lo tanto, el capítulo 3 analiza la movilidad de capitales para la UE-15 entre 1970-2019 en el contexto de la paradoja de Feldstein and Horioka (1980). Como hicimos en el capítulo 2, permitimos cambios estructurales en la regresión de FH. Sin embargo, en este caso, dado que nuestro análisis se basa en un enfoque de panel, el cambio estructural endógeno que se incluye es homogéneo para todo el grupo. Este enfoque presenta la ventaja de identificar cuál ha sido el cambio estructural común más relevante que ha impactado en la movilidad de capitales. Nuestra muestra, limitada a 15 países de la UE, ha sido condicionada por la no disponibilidad de datos para el resto de países[13]. Sin embargo, nuestra muestra de la UE 15 recoge el 87% del PIB total de la UE[14]. Por lo tanto, se han incluído los países más grandes (en términos de PIB) de la UE. Nuestra

[13]Bulgaria, Croacia, Chipre, Estonia, Hungría, Letonia, Lituania, Malta, Polonia, República Checa, Rumania, Eslovaquia y Eslovenia.

[14]PIB, PPA ($ internacionales corrientes) calculados para el periodo 2000-2019. Fuente: base de datos del Banco Mundial (BM).

muestra ha sido obtenida de la base de datos de la OCDE. El enfoque empírico permite analizar de una manera integral la movilidad de capitales, en cuatro dimensiones: primero, la movilidad de capitales en el largo plazo; segunda, la vía de retorno al equilibrio de largo plazo cuando ocurre un choque desestabilizador; tercero, cambios estructurales que han afectado a la relación de inversión-ahorro doméstica, y por último, la movilidad de capitales en el corto plazo. Esta última dimensión de la movilidad de capitales ha sido normalmente desatendida en la literatura. Hasta donde alcanza nuestro conocimiento, no existen estudios previos que aborden todos los elementos mencionados en la evaluación de la movilidad de capitales dentro del contexto de FH.

Para alcanzar los objetivos del capítulo 3, seguimos una estrategia econométrica dividida en dos fases; primero, analizamos las relaciones de largo y corto plazo de la relación entre ahorro e inversión doméstica utilizando Efectos Comunes Correlacionados Dinámicos (ECCD) modelado como un modelo de corrección de error que incluye un cambio estructural homogéneo (Chudik and Pesaran, 2015). Segundo, utilizamos el modelo de Retardos Distribuidos de Sección Cruzada (RDSC) propuesto por Chudik et al. (2016) para evaluar cómo la relación de largo plazo entre ahorro e inversión cambia cuando el riesgo y la apertura económica alcanzan un determinado umbral. Nuestra estrategia econométrica nos permite abordar algunos de los problemas normalmente descuidados para datos de panel: efectos comunes, dependencia de corte transversal, heterogeneidad de parámetros y endogeneidad. El procedimiento econométrico elegido funciona según la secuencia siguiente : primero, contrastamos si existe dependencia de corte transversal en el panel de la regresión de FH. Segundo, determinamos el orden de integración de las variables usando el test de Bai and Carrion-i Silvestre (2009), que toma en cuenta la dependencia de corte transversal y cambios estructurales. En los siguientes pasos, contrastamos la existencia de cointegración usando el test de Banerjee and Carrion-i Silvestre (2015) en el que, como en el caso del test de raíces unitarias, se tienen el cuenta los cambios estructurales y la dependencia de corte transversal. En este paso también identificamos los cambios estructurales que afectan a la relación de inversión y ahorro. Finalmente, como ya hemos descrito, estimamos el ECCD incluyendo un cambio estructural común previamente identificado en el análisis de cointegración y, además, estimamos el modelo de umbral RDSC. Nuestros resultados sugieren que no tener en cuenta los cambios estructurales subestima el nivel de movilidad de capitales. El cambio estructural homogéneo es identificado en el momento de la creación del euro. Cuando incluimos el lanzamiento del euro en nuestra estimación, la relación de largo plazo

entre el ahorro e inversión doméstica desciende drásticamente, mostrando que el nivel de movilidad de capitales es más alto. Sin embargo, los resultados también sugieren que la integración financiera no está completada, confirmando la hipótesis de Ford and Horioka (2017) por la cual la integración completa del mercado de bienes es una condición necesaria para conseguir la integración financiera. La velocidad del ajuste hacia el equilibrio de largo plazo arroja luz sobre los grandes desajustes externos que se observan en los países periféricos, que tardan una media de doce años, mientras que los países centrales retornan en seis. Nuestro análisis de umbrales también muestra que los periodos de crisis económica e incertidumbre financiera en la UE han afectado negativamente a la movilidad de capitales, mientras que existiría un efecto positivo de la apertura financiera.

Después de estudiar el nivel de movilidad de capitales e integración financiera, el capítulo 4 analiza los factores que explican la asignación del stock de acciones y bonos cotizados de los países de la UE durante 2007-2017. Los países de la UE 28 son el centro de nuestra muestra; por lo tanto, incluimos todo stock bilateral de cartera en el que al menos un país de la UE está involucrado, ya sea en el lado inversor o en el emisor del activo. Para abordar el problema de especificación del modelo, seguimos el modelo teórico de gravedad desarrollado por Okawa and Van Wincoop (2012). En un segundo paso lo ampliamos para incluir los efectos potenciales que tienen la calidad del gobierno y el desarrollo de los mercados financieros. Además, una característica que cabe destacar de este capítulo 4 es que las variables de resistencia que se derivan de la ecuación de gravedad son tratadas como restricciones financieras entre el par de países (resistencia bilateral) y relativa al resto del mundo (resistencia multilateral). Dada la creciente relevancia de los paraísos fiscales desde el estallido de la crisis financiera global de 2007-2008, su papel debe tenerse en cuenta en el análisis de la movilidad de capitales. Por lo tanto, utilizamos la base de datos desarrollada por Coppola et al. (2021), que re-mapea el stock de cartera de valores cotizados que han sido emitidos/invertidos a través de algún paraíso fiscal hacia su fuente y destino final. Además, realizamos un ejercicio de comparación, ejecutando nuestro análisis utilizando también la base de datos del FMI (CPIS), construida bajo el principio de residencia, para así mostrar cuán relevante es tener en cuenta el papel de los paraísos fiscales en el sistema financiero mundial. La metodología econométrica utiliza es el estimador de Pseudo Poisson Máxima Verosimilitud (PPMV) desarrollado por Santos Silva and Tenreyro (2006). El PPMV es superior a Mínimos Cuadrados Ordinarios (MCO) cuando se aborda el problema de heteroscedasticidad y ceros en los flujos/stock bilaterales.

Una vez tenido en cuenta el papel de los paraísos fiscales, nuestros resultados sugieren que las variables gravitacionales son significativas tanto para las acciones como para los bonos. En concreto, la distancia tiene un efecto negativo, ya que los países que están más lejos tienden a invertir menos entre ellos. En contraste, el tamaño económico (masa) es positivo, lo que implica que países más grandes tienden a invertir más entre ellos. En lo relacionado con las variables de resistencia, las restricciones financieras bilaterales dañan a las inversiones bilaterales, mientras que el incremento de las restricciones en el resto del mundo relativas a las restricciones bilateral favorece las inversiones entre cada par de países. La variable que muestra si los dos países están en la zona euro es positiva y significativa, lo que confirma el sesgo del euro para la distribución de carteras de activos cotizados. La última extensión de nuestro modelo muestra que la calidad del gobierno y el desarrollo financiero tiene un impacto positivo para la distribución de la cartera.

El siguiente paso consiste en el examen de las diferencias y similitudes de los resultados obtenidos para ambos activos analizados. Este es un tema de interés, ya que ambos activos son diferentes en términos de naturaleza y riesgo. Nuestros resultados muestran algunas diferencias importantes; la distancia y el sesgo del euro son más relevantes para los bonos, lo que implica que la deuda de la UE tiende a ser invertida en la UE. Sin embargo, las acciones tienen una movilidad más internacional, este hecho, a su vez, hace que las acciones sean más sensibles a las restricciones financieras en el resto del mundo y al riesgo global. A pesar de las diferencias, también encontramos ciertas similitudes, tales como el impacto positivo de los lazos históricos, la calidad del gobierno y el desarrollo de los mercados financieros.

Para mostrar cuán relevante es abordar adecuadamente el rol que los paraísos fiscales en los mercados financieros, comparamos los resultados obtenidos cuando aplicamos nuestro análisis a la base de datos de Coppola et al. (2021) bajo el principio de nacionalidad con los obtenidos usando la base de datos del FMI (CPIS), bajo el principio de residencia. En este análisis comparativo encontramos algunas diferencias notables; primero, la distancia y el tamaño de la economía son menos relevantes bajo el principio de residencia. Esta diferencia es explicada probablemente por el rol que tienen los paraísos fiscales como intermediarios. En lo relacionado con las variables de resistencia, la resistencia bilateral tiene un impacto similar; sin embargo, la resistencia multilateral con el resto del mundo tiene un impacto mucho más limitado bajo el principio de residencia. También encontramos algunas inconsistencias para

el caso del riesgo global en bonos. Todas las diferencias comentadas ponen de manifiesto la relevancia de abordar adecuadamente el rol de los paraísos fiscales.

Chapter 2

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

2.1 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 endeavor, 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 90s, 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.

Nevertheless, 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 resilience of Eurozone 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 Eurozone (EZ) are: (i) the fragmented regulatory and institutional frameworks; (ii) the corporate sector's over-reliance on bank financing[1] 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).

After the findings of Feldstein and Horioka (1980), many papers have attempted to identify 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 (2001) developed a model with transaction costs for international trade in goods, finding that the sole existence of frictions in the goods 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 Feldstein and Horioka (1980) results can be due to the absence of globally integrated goods markets. Hence, both financial and goods markets integration are needed for capital mobility to existing.

The EU 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. Unlike most of earlier literature, which focuses

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

on the price approach, we adopt the quantity one based on Feldstein and Horioka (1980); we consider this approach is especially suited to assess the evolution of capital mobility within a monetary union where external imbalances have been persistently growing up to the Great Recession. External disequilibria are caused by macroeconomic imbalances between national savings and investment (S and I, respectively, hereafter) in a context of financial liberalization. Persistent imbalances between national S and I would be at odds with the existence of a Feldstein-Horioka (FH hereafter) puzzle. In Figure 2.1, we plot the current account (CA) balance of the core[2] and peripheral EU countries as the average value of the difference between domestic I and domestic S. The two groups of countries show a mirroring evolution. Indeed, the visual inspection shows a diverging trend between core and peripheral countries, especially since the convergence of interest rates in the EU from 1995 to 1997 on the euro's launching eve. While eliminating currency risk and the broader and deeper financial markets would facilitate the financing of external deficits allowing domestic savings to drift apart from domestic investment, the situation for the peripheral countries changed dramatically with the 2007 financial crisis and the subsequent adjustment afterward[3]. The latter gave rise to a credit crunch in the area, with a subsequent financial fragmentation process. Thus, the financial crisis triggered a double reduction in capital mobility and the gap between core and periphery external positions. However, beyond the former general patterns, and according to Lane and Milesi-Ferretti (2007), the exposures across Europe are very heterogeneous (differences in trade patterns, financial exposures, and net external positions); this can be seen in Figure 2.2. Therefore, to tackle this heterogeneity across countries, a more disaggregated analysis using individual time series seems a convenient empirical approach.

In this paper, we evaluate capital mobility using the FH regression and complement its interpretation by examining the time-series properties of the individual series involved and the stability of the long-run relationship linking domestic saving and investment.[4] 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

[2]Core countries: Austria, Belgium, Finland, France, Germany, Luxembourg, and the Netherlands.

[3]Table 2.A summarizes the main events occurred during the 2007-2008 financial crisis and the subsequent European sovereign crisis.

[4]In contrast, other authors such as Sinn (1992), Jansen (1997, 1998, 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 parallel with periods of changes in financial openness.

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 the tests proposed by Kejriwal and Perron (2010) that allow 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 β) has changed over time. In order to check for the robustness or our results we implement two additional estimations. First, we test for cointegration in a panel for different groupings using the MG/PMG estimators and, second, we apply rolling window regressions to assess the evolution of the saving retention parameters over time.

Our contributions are the following: first, we reassess the FH puzzle for the Eurozone countries for the most extended sample available. Surprisingly, there is 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), Drakos et al. (2018), ECB (2018, 2020) and Camarero et al. (2020), although they use different empirical approaches and cover a shorter time span compared to the present study; second, for this purpose, we take into account the non-stationarity properties of the variables in the same vein of recent literature both in large panels and time series; 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 savings-retention coefficient in the FH equation; fourth, we deal with the expected degree of heterogeneity within the EU considering the existence of several country groups. The groupings are determined endogenously relying on the breaks found and signal a clear difference between core countries and the rest of the sample; fifth, we present robustness checks using in a complementary way both MG/PMG estimators [5] and rolling window regressions. Finally, our results have relevant economic policy implications.

[5] See Pesaran et al. (1999) and related literature

This paper is organized as follows: in Section 2.2, we succinctly present how capital mobility is measured using the FH approach and review the empirical literature on the subject focusing on the time series perspective. Section 4.4 summarizes the econometric methodology and describes the database, while Section 2.4 discusses the empirical results and robustness tests. Finally, Section 2.5 concludes.

2.2 Theoretical and empirical background

2.2.1 Capital mobility: FH condition for financial integration

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, 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[6]. While the first one is known as the *price approach* and focuses on the co-movement 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 valuable complement to the traditional price-based measures. 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:

$$(\frac{I_i}{Y_i}) = \alpha + \beta(\frac{S_i}{Y_i}) \tag{2.1}$$

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 β 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, β should be zero for small countries, whereas it would represent their share of the world capital stock for large countries. The reason for β

[6]See, for instance, Lemmen and Eijffinger (1993, 1995).

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 β 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. This unexpected result has been tested in many papers but has remained robust in the cross-section analysis. However, as it confronts what international macroeconomics predicts in a process of globalization, it has been coined as the Feldstein-Horioka puzzle.

2.2.2 Survey on the main empirical literature

Obstfeld and Rogoff (2001) refer to it as the mother of all puzzles and, consequently, has given rise to extensive literature trying to solve it. This literature can be classified into three categories[7]. While the first focuses on theoretical developments, the second line of research explores possible problems present in the studies (sample selection problems, endogeneity problems, or data problems). Finally, a third strand of the literature has emphasized the need to improve the econometric techniques since the seminal cross-section studies might overestimate or underestimate the value of the saving-retention coefficient. We will limit ourselves to surveying the time series or panel data literature, but always with a time perspective.

Among the time-series studies, Feldstein and Horioka (1980) also ran annual time-series for the original FH sample 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. However, 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)

[7] As the literature is vast, we only refer to the most important papers. For a more exhaustive review, see Apergis and Tsoumas (2009) and Coakley et al. (1998).

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 favor of cointegration.

The analysis implemented in Kejriwal (2008) deserves 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 favor 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 β coefficients determined by the breaks. However, her findings do not support FH's result for the EU countries.

Concerning panel data techniques, the literature is non-conclusive. While some papers, like Krol (1996), Coakley and Kulasi (1997), Corbin (2001), Kim (2001), Coakley et al. (2004) and Narayan (2005), find similar results as using time-series, other authors criticize the panel methodology, as the results would not be valid if no regime change is allowed for. However, there is not much literature on the FH puzzle allowing for structural breaks. A 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.[8]

Focusing on the European case, Katsimi and Zoega (2016) use the difference-in-difference method in a panel of 19 EU countries for 1960-2014, with promising results; Drakos et al. (2018) assess the relationship between domestic saving and investment for 14 EU countries for the period 1970-2015, finding that there is weak evidence in favor 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 (therefore including some Eurozone countries), found that the correlation between domestic saving/investment dropped to record levels right before the 2008 financial crisis, and the puzzle returns afterward. Their results also suggest that the puzzle for net capital-importing and capital-exporting countries differs. In this line, Ketenci (2018) using GMM techniques analyzes the impact of the 2008 financial crisis on the level

[8] In the same vein, Özmen and Parmaksiz (2003), Westerlund (2006), Telatar et al. (2007) and Mastroyiannis (2007) find more evidence of cointegration between saving and investment once they account for structural breaks in the panel.

of capital mobility, finding an insignificant impact. Finally, Camarero et al. (2020) developed a time-varying parameters state-space model applied to panel data covering 12 EU countries, where they show the evolution along time of the FH coefficient as a by-product of a more general OECD sample.[9]

Finally, the ECB performs periodical studies on the degree of financial integration in the Eurozone. ECB (2018) and ECB (2020) analyzes how financial integration has evolved in the Eurozone[10] 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) program 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 fulfillment 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, making the interpretation of the results difficult, which calls for further research.

2.3 Econometric analysis: Unit roots, cointegration and stability

This section examines the link between domestic investment and saving using cointegration techniques that allow for multiple structural breaks. Although we closely follow the empirical 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)

[9] At this point, it is important to underline a caveat. Note that But and Morley (2017) and Camarero et al. (2020) cover a sample of OECD countries following the tradition of the seminal literature on FH. Therefore, neither the econometric approach nor the sample are entirely comparable to the present paper. However, for the original EU countries, they give us a helpful benchmark.

[10] The ECB measures financial integration using the price-based and the quantity-based approaches.

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). 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 β) has changed over time.

The robustness of our findings is checked using two alternative methodologies: MG/PMG estimators in panel data for the analysis of the cointegration relationships and rolling windows regressions to assess the time-varying nature of the savings retention coefficient. The rationale for both robustness checks goes as follows. First, given that we have a large panel of countries for a very long-time span, it can be an interesting exercise to run a mean group estimator and a pooled mean group estimator to uncover how the savings retention coefficient changes both in the long run and short run. Indeed, the recent literature on dynamic heterogeneous panel estimation in which both N and T are large suggests using the MG estimator proposed by Pesaran and Smith (1995) where the intercepts, slope coefficients, and error variances are all allowed to differ across groups. Moreover, the PMG estimator (Pesaran et al., 1999) combines both pooling and averaging, allowing the intercept, short-run coefficients, and error variances to differ across groups (as would the MG estimator) but constraining the long-run coefficients to be equal for all the groups (as would the FE estimator). In a second stage, as it may seem unlikely that international capital mobility is governed only by abrupt events, we use a rolling window regression to analyze the discontinuities along time in the savings retention coefficient. Indeed, due to different reasons (menu cost, technological progress, or policy time lags), we think that letting the FH regression parameter vary overtime to capture this effect can be an interesting robustness check.[11]

As our interest is focused on the evolution of the savings-investment relationship in the EU and the role

[11] See, among others, Telatar et al. (2007), Gomes et al. (2008), Ma and Li (2016), Khan (2017) or Camarero et al. (2020).

of the economic-integration related events[12] 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[13]. 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 more importantly, because the techniques used to endogenously detect the instabilities leave 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[14].

The variable used to measure investment is gross fixed capital formation, whereas, for saving, we use basic saving, as recommended by Baxter and Crucini (1993). This variable is defined as GDP minus total consumption (both public and private); the two variables are expressed as a percentage of GDP. Quarterly data has been seasonally adjusted.

2.3.1 Stability. Perron and Yabu (2009) test

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

[12] 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.

[13] 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.

[14] 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.

$EXP-Wfs$, 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 2.1 shows the Perron and Yabu (2009) stability test. Models I, II, and III have been included since there is no common pattern in the series to discard the others (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, from the quarterly results we reject the null hypothesis for 25 out of 38 time series.

In the case of quarterly data, the two variables follow different behavior: 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 dependence of investment on the economic cycle, hence its higher volatility. The savings rate may be affected by long-term factors that change more slowly, such as demography or the cultural propensity to save.

To complement the assessment of the stability of the variables, Figure 2.2 shows the graphs of domestic investment and saving variables, for both, annual and quarterly frequencies. This analysis is also extended with some descriptive statistics in Tables 2.B and 2.C, with pre-crisis and post-crisis information.

When looking at the graphs and the tables, some patterns become apparent: first, the savings 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, these patterns disappeared after the 2007-2008 global financial crisis.

2.3.2 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[15], 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.

Table 2.2 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 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 2.3 and 2.4 show the unit root tests results proposed by Carrion-i Silvestre et al. (2009) for annual and quarterly data. 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. For quarterly data, evidence in favor of a unit root in the time series is generally found, except for some cases[16]. A robustness check has been performed using the Harvey et al. (2013) unit root test. Results do not differ from the previously obtained in the paper. The results of the Harvey et al. (2013) test are presented in table 2.D.

[15] These tests are MZ_{α}^{GLS}, MSB^{GLS}, MZ_{t}^{GLS} and MP_{T}^{GLS}.

[16] Austria (investment), Greece (saving), Ireland (investment), Latvia (savings), Malta (investment), The Netherlands (investment) and Slovak Republic (saving).

2.3.3 Cointegration and Structural Breaks Tests

As the results of subsection 2.3.1 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 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 changes in the relationship between saving and investment. In Table 2.5, 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[17] 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[18]. Using annual data (section A of Table 2.5), we find between one and three breaks, with the exception of Belgium, Greece, the Netherlands, Portugal and Spain that, according to the sequential and LWZ method have no break. Concerning the quarterly data, in section B, the majority of the countries have two or three breaks. Cyprus, Ireland, Latvia, Luxembourg, Malta and the Netherlands have just one, whereas Finland, France and Italy have none.

[17] 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.

[18] In case of contradictory outcomes, the graph can help with the identification.

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[19].

We consider two different tests. First, the traditional Phillips-Perron and ADF tests for the null hypothesis of no cointegration without breaks[20]. The second cointegration test takes into account possible breaks in the cointegrated relationship. Arai and Kurozumi (2007) allows up to three structural breaks, the number being selected by the sequential procedure, the BIC and LWZ criteria.

For the relationships that were found to be stable, we report in Table 2.6 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.

Then, 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 written as follows:

$$y_t = c_i + z_t'\beta_i + u_t \quad if \;\; (T_{i-1} < tT_i) \tag{2.2}$$

To correct for potential endogeneity of the regressors, equation (2.2) is augmented with leads and lags of the first differences of the I(1) regressors, such as:

$$y_t = c_i + z_t'\beta_i + \sum_{J=-l_T}^{l_T} \Delta Z_{t-j}' \prod_j + u_t^* \quad if \;\; T_{i-1} < tT_i \tag{2.3}$$

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

[19] Structural breaks can be found in the cointegration results (tables 2.7 and 2.8).

[20] As there is no clear trend among the variables, we perform the test with no time trend in the cointegrating regression.

$$\tilde{V}_1(\hat{\lambda}) = (T^{-2}\sum_{t=1}^{T} S_t(\hat{\lambda})^2)/\hat{\Omega}_{11} \tag{2.4}$$

where $\hat{\Omega}_{11}$ is a consistent estimate of the long run variance of u_t^* in (2.7), the date of break $\hat{\lambda} = (\hat{T}_1/T, ..., \hat{T}_k/T)$ and $(\hat{T}_1, ...\hat{T}_k)$ are obtained using the dynamic algorithm proposed in Bai and Perron (2003).

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 including multiple breaks under the null hypothesis of cointegration. The Kejriwal (2008) test of the null of cointegration with multiple (k) structural changes is denoted $\tilde{V}_k(\hat{\lambda})$.

Concerning the results, Tables 2.7 and 2.8 show the Arai and Kurozumi (2007) cointegration test up to three breaks. Using annual data, 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). A robustness check has been performed using the Gregory and Hansen (1996) cointegration test. Results do not differ from the previous cointegration analysis. The results of the Gregory and Hansen (1996) test are presented in table 2.E.

2.4 A linear cointegrated regression model with multiple structural changes

Accounting for parameter shifts is crucial in cointegration analysis since it typically involves long data spans that 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:

$$y_t = c_t + z'_{ft}\delta_f + z'_{bt}\delta_{bj} + x'_{ft}\beta_f + x'_{bt}\beta_{bj} + u_t \quad (t = T_{J-1} + 1, ..., T_J) \tag{2.5}$$

for $j = 1, ..., m + 1$, 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[21]. The break points $(T_1, ..., T_m)$ are treated as unknown.

The general model (2.5) 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 where all coefficients of the $I(1)$ regressors and deterministic components are allowed to change across regimes:

$$y_t = c_j + z'_{bt}\delta_{bj} + u_t \quad (t = T_{j-1} + 1, ..., T_j) \tag{2.6}$$

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)[22] 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):

$$y_t = c_i + z'_{bt}\delta_{bj} + \sum_{j=-l_T}^{l_T} \Delta z'_{bt-j}\Pi_{bj} + u^*_t \quad if \;\; T_{i-1} < t \leq T_i \tag{2.7}$$

for $i = 1, ..., k + 1$, 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:

$$I_t = \alpha + \beta S_t + \varepsilon_t \tag{2.8}$$

As it has been earlier explained in this Section, and because there are only two variables in the estimated

[21] The subscript b stands for "break"and the subscript f stands for "fixed"(across regimes).

[22] 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.

long-run relationship, when there is no structural break we will simply estimate the model by OLS (Tables 2.9 and 2.10). When there are instabilities in the relationship, we estimate by DOLS and the results are presented in Tables 2.11 and 2.12. 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 this is the case using quarterly data for Austria or Belgium).

2.4.1 Individual regression results including the structural breaks

We should emphasize that we have analyzed two different periods: 1970[23]-2019 using annual data and 1995-2019 with quarterly data. In addition, we have estimated country-by-country equations, allowing 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. It is worth to emphasize that there is not a priori classification in country groups for the analysis. On the contrary, the groupings are the output from our empirical results. Clearly, CEEC are not included in the annual data. Therefore, the patterns are confined to core and peripheral countries, and between bailed out and non-bailed out among the seconds. However, for the quarterly data (1995-2019), CEE countries are also included and they show particular features in the financial integration process reflected in common break points that differ from older member countries, either core or peripheral.

In tables 2.9 and 2.10, we present the results for the OLS regression for the annual and quarterly data, respectively. 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 2.6). Therefore, we can interpret the cases of Greece and the Netherlands for the annual data (table 2.9), whereas, for the quarterly data (table 2.10), we can interpret the OLS regression for Finland, Ireland, Luxembourg and Netherlands. The OLS results show a high degree of capital mobility except for Greece (annual data, in table 2.9) and Ireland (quarterly data, in table 2.10), which show a relatively larger coefficient. Next, we report the regression results with breaks, in which we would be able to analyze how capital mobility has changed over time.

[23] In some cases earlier.

We start by interpreting the annual data covering the different integration steps. The first salient feature of the results summarized in Table 2.11 is that most of the breaks are found in the 80s and 90s. However, in some cases, as in Ireland, Italy, Luxembourg and The Netherlands, 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, which 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), even before the euro; in the case of Germany, later in the 1990s, due to the German reunification. For France, annual data shows that capital mobility was minimal from 1960 until 1992, with perfect capital mobility afterward. 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 Austria and Belgium the third break occurred 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.[24]

The second group of countries includes the periphery[25] (Cyprus, Greece, Ireland, Portugal and Spain). They share similar patterns: a continuous improvement in capital mobility in parallel with the integration process (the signature of the Maastricht Treaty and the road to EMU), altered by the financial turmoil in the beginning of the 90s (EMS crisis) and the 2007 financial crisis[26]. 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, evidence favoring 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.

[24]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.

[25]These countries were later bailed-out by the ESM.

[26]However, as already mentioned above, the use of quarterly data complements the annual data analysis, as it provides more observations for the econometric techniques to detect potential breaks at the end of the sample, after the 2007-2008 financial crisis.

Having assessed capital mobility with annual data, we move to the quarterly analysis (table 2.12), 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 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 the 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 was found in 1994. In both cases, the conclusion is the same: the USSR crash caused the saving-retention coefficient to increase. However, the second break in Finland using quarterly data was found in 2005 and confirmed the maintenance of free capital mobility after joining the euro.

As in the case of annual data, we bundle the countries into different 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 afterward (as in Finland, Germany[27] 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 limited capital mobility.

The second set of countries are Central and Eastern countries (CEEC) that joined the EU and the euro later. Those countries received many 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 a critical 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

[27] 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.

mobility. Latvia's (3 breaks)[28] shows a 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 (3 breaks)[29] the situation is quite similar to Latvia's, showing a crisis effect on capital mobility. However, in this case, the housing bubble explains the reason behind the reduction in capital mobility. 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 high capital mobility at the beginning of the sample 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. They were bailed out from 2010 to 2015, and our analysis captures their financial stability programs[30]. In the case of Cyprus (BIC regression)[31] shows no capital mobility until Q2 2012 (when it requested assistance from the Eurozone and the IMF). Afterward, 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 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. However, as Greece's exit of the financial assistance program took place in the third quarter of 2018, we cannot capture it. Ireland (sequential procedure)[32] 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

[28]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. Additionally, the (B, L) regression presents three breaks and more detailed information.

[29]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 2.3.3.

[30]Table 2.F provides an overview of the financial assistance programmes; related countries, objectives and requirements.

[31]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.

[32]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 selects lesser complex models (as it was explained in section 2.3.3).

ESM programs (S)[33], decreasing afterward (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.

2.4.2 Robustness checks

In this Section, we perform two additional robustness checks[34]. First, we test if the paper's main conclusions can still be valid after using a panel framework instead of individual time series. The analysis of an economic integrated area as the EA can be improved using panel data, as it enriches the information included in the analysis. For that purpose, we use the Mean Group (MG) (Pesaran and Smith, 1995) and the Pooled Mean Group (PMG) estimators (Pesaran et al., 1999)[35] to different groupings and time spans. Second, we perform a rolling-window regression over the individual series to assess the expected time-varying nature of the savings retention coefficients.

It is important to clarify that the country groups in the individual time series analysis and the one performed with panel data are not exactly the same. In the first case, we have followed an empirical approach to bundle the countries in different groups without any prior. This means that the classification is made based on the results obtained, when they share similar breaks, giving rise to 3 or 4 groupings, depending on the annual or quarterly nature of the data.[36] However, for the panel data analysis we only consider two groups: *core vs. periphery* with annual data (1070-2019) or *core vs. rest of the countries* (1996-2019); in the latter case CEEC are added to the peripheral countries. Due to the small n-dimension of the panel, we have limited the analysis to these two groupings.

Regarding the panel approach, tables 2.13 and 2.14 show the PMG/MG estimation of the annual and

[33] Both BIC and Sequential criteria display similar results.

[34] We thank the two anonymous reviewers for suggesting both robustness checks, respectively.

[35] The Hausman test is used to select between the PMG and the MG.

[36] More specifically,

1. Core countries: Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands. This classification is standard.
2. Bailed out Peripheral countries: Cyprus, Greece, Ireland, Portugal and Spain.
3. Non bailed out peripheral countries: Italy and Malta.
4. Central and Eastern Europe countries (CCEC): They have been the last ones to enter the European Union and the Euro zone (Slovenia, Slovak Republic, Estonia, Latvia, Lithuania).

quarterly data. Some features become apparent for the annual data covering 1970-2019: first, the whole sample regression shows a low saving retention parameter in both the long and short term; therefore, an overall high degree of capital mobility is observed. Second, if we split our sample into core and periphery countries[37] our results point out that capital mobility is higher for the core countries. Concerning quarterly data covering from Q1 1996 to Q4 2019, our results capture an increase in the long-run parameter (decrease in capital mobility). The subgroups regression highlights two relevant conclusions: First, core countries have perfect capital mobility in both the long and short term. Second, the periphery and the CEEC show a moderate level of capital mobility in the long run; this can be seen as the relevant impact of those countries' financial and sovereign crises. Overall conclusions of the panel approach give evidence in favor of a high degree of capital mobility for the core countries, whereas, for the periphery and CEEC, the results for the period Q1 1996-Q4 2019 point that the financial and sovereign crises have had a more substantial impact on capital mobility. Conclusions are in line with this paper's overall conclusions and highlight the importance of taking into account structural breaks to properly isolate the impact of the financial crisis on the periphery and the CEEC.

As the last step, we have performed a simple rolling-window regression over the individual time series. We can see the results in Figures 2.3 and 2.4. Conclusions are similar to the linear cointegrated regression with breaks presented in this paper. However, a few differences have been noted: first, for the case of Cyprus (quarterly data) from Q2 2016 (BIC approach), Cyprus does not show a perfect degree of capital mobility but a moderate degree instead. Second, Ireland shows a perfect degree of capital mobility from Q4 2015, whereas a moderate degree of capital mobility is observed with the rolling-window regression. In any case, we find that the overall conclusions of this paper are robust.

2.5 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 focuses on the price approach, we adopt the quantity one. The latter can be especially suited to assess the evolution of capital mobility within a monetary union where external imbalances have been persistently

[37] The composition of the groups can be found in tables 2.13 and 2.14.

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 over time. 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 savings was invested in non-tradable sectors, such investment flows caused a boom and later created credit shortage after the 2007 financial crisis, ending with the sovereign crisis. As for the CEEC, 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 CEEC, 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 heterogeneous effects depending on the type of country. The impact 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 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.

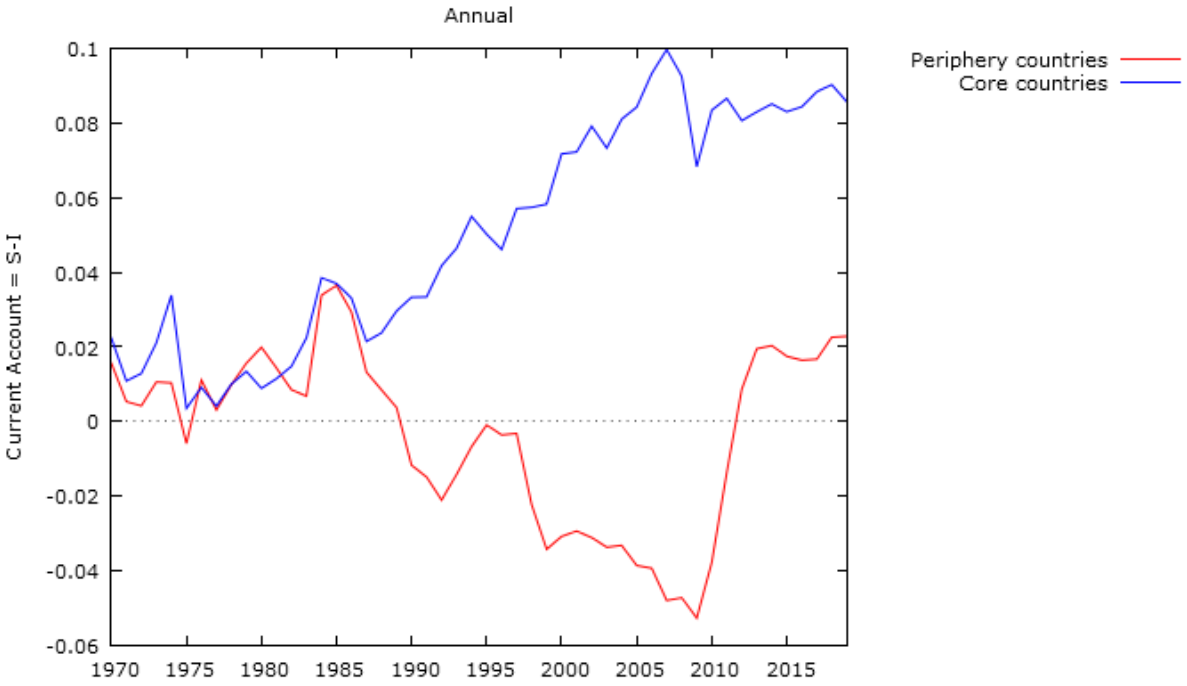
Finally, in the period $2015 - 2019$, after the global financial and European sovereign crisis, capital mobility shows a signal of recovery for the majority of the Eurozone countries. That is the case for the core countries, Italy, Malta, Ireland, Latvia, Slovak Republic and Slovenia. However, it should 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)[38], which has harmed capital mobility, above all, after the bubble busted.

In terms of the FH puzzle, we have found that the value of the cointegrating relationship parameter between domestic saving and investment has been mostly dropping since the 1970s, along with the integration process until the euro's creation. The first countries achieving a high degree of capital mobility have been from EU core. 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.

[38] Excepting for Ireland and Greece, where the reason may has been that the timing does not allow us to capture the effect of the ESM financial program.

Figures

Figure 2.1: Current Account.



1) Current account is defined as domestic saving minus domestic investment. Current account is the average value of the group.
2) Core countries are: Austria, Belgium, Finland, France, Germany, Luxembourg and Netherlands. Periphery: Greece, Italy, Portugal and Spain. Cyprus has been excluded from the annual figure since it started in 1975. Ireland's current account shows a large surplus for the period given the low tax regime (in line with Luxembourg and Netherlands), therefore it has not been included in the periphery group figures.

Figure 2.2: Domestic saving and investment series.

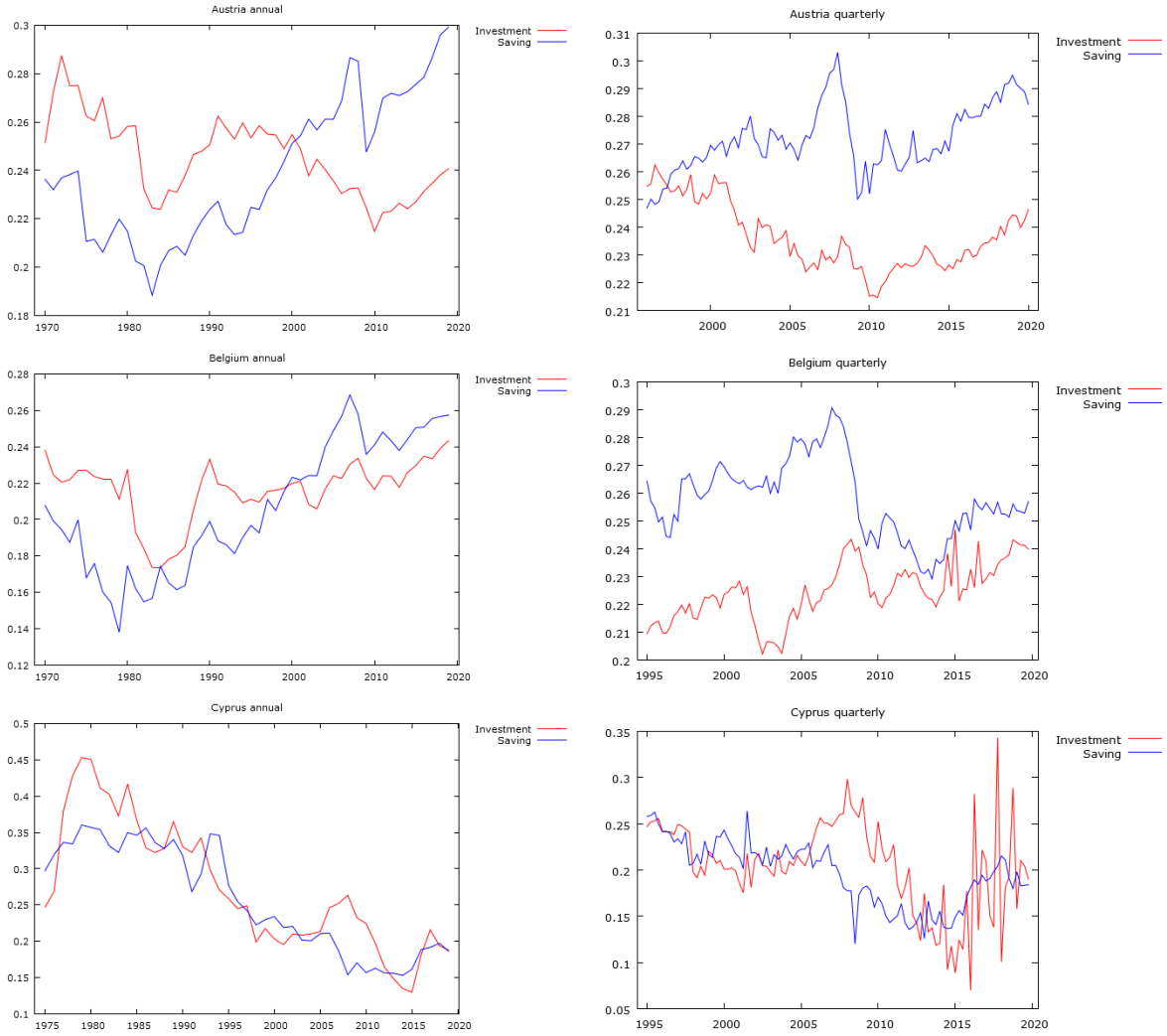


Figure 2.2: Domestic saving and investment series. Cont.

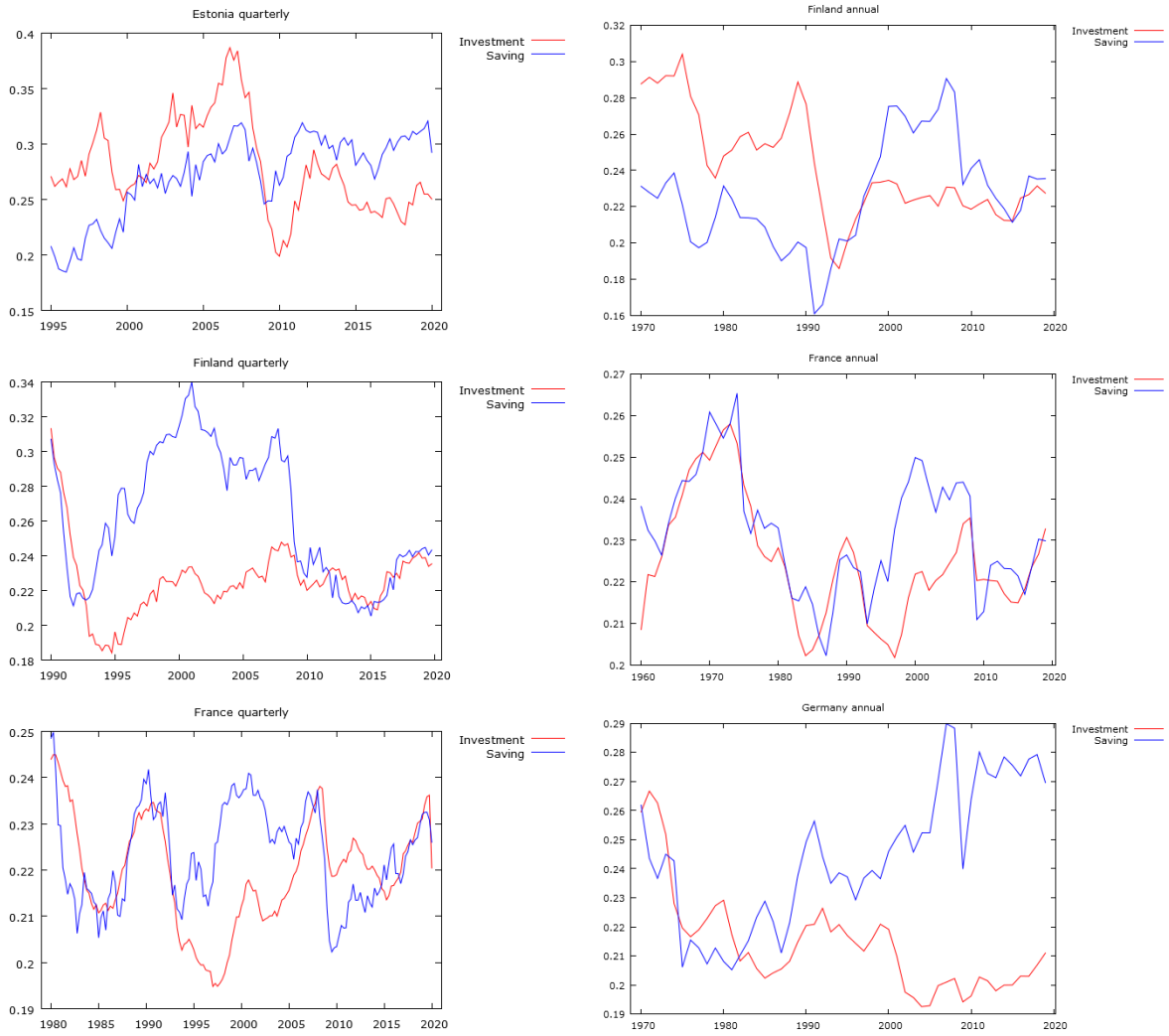
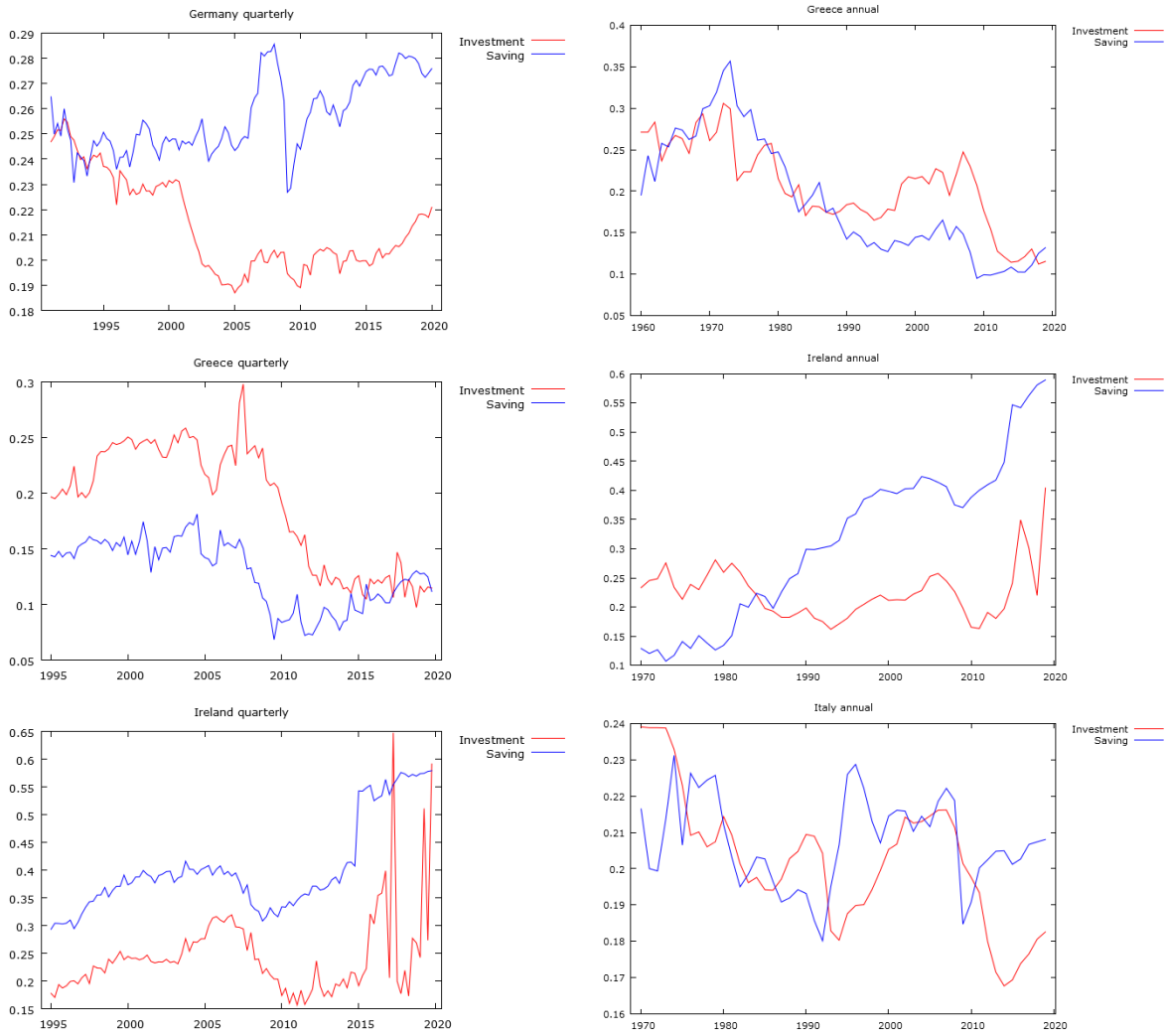


Figure 2.2: Domestic saving and investment series. Cont.



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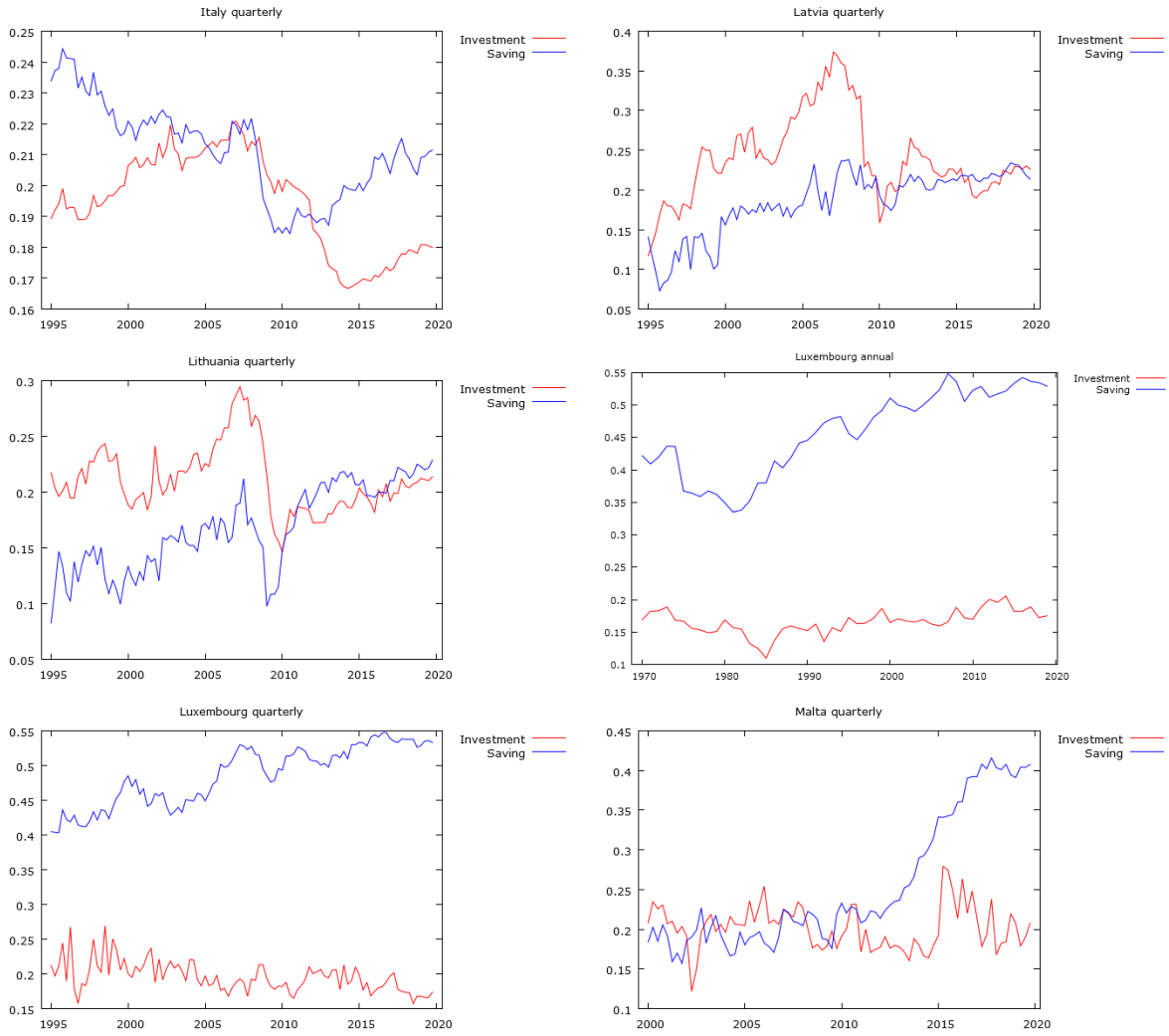


Figure 2.2: Domestic saving and investment series. Cont.

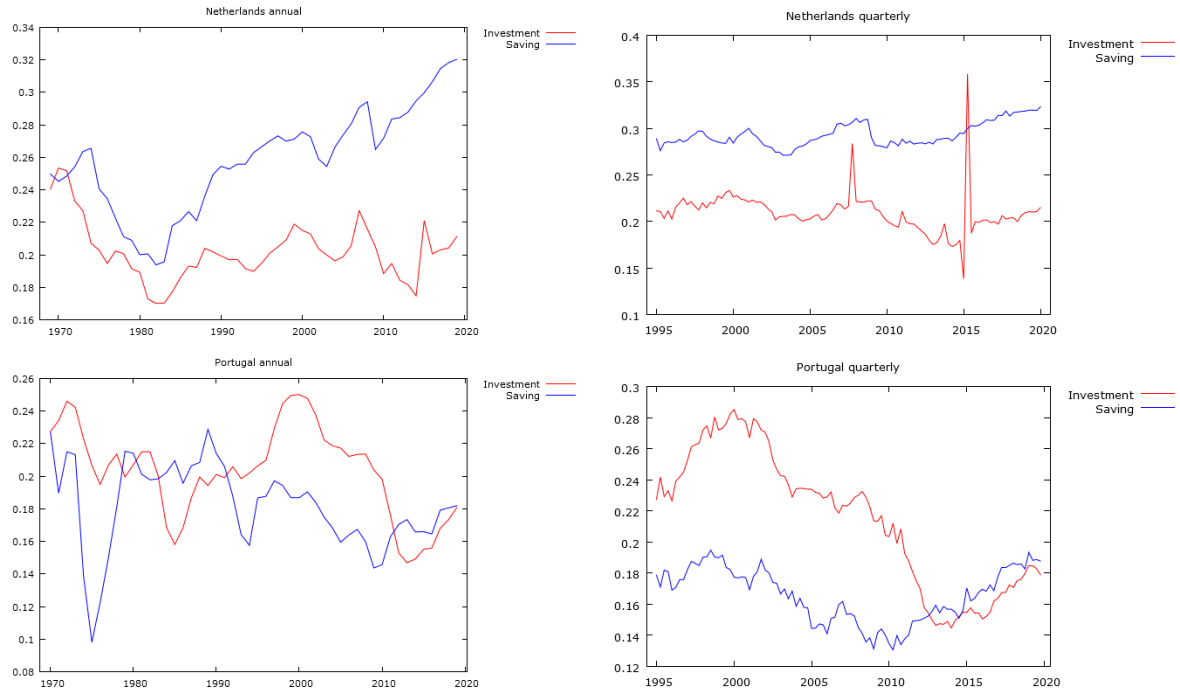
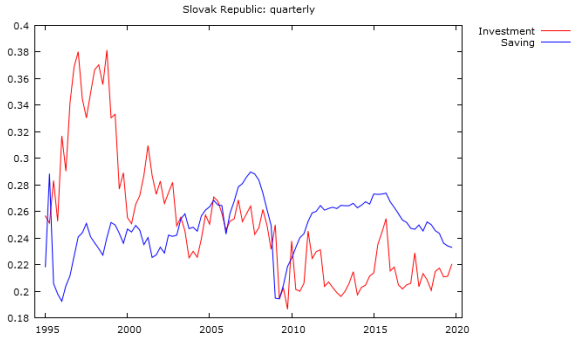
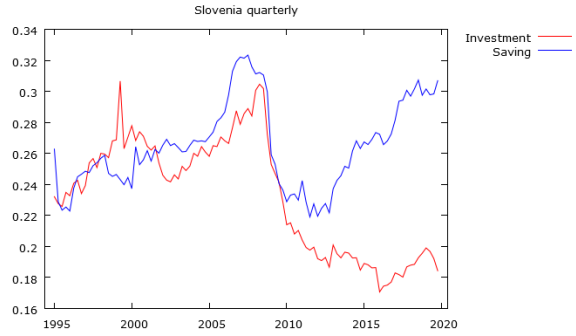
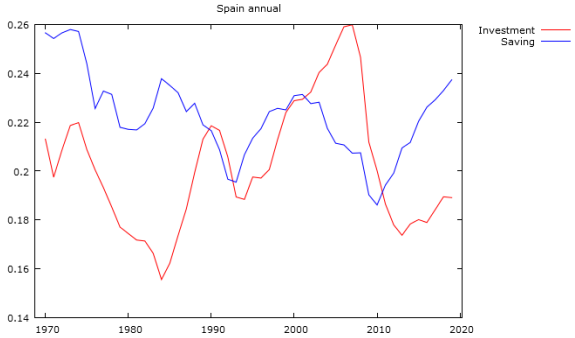


Figure 2.2: Domestic saving and investment series. Cont.







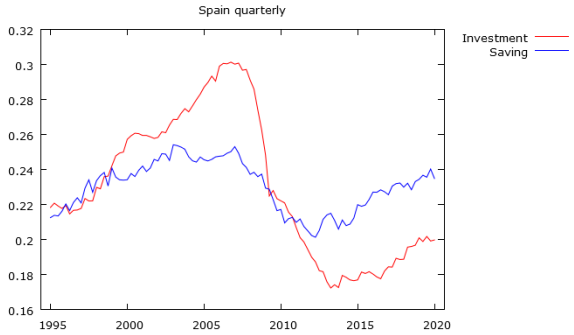


Figure 2.3: Rolling-window. Annual data.

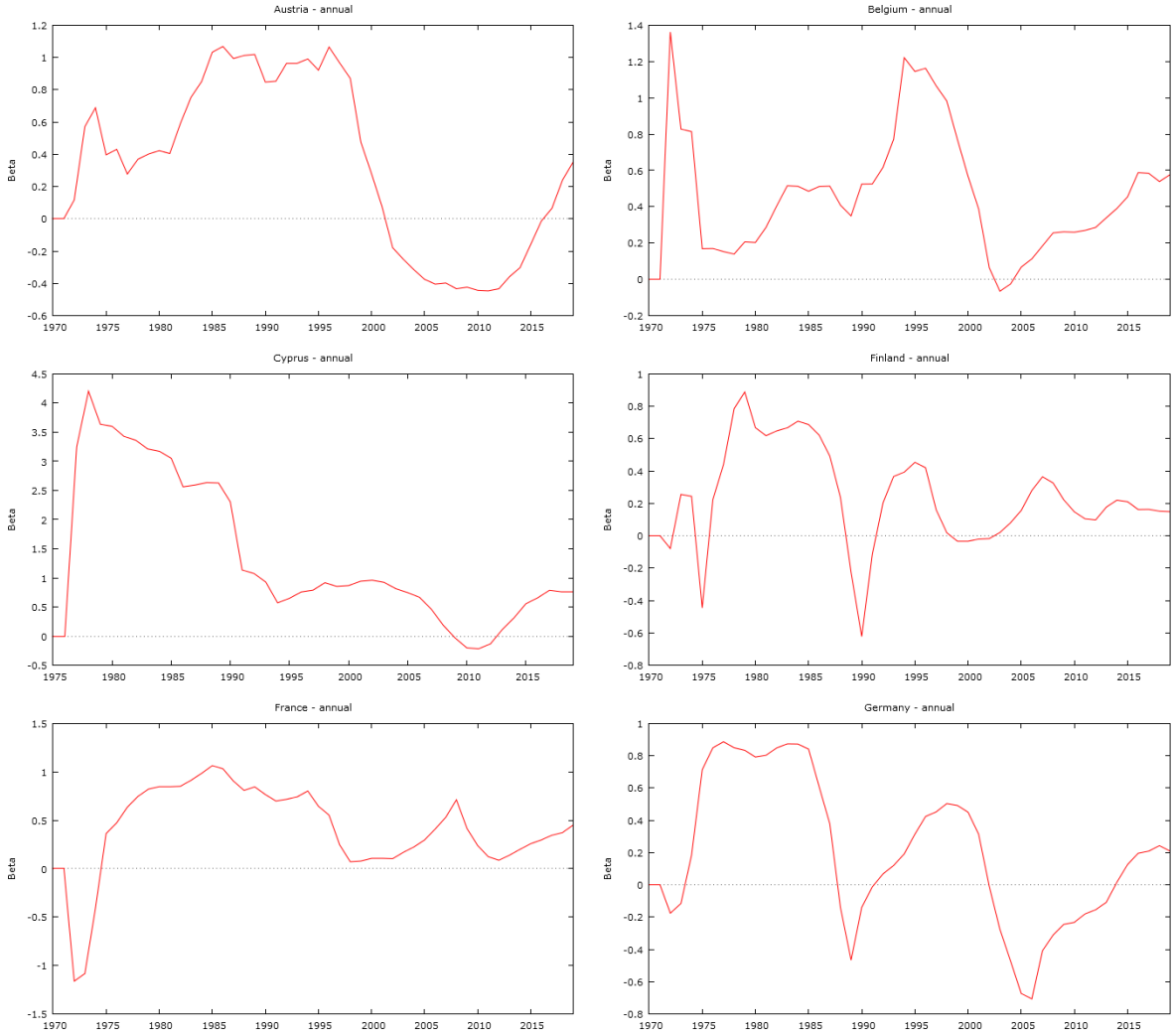


Figure 2.3: Rolling-window. Annual data. Cont.

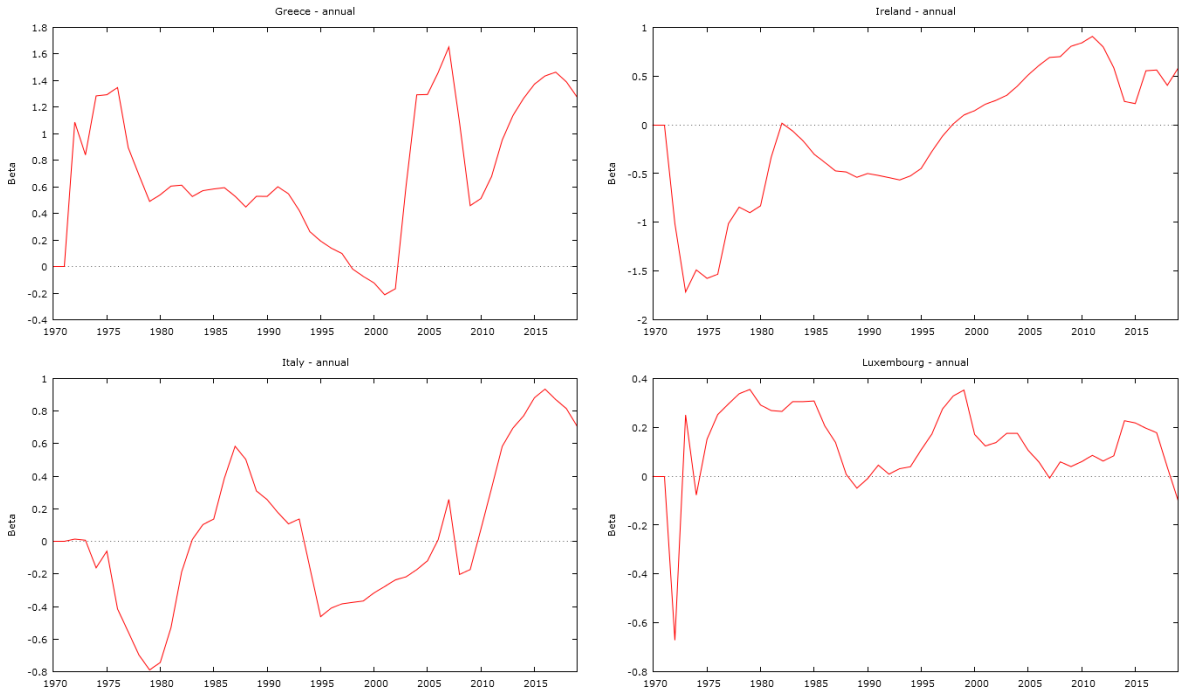


Figure 2.3: Rolling-window. Annual data. Cont.

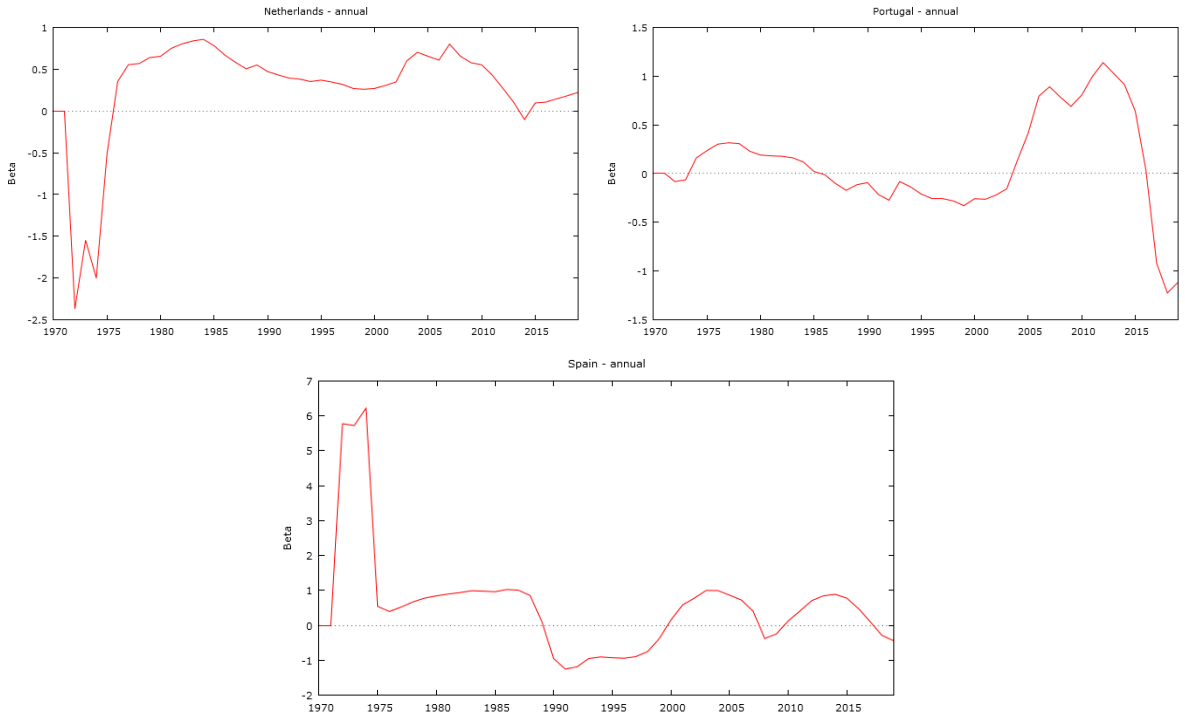


Figure 2.4: Rolling-window. Quarterly data.

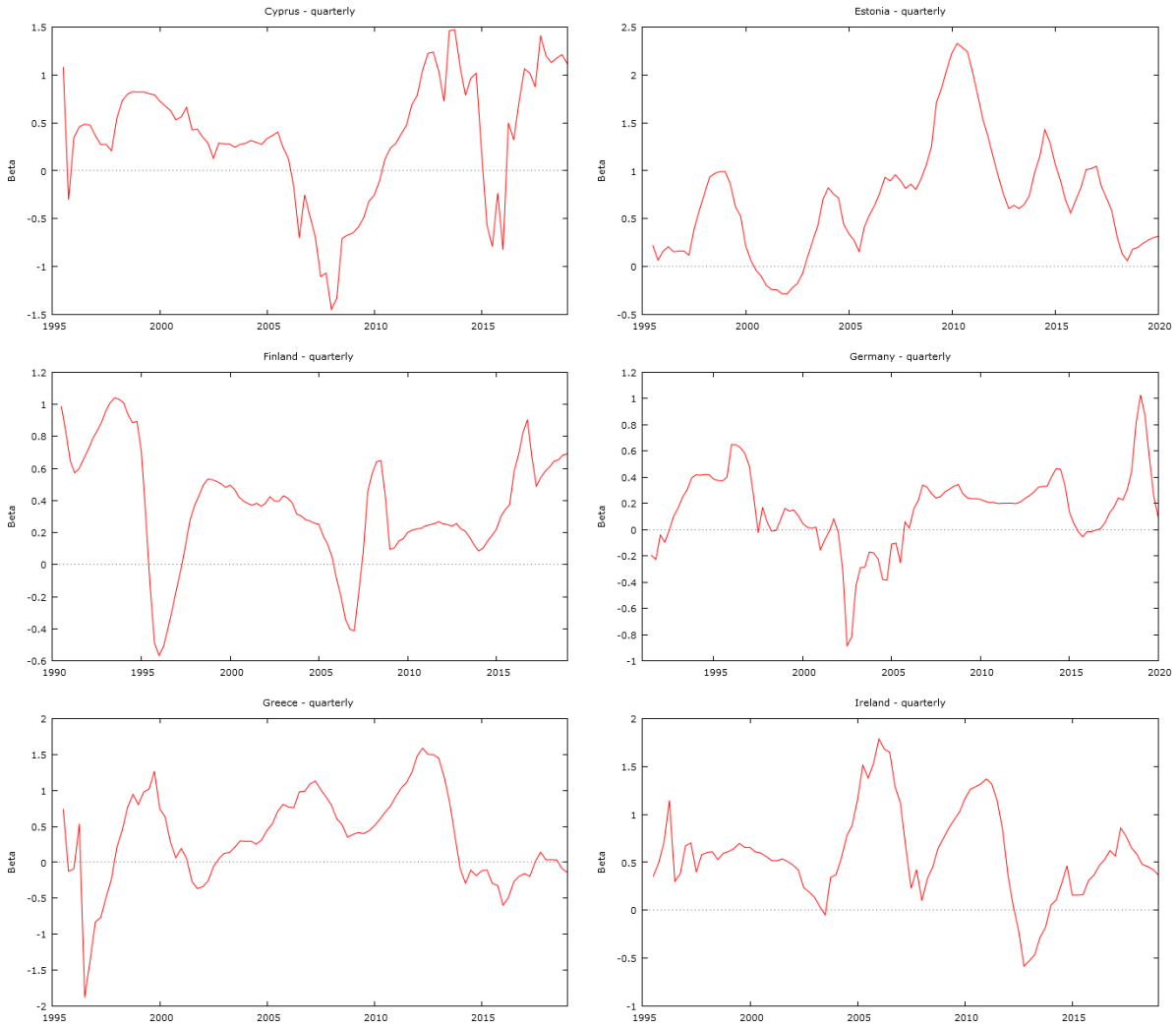


Figure 2.4: Rolling-window. Quarterly data. Cont.

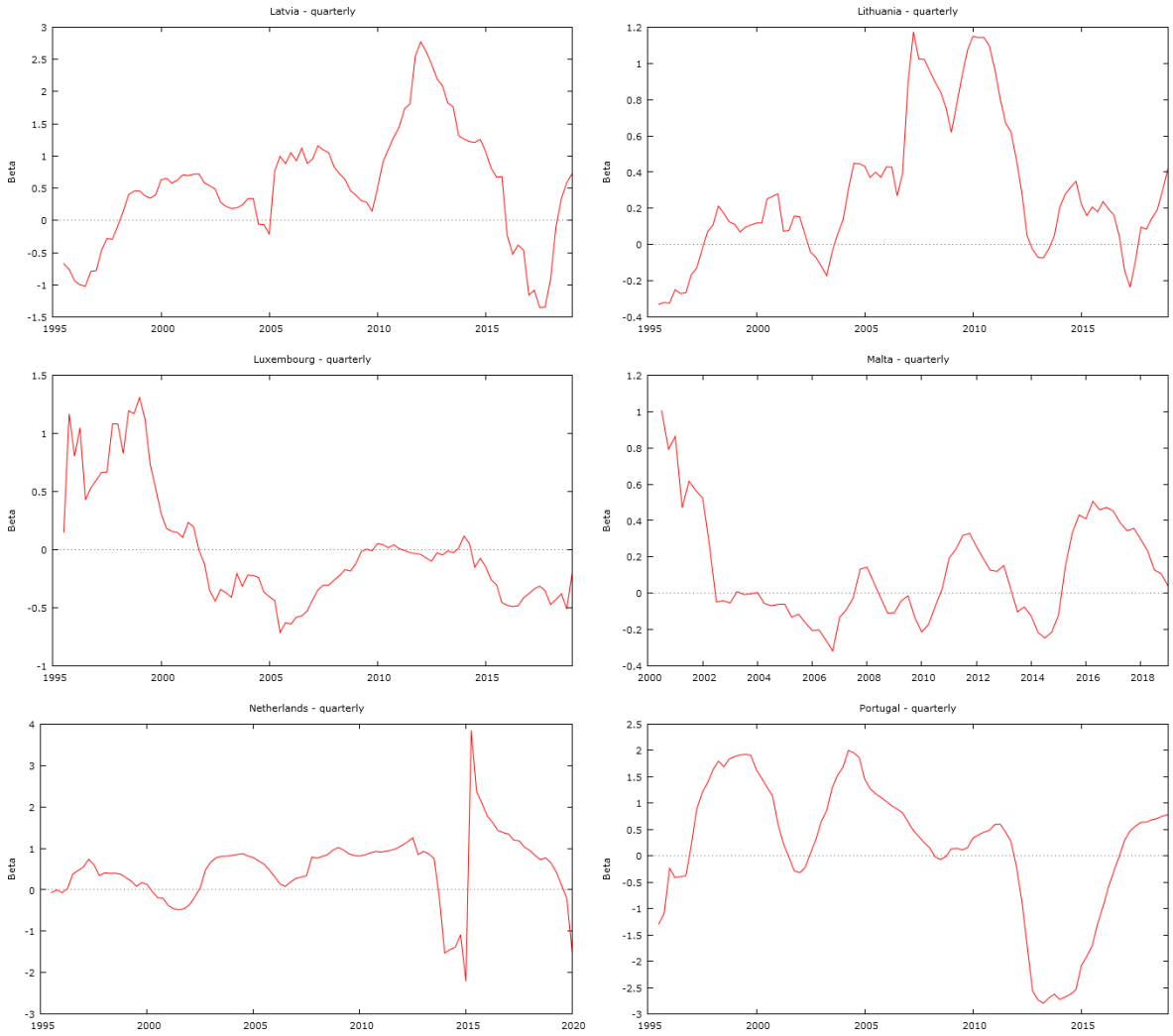
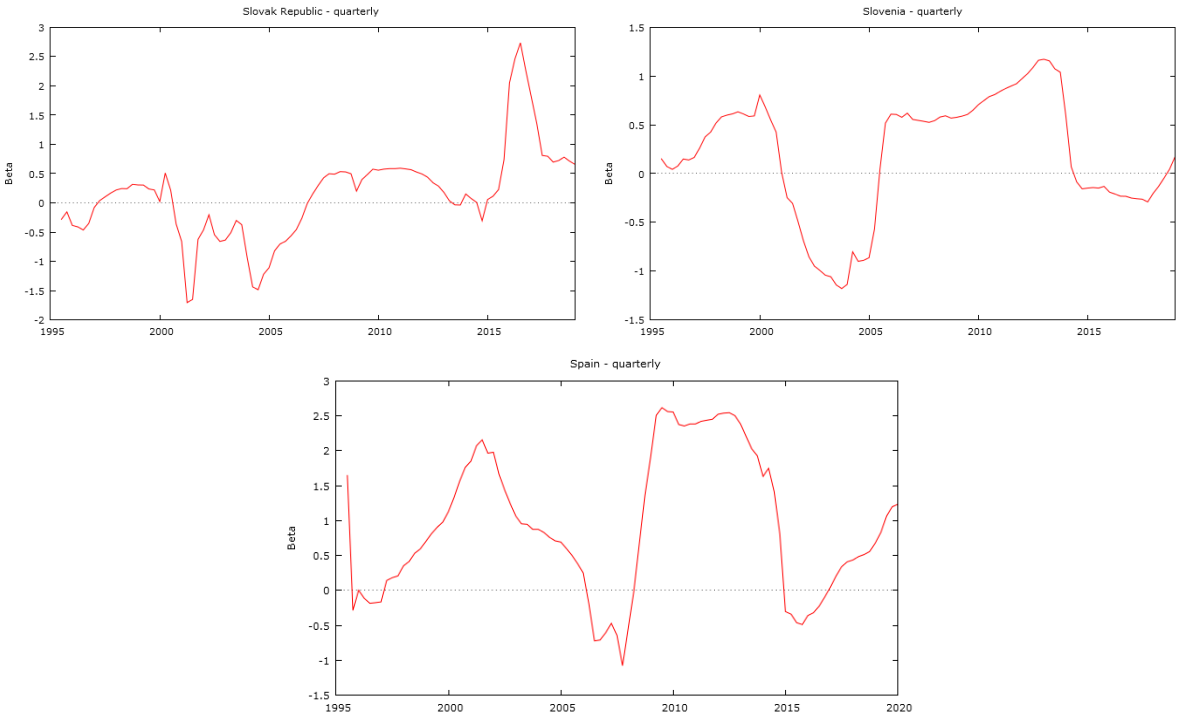


Figure 2.4: Rolling-window. Quarterly data. Cont.



Tables

Table 2.1: 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

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 2.1: Perron and Yabu (2009) tests for structural changes in the deterministic component. Cont.

	Annual data				Quarterly Data		
Country	Model I	Model II	Model III	Country	Model I	Model II	Model III
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	0.64	0.21	7.79***
Slovk S	-	-	-	Slovk S	5.92***	-0.13	5.98***
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 2.2: Ng and Perron (2001) unit root test (stable series).

Country	Data	Mz_{α}^{GLS}	Mz_{t}^{GLS}	MSB^{GLS}	MP_{t}^{GLS}
Bel I	Annual	-4.50	-1.45	0.32	5.55
Bel S	Annual	-1.78	-0.77	0.43	11.45
Cyp I	Annual	-2.36	-1.02	0.43	9.99
Fin I	Annual	-1.90	-0.87	0.46	11.67
Ger I	Annual	-1.00	-0.60	0.60	1.64***
Ire S	Annual	2.07	1.71	0.82	60.07
Lux I	Annual	-8.24**	-2.02**	0.25*	3.01**
Lux S	Annual	-0.88	-0.47	0.54	17.69
Net I	Annual	-4.45	-1.48	0.33	5.53
Por I	Annual	-12.47**	-2.44**	0.20**	2.20**
Por S	Annual	-11.31**	-2.36**	0.21**	2.24**
Bel S	Quarterly	-4.64	-1.51	0.33	5.30
Est I	Quarterly	-5.52	-1.64	0.30	4.50
Est S	Quarterly	-0.08	-0.49	0.59	19.79
Fin S	Quarterly	-1.53	-0.76	0.49	13.69
Fra I	Quarterly	-4.56	-1.46	0.32	5.47
Fra S	Quarterly	-4.39	-1.44	0.33	5.66
Ita I	Quarterly	-1.44	-0.79	0.55	15.71
Ita S	Quarterly	-1.36	-0.76	0.56	16.43
Lux I	Quarterly	-0.35	-0.23	0.64	25.17
Lux S	Quarterly	0.05	0.03	0.68	30.23
Mal S	Quarterly	1.03	0.64	0.62	31.50
Por S	Quarterly	-2.20	-1.00	0.46	10.77
Spa S	Quarterly	-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 2.3: Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Annual.

		Model II				Model III			
Country	m	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}
	1	17.30	-9.52	0.23	-2.15	14.79	-11.25	0.21	-2.32
Aus I	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
	1	12.16	-10.69	0.21	-2.26	11.11	-11.76	0.20	-2.38
Aus S	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
	1	19.82	-8.26	0.23	-1.86	18.86	-8.79	0.22	-1.93
Cyp S	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
	1	23.83	-6.53	0.28	-1.80	14.14	-11.04	0.21	-2.35
Fin S	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
	1	11.45	-14.54	0.18	-2.61	24.95	-6.17	0.27	-1.64
Fra I	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
	1	17.59	-9.19	0.23	-2.13	14.70	-10.99	0.21	-2.35
Fra S	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
	1	6.24	-20.72	0.15	-3.19	21.64	-5.72	0.29	-1.66
Ger S	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
	1	14.22	-11.26	0.21	-2.36	16.98	-9.44	0.22	-2.12
Gre I	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

Notes:
(a): ** denotes rejection the null at the 5% level.
(b): m= number of breaks.

Table 2.3: Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Annual. Cont.

		Model II				Model III			
Country	m	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}
	1	23.96	-6.34	0.25	-1.61	17.79	-9.04	0.22	-1.96
Gre S	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
	1	19.40	-6.24	0.26	-1.60	24.11	-4.87	0.29	-1.43
Ire I	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
	1	8.94	-16.99	0.17	-2.91	22.30	-6.80	0.27	-1.84
Ita I	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
	1	9.75	-13.16	0.19	-2.56	11.08	-11.55	0.21	-2.40
Ita S	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
	1	17.16	-9.56	0.23	-2.18	14.78	-11.16	0.21	-2.34
Net S	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
	1	8.32	-16.49	0.17	-2.85	11.86	-11.82	0.20	-2.42
Spa I	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
	1	18.39	-6.79	0.27	-1.84	18.18	-6.87	0.27	-1.85
Spa S	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 2.4: Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Quarterly data.

		Model II				Model III			
Country	m	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}
	1	6.89**	-23.26**	0.15	-3.39**	7.32	-22.02	0.15	-3.29
Aus I	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
	1	12.00	-13.24	0.19	-2.57	9.64	-16.46	0.17	-2.87
Aus S	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
	1	10.73	-11.30	0.21	-2.38	12.32	-9.85	0.22	-2.21
Bel I	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
	1	25.19	-4.51	0.32	-1.45	30.14	-3.85	0.36	-1.38
Cyp I	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
	1	20.47	-7.52	0.26	-1.94	14.82	-10.45	0.22	-2.26
Cyp S	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
	1	27.89	-5.26	0.31	-1.62	18.54	-7.94	0.25	-1.99
Fin I	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
	1	28.61	-5.40	0.27	-1.48	14.98	-11.34	0.20	-2.30
Ger I	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

Notes:
(a): ** denotes rejection the null at the 5% level.
(b): m= number of breaks.

Table 2.4: Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Quarterly data. Cont.

		Model II				Model III			
Country	m	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}
	1	9.68	-15.15	0.18	-2.74	10.17	-14.35	0.19	-2.67
Ger S	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
	1	21.12	-4.98	0.29	-1.46	16.09	-6.83	0.27	-1.85
Gre I	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
	1	19.28	-7.75	0.25	-1.95	24.58	-6.07	0.29	-1.73
Gre S	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
	1	23.03	-4.79	0.32	-1.53	3.68**	-31.44**	0.13**	-3.94**
Irel I	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
	1	23.83	-5.07	0.31	-1.56	36.30	-3.37	0.39	-1.30
Irel S	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
	1	15.16	-10.01	0.22	-2.24	15.05	-10.16	0.22	-2.22
Lat I	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
	1	32.07	-4.09	0.35	-1.43	5.20**	-25.50**	0.14**	-3.56**
Lat S	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

Notes:
(a): ** denotes rejection the null at the 5% level.
(b): m= number of breaks.

Table 2.4: Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Quarterly data. Cont.

		Model II				Model III			
Country	m	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}
	1	16.49	-9.36	0.23	-2.14	10.93	-14.18	0.19	-2.65
Lit I	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
	1	7.78	-19.53	0.16	-3.12	7.59	-20.00	0.16	-3.16
Lit S	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
	1	7.51	-17.60	0.17	-2.97	4.41**	-29.95**	0.13**	-3.87**
Mal I	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
	1	16.64	-7.34	0.26	-1.91	7.32	-17.15	0.17	-2.90
Net I	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**
	1	12.77	-11.95	0.20	-2.44	14.56	-10.48	0.22	-2.29
Net S	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
	1	10.79	-14.03	0.18	-2.55	38.27	-2.97	0.34	-1.00
Por I	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
	1	13.58	-10.84	0.21	-2.33	18.77	-7.83	0.25	-1.96
Slovk I	2	15.11	-15.38	0.18	-2.77	11.13	-20.87	0.15	-3.23
	3	18.30	-15.22	0.18	-2.75	13.76	-20.2	0.16	-3.18

Notes
(a): ** denotes rejection the null at the 5% level.
(b): m= number of breaks.

Table 2.4: Carrion-i Silvestre et al. (2009) unit root test with breaks (Unstable series). Quarterly data. Cont.

		Model II				Model III			
Country	m	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}	MP_t^{GLS}	Mz_α^{GLS}	MSB^{GLS}	MZ_t^{GLS}
	1	6.71	-23.38	0.15**	-3.39	6.27**	-24.64**	0.14	-3.49**
Slovk S	2	8.95	-24.48	0.14	-3.46	8.18	-26.66	0.14	-3.62
	3	8.76	-27.83	0.13	-3.73	8.09	-30.11	0.13	-3.88
	1	29.34	-4.99	0.30	-1.49	23.04	-6.54	0.27	-1.75
Slo I	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
	1	14.87	-10.28	0.22	-2.23	22.49	-6.73	0.27	-1.82
Slo S	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
	1	18.77	-8.21	0.23	-1.89	61.11	-1.80	0.42	-0.75
Spa I	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 2.5: Tests for the number of structural breaks.

	Annual			Quarterly		
	S	BIC	LWZ	S	BIC	LWZ
Aus	3	3	3	3	3	3
Bel	0	3	2	2	2	2
Cyp	1	1	1	3	3	1
Est	-	-	-	2	2	2
Fin	1	2	1	0	2	2
Fra	1	1	1	0	3	3
Ger	2	2	2	2	3	2
Gre	2	2	0	3	3	2
Ire	2	2	1	3	1	0
Ita	1	3	3	0	3	3
Lat	-	-	-	1	3	3
Lit	-	-	-	3	3	2
Lux	1	2	1	1	1	0
Mal	-	-	-	1	1	1
Net	0	2	1	1	2	0
Por	0	2	1	3	3	3
Slovk	-	-	-	2	2	2
Slo	-	-	-	2	3	3
Spa	0	3	3	3	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 2.6: ADF and PP cointegration test without breaks.

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

Notes:
(a) Where Z_t and Z_α stand for Phillips and Ouliaris (1990) test statistics for non-cointegration and ADF_α 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 2.7: Arai and Kurozumi cointegration test. Annual.

Nº. breaks	Country	$V(\lambda)$	Break fraction 1	Break fraction 2	Break fraction 3	Break 1	Break 2	Break 3
3	Aus (S)	0.04	0.22	0.56	0.78	1982	1997	2007
3	Aus (B,L)	0.06	0.22	0.44	0.76	1982	1992	2006
3	Bel (B)	0.04	0.20	0.47	0.80	1981	1993	2008
3	Ita (B,L)	0.07	0.20	0.62	0.84	1981	2000	2010
3	Spa (B,L)	0.04	0.36	0.60	0.82	1988	1999	2009
2	Bel (L)	0.06	0.20	0.49	-	1981	1994	-
2	Fin (B)	0.07	0.18	0.44	-	1980	1992	-
2	Ger (S,B,L)	0.06	0.22	0.67	-	1982	2002	-
2	Gre (S,B)	0.07	0.22	0.65	-	1974	1998	-
2	Ire (S,B)	0.05	0.47	0.84	-	1993	2010	-
2	Lux (B)	0.05	0.24	0.84	-	1983	2010	-
2	Net (B)	0.03	0.22	0.85	-	1981	2010	-
2	Por (B)	0.06	0.53	0.80	-	1996	2008	-
1	Cyp (S,B,L)	0.08	0.23	-	-	1986	-	-
1	Fin (S,L)	0.08	0.44	-	-	1992	-	-
1	Fra (S,B,L)	0.08	0.45	-	-	1987	-	-
1	Ire (L)	0.05	0.47	-	-	1993	-	-
1	Ita (S)	0.19	0.20	-	-	1981	-	-
1	Lux (S,L)	0.06	0.24	-	-	1983	-	-
1	Net (L)	0.07	0.28	-	-	1984	-	-
1	Por (L)	0.14	0.80	-	-	2008	-	-

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 2.8: Arai and Kurozumi cointegration test. Quarterly.

Nº. Breaks	Country	$V(\lambda)$	Break fraction 1	Break fraction 2	Break fraction 3	Break 1	Break 2	Break 3
3	Aus (S)	0.10**	0.22	0.37	0.85	Q3 2001	Q1 2005	Q1 2016
3	Aus (B,L)	0.12***	0.23	0.39	0.85	Q4 2001	Q3 2005	Q1 2016
3	Cyp (S)	0.05	0.14	0.43	0.66	Q4 1998	Q4 2005	Q2 2011
3	Cyp (B)	0.06	0.43	0.71	0.87	Q4 2005	Q2 2012	Q2 2016
3	Fra (B,L)	0.10***	0.33	0.48	0.65	Q2 1993	Q2 1999	Q1 2006
3	Ger (B)	0.07	0.13	0.37	0.88	Q2 1995	Q4 2001	Q1 2016
3	Gre (S,B)	0.07**	0.14	0.49	0.65	Q4 1998	Q2 2007	Q1 2011
3	Ire (S)	0.02	0.41	0.61	0.85	Q2 2005	Q1 2010	Q4 2015
3	Ita (B,L)	0.11**	0.19	0.69	0.86	Q1 2000	Q1 2012	Q1 2016
3	Lat (B,L)	0.07	0.14	0.37	0.57	Q4 1998	Q2 2004	Q1 2009
3	Lit (S)	0.05	0.43	0.59	0.81	Q4 2005	Q3 2009	Q4 2014
3	Lit (B)	0.05	0.42	0.58	0.81	Q3 2005	Q2 2009	Q4 2014
3	Por (S)	0.12**	0.14	0.29	0.67	Q4 1998	Q3 2002	Q3 2011
3	Por (B,L)	0.06	0.14	0.60	0.82	Q4 1998	Q4 2009	Q1 2015
3	Slo (B,L)	0.07	0.14	0.29	0.63	Q4 1998	Q3 2002	Q3 2010
3	Spa (S)	0.05	0.37	0.72	0.88	Q2 2004	Q3 2012	Q3 2016
3	Spa (B,L)	0.04	0.16	0.37	0.72	Q2 1999	Q2 2004	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 2.8: Arai and Kurozumi cointegration test. Quarterly. Cont.

Nº. Breaks	Country	$V(\lambda)$	Break fraction 1	Break fraction 2	Break fraction 3	Break 1	Break 2	Break 3
2	Bel (S,B,L)	0.14***	0.28	0.52	-	Q2 2002	Q4 2007	-
2	Est (S,B,L)	0.07	0.28	0.57	-	Q2 2002	Q2 2009	-
2	Fin (B,L)	0.10	0.14	0.51	-	Q3 1994	Q2 2005	-
2	Ger (S)	0.10	0.13	0.36	-	Q2 1995	Q3 2001	-
2	Ger (L)	0.11	0.13	0.37	-	Q2 1995	Q4 2001	-
2	Gre (L)	0.06	0.14	0.63	-	Q4 1998	Q3 2010	-
2	Lit (L)	0.08	0.42	0.58	-	Q3 2005	Q2 2009	-
2	Net (B)	0.24**	0.66	0.82	-	Q2 2011	Q2 2015	-
2	Slovk (S)	0.09**	0.32	0.58	-	Q1 2003	Q2 2009	-
2	Slovk (B,L)	0.07	0.17	0.58	-	Q3 1999	Q2 2009	-
2	Slo (S)	0.09	0.61	0.86	-	Q1 2010	Q1 2016	-
1	Cyp (L)	0.15**	0.66	-	-	Q2 2011	-	-
1	Ire (B)	0.08	0.61	-	-	Q1 2010	-	-
1	Lat (S)	0.07	0.57	-	-	Q1 2009	-	-
1	Lux (S,B)	0.09	0.17	-	-	Q3 1999	-	-
1	Mal (S,B,L)	0.11	0.79	-	-	Q2 2015	-	-
1	Net (S)	0.14	0.61	-	-	Q2 2010	-	-

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 2.9: The individual OLS regression. Annual.

Annual.1	Aus	Bel	Cyp	Fin	Fra	Ger	Gre
α	0.30***	0.16**	0.01	0.27***	0.06	0.26***	0.10*
(s.e)	(0.06)	(0.07)	(0.06)	(0.10)	(0.05)	(0.03)	(0.05)
β	-0.22	0.28	1.04***	-0.15	0.72***	-0.20**	0.55***
(s.e)	(0.25)	(0.28)	(0.25)	(0.36)	(0.23)	(0.09)	(0.20)

Annual.2	Ire	Ita	Lux	Net	Por	Spa	-
α	0.21***	0.14***	0.09***	0.16***	0.18***	0.21	-
(s.e)	(0.04)	(0.04)	(0.03)	(0.04)	(0.05)	(0.15)	-
β	0.04	0.29	0.16**	0.18	0.15	-0.04	-
(s.e)	(0.13)	(0.21)	(0.07)	(0.15)	(0.20)	(0.58)	-

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.
(c): The estimated period for the majority of countries is 1970-2019, however, for Cyprus it starts in 1975, Greece and France in 1960 and the Netherlands in 1969.

Table 2.10: The individual OLS regression. Quarterly.

Quarterly.1	Aus	Bel	Cyp	Est	Fin	Fra	Ger	Gre	Ire	Ita
α	0.29***	0.24***	0.09**	0.26***	0.20***	0.16*	0.31***	0.02	0.06	0.13
(s.e)	(0.09)	(0.05)	(0.04)	(0.09)	(0.03)	(0.08)	(0.11)	(0.05)	(0.05)	(0.14)
β	-0.21	-0.08	0.57***	0.06	0.09	0.27	-0.39	1.33***	0.44***	0.32
(s.e)	(0.30)	(0.20)	(0.20)	(0.40)	(0.09)	(0.38)	(0.39)	(0.32)	(0.13)	(0.59)

Quarterly.2	Lat	Lit	Lux	Mal	Net	Por	Slovk	Slo	Spa	-
α	0.15***	0.22	0.32	0.19***	0.15	0.09	0.40***	0.16	-0.29**	-
(s.e)	(0.05)	(0.02)	(0.03)	(0.02)	(0.06)	(0.44)	(0.14)	(1.27)	(0.12)	-
β	0.51	-0.06	-0.27***	0.03	0.21	0.73	-0.57	0.28	2.24***	-
(s.e)	(0.33)	(0.16)	(0.06)	(0.06)	(0.21)	(3.20)	(0.53)	(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.
(c): The estimated period for the majority of countries is Q1 1995 - Q4 2019. For the rest, the estimated period is as follows: Austria (Aus) from Q1 1996 to Q1 2020, 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.

Table 2.11: Estimated regression with breaks (annual data): 1970-2019.

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_1	0.12***	0.12***	0.21***	0.20***	-1.07***	0.13	-0.04*	-0.05**	0.00	0.21***
(s.e)	(0.03)	(0.03)	(0.00)	(0.00)	(0.19)	(0.08)	(0.01)	(0.02)	(0.11)	(0.01)
C_2	-0.07	-0.07	-0.13***	-0.13***	0.05	0.15***	0.36***	0.20***	0.07***	0.11***
(s.e)	(0.04)	(0.04)	(0.02)	(0.20)	(0.06)	(0.02)	(0.06)	(0.04)	(0.02)	(0.02)
C_3	0.44***	0.32***	0.18***	0.14	-	-	0.15***	-	0.12***	-0.08*
(s.e)	(0.05)	(0.00)	(0.01)	(0.34)	-	-	(0.02)	-	(0.03)	(0.04)
C_4	0.07***	0.06***	-0.04*	-	-	-	-	-	-	-
(s.e)	(0.00)	(0.00)	(0.01)	-	-	-	-	-	-	-
β_1	0.65***	0.65***	0.10***	0.10***	4.33***	0.66	1.45***	1.21***	1.04*	0.19***
(s.e)	(0.16)	(0.16)	(0.02)	(0.02)	(0.58)	(0.38)	(0.05)	(0.08)	(0.46)	(0.05)
β_2	1.49***	1.16***	1.89***	1.88***	0.80***	0.31***	-0.47	0.10	0.62***	0.46***
(s.e)	(0.19)	(0.24)	(0.11)	(0.11)	(0.22)	(0.08)	(0.26)	(0.18)	(0.08)	(0.13)
β_3	-0.76***	-0.30***	0.15***	0.37	-	-	0.31***	-	0.29**	1.99***
(s.e)	(0.18)	(0.01)	(0.04)	(1.52)	-	-	(0.06)	-	(0.13)	(0.28)
β_4	0.55***	0.62***	1.06***	-	-	-	-	-	-	-
(s.e)	(0.01)	(0.02)	(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	-	-	-	-	-	-	-

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.
(c): The estimated period for the majority of countries is 1970-2019, however, for Cyprus it starts in 1975, Greece and France in 1960 and the Netherlands in 1969.

Table 2.11: Estimated regression with breaks (annual data): 1970-2019. Cont.

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_1	0.31***	0.31***	0.69***	0.69***	0.03	0.03	0.10***	0.02	0.23***	0.22***	-0.11**
(s.e)	(0.02)	(0.02)	(0.02)	(0.02)	(0.05)	(0.05)	(0.02)	(0.70)	(0.03)	(0.02)	(0.05)
C_2	0.02	-0.04	0.16	0.29***	0.02	0.04	0.09***	0.16***	0.32	0.01	0.13***
(s.e)	(0.03)	(0.04)	(0.11)	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.83)	(0.02)	(0.02)
C_3	-0.14	-	-	0.18***	-	0.86***	-0.18	-	-	0.32	0.56***
(s.e)	(0.10)	-	-	(0.00)	-	(0.12)	(0.07)	-	-	(0.83)	(0.01)
C_4	-	-	-	-0.15	-	-	-	-	-	-	0.17***
(s.e)	-	-	-	(0.07)	-	-	-	-	-	-	(0.00)
β_1	-0.45***	-0.45***	-2.12***	-2.12***	0.37**	0.37**	0.53***	0.85	-1.12	-0.10	1.26***
(s.e)	(0.10)	(0.10)	(0.08)	(0.08)	(0.13)	(0.13)	(0.12)	(2.68)	(0.21)	(0.13)	(0.21)
β_2	0.52***	0.64***	0.18	-0.46***	0.31***	0.26***	0.44***	0.14*	-0.87	1.24***	0.34***
(s.e)	(0.10)	(0.10)	(0.54)	(0.11)	(0.07)	(0.08)	(0.06)	(0.07)	(5.60)	(0.12)	(0.07)
β_3	0.80**	-	-	0.15**	-	-1.27***	1.13**	-	-	-0.87	-1.42***
(s.e)	(0.22)	-	-	(0.02)	-	(0.23)	(0.19)	-	-	(5.60)	(0.06)
β_4	-	-	-	1.59**	-	-	-	-	-	-	0.13**
(s.e)	-	-	-	(0.33)	-	-	-	-	-	-	(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.
(c): The estimated period for the majority of countries is 1970-2019, however, for Cyprus it starts in 1975, Greece and France in 1960 and the Netherlands in 1969.

Table 2.12: Estimated regression with breaks (quarterly data): Q1 1995 - Q4 2019.

Quarterly data	Cyp S	Cyp B	Est S,B,L	Fin B,L	Ger S	Ger B	Ger L	Gre L	Ire S
C_1	-0.03	0.06	0.29***	0.22***	0.06***	0.06***	0.06***	-0.04	-0.01
(s.e)	(0.04)	(0.06)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
C_2	0.19***	0.09	-0.05	0.06**	0.25***	0.26***	0.26***	0.15***	-0.21***
(s.e)	(0.06)	(0.07)	(0.06)	(0.02)	(0.03)	(0.06)	(0.06)	(0.02)	(0.01)
C_3	0.20***	0.19	-0.06	0.18***	0.10	0.13***	0.09	0.16***	0.10***
(s.e)	(0.06)	(0.11)	(0.06)	(0.02)	(0.33)	(0.02)	(0.34)	(0.02)	(0.02)
C_4	-0.01	0.13	-	-	-	0.19	-	-	0.40
(s.e)	(0.05)	(0.21)	-	-	-	(0.23)	-	-	(0.85)
β_1	1.11***	1.21***	-0.05	-0.03	0.76***	0.76***	0.76***	1.66***	0.65***
(s.e)	(0.17)	(0.29)	(0.12)	(0.11)	(0.03)	(0.03)	(0.03)	(0.17)	(0.09)
β_2	0.06	0.82**	1.34***	0.54***	-0.10	-0.12	-0.12	0.60***	1.32***
(s.e)	(0.27)	(0.38)	(0.20)	(0.07)	(0.13)	(0.24)	(0.24)	(0.15)	(0.04)
β_3	0.26	-0.42	1.06***	0.22***	0.39	0.28***	0.40	-0.33**	0.23***
(s.e)	(0.30)	(0.73)	(0.20)	(0.07)	(1.34)	(0.07)	(1.36)	(0.14)	(0.06)
β_4	1.04***	0.34	-	-	-	0.06	-	-	-0.14
(s.e)	(0.31)	(1.09)	-	-	-	(0.81)	-	-	(1.55)
T1	Q4 1998	Q4 2005	Q2 2002	Q3 1994	Q2 1995	Q2 1995	Q2 1995	Q4 1998	Q2 2005
T2	Q4 2005	Q2 2012	Q2 2009	Q2 2005	Q3 2001	Q4 2001	Q4 2001	Q3 2010	Q1 2010
T3	Q2 2011	Q2 2016	-	-	-	Q1 2016	-	-	Q4 2015

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.
(c): The estimated period for the majority of countries is Q1 1995 - Q4 2019. For the rest, the estimated period is as follows: Estonia (Est), The Netherlands (Net) and Spain (Spa) from Q1 1995 to Q1 2020, Finland (Fin) from Q1 1990 to Q4 2019, Germany (Ger) from Q1 1991 to Q1 2020 and Malta (Mal) from Q1 2000 to Q4 2019.

Table 2.12: Estimated regression with breaks (quarterly data) Q1 1995 - Q4 2019. Cont.

Quarterly data	Ire B	Lat S	Lat B,L	Lit S	Lit B	Lit L	Lux S,B	Mal S,B,L	Net S
C_1	-0.05	0.02	0.11	0.15***	0.16***	0.16***	-0.19	0.25***	0.04
(s.e)	(0.06)	(0.04)	(0.44)	(0.03)	(0.03)	(0.03)	(0.19)	(0.03)	(0.06)
C_2	-0.06	0.12***	0.19***	0.15***	0.13**	0.13**	0.34***	0.60***	0.05
(s.e)	(0.06)	(0.04)	(0.02)	(0.01)	(0.05)	(0.05)	(0.03)	(0.08)	(0.05)
C_3	-	-	0.16**	0.13***	0.13***	0.11***	-	-	-
(s.e)	-	-	(0.07)	(0.01)	(0.01)	(0.01)	-	-	-
C_4	-	-	0.12***	0.06**	0.06**	-	-	-	-
(s.e)	-	-	(0.04)	(0.02)	(0.02)	-	-	-	-
β_1	0.82***	1.43***	0.67	0.44**	0.41*	0.41*	0.95*	-0.24*	0.62***
(s.e)	(0.18)	(0.31)	(0.51)	(0.20)	(0.22)	(0.22)	(0.44)	(0.13)	(0.19)
β_2	0.69***	0.46**	0.33**	0.73***	0.79**	0.79**	-0.29***	-0.99***	0.48***
(s.e)	(0.15)	(0.21)	(0.11)	(0.07)	(0.32)	(0.32)	(0.06)	(0.19)	(0.17)
β_3	-	-	0.81**	0.27***	0.25***	0.43***	-	-	-
(s.e)	-	-	(0.31)	(0.07)	(0.05)	(0.09)	-	-	-
β_4	-	-	0.46**	0.68***	0.68***	-	-	-	-
(s.e)	-	-	(0.21)	(0.11)	(0.11)	-	-	-	-
T1	Q1 2010	Q1 2009	Q4 1998	Q4 2005	Q3 2005	Q3 2005	Q3 1999	Q2 2015	Q2 2010
T2	-	-	Q2 2004	Q3 2009	Q2 2009	Q2 2009	-	-	-
T3	-	-	Q1 2009	Q4 2014	Q4 2014	-	-	-	-

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.
(c): The estimated period for the majority of countries is Q1 1995 - Q4 2019. For the rest, the estimated period is as follows: Estonia (Est), The Netherlands (Net) and Spain (Spa) from Q1 1995 to Q1 2020, Finland (Fin) from Q1 1990 to Q4 2019, Germany (Ger) from Q1 1991 to Q1 2020 and Malta (Mal) from Q1 2000 to Q4 2019.

Table 2.12: Estimated regression with breaks (quarterly data) Q1 1995 - Q4 2019. Cont.

Quarterly data	Por B,L	Slovk B,L	Slo S	Slo B,L	Spa S	Spa B,L
C_1	-0.17***	0.00	0.13***	-0.07	-0.14***	0.03
(s.e)	(0.02)	(0.07)	(0.03)	(0.10)	(0.03)	(0.06)
C_2	0.01	0.25*	0.26***	0.54***	-0.29***	0.06
(s.e)	(0.05)	(0.14)	(0.03)	(0.09)	(0.03)	(0.06)
C_3	0.59***	0.20***	0.10**	0.09***	0.06**	-0.29***
(s.e)	(0.03)	(0.06)	(0.03)	(0.02)	(0.02)	(0.03)
C_4	-0.09***	-	-	0.22***	-0.49***	0.01
(s.e)	(0.01)	-	-	(0.02)	(0.02)	(0.05)
β_1	2.32***	1.46***	0.49***	1.28**	1.66***	0.88***
(s.e)	(0.10)	(0.30)	(0.13)	(0.41)	(0.10)	(0.27)
β_2	1.41***	0.01	-0.25**	-1.10**	2.39***	0.84***
(s.e)	(0.32)	(0.53)	(0.11)	(0.37)	(0.16)	(0.25)
β_3	-2.85***	0.06	0.33**	0.64***	0.53***	2.39***
(s.e)	(0.17)	(0.24)	(0.11)	(0.09)	(0.10)	(0.16)
β_4	1.43***	-	-	-0.12	2.94***	0.79***
(s.e)	(0.07)	-	-	(0.11)	(0.08)	(0.23)
T1	Q4 1998	Q3 1999	Q1 2010	Q4 1998	Q2 2004	Q2 1999
T2	Q4 2009	Q2 2009	Q1 2016	Q3 2002	Q3 2012	Q2 2004
T3	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.
(c): The estimated period for the majority of countries is Q1 1995 - Q4 2019. For the rest, the estimated period is as follows: Estonia (Est), The Netherlands (Net) and Spain (Spa) from Q1 1995 to Q1 2020, Finland (Fin) from Q1 1990 to Q4 2019, Germany (Ger) from Q1 1991 to Q1 2020 and Malta (Mal) from Q1 2000 to Q4 2019.

Table 2.13: Panel PMG/MG estimation. Annual data. 1970-2019.

Parameter	Full sample PMG	Core countries PMG	Periphery countries PMG
Long-term parameter	0.25***	0.25***	0.54***
(s.e)	(0.05)	(0.05)	(0.17)
ECM	-0.18***	-0.18***	-0.13***
(s.e)	(0.03)	(0.05)	(0.02)
Short-term parameter	0.11**	0.13*	0.07
(s.e)	(0.05)	(0.07)	(0.07)
Hausman test	1.45	1.29	1.00
BIC model selection criteria	(2,1)	(1,1)	(2,1)

Notes:
(a): For the annual regression, EZ 12 countries are: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. Cyrpus was not included since it stars in 1975.
(b): Core countries are: Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands. Periphery countries: Greece, Ireland, Italy, Portugal and Spain.
(c) The Hausman test is used to choose between the PMG and the MG. *** denotes the rejection of the null hypothesis of homogeneous long-term parameter at the 1% level.

Table 2.14: Panel PMG/MG estimation. Quarterly data. Q1 1996 - Q4 2019.

Parameter	Full sample PMG	Core countries PMG	Rest of the countries PMG
Long-term parameter	0.66***	0.06	0.57***
(s.e)	(0.13)	(0.08)	(0.09)
ECM	-0.12***	-0.19**	-0.18**
(s.e)	(0.04)	(0.09)	(0.09)
Short-term parameter	-0.08	0.14	0.02
(s.e)	(0.05)	(0.09)	(0.09)
Hausman test	3.67	5.81	3.48
BIC model selection criteria	(2,1)	(2,1)	(1,1)

Notes:
(a): For the quarterly regression, EZ 18 countries are: countries already included in the EZ 12 plus Cyprus, Estonia, Latvia, Lithuania, Slovak Republic and Slovenia.
(b): Core countries are: Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands. Periphery countries: Greece, Ireland, Italy, Portugal and Spain. Rest of the countries, periphery countries plus Cyprus, Estonia, Latvia, Lithuania, Slovak Republic and Slovenia.
(c): Quarterly data starts in Q1 1996 to have the larger number of countries included while keeping a large T. Malta could not be included since it stars in Q1 2000.
(d) The Hausman test is used to choose between the PMG and the MG. *** denotes the rejection of the null hypothesis of homogeneous long-term parameter at the 1% level.

Appendix

Table 2.A: Timeline of the European sovereign crisis.

Year	Event
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 2.B: 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 2.C: 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 2.D: 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	-2.45	-3.34
-	-	-	Slovk S	-4.07**	-4.22
-	-	-	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 2.E: Gregory and Hansen cointegration test with one break.

Frequency	Country	Z_t^*	Z_α^*	ADF_t^*
Annual	Cyp (S,B,L)	-4.18	-22.72	-4.69**
Annual	Fin (S,L)	-3.32	-20.03	-4.72**
Annual	Fra (S,B,L)	-4.60	-29.09	-4.42
Annual	Ire (L)	-5.42***	-42.30	-3.85
Annual	Ita (S)	-2.69	-11.92	-3.75
Annual	Lux (S,L)	-5.00**	-33.79	-4.89**
Annual	Net (L)	-3.85	-22.53	-5.52***
Annual	Por (L)	-3.30	-19.71	-4.59
Quarterly	Cyp (L)	-10.14***	-101.73***	-2.67
Quarterly	Ire (B)	-9.12***	-101.49***	-4.14
Quarterly	Lat (S)	-5.36***	-38.93	-5.28***
Quarterly	Lux (S,B)	-9.15***	-91.40***	-8.94***
Quarterly	Mal (S,B,L)	-6.42***	-54.97***	-6.38***
Quarterly	Nel (S)	-11.79***	-117.46***	-11.73***

Notes:
(a) ** and *** denotes the rejection of the null hypothesis of no cointegration at the 5% and 1% levels.
(b) Critical values can be found in Gregory and Hansen (1996).

Table 2.F: Overview of the financial assistance programme.

Program	**ESM loans along with macroeconomic adjustment programme**
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)
Program	**Loans for bank recapitalisation**
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

Chapter 3

The rise and fall of financial flows in EU 15: new evidence using dynamic panels with common correlated effects

3.1 Introduction

Capital mobility is 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 consumption and output dynamics when an asymmetric shock occurs (Kalemli-Ozcan et al., 2003).[1] 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.

[1] 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.

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). Later, the process followed with the creation of the European passport for financial services and the Financial Services Action Plan starting in 1999, the Lamfalussy process from 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.

However, since the Great Recession of 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 to put the building blocks in place towards increasing financial integration[2]. Therefore, the analysis of the evolution of the degree of financial integration in the EU has regained momentum.

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 current account imbalance, as well as in its financial counterpart. That process is not constrained to the Euro area (EA); on the contrary, it has occurred in 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 imbalances; one of the most popular is the savings glut hypothesis, formulated by Bernanke (2005) and extended in Horioka et al. (2016). According to this hypothesis, external disequilibria are caused by macroeconomic imbalances between national 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

[2]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

larger external disequilibria. However, this process sharply ended with the 2007 financial crisis and the subsequent adjustment that took place afterward.

The above 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 imbalance (Baldwin and Giavazzi, 2016). At the core of the problem lies an issue of balance of payments adjustment within a monetary union.[3] 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. The current Covid-19 crisis will only complicate more this scenario with increasingly uncertain external relations across countries.

In this paper, we assess capital mobility for the EU-15 between 1970-2019 in the context of the definitions of Feldstein and Horioka (1980) and Ford and Horioka (2017). Moreover, we focus on the impact that the different stages of financial and real integration have had on capital mobility. Obviously, a reliable and econometrically robust measure of the degree of capital mobility along time, such as an estimate of the savings-retention coefficient, is needed for this purpose. We argue that the high saving-investment correlations found in seminal works were due to the neglect of the non-stationary properties of the series and failure to account for structural breaks in the long run relationship between the variables. Moreover, the analysis of an economic integrated area as the EA can be improved using panel data, as it enriches the information included in the analysis. However, panel data present a series of econometric issues, many times neglected in empirical applications, such as the existence of observed and unobserved common effects, cross-section dependence, parameter heterogeneity, and endogeneity in a multifactor dynamic error framework.[4] Precisely, the salient feature of our econometric approach is that it allows us to exploit both the cross-section and time information included in T-large panels accounting for all these issues

[3] 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.

[4] See, among others, Pesaran (2006), Eberhardt and Bond (2009), Chudik and Pesaran (2015), and Ditzen (2018).

commonly disregarded in previous literature. We follow an empirical approach that allows for a complete analysis of capital mobility, looking at four dimensions: first, the long-run relationships; second, the path followed to return to long-run equilibrium when a shock occurs; third, the presence of structural breaks affecting the relationship and lastly, the short-run impact of domestic saving on domestic investment, an effect usually disregarded in this literature. To the best of our knowledge, there are no studies that jointly address all these elements in the analysis of capital mobility and the FH puzzle. To this aim, we propose an econometric strategy in two stages. First, we examine the long-run and short-run links between domestic investment and saving using Chudik and Pesaran (2015) Dynamic Common Correlated Effects (DCCE hereafter) modelled as an error correction model that allows for one structural break. In a second stage, using the Cross-sectional Distributed lags (CS-DL hereafter) proposed in Chudik et al. (2016) we assess how the long-run relationship between domestic investment and saving changes when risk and economic openness reach a certain threshold. The DCCE is a modified estimator well suited for handling dynamic and heterogenous coefficients of a panel model that incorporates lagged dependent and weakly exogenous regressors.

This paper is organized as follows: in Section 3.2, we review the empirical literature on the subject and present the theoretical background on capital mobility using the FH approach. Section 3.3 summarizes the data and the methodology used in this paper. Section 4.5 discusses the empirical results. Finally, section 4.6 concludes.

3.2 Related literature

3.2.1 Capital mobility: Price vs. quantity approach

The measurement of the degree of capital mobility is essential to assess the state of the global economic environment. In good times, international financial flows channel savings to the countries and regions of the world where they are most productive, while during crises, they have the potential to disrupt the financial systems of the most vulnerable countries and therefore constitute a key factor for global financial instability. However, measuring capital mobility is a challenging task. Financial market integration implies that assets with identical risks and returns should be priced identically regardless of where they

are transacted. However, to get this result, a series of different conditions should be met, and the literature has traditionally considered two approaches[5]. 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.[6].

Concerning the price-approach[7], there are three accumulative criteria that have been posited in the literature. The first criterion (capital mobility of type I) 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.

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

The third criterion is the real interest parity or RIP. This is the most restrictive definition of capital mobility as it requires criteria I and II to hold plus zero expected real depreciation. If this criterion, also called capital mobility of type III, 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 rates 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.

[5]We follow Dooley et al. (1987) and Lemmen and Eijffinger (1993, 1995) in this Section.

[6]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.

[7]For an in-depth analysis, see Frankel (1988).

3.2.2 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:

$$\left(\frac{I_i}{Y_i}\right) = \alpha + \beta \left(\frac{S_i}{Y_i}\right) \tag{3.1}$$

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. Coefficient β is called the saving-retention coefficient, which 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, β should be zero for small countries, whereas it would represent their share of the world capital stock for large countries. The reason for β 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 β 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).

3.2.3 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:

$$\left(\frac{I_i}{Y_i}\right) = \beta_0 - \beta_1 r_i + u_i \tag{3.2}$$

where (3.2) 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 differently from the domestic real interest rate).

Second:

$$Cov\left(u_i, \frac{S_i}{Y_i}\right) = 0 \tag{3.3}$$

(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:

$$r_i = r^* \tag{3.4}$$

Assuming that the real interest parity holds, then (3.4) implies that the country is unable to affect the world real interest rate, that is, r^* is exogenous.

Therefore to obtain a zero saving-retention coefficient in equation (3.2) the world interest rate r^* has to be exogenous as well as the error term in equation (3.3) should not be correlated with the saving rate.

Ford and Horioka (2017) argued that the real interest parity does not need to hold (the third assumption above). Instead, they claimed that the integration of both goods and financial markets is necessary to obtain a zero coefficient in the saving retention parameter.

3.2.4 Assessment of capital mobility: still a debate

After the findings of Feldstein and Horioka (1980), many papers have looked for 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 re-

sults 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 existing. Eaton et al. (2016), have underlined that the net transfers of capital among countries depend not only on the integration of the financial markets but also on the integration of goods and services market. This evidence is also in line with the joint fulfillment of the UIP and the purchasing power parity (PPP) conditions as shown in Johansen and Juselius (1992), Juselius (1995), Camarero and Tamarit (1996), and more recently, in Pesaran et al. (2000).

In this sense, our EU sample is a natural test for capital mobility because there are no barriers either to capital or to goods mobility and there has been a gradual integration process that substantially decreased financial and trade frictions. 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 (financial and real) in Europe has encouraged capital mobility.[8]

3.2.5 Attempts to solve the FH puzzle

The FH puzzle (Feldstein and Horioka, 1980; Feldstein, 1982) has given rise to extensive literature trying to solve it. This literature can be classified into three categories[9].

The first one seeks to reconcile the large correlation found between domestic saving and investment with the existence of 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; Tobin, 1983; Westphal, 1983; Summers, 1988).

The second line of research includes those papers that do not agree with Feldstein and Horioka (1980)

[8] 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 fulfillment 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.

[9] 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).

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. 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. A second, criticism of the results is due to Tobin (1983). He argues that the FH regression suffers from *endogeneity problems* that should be properly addressed[10]. Later studies have supported his view, such as Dooley et al. (1987), Bayoumi (1990), Tesar (1991) and Kasuga (2004). The third 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 tend to overestimate or underestimate the value of the saving-retention coefficient.

Relying on the previous objections, the empirical literature has focused on improving the econometric techniques in order to overcome previous pitfalls. We can classify the papers according to the statistical methods depending on the data used: cross-section, time series, and panel data methodologies. First, 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 within the cross-sectional setting, the FH result has remained robust.

[10]This problem may arise if both variables react to population or productivity shocks or to a government response to correct a current account imbalance.

As for *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. Kejriwal (2008) revisits the FH puzzle for 21 OECD countries. He finds evidence from 1 to 3 regime changes. Ketenci (2012) and Camarero et al. (2021) apply the same econometric methodology than Kejriwal (2008) to the EU. The latter study the period 1970-2019 and find a downward trend in the saving-investment retention since the 70s for the so-called "core countries" and identify several breaks coinciding with relevant economic integration episodes.

However, to analyze economic areas, the use of panel data can be more suitable. Indeed, panel data provides more information, variability, efficiency and it minimizes estimation biases compared to pure cross-sectional and time series data. Examples of applied papers testing the FH relationship are: Coakley et al. (2004), Krol (1996), Coakley and Kulasi (1997), Corbin (2001), Dash (2019), Narayan (2005) and Kim (2001) with similar results than those found using time-series. However, these studies do not take into account structural breaks in the long-run saving-investment relationship. This issue is tackled by a few number of papers: Westerlund (2006) finds more evidence of cointegration between saving and investment once he accounts for structural breaks in the panel. Katsimi and Zoega (2016) found that the breaks coincide with the European single market in 1993, the euro in 1999 and the 2008 financial crisis. Kumar (2015) associates structural breaks with regional agreements and finds that these agreements have encouraged capital mobility[11]. An alternative solution to abrupt structural breaks is to allow for the parameter in the FH regression to vary over time. This is the approach, among others, adopted by Telatar et al. (2007), Gomes et al. (2008), Ma and Li (2016), or Khan (2017). More recently, Camarero et al. (2020) develop a time-varying parameters state-space model that they apply to a panel of EU countries.

Another potential problem of the traditional panel methods is that they are built under strong cross-sectional independence assumptions. Several studies have addressed this issue. First, Byrne et al. (2009)

[11]The author called for further research to account for endogenous breaks and heterogeneous parameters.

decompose idiosyncratic and global components of the long-run saving-investment relationship and find that the global components in saving and investment react to global shocks. Giannone and Lenza (2010) propose the use of factor-augmented panel regressions to isolate idiosyncratic sources of fluctuations so that countries are allowed to react with specific sign and magnitude to global shocks. Such heterogeneous propagation mechanism of global shocks yields saving-retention coefficients that drop from the 1980s. In the same vein, Costantini and Gutierrez (2013) found that, once global shocks are taken into account through common factors, the FH puzzle disappears. Finally, Murthy and Ketenci (2020) use Pesaran (2006)'s CCEMG and Chudik and Pesaran (2015) DCCEMG tests to investigate the FH puzzle for a panel of 27 African countries.

Focusing on the European case, Drakos et al. (2017) and Drakos et al. (2018) assessed the correlation between domestic saving and investment for 14 EU countries employing panel data techniques for the period 1970-2013 and 1970-2015, sequentially. In the former paper, they obtained a sizeable saving-retention coefficient suggesting that this result is consistent with the intertemporal budget constraint. They concluded that the speed of adjustment towards the long-run equilibrium showed some sign of capital mobility. However, the speed of adjustment obtained for Greece (2 years), Italy (2 years), Portugal (4 years), and Spain (4 years) did not support the large and persistent external imbalances observed for these countries[12]. In the latter paper, they took into account cross-sectional dependence and found a moderate degree of capital mobility and that the FH puzzle was partially present. However, both papers failed to consider structural breaks, which may lead to an underestimation of the degree of capital mobility. But and Morley (2017), applying panel techniques for a sample of OECD countries (some of the EA members), found that the correlation between domestic saving and investment dropped to record levels right before the 2008 financial crisis, and the puzzle returns afterward. Their results also suggest that the puzzle for net capital-importing and capital-exporting countries differs. By contrast, Ketenci (2018) found an insignificant impact of the 2008 financial crisis on the level of capital mobility. Camarero et al. (2020), using time-varying parameters techniques with panel data, found that the FH coefficient declines over time, confirming an increase in capital mobility and international openness.

[12]Moreover, their results showed that the FH puzzle was also partially present in the short-run for the majority of northern countries, but not for the periphery, which seems unlikely.

Finally, the ECB performs periodical studies on the degree of financial integration in the EA.[13] 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 EA 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, ECB (2018) analyzes the degree of financial integration in the EA and the fulfillment of the FH puzzle. They 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 making the interpretation of the results difficult, which calls for further research in the area.

3.3 Methodology

3.3.1 Description of the methodology and data

In this section, we describe the econometric methodology applied in this paper. We divide our analysis into two parts. In the first one, we examine the long-run and short-run links between domestic investment and saving using Chudik and Pesaran (2015)'s Dynamic Common Correlated Effects (DCCE) estimator. Moreover, we obtain an error correction model allowing for one common structural break. In the second part, we examine how the long-run relation between domestic investment and saving changes when risk and economic openness reach a certain threshold. For this, we apply Cross-sectional Distributed lags (CS-DL), as proposed by Chudik et al. (2016). Sequentially, the econometric procedure is as follows. First, we apply Pesaran (2020) test to assess the existence of cross-sectional dependence not only on the variables but also on the saving-investment regression. Second, once the existence of dependence has been tested, we determine the order of integration of the variables using Bai and Carrion-i Silvestre (2009) unit root test with cross-sectional dependence and structural breaks. In a third step, we test for cointegration between domestic savings and investment by applying Banerjee and Carrion-i Silvestre (2015) approach. As in the case of the unit root test, the Banerjee and Carrion-i Silvestre (2015)

[13] ECB (2018) and ECB (2020) analyze how financial integration has evolved in the EA. The ECB measures financial integration using both the price and the quantity-based approaches, 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) program and the banking union announcement.

cointegration test allows for structural breaks and cross-sectional dependence. Using this approach, we identify and analyze the heterogeneous breaks that affect the domestic I-S relationship for all the panel members. For comparability, we also apply the cointegration test by Banerjee and Carrion-i Silvestre (2017) that takes into account cross-sectional dependence using Common Correlated Effects (CCE hereafter) introduced by Pesaran (2006). Finally, we estimate a panel error correction model augmented by the cross-sectional averages and their lags, based on the DCCE with a common structural break (Chudik and Pesaran, 2015). Then, we study the effect of economic risk and openness on the FH relationship when a certain threshold is reached using CS-DL (Chudik et al., 2016).

As our interest is focused on the long-run and short-run impact of the savings-investment relationship in the EU, the role of economic integration, and how economic risk can affect capital mobility in the EU, we have tried to obtain the largest panel available with annual data. In our case, we have worked with the EU15[14] and the source of the data is the OECD database for the period 1970-2019.

Regarding our data, we measure investment with gross fixed capital formation, whereas, for saving, we 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. To measure the overall economic openness for the EU 15, we use the average KOFEcGI index (financial and trade globalization) for our EU 15 sample[15]. Note that for this variable data are only available from 1970 to 2018. Therefore, the threshold analysis has been constrained to that period. Further information about the components of these variables can be found in table 3.A. The source is the KOF Swiss Economic Institute based on the paper of Gygli et al. (2019) and the original contribution of Dreher (2006). The variable to measure economic risk is the 10-year long-term government bond yield differentials between the EA and the United States. The variable is not available for the EU, and the individual variables are not available for the entire period. Nonetheless, the economic risk for the EA can be used as a representative proxy for the economic risk in the EU given that the EA countries are all EU members and represent a large percentage of EU GDP[16]. Additionally, 12 out of 15 countries in our sample are EA countries.

[14] Austria (Aus), Belgium (Bel), Denmark (Den), Finland (Fin), France (Fra), Germany (Ger), Greece (Gre), Ireland (Ire), Italy (Ita), Luxembourg (Lux), The Netherlands (Net), Portugal (Por), Spain (Spa), Sweden (Swe) and the United Kingdom (UK). The latter was included since it was part of the EU during the sample period.

[15] We have obtained the average index based on the individual indexes from our sample.

[16] To be more precise, they are 19 out of 28 countries, that is 68% of its members, 70% after Brexit, as well as 80% of its

This variable has been obtained from the Federal Reserve Economic Database (FRED), provided by the Federal Reserve Bank of St. Louis[17]. Table 3.1 summarizes the variables used and data sources.

3.3.2 Cross-section dependence test and order of integration

We start by applying the Pesaran (2020) cross-sectional dependence test (CD hereafter). The CD test is based on the average of pair-wise correlation coefficients of the OLS residuals from the individual regressions[18]. Pesaran (2020) showed that the test is robust to single or multiple breaks in the slope coefficient and error variances. The CD test is given by:

$$CD = \sqrt{\frac{2T}{N(N-1}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right) \tag{3.5}$$

Once cross-sectional dependence has been assessed, we test for the order of integration applying Bai and Carrion-i Silvestre (2009) methodology. We have considered the existence of potential and unknown structural changes. This is a non-trivial matter given that unit root tests can lead to misleading conclusions if the presence of structural breaks is not accounted for (Perron, 1989, see the seminal paper). The panel includes all the individual countries, where we allow for multiple and unknown structural breaks and for cross-country dependence.

Bai and Carrion-i Silvestre (2009) propose a set of panel unit root tests that pool the modified Sargan-Bhargava (hereafter MSB) tests Sargan and Bhargava (1983) for individual series, both taking into account the possible existence of multiple structural breaks (adapting Bai and Perron (2003) methodology to a panel data framework), and cross-section dependence, modeled as a common factors model as described in Bai and Ng (2004) and Moon and Perron (2004). The common factors may be non-stationary processes, stationary processes, or a combination of both. The number of common factors is estimated using the panel Bayesian criterion information in Bai and Ng (2002). We have used the GAUSS code provided by the authors, allowing for a maximum number of 3 breaks, determined through the Bai and

GDP in 2020.

[17] A popular alternative variable to account for global risk is the CBOE Volatility Index (VIX), which measures the stock market's expectation of volatility implied by the options on the S&P 500 index, calculated and published by the Chicago Board Options Exchange. However, this variable was not available for the whole period.

[18] Figure 3.1 shows the domestic investment and saving individual time series for the sample of countries.

Perron (1998) procedure[19].

3.3.3 Cointegration test

Banerjee and Carrion-i Silvestre (2015) propose a panel cointegration test that allows for structural breaks and cross-sectional dependence under the null of no cointegration. Structural breaks can affect both the deterministic components and the cointegrating vector and they can be treated as known or unknown.

The data generating process (DGP) in structural form as:

$$y_{i,t} = D_{i,t} + x'_{i,t}\delta_{i,t} + u_{i,t} \tag{3.6}$$

$$u_{i,t} = F'_t\pi_i + e_{i,t} \tag{3.7}$$

$$(1 - L)F_t = C(L)w_t \tag{3.8}$$

$$(1 - \rho_i L)e_{i,t} = H_i(L)\varepsilon_{i,t} \tag{3.9}$$

$$x_{i,t} = k_i + x_{i,t-1} + G'_t\zeta_i + \Xi_i(L)v_{i,t} \tag{3.10}$$

$$G_t = \Gamma(L)\bar{\omega}_t \tag{3.11}$$

where $i = 1, ..N, t = 1, ..., T$, $C(L) = \sum_{j=0}^{\infty} C_j L^j$, $H_i(L) = \sum_{j=0}^{\infty} h_{i,j} L^j$, $\Xi_i(L) = \sum_{J=0}^{\infty} \Xi_{i,j} L^j$ and $\Gamma(L) = \sum_{j=0}^{\infty} \Gamma_j L^j$. Common factors and factor loadings are estimated using principal components. The optimum number of factors is obtained using the BIC criterion, as recommended by Bai and Ng (2004).

The general functional form for the deterministic term $D_{i,t}$ is

[19] See Bai and Carrion-i Silvestre (2009) for details.

$$D_{i,t} = \mu_i + \beta_i t + \sum_{j=1}^{m_i} \theta_{i,j} DU_{i,j,t} + \sum_{j=1}^{m_i} \gamma_{i,j} DT_{i,j,t} \tag{3.12}$$

where $DU_{i,j,t} = 1$ and $DT_{i,j,t} = (t - T_{i,j}^B)$ for $t > T_{i,j}^b$ and 0 otherwise. T denoting the timing of the jth breaks, $j = 1, ..., m_i$. The cointegration vector in equation (3.6) is a function of time:

$$\delta_{i,t} = \delta_{i,j} \quad for \;\; T_{i,j-1}^c < t \leq T_{i,j}^c \tag{3.13}$$

Where $T_{i,0}^c = 0$ and $T_{i,n_i+1}^c = T$, $T_{i,j}^c$ and denotes the jth time of th break.

The panel cointegration test statistics are obtained based on the sum of the individual ADF:

$$SADF_j(\lambda) = \sum_{i=1}^{N} t_{\tilde{e}_i^*}^j(\lambda_i), \;\; j = c, \tau, \gamma \tag{3.14}$$

The limiting distribution of the statistics is given by:

$$Z_j(\lambda) = \frac{N^{-\frac{1}{2}} SADF_j(\lambda) - \Theta_j^e(\lambda)\sqrt{N}}{\sqrt{\Psi_j^e(\lambda)}} \tag{3.15}$$

Banerjee and Carrion-i Silvestre (2015) test allows for six possible specifications of the long-run model: from a no-break cointegration vector with an intercept up to structural changes affecting the cointegration vector, the trend and the intercept. The breaks are estimated by minimizing the sum of square residuals as in Bai and Perron (1998).

For comparability, we include Banerjee and Carrion-i Silvestre (2017) panel cointegration test. Banerjee and Carrion-i Silvestre (2017) test also accounts for cross-sectional dependence, but in this case, cross-sectional dependence is approximated by the cross-sectional averages in the spirit of the Pooled Common Correlated Effects (PCCE) approach by Pesaran (2006). Additionally, it is also interesting to compare the results of the cointegration analysis when we do not take into account structural breaks in the data.

Banerjee and Carrion-i Silvestre (2017) test is applied in fourth steps. First, the long-run coefficient is calculated by Pesaran (2006) PCCE. Second, they define the following variable:

$$\tilde{y}_{i,t} = y_{i,t} - x'_{i,t}\hat{\beta}_{PCCE}, \tag{3.16}$$

and estimate the following model using OLS:

$$\tilde{y}_{i,t} = D_{i,t} + v_{i,t}, \tag{3.17}$$

In a third step, the OLS residuals are computed as:

$$\hat{v}_{i,t} = \tilde{y}_{i,t} - \hat{D}_{i,t}, \tag{3.18}$$

Finally, the null hypothesis of no cointegration is tested applying the Cross-section Augmented Dickey-Fuller cointegration statistic (CADF):

$$CADF_p = N^{-1}\sum_{i=1}^{N} t_{\hat{\alpha}_{i,0}}. \tag{3.19}$$

3.3.4 Estimating long-run relationships

According to Pesaran and Smith (1995), there are four procedures to estimate the average effect for large panels: the first is to estimate separate regressions for each group and then average the coefficients over groups, an estimator that is called Mean Group (MG hereafter); the second involves estimating pooled regressions by imposing common slopes and allowing for fixed or random effects; the third involves averaging the data over groups and to estimate aggregate time-series regressions; finally, the fourth involves averaging the data over time and to estimate cross-section regressions on group means. Pesaran and Smith (1995) argued that except for the MG estimator, the pooled and aggregate estimator will yield inconsistent estimates for dynamic models. The reason is that when the regressors are serially correlated, ignoring coefficient heterogeneity causes serial correlation in the disturbance even when $T \rightarrow \infty$.

Pesaran et al. (1999) introduced an intermediate procedure between the MG and the pooled estimator, which is called Pooled Mean Group (PMG hereafter). The PMG constrains the long-run coefficients to be homogeneous but allows the short-run coefficients and error variances to be heterogeneous. The homogeneous long-run coefficients are estimated using the Maximum likelihood (ML) estimator, then the short-run coefficients and the group-specific error correction coefficient are estimated by individual OLS regressions.

Traditional panel methods (including PMG and MG) are built under the assumption of cross-sectional independence across the $i-units$ in the panel. However, this assumption seems to be implausible in many applications.[20] Cross-sectional dependence may arise due to spillover effects, omitted common effects, or just as a result of the socioeconomic interaction network. To overcome this econometric issue, Pesaran (2006) proposed a new approach to estimate panel data models with a multifactor error structure where the unobserved common factors are allowed to be correlated with the exogenous individual-specific regressors and the factor loadings differ over the cross-section units. The unobserved common factors are eliminated by filtering the individual-specific regressors by the means of cross-section aggregates. This approach is called the Common Correlated Effects estimator[21] or CCE.

Chudik and Pesaran (2015) extend the CCE to heterogeneous dynamic panel data. This approach is called Dynamic Common Correlated Effects (DCCE). They show that the CCE estimator is still valid to deal with the dynamics if two conditions are satisfied: first, a sufficient number of lags of cross-section averages are included, and second, the cross-section averages must be at least as large as the number of unobserved common factors. Chudik and Pesaran (2015) consider the following panel ARDL (1,1) model with a multifactor error structure:

$$y_{it} = c_{yi} + \phi_i y_{i,t-1} + \beta_{0i} x_{it} + \beta_{1i} x_{i,t-1} + u_{it}, \;\; u_{it} = \gamma_i' \mathbf{f}_t + \varepsilon_{it} \tag{3.20}$$

with $i = 1, ..., N$ and $t = 1, ..., T_I$,. $\mathbf{f}_t = (f_{t,1}, ..., ft, m_f)'$ is the unobserved common factors and m_f the number of factors. Chudik and Pesaran (2015) showed that the common factors in equation (3.20)

[20] This assumption appears to be unrealistic for the EU and the EA, given the spillover effects. Proof of that is the contagion effect that triggered the Sovereign debt crisis in the EA during the period 2010-2015.

[21] CCE can be based on both the MG or Pooled version.

can be approximated by the cross-sectional averages of the dependent and independent variables and their $T^{\frac{1}{3}}$ lags:

$$y_{it} = c_{yi} + \phi_i y_{i,t-1} + \beta_{0i} x_{it} + \beta_{1i} x_{i,t-1} + \sum_{\ell=0}^{p_T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.21}$$

where $\bar{z}_t = N^{-1} \sum_{i=1}^{N} z_{it} = (\bar{y}_t, \bar{x}_t, \bar{g}_t)'$. p_T is equal to the integer part of $T^{\frac{1}{3}}$. For this specific case, the mean group estimator of $\pi = E(\pi_i) = (\phi, \beta'_0, \beta'_1)$ can be estimated as follows:

$$\hat{\pi}_{MG} = \frac{1}{N} \sum_{i=1}^{N} \hat{\pi}_i. \tag{3.22}$$

3.3.4.1 Error correction model and structural breaks

The DCCE can be transformed into an error correction model (DCCE-ECM hereafter):

$$\Delta y_{it} = c_{iy} + \beta_{0i} \Delta x_{it} - \lambda_i (y_{i,t-1} - \gamma_{1i} x_{i,t-1}) + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.23}$$

where λ_i and γ_{1i} are defined as: $\lambda_i = (1 - \phi)$ and $\gamma_{1i} = \frac{\beta_{0i} + \beta_{1i}}{(1-\phi)}$. In Appendix A we show how the DCCE can be transformed into an ECM. One characteristic of the ECM is that there would be a long-run relationship provided that λ_i is negative and significant.

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

$$I_t = \alpha + \beta S_t + \varepsilon_t \tag{3.24}$$

The FH relationship to be estimated takes the form:

$$\Delta I_{it} = c_{iI} + \beta_{0i} \Delta S_{it} - \lambda_i (I_{i,t-1} - \gamma_{1i} S_{i,t-1}) + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit}, \;\; \bar{z} = (\bar{I}, \bar{S}) \tag{3.25}$$

The main advantage of the ECM is that it jointly estimates the short-run dynamics, the long-run equilibrium and the speed of adjustment toward equilibrium. Additionally, to obtain it we can use the MG

estimator (CS-MG hereafter) which allows all parameters to be heterogeneous, the PMG estimator (CS-PMG hereafter) allows the short-run dynamics and the speed of adjustment to be heterogeneous while the long-run equilibrium is homogeneous, and finally, the pooled version, that constrains the parameters to be homogeneous. In this paper, we only focus on the CS-MG and the CS-PMG estimations[22]. The Hausman test is used to choose between the CS-MG and CS-PMG estimators.[23]

Last, we extend the DCCE-ECM estimator by allowing structural breaks as in Camarero et al. (2016). Based on the break dates and the models obtained from the Banerjee and Carrion-i Silvestre (2015) cointegration approach, we include the break in our DCCE-ECM by filtering the variables by the break[24]. In this paper, we only include one homogeneous break, since the heterogeneous breaks analysis has already been covered in Camarero et al. (2021).

3.3.5 Threshold analysis applying CS-DL

Chudik et al. (2016) develop a cross-sectionally augmented distributed lags (CS-DL hereafter) approach to estimate the long-run effects in large dynamic heterogeneous panel data with cross-sectional dependence. The CS-DL estimator is robust to misspecification of dynamics and error serial correlation. Moreover, the CS-DL approach is superior to ARDL when T is not too large. The CS-DL estimator is based on the following auxiliary regression:

$$y_{it} = c_{yi} + \theta_i' x_{it} + \sum_{\ell=0}^{p-1} \delta_{i\ell} \Delta x_{i,t-\ell} + \sum_{\ell=0}^{p_{\bar{y}}} \omega_{y,i\ell} \bar{y}_{t-\ell} + \sum_{\ell=0}^{p_{\bar{x}}} \omega_{x,i\ell}' \bar{x}_{t-\ell} + e_{it} \tag{3.26}$$

Where $\bar{x}_t = N^{-1} \sum_{i=1}^{N} x_{it}$ and $\bar{y}_t = N^{-1} \sum_{i=1}^{N} y_{it}$, $p_{\bar{x}}$ is set equal to the integer part of $T^{\frac{1}{3}}$, $p = p_{\bar{x}}$ and $p_{\bar{y}}$ is set to 0.

We apply the methodology proposed by Chudik et al. (2016) to estimate the threshold model[25]. They

[22] The homogeneity assumption of the pool version is not realistic, as it would imply homogeneity for the short-run dynamics and the speed of adjustment, that does not hold from a theoretical point of view

[23] Rejection of the null of a homogeneous long-run coefficient implies using the CS-MG estimator. In contrast, if the null cannot be rejected, the CS-PMG would be a more efficient estimator, since the MG would just add inefficient long-run variability to the estimation.

[24] In the case that the break affects the cointegration vector (models 4, 5 and 6), a new long-run variable is added to the regression to take into account the change in the cointegration vector.

[25] An alternative for the threshold analysis is the approach developed by Hoke and Kapetanios (2021). However, our sample size is not long enough for its correct implementation.

investigate whether the debt-growth relationship varies with the level of indebtedness. To do this, they develop tests for threshold effects using the CS-DL estimator[26]. Chudik et al. (2017) choose the level of indebtedness as the threshold variable, that is also included in the model[27]. In our case, the objective is to estimate the saving retention coefficient at different levels of risk and openness. The threshold variables (economic risk and financial plus trade openness) do not enter the estimated equation but they restrict it depending on whether they are above or below the threshold. Our specific threshold model takes the following form:

$$I_{it\tau_+} = c_{Ii\tau_+} + \theta_i' S_{it\tau_+} + \sum_{\ell=0}^{p-1} \delta_{i\ell\tau_+} \Delta S_{i,t-\ell,\tau_+} + \sum_{\ell=0}^{p_{\bar{I}}} \omega_{I,i\ell\tau_+} \bar{I}_{t-\ell,\tau_+} + \sum_{\ell=0}^{p_{\bar{S}}} \omega_{S,i\ell\tau_+}' \bar{S}_{t-\ell,\tau_+} + e_{it\tau_+} \quad (3.27)$$

$$I_{it\tau_-} = c_{Ii\tau_-} + \theta_i' S_{it\tau_-} + \sum_{\ell=0}^{p-1} \delta_{i\ell\tau_-} \Delta S_{i,t-\ell,\tau_-} + \sum_{\ell=0}^{p_{\bar{I}}} \omega_{I,i\ell\tau_-} \bar{I}_{t-\ell,\tau_-} + \sum_{\ell=0}^{p_{\bar{S}}} \omega_{S,i\ell\tau_-}' \bar{S}_{t-\ell,\tau_-} + e_{it\tau_-} \quad (3.28)$$

When risk and openness are larger than the threshold level (represented by subindex τ_+), equation (3.27) is estimated. In contrast, when risk and openness are lower than the threshold level (represented by subindex τ_-) equation (3.28) is estimated.

The thresholds have been chosen based on two factors: first, the thresholds should define the limit between low and high economic risk and a low and high degree of openness; second, we set a minimum of periods to be estimated of $T > 25$[28]. Hence, the thresholds are defined as follows: for risk, we set a low degree of economic risk for a spread lower than 70 basis points (0.7 in our data)[29], whereas risk is high when the spread is over 70. For the openness index, we set the threshold at 70%, so that over this level openness is considered to be high.

[26]Chudik et al. (2017) also use the CS-ARDL estimator, however, as it was showed by Chudik et al. (2016), the CS-DL estimator has better small sample properties, especially for $T < 50$ (as in our case).

[27]To clarify, the Chudik et al. (2017) homologous case for our FH model $I = \alpha + \beta S$ would be how the FH relationship would change when a certain $\%$ threshold of Saving/GDP is reached, which is not the goal of this paper.

[28]With the exception of the openness index ($T = 24$) when it is low.

[29]As a robustness check, we have also tried with a spread lower than 100, with no significant differences.

3.4 Results

3.4.1 Dependence and order of integration

We present in the first part of Table 3.2 the results of the Pesaran (2020) CD test on the individual variables. We have included both, Case 2 (model with constant) and 3 (model with constant and trend) since there is no clear pattern in the series and we did not want to restrict the analysis to one model. The results of the CD test on saving and investment show strong evidence against the null of cross-sectional independence. In the second part of table 3.2 we present the CD test applied to the saving-investment regression (cases 2 and 3). In line with the individual time series analysis, we find strong evidence against the null hypothesis of cross-sectional independence. From these results, we conclude that cross-sectional dependence should be taken into account.

Next, in Table 3.3 we present the panel unit root tests that account for cross-section dependence. When allowing for common factors and structural breaks, the results support the non-stationarity of the two variables, saving and investment[30]. Moreover, we also find strong evidence of multiple structural breaks affecting most of the variables analyzed, differing in number and position for individual countries, as shown in Table 3.4. Thus, we can conclude that the variables in Table 3.3 are I(1) with structural breaks.

3.4.2 Cointegration results and structural breaks

Once we have assessed the order of integration of the variables, we move to the analysis of cointegration. The results of the Banerjee and Carrion-i Silvestre (2015) test for one and two heterogeneous breaks are presented in tables 3.5 and 3.6, respectively. When we consider just one heterogeneous break, we find that the null of no cointegration is rejected for model 3 (chosen according to the AIC and BIC criteria). The first salient feature is that the location of the break coincides with the 2008-10 financial crisis for the majority of countries[31]. With some exceptions, the other breaks are found either at the end of the 70s, when the European Monetary System was adopted(Belgium, Ireland and Luxembourg[32]), the end of the 90s for Portugal, coinciding with the inception of the Euro or, in the case of Finland, in the early 90s,

[30] With a few exceptions for the Z and Z^* tests.

[31] Austria, Denmark, France, Germany, Greece, Italy, the Netherlands, Spain, Sweden and the UK

[32] They were three of the eight original members (together with Denmark, France, Germany, Italy and Netherlands).

capturing the Finnish crisis after the collapse of the Soviet Union[33]. In the case of two heterogeneous breaks (table 3.6), we cannot reject the null of no cointegration in the chosen model (model 3). However, we can reject the null for model 4, which allows for breaks in the cointegration vector. The first break in model 4 is found at the beginning of the 80s or late 70s with the EMS creation (1979), and later, during the 80s, parallel to the financial liberalization measures of the Single Market project. However, in some cases, such as France and Italy, the first break is found in the 90s, at the Maastricht treaty signature and the EMS crisis. Regarding the second break, we can split the analysis into two groups: core countries and periphery [34]. For the first group, the break occur at the Euro inception (Austria, Belgium, Germany) and the Maastricht treaty/Single Market (Finland[35], Luxembourg and Sweden). UK's break is found after the Pound left the EMS, whereas the second break for Denmark is found in 1987[36]. Regarding the peripheral countries, the 2007-2008 financial crisis and the sudden stop of capital inflows provoked large external imbalances that led to the sovereign debt crisis. Therefore, the second break for this group is found around the financial and sovereign crisis.[37]

Table 3.7 shows the Banerjee and Carrion-i Silvestre (2015) test for one homogeneous break. In this case, we can reject the null of no cointegration for all the models, with the exception of model 1. According to the AIC and BIC criteria, the best model is model 3, which allows for a break in the intercept and the trend. In this model, the break is found in 2001, at the inception of the euro, when the exchange rate risk was significantly reduced after a period of rapid financial integration. Therefore, if we restrict the endogenous selection procedure to find a single common break, the creation of the euro is the most important factor affecting the domestic investment and saving relationship for our sample.

For comparability, we report in table 3.8 the results from the Banerjee and Carrion-i Silvestre (2017) panel cointegration test, which shows no evidence of cointegration. Two potential reasons may explain this result: first, the presence of structural breaks unaccounted for; second, the role of dynamics in

[33]The Soviet Union was one of the most relevant trade partners of Finland, as well as its main supplier of energy. The end of the Soviet Union between 1990-1991 caused a large increase in the cost of energy which was one of the main factors of the Finnish crisis.

[34]France, Greece, Ireland, Italy, Portugal and Spain.

[35]For the specific case of Finland, the break can be mixing two effects: the Finnish crisis in the early 90s and the accession to the EU in 1995.

[36]The exception being the Netherlands, where the second break is found around the financial crisis.

[37]We can reject the null of no cointegration for model 1 both for one and two breaks; however, these are not the best models according to the AIC and BIC criteria.

the investment-saving relationship. The CCE estimator does not have a good dynamic performance. Therefore, we use the DCCE estimator, which is a more suitable alternative.

3.4.3 Implications in terms of capital mobility and the FH puzzle

Once we have assessed the order of integration of the variables, as well as the existence of cointegration between domestic investment and saving, the next step is to analyze the FH puzzle. We start with the traditional FH regression with no breaks (model 1)[38]. The regression with no structural breaks is included for comparability reasons since it is not the preferred model according to the AIC and BIC criteria. Concerning the regression with breaks, we report first the results with one homogeneous break. Keeping in mind the original interpretation of the FH regression, we can adapt it to our ECM model. When we obtain a parameter equal to 1 or 0 for the long-run and short-run parameters, there is capital immobility in the former case and perfect capital mobility in the latter. When the parameter is between 0 and 1, the degree of capital mobility is moderate to high. Negative values will be also interpreted as perfect capital mobility. Regarding the error correction term, it measures the speed of adjustment towards equilibrium. Therefore, if the speed is slow it will be taken as evidence in favor of capital mobility since the gap between investment and saving needs to be filled by international capital flows or investing abroad if $S > I$ (countries with current account surpluses).

Regarding the regression without breaks, we present the results for the CS-PMG estimations in table 3.9 (left side). The Hausman test of homogeneous long-run coefficients cannot be rejected, therefore, we will interpret the estimates from the CS-PMG model since they are more efficient than the CS-MG estimator with long-run heterogeneous coefficients. We report the country analysis in Table 3.10. Our main findings are, first, that the coefficient in the model without trend is large (1.27 but statistically equal to one) and significant. This evidence points in favor of strong capital immobility. However, this conclusion should be qualified if we take into account the error correction model since there is no short-run impact of domestic saving in domestic investment[39]. Additionally, the error correction parameters show a slow return to the equilibrium (12 years on average), which would point to capital mobility. The error correction parameters are significant and negative for all the countries with a long-run relationship.

[38] We have found evidence of cointegration for Model 1.

[39] With the exception of Belgium, where some short-run impact is observed.

Second, the peripheral countries (except for Ireland) have slower returns to the equilibrium than the core countries. This persistence in the investment-saving adjustment is in line with the large external imbalances observed from the inception of the euro up to the Great Recession.

The above analysis, where no breaks are allowed in the model, stresses the relevance of correctly including structural breaks in the study. Interestingly, when breaks are not considered, the results show a shallow level of economic integration and capital mobility in the long run. Therefore, not taking into account breaks in the analysis may underestimate capital mobility[40]. Non-linearity can be introduced by including structural breaks or by performing a threshold analysis. This is the goal of the analysis below.

In tables 3.9 (right side) and 3.11, we report the panel and country-by-country results for model 3 (break model). Based on the results of the Hausman test in table 3.9, we cannot reject the null hypothesis of homogeneity of the long-run parameters; hence, the efficient estimators are those obtained in the CS-PMG case.

Table model 3 (table 3.11) shows the results in our estimation. The break coincides with the inception of the euro. In this case, the value of the long-run retention parameter drastically drops to 0.34. This result shows that capital mobility is relatively high, although it is not perfect (following the definition of Feldstein and Horioka (1980)). According to Ford and Horioka (2017), a zero coefficient in the saving retention parameter means perfect integration in both goods and financial markets. Therefore, our results suggest that economic integration is relatively high for our EU sample, although it is still incomplete. Regarding capital mobility in the short-run, it is generally high, with some exceptions; Belgium and Greece, for which we observe a moderate degree of capital mobility. For Finland and France, despite observing an impact on domestic saving on domestic investment in the short-run, we can conclude that capital mobility is relatively high (although not perfect). The error correction parameters are significant and negative for all the countries. The average speed of adjustment for the panel is ten years. Again, some patterns in the speed of adjustment become apparent: for the northern countries, the adjustment is moderately quick, taking six years on average. In contrast, the peripheral countries show a slower speed of adjustment, with an average of twelve years. However, the speed of adjustment varies

[40]We can easily observe discontinuities in the series derived from several relevant economic events that occurred during the period studied: among others, the EMS creation, the signature of the Maastricht Treaty, the inception of the Euro, the financial and sovereign crisis and lastly, the recovery period up to the Covid-19 pandemic.

across them, being more sluggish for Spain and Portugal. Compared with the no-break case, Ireland is a peripheral country. This analysis, in general, concurs with the observed patterns and the persistence of the imbalances, as a slow return to the equilibrium may induce those countries to keep borrowing from abroad, enlarging their external imbalance.

We can compare our results with other papers that test the FH puzzle using a similar sample. To the best of our knowledge, only three papers have studied the same country group. Camarero et al. (2020) found that the saving-investment coefficient has been dropping over time, implying an increase in capital mobility. The authors also highlight the heterogeneity of FH relationship, even among highly integrated economies. We find similar broad results, although the econometric techniques are different. Drakos et al. (2017, 2018) using the panel cointegration methodology found moderate capital mobility. However, as we have shown, the degree of capital mobility can be underestimated if structural breaks are not taken into account.

In addition, we report in Tables 3.B and 3.C of the Appendix the results for models 5 and 6. Even though these models are not preferred, it is an interesting exercise since they also incorporate structural breaks. Model 5 adds one structural break that affects the cointegration vector. In this case, the break is found close to the year of the signature of the Maastricht treaty, in which capital barriers were removed among the EU countries. The results obtained for model 5 show an improvement in capital mobility after 1991. However, long-run capital mobility is still low. Regarding model 6, the break that affects the cointegration vector is found after the Euro inception, similar to model 3. However, we do not obtain a statistically significant effect for this structural break. Regarding the short-run capital mobility, results are in line with model 3. Overall, we can conclude that the preferred model (model 3) outperforms these other two models.

3.4.4 Threshold results

Finally, in the last step of our analysis, we estimate the saving retention coefficient at different levels of risk and openness. The objective is to assess if capital mobility and economic integration may change when a certain level of openness and risk is reached. Prior to the regression results, we briefly describe the patterns observed in the graphs of Figure 3.2. The first two graphs show the 10-year government

bond yields for the EA and the US (left-hand-side graph). We can observe a clear downward trend since 1990. In the right-hand side graph we show the risk premium, that is, the differential between the US and the EA 10-year government bond[41]. The risk premium differential displays some remarkable features: First, the differential has been higher during the periods of crises in the EA countries (the EMS crisis in the early 90s and the sovereign crisis). In contrast, the euro had an unprecedented low-risk period up to the financial crisis. In addition, the graph shows how the EMS has contributed to financial stability (until the early 90s). The third graph shows the overall openness index for the period 1970-2018. The upward trend observed until the euro coincides with the financial integration policies that started in the 70s. After the launching of the euro, openness has remained high and stable.

We now apply the threshold methodology to our data, looking for the potential impact of risk and openness on capital mobility. The previous results confirm the importance of some economic milestones behind the reduction of the saving retention coefficient. However, these nonlinearities can also be captured using variables that may explain the changes between regimes. In Tables 3.12 and 3.13 we show the results. In the case of risk (table 3.12), when it is perceived as high, we observe a significant long-run parameter that reaches 0.71 (capital immobility). As we found in our previous analysis, high risk was present during the EMS crisis in the early 90s and, more recently, during the sovereign debt crisis. In contrast, we found that the saving retention coefficient drops to zero when the risk is lower than the threshold (low-risk stage)[42]. These results show that capital mobility tends to decrease in periods of risk. However, capital mobility and economic integration increase in periods of low risk. We turn now to the threshold analysis for the openness variable. When we use the financial and trade openness index (see Table 3.13), if openness is low, we find a moderate level of capital mobility. However, for high values of the index, the FH coefficient turns out to be statistically not different from zero. In line with Ford and Horioka (2017), this result means that when openness is high, the saving retention coefficient provides evidence in favor of integrated capital and goods markets for our EU-15 group. It should be noted that the index reached its highest value after 1994[43], as its level remains a bit over 70%. According to this, perfect capital mobility was achieved even before the euro's inception, with the EU's removal of trade

[41] An increase in the risk premium differential means that the 10-year government bond yields are higher for the EA.

[42] We have repeated the estimation for a spread lower than 1 (100 basis points) and the result remains unchanged.

[43] Probably related with the completion of the Single Market and the elimination of trade and capital controls, as well as the signature of the Maastricht Treaty in 1992

and capital controls.

Both DCCE and threshold analysis provide evidence in favor of capital and economic integration; however, the latter gives more precise results. Note that both methods are complementary: while the DCCE approach estimates the whole period (1970-2019), including a structural break in 2001 (euro effect), the threshold provides information to distinguish between regimes with different degrees of risk and openness.

3.5 Conclusions

This paper studies the evolution of capital mobility in the EU-15 during the period 1970-2019 using annual data. We adopt the quantity approach, unlike most of the earlier literature, that focuses on the price approach. Our perspective can be especially suited to assess the evolution of capital mobility in the EU, where external imbalances have been a recurring problem for financial stability, especially during the last two decades, where they were persistently growing up to the 2008 financial crisis. From an econometric standpoint, we base our analysis on recent panel data techniques that exploit the cross-section and time information involved in large T-panels considering key statistical issues usually neglected in previous literature: cross-sectional dependence, structural breaks, endogeneity and dynamics.

The main contributions of our analysis are: first, we provide a complete assessment of capital mobility in the EU-15, studying not only the long-run but also providing evidence about the short-run dynamics towards equilibrium. Second, we have an appraisal on how capital mobility evolves when structural breaks are accounted for. Third, we provide empirical evidence of the Ford and Horioka (2017)'s hypothesis, according to which both financial and goods integrated markets are necessary conditions to obtain a zero coefficient in the saving retention parameter. Fourth, we analyze whether large and persistent external imbalances can be explained by the long-run relationship between domestic saving and investment; finally, we obtain an assessment of the impact of risk and openness on capital mobility.

Regarding our first three questions, when we do not account for structural breaks, our results confirm capital immobility and a very low level of economic integration in the long-run. However, capital mobility is high in the short-run. When we include multiple heterogeneous structural breaks in our analysis,

we observe that the long-run domestic saving-investment relationship has been affected by the creation of the EMS, as well as by the EMS crisis in the early 90s, the Maastricht Treaty and the financial and sovereign crises. But we find the homogeneous common break at the inception of the euro. When we incorporate the euro launching as a break in our estimation, the long-run saving retention coefficient drastically decreases, showing an improvement in capital mobility. Thus, according to Ford and Horioka (2017), the saving retention parameter obtained shows that capital mobility is high, however, the results also suggest that both, financial and real integration are incomplete. This finding is a salient feature of this paper in comparison with earlier studies and highlights the importance of accounting for structural breaks, stressing the key role played by the euro as a booster for both financial and real integration. As our methodology assesses long-run behavior, the impact of the financial and sovereign crisis cannot be isolated. Nonetheless, our threshold analysis is able to capture the financial and debt crises, characterized as a high risk period, and shows how the I-S relationship changes when risk and openness are high.

Concerning the speed of adjustment towards the long-run equilibrium, while the core countries tend to return to the equilibrium rather quickly (six years), peripheral countries return at a lower speed (twelve years). This very long path towards equilibrium, together with the savings glut generated in the core countries and the removal of capital controls may explain the large and persistent external imbalances observed within the EU-15.

Finally, we give a glimpse at some of the factors that may affect capital mobility: risk and openness. Using threshold models, we find that capital was highly immobile when economic risk was perceived as high, coinciding with episodes of economic crisis in the EU (the early 90s EMS crisis and the 2011 sovereign crisis). However, perfect capital mobility was found when the risk is low. Additionally, financial and trade openness also have an impact on capital mobility. When the openness index was low, we find evidence of moderate capital mobility, while high openness is associated to perfect mobility. This result confirms the relevance of increasing integration in the goods market as a necessary condition to achieve net transfers of financial capital.

In terms of the FH puzzle, we find that the puzzle cannot be rejected if we ignore the structural breaks that are indeed present in our sample. When we allow for structural breaks, the FH coefficient sharply decreases showing high capital mobility, although not completed yet. Our results also show that the FH

puzzle tends to return in periods when risk is perceived as high, which may hamper the transmission of monetary policy in the EA.

Figures

Figure 3.1: Domestic saving and investment series.

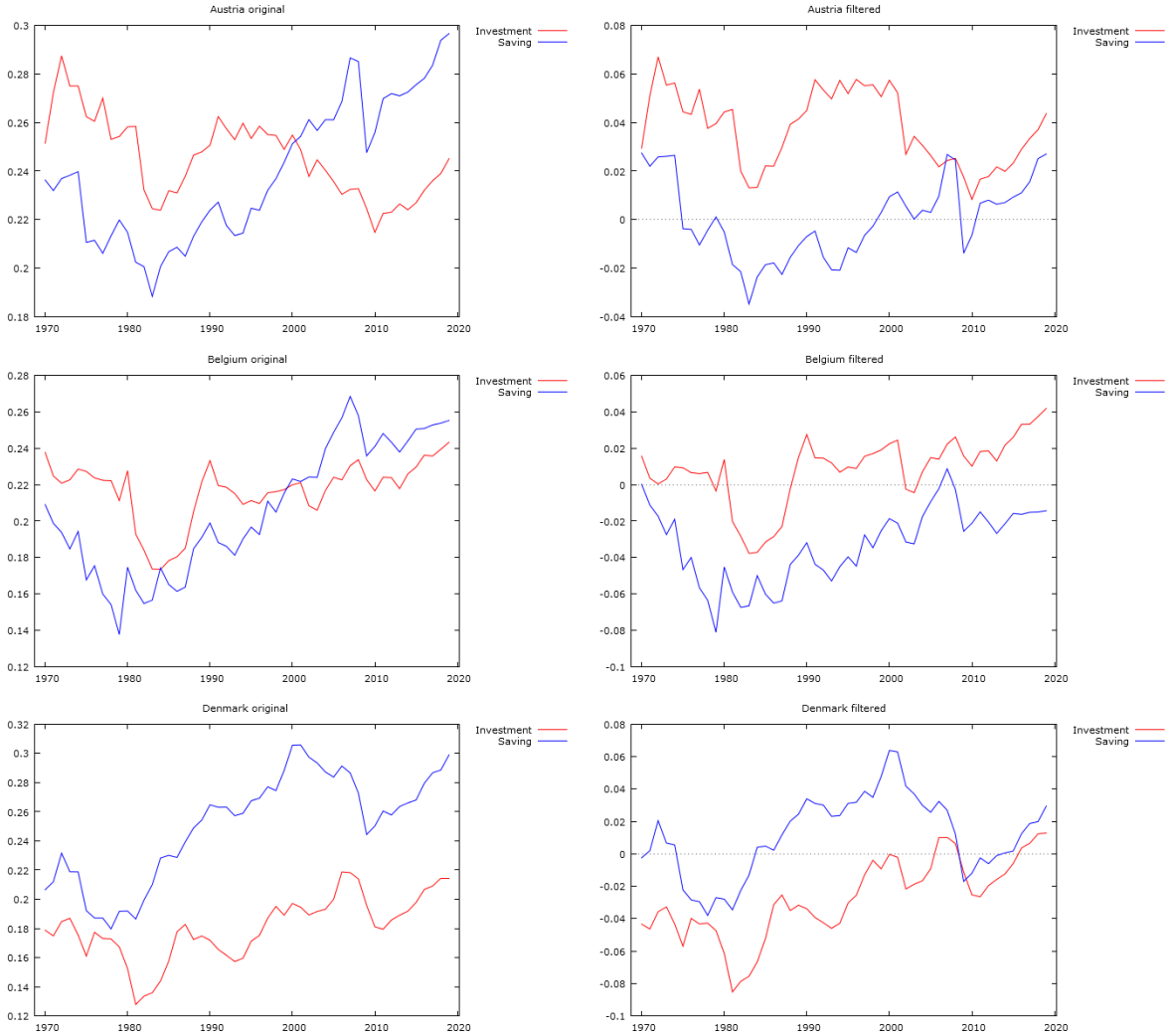


Figure 3.1: Domestic saving and investment series. Cont.

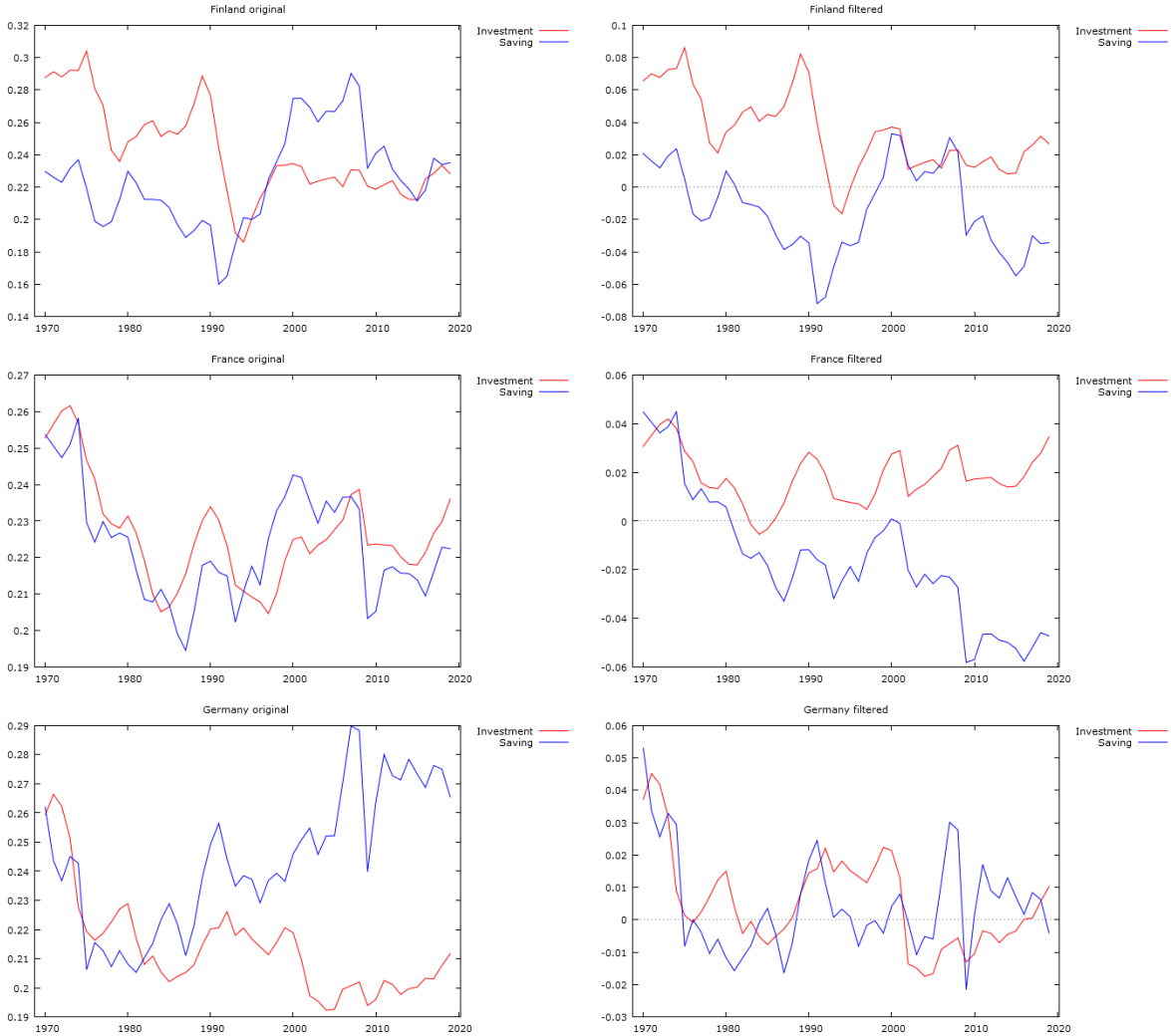


Figure 3.1: Domestic saving and investment series. Cont.

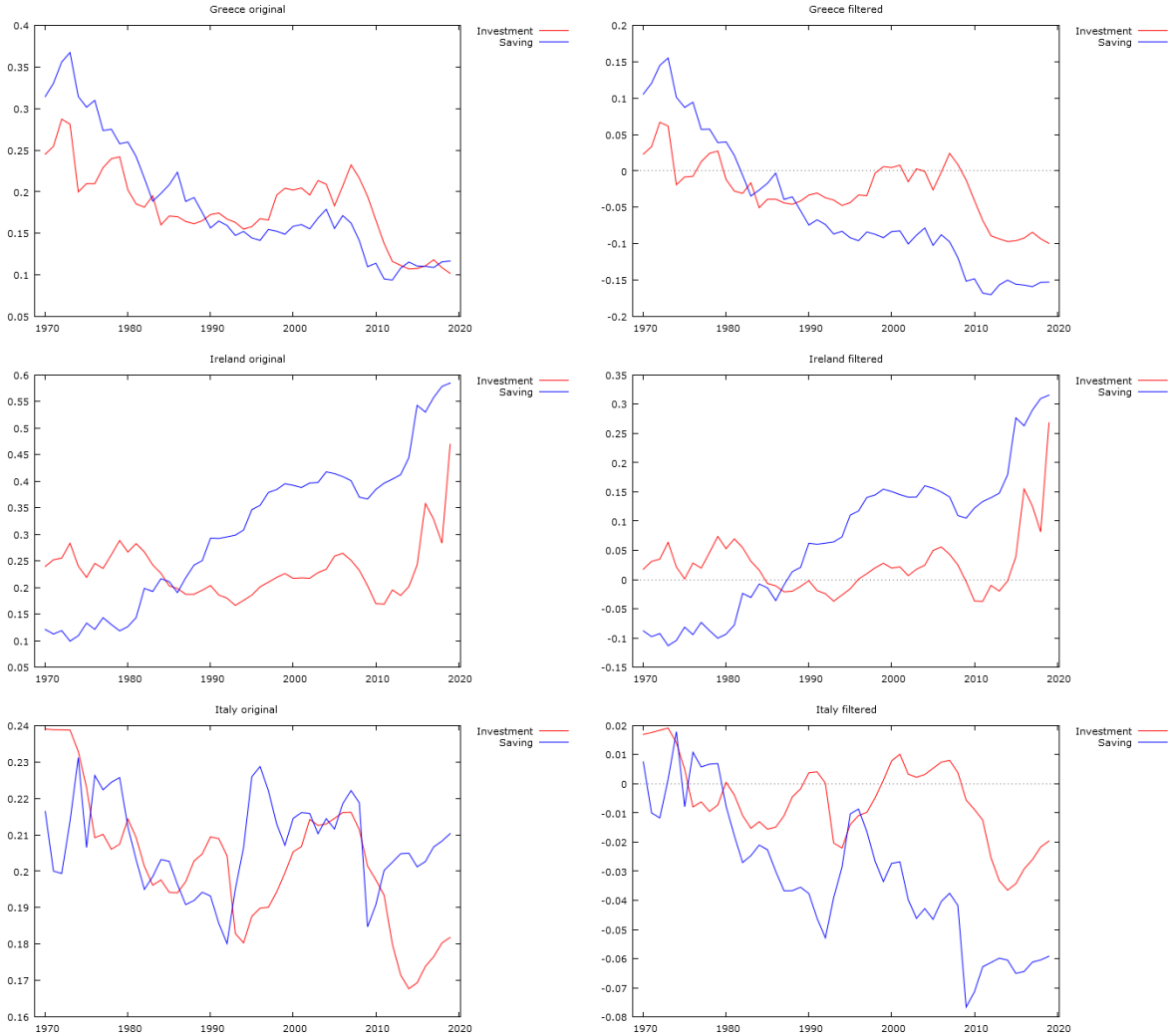


Figure 3.1: Domestic saving and investment series. Cont.

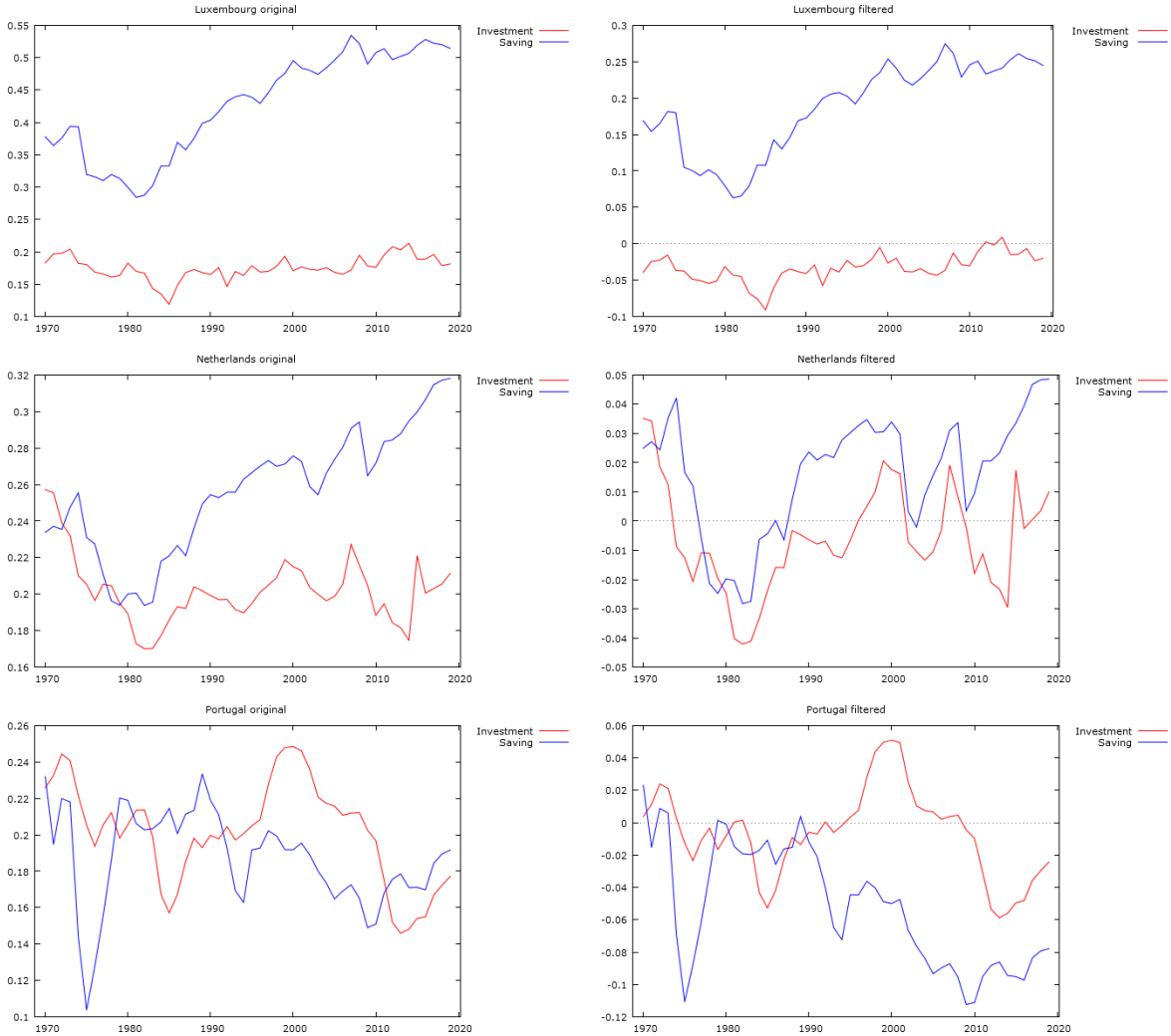


Figure 3.1: Domestic saving and investment series. Cont.

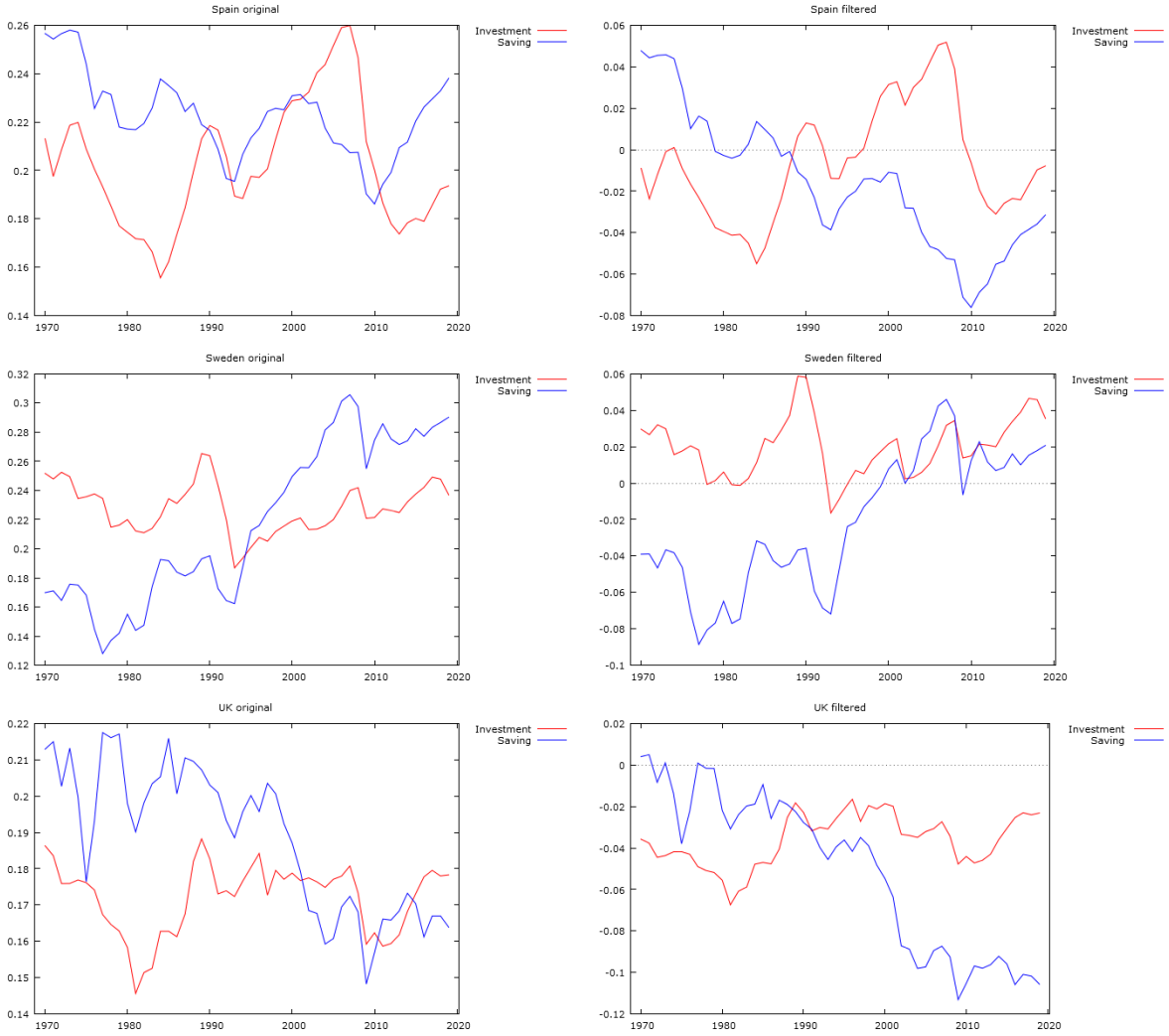


Figure 3.1: Domestic saving and investment series. Cont.

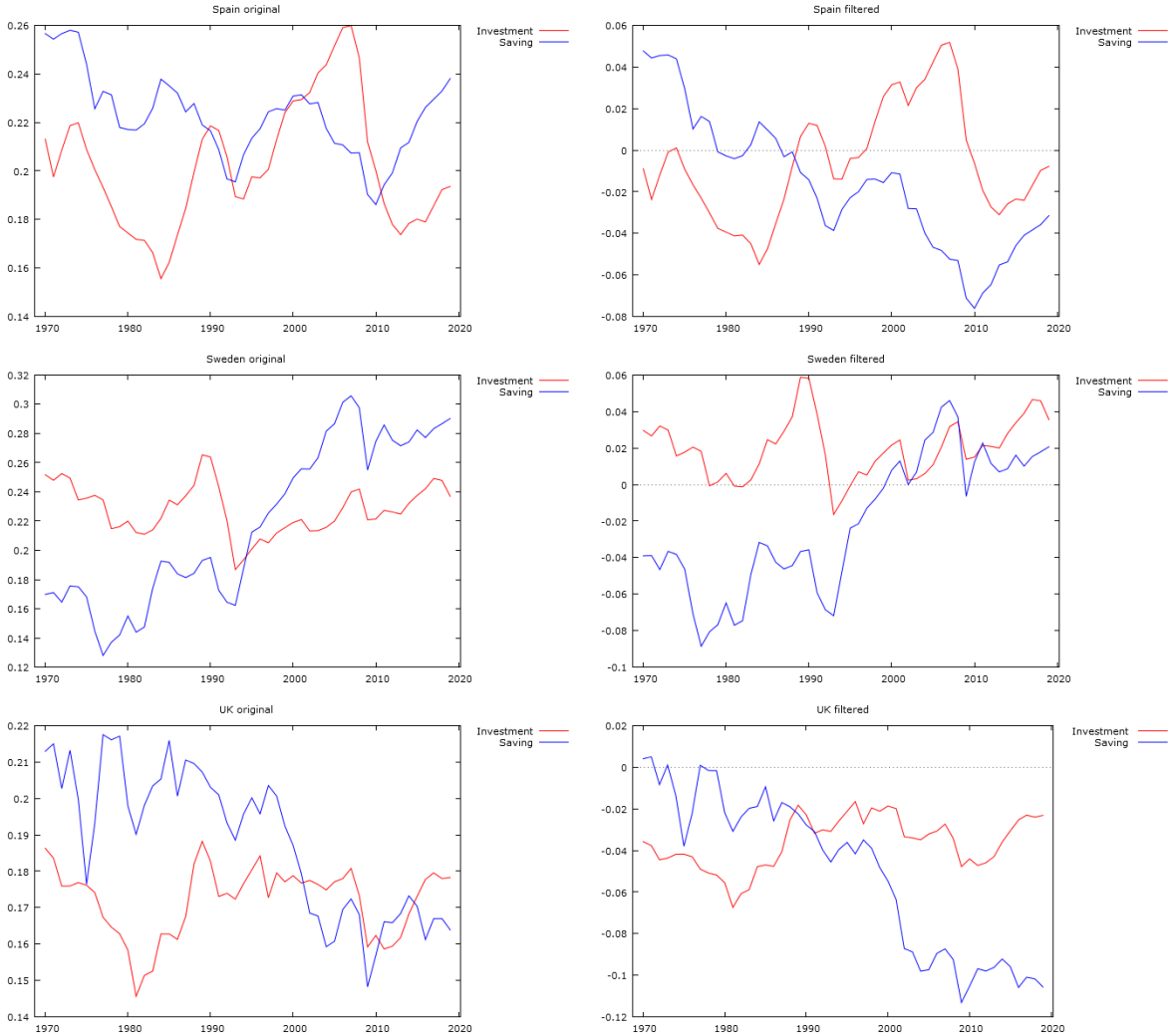
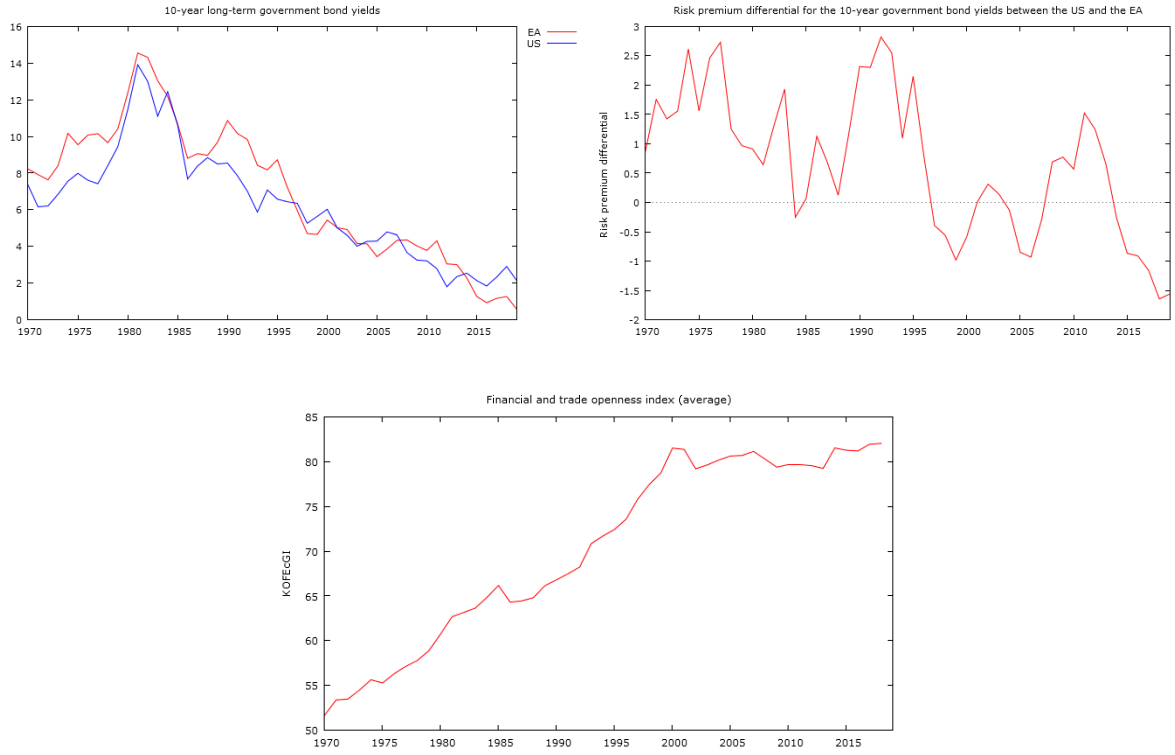


Figure 3.2: Risk, trade and financial openness index figures.



Tables

Table 3.1: Data sources.

Variable	Definition	Source
Investment	Gross fixed capital formation over GDP	OECD
Saving	GDP minus total consumption over GDP	OECD
Overall economic openness	KOFEcGI index	KOF Institute
Economic risk	10 year long-term government bond differentials between the EA and EEUU	FRED by the Federal Reserve of St. Louis

Table 3.2: Pesaran (2020) cross-sectional dependence test (CD).

A. CD on the time series

	Model 2: intercept		Model 3: intercept and trend	
ρ	Investment	Saving	Investment	Saving
0	15.48^{***}	24.79^{***}	15.66^{***}	22.24^{***}
1	11.84^{***}	24.59^{***}	12.28^{***}	21.92^{***}
2	11.84^{***}	23.18^{***}	12.38^{***}	21.21^{***}
3	11.86^{***}	23.35^{***}	12.24^{***}	21.72^{***}

B. CD on the FH regression

WCD	Model 2: intercept	Model 3: intercept and trend
$CD - statistic$	10.60^{***}	10.76^{***}

Notes:
(a): The WCD test is carried out at the 2-sided nominal significant level. ** and *** denote the rejection of weak cross-sectional dependence at the 5% and 1% levels, respectively.
(b): For the CD performed on the time series, ρ is the autoregressive order following an AR(ρ).
(c): CD test on the FH regression is performed on the Pesaran et al. (1999) Pooled Mean Group.

Table 3.3: Bai and Carrion-i Silvestre (2009) Panel Unit Root Test with common factors and structural breaks.

Variables	BIC/S	Z	P_m	P	Z^*	P_m^*	P^*	T	N	m	fr
Investment	BIC	0.62	-1.02	22.12	13.11***	-1.15	21.13	50	15	3	46
	S	0.62	-1.02	22.12	13.11***	-1.15	21.13	50	15	3	46
Saving	BIC	-1.38	0.77	35.99	4.55	0.49	33.80	50	15	3	46
	S	3.49***	-1.75	16.47	7.59	-1.69	16.90	50	15	3	46

Notes:
(a): Z, P and P_m denote the test statistics proposed by Bai and Carrion-i Silvestre (2009). Z and P_m follow a standard normal distribution and their 1%, 5% and 10% critical values are 2.326, 1.645 and 1.282, respectively. P follows a Chi-squared distribution with N x breaks (m) + 1 degrees of freedom (fr) and critical values 69.96, 61.66 and 57.51, at 1%, 5% and 10%, respectively. The number of common factors is chosen using the panel Bayesian information criterion proposed by Bai and Ng (2002). Z^*, P^* and P_m^* refer to the corresponding statistics obtained using the p-values of the simplified MSB statistics. One, two and three asterisks denote the rejection of the null hypothesis of a unit root at 10%, 5% and 1% significance levels, respectively, when the statistic is greater than the upper level.
(b): BIC and S denote the BIC and Sequential procedure used to select the number of breaks according to Bai and Perron (2003).
(c): Model 2 (change in the constant and trend).

Table 3.4: Bai and Carrion-i Silvestre (2009) Structural breaks.

Country	Investment		Saving	
	BIC	S	BIC	S
Belgium	1977	1977	-	1979
Denmark	-	-	-	2006
France	1997	1997	-	-
Germany	1977	1977	-	-
Greece	-	-	-	2007
Ireland	2011	2011	-	-
Netherlands	-	-	1996	-
	-	-	2003	-
Spain	-	-	2010	-

(a): BIC and S denote the BIC and Sequential procedure used to select the number of breaks according to Bai and Perron (2003).

Table 3.5: Banerjee and Carrion-i Silvestre (2015) panel cointegration test with 1 heterogeneous break.

1 break	Model 1	Model 2	**Model 3**	Model 4	Model 5
Austria	-	-	2010	1981	1981
Belgium	-	-	1980	1980	1980
Denmark	-	-	2008	1980	1980
Finland	-	-	1990	1992	1992
France	-	-	2008	1996	1996
Germany	-	-	2009	2001	2001
Greece	-	-	2005	1977	1977
Ireland	-	-	1981	1980	1979
Italy	-	-	2008	1992	1992
Luxembourg	-	-	1983	1985	1985
Netherlands	-	-	2006	1980	1980
Portugal	-	-	2002	1983	1983
Spain	-	-	2008	2008	2008
Sweden	-	-	2008	1992	1992
UK	-	-	2008	1980	1980
Z_J^*	-2.43***	-0.55	-3.43***	-2.14	-1.03
AIC	-7.85	-8.80	**-9.12**	-8.36	-8.95
BIC	-7.66	-8.53	**-8.75**	-7.99	-8.48

Notes:
(a): Bold values indicate the preferred model based on the information criteria. Model 1 is a stable cointegration model with constant; model 2 is a stable cointegration model that includes a trend; model 3 includes a constant and a trend allowing for changes in the constant; model 4 includes no trend and the constant and the cointegration vector may have structural changes; model 5 includes a stable trend and the constant and the cointegration vector may have structural changes.
(b) Following Banerjee and Carrion-i Silvestre (2015), Model 3 (with breaks in the trend) and model 6 cannot be performed for the cases of heterogeneous unknown breaks due to the fact that the trend cannot have heterogeneous breaks.
(c): ** and *** denote the rejection of the null of no cointegration at the 5% and 1% levels, respectively. Critical values for the Z_j^* statistic are found in Banerjee and Carrion-i Silvestre (2015) table III.
(d): Z_i^* statistic is estimated with a maximum of six common factors and up to the twelfth autoregressive order for the $AR(\rho)$.

Table 3.6: Banerjee and Carrion-i Silvestre (2015) panel cointegration test with 2 heterogeneous breaks.

2 breaks	Model 1	Model 2	**Model 3**	Model 4	Model 5
Austria	-	-	1981	1981	1981
	-	-	2008	2001	2001
Belgium	-	-	1980	1980	1980
	-	-	1987	2001	2001
Denmark	-	-	1980	1980	1980
	-	-	2008	1987	1987
Finland	-	-	1990	1977	1977
	-	-	2008	1992	1992
France	-	-	1992	1996	1996
	-	-	2008	2006	2006
Germany	-	-	1988	1980	1980
	-	-	2009	2001	2001
Greece	-	-	2002	1983	1983
	-	-	2010	2008	2008
Ireland	-	-	1981	1980	1979
	-	-	2004	2009	2009
Z_J^*	-2.43	-0.55	-0.94	-2.60**	-0.97
AIC	-7.86	-8.80	**-9.10**	-8.13	-9.00
BIC	-7.67	-8.53	**-8.64**	-7.57	-8.35

Notes:
(a): Bold values indicate the preferred model based on the information criteria. Model 1 is a stable cointegration model with constant; model 2 is a stable cointegration model that includes a trend; model 3 includes a constant and a trend allowing for changes in the constant; model 4 includes no trend and the constant and the cointegration vector may have structural changes; model 5 includes a stable trend and the constant and the cointegration vector may have structural changes.
(b) Following Banerjee and Carrion-i Silvestre (2015), Model 3 (with breaks in the trend) and model 6 cannot be performed for the cases of heterogeneous unknown breaks due to the fact that the trend cannot have heterogeneous breaks.
(c): *, ** and *** denote the rejection of the null of no cointegration at the 10% 5% and 1% levels, respectively. Critical values for the Z_j^* statistic are found in Banerjee and Carrion-i Silvestre (2015) table III.
(d): Z_t^* statistic is estimated with a maximum of six common factors and up to the twelfth autoregressive order for the $AR(\rho)$.

Table 3.6: Banerjee and Carrion-i Silvestre (2015) panel cointegration test with 2 heterogeneous breaks. Cont.

2 breaks	Model 1	Model 2	**Model 3**	Model 4	Model 5
Italy	-	-	1996	1992	1992
	-	-	2008	2011	2011
Luxembourg	-	-	1985	1985	1985
	-	-	1993	1992	1992
Netherlands	-	-	1987	1980	1980
	-	-	2006	2009	2006
Portugal	-	-	1986	1983	1983
	-	-	2002	2011	2011
Spain	-	-	1986	1977	1977
	-	-	2008	2008	2008
Sweden	-	-	1990	1977	1977
	-	-	2008	1992	1992
UK	-	-	1979	1980	1980
	-	-	2008	1996	1996
Z_J^*	-2.43***	-0.55	-0.94	-2.60**	-0.97
AIC	-7.86	-8.80	**-9.10**	-8.13	-9.00
BIC	-7.67	-8.53	**-8.64**	-7.57	-8.35

Notes:
(a): Bold values indicate the preferred model based on the information criteria. Model 1 is a stable cointegration model with constant; model 2 is a stable cointegration model that includes a trend; model 3 includes a constant and a trend allowing for changes in the constant; model 4 includes no trend and the constant and the cointegration vector may have structural changes; model 5 includes a stable trend and the constant and the cointegration vector may have structural changes.
(b) Following Banerjee and Carrion-i Silvestre (2015), Model 3 (with breaks in the trend) and model 6 cannot be performed for the cases of heterogeneous unknown breaks due to the fact that the trend cannot have heterogeneous breaks.
(c): *, ** and *** denote the rejection of the null of no cointegration at the 10% 5% and 1% levels, respectively. Critical values for the Z_j^* statistic are found in Banerjee and Carrion-i Silvestre (2015) table III.
(d): Z_t^* statistic is estimated with a maximum of six common factors and up to the twelfth autoregressive order for the $AR(\rho)$.

Table 3.7: Banerjee and Carrion-i Silvestre (2015) panel cointegration test with 1 homogeneous break.

1 break	Model 1	Model 2	**Model 3**	Model 4	Model 5	Model 6
Z_j^*	-0.48	-3.24***	-5.09***	-3.20***	-4.80***	-7.05***
AIC	-7.98	-9.05	**-9.74**	-7.70	-8.91	-9.69
BIC	-7.80	-8.77	**-9.28**	-7.33	-8.45	-9.13
$Break$	-	-	2001	1983	1991	2001

Notes:
(a): Bold values indicate the preferred model based on the information criteria. Model 1 is a stable cointegration model with constant; model 2 is a stable cointegration model that includes a trend; model 3 includes a constant and a trend allowing for changes in both; model 4 includes no trend and the constant and the cointegration vector may have structural changes; model 5 includes a stable trend and the constant and the cointegration vector may have structural changes; model 6 allows for breaks in the constant, the trend and the cointegration vector.
(b): ** and *** denote the rejection of the null of no cointegration at the 5% and 1% levels, respectively. Critical values for the Z_j^* statistic are found in Banerjee and Carrion-i Silvestre (2015) table III.
(d): Z_t^* statistic is estimated with a maximum of six common factors and up to the twelfth autoregressive order for the $AR(\rho)$.

Table 3.8: Banerjee and Carrion-i Silvestre (2017) panel cointegration test using Pesaran's PCCE estimator.

	Model 1: intercept		Model 2: intercept and trend	
ρ	$r=1$	$r=2$	$r=1$	$r=2$
0	-2.04	-2.21	-2.26	-2.12
1	-2.25	-2.49	-2.48	-2.37
2	-1.91	-2.06	-2.18	-2.03

Notes:
(a): ** and *** denote the rejection of the null of no cointegration at the 5% and 1% levels, respectively. Critical values are found in Banerjee and Carrion-i Silvestre (2017) table 1, 2, 3 and 4.
(b): r refers to the number of common factors and ρ is the order of the autoregressive correction for the panel cointegration CCE statistic (CADF).
(c): Following Banerjee and Carrion-i Silvestre (2017), the number of common factor (r) is assumed to be the same as the k variables (rank condition is met with inequality) or k+1 variables (rank condition is met with equality) in the long-run specification of the Pooled Common Correlated Effects (PCCE). In our case, r=1 and r=2, respectively.

Table 3.9: Panel Chudik and Pesaran (2015) DCCE-ECM Panel results.

	1970-2019	
	Model 1 (traditional FH)	Model 3 (with breaks)
Parameter	DCCE(CS-PMG)	DCCE (CS-PMG)
LR parameter	1.27***	0.34***
(s.e.)	(0.22)	(0.05)
EC term	-0.14***	-0.18***
(s.e.)	(0.02)	(0.05)
SR parameter	-0.13**	-0.04
(s.e.)	(0.05)	(0.07)
Hausman test	2.45	1.36
(p-value)	(0.12)	(0.24)

Notes:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. Number in brackets are standard errors.
(b): LR, EC and SR stand for long-run, error correction and short-run, respectively.
(c): DCCE(CS-PMG) refers to the DCCE estimated by the PMG.
(d): For the Hausman test, *, ** and ** denote the rejection of the null of long-run parameter homogeneity at the 10%, 5% and 1% levels.

Table 3.10: Chudik and Pesaran (2015) DCCE-ECM (CS-PMG) country analysis (no break model with constant).

EU 15	Model with constant and no breaks 1970-2019			
Country	LR parameter	EC term	SR parameter	Years to return
Austria	1.27***	-0.11***	-0.01	9
	(0.22)	(0.01)	(0.04)	
Belgium	1.27***	-0.13***	0.42***	8
	(0.22)	(0.01)	(0.02)	
Denmark	1.27***	-0.08***	-0.01	11
	(0.22)	(0.01)	(0.03)	
Finland	1.27***	-0.22***	-0.13***	5
	(0.22)	(0.01)	(0.02)	
France	1.27***	-0.04***	0.06*	25
	(0.22)	(0.02)	(0.02)	
Germany	1.27***	-0.21***	-0.30**	5
	(0.22)	(0.01)	(0.01)	
Greece	1.27***	-0.08***	0.03	13
	(0.22)	(0.01)	(0.04)	
Ireland	1.27***	-0.29***	-0.30***	3
	(0.22)	(0.01)	(0.04)	
Italy	1.27***	-0.05***	-0.27***	20
	(0.22)	(0.01)	(0.01)	
Luxembourg	1.27***	-0.26***	-0.38***	4
	(0.22)	(0.01)	(0.02)	
Netherlands	1.27***	-0.23***	-0.39***	4
	(0.22)	(0.01)	(0.06)	
Portugal	1.27***	-0.03***	-0.12***	33
	(0.22)	(0.01)	(0.01)	
Spain	1.27***	-0.04***	-0.29***	25
	(0.22)	(0.01)	(0.03)	
Sweden	1.27***	-0.26***	-0.17***	4
	(0.22)	(0.01)	(0.02)	
United Kingdom	1.27***	-0.10***	-0.17***	11
	(0.22)	(0.01)	(0.01)	
Average years to return				12
Model selection criteria		BIC (1,1)		

Note:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. Number in brackets are standard errors.
(b): LR, EC and SR stand for long-run, error correction and short-run, respectively.

Table 3.11: Chudik and Pesaran (2015) DCCE-ECM (CS-PMG) country analysis with one break (model 3).

EU 15	1970-2019			
Country	LR parameter	EC term	SR parameter	Years to return
Austria	0.34***	-0.12***	-0.09	8
	(0.05)	(0.01)	(0.05)	
Belgium	0.34***	-0.12***	0.49***	8
	(0.05)	(0.01)	(0.01)	
Denmark	0.34***	-0.08***	0.05	12
	(0.05)	(0.01)	(0.04)	
Finland	0.34***	-0.17***	0.12***	6
	(0.05)	(0.01)	(0.02)	
France	0.34***	-0.03***	0.19**	30
	(0.05)	(0.01)	(0.02)	
Germany	0.34***	-0.19***	-0.14***	5
	(0.05)	(0.01)	(0.01)	
Greece	0.34***	-0.11***	0.40***	9
	(0.05)	(0.01)	(0.04)	
Ireland	0.34***	-0.11***	0.01	9
	(0.05)	(0.01)	(0.04)	
Italy	0.34***	-0.11***	-0.29***	9
	(0.05)	(0.01)	(0.01)	
Luxembourg	0.34***	-0.52***	-0.39***	2
	(0.05)	(0.01)	(0.02)	
Netherlands	0.34***	-0.77***	-0.43***	2
	(0.05)	(0.02)	(0.04)	
Portugal	0.34***	-0.05***	-0.09***	20
	(0.05)	(0.01)	(0.01)	
Spain	0.34***	-0.08***	-0.36***	13
	(0.05)	(0.01)	(0.03)	
Sweden	0.34***	-0.22***	0.06**	5
	(0.05)	(0.01)	(0.02)	
United Kingdom	0.34***	-0.14***	-0.17***	7
	(0.05)	(0.01)	(0.01)	
Average years to return				10
Model selection criteria		BIC (1,1)		

Note:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. Number in brackets are standard errors.
(b): LR, EC and SR stand for long-run, error correction and short-run, respectively.

Table 3.12: Chudik et al. (2016) CS-DL threshold model with risk variable.

	1970-2019		
Parameter	Spread <0.7	Spread <1	>0.7
Long-run coefficient	0.02	0.16	0.71**
(standard error)	(0.33)	(0.17)	(0.31)
Constant	0.02	0.00	-0.00
(standard error)	(0.00)	(0.00)	(0.00)
T	25	30	25
N	15	15	15
NxT	375	450	375

Notes:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. According to the sample size, 2 distributed lags of saving have been included.
(b):Number in brackets are standard errors.

Table 3.13: Chudik et al. (2016) CS-DL threshold model with trade and financial openness index.

	1970-2018	
Parameter	Index lower than 70%	Index larger than 70%
Long-run coefficient	0.58***	0.04
(standard error)	(0.17)	(0.10)
Constant	0.00	0.00
(standard error)	(0.00)	(0.00)
T	24	25
N	15	15
NxT	360	375

Notes:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. According to the sample size, the cross-sectional averages, $T^{1/3}$ lags are included to acount for cross-sectional dependence. According to the sample size, 2 distributed lags of saving have been included.
(b): Number in brackets are standard errors.

Appendix

3.A Mathematical transformation of the DCCE into an ECM

$$y_{it} = c_{iy} + \phi_i y_{i,t-1} + \beta_{0i} x_{it} + \beta_{1i} x_{i,t-1} + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.29}$$

$$y_{it} - y_{i,t-1} = c_{iy} + \phi_i y_{i,t-1} - y_{i,t-1} + \beta_{0i} x_{it} + \beta_{1i} x_{i,t-1} + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.30}$$

$$\Delta y_{it} = c_{iy} - (\phi_i - 1) y_{i,t-1} + \beta_{0i} x_{it} + \beta_{1i} x_{i,t-1} + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.31}$$

$$\Delta y_{it} = c_{iy} - (\phi_i - 1) y_{i,t-1} + \beta_{0i} x_{it} - \beta_{0i} x_{i,t-1} + \beta_{0i} x_{i,t-1} + \beta_{1i} x_{i,t-1} + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.32}$$

$$\Delta y_{it} = c_{iy} - (\phi_i - 1) y_{i,t-1} + \beta_{0i} \Delta x_{it} + \beta_{0i} x_{i,t-1} + \beta_{1i} x_{i,t-1} + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.33}$$

$$\Delta y_{it} = c_{iy} - (\phi_i - 1) y_{i,t-1} + \beta_{0i} \Delta x_{it} + \gamma_{1i} x_{i,t-1} + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.34}$$

Being: $\gamma_{1i} = \beta_{0i} + \beta_{1i}$

$$\Delta y_{it} = c_{iy} + \beta_{0i} \Delta x_{it} - \lambda_i (y_{i,t-1} - \gamma_{1i} x_{i,t-1}) + \sum_{\ell=0}^{\rho T} \delta'_{i\ell} \bar{z}_{t-\ell} + e_{yit} \tag{3.35}$$

λ_i and γ_{1i} are defined as: $\lambda_i = (1 - \phi)$ and $\gamma_{1i} = \frac{\beta_{0i} + \beta_{1i}}{(1-\phi)}$

Table 3.A: KOFEcGI index definition.

Index	Variable name	Variable definitions
	Foreign direct Investment	Sum of stocks of assets and liabilities of Foreign direct Investment (% of GDP)
	Portfolio investment	Sum of stocks of assets and liabilities of international equity portfolio investments (% of GDP)
	International debt	Sum of inward and outward international portfolio debt securities and international bank loans and deposits (% of GDP)
	International reserves	Includes foreign exchange (excluding gold), SDR holdings and reserve position in the IMF (% of GDP)
	International income payments	Sum of capital and labour income to foreign nationals and from abroad (% of GDP)
KOFEcGI	Investment restrictions	Prevalence of foreign ownership and regulations to international capital flows
	Capital account openness	Chinn-Ito index of capital account openness
	International investment agreements	Number of Bilateral Investment Agreements (BITs) and Treaties with Investment Provisions (TIPs)
	Trade in goods	Exports and imports of goods (% of GDP)
	Trade in services	Exports and imports of services (% of GDP)
	Trade partner diversity	Average of the Herfindahl-Hirschman market concentration index for exports and imports of goods (inverted)
	Trade regulations	Average of two subcomponents: Prevalence of non-tariff trade barriers and compliance costs of importing and exporting
	Trade taxes	Income from taxes on international trade as percentage of revenue (inverted)
	Tariffs	Unweighted mean of tariff rates
	Trade agreements	Number of bilateral and multilateral free trade agreements

Table 3.B: Chudik and Pesaran (2015) DCCE-ECM country analysis (model 5).

EU 15	1970-2019					
Country	LR before 1991	LR after 1991	EC term	SR before 1991	SR after 1991	Years to return
Austria	0.72***	0.60***	-0.15***	-0.10	0.02***	7
	(0.12)	(0.02)	(0.01)	(0.05)	(0.01)	
Belgium	0.72***	0.60***	-0.16***	0.44***	0.03***	6
	(0.12)	(0.025)	(0.01)	(0.01)	(0.03)	
Denmark	0.72***	0.60***	-0.08***	0.11**	0.01***	13
	(0.12)	(0.02)	(0.01)	(0.03)	(0.01)	
Finland	0.72***	0.60***	-0.25***	0.05	-0.08***	4
	(0.12)	(0.02)	(0.01)	(0.02)	(0.01)	
France	0.72***	0.60***	-0.26***	0.10***	0.01***	4
	(0.12)	(0.02)	(0.01)	(0.01)	(0.01)	
Germany	0.72***	0.60***	-0.10***	-0.07***	0.05***	10
	(0.12)	(0.02)	(0.01)	(0.01)	(0.01)	
Greece	0.72***	0.60***	0.03**	0.46***	0.06***	-
	(0.12)	(0.02)	(0.01)	(0.04)	(0.01)	
Ireland	0.72***	0.60***	-0.20***	-0.08*	0.02*	5
	(0.12)	(0.02)	(0.01)	(0.03)	(0.01)	

Note:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. Number in brackets are standard errors.
(b): LR, EC and SR stand for long-run, error correction and short-run, respectively.

Table 3.B: Chudik and Pesaran (2015) DCCE-ECM country analysis (model 5). Cont.

EU 15	1970-2019					
Country	LR before 1991	LR after 1991	EC term	SR before 1991	SR after 1991	Years to return
Italy	0.72***	0.60***	-0.11***	-0.31***	0.03***	9
	(0.12)	(0.02)	(0.01)	(0.01)	(0.01)	
Luxembourg	0.72***	0.42***	-0.37***	-0.37***	-0.03***	3
	(0.12)	(0.02)	(0.01)	(0.02)	(0.01)	
Netherlands	0.72***	0.60***	-0.40***	-0.65***	-0.05***	3
	(0.12)	(0.02)	(0.01)	(0.04)	(0.01)	
Portugal	0.72***	0.60***	0.03***	-0.06***	0.06***	-
	(0.12)	(0.02)	(0.01)	(0.01)	(0.02)	
Spain	0.72***	0.60***	-0.06***	-0.23***	-0.01***	17
	(0.12)	(0.02)	(0.01)	(0.02)	(0.01)	
Sweden	0.72***	0.60***	-0.39***	-0.20***	0.00	3
	(0.12)	(0.02)	(0.01)	(0.02)	(0.01)	
United Kingdom	0.72***	0.60***	-0.19***	-0.17***	0.03***	5
	(0.12)	(0.02)	(0.01)	(0.01)	(0.01)	
Average years to return						7
Model selection criteria			BIC (1,1)			

Note:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. Number in brackets are standard errors.
(b): LR, EC and SR stand for long-run, error correction and short-run, respectively.

Table 3.C: Chudik and Pesaran (2015) DCCE-ECM country analysis (model 6).

EU 15	1970-2019					
Country	LR before 2001	LR after 2001	EC term	SR before 2001	SR after 2001	Years to return
Austria	0.54***	0.01	-0.16***	0.07	-0.24***	6
	(0.09)	(0.05)	(0.01)	(0.06)	(0.04)	
Belgium	0.54***	0.01	-0.11***	0.44***	0.13**	9
	(0.09)	(0.05)	(0.01)	(0.01)	(0.03)	
Denmark	0.54***	0.01	-0.12***	0.23**	-0.22***	8
	(0.09)	(0.05)	(0.01)	(0.04)	(0.01)	
Finland	0.54***	0.01	-0.35***	-0.15***	0.09**	3
	(0.09)	(0.05)	(0.01)	(0.02)	(0.03)	
France	0.54***	0.01	-0.27***	0.00	0.34***	4
	(0.09)	(0.05)	(0.01)	(0.01)	(0.01)	
Germany	0.54***	0.01	-0.30***	-0.37***	0.08***	3
	(0.09)	(0.05)	(0.01)	(0.01)	(0.01)	
Greece	0.54***	0.01	-0.11***	-0.25***	0.33***	9
	(0.09)	(0.05)	(0.01)	(0.04)	(0.03)	
Ireland	0.54***	0.01	-0.13***	-0.40***	0.61***	8
	(0.09)	(0.05)	(0.01)	(0.04)	(0.03)	

Note:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. Number in brackets are standard errors.
(b): LR, EC and SR stand for long-run, error correction and short-run, respectively.

Table 3.C: Chudik and Pesaran (2015) DCCE-ECM country analysis (model 6). Cont.

EU 15	1970-2019					
Country	LR before 2001	LR after 2001	EC term	SR before 2001	SR after 2001	Years to return
Italy	0.54***	0.01	-0.05***	-0.28***	-0.16***	20
	(0.09)	(0.05)	(0.01)	(0.01)	(0.01)	
Luxembourg	0.54***	0.01	-0.54***	-0.49***	0.01**	2
	(0.09)	(0.05)	(0.01)	(0.02)	(0.01)	
Netherlands	0.54***	0.01	-0.67***	-0.26***	-0.51***	1
	(0.09)	(0.05)	(0.02)	(0.04)	(0.06)	
Portugal	0.54***	0.01	-0.11***	-0.19***	0.06*	9
	(0.09)	(0.05)	(0.01)	(0.01)	(0.02)	
Spain	0.54***	0.01	-0.04***	-0.24***	-0.28***	25
	(0.09)	(0.05)	(0.01)	(0.03)	(0.04)	
Sweden	0.54***	0.01	-0.37***	-0.20***	0.03	3
	(0.09)	(0.05)	(0.01)	(0.03)	(0.03)	
United Kingdom	0.54***	0.01	-0.19***	-0.18***	0.04***	5
	(0.09)	(0.05)	(0.01)	(0.01)	(0.01)	
Average years to return						8
Model selection criteria			BIC (1,1)			

Note:
(a): *, ** and ** denote statistical significance at the 10%, 5% and 1% levels. Following Chudik and Pesaran (2015), the cross-sectional averages and $T^{1/3}$ lags are included to account for cross-sectional dependence. Number in brackets are standard errors.
(b): LR, EC and SR stand for long-run, error correction and short-run, respectively.

Chapter 4

Unveiling the drivers of portfolio equity and bond investment in the European Union: The interplay of tax havens and gravity factors

4.1 Introduction

Capital mobility is a key issue in international macroeconomics. Baele et al. (2004) outline three widely accepted interrelated benefits of financial integration: higher efficiency, better risk-sharing opportunities, and more growth potential. 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 provide broader protection from shocks in a single currency area and enhance cross-country risk-sharing, that is, help to decouple consumption and output dynamics when an asymmetric shock occurs (Kalemli-Ozcan et al., 2003).[1] To reap the benefits of these favorable effects, impediments

[1] 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, capital market integration facilitates the absorption of structural shocks that affect permanent income via risk dispersion and diversification from the cross-border holding of assets.

to capital mobility began to be dismantled in the US and the UK in the 1970s, and other developed countries followed suit in the 1980s.

In the EU, this liberalization process also started in the 1980s and the beginning of the 1990s following the Single Market initiative, which implied full capital mobility by 1992 after the Maastricht Treaty (OECD, 2011). The process continued with the creation of the European passport for financial services and the Financial Services Action Plan starting in 1999, the Lamfalussy process from 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.

The creation of the EU has significantly impacted the cross-border allocation of capital in bonds and equity portfolios within its member countries. The EU integration process created a single market for financial services, facilitating cross-border investment and increasing market efficiency. One of the key developments in the EU integration process has been the creation of the Eurozone. The euro adoption has accelerated financial integration between member states, eliminated currency exchange risks, and reduced transaction costs for cross-border investments. Another important factor contributing to integrating capital markets within the EU is the harmonization of financial regulations. The EU has implemented a range of directives and regulations to create a level playing field for financial markets, including the Markets in Financial Instruments Directive (MiFID) and the Capital Requirements Directive (CRD). These directives have helped to harmonize financial regulations and reduce regulatory barriers to cross-border investment.

The growth of cross-border financial institutions, such as investment banks and asset managers, has also facilitated the integration of capital markets within the EU. These institutions have expanded their operations across multiple member states, creating a pan-European financial services network that has made it easier for investors to access and invest in different markets.

As a result of these developments, the cross-border allocation of capital in bonds and equity portfolios within the EU has increased significantly. According to data from the European Central Bank (ECB, 2022), the share of cross-border holdings in euro-denominated bonds and equities has risen steadily since introducing the euro in 1999. For example, in 2020, cross-border holdings accounted for approximately

54% of the outstanding euro-denominated bonds and 22% of the euro-denominated equities.

However, since the Great Recession of 2007-2008, financial markets have experienced a series of severe drawbacks regarding the ongoing process of globalization. In the case of the euro area, the risk is derived from market fragmentation, excessive sovereign debt, and uncertainty caused by the fears of an eventual break-up of the European Monetary Union (EMU). The ECB has been carrying out measures[2] to fight market fragmentation since the beginning of the financial crisis and the subsequent sovereign crisis (2010-2012) and COVID-19 pandemics (2020-2022). Despite its efforts, the issue is far from being over. Nowadays, high inflation is a novel feature in the economic situation that makes the fight against financial fragmentation more arduous. In this sense, market fragmentation entails risk premia for sovereign bonds, interbank market disconnect, lower cross-border capital flows, and asymmetrical monetary policy transmission.

Another pivotal hallmark of this study, primarily neglected in the analysis of capital mobility, is the role played by tax havens. Their relevance has been increasing since the outbreak of the financial crisis. This remarkable fact coincides with global companies issuing securities through cross-border affiliates in tax havens aiming to avoid capital controls, reduce tax loads, or access global capital markets (with better financial conditions or longer maturities). As mentioned above, the impact of tax havens has usually been neglected in the literature on global capital mobility; however, given their growing relevance, an analysis of capital mobility drivers cannot be performed without adequately treating these tax havens.

According to the 6th Edition of Balance of Payments and International Investment Position Manual (IMF, 2009), the functional categories used for financial transactions and position are: a) Direct investment (FDI), b) portfolio investment (both equity and bonds), c) financial derivatives[3] and employee stock options, d) other investment and e) reserve assets. In this paper, we focus our analysis on portfolio equity and bond stocks. In contrast to another type of investment (such as FDI[4]), portfolio investment usually has less decision power in the company's operational management. However, it provides easy access to

[2]For example, the Securities Market Programme (SMP) between 2010 and 2012, the Outright Monetary Transactions (OMT) from 2012 onward, and the Public Sector Purchase Programme (PSPP) since 2015. With the outbreak of the COVID-19 crisis, the ECB launched the Pandemic Emergency Purchase Programme (PEPP).

[3]Other than reserves.

[4]Equity can be classified as FDI or portfolio. Ownership of 10 percent of the voting power of an enterprise by a non-resident investor is taken as evidence of a direct investment relationship.

the financial markets, liquidity, and flexibility.

This paper assesses the drivers of portfolio equity and bonds stocks in the EU's aftermath of the Great Recession and the European debt crisis, covering the sample period 2007-2017. To the best of our knowledge, no studies jointly address drivers of portfolio investments using the gravity equation, in which resistance variables are modeled through financial restrictions and the existence of tax havens is taken into account. This is especially true in the case of the EU.

We contribute to the literature in different respects. First, unlike most previous studies, we use a recent database put together by Coppola et al. (2021) that accounts for the role of financial intermediaries that issue assets through tax havens. In this vein, the database re-maps portfolio stock to the actual source and destination countries. This is a crucial improvement compared to traditional databases for portfolios (for example, the IMF CPIS database) built under the residence principle. Properly addressing the role of tax havens is particularly relevant for some types of assets with a significant presence, for instance, portfolio equity.

Second, another salient feature of this paper is that we estimate the gravity equation following the theoretical model developed by Okawa and Van Wincoop (2012). Specifically, we model bilateral and multilateral resistance with financial restrictions between the country pair and relative to the rest of the world. By doing so, we provide a more comprehensive analysis of the determinants of cross-border asset trade holdings. This might help researchers and policymakers better understand the complex dynamics underlying these assets. We also perform a robustness check to ensure that our results remain robust to model specification and use a different set of variables to model first, bilateral and multilateral resistance and second, historical links.

Finally, as a comparison exercise, we perform the analysis using the IMF (CPIS) database built under the residence principle and compare the results with the ones obtained with the Coppola et al. (2021) database.

The remainder of the paper is organized as follows: in section 4.2, we present the stylized facts and the role of tax havens that justify our paper; in section 4.3, we review the empirical literature on the subject. Section 4.4 summarizes the data and econometric methodology used. Section 4.5 discusses the empirical

results. Finally, section 4.6 concludes.

4.2 The relevance of tax havens for portfolio investments: some stylized facts

The large and growing capital flows of securities have long been an important subject for research in international finance. Yet, the literature accounting for the relative importance of tax havens' among the motives and incentives behind these flows is scarce. This is due to a lack of reliable data quantifying the inflows and outflows across years and countries and information on investors, issuers, and asset types. This situation has recently changed. Fresh papers like Damgaard et al. (2019) for the case of FDI and Coppola et al. (2021) and Beck et al. (2023) for portfolio investment provide data to document the increasing role of tax havens. Offshore centers with enormous inward and outward positions blur statistics on international investments. To solve this problem, these new databases account for offshore investment and financing vehicles in tax havens remapping from a residence to a nationality basis.

A tax haven is a jurisdiction that offers individuals, businesses, or financial intermediaries more favorable regulations and low or no tax liability. Economic, political, and legal factors largely drive the existence of tax havens. From an economic perspective, tax havens serve as attractive destinations for individuals and businesses seeking to reduce their tax burden. From a legal perspective, tax havens result from favorable laws and regulations that allow individuals and companies to minimize their tax liabilities. These laws and regulations often include strict bank secrecy laws, which protect the confidentiality of financial information, and limited exchange of information agreements with other jurisdictions, which prevent sharing of financial information with foreign tax authorities.

During the 1960s and 1970s, the persistence of outdated and distorting regulations in the financial sectors of industrial countries played a significant role in the emergence of offshore banking and the proliferation of Offshore Financial Centers (OFCs), more commonly known as *tax havens*. In this text, we are going to use indistinctly both terms. Although there is no strict definition of OFCs, the IMF (IMF, 2000) proposes an operational definition based on three characteristics: a) Jurisdictions that have a relatively high number of financial institutions engaged in business with non-residents, b) Financial systems with

external assets and liabilities out of proportion to domestic financial intermediation designed to finance domestic economies, and c) Centers that provide some or all of the following services: low or zero taxation; moderate or light financial regulation; banking secrecy and anonymity.

The existence of tax havens can be attributed to a multitude of factors, but three primary drivers have been identified. Firstly, minimizing their tax burden is paramount for multinational corporations with substantial intangible assets. Secondly, firms operating in emerging markets are keen to enhance their access to the global financial markets. In this context, firms from certain jurisdictions may benefit from lower financing costs (in terms of interest rates) when issuing from a financial intermediary and obtaining longer tenors. Financial intermediaries located in tax havens are also viewed as a means of circumventing capital controls and other regulatory barriers[5]. Lastly, the significance of mutual and investment funds in global equity and bond portfolio markets continues to increase. In the European Union, the first driver has been the primary reason companies relocate their holdings from other EU member states to countries like Cyprus, Ireland, Luxembourg, Malta, and the Netherlands.

In Asia, the development of offshore interbank markets gained momentum in 1968 with the launch of the Asian Dollar Market (ADM) in Singapore and the introduction of Asian Currency Units (ACUs). In the early 1970s, Luxembourg in Europe started attracting investors from Germany, France, and Belgium. This was primarily due to its low-income tax rates, absence of withholding taxes for nonresidents on interest and dividend income, and strict banking secrecy rules. Similarly, the Channel Islands and the Isle of Man presented similar investor opportunities. Moving to the Middle East, Bahrain emerged as a significant hub for collecting the region's oil surpluses during the mid-1970s. It achieved this by enacting banking laws and offering tax incentives to facilitate the establishment of offshore banks. In the Western Hemisphere, the Bahamas and the Cayman Islands provided comparable facilities to attract investors.

Towards the end of the 1990s, the appeal of offshore banking began to shift for financial institutions in industrial countries. Factors such as reserve requirements, interest rate controls, and capital controls diminished significantly, while the tax advantages continued to exert a strong influence. Moreover, major industrial countries like the United States and Japan started offering similar incentives within their

[5]For instance, Variable Interest Entities (VIEs) are employed as opaque corporate structures to access China's key industry companies, such as Alibaba Group Holding Limited, headquartered in the Cayman Islands.

jurisdictions. Consequently, the relative appeal of OFCs for traditional banking has diminished for industrial countries, although the tax advantages associated with asset management have gained significance. Presently, banking operations within OFCs are primarily conducted by branches and subsidiaries of banks incorporated elsewhere, primarily in major countries and larger emerging market economies. Offshore banks engage in diverse activities, including foreign currency loans (syndicated loans) and deposit-taking, issuance of securities, over-the-counter (OTC) trading in derivatives for risk management and speculation, and the administration of clients' financial assets.

In the corporate context, financial services offered by OFCs can generate a large amount of inward and outward capital flows. Hence, these jurisdictions have also been recently referred to as investment hubs, distorting the statistics as significant drivers of cross-border investments. Indeed, we can find a systematic overestimation of foreign financial operations in specific jurisdictions classified as OFCs. Intermediaries located in tax havens make it more challenging to determine the origin of portfolio investments. Indeed, assigning the origin of investments can be challenging when financial intermediaries in tax havens are involved. This is because tax havens are often used as investment conduits, making it difficult to determine the trustworthy source of the funds. By their very nature, tax havens are designed to offer secrecy and confidentiality to individuals and businesses. Therefore, the investment's origin, ownership, and control may be hidden behind a web of shell companies and other legal entities. An investment may be routed through an intermediate country for various reasons, such as to take advantage of favorable tax treaties or lower tax rates. However, this routing can also make it difficult to determine the true source of the funds, as the investment may have been sourced from another country entirely.

In addition to the difficulties posed by tax havens as intermediate financial centers, there is also the transfer pricing issue. Transfer pricing allocates the value of goods and services between different units of a multinational corporation in various countries. This practice can artificially shift profits from high-tax to low-tax jurisdictions, making it difficult for tax authorities to determine the true origin of an investment.

Ultimately, the difficulties in assigning the origin of investments due to financial intermediaries located in tax havens result from the complex and often opaque nature of the global financial system. Despite the efforts of tax authorities and international organizations to improve transparency and tackle tax

avoidance, these difficulties will persist and continue to pose challenges for tax authorities worldwide. While cross-border and offshore banking has been at the core of the Basel Committee's work since the mid-1970s, OFCs have more recently become a significant target of the Financial Action Task Force (FATF)[6] and OECD because some are increasingly viewed as offering money laundering and tax evasion opportunities and raising obstacles to anti-corruption investigations.

Summing up, tax havens have become critical players in the global financial system for facilitating cross-border capital flows. Since the outbreak of the financial crisis in 2007-2008, the role of tax havens has become even more critical. Being mere conduits between the source country and the final destination, it is crucial to consider the role of tax havens better to understand a country's actual international financial position. Small financial centers like Luxembourg, Switzerland, and the Cayman Islands often serve as intermediaries for cross-border investment flows. These centers provide various services, including fund administration, custody, and asset management. They usually have favorable tax and regulatory environments that make them attractive to investors and financial intermediaries [7]. They provide access to a broader range of investment opportunities and can help investors manage their portfolios more effectively. They also help to reduce transaction costs and improve market efficiency by providing liquidity and price discovery. However, financial intermediaries in tax havens can face challenges when gathering accurate and reliable statistics. This is because they often operate across multiple jurisdictions and may not have access to the same data sources or reporting standards. In addition, some financial intermediaries may be less transparent than others, making it difficult to assess the quality of their data or the risks associated with their investments. Another issue with financial intermediaries in tax havens is that they may be subject to less stringent regulatory oversight, which can create opportunities for regulatory arbitrage and make it more challenging to track cross-border investment flows.

Recent studies have delved into analyzing the limited information reliability of the statistics on capital allocation when tax havens are not accounted for. Avdjiev et al. (2016) highlighted the increasing dis-

[6]FATF members include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, China, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States, the European Commission, and the Gulf Cooperation Council. Observer members are Argentina, Brazil, and Mexico. The FATF Secretariat is based at the OECD.

[7]Financial intermediaries located in tax havens play a crucial role in the cross-border allocation of assets because they have the expertise and resources to navigate complex markets, manage risk, and facilitate transactions

crepancies between databases assembled under the residence principle. Bertaut et al. (2019) compare the U.S. TIC data under both residence and nationality, arguing that the residence principle is increasingly uninformative given the complexity of the multinational firms' financial operations[8]. Although the role of tax havens has received recent attention, there is still relatively scarce empirical literature on the subject. Lane and Milesi-Ferretti (2011) assessed the role of small financial centers in the international financial system and highlighted their relevance. Dharmapala (2008) and Dharmapala and Hines (2009) analyzed the role of tax havens in the global financial markets and why countries become tax havens. Rose and Spiegel (2007) focused on the causes and consequences of OFCs and concluded that proximity to those OFCs leads to a more competitive domestic banking system and greater overall financial depth.

More specifically, Lane and Milesi-Ferretti (2018) highlights the increasing relevance of financial intermediaries in tax havens in the global capital markets. This role is also evident in other areas like Asia-Pacific (Black and Munro, 2010) or North America (Tørsløv et al., 2022). Tax havens also play a significant role in cross-border European Union (EU) allocation. While the EU has a highly integrated financial market, small financial centers like Luxembourg, Ireland, and Malta have emerged as essential intermediaries in cross-border investment flows, particularly in fund management and securitization. Milesi-Ferretti et al. (2010) signal a significant gap in identifying holders of euro area portfolio given the role of financial centers in small euro area countries (Ireland and Luxembourg).

In conclusion, empirical studies suggest that tax havens play an important role in cross-border capital allocation in the EU, particularly in fund management, securitization, and real estate finance. These intermediaries have become crucial for cross-border investment flows, and their impact on the distribution of capital flows is influenced by a range of factors, including regulatory frameworks, tax regimes, and the availability of skilled labor. However, the challenge of gathering accurate and reliable data on cross-border investment flows remains a crucial issue in this area of research.

In the following paragraphs, we aim to give an overview of the stylized facts and the role played by tax havens in both the global portfolio markets and the European Union. This analysis will provide valuable insights into the significance of tax havens in shaping the international financial landscape.

[8]Damgaard et al. (2019) used new data to estimate global FDI and allocate real investment to ultimate investor economies. The authors found that phantom investments without economic substance account for 40 percent of global FDI, and reallocating those investments increases explanatory power.

In Figure 4.1, using data from the IMF (CPIS) database under the residence principle, we present the percentage weight of tax havens in total portfolio equity and bonds between 2001 and 2020[9]. Figure 4.1 reveals several notable trends: first, the proportion of tax havens in portfolio equity has steadily risen, reaching 35%. Second, this ascent accelerated notably following the onset of the global financial crisis in 2007-2008. Third, while the weight of tax havens in portfolio bonds initially increased until the financial crisis, it subsequently declined, attributed to the debt-focused nature of the crisis. Last, a comparison between tax havens' weight in portfolio bonds and equity reveals greater significance in the equity domain. This disparity arises as portfolio bonds encompass corporate and sovereign bonds, the latter of which cannot be issued through intermediaries in tax havens[10].

Turning our attention to the European Union, Figure 4.2 illustrates the proportion held by EU tax havens (Cyprus, Ireland, Luxembourg, Malta, and the Netherlands)[11]. Notably, there is a consistent upward trajectory in the share of tax haven countries concerning portfolio equity, accounting for 65% of the total weight. In contrast, the presence of EU tax havens remains relatively stable in portfolio bonds, fluctuating between 18% and 22%. These findings underscore the enduring significance of tax havens within the European Union.

Subsequently, we focus on the investment patterns of the European Union (EU) concerning portfolio equity and bonds separately. Due to data availability constraints, our analysis is segmented between an aggregate of the Euro Area (EA) and individual non-Euro Area countries[12]. The first column of Table 4.1 shows the percentage of portfolio equity investment by each EU country (or the EA aggregate) within the EU. Notably, EU countries predominantly invest in other EU nations, with the exception of the United Kingdom, accounting for only 26% of investments. Correspondingly, the second column of the Table delineates the percentage of EU equity investment located within the EA, which typically ranges between 80-90%, except for Denmark and Sweden, where the percentage is marginally lower.

[9] The tax havens classified as such are listed in Table 4.C.

[10] For instance, Germany's government cannot issue sovereign bonds through a Cayman Islands-based affiliate.

[11] While not officially designated as tax havens, these countries function as intermediaries between investment sources and final destinations, thus qualifying as tax havens for the purposes of this paper.

[12] We refer to the seven non-EA members of the EU: Bulgaria, the Czech Republic, Denmark, Hungary, Poland, Romania, and Sweden, alongside the UK. These countries maintain their national currencies, though all, except Denmark (and the UK before Brexit), are obligated to adopt the euro once they fulfill the euro convergence criteria

When we split the EU portfolio equity investment position by issuer country (Figure 4.3) in the pie chart on the left, the first salient feature is that the US is the leading destination country (22% of total equity investment), followed by 4 EU countries (Germany, France, United Kingdom, and Ireland). In fact, 78% of total investment is concentrated in eleven countries. For comparability, we report the same information in the right-hand side chart using the IMF CPIS database under the residence principle (Figure 4.3). It shows that, for non-EU countries (US, Japan, Switzerland), the pattern is very similar. However, at first sight, a striking feature is that Luxembourg, under the residence principle, gathers 20% of the total EU equity investment position but does not have any relevant role under the nationality principle. This highlights the relevance of properly re-mapping assets issued by tax havens according to the actual destination country. Second, other tax havens are now included among the most relevant destinations (Cayman Islands). Third, Germany and France have a lower weight in the sample, given that many of their investments are channeled through Luxembourg.

Concerning portfolio bond investment, its distribution by countries following the nationality principle is illustrated in the pie chart on the left (Figure 4.4). Similar to equity investments, EU countries predominantly allocate their portfolio bonds within the EU, particularly within the Euro Area (EA). Notably, the United States holds a comparable percentage to Germany in terms of investment volume, with Germany being the primary EU destination. Note that 59% of EU portfolio bonds are concentrated in just six countries. For enhanced comparability, in the pie chart on the right of Figure 4.4, we include EU portfolio bond investment by issuer country using the IMF CPIS database under the residence principle. Here, a significant increase in the prominence of the United States and tax havens such as the Netherlands, Ireland, and Luxembourg, along with other offshore centers categorized within the ”rest of the world” group, is evident. Consequently, some portfolio bonds issued in EU tax havens are ultimately located in Germany, France, Italy, and Spain.

Given the above facts, it becomes apparent that cross-border EU investment has a strong bias[13]. The United Kingdom has been an outlier, as its investment outside the EU is larger than within the area (especially for portfolio equity investment). For the specific case of portfolio bonds, there is a downward trend in the percentage of investment in other EU countries, which implies that the EU bias has decreased.

[13]This fact has already been highlighted in the literature; see section 4.3.

4.3 Literature review and theoretical foundation

The study of portfolio investment drivers has witnessed a significant evolution over the years as researchers seek to unravel the complexities underlying investors' decision-making processes in the global financial landscape. This section aims to critically examine the existing literature on empirical models for portfolio investment drivers, focusing on the transition from earlier push-pull models to the contemporary prominence of the gravity model.

Historically, the early literature on portfolio investment was often characterized by push-pull frameworks that attempted to explain capital flows based on a limited set of factors. These models, while informative, were inherently reductionist and failed to capture the multifaceted nature of investment decision dynamics. The push-pull paradigm essentially conceptualized capital flows as a consequence of a few primary factors, such as interest rate differentials, economic growth differentials, and political stability. While these variables undoubtedly play crucial roles, early models showed limited predictive power and explanatory scope (Koepke, 2019).

Over time, the need for more comprehensive frameworks has become more evident. The gravity model has emerged as an alternative approach in portfolio investment research, offering a more sophisticated and empirically robust framework for analyzing the drivers of cross-border capital flows. Its appeal lies in its ability to capture the gravitational forces that govern investor behavior, acknowledging that larger, proximate economies exert a stronger pull on capital. This gravitational perspective enhances the model's explanatory power and provides a more realistic representation of the interconnected global financial system. This section explores the key contributions and limitations of the early push-pull models and the contemporary gravity model, which we implement in our empirical exercise.

4.3.1 Push-pull models

The push-pull framework originates in the empirical literature that studied international capital flows since the early nineties and looked for the drivers or factors that attract foreign capital to one particular country even if no specific motivation comes from economic theory, as Koepke (2019) mentions, the role of external versus domestic drivers is compatible with modern portfolio theory, where we can find

the theoretical foundation for portfolio diversification, as rational investors care about two main factors: expected returns and risk.

From an empirical point of view, the waves of capital flows that happened in the 1980s and 1990s generated this academic interest, according to Forbes and Warnock (2012). The seminal papers, like Calvo et al. (1993, 1996) and Fernandez-Arias (1996), focused on developing countries and, specifically, Latin America, that received during these decades substantial capital inflows with origin in more mature economies. The question was whether these flows were "pushed" by the adverse conditions in the developed countries or "pulled" by attraction factors of the host countries[14]. These seminal papers mostly found evidence favoring the external side (push factors). Since then, many researchers have studied asset trade flows by distinguishing between "push" and "pull" factors that influence them. Caballero et al. (2008) and Mendoza et al. (2009) propose models that differ in the approach to risk, and both emphasize pull or internal factors.

Concerning the variables included in each category, the push factors more frequently considered in the literature are global risk aversion, the interest rates of country j (often called the "mature" economy), and output growth in country j. As for the pull factors, domestic output growth (in country i), asset returns and country risk indicators are the prominent ones. Many empirical papers have analyzed capital flows from this perspective and studied the role of the different drivers. Koepke (2019) surveys the literature that has focused on emerging countries. He concludes that push factors, such as global risk aversion and external interest rates, are the main drivers of portfolio equity and bond flows, but not banking flows. Pull factors, such as domestic output growth, asset returns, and country risk, matter for all types of flows, but most for banking.

The empirical literature based on this approach still flourishes, and after the global financial crisis, the interest was extended to other countries, including the US. In this vein, also going beyond emerging countries, Sarno et al. (2016) assess the contribution of push and pull factors to the variation of bond and equity flows from the US to 55 other countries. They concluded that push factors account for 80% of the total variation. Koepke and Paetzold (2020) provide an analytical overview of the main data sources

[14]For example, a country with a well-developed financial sector and high-interest rates may attract cross-border investment due to its level of financial development, which is a pull factor. At the same time, investors in another country may be seeking to diversify their portfolios, which is a push factor that could drive them to invest in assets from the first country.

used in the literature and extend the 34 papers studied by Koepke (2019) to 88 papers by flow component and frequency, also focusing on pull vs. push factors. The authors summarize the main results in the literature by type of flow and sample frequency. For the portfolio case, the results suggest that push factors are the main drivers of capital mobility, followed by a combination of both push and pull factors.

4.3.2 A gravity approach to cross-border asset mobility

Economics commonly uses gravity models to model trade flows between countries or regions. These models are based on the principle that trade volume between two locations is directly proportional to the product of their economic sizes and inversely proportional to the distance between them. The literature on gravity equations applied to asset trade flows existed before its theoretical foundations were confirmed as a generalization of the trade literature equivalent. Early applications were successful in explaining cross-border trade in a variety of financial assets. More recently, researchers have successfully applied gravity models to studying asset trade flows, including stocks, bonds, and other financial assets. Overall, the literature on gravity models of asset trade flows provides a valuable framework for understanding the patterns and determinants of cross-border financial transactions.

Over the past few decades, the gravity model's application has expanded to elucidate the international co-movements of portfolio investment, as demonstrated by scholars such as Portes and Rey (1998). The initial financial gravity model was formulated by Martin and Rey (2004) and later adapted by Coeurdacier and Martin (2009). However, two papers by Helene Rey can be considered the link between the push-pull literature and the gravity equation applied to capital inflows. Hau and Rey (2006) develop a structural model of capital allocation to address the push-pull issue. They found that geographic and cultural proximity to potential trading partners was essential in explaining portfolio diversification. Portes and Rey (2005) apply the gravity equation to asset transactions using panel data on bilateral gross cross-border equity flows for 14 countries between 1989 and 1996. Their results stress the relevance of market size and trading cost (regarding information and transaction technology) and show weak support for diversification.

In the same vein, Lane and Milesi-Ferretti (2008) use a gravity model to examine the determinants of international equity holdings and derive the gravity equation in a multi-country extension of the Obstfeld

and Rogoff (2000) model relating bilateral international portfolio with goods and services trade. They found that the size of the source country's equity market, the host country's economy, and the degree of financial development in both countries were significant factors in explaining equity flows. Aviat and Coeurdacier (2007) combine the gravity approach applied to international trade in goods with international asset portfolios and find that they are both reinforcing. They use a gravity model and conclude that only trade in goods has an actual gravity structure, and the effect of distance on asset holdings comes through trade.

However, this initial group of papers was a natural extension of the gravity approach used in trade to explain the cross-border allocation of investments without formalizing the gravity model for financial assets. Okawa and Van Wincoop (2012) have established additional theoretical foundations for the financial gravity model. They were the first to provide such a theoretical foundation and argue that, under certain conditions, it is possible to derive a gravity equation for asset trade. They avoid inconsistencies with the theory of some applied work (such as the incorrect introduction of source and destination fixed effects or the inclusion of variables with no theoretical justification). What they obtain is closely related to the gravity equation for trade: bilateral financial positions depend on relative barriers, that is, multilateral resistance, faced by the source and destination countries. Two conditions are necessary: first, the equivalent to trade separability, that is, that the decisions about overall demand for assets are separable from the portfolio allocation across assets, and second, that asset demand depends on relative prices.

They derive the model from a static portfolio choice framework with $N + 2$ assets. Investors can invest in N country-specific risky assets, and the gravity equation applies to them. These assets can be equity, bonds, or bank holdings but they use the term "equity" to refer to any of them. K_i is the supply of the asset in country i, which can be considered the country's capital stock. Asset returns are affected not only by country-specific factors but also by global innovations (shocks). In addition to the N country-specific risky assets, there is also a risk-free asset (with return R_f) and another asset whose return is R_g and perfectly correlates with the global shock. The global asset is crucial to derive the gravity equation, as it allows the agents to hedge the global risk factor so that the only risks that matter are the country-specific.

The agents choose consumption and portfolio allocation among the $N + 2$ assets. Thus, in country j, α_{ij} is the fraction invested in country i equity, whereas α_{gj} and α_{fj} are the fractions invested in the

global and the risk-free asset, respectively. Okawa and Van Wincoop (2012) introduce international financial frictions derived from information asymmetries about the country-specific return components. Differences in language and regulation and better access to information make domestic agents more informed than foreigners. From the perspective of agents in country j, innovations of asset i or ϵ_i have zero mean and variance $\tau_{ij}\sigma_i^2$ for $i \neq j$. This is a crucial point, as the main difference between the gravity equation in goods and asset trade is that the latter involves risk. Equity portfolio shares or α_{ij} will depend on the ratio of the expected excess return and the variance of excess return[15] Global components are removed, as the global risk can be separately hedged.

Okawa and Van Wincoop (2012) define a variable p_i as proportional to the risk-return ratio. The higher p_i, the lower the demand for the asset. This variable is endogenous, as it depends on the expected excess return, then in equilibrium, adjusts to clear equity markets. In equilibrium $\alpha_{ij} = 1/\tau_{ij}p_i$, being τ_{ij} the bilateral frictions. Thus, they interpret $\tau_{ij}p_i$ as the "price" faced by agents of country j investing in country i. In aggregated terms, total equity claim X_{ij} by country j on country i can be written as:

$$X_{ij} = \frac{P_j}{\tau_{ij}p_i}E_j \tag{4.1}$$

where P_j are aggregate prices and E_j are total equity holdings from country j. Moreover, $E_j = \sum_{i=1}^{N} \alpha_{ij}W_j$, where W_j is total wealth in country j. Equation (4.1) is important in this context, as bilateral asset demand depends on a relative price: the risk-return ratio of country i equity relative to an overall price index.

Then, they obtain the gravity equation by combining the demand equation above with the market clearing equations. The asset market clearing condition is $\sum_{j=1}^{N} X_{ij} = S_i$, where S_i is country i equity supply. As $S = E = \sum_{j=1}^{N} E_j = \sum_{i=1}^{N} S_i$, the solution for p_i is $p_i = \frac{S}{S_i}\frac{1}{\Pi_i}$, where $\frac{1}{\Pi_i} = \sum_{j=1}^{N} \frac{P_j}{\tau_{ij}}\frac{E_j}{E}$. Having all this in mind, the gravity specification they obtain is the following:

$$X_{ij} = \frac{S_i E_j}{E}\frac{\Pi_i P_j}{\tau_{ij}} \tag{4.2}$$

Then, in the gravity equation, bilateral financial holdings depend on the product of the variables that

[15] See Okawa and Van Wincoop (2012) for further details and the algebraic solution.

measure economic size divided by relative financial frictions. This specification is the asset equivalent to the demand-side gravity as proposed by Anderson and Van Wincoop (2004) and revised recently by Yotov (2022).

They propose to use stock market capitalization in the destination country and total investment stock in the source country as size variables[16]. Relative friction is the bilateral financial friction divided by the product of the two (source and destination) multilateral resistance terms. As in the case of trade flows, bilateral asset holdings are affected not merely by the bilateral friction τ_{ij}, but also by the relative friction $\frac{\tau_{ij}}{\Pi_i P_j}$. Okawa and Van Wincoop (2012) call Π_i and P_j multilateral resistance variables, as they measure average financial frictions. This can be interpreted as follows: given the size factor $S_i E_j / E$, relative financial friction (information asymmetries) drives bilateral asset holdings. For example, an increase in the financial friction of 1% raises the country-specific variance by the same amount, and the portfolio share invested in this country is also reduced by 1% (assuming unitary elasticity). Thus, a source country j will allocate more of its equity to countries where the bilateral resistance τ_{ij} is low compared to the average P_j relative to all destination countries. In addition, the relative financial friction is also affected by the multilateral resistance of the destination country Π_i. If this term is high, country i faces financial frictions with many source countries. To return to equilibrium in financial equity E_i, it will offer a low price or a higher expected return. In this case, any friction τ_{ij} will raise X_{ij}.

The primary inference drawn by Okawa and Van Wincoop (2012) is that not all empirical studies that apply the gravity model to international asset flows align seamlessly with the associated theoretical framework. Investors do not make efficient use of the opportunities for geographical diversification available to them, given their access to diverse capital markets worldwide; instead, they are invested to an exaggerated extent in their respective home markets. The factors that explain this *home bias* are only partly related to investor behavior and partly institutional. Therefore, a robust specification of the explanatory factors focusing on investor preferences encompasses size, frictions, and asymmetries as fundamental components. Additionally, multilateral resistance terms, akin to their role in the goods trade equivalent, are deemed crucial. Moreover, other additional factors that may contribute to improving the explanatory power of the empirical specification include *institutional and regulatory factors* and *political factors*.

[16]Generally, in the financial gravity equation, GDP is either replaced or supplemented by market capitalization as a regressor. Market capitalization may possess superior explanatory capability in forecasting financial cross-border flows.

More recently, Pellegrino et al. (2022) introduced a novel theoretical framework, drawing inspiration from Eaton and Kortum (2002). Their model encompasses numerous bilateral frictions that significantly influence investor utility. Within this economic framework, a portion of investors exhibit preferences for specific foreign investment opportunities, a tendency influenced by bilateral factors such as shared language, cultural proximity, and bilateral investment taxes. Pellegrino et al. (2022) model a vector comprising measures of bilateral distances, where τ_{ij} represents the tax incurred by investors in country j who invest in country i. Again, this model resorts to a gravity empirical formulation to explain international assets investment allocation.

In the empirical literature, the most popular formula combines a gravity approach with the traditional analysis of pull-push factors. Galstyan and Lane (2013) show that the size of the initial bilateral holding, gravity variables, and institutional linkages help to explain adjustment essentials. In the same vein, Cavallaro and Cutrini (2019) develop a model with a quality-based differentiation of assets. Other additional factors can also be relevant drivers leading to capital allocation. First, Forbes and Warnock (2012)'s results point out that global factors (especially global risk) are associated with extreme capital flows (stop and retrenchment) and contagion episodes, pull factors and capital controls are less important though[17]. Second, Chitu et al. (2012) using data on US investors' holdings of foreign bonds documented a *history effect* in which the historical pattern of holdings continues to influence holding today. Third, more recently, Galstyan et al. (2016) has shown how the results obtained can be sector-dependent, suggesting that a more granular-level analysis may be more informative.

As for the EU, some distinctive characteristics can be drawn about drivers and obstacles to an efficient capital allocation in the area. Lane (2006) examines bilateral international bond portfolio for the euro area. His empirical results support the euro-area bias and currency unions' impact on financial integration. Lane and Milesi-Ferretti (2008), using data on international equity holding for 2001, found that bilateral equity holding is linked to bilateral trade in goods and services and informational proximity. They also found a euro-area bias according to underlying fundamentals. Schmidt and Zwick (2015) analyze the link between different measures of uncertainty and extreme capital flows for 12 euro area

[17]The literature on capital controls and cross-border portfolio allocation in bonds and debt is relatively sparse. However, several studies have examined this issue in recent years. Some studies, like Binici et al. (2010) or Nispi Landi and Schiavone (2021), find a strong effect, while others find that capital controls are effective in the short run but have no lasting effects (Boero et al., 2019) or depending on the type of countries (Bricongne et al., 2021).

countries. They find that country-specific risk factors play an important role in periods of extreme capital flows. Coeurdacier and Martin (2009) and De Santis and Gérard (2009) analyzed the determinants of cross-border asset trade, focusing on the impact of the euro and finding evidence of a home bias. They show that the European Monetary Union eased equity and bond market access. Heckemeyer (2022) argues that different national tax systems bring barriers to cross-border business in the European Single Market. Finally, a series of studies have investigated how boom-bust cycles have affected the behavior of gross and net capital flows (Lane, 2013; De Santis and Gérard, 2009; Afonso et al., 2022) and how capital market integration has affected business cycle synchronization (BCS) for the European Union (Beck, 2021).

In summary, the literature on gravity models and asset trade flows has identified several essential determinants of cross-border asset trade. While there is some variation across studies, overall, the evidence suggests that economic size, distance, interest rates, exchange rates, and financial development all play a significant role in explaining the patterns and determinants of cross-border asset trade flows. Language barriers, regulatory variations, and institutional differences also exacerbate information asymmetry.

In the next Section, we present our empirical model. The empirical specification is grounded in theoretical models that produce gravity equations, emphasizing information asymmetries and disparities in institutional quality. These econometric specifications are sufficiently flexible to incorporate transaction costs, which we interpret in the context of the level of development in capital markets and friction in information. Subsequently, we utilize this model to formulate a testable equation for bilateral trade in equity and bonds, aligning with the relevant literature mentioned earlier.

4.4 Data and econometric methodology

One common issue in the literature on tax havens is the challenge of gathering accurate and reliable data on cross-border investment flows. As noted earlier, financial intermediaries in tax havens may be subject to less stringent reporting standards, making it more challenging to track cross-border investment flows. However, recent efforts by the EU to improve data collection and reporting standards have helped to address this issue.

In portfolio databases, two common principles to identify the origin of an investor are the residence principle and the nationality principle. The residence principle is based on the physical location of an investor. Under this principle, an investor's origin is determined by the country in which they reside. This principle is relatively simple to apply; however, it does not consider the investor's nationality, which may be essential for tax purposes or other legal reasons.

Under the residence principle, commonly used databases are the IMF Coordinated Portfolio Investment Survey (CPIS) for portfolio investment and Finflows, which also covers other types of flows/stocks (FDI and other investments, including banking transactions), following the methodology proposed by Hobza and Zeugner (2014). Both databases report the bilateral position between the investor and the security issuer. Lane and Milesi-Ferretti (2018) elaborated a database for external assets and liabilities, including portfolio equity and debt; however, this database does not show the counterpart. To overcome the limitations of the residence principle, Coppola et al. (2021) have recently published a database under the nationality principle.

In this paper, we use the database developed by Coppola et al. (2021) of bilateral portfolio equity and bonds[18]. The authors re-map traded securities issued by firms in tax havens with their issuer's ultimate parent and then restate bilateral investment positions. Traditional databases are built under the residence principle; by contrast, Coppola et al. (2021) database re-maps bilateral portfolio investment under the nationality principle. Under the residence principle, security is associated with the immediate location of the issuer. Given the uptrend relevance of tax havens as crucial players in international capital markets, traditional databases based on the residence principle fail to identify the true origin when financial intermediaries in tax havens are involved.

In summary, the Coppola et al. (2021) database works as follows: A Swedish company issues security through its affiliate in Luxembourg (tax haven). A German agent acquires the security. Once capital is collected in Luxembourg, it is transferred to the Swedish company in Sweden by FDI. Under the residence principle, they will be recorded as two separate transactions: first, a security is issued by Luxembourg and acquired by a German agent, and second, FDI is transferred from Luxembourg to

[18]The authors use three different methodologies: *fund holdings*, *issuance* and *enhanced fund holdings*. We use the *issuance* methodology because it covers all the countries of interest and their counterparts.

Sweden. Economic factors do not drive this transaction, and the economic analysis of global capital mobility may be distorted. In contrast, a nationality-based database re-maps the transaction and identifies a direct transaction between a Swedish company in Sweden and a German agent[19].

Table 4.A shows the EU equity portfolio investment in equity securities issued by global tax havens.[20] As noted above, the position data using the residence principle comes from the FMI CPIS, whereas the one on nationality principle has been obtained from the database by Coppola et al. (2021). The nationality principle re-maps the transaction, removing the tax havens's role and identifying the investment's source and final destination. Coppola et al. (2021) database re-mapped between 27% and 35% of total stock portfolio equity issued through any tax haven. In table 4.B, we include the US investments in equity securities issued by EU tax havens. Remarkably, a relevant percentage (peaking in 2015 at 52%) of US equity portfolio investments in the EU tax havens needs to be re-mapped. These facts highlight the relevance of properly considering the tax havens' role in analyzing global capital mobility.

The database by Coppola et al. (2021) on bilateral portfolio equity and bonds stock identifies the investor and the issuer countries for the period 2007 to 2017[21]. The EU 28 countries are a central pillar of our sample[22]. Therefore, we include all the bilateral portfolio stocks in which at least one EU country is involved, either on the investor or issuer side. Thus, our analysis covers all portfolio stocks where EU countries participate: first, EU investments in non-EU countries; second, non-EU investments in EU countries; and third, EU investments in other EU countries. Data availability has constrained the sample period. The European Monetary Union is considered a block in the Coppola et al. (2021) database when acting as an investor since mutual funds are concentrated in Luxembourg and Ireland but collect investments from the rest of the countries in the European Union. Individual countries are instead kept as separate entries when on the issuer side.

The variables described below and in Table 4.2 have been chosen to specify a gravity model for cross-country bilateral portfolio stocks following the theoretical model developed by Okawa and Van Wincoop (2012). In particular, size, distance, country dummies, and multilateral resistance terms are all included

[19] For an in-depth understanding of the database, see Coppola et al. (2021).
[20] The list of tax havens is reported in table 4.C.
[21] See the complete sample list in tables 4.D and 4.E.
[22] The UK is included in the sample since it was part of the EU during the period.

in the specification. In this paper, we set a scenario in which bilateral international portfolio stock is explained by several groups of variables. First, the main **gravity variables**, that is, *distance* between issuer and investor countries, as well as their respective *GDPs* to account for economic size; second, **additional gravitational variables** commonly used in the literature are included in extended specifications, such as *common official language*, *colonial links* and *euro area membership*. Moreover, to be consistent with the gravity model by Okawa and Van Wincoop (2012), we include **resistance** or barriers in the form *bilateral financial restrictions* faced by investor j when investing in issuer i and *multilateral resistance* defined as the relative position of bilateral barriers relative to average barriers with the rest of the world. In particular, bilateral resistance[23] is measured as financial restrictions in the investor and the issuer country, respectively.

In contrast, multilateral resistance is the average global financial restrictions once the countries i and j have been excluded. We also include a **global risk** or uncertainty variable for comparison. Finally, two additional variables capture, respectively, the **quality of the regulator** and **financial development** in the countries involved. The complete list of variables used in this paper and their sources can be seen in Table 4.2.

Our paper estimates the gravity model (4.2) using the PPML estimator. The following equation can represent the empirical model:

$$X_{ijt} = \exp[\gamma_1 Z_{ijt} + \gamma_2 W_{ij}] x \epsilon_{ijt} \tag{4.3}$$

where X_{ijt} represents the portfolio stock (country j) to the issuer country i. Moreover, Z_{ijt} is a vector of gravity variables related to the elements mentioned previously in equation (4.2): the economic mass of the investor and the issuer country, bilateral and multilateral resistance as well as other variables also included in the model with temporal dimension (financial development, global risk, and regulator quality). In addition, W_{ij} includes the gravity time-invariant control variables, such as distance, common language, euro-area membership, and colonial links. γ_1 and γ_2 are vectors of parameters. Lastly, $\epsilon_{j,it}$ is

[23] Bilateral resistance/barriers faced by investor country j when investing in the issuer country i are given by the individual financial restrictions. However, financial restrictions in the investor country must allow capital to be invested abroad. Financial restrictions in the issuer country must allow foreign capital to be invested in national assets.

a white noise error with zero mean and constant variance.

We start our analysis with the most straightforward gravity equation (that we call **model I** in Tables 4.3 to 4.8), which includes distance, the two countries' GDP (size) and bilateral and multilateral resistance to asset trade (to measure financial restrictions or resistance). Our baseline specification is the one derived from the theoretical model.

$$\text{Portf}_{ij,t} = \beta_1 \ln(\text{dist}_{ij}) + \beta_2 \ln(\text{GDP}_{i,t}) + \beta_3 \ln(\text{GDP}_{j,t}) + \beta_4(\text{KOFEcGIdf}_{i,t}) + \beta_5(\text{KOFEcGIdf}_{j,t}) + \beta_6(\text{KOFEcGIdf(RoW)}_{ij,t}) \tag{4.4}$$

where "Portf" is the portfolio definition adopted (either equity or bonds), "dist" stands for distance, and "KOFEcGIDF" is the KOF index of "de facto" economic globalization (defined in Table 1) and captures bilateral resistance (for countries i and j), whereas "KOFEcGIdf(RoW)" is the multilateral version.

We gradually augment the gravity equation from the baseline specification by adding other potential explanatory factors. First, **(Model II)** includes "Global risk" in the form of VIX (CBOE volatility index) for equity and the World Uncertainty Index for bonds. The theoretical model assumes that agents can hedge global risk by choosing among their portfolio assets correlated with global risk. This variable captures any remaining global risk, given the negative impact of risk and uncertainty in preventing capital mobility.

In **Model III**, we add a dummy (Euro area pair) that takes the value 1 when the two countries are euro area members to capture any potential euro area bias.[24] The following specification, **Model IV**, contains global risk and the euro area pair dummy. **Model V** augments the previous specification with an additional gravity control dummy that takes the value of 1 if both countries share the same official language to capture historical links. Except for global risk, **Models I to V** follow the conventional gravity model of Okawa and Van Wincoop (2012); however, in the following two models, **VI** and **VII**,

[24]It would have also been interesting to include a dummy that identifies if both countries are European Union countries; however, given that the sample always contains one European Union country, there is not much sample left to estimate that model.

respectively, we extend the gravity equation to capture the potential effect on portfolio holdings of the quality of government and financial market development. Lastly, **Model VIII** includes all the variables.

According to the theory, portfolio choices are expected to have a negative relation with distance, as remote countries tend to invest less in each other. However, economic size is expected to affect portfolio holding allocation positively. For the case of the resistance variables, two opposite effects are at play; first, we should expect a negative impact from bilateral resistance since this implies an increase of financial restrictions between the two countries; concerning the financial restrictions from the rest of the world, an increase would have a positive effect, given that more restrictions in the rest of the world relative to the investor and issuer countries would make more difficult for both countries to trade with the rest of the world than between them. The risk variable is expected to hurt portfolio holdings invested in each other, given the negative role that risk/uncertainty plays on capital mobility. Euro area pair dummy is expected to be positive due to the Euro area bias observed in section 4.2. The gravity literature also suggests a positive effect on the historical links. Finally, we expect a positive impact on government quality and financial development.

We conduct various robustness checks to ensure the reliability of our findings. Initially, we employ alternative variables for assessing the bilateral and multilateral resistance, utilizing the KOF indicators. These alternatives replace the previous variables with the average between the *de facto* and *de jure* measures. Second, we substitute the variable used to measure historical links (Common official language) with a variable that captures if the countries have ever had a colonial relationship (Colony). Finally, concerning the database, an additional robustness check is in order. The data comes from a new database that re-maps the portfolio holdings channeled by tax havens and identifies the final country destination following the nationality principle. Therefore, we estimate the same specifications detailed above using the portfolio positions from IMF (CPIS) built under the residence principle.

The econometric methodology used in this paper is the Poisson Pseudo Maximum Likelihood (PPML) estimator developed by Santos Silva and Tenreyro (2006). The PPML is superior to the OLS estimator due to its ability to deal with heteroskedasticity and zeros stocks/flows. The gravity equation is estimated using the multiplicative form with two-way clustered standard errors[25]. The RESET test is also obtained

[25]The econometric analysis has been performed using ppmlhdfe Stata command developed by Correia et al. (2020).

for each model to test for potential omitted variables[26].

4.5 Results

4.5.1 Portfolio equity estimations

In this section, we discuss the results[27] and start with portfolio equity holdings as shown in Table 4.3. The first column (Model I) is our baseline specification under the nationality principle, and the following columns include additional variables and controls to the specification, as discussed above. The first five specifications are closer to the theoretical model, and we discuss them first. Concerning distance, the sign is negative, as expected (between -0.28 and -0.18): as countries are further away, they tend to invest less in each other. In this sense, the distance variable can also be interpreted as a proxy for information asymmetries as well as cultural differences, including the "euro area pair" dummy aimed to capture the euro bias (Model III onward). We find a significant positive effect (from 0.51 to 0.68), which confirms a strong euro area bias, congruent with the stylized facts described in section 4.2. Moreover, when we include the euro area pair dummy, the distance effect decreases because euro area countries are also nearer; hence, part of the distance variation is absorbed by the euro area dummy.

Regarding economic size, both investor and issuer GDP sizes show a significant and positive coefficient larger than one, implying that large countries tend to invest more in each other. Concerning the role of the resistance terms, in the case of bilateral resistance (KOFEcGIdf Investor and issuer), the two variables show the correct (negative) sign in all the models as well as statistical significance. Thus, capital mobility is enhanced if financial restrictions are low in investors' and the issuers' countries. According to our results, if financial restrictions increase on the investor or the issuer side, the portfolio equity invested in both countries would decrease between -2% and -5%. The Multilateral resistance term (KOFEcGIdf RoW) is significant in most specifications. It has a positive sign, meaning that the more the financial restrictions in the rest of the world relative to bilateral financial restrictions between countries pairs, the

[26]The null hypothesis of the RESET test is that the model does not suffer from misspecification. The rejection of the RESET test's null will imply that the model cannot be interpreted.

[27]The coefficients of the logged regressors (distance and GDPs) are elasticities; therefore, they will be interpreted directly. However, the regressors not in logs (i.e., the rest of the variables) are semi-elasticities. For their correct interpretation, they should be transformed using the following formula $(exp(\beta) - 1)^{*}100$.

more portfolio equity holdings between countries i and j. The impact of multilateral resistance varies among models, being much more relevant in the specifications that do not include government quality and financial development[28]. Second, the impact of multilateral resistance on portfolio equity holdings is much larger than bilateral resistance. This result has further implications for portfolio equity allocation since it implies that if financial restrictions in the rest of the world decrease, the investor country would reallocate portfolio investments from the issuer country elsewhere. Therefore, if average financial restrictions in the world decrease, we should expect risk sharing to improve. Third, multilateral resistance is non-significant when global risk is not included in the specification (Models I and III). Concerning global risk, its impact is negative and significant in all the models where it is included, highlighting the relevance and downside effect of global risk to portfolio equity holdings. The historical links measured by the common language dummy are significant and have a positive sign in all the specifications that include them.

Lastly, we extend the gravity specification to analyze the role played by the quality of institutions (government in this case) and financial development on portfolio equity holdings. The specification in column VI includes the regulatory quality of investor and issuer countries: both variables are positive and significant; that is, the ability of the government to formulate and implement sound policies and regulations encourages portfolio investment between countries. Similar results are obtained in model VII, which includes financial development in countries i and j measured as the depth, access, and efficiency of their financial institutions and markets. The two variables are significant and have a positive sign. However, despite all the variables of the model having the expected sign and being significant, the RESET test is rejected. Finally, we include in column VIII all the variables considered up to now, and we find that only financial development in the issuer country has a positive and significant impact. In contrast, the quality of government of the issuer becomes insignificant. The rest of the variables have the expected sign and are significant.

For robustness, we have also estimated the same specifications using the IMF (CPIS) database, where data are obtained under the residence principle (Table 4.4) and, therefore, when the role of tax havens is not adequately addressed. The analysis under the residence principle differs from the nationality data in

[28] Models I to V.

several respects: First, distance and size are less relevant under the residence principle, not only in statistical significance but also in the value of the smaller parameters. Second, the coefficients for bilateral resistance are similar in size. However, they are not significant when we extend the gravity specification to include institutional quality and financial development (Models V, VII and VIII)[29]. Third, we have also found that the parameter of multilateral resistance is much smaller under the residence principle[30]. These differences signal that measurement problems in the dependent variable reduce the impact and significance of the gravitational variables. Concerning the variables of the extended specification (global risk, euro area pair, historical links) as well as regulatory quality and financial development, the value of the parameters is unaffected.

Finally, using the re-mapped database under the nationality principle, we do an additional robustness check (Table 4.5) regarding the explanatory variables. We modify our choices for resistance and historical links. First, we use the ”de facto” KOF index instead of the ”de iure” version to measure bilateral resistance. Second, instead of the dummy ”common official language,” we use ”colony” (that is, a variable that takes the value 1 when the issuer and investor countries maintain a colonial link) to capture the historical ties. Distance has a lower impact on the gravity variables than in our baseline specifications analysis (Table 4.3). In contrast, economic size and the resistance terms are similar in magnitude and statistical significance. We also obtained similar results for the global risk variable, the euro pair dummy, regulatory quality, and financial development.

Regarding historical links, we can observe that historical links have a positive impact in both analyses. However, using the variable ”colony,” we obtain a lower effect, probably because common language may be a more appropriate measure for integration of capital markets than goods markets. Nevertheless, the robustness check confirms that our main conclusions remain robust when we use different variables to measure resistance/barriers and historical links.

4.5.2 Portfolio bonds estimations

The second part of our analysis is focused on portfolio bond holdings. As for portfolio equity, we start with the database built under the nationality principle (Table 4.6). All the specifications show that

[29] Except for KOFEcGIdf investor in Model VII.
[30] Except for Model VIII.

distance has a negative effect, as expected, ranging from -0.47 to -0.77. As in the case of portfolio equity holdings, distance can also be interpreted as a proxy for information asymmetries as well as cultural differences. As we did in the case of equity, we include a euro area pair dummy to assess the relevance of the euro area bias (columns II and IV onward) for portfolio bond holdings that we find to be strong, in line with the stylized facts described in section 4.2. Moreover, including the euro area pair dummy reduces the effect of distance, as euro area countries are neighbors. Hence, the euro area dummy absorbs part of the variation formerly attributed to distance.

Regarding economic size, both investor and issuer GDPs are significant and larger than one. We also find that the parameter of the issuer size slightly decreases when we extend our baseline specification to add quality of government and financial development, but the coefficient is still large and significant. Regarding bilateral resistance, both investor and issuer coefficients are significant in the baseline and global risk specifications (from Model I to IV), in line with expectations. Financial restrictions reduce capital mobility, and we find a negative coefficient that ranges between -2% and -5%. In addition, financial restrictions on the issuer side (KOFEcGIdf issuer) are not statistically significant when we extend the baseline specification to include government quality and financial development (Models VI, VII, and VIII). However, when we only use these models regarding the multilateral resistance, the sign is positive, as expected, meaning that more financial restrictions in the rest of the world relative to bilateral financial restrictions between i and j increases the bond holdings between them. Also, in this case, the impact of multilateral resistance varies among specifications, with a higher impact when government quality and financial development are not included. Second, the effect on portfolio bond holdings is much larger than the bilateral resistance. This result has further implications for portfolio bond allocation as it implies that if financial restrictions in the rest of the world decrease, the investor country would reallocate portfolio investments from the issuer country elsewhere. Therefore, as in the case of portfolio equity holdings, if average financial restrictions in the world decrease, we should expect an improvement in risk sharing. When looking at global risk, we can observe that the impact is negative and significant in the baseline specification (from I to IV), pointing out that global risk has not been entirely hedged and has a negative effect on bond holdings. Concerning the euro area bias, the effect is large and very significant, and, as in the case of equity, the coefficient of distance lowers its size when the euro dummy is in the specification.

Regarding historical links (common language), they are not significant in the case of portfolio bonds. The impact of the quality of government and financial development on portfolio bond holdings is also significant in the case of bonds. Models VI and VIII confirm the role of regulatory quality. Similar results are obtained when we add financial development (Model VII) so that countries with higher financial development have a positive and significant impact. However, looking at Model VIII, we can see that the financial growth in the investor country is not significant, whereas the quality of government maintains its relevance in the two countries.

We estimate the same specifications for bond holdings using the IMF (CPIS) database, obtained under the residence principle. The results are presented in Table 4.7. We find that, first, the gravitational variables distance and economic size are highly significant, but the coefficients are smaller. Second, the parameters of bilateral resistance maintain their value compared with the nationality data. Still, they are insignificant when we include the regulatory quality in the specification (columns VI and VIII). Third, multilateral resistance maintains its value along the different specifications, in a similar magnitude as in the nationality data. Fourth, global risk is significant and correctly signed in specifications II, III, and IV. Still, its sign becomes positive once government quality and financial development are included in the specification (contrary to logic and theory). Fifth, the euro area dummy is significant in all the Models (III to VIII), but the coefficient size is smaller than under the nationality principle. Concerning financial development and quality of government, they are significant in all instances, as in previous cases. Still, their presence in the specifications reduces the value of the GDP parameters (for example, in column VI, the coefficient of GDP issuer decreases from 0.93 to 0.74 once we account for the quality of government).

In conclusion, the gravity models estimated for equity and bonds portfolio holdings differ depending on the principle (residence or nationality) applied to obtain the data. When the nationality principle is used, the results are more coherent with the theoretical model. Therefore, correctly re-mapping portfolio holdings channeled through tax havens is crucial. This conclusion is particularly true for the gravity variables, for which the nationality analysis outperforms the residence analysis.

Finally, we complete the analysis of portfolio bond holdings by doing an additional robustness check (Table 4.8). As in the case of portfolio equity, we use the alternative definition of the KOF index for bilateral resistance and the dummy ”colony” instead of the common language as an additional gravity

variable. Compared with the results presented in Table 4.6, the baseline specification I maintains the parameters' sign, magnitude and significance. Similar results were also obtained for global risk, euro area dummy, regulator quality, and financial development. In contrast, there is a difference concerning the variable that represents the historical links: we now find a positive and significant impact of the dummy "colony." We should bear in mind that "common language" was not relevant in specifications VI to VIII. Our robustness check confirms that our main conclusions remain robust when we use different variables to measure resistance. Still, we can improve the estimation by using an alternative definition of the historical links.

4.5.3 Portfolio equity vs bonds

The last phase entails an examination of the differences and similarities within our assessments of portfolio equity and bond analyses based on the results obtained with the nationality principle database of Coppola et al. (2021). This is also a topic of interest since they are totally different assets regarding nature and risk. When comparing our results, some differences become apparent. First, distance and the euro bias are more relevant for portfolio bonds than equity. Portfolio debt tends to be invested in neighboring countries; more specifically, EU debt tends to remain in the EU. This fact is even more critical for euro area countries. Moreover, we also find that multilateral resistance is less relevant for portfolio bonds, as EU investors have an EU bias. Thus, this provides isolation from the rest of the world, and the effect of financial restrictions outside of the EU becomes less relevant. Regarding economic size, both for equity and bonds, it is a relevant gravity factor explaining portfolio holdings. Bilateral resistance has a similar role for the two types of assets, pointing out the need for lower bilateral financial restrictions in both the investor and issuer to improve trade in financial assets. Global risk is relevant for equity and bonds, but the effect is more significant in portfolio equity, possibly due to the heightened variability in portfolio equity yields compared to bonds. Moreover, portfolio bond holding tends to be invested in neighboring countries, where global risk may have a much-limited impact. Historical links are positive in both cases, but their role is more evident for portfolio equity. Lastly, better government quality and financial development promote trade in portfolio equity and bonds.

4.6 Conclusions

Following a gravity approach, this paper studies the drivers of portfolio equity and bonds involving any EU 28 countries as a counterpart from 2007 to 2017. Our approach considers the role of tax havens in our analysis by using a recent database by Coppola et al. (2021) that re-maps portfolio stock to the ultimate partner (nationality principle), in contrast to the traditional databases built under the residence principle. We have applied the gravity equation based on the model proposed by Okawa and Van Wincoop (2012) in which bilateral and multilateral resistance to trade in assets are modeled as financial restrictions. We estimate, using PPML, a baseline specification of the gravity equation, including distance, size, and bilateral and multilateral resistance. We then extend the specification by including global risk and other gravity control variables, such as historical links and a euro area pair dummy. We also extend our baseline to capture the potential role of quality of government and financial development on portfolio holdings. For comparability, we also repeat our analysis using the IMF (CPIS) database to assess the differences when the presence of tax havens' is not accounted for in the data.

The main contributions of our analysis are: first, the main drivers of capital mobility for portfolio equity and bonds stocks are analyzed using a novel database that re-maps portfolio stocks to remove the financial intermediaries located in tax havens and focus on the final destination of the transactions. Second, we follow the theoretical gravity model proposed by Okawa and Van Wincoop (2012) instead of augmenting the gravity equation with push-pull variables that usually lack theoretical foundations. Third, we measure bilateral and multilateral resistance as financial restrictions between the investor and issuer countries (bilateral restrictions) and financial restrictions relative to the rest of the world (multilateral resistance). To our knowledge, previous gravity literature applied to asset trade does not account for resistance. Fourth, we compare our results using the IMF-CPIS database, which does not account for tax havens in asset trade. Finally, we focus on the main drivers of portfolio equity and bond positions for all the EU countries when they act as issuers or investors with the rest of the world or among them.

Regarding our first and second contributions, the stylized facts show that tax havens are increasingly relevant in portfolio equity stock. This fact has been even more marked since the financial crisis. For the specific case of portfolio bond positions, tax havens have deviated between 14% and 19% of the

total amount[31]. The increasing relevance of tax havens in asset markets constitutes this paper's primary motivation and contribution and adds value to a new strand of the literature.

Concerning our portfolio equity results, we find first that gravitational variables are significant and show the correct expected signs, such as the negative effect of distance and the attraction of mass, as large countries (in terms of economic size) tend to invest more between them. Bilateral resistance harms equity holdings as more financial restrictions deter investments between country pairs. By contrast, multilateral resistance, measured as financial restrictions in the rest of the world, has a positive impact, meaning that more financial restrictions in the rest of the world will increase asset trade between the two countries. Second, global risk remains relevant and does not seem to have been hedged as predicted by the model. Additional gravity variables also show the expected sign and relevance: historical links and the euro area dummy have a positive sign, with evidence of euro bias (as observed in the stylized factors in section 4.2). Third, both are also significant when we extend our traditional gravity equation to include regulator quality and financial development.

Regarding portfolio bonds, we also confirm the relevant role of the gravitational variables in our baseline specification and the euro bias. Economic size, as well as multilateral resistance, have a positive effect on portfolio bonds. The impact of global risk and bilateral resistance is negative. Historical links are significant, but only when the chosen variable is "colony". Lastly, we also find that regulatory quality and financial development positively impact portfolio bonds.

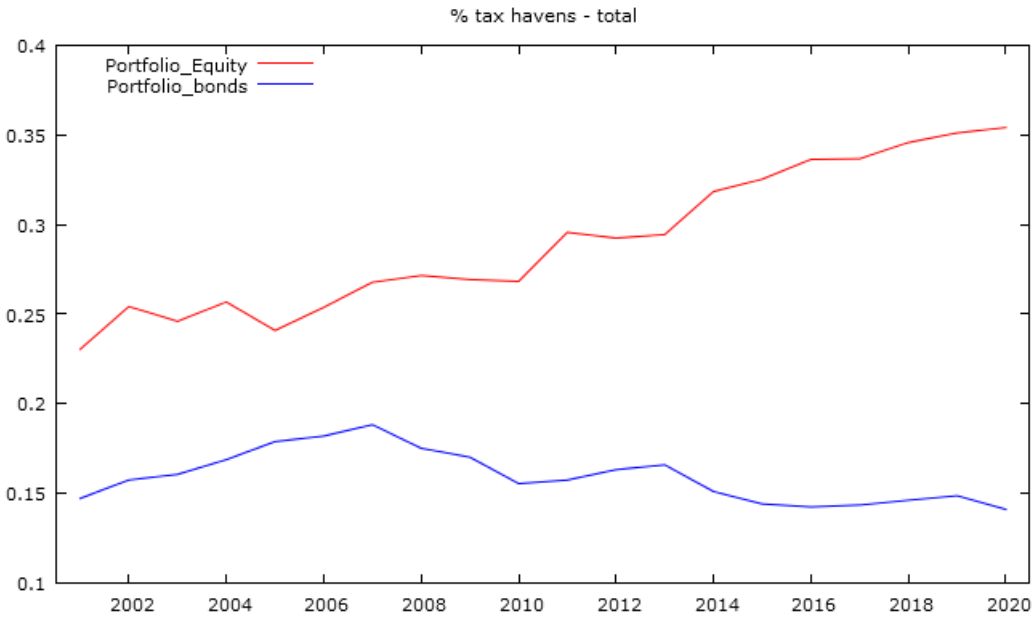
However, portfolio equity and bonds are two different assets in terms of nature and risk. We have found that distance and the euro area pair dummy are more relevant for bonds, probably because portfolio bonds tend to be bought from neighboring issuing countries. Thus, EU debt tends to remain in the EU, particularly in euro-area countries. In contrast, portfolio equity seems to have much more international mobility, but even in this case, we find evidence favoring a euro-area bias. In this vein, given that portfolio equity is more mobile than bonds, this asset is more sensitive to financial restrictions in the rest of the world and to global risk. Despite the differences, we also found similarities, such as the role of historical links, institutional quality, and financial development.

[31] 18% and 23%, when we focus only on the EU tax havens.

We repeated our analysis using the IMF (CPIS) database built under the residence principle for comparability. We obtained essential differences in the gravity variables for portfolio equity and bonds. Distance (probably due to the intermediary role of tax havens) is found to be much less significant under the residence principle. Similar conclusions are obtained for economic size. Regarding the resistance variables, bilateral financial restrictions have a similar role as in the nationality analysis, whereas multilateral resistance's role is much more limited under the residence principle. Using the residence data, we also find some inconsistencies in the global risk variable for portfolio bonds. The differences observed above point to the relevance of addressing the role of tax havens, as ignoring them blurs the actual effect of the gravity variables on explaining portfolio holdings.

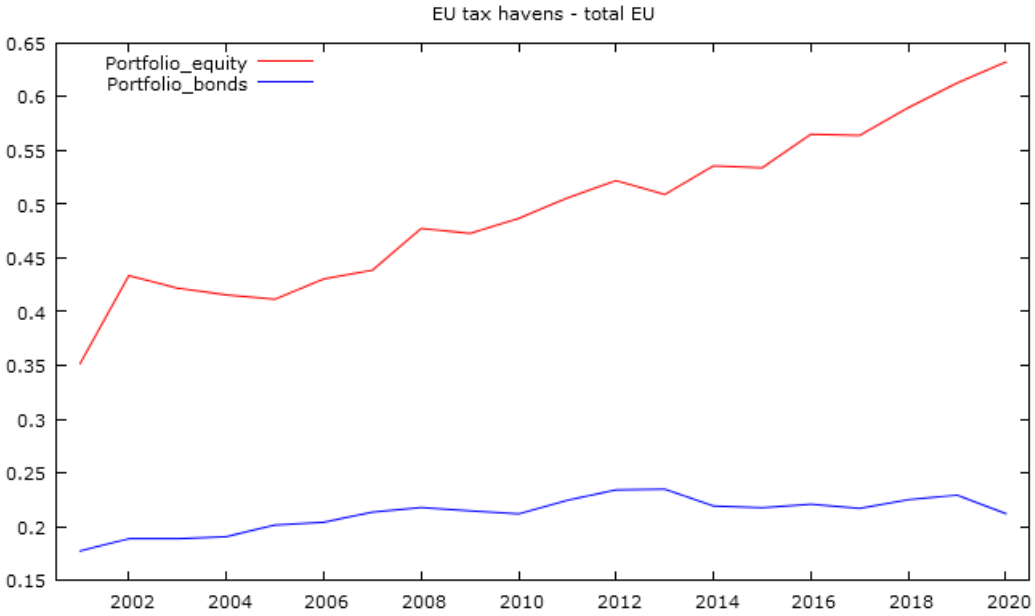
Figures

Figure 4.1: World tax havens.



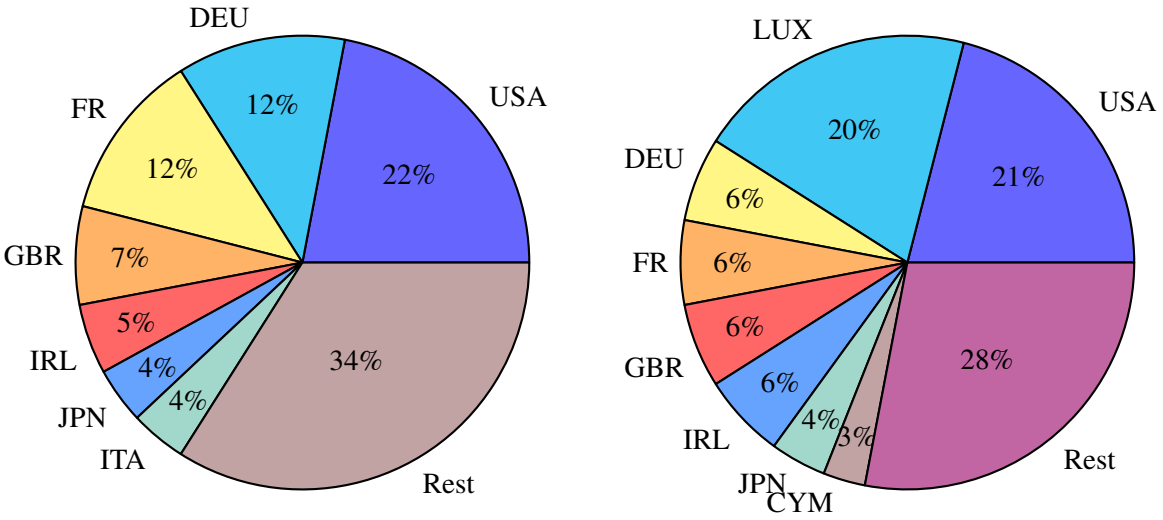
Notes: (a) Data obtained from the IMF (CPIS) database (residence principle); (b) Tax havens included in the graph are listed in table 4.C.

Figure 4.2: Total EU tax havens.



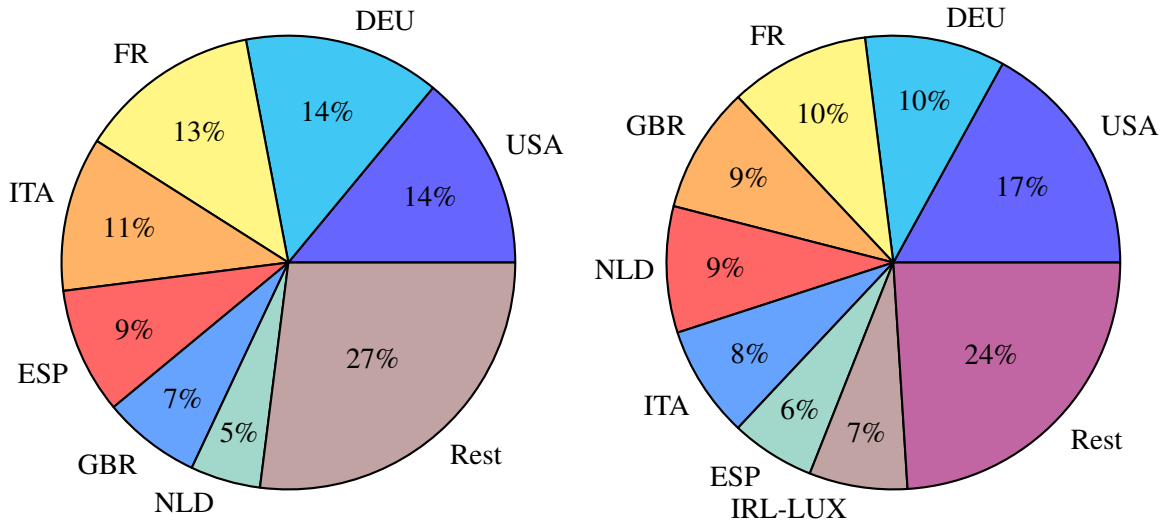
Notes: (a) Data obtained from the IMF (CPIS) database (residence principle); (b) EU tax havens: Cyprus, Ireland, Luxembourg, Malta, Netherlands.

Figure 4.3: EU portfolio equity investment position by issuer country.



Notes: (a) The nationality principle position (left chart) comes from Coppola et al. (2021); (b)The residence principle (right chart) position has been obtained from the IMF (CPIS) database; (c) Croatia is only included in the Coppola et al. (2021) database on the investor but not on the issuer side. (d) CYM= Cayman Islands, DEU = Germany, FR = FRANCE, GBR = United Kingdom, IRL = Ireland, ITA = Italy, JPN = Japan, LUX = Luxembourg, NLD = The Netherlands, USA = United States. (f) CYM has been rounded up to 3% to fit into the pie chart (actual = 2,2%).

Figure 4.4: EU portfolio bond investment position by issuer country.



Notes: (a) The nationality principle position (left chart) comes from Coppola et al. (2021); (b)The residence principle (right chart) position has been obtained from the IMF (CPIS) database; (c) Croatia is only included in the Coppola et al. (2021) database on the investor but not on the issuer side; (d) DEU = Germany, ESP = Spain, FR = FRANCE, GBR = United Kingdom,IRL = Ireland, ITA = Italy, LUX = Luxembourg, NLD = The Netherlands, USA = United States.

Tables

Table 4.1: EU portfolio equity investment position.

Investor	Issuer EU - Investor EU	Issuer Euro Area - Investor EU
Euro area members	61%	84%
Non-members of Euro area		
Bulgaria	71%	93%
Czech Republic	82%	92%
Denmark	40%	64%
Hungary	78%	86%
Poland	64%	89%
Romania	95%	94%
Sweden	47%	76%
United Kingdom	26%	91%

Notes: (a) Data obtained from Coppola et al. (2021), under the nationality principle; (b) Croatia is only included in the Coppola et al. (2021) database on the investor but not on the issuer side. (b) Data covers the full sample period (2007-2017).

Table 4.2: List of variables.

Variables	Definition	Source
Dependent variable		
Portfolio equity stock	Portfolio equity stock between investor and issuer countries.	Coppola et al. (2021)
Portfolio bond stock	Portfolio bond stock between investor and issuer countries.	Coppola et al. (2021)
Gravity variables		
Distance	Distance between the most populated cities of each country in km. EMU (investor) values are the average of individual EMU countries.	CEPII
Economic size	Investor and issuer's GDP (constant 2015 USD). Millions.	World bank open data
Multilateral resistance		
Bilateral financial friccions	Economic Globalization de facto index (KOFEcGIdf). The index ranges between 1 (lowest openness level) and 100 (highest openness level). Economic frictions are the difference between frictionless economic openness (100) minus the actual country value. For robustness check, we also use the KOFEcGI index, an average of the Economic Globalization de facto and de jure indices. EMU (investor) values are the average of individual EMU countries.	Gygli et al. (2019) and Dreher (2006)
Multilateral financial friccions	Also based on KOFEcGIdf as above. Ranges between 1 and 100. For the multilateral measure, we use the world average, excluding investor and issuer countries. For robustness check, we use the KOFEcGI index. EMU (investor) values are the average of individual EMU countries.	Gygli et al. (2019)

Notes: CEPII=Centre d'Etudes Prospectives et d'Informations Internationales, IMF=International Monetary Fund, WGI=Worldwide Governance Indicators.

Table 4.2: List of variables. Cont.

Variables	Definition	Source
Resistance-barriers variables		
Global uncertainty/risk (equity)	CBOE Volatility Index (VIX).	FRED database
Global uncertainty/risk (bonds)	World Uncertainty Index (WUI). The index is divided by 1.000.	Ahiret al.(2022)
Additional gravity variables		
Euro area pair	Takes value of 1 when both investor and issuer are EZ members.	Own calculations
Common language	Takes value of 1 when both share common official or primary language.	CEPII
Colony	Takes value of 1 if the two countries have ever had a colonial link	CEPII
Institutional quality		
Regulatory quality framework	Regulatory quality: perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Index between -2.5 (poor) and 2.5 (strong quality). The index is multiplied by 10. EMU (investor) values are the average of individual EMU countries.	WGI
Financial development quality		
Financial development	Measures depth, access, and efficiency of the country's financial institutions and markets. The Financial Development index is an aggregate of the financial institution's index and the Financial Markets index. Ranges between 0 (no financial development) and 1 (full). In %. EMU (investor) values are the average of the individual EMU countries.	IMF dataset

Notes: CEPII=Centre d'Etudes Prospectives et d'Informations Internationales, IMF=International Monetary Fund, WGI=Worldwide Governance Indicators.

Table 4.3: PPML estimation. Portfolio equity data.

Variable and group	I	II	III	IV	V	VI	VII	VIII
Gravity								
ln (Dist)	-0.28***	-0.28***	-0.18**	-0.18**	-0.19**	-0.19**	-0.15**	-0.20***
ln (GDP) investor	1.15***	1.20***	1.10***	1.14***	1.17***	1.13***	1.16***	1.14***
ln (GDP) issuer	1.20***	1.20***	1.20***	1.19***	1.14***	1.00***	0.91***	0.89***
Bilateral resistance								
KOFEcGIdf investor	-0.04***	-0.04***	-0.04***	-0.04***	-0.04***	-0.03***	-0.05***	-0.03***
KOFEcGIdf Issuer	-0.05***	-0.05***	-0.05***	-0.05***	-0.04***	-0.02***	-0.03***	-0.02***
Multilateral resistance								
KOFEcGIdf RoW	0.05	0.49***	0.05	0.55***	0.38***	0.21***	0.21***	0.21***
Other resistance variables								
Global risk	-	-0.05***	-	-0.06***	-0.04***	-0.04***	-0.03***	-0.04***
Additional gravity variable								
Euro area pair	-	-	0.51**	0.57***	0.68***	0.91***	1.00***	0.97***
Common language	-	-	-	-	1.14***	0.73***	0.65***	0.64***
Government quality								
Regulator quality investor	-	-	-	-	-	0.09***	-	0.10***
Regulator quality issuer	-	-	-	-	-	0.06***	-	0.02
Financial development								
Financial development investor	-	-	-	-	-	-	0.02***	0.00
Financial development issuer	-	-	-	-	-	-	0.03***	0.03***
N observations	31.495	31.495	31.495	31.495	31.495	31.495	29.376	29.376
RESET test (Chi^2)	2.73	3.87	1.76	2.36	5.93	5.98	9.07*	6.23

Notes: (a) *, ** and *** denote significance at the 10%, 5% and 1% levels; (b) Dist stands for bilateral distance, KOFEcGIdf RoW is the KOFEcGIdf index calculated for the Rest of the World; (c) Chi^2 refers to the RESET test. * denotes rejection of the null hypothesis of correct model specification at 1% significance.

Table 4.4: PPLM estimation. Portfolio equity data - IMF.

Variable and group	I	II	III	IV	V	VI	VII	VIII
Gravity								
ln (Dist)	-0.22**	-0.22***	-0.13	-0.13	-0.08	-0.22***	-0.11	-0.22***
ln (GDP) investor	0.93***	0.92***	0.93***	0.93***	0.86***	0.63***	0.55***	0.48***
ln (GDP) issuer	0.78***	0.78***	0.79***	0.79***	0.72***	0.51***	0.41**	0.37**
Bilateral resistance								
KOFEcGIdf investor	-0.05***	-0.05***	-0.05***	-0.05***	-0.04***	0.01	-0.02**	0.01
KOFEcGIdf Issuer	-0.05***	-0.04***	-0.05***	-0.04***	-0.04***	0.01	-0.01	0.01
Multilateral resistance								
KOFEcGIdf RoW	-0.04	0.11***	-0.03	0.11***	0.08***	0.14***	0.20***	0.22***
Other resistance variable								
Global risk	-	-0.02***	-	-0.02***	-0.02***	-0.04***	-0.05***	-0.05***
Additional gravity variables								
Euro area pair	-	-	0.52**	0.52**	0.57**	0.79***	1.02***	1.08***
Common language	-	-	-	-	1.34***	1.15***	1.05***	0.96***
Government quality								
Regulator quality investor	-	-	-	-	-	0.14***	-	0.10***
Regulator quality issuer	-	-	-	-	-	0.12***	-	0.07***
Financial development								
Financial development investor	-	-	-	-	-	-	0.05***	0.04***
Financial development issuer	-	-	-	-	-	-	0.05***	0.04***
N observation	28.638	28.638	28.638	28.638	28.638	28.638	27.496	27.496
RESET test (Chi^2)	4.63	4.30	3.41	3.14	1.83	1.38	0.01	0.04

Notes: (a) *, ** and *** denote significance at the 10%, 5% and 1% levels; (b) Dist stands for bilateral distance, KOFEcGIdf RoW is the KOFEcGIdf index calculated for the Rest of the World; (c) Chi^2 refers to the RESET test. * denotes rejection of the null hypothesis of correct model specification at 1% significance.

Table 4.5: PPLM estimation. Portfolio equity data - robustness check.

Variables and group	I	II	III	IV	V	VI	VII	VIII
Gravity								
ln (Dist)	-0.18**	-0.19**	-0.07	-0.07	-0.10	-0.16*	-0.12*	-0.18**
ln (GDP) investor	1.11***	1.15***	1.06***	1.10***	1.11***	1.08***	1.09***	1.10***
ln (GDP) issuer	1.09***	1.09***	1.10***	1.10***	1.06***	1.00***	0.90***	0.88***
Bilateral resistance								
KOFEcGI investor	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.04***	-0.07***	-0.04***
KOFEcGI Issuer	-0.07***	-0.07***	-0.07***	-0.06***	-0.06***	-0.03***	-0.04***	-0.03***
Multilateral resistance								
KOFEcGI RoW	0.06	0.43***	0.10**	0.59***	0.37***	0.14***	0.21***	0.18***
Additional resistance variable								
Global risk	-	-0.03***	-	-0.04***	-0.03***	-0.02***	-0.03***	-0.03***
Other gravity variables								
Euro area pair	-	-	0.56***	0.64***	0.70***	0.90***	0.97***	0.97***
Colony	-	-	-	-	0.75***	0.53***	0.37**	0.38**
Government quality								
Regulator quality investor	-	-	-	-	-	0.08***	-	0.08**
Regulator quality issuer	-	-	-	-	-	0.04***	-	0.01
Financial development								
Financial development investor	-	-	-	-	-	-	0.02***	0.00
Financial development issuer	-	-	-	-	-	-	0.03***	0.03***
N observation	31.387	31.387	31.387	31.387	31.387	31.387	29.376	29.376
RESET test (Chi^2)	1.60	2.96	1.40	2.77	6.90*	8.40*	5.84	5.46

Notes: (a) *, ** and *** denote significance at the 10%, 5% and 1% levels; (b) Dist stands for bilateral distance, KOFEcGIdf RoW is the KOFEcGIdf index calculated for the Rest of the World; (c) Chi^2 refers to the RESET test. * denotes rejection of the null hypothesis of correct model specification at 1% significance.

Table 4.6: PPLM estimation. Portfolio bonds data.

Variables and groups	I	II	III	IV	V	VI	VII	VIII
Gravity								
ln (Dist)	-0.77***	-0.77***	-0.47***	-0.47***	-0.47***	-0.48***	-0.50***	-0.53***
ln (GDP) investor	1.37***	1.36***	1.11***	1.10***	1.11***	1.10***	1.16***	1.15***
ln (GDP) issuer	1.14***	1.14***	1.12***	1.12***	1.13***	0.97***	0.84***	0.81***
Bilateral resistance								
KOFEcGIdf investor	-0.05***	-0.05***	-0.04***	-0.04***	-0.04***	-0.02***	-0.04***	-0.03***
KOFEcGIdf Issuer	-0.03***	-0.03***	-0.02***	-0.02***	-0.02***	0.00	0.00	0.01
Multilateral resistance								
KOFEcGIdf RoW	0.25***	0.22***	0.24***	0.22***	0.22***	0.12***	0.14***	0.10***
Additional resistance variable								
Global risk	-	-0.01***	-	-0.01***	-0.01***	-0.00	0.00	0.00
Other gravity variables								
Euro area pair	-	-	1.40***	1.40***	1.40***	1.63***	1.59***	1.60***
Common language	-	-	-	-	-0.02	-0.08	0.10	0.06
Government quality								
Regulator quality investor	-	-	-	-	-	0.07***	-	0.06***
Regulator quality issuer	-	-	-	-	-	0.07***	-	0.03*
Financial development								
Financial development investor	-	-	-	-	-	-	0.02***	0.01
Financial development issuer	-	-	-	-	-	-	0.04***	0.03***
N observations	31.495	31.495	31.495	31.495	31.495	31.468	29.376	29.376
RESET test (Chi^2)	2.81	2.76	1.70	1.69	2.07	0.86	0.74	1.07

Notes: (a) *, ** and *** denote significance at the 10%, 5% and 1% levels; (b) Dist stands for bilateral distance, KOFEcGIdf RoW is the KOFEcGIdf index calculated for the Rest of the World; (c) Chi^2 refers to the RESET test. * denotes rejection of the null hypothesis of correct model specification at 1% significance.

Table 4.7: PPML estimation. Portfolio bonds - IMF.

Variables and group	I	II	III	IV	V	VI	VII	VIII
Gravity								
ln (Dist)	-0.48***	-0.48***	-0.28***	-0.29***	-0.26***	-0.35***	-0.31***	-0.39***
ln (GDP) investor	0.78***	0.79***	0.80***	0.80***	0.78***	0.57***	0.51***	0.43***
ln (GDP) issuer	0.94***	0.94***	0.95***	0.95***	0.93***	0.74***	0.73***	0.67***
Bilateral resistance								
KOFEcGIdf investor	-0.04***	-0.04***	-0.04***	-0.04***	-0.04***	0.00	-0.02***	0.00
KOFEcGIdf Issuer	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	0.01	-0.01**	0.01
Multilateral resistance								
KOFEcGIdf RoW	0.20***	0.18***	0.20***	0.18***	0.17***	0.12***	0.14***	0.11***
Other resistance variable								
Global risk	-	-0.01***	-	-0.01***	-0.01***	0.00**	0.01***	0.02***
Other gravity variables								
Euro area pair	-	-	0.97***	0.97***	1.01***	1.20***	1.28***	1.38***
Common language	-	-	-	-	0.61***	0.55***	0.40**	0.37**
Government quality								
Regulator quality investor	-	-	-	-	-	0.13***	-	0.10***
Regulator quality issuer	-	-	-	-	-	0.10***	-	0.06***
Financial development								
Financial development investor	-	-	-	-	-	-	0.04***	0.03***
Financial development issuer	-	-	-	-	-	-	0.04***	0.03***
N observations	29.604	29.604	29.604	29.604	29.604	29.588	29.398	29.398
RESET test (Chi^2)	0.27	0.30	0.12	0.14	0.01	0.09	1.68	2.09

Notes: (a) *, ** and *** denote significance at the 10%, 5% and 1% levels; (b) Dist stands for bilateral distance, KOFEcGIdf RoW is the KOFEcGIdf index calculated for the Rest of the World; (c) Chi^2 refers to the RESET test. * denotes rejection of the null hypothesis of correct model specification at 1% significance.

Table 4.8: PPML estimation. Portfolio bonds - robustness check.

Variables and group	I	II	III	IV	V	VI	VII	VIII
Gravity								
ln (Dist)	-0.71***	-0.70***	-0.37***	-0.37***	-0.40***	-0.45***	-0.51***	-0.54***
ln (GDP) investor	1.34***	1.34***	1.08***	1.08***	1.03***	1.02***	1.08***	1.08***
ln (GDP) issuer	1.09***	1.09***	1.09***	1.09***	1.08***	1.03***	0.86***	0.85***
Bilateral resistance								
KOFEcGI investor	-0.07***	-0.07***	-0.06***	-0.06***	-0.05***	-0.03**	-0.05***	-0.03**
KOFEcGI Issuer	-0.04***	-0.04***	-0.03***	-0.04***	-0.03***	-0.01	-0.01	0.00
Multilateral resistance								
KOFEcGI RoW	0.23***	0.20***	0.32***	0.30***	0.28***	0.16***	0.18***	0.14***
Additional resistance variable								
Global risk	-	-0.02***	-	-0.01***	-0.01***	-0.01*	-0.00	-0.00
Other gravity variables								
Euro area pair	-	-	1.46***	1.45***	1.60***	1.76***	1.72***	1.73***
Colony	-	-	-	-	0.33**	0.35**	0.31**	0.30**
Government quality								
Regulator quality investor	-	-	-	-	-	0.05***	-	0.05**
Regulator quality issuer	-	-	-	-	-	0.03*	-	0.01
Financial development								
Financial development investor	-	-	-	-	-	-	0.01***	0.02
Financial development issuer	-	-	-	-	-	-	0.03***	0.03***
N observation	31.387	31.387	31.387	31.387	31.387	31.378	29.376	29.376
RESET test (Chi^2)	4.32	4.34	1.02	0.99	1.15	0.87	0.57	0.57

Notes: (a) *, ** and *** denote significance at the 10%, 5% and 1% levels; (b) Dist stands for bilateral distance, KOFEcGIdf RoW is the KOFEcGIdf index calculated for the Rest of the World; (c) Chi^2 refers to the RESET test. * denotes rejection of the null hypothesis of correct model specification at 1% significance.

Appendix

Table 4.A: EU portfolio equity investment in world tax havens.

Year	**Residence princ. position**	**Nationality princ. position**	%
2007	1.278.723	895.089	30%
2008	712.057	507.016	29%
2009	990.563	672.263	32%
2010	1.126.968	727.875	35%
2011	1.046.592	682.021	35%
2012	1.284.487	860.362	33%
2013	1.554.568	1.055.663	32%
2014	1.563.544	1.063.716	32%
2015	1.547.207	1.093.138	29%
2016	1.682.982	1.228.221	27%
2017	2.295.295	1.639.746	29%

Notes: (a) Tax havens included in the table are listed in table 4.C; (b) residence principle position data comes from the IMF CPIS, whereas Nationality principle position data comes from the database by Coppola et al. (2021).

Table 4.B: USA portfolio equity investment in EU tax havens.

Year	Residence princ. position	Nationality princ. position	%
2007	216.360	174.337	19%
2008	97.031	79.987	18%
2009	196.728	131.029	33%
2010	232.155	144.959	38%
2011	216.822	137.157	37%
2012	275.693	166.405	40%
2013	459.257	278.643	39%
2014	555.426	297.192	46%
2015	654.096	314.308	52%
2016	634.047	329.483	48%
2017	758.898	425.398	44%

Notes:
(a) EU tax havens are Cyprus, Ireland, Luxembourg, Malta, and Netherlands. (b): residence principle position data comes from the IMF CPIS, whereas nationality principle position data comes from the database by Coppola et al. (2021).

Table 4.C: List of tax havens.

Country	**Country**
Aruba	Saint Kitts and Nevis
Anguilla	Lebanon
Andorra	Liberia
Netherlands Antilles	Saint Lucia
Antigua and Barbuda	Liechtenstein
Bahrain	Luxembourg
Bahamas	Macao
Belize	Monaco
Bermuda	Maldives
Barbados	Marshall Islands
Cook Islands	Malta
Costa Rica	Montserrat
Curaçao	Mauritius
Cayman Islands	Niue
Cyprus	Netherlands
Djibouti	Nauru
Dominica	Panama
Micronesia, Federated States of	Singapore
Guernsey	San Marino
Gibraltar	Seychelles
Grenada	Turks and Caicos Islands
Hong Kong	Tonga
Isle of Man	Saint Vincent and the Grenadines
Ireland	Virgin Islands, British
Jersey	Vanuatu
Jordan	Samoa

Source: Coppola et al. (2021)

Table 4.D: Countries in the sample. Equity.

Investor	**Period**
Argentina, Bahrain, Bermuda, Brazil, Bulgaria, Canada, Cayman Islands, Chile, Colombia, Costa Rica Czech Republic, Denmark, Egypt, European Monetary Union, Hong Kong, Hungary, Iceland, India Indonesia, Israel, Japan, Kazakhstan, Korea, Republic of, Kuwait Lebanon, Macao Malaysia, Mauritius, Mexico, New Zealand, Pakistan, Panama, Philippines, Poland Romania, Russian Federation, Singapore, South Africa, Sweden, Switzerland, Thailand Turkey, Ukraine, United Kingdom, United States, Uruguay	2007-2017
Mongolia	2010-2017
Bolivia	2011-2017
Saudi Arabia	2013-2017
Bangladesh, Belarus, Honduras, Norway	2014-2017
Albania, China, Peru	2015-2017
Macedonia	2016-2017
Australia	2017

Issuer	**Period**
Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin Bermuda, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Cayman Islands, Central African Republic Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Côte d' Ivoire, Croatia, Cyprus, Czech Republic Denmark, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia	2007-2017

Table 4.D: Countries in the sample. Equity. Cont.

Issuer. Cont.	**Period**
Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland India, Indonesia, Iran, Islamic Republic of, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan Kenya, Kiribati, Korea, Republic of, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macao, Macedonia, Madagascar, Malawi, Malaysia Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Federated States of Moldova Republic of, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Saint Kitts and Nevis Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania, United Republic of, Thailand, Togo Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Vietnam, Yemen, Zambia, Zimbabwe	2007-2017
Eritrea	2007-2011
Djibouti	2013-2017

Table 4.E: Countries in the sample. Bonds.

Investor	**Period**
Argentina, Bahrain, Bermuda, Brazil, Bulgaria, Canada, Cayman Islands, Chile, Colombia, Costa Rica, Czech Republic, Denmark Egypt, European Monetary Union, Korea, Republic of, Kuwait, Lebanon, Macao, Malaysia, Mauritius, Mexico New Zealand, Pakistan, Panama, Philippines, Poland, Romania, Russian Federation, Singapore, South Africa Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom, United States, Uruguay	2007-2017
Bahamas	2007-2014
Barbados	2007-2015
Mongolia	2010-2017
Bolivia	2011-2017
Saudi Arabia	2013-2017
Bangladesh, Belarus, Honduras, Norway	2014-2017
Albania, China, Peru	2015-2017
Australia	2017
Bahrain	2007-2011
Aruba, United Kingdom	2007-2016
Macedonia	2016-2017
Djibouti	2013-2017
Eritrea	2007-2011

Table 4.E: Countries in the sample. Bonds. Cont.

Issuer	**Period**
Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia, Austria Azerbaijan, Bahamas, Bahrain, Bangladesh, Belgium, Belize, Benin, Bermuda, Bhutan, Bolivia, Bosnia and Herzegovina Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada Cape Verde, Cayman Islands, Central African Republic, Chad, Chile, China, Colombia, Comoros Congo, Democratic Republic of the, Cost Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominica, Dominican Republic Ecuador, Egypt, El salvador, Equatorial Guinea, Côte d'Ivoire, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia Georgia, Germany, Ghana, Greece, Grenada, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong kong Hungary, Iceland, India, Indonesia, Iran, Islamic Republic of, Iraq, Ireland, Israel, Italy, Jamaica, Japan Jordan, Kazakhstan, Kenya, Kiribati, Korea, Republic of Kuwait, Kyrgyzstan, Lao People's Dem. Republic, Latvia Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macao, Macedonia, Madagascar, Malawi, Malaysia Maldives, Mali, Malta, Marshall Islands, Mauritius, Mexico, Micronesia, Moldova, Mongolia, Morocco Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway Oman Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar Romania, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Singapore, Seychelles, Sierra Leone, Slovakia, Slovenia Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syrian Arab Republic Tajikistan, Tanzania, United Republic of, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan Vanuatu, Vietnam, Yemen, Zambia, Zimbabwe	2007-2017
Djibouti	2013-2017
Eritrea	2007-2011

Chapter 5

Summary and conclusions

Over the last decades, capital mobility and financial integration have attracted considerable attention from researchers and policy makers due to their benefits on risk sharing, capital allocation efficiency, and potential growth. Nonetheless, with the removal of capital barriers that started in the developed countries, capital mobility has been affected by periods of financial turmoil. In addition, the 2007-2008 global financial crisis heavily harmed the process of globalization and capital mobility. In particular, the case of the European Union, during the 2007-2008 crisis, unleashed a series of episodes of financial instability (especially in the euro area countries) with the 2010-2015 European Sovereign crisis. This period is characterized by sudden stops that created a process of fragmentation within the European Union. This fragmentation process has been complex to fight due to the large external imbalances created after the Maastricht Treaty of 1992. Despite the efforts carried out by the European financial regulators, the issue is far from being solved. The outbreak of the COVID-19 pandemic in 2020 and the geopolitical tensions in Europe after the Russian invasion of Ukraine have put more pressure on the fragmentation process.

The literature on capital mobility has used the price and quantity approach to assess the degree of capital mobility in conjunction with well-developed econometric techniques. The push-pull and gravity approach or a combination of both have been applied to identify the drivers that explain capital mobility. However, concerns have been raised regarding the need for more robust theoretical foundations when applying the push-pull or gravity approach.

In this context, this doctoral dissertation has aimed to contribute to the literature by measuring the degree of capital mobility and financial integration in the European Union and identifying the drivers of capital allocation, in this case, for portfolio equity and bonds stocks. Assets issued through market-based financial systems have a genuine policy interest in the European Union due to the overweight relevance of the banking system as a channel for European investment.

For this purpose, in chapter 2, given the interest in measuring the impact of the European integration process and the episodes of financial turmoil on long-run capital mobility, we focus on 19 euro area countries for 1970-2019. Due to the countries' trade pattern heterogeneity, financial exposure, and external positions, we followed a time-series approach with cointegration techniques. In addition, the econometric methodology allowed us to identify the structural breaks that affected the individual investment-saving regressions and relate them to the process of economic integration in the EU. Thus, the euro area countries are an interesting case of study since this area has progressed toward a complete monetary union by creating the euro as its common currency.

The motivation of the following chapter was to improve the analysis of financial integration in the European Union using panel data since it allows the exploitation of both the cross-section and time information included in large T panels. Therefore, chapter 3 assessed capital mobility for 15 European Union countries between 1970-2019. Although the sample was restricted by data availability, the countries included in the analysis cover around 87% of total EU GDP, allowing us to derive conclusions that can be extended to the whole area. To overcome some relevant panel data issues (common correlated effects, cross-sectional dependence, parameter heterogeneity, and endogeneity), we used in chapter 3 the Chudik et al. (2016) Dynamic Common Correlated Effects (DCCE) estimator, modeled as an error correction mechanism that includes one structural break. In addition, in this chapter, we include other non-linearities, such as threshold models, to assess how financial openness and economic risk affect financial integration when they reach a specific benchmark.

Finally, after assessing the degree of financial integration in the EU and how the economic integration process and episodes of financial turmoil affected capital mobility, in chapter 4, we focus on the drivers of portfolio equity and bond stock investments. For this goal, we followed a gravity approach consistent with the theoretical model developed by Okawa and Van Wincoop (2012). From an econometric point

of view, in this chapter we use the Poisson Pseudo Maximum Likelihood (PPML) developed by Santos Silva and Tenreyro (2006) that helps to overcome some limitations of the traditional OLS (Ordinary Least Square). Our sample covers all the EU 28 countries and their counterparts, both EU and non-EU countries.

Concerning the main contributions of this dissertation, it provides discussions and adds value to the literature in several aspects. First, our sample period allows us to assess the degree of capital mobility from the early stages of the EU integration process and then relate the structural breaks found with the integration process and the episodes of financial turmoil. Second, the results of the analysis of capital mobility are robust in the presence of non-stationarity of the data, and state-of-the-art cointegration analysis is implemented. In the first two chapters, non-linearities are accounted for with structural breaks and threshold levels included in the estimated models. Third, the gravity model in chapter 4 follows the theory-based model of Okawa and Van Wincoop (2012) instead of ad-hoc approaches based on push-pull or gravity models without theoretical foundation, avoiding model specification issues present in previous literature. Fourth, the increasing relevance of tax havens in the global financial system, especially for portfolio equity, is accounted for using the database of Coppola et al. (2021). Lastly, as the banking sector is predominant in the European financial system as a channel for investment, identifying the drivers of financial assets issued in the market-based financial system may help European regulators monitor the overweight of the banking system.

As for the measurement of financial integration, our findings suggest that the FH coefficient has decreased over time, which implies an improvement in capital mobility since the Maastricht Treaty. This process was led by the core countries that were the first to achieve high capital mobility. However, exogenous events such as the EMS crisis, the German reunification, the USSR downfall, the 2007-2008 world financial crisis, and the European sovereign debt have negatively affected capital mobility. In this context, the European economic integration process encouraged capital flows from the core to the periphery, allowing the former countries to run large external imbalances. Subsequently, the impact of 2007-2008 and the European sovereign debt crisis on the euro area countries has differed depending on their net external position. In this regard, the crisis heavily affected the peripheral countries; however, the impact was more limited for the rest of the euro area (core and CEEC countries). To mitigate market

fragmentation during the sovereign debt crisis, the EFSM and the ESM were created to provide financial assistance to EU countries experiencing financial difficulties. These programs, implemented during the European sovereign debt crisis, have helped host countries improve capital mobility; however, some have not yet returned to their pre-crisis levels.

When we focus on the 15 largest economies of the European Union, the euro is the most relevant structural change affecting capital mobility: the absence of exchange rate uncertainty may have boosted trade and financial transactions. Our results show that neglecting structural breaks in the analysis would underestimate the degree of long-run capital mobility. Our panel approach helped to provide a complete assessment of capital mobility, as we simultaneously account for long-run and short-run capital mobility and the speed of adjustment towards the equilibrium after a shock. Interestingly, this bi-dimensional nature of capital mobility helps to understand the external imbalances observed in the European Union. In this regard, while the core countries tend to return relatively quickly to their long-run equilibrium, peripheral countries return at a lower speed. These persistent differences between domestic investment and saving explained the large external imbalances found in some European Union countries. Regarding the long-run parameter, the results show a high level of capital mobility. However, the European financial markets still need to be fully integrated. The threshold analysis also shows how economic risk and openness affect capital mobility. During episodes of financial turmoil, capital mobility was low. Examples are the early 90s EMS crisis and the 2011 sovereign crisis. However, perfect financial integration appeared in periods when economic risk was low. In this context, economic openness also boosts capital mobility since periods of high economic openness (including trade and financial openness) are associated with perfect capital mobility. In contrast, capital mobility was moderate when the openness index was low.

The results described above leave some interesting conclusions with an economic policy dimension. First, our analysis suggests that the integration of the financial market in Europe is incomplete. Therefore, further economic policy steps should be carried out. Second, encouraging financial integration through capital mobility is not sufficient to achieve fully integrated capital markets, as integrated good markets are a necessary condition. Therefore, policymakers should focus on both goals at the same time. Third, there are still significant differences between core and peripheral countries regarding financial weaknesses depending on their net external position. Consequently, relevant market fragmentation processes arise

in financial turmoil and economic uncertainty episodes. Hence, correcting these external imbalances is needed to prevent financial fragmentation.

Once the degree of capital mobility and financial integration has been assessed, this dissertation's next logical step was to identify the drivers that explain capital mobility. For this goal, we focused on bilateral portfolio equity and bond stocks in which at least one EU country is involved, either on the investor or the issuer side. The results show that gravitational variables are significant for both assets, meaning that larger countries closer to each other tend to invest more between them. In addition, the resistance variables, defined as financial restrictions, also play a significant role in asset holdings. In this sense, bilateral restrictions between country pairs harm bilateral holdings. In contrast, an increase in financial restrictions in the rest of the world relative to the bilateral restrictions increases asset trade between the two countries. We also found that global risk has a negative effect, which aligns with previous literature about risk and uncertainty's role in capital mobility.

When we extend our model, we also capture the positive effect of historical links, quality of the government, and financial development on portfolio allocation. Our analysis shows a strong euro-area bias in portfolio allocation regarding the financial and economic links between the euro-area countries. We also extract some relevant conclusions when we compare the differences and similarities between portfolio equity and bonds. This is a particularly interesting topic, as they are different assets regarding nature and risk. When comparing the results, some differences are apparent: first, distance and the euro bias are more relevant for portfolio bonds, as the EU debt tends to remain in the EU. This is even more relevant for the case for the euro area countries. However, portfolio equity has more international mobility, even if we also found evidence of euro area bias. The fact that portfolio equity is more mobile than bonds explains its sensitivity to financial restrictions in the rest of the world and to global risk. Despite the differences, our results also display similarities, such as the role of historical links, institutional quality, and financial development. Lastly, our results also point out the need to adequately address the role of tax havens, specifically for assets in which tax havens are more relevant, as is the case for portfolio equity.

The predominance of the banking sector characterizes the current European financial system as the main channel of European investment; therefore, our assessment of the drivers of portfolio stocks, which is an example of a market-based financial system, may help policymakers to carry out specific policies to

promote and develop this type of financial system models. In addition, our results may provide some recommendations for policymakers. First, the strong EU bias found for portfolio debt implies that default would highly impact the EU since the EU's main creditors are the EU countries. Second, the government's quality and well-developed financial markets play a relevant role in attracting capital; therefore, to encourage capital mobility, both should be fostered in all European countries. Lastly, in the analysis of the drivers of portfolio equity and bonds the role of tax havens cannot be ignored. The analysis of the drivers of assets using a database that does not correctly account for the role of tax havens as intermediaries blur the actual factors behind portfolio allocation.

Finally, the research conducted in this dissertation presents some limitations that also give rise to two potential avenues for future research. First, the analysis in chapter 4 has been constrained by data availability. In this sense, developing new databases with longer data span that account for the role of tax havens would allow the use of cointegration techniques and a long-run analysis of the drivers of portfolio stocks. Additionally, as we already did in chapters 2 and 3 of this dissertation, adding structural breaks to the analysis would be a topic of interest to assess potential changes in the impact of those drivers over time. Second, the gravity approach used in chapter 4, in conjunction with a database that re-maps the flows/stocks of portfolio investment when accounting for the role of tax havens, may be applied to another type of financial assets, such as FDI.

Resumen y conclusiones

A lo largo de las últimas décadas, la movilidad de capitales y la integración financiera han atraído una considerable atención por parte de académicos y reguladores económicos debido a los beneficios implícitos que tiene sobre la diversificación del riesgo, distribución eficiente del capital y sobre el potencial de crecimiento. Sin embargo, con la eliminación de barreras de capital que empezaron en los países desarrollados, la movilidad de capitales se ha visto afectada por periodos de turbulencias e incertidumbre financiera. Además, la crisis financiera global de 2007-2008 tuvo un impacto negativo sobre el proceso de globalización y de movilidad de capitales. En particular, en el caso de la Unión Europea, los hechos acontecidos durante la crisis de 2007-2008 desencadenaron una serie de inestabilidades financieras (especialmente en los países de la zona euro) con la crisis europea de deuda soberana. Este periodo se caracteriza por la paralización repentina de los flujos de capital, que creó un proceso de fragmentación financiera dentro de la Unión Europea. Este proceso de fragmentación ha sido complejo de corregir debido a los grandes desequilibrios externos originados después del Tratado de Maastricht de 1992. A pesar de los esfuerzos llevados a cabo por los reguladores financieros de la UE, el problema está lejos de solucionarse. El estallido de la pandemia COVID-19 en 2020 junto con las tensiones geopolíticas en Europa después de la invasión rusa de Ucrania, han puesto mucha más presión sobre el proceso de fragmentación.

La literatura sobre movilidad de capitales ha utilizado los enfoques de precio y cantidad para evaluar el nivel de movilidad de capital, mediante técnicas econométricas sólidas. El enfoque de "atracción-repulsión" y el modelo de gravedad, o una combinación de ambos, se han estado aplicando para identificar los factores que explican la movilidad de capitales. Sin embargo, existen dudas sobre la robustez de los fundamentos del enfoque de atracción-repulsión, frente al de gravedad.

En este contexto, el propósito de esta tesis doctoral ha sido contribuir a la literatura mediante el análisis del grado de movilidad de capitales e integración financiera en la Unión Europea, así como la identificación de los factores que explican las decisiones de invertir en un país este capital. Para este último propósito, se ha elegido el stock de acciones y bonos cotizados. La emisión de activos a través de un modelo financiero basado en mercados cotizados tiene un interés especialpara la política económica de

la UE debido al sesgo que muestra la UE hacia el sistema bancario como canalizador de la inversión en activos.

Por este motivo, en el capítulo 2, dado el interés por el impacto que proceso de integración europeo y los episodios de incertidumbre financiera han tenido en la movilidad de capitales a el largo plazo, nos hemos centrado en los 19 países de la zona euro durante el periodo 1970-2019. Debido a que estos países presentan un alto grado de heterogeneidad en cuanto a patrones de comercio, exposición financiera y posición externa neta, hemos seguido un enfoque de series temporales junto con técnicas de cointegración. Además, la metodología econométrica nos permite identificar los cambios estructurales que afectaron a las regresiones individuales de inversión-ahorro y relacionarlas con el proceso de integración económica en la UE. Por otra parte, los países de la zona euro son un caso especialmente interesante de estudio, ya que han avanzado más en el proceso de integración financiera con la creación de la Unión Monetaria.

La motivación del siguiente capítulo fue la de mejorar el análisis de la integración financiera en la Unión Europea utilizando datos de panel, ya que nos permite explotar no solo los datos de corte transversal, sino también la información temporal que se incluye en paneles con largos horizontes temporales. Por lo tanto, el capítulo 3 evalúa la movilidad de capital para quince países de la Unión Europea durante el periodo 1970-2019. Aunque la muestra ha estado limitada por la disponibilidad de datos, los países incluidos en el análisis cubren el 87% del PIB total de la UE, permitiendo extraer conclusiones que pueden ser extrapolables a toda el área. Para abordar algunos problemas relacionados con el uso de datos de panel (efectos comunes correlacionados, dependencia de corte transversal, heterogeneidad de parámetros y endogeneidad), en el capítulo 3, utilizamos el estimador Efectos Comunes Correlacionados Dinámicos (ECCE) propuesto por Chudik et al. (2016), modelizado como un mecanismo de corrección de error, que incluye un cambio estructural común a toda la muestra. Además, en este capítulo, incluimos otras no linealidades, tales como modelos de umbrales, para evaluar cómo la apertura financiera y el riesgo económico afectan a la integración financiera cuando alcanzan un determinado nivel.

Finalmente, después de evaluar el grado de integración financiera en la UE y cómo la integración económica y los episodios de turbulencias financieras afectaron a la movilidad de capitales, en el capítulo 4, nos centramos en los factores que atraen la inversión en acciones y bonos cotizados. Para este obje-

tivo seguimos un enfoque gravitacional, consistente con el modelo teórico desarrollado por Okawa and Van Wincoop (2012). Desde un punto de vista econométrico, en este capítulo se utiliza el estimador Pseudo Poisson Máxima verosimilitud (PPMV) desarrollado por Santos Silva and Tenreyro (2006) que ayuda a abordar algunas limitaciones del tradicional Mínimos Cuadrados Ordinarios (MCO). Nuestra muestra cubre todos los países de la UE 28 junto con sus relaciones bilaterales.

Respecto a las principales contribuciones de esta Tesis, ésta aporta discusión y contribuye a la literatura en varios aspectos. Primero, nuestra muestra nos permite evaluar el grado de movilidad de capitales desde las primeras etapas del proceso de integración de la UE y relacionar los cambios estructurales encontrados con el proceso de integración y los episodios de turbulencias financieras. Segundo, los resultados del análisis de la movilidad de capitales son robustos a las características no estacionarias de los datos, además de aplicar técnicas de cointegración vanguardistas. En los dos primeros capítulos, las no linealidades se incorporan a través de cambios estructurales y umbrales que se especifican en los modelos estimados. Tercero, la ecuación de gravedad estimada en el capítulo 4 se basa en los fundamentos teóricos de Okawa and Van Wincoop (2012), en lugar de utilizar enfoques ad-hoc basados en modelos de atracción-repulsión o gravedad que no están basados en fundamentos teóricos; con ello se evitan problemas de especificación del modelo presentes en la literatura previa. Cuarto, la relevancia creciente de los paraísos fiscales en el sistema financiero global, especialmente para la cartera de acciones cotizadas, se toma en consideración mediante el uso de la base de datos de Coppola et al. (2021). Por último, debido a que el sector bancario tiene un papel predominante en el sistema financiero de la UE como canalizador de la inversión, identificar los factores explicativos de la asignación espacial de activos financieros emitidos por sistemas financieros basados en el mercado podría ayudar a los reguladores europeos a monitorizar el excesivo peso del sistema bancario.

Respecto a la medición de la integración financiera, nuestros resultados sugieren que el coeficiente de FH ha decrecido a lo largo del tiempo, lo que implicaría una mejora de la movilidad de capitales desde el Tratado de Maastricht. Este proceso ha sido liderado por los países centrales de la UE, que fueron los primeros en alcanzar un nivel de movilidad de capitales alto. Sin embargo, eventos exógenos tales como la crisis del Sistema Monetario Europeo (SME), la crisis de reunificación de Alemania, la caída de la URSS, la crisis financiera global de 2007-2008, y la crisis de deuda soberana europea afectaron

de manera negativa a la movilidad de capitales. En este contexto, el proceso de integración económico europeo incentivó el flujo de capitales desde los países centrales a los periféricos, permitiendo a este último grupo de países alcanzar altos niveles de endeudamiento y, en consecuencia, desequilibrios externos. El impacto de la crisis de 2007-2008 y de la crisis de deuda soberana europea sobre los países de la zona euro ha diferido dependiendo su posición externa neta. En este sentido, la crisis afectó de manera sustancial a los países periféricos; sin embargo, el impacto fue mucho más limitado en el resto de la zona euro (países centrales y los países del centro-este). Para mitigar la fragmentación del mercado durante la crisis de deuda soberana europea, se creó el EFSM y el ESM para asistir financieramente a los países de la UE que experimentaban dificultades. Estos programas, implementados durante la crisis de deuda soberana, han ayudado a los países receptores a mejorar el nivel de movilidad de capitales; sin embargo, algunos no han retornado a sus niveles pre-crisis.

Cuando nos centramos en los quince países más grandes de la Unión Europea, el cambio estructural más relevante que ha afectado a la movilidad de capitales ha sido el euro: la ausencia de incertidumbre relacionada con el tipo de cambio ha incentivado las transacciones tanto reales como financieras. Nuestros resultados muestran que no tener en cuenta los cambios estructurales en el análisis subestima el nivel de movilidad de capitales a el largo plazo. Nuestro enfoque de panel ayudó a obtener un análisis completo de la movilidad de capitales, ya que de manera simultánea analizamos la movilidad de capitales en el largo y corto plazo y la velocidad de ajuste al equilibrio cuando ocurre un choque desestabilizador. Un aspecto interesante es que la naturaleza bidimensional de la movilidad de capitales ayuda a entender los desequilibrios externos observados en la Unión Europea. Así, mientras que los países centrales tienden a retornar más rápidamente al equilibrio de largo plazo, los países periféricos lo hacen con mayor lentitud. Por consiguiente, estas diferencias persistentes entre el ahorro e inversión doméstica explican los grandes desequilibrios externos observados para los países de la UE. En lo relacionado con el parámetro de largo plazo, los resultados sugieren un nivel alto de movilidad de capitales. Sin embargo, los mercados financieros europeos todavía no están integrados completamente. Adicionalmente, durante periodos de turbulencias financieras, la movilidad de capitales fue baja, los ejemplos más claros son la crisis del SME a comienzo de los 90 y la crisis de deuda soberana de 2011. Sin embargo, se obtiene una integración financiera perfecta cuando hay periodos de riesgo económico bajo. En este contexto, la apertura financiera también incentiva la movilidad de capitales, ya que periodos de alta apertura fi-

nanciera (incluyendo comercial y financiera) están asociados con una perfecta movilidad de capitales. Por el contrario, la movilidad de capitales fue moderada cuando el índice de apertura fue bajo.

Los resultados descritos en los párrafos anteriores permiten llegar a algunas conclusiones interesantes con dimensión de política económica. En primer lugar, nuestro análisis sugiere que la integración de los mercados financieros en Europa es incompleta. Por lo tanto, debería llevarse a cabo políticas económicas adicionales. Segundo, incentivar la integración financiera a través de la movilidad de capitales no es suficiente para alcanzar mercados de capitales totalmente integrados, ya que la integración del mercado de bienes es una condición necesaria. Por lo tanto, los encargados de la política económica y los reguladores deberían centrarse en ambos objetivos al mismo tiempo. Tercero, todavía existen diferencias significativas entre los países centrales y periféricos en lo relativo a las debilidades financieras, dependiendo éstas de la posición externa neta. Consecuentemente, pueden producirse procesos de fragmentación de cierta relevancia durante episodios de turbulencias financieras e incertidumbre. Por tanto, es necesario corregir estos desequilibrios externos para prevenir la fragmentación financiera.

Una vez hemos analizado la movilidad de capitales y la integración financiera, el siguiente paso lógico de esta Tesis fue identificar los factores explicativos de la movilidad de capitales. Para cumplir con este objetivo, nos centramos en el stock bilateral de acciones y bonos cotizados en el que esté involucrado al menos un país de la UE, ya sea en la parte del inversor o en la del emisor del activo. Los resultados nos muestran que las variables gravitaciones son relevantes para ambos activos, lo que implica que países más grandes y a su vez más cercanos tienen más transacciones entre ellos. Además, las variables de resistencia, definidas como restricciones financieras, también juegan un papel relevante. De esta forma, las restricciones financieras entre los pares de países perjudican la posesión de activos bilaterales. Por el contrario, si las restricciones en el resto del mundo relativas a las restricciones bilaterales aumentan, esto favorece las transacciones de activos entra cada par de países. Por otra parte, también concluimos que el riesgo global tiene un efecto negativo, en línea con los resultados de la literatura sobre el papel del riesgo y la incertidumbre en la movilidad de capitales.

Cuando extendemos nuestro modelo, captamos un efecto positivo de los lazos históricos, la calidad del gobierno y el desarrollo financiero sobre la distribución de la cartera de inversión. Nuestro análisis revela un sesgo del euro bastante relevante a la hora de asginar la cartera de activos cotizados, vinculado con

los lazos financieros y económicos que existen entre los países de la zona euro. También extraemos conclusiones relevantes cuando comparamos las diferencias y similitudes entre la cartera de acciones y bonos. Esto es un tema de especial interés, ya que son dos tipos de activos diferentes en términos de naturaleza y riesgo. Cuando comparamos los resultados, aparecen ciertas diferencias: primero, la distancia y el sesgo del euro son más relevantes para la cartera de bonos, ya que la deuda de la UE tiende a permanecer en la UE. Esto es incluso más relevante para el caso de los países de la zona euro. Sin embargo, la cartera de acciones tiene una movilidad internacional mayor, pero incluso en este caso también encontramos evidencia del sesgo provocado por euro. El hecho de que la cartera de acciones sea más móvil que la cartera de bonos explica su mayor sensibilidad a las restricciones financieras en el resto del mundo y al riesgo global. A pesar de las diferencias, nuestros resultados también reconocen ciertas similitudes, tales como el rol de los lazos históricos, la calidad institucional, y el desarrollo financiero. Por último, nuestros resultados también apuntan a la necesidad de tener en cuenta el papel de los paraísos fiscales, especialmente para activos en los cuales los intermediarios localizados en los paraísos fiscales operan con más frecuencia, como es el caso de la cartera de acciones.

Una de las características del sector financiero europeo actual es la predominancia del sector bancario como principal canal de las inversiones europeas. Por lo tanto, nuestro análisis de los factores que explican la distribuición de la cartera de inversión, que es un ejemplo de sistema financiero basado en mercados cotizados, podría ayudar a los responsables de política económica a llevar a cabo políticas específicas para promover y desarrollar este tipo de modelos de sistema financiero. Adicionalmente, nuestros resultados pueden ofrecer algunas recomendaciones a los responsables económicos. Primero, el sesgo del euro en la cartera de deuda implica que una quiebra afectaría directamente a la UE, ya que los acreedores de la UE son los mismos países de la UE. Segundo, que la calidad del gobierno y de los mercados financieros juegan un papel relevante para atraer capitales; por lo tanto, para incentivar la movilidad de capitales, ambos elementos deberían ser reforzados en todos los países de la UE. Por último, en el análisis de los factores que explican la movilidad de la cartera de acciones y bonos, no se debe ignorar el papel que jueganlos paraísos fiscales. El análisis de la movilidad de capitales utilizando bases de datos que no tienen en cuenta los paraísos fiscales como intermediarios desvirtúa la identificación de los verdaderos factores tras las decisiones de realizar inversiones de cartera de acciones y bonos cotizados.

Finalmente, la investigación llevada a cabo en esta Tesis presenta algunas limitaciones que también dan lugar a dos potenciales líneas de investigación futura. Primero, el análisis del capítulo 4 se ha visto limitado por la disponibilidad de datos. Si se desarrollan nuevas bases de datos con horizontes temporales más largos, que tengan en cuenta los paraísos fiscales permitiría un análisis con técnicas de cointegración y a largo plazo de los factores que explican las decisiones de invertir en cartera de acciones y bonos cotizados. Además, como ya hicimos en los capítulos 2 y 3 de esta Tesis, sería interesante incluir también cambios estructurales en análisis del impacto de estos factores a lo largo del tiempo. Segundo, el enfoque gravitacional utilizado en el capítulo 4, junto con bases de datos que mapeen correctamente los flujos/stock de la cartera de acciones y bonos cotizados emitidos en paraísos fiscales podría también aplicarse a otro tipo de activos financieros, tales como IED.

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