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Essays in Macroeconomics and Finance

A THESIS SUBMITTED TO THE UNIVERSITY OF DUBLIN, TRINITY COLLEGE
IN APPLICATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

BY

Benedetta Bianchi

Supervised by
Professor Philip R. Lane
and
Professor Vahagn Galstyan



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Benedetta Bianchi

Summary

This dissertation consists of three essays, which deal with issues relating to the financial sector. Although the three chapters are independent, a common underlying theme is financial crises.

The first essay studies the varying perception of the risk attributed to European sovereign bonds. There was a shift in risk perception after 2009, most evident in the relation between sovereign risk and net foreign assets. Before the breakout of the Euro debt crisis, the external imbalances accumulated by the poorer countries in the Euro periphery were interpreted to be the result of a natural convergence process which induced net capital inflows towards poorer, relatively more productive countries. Later, the same imbalances were seen as one of the main factors of financial distress in crisis countries. We investigate the role of market uncertainty in the relation between net foreign assets and sovereign risk in the years following the introduction of the euro up to the end of the sovereign debt crisis (2000-2013). Furthermore, we ask which component of the international balance sheet, in terms of debt and equity instruments, is most relevant in explaining the external-sovereign nexus. We find that a negative net foreign asset position can have a negative or positive relation with sovereign yield spreads. Portfolio equity and FDI are related to sovereign risk in a stable manner, while net negative external debt as large as GDP can be associated with government yield spread spikes as high as 3%.

The second essay aims at identifying structural and cyclical components in the ratio of non-financial private sector credit to GDP. We propose a transparent method to decompose the

time series of the ratio, providing a tool to understand when macroeconomic conditions are consistent with excessive credit. We first estimate a long-run relation between the private sector credit-to-GDP ratio and macroeconomic outcomes related to the sustainability of debt. We then predict the structural level of credit, using a simple rule to approximate the structural level of macroeconomic outcomes. Finally, we assess the ability of our assumption to identify structural changes consistent with increases in the ratio of private sector credit to GDP. We find that the structural level of private sector credit-to-GDP ratio increased in several countries in the decades preceding the crisis. However, we show that patterns consistent with the financial cycle are identifiable in the years preceding the crisis in the country we take as example: Ireland. To some extent, similar patterns are present in the current period in France and Sweden. We also perform the same analysis on household and non-financial corporation sectors; we find that in France and Sweden, the level of credit to the household sector may be excessive.

The third essay looks at a building block of the response of financial regulators to the global financial crisis: central clearing. In a centrally cleared transaction, a central counterparty interposes itself between the contracting parties after a financial trade has taken place, becoming the counterparty to both seller and buyer. Recent financial regulatory reforms in the EU mandated the use of central counterparties for over-the-counter derivatives transactions. As a result, the increased use of central clearing transformed central counterparties into nodes of systemic importance in the financial system. Notwithstanding this primary role, the literature lacks a description of the clearing market landscape, owing to the lack of comparable data on transactions cleared and size of the default resources. We assemble a dataset based on a recently disclosed set of standardised data, and propose measures to monitor trends in the central clearing market. Moreover, we focus on liquidity and liquidation issues relating to the holding by central counterparties of the collateral collected from clearing participants. We signal that in some cases, re-investment of participants cash in domestic government bonds exposes central counterparties to margin wrong-way risk, especially when the clearing member base is mostly domestic.

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Al nonno Athos

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Chapter 1

Introduction

Recent decades have witnessed an exceptional growth of financial systems and international financial integration. The global financial crisis and the European sovereign debt crisis exposed risks associated with increased complexity of finance and its interconnectedness with other sectors of the economy, which were not fully clear before. Given the potential benefits of a well-functioning financial system, not only in terms of growth, but also more equal opportunities through the financing of capital constrained individuals, understanding the opportunities and pitfalls of developments in the financial sector is important.

This thesis gathers three essays on three distinct aspects of the functioning of financial systems which arose with the global financial crisis and the European debt crisis. The first aspect is the time-varying perception of the fundamental factors considered in the pricing of risk; the application of this concept to the European sovereign debt crisis is the object of the next chapter. The second aspect examined is the non-trivial separation between financial deepening and credit excesses; we tackle this issue in the third chapter, where it is shown that the long-run trend of the macroeconomic system helps understand when excess credit may be building up. The third aspect we focus on is the increased transparency required of financial sector institutions, given the systemic consequences of their actions for the wider economy. This is the subject of the last essay, where we study the

public disclosures of a type of financial market infrastructure that has gained importance in recent times: central clearing counterparties.

An influential view put forward by Claudio Borio, Craig Furfine and Philip Lowe explains extreme fluctuations in the provision of credit with the tendency to underestimate risk during booms, and overestimate it in recessions. Low perception of risk during upturns means that the potential negative consequences of present choices are assigned too low a probability. As a result, credit growth is excessive, credit spreads too low, and asset prices inflated. When a risk materialises, the reverse process feeds a recession.

The second chapter is an application of this concept to external imbalances and the European sovereign debt crisis. We show that the accumulation of external imbalances has an opposite relation with sovereign spreads, depending on the perceived uncertainty in financial markets. When uncertainty was low before the crisis, the potential risks in the build-up of external imbalances were understated. The accumulation of current account deficits was seen as an adjustment path for poorer countries with relatively high marginal productivity. This was associated with lower sovereign risk, since the expected growth financed by capital inflows would have reduced the size of public debt relative to output.

With the unfolding of the Greek crisis, the uncertainty associated with it diminished optimism and increased the perception of the constraints associated with a large external debt, and the perception of its relevance for sovereign risk increased. We identify three general channels by which a negative net foreign asset position increases sovereign risk, all of which are stronger for external debt. In addition to these, which are explained below, other idiosyncratic factors increased the vulnerability of the public sector in the most affected countries, for example where foreign capital was used for non-tradable, non-productive investment, such as real estate.

First, even when the temporary accumulation of current account deficits leads to future growth, the ensuing external adjustment requires a depreciation of the exchange rate to reduce net capital inflows. When a depreciation is expected by foreign investors, they will require a higher interest rate. Second, the line between private and public becomes

blurred during a crisis: the government may take over the responsibility of private debts, for example through the recapitalisation or bailout of externally exposed banks. Third, external crises have been shown to anticipate banking crises, which in turn often precede or accompany sovereign debt crises. These channels imply a negative relation between net external debt and sovereign spreads. In the second chapter, we show empirically that a negative relation is present when the level of uncertainty in financial markets is high. A slightly positive relation is found for calm periods.

One of the problems associated with underestimation of risk during booms is that financial institutions hold too little capital to absorb possible future losses. Among the macroprudential regulatory responses to the global financial crisis is the introduction of the countercyclical capital buffer. This requires banks to accumulate capital in periods of excessive credit growth, in order to enhance resilience were a crisis to unfold. In order to identify when private sector credit is excessive, the Basel III framework suggests calculating a signalling indicator derived from the ratio of private sector credit over GDP, the credit-to-GDP gap. Policy makers should assess a broad set of information along with the credit-to-GDP gap, and consider whether the inferences from the gap are consistent with those from the other variables.

The third chapter provides a method to guide the identification of excessive increases in credit. Our approach considers the evolution of macroeconomic variables which relate to the sustainability of the ratio of credit to GDP (which we sometimes call, for short, the credit ratio). This increases our understanding of the economic forces driving medium-term increases in the credit ratio.

This approach can be used to assist policy makers in the analysis of the information which informs the decision to activate the counter-cyclical capital buffer. We find that using our approach, a number of patterns are visible in the data before the crisis for the countries where credit contracted the most after the crisis, such as Ireland and Spain. Similar patterns are currently present in France and Sweden, which suggests that vulnerabilities may be building up in these countries. Whereas additional qualitative and quantitative

information should be considered before activation of the counter-cyclical capital buffer, the current application of the buffer in Sweden confirms the result of our analysis for this country.

The fourth chapter relates to another component of the regulatory action following the global financial crisis: the obligation to clear certain financial transactions through central clearing counterparties (CCPs). Central clearing involves the interposition of a CCP between the contracting parties; by novating the contract, the CCP becomes counterparty to both the seller and the buyer, taking on the risk of default. A number of risk management strategies are in place to manage the default of participants, which are designed to decrease the potential consequences of the default of a financial trader.

CCPs grew in size and interconnectedness since 2009, becoming nodes of systemic importance in the financial sector. However, despite the growing centrality of CCPs, a literature studying the structure of the clearing market is absent. The goal of the fourth chapter is to construct a dataset to study the European CCP ecosystem using publicly available information. One contribution of the paper consists in documenting aspects of the European central clearing landscape, including the type of financial assets cleared by each CCP, the size of the markets served and the resources held against the risk of default.

Moreover, the chapter contains an analysis of liquidity, with particular attention to the practice by CCPs to invest in securities the cash received as collateral. We find significant re-investment in sovereign bonds. Such re-investment may expose central counterparties to margin wrong-way risk, whereby the value of collateral (sovereign bond) is negatively correlated with the probability of default of clearing members (typically, banks). The probability of a positive correlation is higher for CCPs where the member base is mostly domestic and there is considerable re-investment in domestic sovereign bonds.

On the policy side, the fourth chapter contributes to understanding the extent to which the public disclosures required by international standard setting bodies allow an assessment of the risks posed by CCPs to the clearing members and the economy at large.

Chapter 2

Sovereign risk and the international balance sheet

2.1 Introduction

Traditionally, the sustainability of public indebtedness has been assessed considering measures of government absorption of domestic income. In the euro debt crisis, it has been pointed out that some of the factors contributing to the sovereign crisis were not *ex ante* related to public finances. In particular, the literature has highlighted that the accumulation of external deficits can be destabilising for sovereigns, if the imbalances are the result of distortions in the economy that prevent optimal allocation decisions. In the euro area, excessive optimism on future growth and the use of foreign capital for non-tradable, non-productive investment (such as real estate) have led to the accumulation of large negative net international investment positions (NIIPs) without boosting future growth while weakening the financial sector (Lane and Pels, 2012; Giavazzi and Spaventa, 2011; Lane, 2012). In this paper, we analyse the risk premia associated with these two sovereign risk factors - external and fiscal dimensions - and their time varying properties, and we show that the composition of the international balance sheet matters for the level and the variability or sovereign risk premia.

We contribute to the literature by highlighting that the overall indebtedness of the economy towards foreign investors influences fiscal space through the interest rate that financial markets ask in compensation for sovereign risk. We show that the perception of the factors that pertain risk is strongly dependent on the level of global uncertainty. While the net foreign asset position matters because it speaks to the relation between income and absorption that has prevailed in the past and that determines adjustment needs, influencing fiscal capacity, the financing side is also important: the payment structure and the allocation of risk among the parties is what ultimately determines the sustainability of the net external position. Expectations on the future pattern of the economy are more important, and as a result the relevance of the net external position for sovereigns is accentuated, when negative net foreign assets are mostly composed of debt instruments.

2.2 Motivation and previous literature

The net external position matters for sovereign risk for several reasons, that can be summarised under three main threads, relating to the sectoral composition of the economy and the real exchange rate, the boundaries separating the government from the rest of the economy, and the relation between public and financial sectors. In all of the three channels, the link is stronger when the position is mostly composed of debt instruments.

First, when the accumulation of current account deficits comes about as a short-run outcome in the expectation of high future growth, it can become unsustainable if accompanied by an overexpansion of the nontradable sector, and even less sustainable if expectations of growth exceed what can be justified by a convergence mechanism (Giavazzi and Spaventa, 2011; Lane and Pels, 2012). The sectoral misallocation is typically large in credit boom episodes, often associated with net debt inflows (Mendoza and Terrones, 2008; Lane, 2012). The conversion to tradables, requiring a depreciation of the real exchange rate, makes the real burden of public (and external) debt higher. When the adjustment is hampered by distortions that delay the required depreciation, the longer path towards sectoral rebalancing increases the probability of a crisis: if uncertainty spikes, risk premia can make debt

servicing prohibitively expensive. In a monetary union, the adjustment path is longer due to the absence of nominal exchange rate flexibility (Blanchard, 2007; Lane, 2012).

Furthermore, a depreciated real exchange rate is required also when the external position is negative in the steady state. The net transfers to the rest of the world that countries with foreign liabilities need to pay require them to run trade surpluses in equilibrium. Persistent export surpluses are associated with a depreciated real exchange rate, mostly through the effect on the price of nontradables (Lane and Milesi-Ferretti, 2004, 2002; Zhang and MacDonald, 2014). The negative relation between the NIIP and the real exchange rate means that the burden of debt is heavier in countries with a negative net external position.

Second, the line between private and public becomes blurred during a crisis: the government could take over the responsibility of private debts and become the direct counterpart to the contracts with foreign residents, for example through the recapitalisation or bailout of externally exposed banks. Alternatively, in the framework of the traditional models of sovereign debt repayment, where the main assumption is the preference of the government for domestic residents, negative NIIPs lower the credibility of sovereign debt repayment. In Obstfeld and Rogoff (1996), net foreign liabilities reduce the size of possible sanctions relative to payment owed.¹ In the framework of Broner et al. (2010, 2014), foreign investors value government bonds on the basis of the probability of being repaid; to the extent that a more negative NIIP decreases repayment probability, the risk premia required by non-residents increases.

A third reason why net external assets matter for sovereign risk relates to the financial sector. An empirical connection has been found between external and banking crises, and between the latter and sovereign crises. In particular, Reinhart and Rogoff (2010) shows that external crises anticipate banking crises, which in turn often precede or accompany sovereign debt crises; in Catão and Milesi-Ferretti (2014), a negative NIIP predicts external crises and is an even stronger predictor when the definition is restricted to include sovereign defaults and restructurings only. These analyses are consistent with the importance of the

¹see Appendix 6B.

financial cycle for the connection between external and fiscal dimensions: foreign capital has an impact on domestic credit conditions and asset price cycles and these in turn influence fiscal outcomes.

In terms of the first effect, Lane and Milesi-Ferretti (2012) shows that larger capital flow reversals occurred in countries with more negative external positions: it is not just the presence of a current account deficit, but also the persistent accumulation of deficits in the past that makes countries more vulnerable. Concentrating on gross flows, Forbes and Warnock (2014) identifies the most common extreme capital flow episodes to be led by debt flows, and Baek and Song (2016) find that, among other factors, global uncertainty is a determinant of extreme episodes involving foreign loans. In turn, net external debt flows are particularly important in the determination of domestic credit growth, a strong predictor of financial crises (Lane and McQuade, 2014; Jordà et al., 2016). Finally, Bénétrix and Lane (2013) shows that the financial cycle affects fiscal policy even beyond its relation with the business cycle: in the euro area, the government balance co-moves with the financial cycle in a way orthogonal to the fluctuations of the real economy.

Cycles do not necessarily bear consequences in terms of fiscal sustainability. However, between the banking and the public sector there exists an intimate connection whereby, under certain conditions, weaknesses in one of the two can trigger fragility in the other and vice versa, creating a feedback loop (see Acharya et al., 2014; Gennaioli et al., 2014; Mallucci, 2013, among many others). In the presence of state guarantees on banks liabilities or outright bailouts, the stress in the banking sector is transmitted to the public sector. The fragility acquired this way by sovereigns translates into a lower price of government bonds if the central bank is not expected to finance the sovereign in case of trouble; the large stocks of government bonds held by banks mean that they acquire further weakness, leading to additional vulnerability of the public sector, and so forth. This vicious cycle is transmitted to the real economy through the contraction of banks balance sheet, higher risk premia and the lack of public stimulus due to the limited fiscal space. These effects are stronger in a monetary union like the euro area, where fiscal policy is rule-constrained, the central bank is not expected to act as a lender of last resort and nominal exchange rate

rigidity makes deleveraging more painful (Popov and Van Horen, 2013; Wyplosz, 2005; De Grauwe, 2012; Fornaro, 2015). By hindering the adjustment in both sectors, the two-way loop exacerbates the downturn, prevents recovery, and sustainability may become a concern. The newly introduced banking union is expected to mitigate the feedback loop to the extent that sovereigns share the burden of bailing out their banks.

Importantly, the three channels are not sealed off from each other, on the contrary they are strictly interlinked. For instance, the line between private and public liabilities is especially vague when the banking sector is concerned, and the financial sector is the channel through which the nontradable sector is financed. The separation of the three issues, put forward for the sake of exposition, should not hide the important interconnections between them.

2.2.1 Instrumental breakdown

In the literature on the euro-area government debt crisis, the role of competitiveness adjustments needed to rebalance the external dimension of peripheral countries has been widely discussed. Little emphasis has been put on the structure of the international balance sheet that has been used to finance past current account deficits.

The net international investment position consists of two types of instruments: net external debt, composed of portfolio securities and other debt instruments, and net external equity, where we include also foreign direct investment (FDI). Foreign debt is more important than equity in the connection between NIIP and sovereign risk because it entails non-contingent payments. Of course, the whole of private debt (external or not) is relevant in this respect and matters in a debt overhang: measures of private credit have been used in the literature on the determinants of sovereign risk (see Barbosa and Costa, 2010 and Giordano et al., 2013). However, as highlighted in the previous section, net external debt is also (and especially) important in terms of the relation between external capital, financial sector and sovereigns: Lane and McQuade (2014) has shown that domestic credit booms are strongly related to the debt component of capital inflows (portfolio debt and

other investment). To the extent that credit booms are disproportionately used towards an expansion of the nontradable sector (e.g. construction activity boosted by cheap credit), debt is also more distortionary from the point of view of the real economy.

In contrast, portfolio equity is a more stable type of instrument and allows more international risk sharing, and FDI is viewed as a “good cholesterol” type of capital flow: it is the least volatile component of the financial account and it provides scope for technological spillovers into the domestic economy. For these reasons, we expect the link between external and fiscal dimension to be stronger when debt instruments are involved.

2.2.2 Determinants of sovereign yield spreads

The literature on sovereign bond yield spreads extensively studied the importance of default, liquidity and exchange rate risk in European sovereign bond pricing. An important finding is that the euro largely reduced liquidity premia,² likely due to increased financial market integration; conversely, default risk has acquired more relevance (Bernoth et al., 2012; Alessandrini et al., 2014; Favero and Missale, 2012). Moreover, since the inception of the euro, international risk factors are more important than liquidity in explaining sovereign yield spreads (Codogno et al., 2003). Given these findings, it seems appropriate to model euro area spreads with a combination of default risk measures, in the form of variables that increase sovereign credit risk, and a global risk factor.

The third typical determinant of sovereign yields considered in the literature, exchange rate risk, in a monetary union depends on expectations of exit from the union. Arghyrou and Kontonikas (2012) builds a theoretical model with four possible expectation regimes regarding credibility of commitment to the union and fiscal guarantees; the empirical results are consistent with the view that exchange rate risk was not discounted before the crisis while it started to matter afterwards. This helps explain the remarkable difference in spread dispersion at different phases of the crisis, since countries with weaker fundamentals

²Liquidity risk is intended here as the risk of not being able to liquidate positions in a short time.

should be expected to undergo a larger depreciation of their currency in case of exit from the union. Furthermore, the model is consistent with the general reduction in spreads occurred after the decision made by the central bank of doing “whatever it takes” to save the euro in the context of the Outright Monetary Transactions program, to the extent that the announcement convinced markets that exit from the euro is ruled out.

Other studies investigating the shift in expectations occurred during the crisis make use of the concept of contagion. Among these, the paper closer to our is Giordano et al. (2013), which finds evidence of wake-up-call contagion, a shock to expectations that makes fundamentals be considered again after a period of neglect. Related to this discussion, the possibility of crisis propagation due to a shift in market sentiment has led to proposals for union-wide bonds that would insulate sovereigns from contagion (see, for instance, Favero and Missale, 2012).

Several papers consider the external dimension as a factor determining sovereign spreads. Gibson et al. (2012) focuses on Greece and finds a cointegrating relation between the spread and fundamentals, considering relative prices as a proxy for competitiveness, among other things. This estimation is used to assess whether and to what extent there has been an over- or under-shooting of the variable with respect to its long-run predicted value, and it is concluded that it was deviating under the norm in some periods before 2010 and was over-shooted afterwards. In our work, we attempt to explain the premium in excess of the linear relation with a combination of global market uncertainty and idiosyncratic factors; moreover, we use the cumulated external position as an ex-post measure of competitiveness losses.³

Alessandrini et al. (2014), Barbosa and Costa (2010) and Barrios et al. (2009) are also concerned with the foreign sphere. The first study investigates the roles of external and fiscal imbalances in the euro debt crisis using liabilities to German banks. Barbosa and Costa (2010) includes the level of the NIIP in 2006 in the analysis, without allowing this variable to vary in time, thereby missing the role of fluctuations in its risk premium.

³In Gibson et al. (2012) the dependent variable is treated as nonstationary, as the sample ends in 2010, before the reversion occurred with the announcement of the OMT program.

The work that most closely compares to this study is Barrios et al. (2009). It uses a measure of market uncertainty and allows it to interact with fundamentals. Among the country-specific variables, it includes the current account balance, which is significant when interacted with the budget deficit forecast: the joint effect of high current account deficit and high fiscal deficit sharply increases the spread. One problem with using the current account is that it shrinks in crisis periods and it tells us nothing about the past behaviour of imbalances. For example, in 2011 the current account of Spain and Italy is of the same magnitude while the past balances of Spain are reflected in its large negative NIIP. Moreover, the external position allows us to look at the exposure of the balance sheet, in terms of the financial instruments used to fund past deficits.

2.3 Empirical approach

In the empirical analysis, we first investigate the relation between the overall net external position and government bond spreads, and subsequently split the position into its components in terms of underlying instruments. When estimating the sensitivity of the spreads to fundamentals, it is important to account for market uncertainty. We define this concept as the dispersion in the probability distribution of expected repayment given the macroeconomic conditions. A wider distribution means that there is more disagreement between market participants over the probability of expected outcomes, leading to a higher risk premium attached to any level of fundamentals. We measure uncertainty using the VIX index, a measure of expected future volatility of the US stock market derived from option prices. This choice is in line with previous studies (Beber et al., 2009; Giordano et al., 2013; Arghyrou and Kontonikas, 2012; Belhocine and Dell’Erba, 2013).⁴

Following the literature, we assume Germany as a risk-free country and consider all variables in difference from this benchmark. In our baseline specification, we thus estimate the factors that determine the sovereign spread level using the equation:

⁴We estimated the regressions using the European equivalent of the VIX, VSTOXX, and the results were similar. We opted for the VIX as this is the most commonly used measure of market uncertainty even in studies of Europe.

$$spread_{it} = \beta_0 + \eta_t + \gamma spread_{it-1} + \beta_1 VIX_t + \beta_2 F_{it-1} + \beta_3 Fsq_{it-1} + \beta_4 F_{it-1} * VIX_t + \varepsilon_{it} \quad (2.1)$$

where sovereign risk is proxied by 10-year sovereign bond yield spreads, the dependent variable; F and Fsq are two column vectors collecting the levels of public debt and net foreign assets and their squares. In a second specification, net foreign assets are replaced by the sum of net external debt and net external equity. β_2, β_3 and β_4 are row vectors containing the coefficients on linear, squared and interacted terms, respectively.⁵ All country-specific variables are measured as deviations from German levels. As stated above, we introduce the interactions between fundamentals and the uncertainty measure to allow for time-varying sensitivity of spreads to fundamentals. The squared terms capture the possibility that the price of risk increases more than proportionally with quantity and assure that the interactions with VIX are not biased by this different kind of nonlinearity. Finally, we include time fixed effects and a lag of the dependent variable.

2.3.1 Data

The countries under study are the 12 original members of the euro area excluding Germany - the risk-free benchmark - and Luxembourg. The latter is an outlier in terms of its role as an international financial centre, which complicates the interpretation of its external position. The time period spans from 2000 through 2013 at quarterly frequency.

Turning to the single variables, sovereign bond yields are taken from Datastream; the VIX index is from the Chicago Board Options Exchange website. For these two variables we use average values over the quarter to remove the influence of short-run volatility.

⁵We ran models including current account and primary balance variables. They were not relevant, hence we opted for the more parsimonious specification.

Public debt is taken from Eurostat; from this source, quarterly NIIP has many missing values (178 country-period observations). To overcome this, we use the External Wealth of Nations dataset, from which are taken the NIIP figures as well as the external debt and equity components. The former is complemented using Eurostat current account data, cumulated to allow for the inclusion of 2013 data.

Figure 2.1 plots the time-series behaviour of yields. In the period between early 2000 and late 2008, yields are very low and close together: markets do not seem to make a distinction among euro area countries on the basis of their riskiness. After the global financial crisis, yields start rising and diverging, and after a temporary slowdown in 2009, they peak at unprecedented levels in 2011, then decline. In the figure the VIX index is also plotted against time (right scale).

In Figure 2.2 is depicted the evolution of public indebtedness of euro area countries. Before 2008, public debts were decreasing everywhere except France and Portugal, while after that year they increase in all countries. Of the six members with public debt lower than 60% in 2001, only four respect this Maastricht criterion in 2006 (France and Portugal break the ceiling), and only one, Finland, in 2012. Ireland and Spain are among the members with a public debt lower than 60% in 2006.

The NIIP is defined as the difference between external financial assets and liabilities and is shown in Figure 2.3. Crisis countries have decreasing positions, while non-crisis countries have slightly increasing positions, until 2009, after which all NIIPs flatten out. Before the crisis, valuation effects were running in the same direction as current accounts, making debtor countries lose, and creditor countries gain, on their positions; post crisis, valuation effects change sign and current account deficits shrink, both contributing to slow down the diversion between the NIIP of crisis and non-crisis countries (Lane, 2013). France and Italy behave differently from the groups to which they belong: Italy has a much smaller negative position than other peripheral countries; France alternates negative and positive positions until 2007, when its NIIP turns negative. Overall, all countries that received financial help from the Troika have a negative NIIP as large as their respective GDP between 2009 and 2012, while all other countries are in the range (-25%, +50%) of GDP in the same period.

In Figure 2.5, spreads are plotted against NIIPs (in difference from German level) at two points in time: 2006, when VIX is at the minimum (which is virtually the same value as the 10% percentile), and 2011, when it is at the 90% percentile. It is evident that spreads in 2011 are associated with a steeper relation between the two variables. As we shall see, global uncertainty is not the only source of difference in these two periods. However, it is a useful measure to approximate the effect of market expectations on interest rate differentials.

2.3.2 Estimation issues

We estimate variants of the above equation using OLS with panel-corrected standard errors, to account for panel heteroscedasticity and contemporaneous correlation of the errors. Serial correlation is largely reduced with the inclusion of a lag of the dependent variable. We assume stationarity of the regressand: while panel-data unit root tests give mixed results when performed on the full sample, they strongly reject unit roots when applied to the later period, where the bulk of the variability in the data is observed. Since there is no theoretical reason to think that spreads are non-stationary, we are confident this assumption is not too restrictive and insert a lag of the dependent variable as a regressor to handle its high persistence.

Squared terms are transformed to be negative when the linear term is negative, in the assumption that when fundamentals are more robust than Germany, the negative impact on spread can increase as they get stronger. Compared with a model where a parabola is imposed, this improves the fit and reduces the coefficient on the lag of the dependent variable. Germany is considered the safe benchmark for its combination of low public debt and largely positive net foreign assets, which both contribute to strong repayment capacity; however, some countries perform better than the benchmark in one of the two measures.

To prevent the potential for bias in our estimates due to valuation effects, and to minimise the risk of other possible endogeneity issues, we use lagged versions of the independent

variables, only allowing for the VIX to contemporaneously affect the sovereign spread. The persistence of the right hand side variables is controlled for by the inclusion of time dummies.

2.4 Estimation results

2.4.1 Net foreign assets

Estimates of the baseline specifications are presented in Table 2.3. We start by estimating a simple model including only the fiscal variable, and without accounting for uncertainty. In the long-run, the predicted value for the spread is positive only when public debt is 40% of GDP higher than Germany, as can be seen at the bottom of the table. This is a very high level, not common for most countries in the sample except for Italy and Greece, where public debt is higher than this threshold for most of the sample period, and Belgium, where the threshold is breached only in the first years of the euro. In the second column, we introduce the net international investment position. In this simple model, the coefficient is only marginally significant: not accounting for market uncertainty does not allow to identify the pricing pattern of this variable, which can be associated with different interpretations of the future path of the economy, as we will see later in this section.

In column III, the VIX index is introduced in linear form, such that uncertainty can only affect the spread uniformly across the levels of public debt and NIIP. In this setting, the coefficient is positive, consistent with a higher premium for higher uncertainty, for any level of the fundamentals. It is noteworthy to point out how the sign of this coefficient becomes negative when its interaction with *NIIP* is introduced, in columns V and VI. This could be due to the fact that the external position is the relevant factor for a country to be considered safe: in the model in column IV, a country with the same level of public debt as Germany sees its spread increase when uncertainty increases. In contrast, having an external position like the German one, corresponding to around 30% of GDP as of

2006-2014, according to the model in column VI is associated with a spread decreasing in distressed times, consistent with a “safe haven” status. While the coefficient is not significant, it is nevertheless statistically different from the large positive coefficient in column IV.

To obtain a more accurate measure of the ability of each model to explain variation in the data, we examine the Partial R^2 : the portion of residual variance that a model is able to explain once the effects of the lagged dependent variable and time fixed effects have been removed. As can be seen at the bottom of the table, the partial R-squared increases meaningfully only when the interactions between country-specific variables and the VIX are included. For ease of comparison, in the rest of this section we consider two periods of time, 2006 and 2011, when the VIX index assumed very different values, and show how the coefficients on fundamentals change depending on market uncertainty. We pick those years because they are meaningful from the point of view of historical events as well as from the point of view of the VIX distribution, in that they are around the values of the 10th and the 90th percentile, respectively.

The model in column VI is the preferred baseline model. As in all models, the squared terms are multiplied by -1 when the fundamental is negative, which makes the shape of the curve symmetric around the origin. We will mostly describe the curves for positive public debt and negative net foreign assets (in difference from German levels), the most interesting cases and those applying to crisis countries. By the use of the interactions between the macroeconomic variables and the VIX, the model shows how fundamentals can be priced differently due to market uncertainty.

Similarly to the models in the previous columns, the long run relation between the fiscal variable and the spread is U-shaped when public debt is higher than Germany and bell-shaped when it is lower. Here, however, the slope depends on the perception of future uncertainty, and the constant depends on both uncertainty and the NIIP, such that the level at which the public debt is associated with a positive spread in the long run can change dramatically, as shown in the last lines of the table. Assuming the NIIP is zero and

the VIX is at the level recorded in 2006, the long run equation predicts a positive spread only when public debt exceeds the German level by 48%. Keeping the NIIP constant and raising the VIX to its 2011 level, the threshold decreases to 39%. This still high threshold implies that with a strong external position, even in high uncertainty periods, a positive premium is required only when public finances are in critical conditions, experienced in the data only by few countries.⁶ The high threshold is due to our assumption regarding the external dimension; if instead we assume a negative NIIP, say -100%, the level that crisis countries had at the outset of the euro debt crisis, the risk premium is positive even with a public debt *lower* than Germany by 38% of GDP (that is, a public debt between 0 and 40% of GDP), assuming uncertainty at the level of 2011.⁷ This is consistent with the external dimension being an important factor in determining sovereign risk.

Considering the *NIIP* coefficients, the addition of the interaction with the VIX in column VI improves the statistical importance of this fundamental, with the interaction significant at the 5% level. The coefficients on the variable mean that a negative NIIP demands a positive premium only when uncertainty is high: at the VIX of 2011, and *NIIP* of crisis countries (-100 relative to Germany), the predicted spread from the long run equation is 170 basis points, abstracting from the additional effect of public debt. In contrast, at the VIX of 2006, the same level of NIIP is associated with a negative spread around 200 basis points in the long run. In other words, when uncertainty is low, having a negative net foreign assets position is not associated with a positive risk premium for sovereigns. This could be due to the fact the external dimension is liable of widely differing interpretations of its structural determinants. Typically, before the crisis, when uncertainty was low, the negative positions of crisis countries tended to be interpreted as the natural outcome of poorer countries catching up the richer ones, and therefore it was associated with high future growth expectations (Blanchard and Giavazzi, 2002). After the global financial crisis and at the outset of the euro debt crisis, on the contrary, the same negative external positions were seen by many as being the result of excesses that lead to competitiveness

⁶Except Italy and Greece, which exceed the threshold for most of the time period, such a high level of public debt has been reached by some governments only for brief periods after the global financial crisis, before consolidation took place

⁷In our sample, only Ireland ever recorded such a low level of public debt relative to Germany.

losses and the accumulation of disproportionate current account deficits (Giavazzi and Spaventa, 2011). While it is hard to disentangle the effect of lower confidence (in the sense of more pessimistic expected value) from that of higher uncertainty (higher dispersion of the distribution of possible outcomes) in this simple setting, the correlation between uncertainty and risk premia is still highly informative of the extent to which fundamentals can be subject to inconsistent pricing behaviour along the swings in market uncertainty.

In this section we showed that the spike in spreads of some European countries can be explained by the effect of uncertainty on risk premia. The literature has shown that a change in expectations about the future of the euro occurred after the global financial crisis: the Greek crisis and the losses suffered by the Irish banking system resulting in public sector involvement meant that sovereign defaults and exit from the euro began to be perceived as possible events after 2009 (Arghyrou and Kontonikas, 2012; Mody and Sandri, 2012). In the next section we compare the coefficients of the baseline specification applied to the periods before and after the crisis.

2.4.2 Before and after 2010

Before 2010, European sovereign bond yields did not show wide variations. Fiscal rules and collateral requirements seemed to justify similar treatment of euro-area sovereign bonds, and as a result the yield spread over German Bunds rarely exceeded 60 basis points. The events that took place after the global financial crisis introduced European sovereign defaults among the possible future outcomes for Europe: possibilities that were previously ruled out came to form part of the range of events with positive probability. As a result, fluctuations of uncertainty have a higher impact on risk premia in the latter period.

We run the baseline model on a shorter sample, ending in 2009. The comparison of the models in the first two columns of Table 2.4 is consistent with such a change in expectations: the coefficients are statistically significant in the shorter sample, however the impact is economically smaller. Moreover, before 2009 there is little evidence of a runaway from

countries with poor fundamentals towards stronger economies, consistent with the idea that no safe-haven effect was present since all sovereign bonds were considered relatively safe.

To visualise the different long-run impacts of public debt and the NIIP before and after 2009, it is useful to compare the predictions that the two samples deliver, keeping in mind that the full sample coefficients are an average of the short sample and the post-2010 period. Consider Figures 2.6 and 2.7: they compare the effect of uncertainty in the two samples, by plotting the product of the long-run coefficients on single term, squared term and interaction with the VIX by the respective variables, using the actual values in our sample. We want to show how cross-country differences in predicted spread depend on uncertainty – as well as fundamentals, and how this dependence matters much more after 2009.⁸ Consider the left hand panel: two countries with high and low levels of public debt, say +50 and -50% relative to Germany, have a difference in the predicted spread around 40 basis points for low VIX and around 80 for high VIX. According to the estimates based on the full sample and shown in the right hand panel, the difference is around 500 basis points for low VIX and exceeds 1000 basis points for high VIX: the long run impact of uncertainty on risk premia is much larger in the full sample. Similarly, Figure 2.7 shows that the difference in spread between external creditor and debtor countries is substantially larger in the full sample.

In the third and fourth columns of Table 2.4, we perform a check on the poolability of the panels, by excluding Greece from the regressions.⁹ While public debt loses importance, the NIIP retains its significance in both models, with remarkably similar coefficients, particularly before 2010.

2.4.3 Net external debt and net external equity

In this section, we split the NIIP into its two broadest components in terms of instrumental breakdown: net external debt is the sum of net portfolio debt assets, net other investment,

⁸We therefore abstract from the constant and the *VIX* coefficient, which are the same for every country.

⁹When we exclude each of the other countries in turn, all the results are qualitatively unchanged and quantitatively very similar.

and reserves; net external equity is net portfolio equity plus net FDI. While the overall position summarises the cumulated balances and the relation between production and absorption prevalent in the past, the types of contract underlying the net outstanding assets or liabilities determine the financial risks of holding the position. Because debt instruments entail non-contingent payments, they are associated with higher systemic risk and lower risk sharing among the two parties of the contract, thus increasing the likelihood of a worsening of public sector balance sheet.

If a negative NIIP could be justified by convergence patterns, funding it with debt would be more risky than equity financing. Moreover, net external debt could make the overall position more negative than convergence would justify when the absorption of the external capital is not associated with an increase in the productive capacity. The credit boom experienced by several European deficit countries was fuelled by debt flows and mostly used for non-productive purposes (Lane and Pels, 2012; Lane and McQuade, 2014).

The data on the components of the NIIP used in this section are taken from the External Wealth of Nations dataset, whose series end in 2012.¹⁰ Observations are further reduced by the exclusion of Ireland, an outlier in the composition of the NIIP due to its large and internationally active mutual fund industry, that issues equity liabilities and invests mostly in debt instruments. These operations cancel out in the calculation of the overall net external position, but they are not neutral when the focus is on financial instruments.

In Figure 2.4, we plot net external debt and net external equity over time, in percent of GDP. European countries, similarly to the recent pattern common to most advanced countries, tend to have positive equity positions coupled with negative debt. This combination of assets and liabilities is particularly dangerous during periods of global uncertainty because of contingent investment income streams and non-contingent payments, and because equity assets are more sensitive to valuation effects than debt liabilities. However, recent experience has shown that valuation effects can be large for debt instruments as well, also because they represent a larger fraction of the international balance sheet.

¹⁰From the updated version of Lane and Milesi-Ferretti (2001).

In the econometric analysis, squared terms are transformed to be negative when linear terms are negative, for consistency with previous analysis. Table 2.5 presents the results. The regression coefficients of the model in the first column, where the NIIP is replaced by net external debt, are similar to those obtained using the baseline specification. When we replace it with equity in the second column, the coefficients are not significant; however, when both instruments are included in the last column, the linear and squared equity coefficients become significant. The impact of net external equity and FDI is not related to the level of uncertainty: while a lower equity position reduces the overall NIIP and, through it, increases sovereign risk, the impact does not depend on uncertainty. The long run predictions for most possible values of equity in the sample are in the range $[-200; 200]$ basis points.

Turning to net external debt, the impact is strongly dependent on global uncertainty. In low-risk periods, cumulated debt inflows are associated with lower spread. One possible interpretation is that when risk-free interest rates are low and capital is flowing into a deficit country, the risks associated to the excessive inflows are overlooked, and the credit boom exerts pressure on lending rates such that the risk premium might even be negative. When global uncertainty rises, large net external debt becomes alarming and requires a positive risk premium. Notice that the linear *VIX* coefficient is negative only in the models including net external debt, another indication of the importance of this instrument in the judgement on whether a country is a safe investment during crises.

Figure 2.8 shows the long-run impacts of public debt and net external debt on relative spreads at different levels of uncertainty, based on the estimates in column III and similarly to Figures 2.6 and 2.7. The impact of net external debt (right-hand panel) depends on global uncertainty much more strongly than public debt: while for the traditional variable the magnitude of the premium is similar across the two lines, in the case of net external debt the risk premium is heavily dependent on the level of the *VIX*, which determines its sign. In particular, in low-risk periods a negative net external debt is not priced as risky, being on the contrary associated with a lower spread. In high-risk periods instead, net external debt 130% of GDP lower than Germany predicts a positive spread of almost 100

basis points. The same level is associated with a 300 basis point lower spread in optimistic periods: a spike in uncertainty from the 10th to the 90th percentile of the VIX distribution implies an increase in spread of around 4% in the long run.

The diametrically opposite prediction can be explained by the different expectations of the market about the future of the economy. During an upturn, high growth prospects mean that the dependence on foreign capital does not raise concerns and is perceived as a natural path towards increased productivity; when confidence on future growth becomes unsound, markets give a higher weight to negative outcomes and large net external debt liabilities are perceived as a weakness of the economy, potentially dangerous for the balance sheet of the public sector.

Moreover, the figure shows that in times of distressed financial markets, countries with strong net external debt positions become safe havens, while weaker countries encounter difficulties in raising funds. As in Table 2.3, this is also reflected in the sign of the linear *VIX* coefficient (in column III of table 2.5).

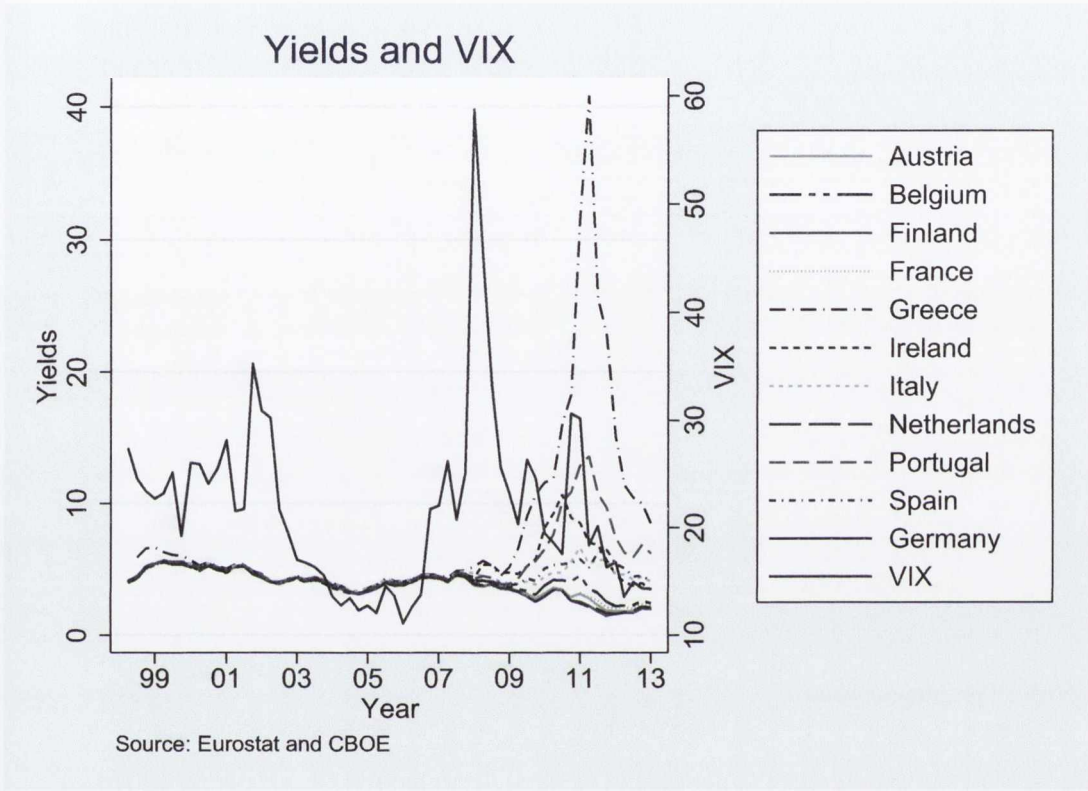
2.5 Conclusion

This paper has sought to shed light on the aspects of the economy that increase sovereign risk, with particular focus on the effect of global uncertainty on the perception of risk factors. Public indebtedness represents one of the reasons why financial markets become concerned about the ability of governments to repay; however, this analysis has shown that the foreign indebtedness of the overall economy also matters. Because the relation between the external dimension and sovereign risk is strongly dependent on global uncertainty, governments might downplay the risks that the private sector is building up in calm periods, and the acquired weakness can become manifest abruptly when expectations turn more uncertain. When this happens, the stabilising role of fiscal policy is limited because of the difficulties in raising funds in financial markets, in the moment when government intervention is more needed and fiscal revenues low.

In light of this, it is appropriate to monitor not only fiscal, but also external variables, in the assessment on whether public finance is on a sustainable path; in boom periods, scenarios more pessimistic than the expected one should be assigned a higher probability. While the recent focus on the external dimension is welcome, the composition of the international balance sheet must also be considered. Moreover, the sectoral composition of output and the external activity of credit intermediation institutions are important factors related to foreign debt to keep under scrutiny. It is outside the scope of this paper to suggest the extent of public intervention in these sectors; what this analysis implies is that public finance sustainability depends on the whole situation of the economy, and that governments must be aware of these factors when deciding the boom-period fiscal stance, and act accordingly.

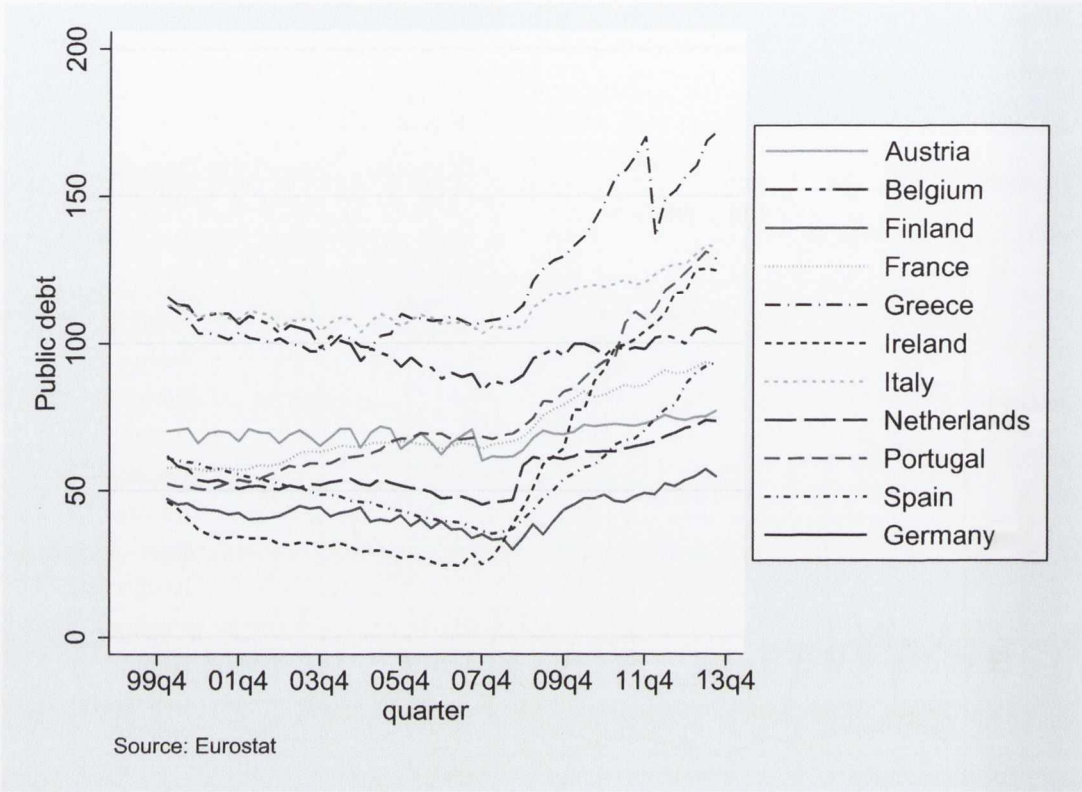
Tables and Figures

Figure 2.1: Annual yields and VIX.



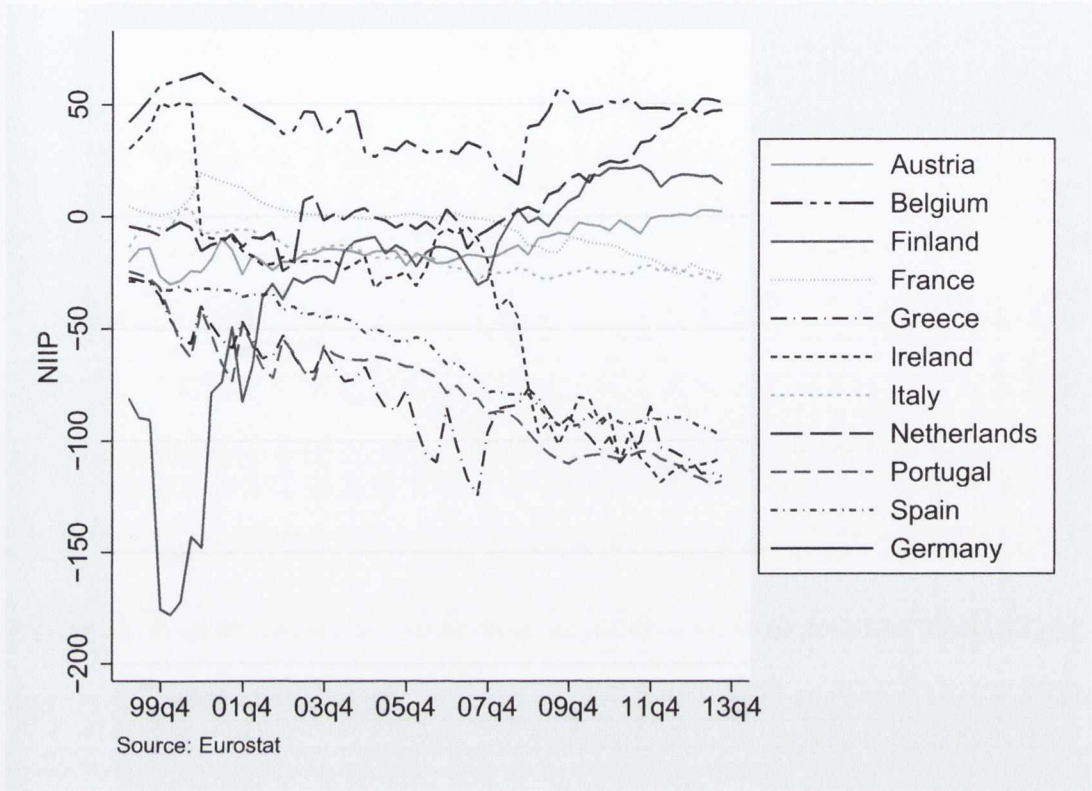
Note: Yields in percent. VIX is CBOE Volatility Index, a measure of expected volatility implied in S&P 500 stock index option prices.

Figure 2.2: Ratio of public debt to GDP.



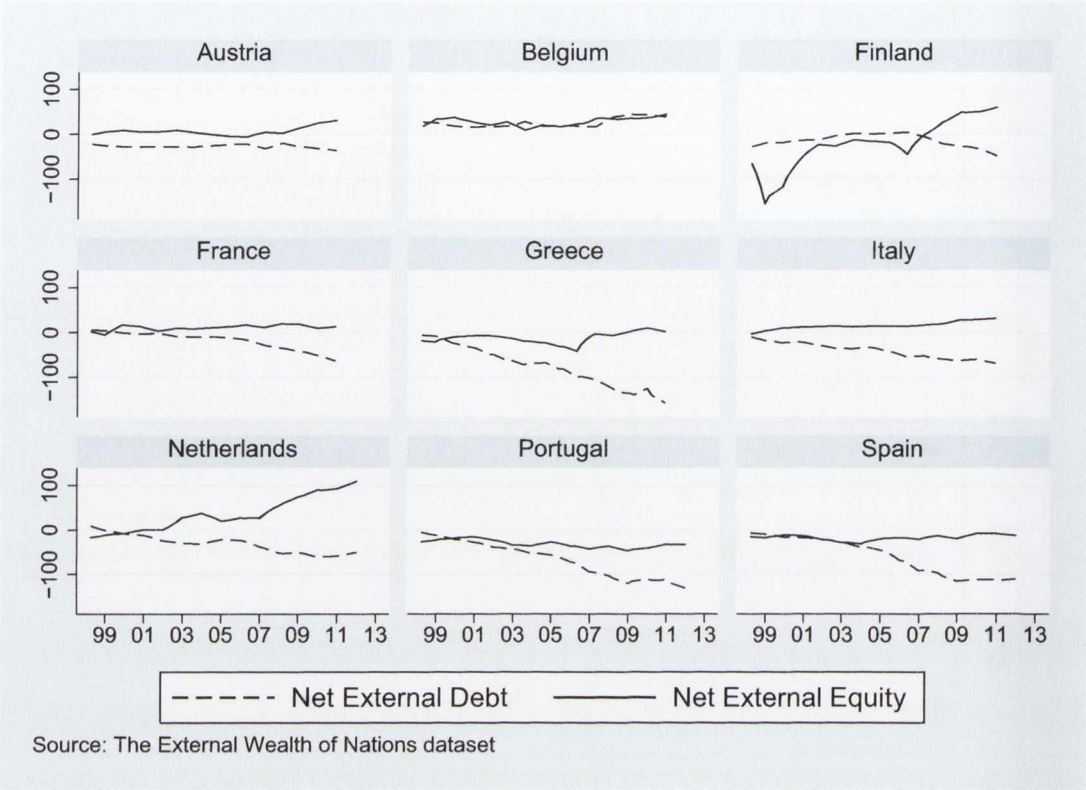
Note: Percentage points.

Figure 2.3: Ratio of net international investment position to GDP.



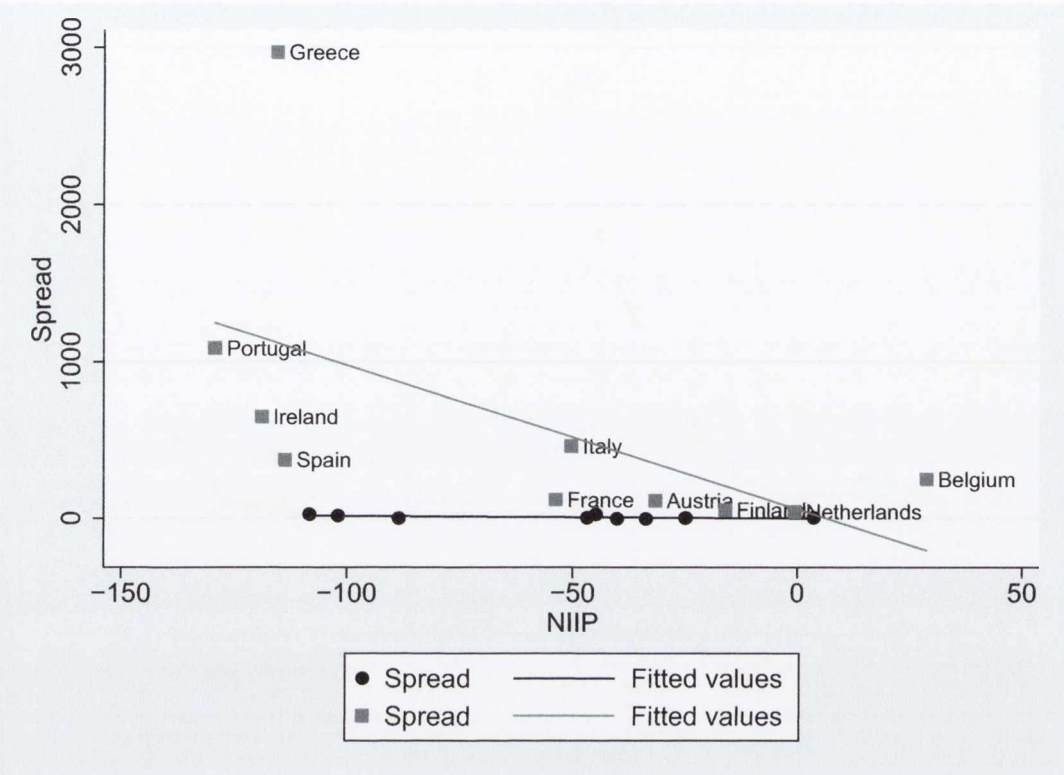
Note: Percentage points.

Figure 2.4: Ratios of Net External debt to GDP and Net External Equity to GDP.



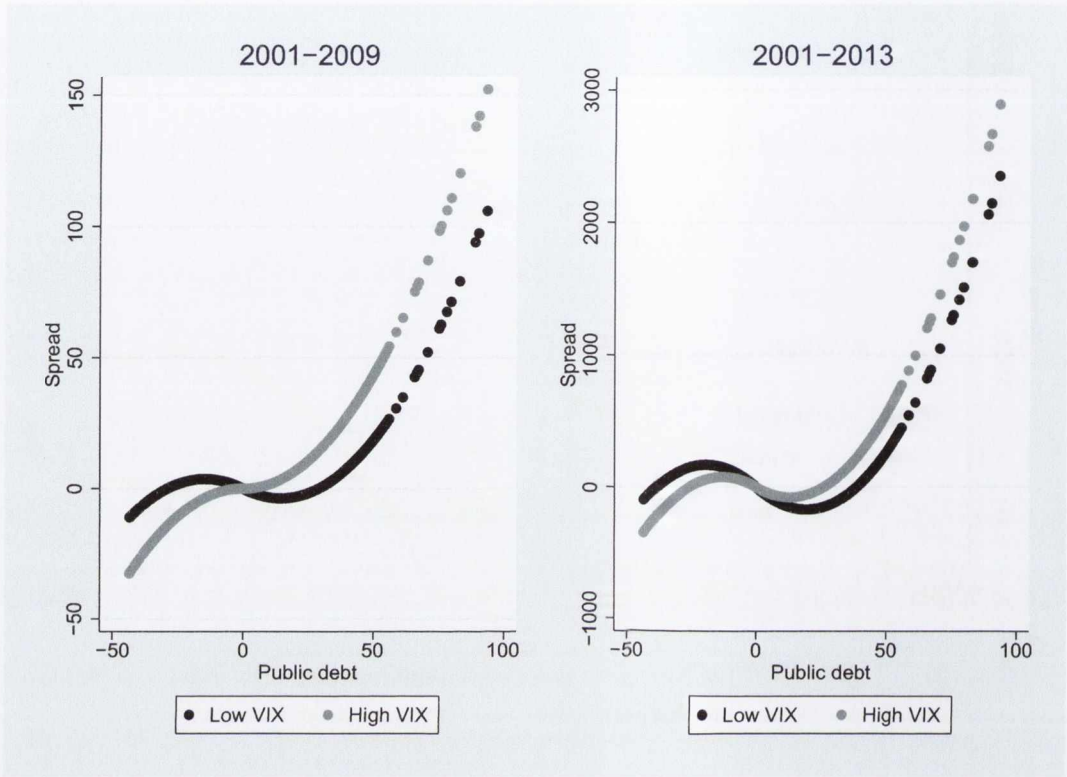
Note: Percentage points

Figure 2.5: Ratio of Net International Investment Position to GDP and Spread in 2006 and 2011.



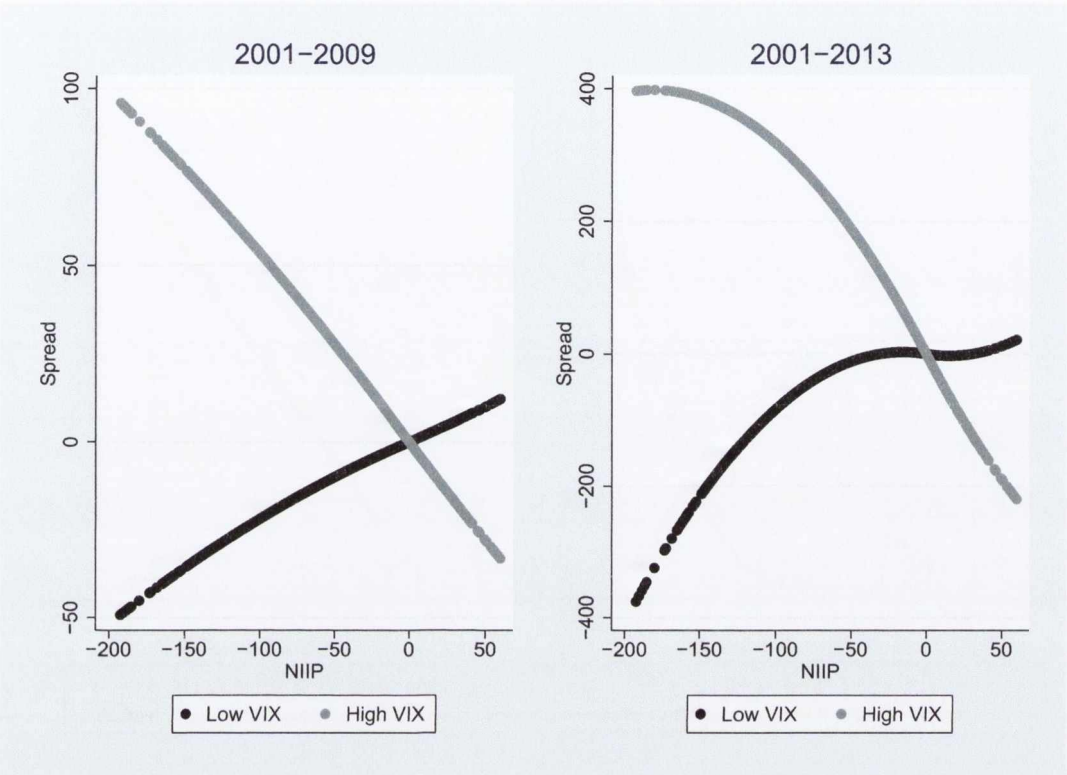
Note: Spread in basis points. NIIP in percentage points. Black is 2006; grey is 2011.

Figure 2.6: Long-run effect of public debt on spreads at different levels of uncertainty. Short and long sample.



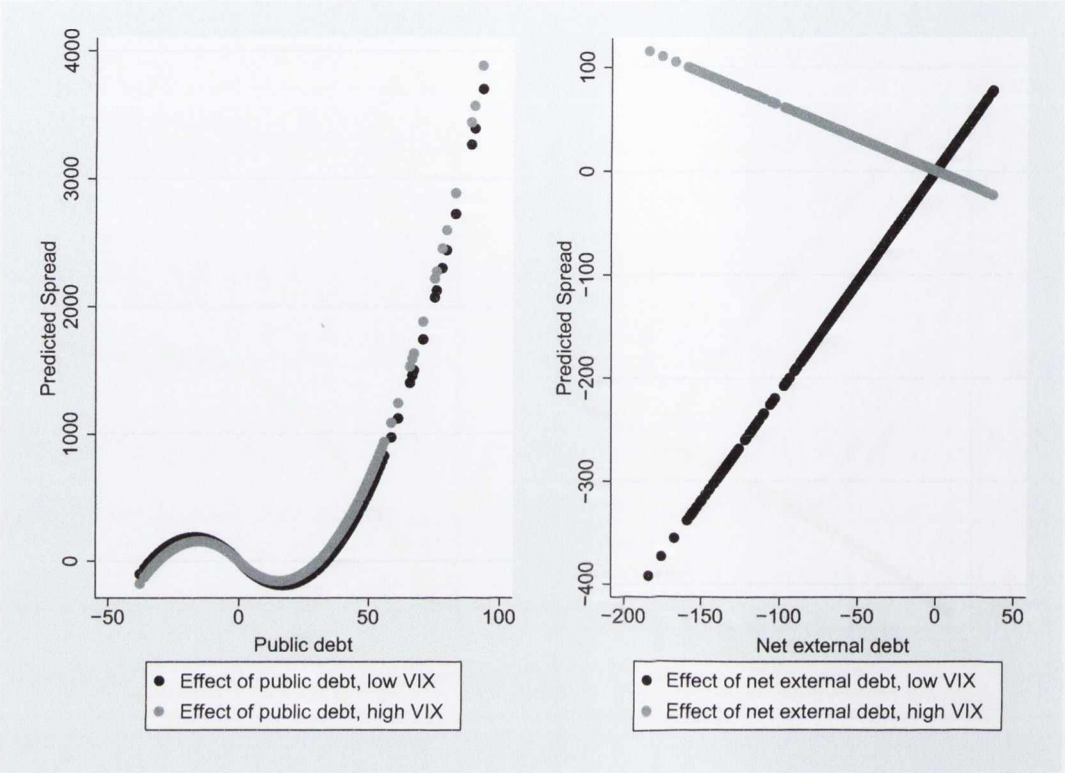
Note: Predictions based on full sample estimates in Table 2.4. Note the different scale of the y-axis.

Figure 2.7: Long-run effect of net external assets on spreads at different levels of uncertainty. Short and long sample.



Note: Predictions based on full sample estimates in Table 2.4. Basis points. Note the different scale of the y-axis.

Figure 2.8: Long-run effect of public debt and net external debt on spreads at different levels of uncertainty.



Note: Predictions based on estimates in column III in Table 2.5. Basis points. Note the different scale of the y-axis.

Table 2.1: Summary Statistics. Spread and VIX.

Country	mean	sd	min	max
Austria	28	29	-3.9	112
Belgium	49	56	-.57	250
Finland	16	18	-12	57
France	28	31	-.033	123
Germany	0	0	0	0
Greece	471	828	9.7	3905
Ireland	146	217	-22	762
Italy	107	128	10	461
Netherlands	18	17	-3.5	65
Portugal	204	315	-2	1182
Spain	103	144	-3.5	513
VIX	21	8.8	11	59

Note: *Spread* in basis points. *VIX* is the CBOE Volatility Index, a measure of expected volatility implied in S&P 500 stock index option prices. Time span: 2000 through 2013.

Table 2.2.A Summary Statistics: Ratio of Public Debt to GDP.

Country	mean	sd	min	max
Austria	69	4	60	77
Belgium	98	6.8	84	110
Finland	43	6.1	30	57
France	71	11	57	94
Germany	70	7.4	59	83
Greece	120	24	97	172
Ireland	55	34	25	125
Italy	113	8.1	103	133
Netherlands	56	8	45	74
Portugal	77	23	50	131
Spain	54	15	36	93

Note: Percent of GDP. Time span: 2000 through 2013.

Table 2.2.B Summary Statistics: Ratio of NIIP to GDP.

Country	mean	sd	min	max
Austria	-12	7.8	-26	2.3
Belgium	44	16	14	67
Finland	-13	25	-82	19
France	-7	7.9	-26	3
Germany	23	13	3.2	54
Greece	-77	24	-116	-37
Ireland	-48	38	-110	-4.5
Italy	-19	6.5	-28	-5.6
Netherlands	9.2	24	-24	76
Portugal	-81	26	-118	-39
Spain	-67	23	-95	-32

Note: Percent of GDP. Time span: 2000 through 2013.

Table 2.3: Baseline results.

<i>Spread</i>	I	II	III	IV	V	VI
<i>Spread_{t-1}</i>	0.83 [0.05]***	0.82 [0.05]***	0.82 [0.05]***	0.83 [0.05]***	0.82 [0.05]***	0.82 [0.05]***
<i>PD</i>	-2.61 [0.74]***	-2.53 [0.75]***	-2.54 [0.75]***	-3.88 [0.95]***	-2.55 [0.74]***	-3.74 [0.94]***
<i>PD²</i>	0.08 [0.02]***	0.08 [0.02]***	0.08 [0.02]***	0.08 [0.02]***	0.08 [0.02]***	0.08 [0.02]***
<i>NIIP</i>		-0.58 [0.30]*	-0.57 [0.30]*		0.35 [0.44]	0.35 [0.44]
<i>NIIP²</i>		0.004 [0.002]	0.003 [0.002]		0.003 [0.002]	0.002 [0.002]
<i>VIX</i>			1.72 [0.71]**	1.60 [0.67]**	-0.33 [0.83]	-0.34 [0.82]
<i>PD * VIX</i>				0.06 [0.03]*		0.05 [0.03]*
<i>NIIP * VIX</i>					-0.04 [0.02]**	-0.04 [0.02]**
<i>Constant</i>	-22.09 [18.75]	-27.93 [18.76]	-68.36 [24.79]***	-61.29 [23.92]**	-23.18 [25.66]	-24.47 [25.16]
<i>R²</i>	0.90	0.90	0.90	0.90	0.90	0.91
<i>N</i>	550	550	550	550	550	550
<i>Part R²</i>	0.12	0.13	0.14	0.15	0.16	0.17
<i>Low VIX :</i>						
<i>NIIP = 0, $\beta X > 0$ if $PD >$</i>	40%	41%	46%	51%	39%	48%
<i>NIIP = -100, $\beta X > 0$ if $PD >$</i>	40%	34%	41%	51%	45%	50%
<i>High VIX :</i>						
<i>NIIP = 0, $\beta X > 0$ if $PD >$</i>	40%	41%	38%	31%	41%	39%
<i>NIIP = -100, $\beta X > 0$ if $PD >$</i>	40%	34%	30%	31%	36%	-38%

Note: Dependent variable is 10-year government bond yield minus German yield, PD is public debt and NIIP is net international investment position; all regressors are in difference from German values; regressions include time fixed effects. All columns report results for OLS regressions with panel-corrected standard errors in square brackets. ***, **, * denote significance at 1,5 and 10 percent levels, respectively.

Table 2.4: Before and after 2010.

<i>Spread</i>	Full sample		Without Greece	
	2001-2009	2001-2013	2001-2009	2001-2013
$Spread_{t-1}$	0.73 [0.06]***	0.82 [0.05]***	0.78 [0.06]***	0.96 [0.03]***
PD	-0.22 [0.09]**	-3.74 [0.94]***	-0.10 [0.07]	-0.06 [0.23]
PD^2	0.005 [0.002]**	0.08 [0.02]***	0.003 [0.002]	-0.008 [0.005]
$NIIP$	0.17 [0.05]***	0.35 [0.44]	0.13 [0.04]***	0.26 [0.15]*
$NIIP^2$	0.0001 [0.0002]	0.002 [0.002]	0.0002 [0.0002]	-0.0002 [0.0007]
VIX	0.56 [0.16]***	-0.34 [0.82]	0.59 [0.15]***	0.41 [0.35]
$PD * VIX$	0.01 [0.002]***	0.05 [0.03]*	0.002 [0.002]	0.02 [0.01]**
$NIIP * VIX$	-0.01 [0.002]***	-0.04 [0.02]**	-0.01 [0.001]***	-0.02 [0.01]***
$Constant$	-8.69 [5.44]	-24.47 [25.16]	-8.88 [5.15]*	-8.64 [10.54]
R^2	0.90	0.91	0.89	0.96
N	390	550	351	495

Note: Dependent variable is 10-year government bond yield minus German yield, PD is public debt and NIIP is net international investment position; regressors are in difference from German values; regressions include time fixed effects. All columns report results for OLS regressions with panel-corrected standard errors in square brackets. The short sample is 2001-2009, the full sample is 2001-2013. *** significant at 1%, ** significant at 5% and * significant at 10%.

Table 2.5: Net External Debt and Net External Equity.

<i>Spread</i>	I	II	III
<i>Spread</i> _{<i>t</i>-1}	0.77 [0.05]***	0.74 [0.05]***	0.76 [0.05]***
<i>VIX</i>	-0.05 [0.97]	1.58 [0.67]**	-0.14 [0.92]
<i>PD</i>	-5.30 [0.97]***	-5.64 [0.97]***	-5.67 [0.95]***
<i>PD</i> ²	0.14 [0.02]***	0.15 [0.02]***	0.16 [0.02]***
<i>PD</i> * <i>VIX</i>	0.03 [0.03]	0.04 [0.03]	0.02 [0.03]
<i>NED</i>	0.73 [0.51]		0.90 [0.44]**
<i>NED</i> ²	-0.0001 [0.004]		0.003 [0.004]
<i>NED</i> * <i>VIX</i>	-0.03 [0.02]*		-0.04 [0.02]**
<i>NEE</i>		-0.45 [0.59]	-1.52 [0.48]***
<i>NEE</i> ²		0.004 [0.003]	0.01 [0.003]***
<i>NEE</i> * <i>VIX</i>		-0.02 [0.02]	-0.001 [0.02]
<i>Constant</i>	-41.80 [29.44]	-100.49 [27.24]***	-71.76 [29.21]**
<i>R</i> ²	0.91	0.91	0.92
<i>N</i>	468	468	468

Note: Dependent variable is 10-year government bond yield minus German yield, PD is public debt, NED is net external debt and NEE is net external equity; regressors are in difference from German values; regressions include time fixed effects. All columns report results for OLS regressions with panel-corrected standard errors in square brackets. *** significant at 1%, ** significant at 5% and * significant at 10%.

Chapter 3

Towards a structural credit-to-GDP ratio

3.1 Introduction

This paper seeks to contribute to the identification and understanding of the build-up of financial sector vulnerabilities related to the cycle of credit to the private non-financial sector. Recent experiences of developed and developing countries have shown that fast growth of private credit both increases the probability of a crisis and makes the recovery more painful (Demirguc-Kunt and Detragiache, 1998; Schularick and Taylor, 2012; Jordà et al., 2013). Further, aggregate private credit is a good predictor of crises: measures of excessive credit fare better in anticipating financial distress than monetary aggregates and other real and financial macroeconomic variables, such as GDP growth, asset prices, and bank profitability (Drehmann et al., 2010). In particular, it is the accumulation of excessive credit over long periods of time that is found to be associated with vulnerability; the cumulative process, captured by deviation in the ratio of private non-financial sector credit to GDP from its trend, predicts crises more accurately than yearly growth rates (Borio and Lowe, 2002b).

Several theoretical explanations for why aggregate credit fluctuations undermine financial stability have to do with the pro-cyclicality of financial actors (see, for example, Adrian

and Shin, 2010; Geanakoplos, 2010). Borio et al. (2001) argues that boom-bust cycles in credit to the private sector are explained by time variation in the measurement of risk. In good times, risk is underestimated, credit provision is excessive, asset prices are inflated, and financial institutions hold low levels of capital. During a downturn, overestimation of risk causes subdued credit and asset prices.

Along this line of thought, policy makers introduced the countercyclical capital buffer, a measure that requires banks to raise additional capital when credit to the private non-financial sector is increasing at a pace and under conditions which are deemed unsustainable, in order to increase resilience when the risks materialise. To identify periods of excessive credit and activate the buffer, the prudential regulator assigned a prominent role to the credit-to-GDP gap. This is defined as the distance of the ratio of credit to GDP from its long-run trend, obtained with a univariate statistical technique, the Hodrick-Prescott filter. The gap indicator is meant as a common reference point for authorities, whom are expected to use also other sources of information to evaluate the risks.

Previous research has shown that the credit-to-GDP gap can be a powerful predictor of banking crises; however, the indicator does not always work well in all economies and at all times (Borio and Lowe, 2002a; Borio and Drehmann, 2009; Drehmann et al., 2010). Policy makers should assess a broad set of information along with the credit-to-GDP gap, and consider whether the inferences from the gap are consistent with those of other variables (BCBS, 2010).

This is because the level of credit in an economy may increase fast relative to income not only in the case of a credit boom, but also for structural reasons. For example, the sustainable ratio of credit to GDP increases in the process of financial deepening, whereby agents are able to borrow larger proportions of income when a country develops institutions important for finance. Creditor rights protection, more effective monitoring of borrowers by banks, for instance, increase credit supply in a sustainable fashion (Djankov et al., 2007; Druck et al., 2007). Moreover, the ratio of private credit to GDP may increase when economic outcomes become more favourable to debt sustainability; for example, a

permanent fall in interest rates reduces the debt servicing burden thus allowing a higher level of debt relative to income (Juselius and Drehmann, 2015).

This paper seeks to provide a method to help the identification of “good” and “bad” increases in the credit-to-GDP ratio. Our approach considers the evolution of macroeconomic variables in conjunction with changes in the credit-to-GDP ratio (which we sometimes call, for short, the credit ratio). We estimate a long-run relation between the credit ratio and a set of macroeconomic variables associated with the sustainability of debt. We then smooth the macroeconomic variables to obtain a projection for the level of credit-to-GDP which is consistent with medium-term economic outcomes. Looking at medium-term fluctuations in these variables and their implications for the sustainability of debt increases our understanding of the economic forces driving medium-term increases in the credit-to-GDP ratio.

The paper is organised as follows. The next section lays out the motivation for the empirical analysis and discusses the choice of the concepts included in the long-run relation. Section 3 describes the data. Section 4 introduces the econometric approach and discusses the results. Section 5 concludes.

3.2 Motivation

The approach suggested by the Basel III framework to guide the identification of periods of excessive credit growth is a purely statistical method. The cyclical component of the credit-to-GDP series is extracted with the Hodrick-Prescott (HP) filter, and a threshold indicates when upward cyclical fluctuations may be excessive. This signal is the starting point of the analysis, since this purely statistical method may not capture fast changes in trend in real time.

An example where the trend estimated by HP filter may not work well is the case of formerly planned economies. In Central and Eastern Europe, the creation of markets opened the

door to price-based supply of credit, supported by the increased use of bank deposits and, in some cases, inflows of foreign capital. These structural changes, and the relatively fast economic growth that followed, supported an increase in the level of private credit, often at a faster pace than nominal growth (Cottarelli et al., 2005). The Basel III credit-to-GDP gap, unable to capture structural changes accompanying increases in the credit ratio, can be misleading when the economy is undergoing fundamental economic transformations.

This example shows the importance of considering other economic and financial variables and also qualitative information in forming a judgement over the sustainable level of credit in an economy. In the credit boom literature, patterns of micro and macroeconomic variables before and after episodes of sharp increases in credit are studied to understand the features of boom-bust cycles (Gourinchas et al., 2001; Mendoza and Terrones, 2008; Schularick and Taylor, 2012).

In this paper, we build on a method that has been used in the case of formerly planned economies, whereby a long-run relation between a credit measure and a set of macroeconomic variables is estimated and used to assess the current level of credit relative to the long-run trend (Égert et al., 2006; Kiss et al., 2006; Cottarelli et al., 2005).

In these studies, the sustainable level of credit is estimated by model projections based on the current level of macroeconomic variables. This may be appropriate in the case of transition economies, where the fast changes in macroeconomic variables typically reflect convergence towards a new equilibrium. However, for relatively developed countries, separating a credit boom from a structural increase in credit requires assessing the sustainability of the macroeconomic conditions which accompany the increase in credit.

We thus proceed in three steps. First, we estimate a long-run relation between the credit ratio and a parsimonious set of financial and real variables relating to the ratio of credit to GDP in the long run. Second, we calculate two sets of model projections, using either the current level of the macroeconomic variables or the medium-term average. When the current-value projection is higher than the actual credit ratio, the system is stretched

towards a higher credit ratio. This may be due to structural or cyclical reasons. A preliminary indication is given by the model projections based on medium term averages, as short-term cycles are removed. We investigate this further in the third step, where we decompose the medium-term projection by looking at medium-term changes in the macroeconomic variables and their implications for the sustainable level of credit.

The paper that most closely relates to our work is Albuquerque et al. (2014), which estimates a long-run relation between household credit-to-GDP in US states and uses it to assess the deleveraging needs of US households.

3.2.1 Choice of covariates

Given that our approach is based on the interaction between credit-to-GDP and a set of economic outcomes that determine credit sustainability, it is important to select the variables that appropriately capture these interactions. Note that since our aim is to determine the extent to which economic patterns are consistent with the long-run level of the ratio of credit to GDP, concepts which are related with credit provision in the short run are not considered. For example, open-economy variables such as capital inflows, which are associated with increases in credit but do not necessarily increase repayment capacity, are not considered. Building on the findings of previous literature, we select the concepts to be considered as follows.

The amount of credit relative to income that an economy can afford to repay depends first and foremost on the level of economic development. Richer countries can borrow more because they can more credibly commit resources; higher production *per capita* is typically paired with more wealth, higher financial development and lower political instability. Buncic and Melecky (2014) provide empirical support for this hypothesis, by showing that country-specific long-run estimates of the income elasticity of real private credit are positively related to the level of financial and economic development. The results of Kelly et al. (2011) are consistent with this interpretation: the paper documents a structural break in

the relation between nominal private sector credit and nominal GDP in the Irish economy around 1998, after a period of intense deregulation of credit markets and during years of impressive GDP growth.

In addition, the sustainability of the credit-to-GDP ratio is related to nominal interest rates via the debt service burden. At the microeconomic level, the sustainable debt-to-income ratio for a borrower decreases when the nominal interest rate rises, because debt servicing costs use up a larger share of income. If the propensity to consume of lenders is lower than of borrowers, or if frictions prevent the expenditure of lenders from compensating for the fall in the expenditure of borrowers, the negative relation between the interest rate and credit-to-GDP carries over to the aggregate level (Juselius and Drehmann, 2015; Eggertsson and Krugman, 2012). Studies analysing the long-run correlates of the ratio of private credit to GDP consistently find a negative relation with the interest rate (Kiss et al., 2006; Castro et al., 2016; Juselius and Drehmann, 2015).

These studies also find a negative association between the credit ratio and inflation. The negative relation can be explained by the reduction in credit supply that occurs when prices increase at a fast rate, due to the difficulty of financial intermediaries to predict future profits of borrower firms (Druck and Garibaldi, 2000). The literature attributes this effect to the increase in relative price variability, with which a high-inflation environment is frequently paired. If the relative price of inputs and output of firms are hard to predict, and if costs of monitoring and repossession are so high that the interest rate needed to cover these costs increases the probability of default of the borrower, credit is rationed in equilibrium (Williamson, 1987; Druck et al., 2007; Boyd et al., 2001). Because it is difficult to obtain long time series of measures of price variability that are comparable across countries, we use the rate of inflation; specifically, the realised rate of inflation, in light of previous findings pointing to a relation between variability of relative prices and both anticipated and unanticipated inflation (Parks, 1978; Fischer et al., 1981).

The sustainability of the credit-to-GDP ratio also relates to the level of asset prices. In a world with collateral constraints, credit is bounded by the fraction of assets that can be

pledged; in the steady state, if borrowers are credit constrained, aggregate credit hits the collateral constraint limit, and leverage, defined as credit over assets, is constant (Bernanke et al., 1999; Kiyotaki and Moore, 1997). In this setting, an increase in asset prices has a positive impact on private sector borrowing, by relaxing credit constraints. Empirically, a positive long-run relation between aggregate credit and asset prices for industrialised countries is documented in Hofmann (2001).

The collateral constraint limit also implies a positive relation between the credit-to-GDP ratio and asset prices: when asset prices rise, credit increases proportionally to keep leverage constant, while output is unchanged (Juselius and Drehmann, 2015). Similar to the setting in Juselius and Drehmann (2015), in our analysis it would be optimal to use an index of asset prices encompassing residential and commercial real estate, and equity shares, in the spirit of Borio et al. (1994). However, availability of the data needed to build such an index is limited for several countries in our sample. Given the relative importance of property prices in securing debt, and to maximise country coverage and time series length, we focus on real estate prices. Borio and Lowe (2002b) shows a comparison between an aggregate asset price index and its components: for European countries, real estate prices track the aggregate asset price index remarkably well.

An additional concept may influence the credit ratio in the long run: the share of fixed capital investment in GDP. In the collateral constrained framework described above, if the share of assets created from production increases, the leverage limit implies that credit rises relative to GDP. Moreover, credit demand rises to smooth the additional future income deriving from increased investment. In sum, credit-to-GDP rises with investment-to GDP (the investment ratio).

In summary, our model contains two real economy variables, real GDP *per capita* and the investment ratio, which capture current and future economic development. A third variable, inflation, captures uncertainty in future relative prices and firms profitability. Finally, the model contains two variables relating to the financial side, representing the burden of debt and the value of collateral. The next section describes the data which underpins the empirical analysis.

3.3 Data

We use the credit data compiled by the Bank for International Settlements. The database comprises credit to the non-financial private sector, split by borrower sector (households and non-financial corporations). Credit encompasses all instruments, including bonds. For a detailed description of the concepts captured by the credit variables used in this paper, see Dembiermont et al. (2013).

Economic development is measured by real GDP *per capita* in 2005 US dollars, from World Bank national accounts data. The proxy for the lending rate is the short-term interbank market rate, from the AMECO database. Our inflation variable comes from the same database, and is derived from the GDP deflator.¹ Real house prices are from the OECD Analytical House Price database: the base year is 2010. The investment share in GDP, or investment ratio, is the ratio of gross fixed capital formation to GDP from the World Bank. Summary statistics are gathered in Tables 3.1 to 3.5.

3.3.1 Structural and cyclical changes

In the previous section, we set out a framework linking macroeconomic concepts to the ratio of non-financial private sector credit to GDP. For economic developments to allow for a higher sustainable credit-to-GDP, the change ought to be permanent. In this section, we show the time series of the variables used in our model and the smoothed series which will be used for medium-term projections in the following sustainability analysis.

Figure 3.1 plots the credit ratios of the whole non-financial private sector and its sub-sectors. In all the countries considered, credit ratios increased over the sample period. Only in Austria did the ratio of non-financial private sector credit-to-GDP increase steadily over

¹The inflation series is derived from nominal and real interest rates. We choose to use this source because it contains data from 1970, whereas more standard sources such as the World Economic Outlook (WEO) provide data from 1980 only. The correlation between AMECO and WEO series is 0.9; as a result, when the econometric model is estimated using the WEO series, the coefficients are economically almost identical, although the statistical significance is reduced.

the whole sample period. In the other countries, an acceleration of private credit to GDP is observable from around 1995; countries where the private sector credit ratio surged the most before the crisis also experienced a contraction during the crisis (Denmark, Greece, Ireland, Portugal, Spain and UK). The non-financial private sector credit ratio closely follows movements in the non-financial corporations credit ratio until recently, when borrowing of the household sector gained importance. Still, the productive sector is allocated the majority of private sector credit in many countries (Germany, Denmark, UK and more recently Greece, are exceptions).

Figures 3.2 to 3.6 chart the time series of the variables included in the long-run equation, along with the respective ten-year moving averages. In the empirical analysis in the following section, we will use the moving average as a first approximation towards the long-run value of these variables. It is therefore important to understand the ability of the smoothed series to capture the long term component, leaving out cyclical fluctuations. In order to permit real-time analysis, we take backward looking moving averages.

Figure 3.2 shows the log of real GDP *per capita*, in constant 2005 dollars. Due to the upward trending nature of this variable, the backward-looking moving average is almost always below the actual series. In the severe recession following the global financial crisis, the moving average decreases in Greece, Italy, Portugal and Spain. This suggests that in these countries, the moving average overestimates the long-run trend.

At the same time, interest rates and inflation decline in all countries in the period considered (Figures 3.3 and 3.4). Considering the variability of these variables, the approximation captures the long-term trend of these variables relatively well, removing to a large extent short- to medium-term fluctuations.

Real house prices increased in all countries in our sample, except Germany and Portugal (Figure 3.5). The countries with the largest increase in private sector credit ratios are also the ones with the largest increase in the real house price index, with few exceptions.²

²There are two exceptions: France, where the increase in credit is not comparable to the surge in real house prices starting in 2000; and Portugal, where private credit increased dramatically without a corresponding increase in real house prices.

A large share of the increase in house prices was reverted during the crisis in Denmark, Greece, Ireland, Italy, Netherlands, Spain and UK. The moving average smooths shorter-term cyclical movements, although the most pronounced fluctuations are not completely removed.

The same countries where real house prices increased fast and then reverted, also had a surge in investment relative to output during the same period, against the background of a long-term trend towards decreasing investment ratios (Figure 3.6). The rise in investment has been associated with a construction boom supported by rising house prices. A similar pattern is present in the data for Sweden and France, where current real house prices and gross fixed capital formation are increasing along with the credit ratio. In Sweden, the pace of rising house prices is even faster, and the investment ratio even higher, in 2015 than in 2000.

These stylised facts document a number of long-run changes that European economies went through in the last four decades. Economic development, lower inflation and higher house prices are all consistent with higher credit-to-GDP. In the next section, an econometric framework is used to identify a long run relation between the credit-to-GDP ratio and the variables affecting credit sustainability. We argue that assessing the sustainability of credit ratios should start from an assessment of the sustainability of the long-run covariates of credit.

3.4 Econometric analysis

We estimate a long run equation relating the ratio of non-financial private sector credit to GDP with variables capturing the concepts set out above, using a single-equation panel error-correction model. The aim is to identify a long-run relationship between the variables and to determine when the credit ratio differs from the value predicted by the common trend. For this purpose, we do not need to identify causal relationships between the credit ratio and its covariates; we can use a parsimonious single-equation model, on the basis of

the results of Johansen tests for cointegration run separately for each country, which find a single cointegrating vector among the non-stationary variables in the model. Instead of relying on the identification assumptions needed to isolate structural shocks in a multiple-equation setting, we believe it is more transparent to just assume credit to be the only variable adjusting towards the common trend when the system is off-equilibrium. The equation to be estimated is:

$$\Delta \frac{credit_{it}}{GDP_{it}} = \mu_i + \phi \left(\frac{credit_{it-1}}{GDP_{it-1}} - \beta' X_{it-1} \right) + \delta' \Delta X_{it} + \varepsilon_{it} \quad (3.1)$$

where μ_i are country fixed effects, ϕ is the adjustment coefficient, and X is a vector collecting the long-run covariates of the credit ratio. The dependent variable is the ratio of non-financial private sector credit to GDP.

The unbalanced panel contains 15 countries which are members of the European Economic Area.³ The focus is on the EEA because the common market, converging regulatory frameworks, and exchange rate pegs ensures these countries are a relatively homogeneous group. We assume equal coefficients across countries; the appropriateness of this assumption is discussed in Section 3.4.2.

The model is estimated at quarterly frequency and spans from 1970 to 2014. To ensure meaningful long run analysis, only countries with data at least from 2000 are included. For eight countries, data stretches back to 1970. Sensitivity analysis shows that estimating the model on these countries alone does not change the results. This is discussed in Section 3.4.2.

³The countries are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and UK.

Table 3.6 reports long-run within-correlations between the variables. These reflect the stylised facts described above: for instance, real GDP *per capita* is positively correlated with the credit ratio and real house prices and negatively correlated with the investment ratio; interest rate and inflation are positively correlated.

We ran unit root tests based on augmented Dickey Fuller regressions, summarised in Table 3.7. The credit ratio, the interest rate and the real house price index are integrated of order one. The presence of a unit root is rejected in the log of real GDP *per capita*, although tests run separately on the level suggest that real GDP *per capita* is $I(1)$. The other variables are also stationary. Pedroni tests for cointegration strongly reject the null of no cointegration in all our specifications (bottom line of Table 3.8).

We estimate the error-correction model by dynamic OLS with Newey-West standard errors. The standard errors of the coefficients in the long run equation reported in Table 3.8 are calculated with the delta method; in all the specifications, the adjustment coefficient is highly significant and negative, consistent with the presence of cointegration.

3.4.1 Estimation results

Table 3.8 reports the coefficients of the estimated long-run equations. The sign of all coefficients confirm the expectations arising from our discussion. In the first column, a 1 percent increase in real GDP *per capita* is associated with a 2.3 percentage point increase in the credit ratio. Controlling for cost of borrowing and inflation reduces the linear association to 1.5 percentage points in columns 2 and 3. In the second column, an increase in the nominal interest rate by 1 percent reduces the sustainable private credit ratio by 3.8 percentage points, consistent with the prediction that economies where interest rates are structurally low can afford to borrow a higher proportion of income.

When inflation is added to the model, the relation between interest rate and private sector credit ratio disappears. This suggests that inflation, rather than the debt service burden,

explains the negative relation between the nominal interest rate and the credit ratio via its impact on the nominal interest rate.

Compared to an economy where prices grow 2 percent annually, a country with an inflation rate of 12 percent has a ratio of private sector credit-to-GDP that is lower by 57 percentage points, *ceteris paribus* (column 2). While the economic magnitude of this relation might seem large, an inflation rate of 12 percent can be associated with large relative price variation and macroeconomic uncertainty (Fischer et al., 1981), resulting in hardly predictable profitability of the projects proposed by loan applicants and uncertain future values of asset prices.

Real house prices are strongly positively associated with the private sector credit ratio in columns 5 through 7; the R-squared of the error correction model increases by 6 percentage points when real house prices are added in column 5, consistent with the presence of significant collateral effects. In addition, the investment ratio further increases the explained variance by 9 percentage points.

In column 6, a 1 percentage point increase in the investment ratio is associated with 18.7 percentage point rise in the credit-to-GDP ratio, *ceteris paribus*. At first look, the economic magnitude of this coefficient might seem large. To reconcile it with intuition, consider that the variability of the investment ratio in the long run is low (Figure 3.5). A structural increase in the investment ratio by 1 percentage point in one quarter is a considerably large addition to fixed assets, in relative terms. Moreover, because the investment ratio has a strong positive correlation with inflation and the interest rate, and a strong negative relation with real GDP *per capita* (Table 3.6), in a non-orthogonalised world, increases in investment are often accompanied by the counteracting effect of these variables. This interpretation is also consistent with the impact of including the investment ratio in the model on the coefficients on real GDP *per capita* and inflation.

3.4.2 Robustness

Before proceeding with the sustainability analysis, we perform a number of checks on the estimation. In Table 3.9, we restrict the sample to exclude countries where data availability starts after the year 1980. The coefficients in the top half of the table are not statistically different from the coefficients in Table 3.8. Further, we test for equality of the coefficients across countries in the bottom part of the table, by interacting country dummies with each of the variables in the model. This is done separately for each country in the columns of the table. For all the interaction terms except two, the interactions are not significant, and in the two cases where the coefficients are different from the baseline, the statistical significance is 10%. We conclude that the assumption of equal coefficients is appropriate.

Moreover, we are concerned that the common trend may vary when the level of credit is a large share or multiple of income. The long-run relation may vary due to two factors. First, this may reflect financial deepening. The credit-to-GDP ratio has been used in the literature to proxy financial development (for example, Arcand et al., 2012). It is possible that the economic mechanisms at play in our model change with the level of financial development. For example, collateral constraints may be slack in more developed financial systems, attenuating the relationship between house prices and credit. Second, if credit reaches saturation levels, debt overhang may change the relation between credit and the rest of the economy. For example, in an economy with high debt to income ratios, a fall in the interest rate may not increase credit capacity but simply reduce the current debt overhang.

We split the sample at the 50th, 70th, and 80th percentile, corresponding to credit 120%, 150% and 170% of GDP, and test for different coefficients above and below these thresholds. Table 3.10 presents the results. The log of real GDP *per capita* has a steeper relationship with the credit ratio in the lower part of the sample. When credit-to-GDP reaches high levels, increases in financial deepening may be accompanied by smaller improvements in financial and economic development (Arcand et al., 2012).

The interest rate is positively associated with the credit ratio in the upper half of the sample. This is consistent with the idea that at high levels of debt, there is less room for manoeuvre which impedes adjustment and if the interest rate increases, debt increases mechanically, *ceteris paribus*.

The role of inflation does not vary in the upper samples except in the first column. This dip in the coefficient between the 50th and the 70th percentile seems to be a statistical artifact capturing the temporary acceleration in the rise of credit ratios which occurred in a number of countries between 1985 and 1995, during years when inflation flattened out. Removing the period 1985-1995 from the sample, the interaction becomes statistically not significant.

Turning to real house prices, the index is related to credit to GDP ratio only in the 50th-80th percentile interval. This result does not support the interpretation that collateral constraints disappear with financial deepening.

Finally, the relationship with the investment ratio does not change for high levels of the credit ratio. Also here, the coefficient in the first column is driven by the period 1985-1995 when the correlation between the two ratios is temporarily stronger. When, in a long-run model, we restrict the sample to short time periods, there is the risk to capture dynamics which are idiosyncratic to the period selected, as the estimator of the trend is prevented from seeing through the cycle.

3.4.3 Sustainability analysis

We now turn to using model projections to help assess the sustainability of credit-to-GDP ratios. Cointegration between the variables ensures that any deviation of the credit ratio from the projection based on the common trend disappears in the long run. To the extent that the variables plugged in the long-run equation are in equilibrium, the credit ratio is in equilibrium too. If these variables are off their structural value, they will tend to revert to it; consequently, the credit ratio will also be off-equilibrium.

We propose a transparent method to look at the economic system and understand underlying patterns. As a first step, we look at model projections based on the current level of the macroeconomic variables; we name these “current projections”. When current projections are above the actual level of credit-to-GDP, the system is stretched towards a higher credit ratio. Whether the higher level is sustainable depends on whether the macroeconomic variables will revert. For example, in an expansion where interest rate is only temporarily low, and real GDP, the investment ratio and real house prices are higher than their fundamental value, the current projection will not represent a sustainable credit ratio. When these variables return to the level justified by fundamentals, the projection will revert too.

In a second step, we project the credit ratio onto ten-year moving averages of the macro variables (“medium-term projections”). In the smoothed series, the short-term component is removed. This brings us closer to a structural prediction, although medium-term fluctuations are still captured in the projection. In other words, the projections obtained this way may still contain a revertible component.

In a third step, we study the yearly change in the medium-term projections, looking at the contribution of each variable. This is done by multiplying yearly changes by the respective long-run coefficient. This allows us to see which variables are contributing to the rise or fall of the projection; external information on future changes in these variables bears a meaning on the sustainability of the projected change in the credit ratio. This is a practical way of looking at several variables at once and also take into account the implications of these patterns for the ratio of credit to GDP.

In the charts to follow, to simplify exposition we separate economies into three groups: EMU crisis countries, EMU non-crisis countries, and non-EMU countries. In figures 3.7, 3.8 and 3.9, we plot current projections, medium-term projections, actual credit ratios, and HP-filtered credit ratios in each of the three groups of countries. In the run-up to the crisis, current projections are above actual credit ratios in Greece, Ireland, Italy, Spain, Finland, France, Netherlands, Denmark, and to a smaller extent, Belgium and Sweden. The countries where the current projection was farthest from the actual value are those

where the boom was most pronounced and which suffered the most from the crisis. Indeed, current projections fall sharply in these countries when the crisis breaks out.

In a sense, the difference between current projection and actual value provides a signal similar to the HP-filter in that it announces increases in the credit ratio. In all EMU crisis countries, the current projection goes above the actual ratio around the same time that the HP gap becomes positive, or even earlier. However, like for the HP gap, the signal does not distinguish between excessive increases in credit and increases which are supported by underlying economic forces.

This brings us to medium-term projections. A comparison of current and medium-term projections in figures 3.7, 3.8 and 3.9 demonstrates that removing boom-bust patterns helps the projection of long-run changes. For example, for Spain in Figure 3.7, current projections in 2015 are at the level of 1995. This is because the recession depressed GDP, real house prices and investment; however, if these variables revert to their normal level, they will bring the projection closer to the equilibrium level. Figure 3.7 shows that medium-term projections partly overcome this problem but do not remove long and wide cyclical fluctuations. Consider the Irish case: the medium term projection is higher than the actual ratio in the boom, and falls in the recession, because the ten-year averages do not remove cycles completely.

In Figures 3.8 and 3.9, the impact of cycles on medium-term projections is less clear-cut. Contrary to the cases of Ireland and Spain, the credit boom is relatively easy to identify *ex-post*, in EMU non-crisis and non-EMU countries, whether medium-term projections are capturing a cycle is less obvious. The next part of our analysis is a simple and standardised first step towards understanding the economic patterns which are related with credit both in the medium and long run. Whereas structural and cyclical components are unobservable and any assessment that tells them apart implies some judgement, our method offers a tool to guide judgement by considering several aspects of the economy at different time horizons.

In Figures 3.10, 3.11 and 3.12, we decompose the medium-term projected change in the credit ratio. We multiply yearly changes in the ten-year backward-looking moving averages by the respective long-run coefficients. Whereas averaging over the previous ten years can remove business cycle fluctuations, it may not remove completely financial cycles, which can span more than a decade (Schularick and Taylor, 2012; Schüler et al., 2015).

Also in Figures 3.10, 3.11 and 3.12, the extent to which predicted changes in the credit-to-GDP ratios can be interpreted as structural depends on whether one sees the changes in the moving averages as sustainable. To inform such assessment, it is useful to consider how the right-hand side variables co-move along the financial cycle. Firstly, house prices, real GDP and inflation positively co-move with the financial cycle, whereas interest rates have a negative co-movement (Schüler et al., 2015). Moreover, the investment ratio positively correlates with the financial cycle and can be associated with unsustainable patterns. For example, before the global financial crisis, many countries had investment booms in capital employed in the production of non-tradable goods, or non-productive capital, such as real estate. When the boom comes to an end and these sectors disinvest, it can be difficult to shift production and investment back towards more productive uses, aggravating the recession (Blanchard, 2007; Lane, 2012). Moreover, in upturns of the financial cycle, projects with negative net present value are more likely to receive financing because of the pro-cyclicality of risk measurement (Borio et al., 2001); in sum, fixed capital investment is pro-cyclical.

Visual inspection of medium-term dynamics of the right-hand variables, their co-movement with one another, and their relation with the credit ratio, helps understand the structural or cyclical nature of macroeconomic patterns. Consider the example of Ireland in Figure 3.10: in the 1996-2008 period, all variables change in directions consistent with the financial cycle. House prices, real GDP *per capita* and the investment ratio increase, whereas the interest rate decreases. To a lesser extent, inflation also increases. This pattern is consistent with the expansionary phase of the financial cycle, and with the exception of inflation and the interest rate, in our model the pattern also predicts an increasing credit ratio. On the other hand, in the 1981-1995 period, the co-movement of these variables does not suggest

the presence of a credit boom: inflation is on a decreasing path after the oil price shocks of the 1970s, gross fixed capital formation-to-GDP is decreasing but real GDP *per capita* is growing steadily. It is not unreasonable to pose that, between 1981 and 2005, changes in inflation, real GDP *per capita* and, only part of the increase in real house prices, can be considered structural changes.

Similar features are visible in recent years in France (Figure 3.11) and Sweden (Figure 3.12). In both cases, the moving average of both real house prices and the investment ratio are rising since 2001. The increase in real house prices, in particular, has continued after a short slow-down during the crisis. The increase in the investment ratio is smaller than in the Irish case before the crisis, and is small compared to the prolonged fall that occurred in these countries in the years before 2003. Still, the large and continuous increase in house prices, and the associated increase in credit ratios observed in Sweden and France in the last decade, raise concerns over their sustainability.

3.5 Conclusion

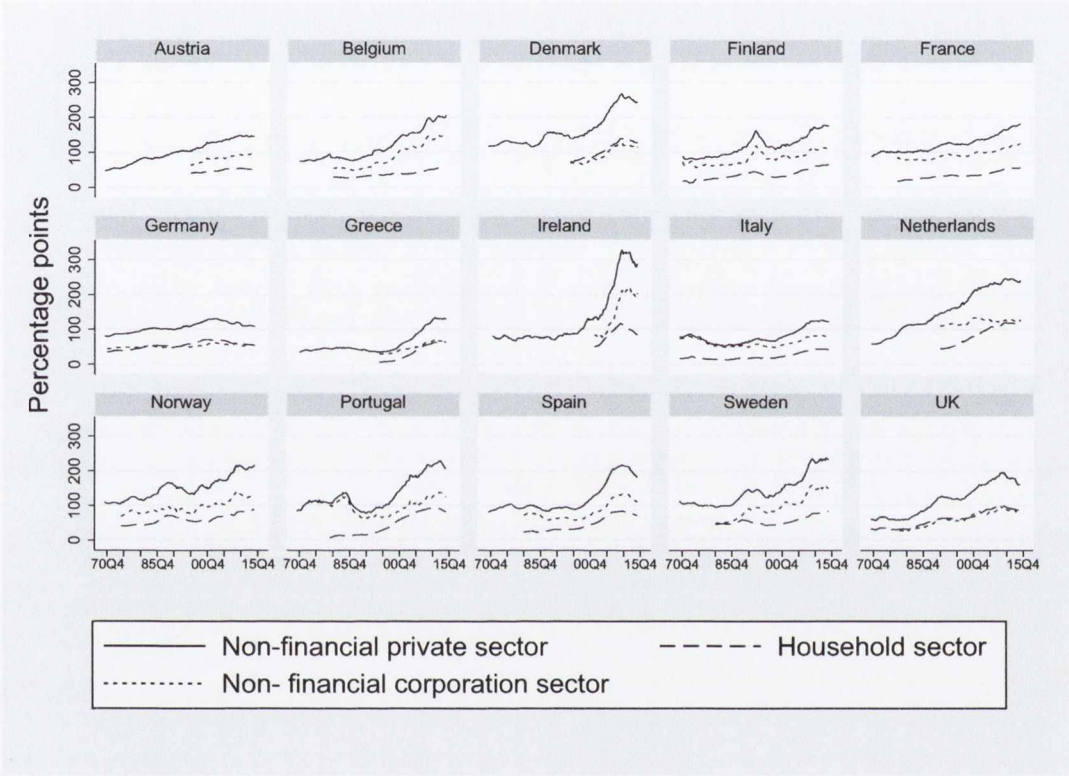
Rising indebtedness relative to income is a positive development if it is the result of a permanent improvement of borrowers repayment capacity or a loosening of collateral or credit constraints. When the increase in aggregate indebtedness is only supported by cyclical patterns, however, the subsequent deleveraging needs may be bitter. The analysis in this paper aims at helping the assessment of the amount of credit to the non-financial private sector that is consistent with long term sustainability. We provide a transparent framework to match changes in the ratio of private credit to GDP with patterns in the rest of the economy.

This approach can be used to assist policy makers in the analysis of the information which informs the decision to activate the counter-cyclical capital buffer. We find that using our approach, a number of patterns are visible in the data before the crisis for the countries where credit contracted the most after the crisis such as Ireland and Spain. Similar patterns

are currently present in France and Sweden, which suggests that vulnerabilities may be building up in these countries. Whereas additional qualitative and quantitative information should be considered before activation of the counter-cyclical capital buffer, the presence of a buffer in Sweden confirms the result of our analysis.

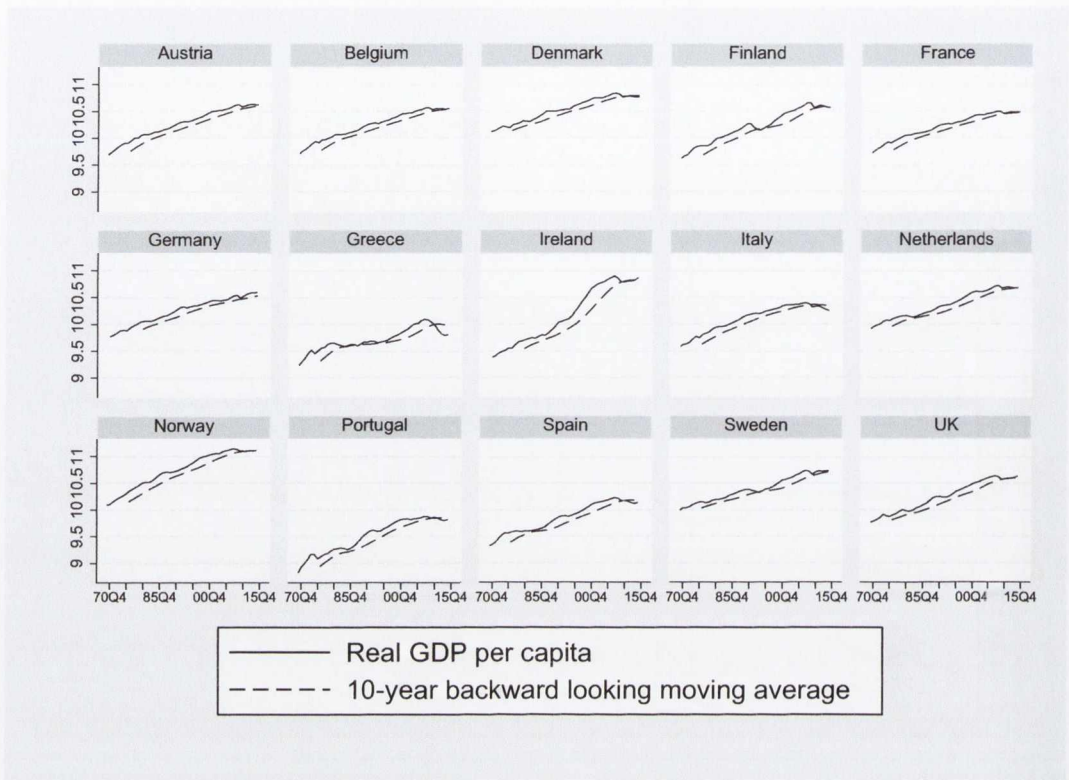
Tables and Figures

Figure 3.1: Private sector credit-to-GDP ratios, 1970Q1 to 2014Q4.



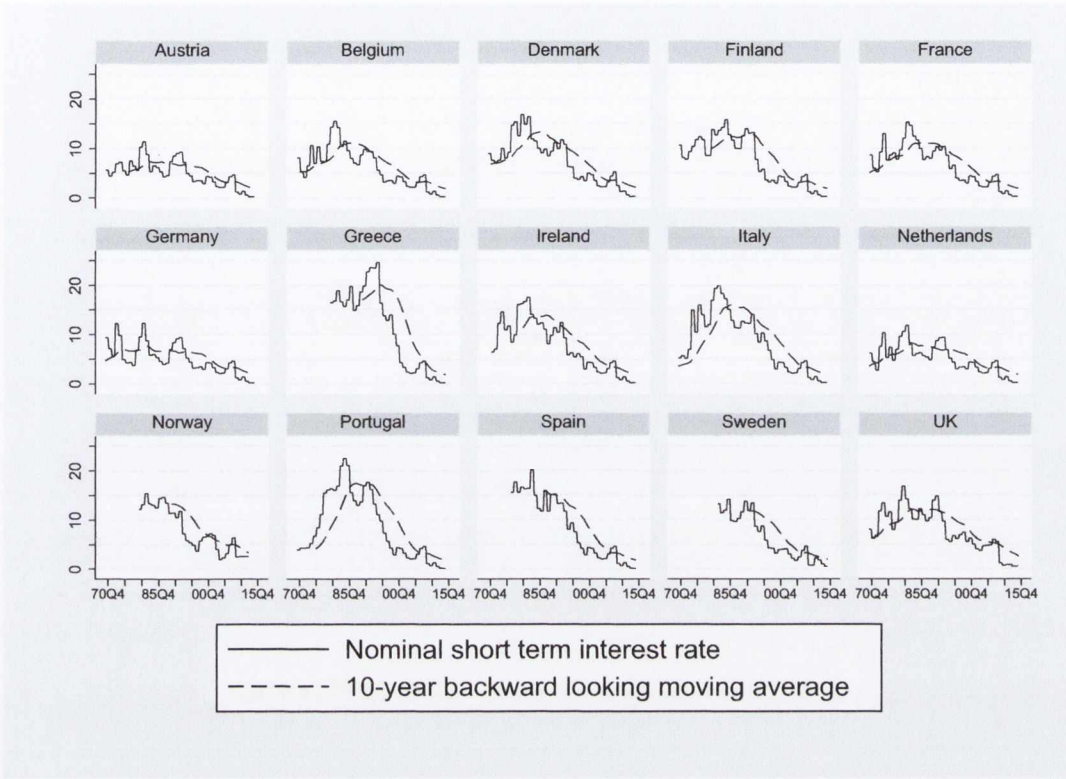
Note: Non-financial private sector is the sum of household and non-financial corporation sectors.

Figure 3.2: Log of Real GDP *per capita*, 1970Q1 to 2014Q4.



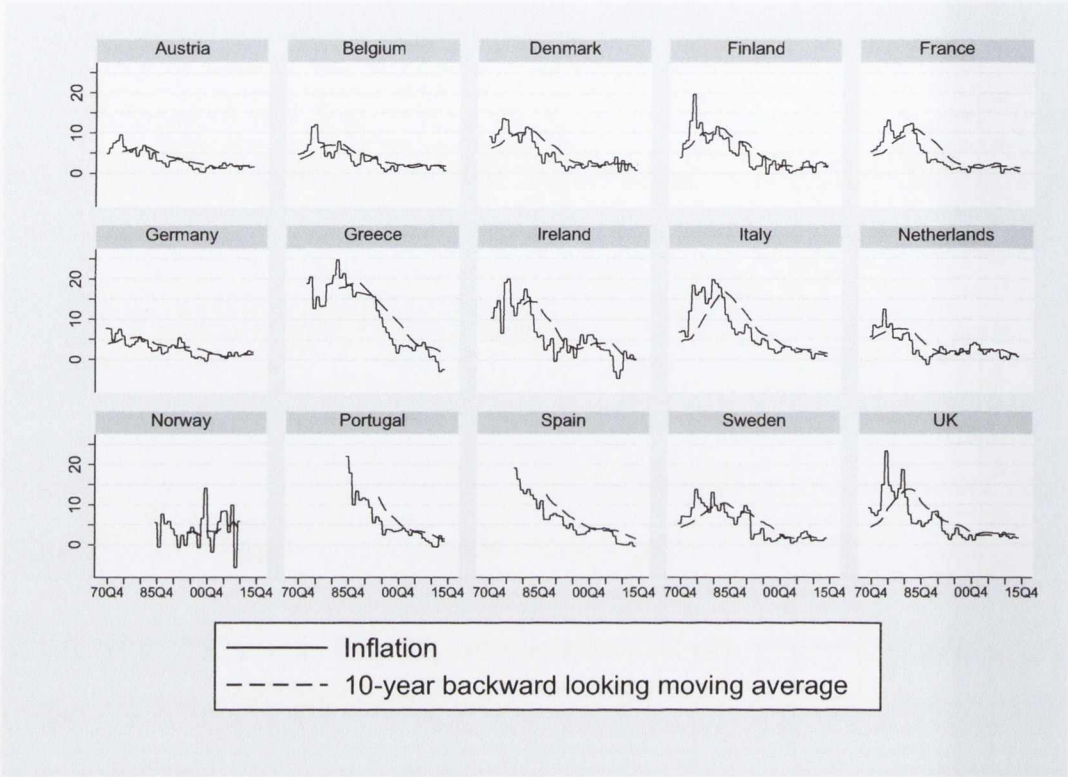
Note: Constant 2005 US dollar. Natural log.

Figure 3.3: Nominal short term interest rate, 1970Q1 to 2014Q4.



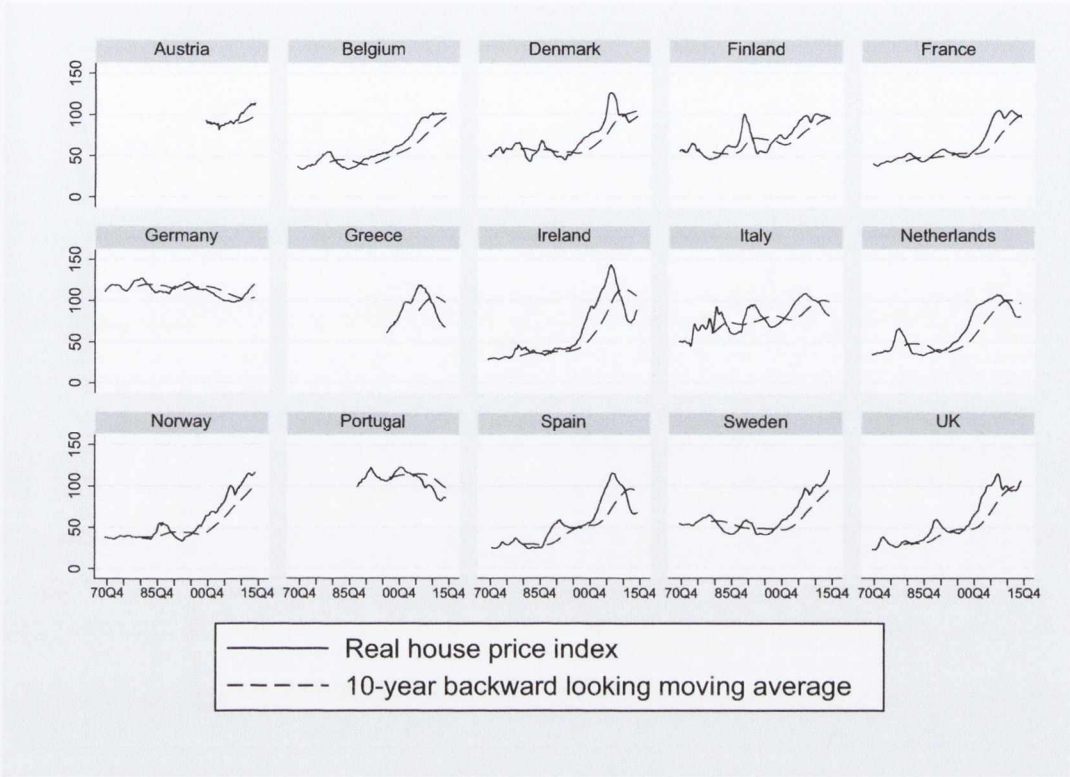
Note: 3-month interbank interest rate. Annual rate, per cent.

Figure 3.4: Inflation, 1970Q1 to 2014Q4.



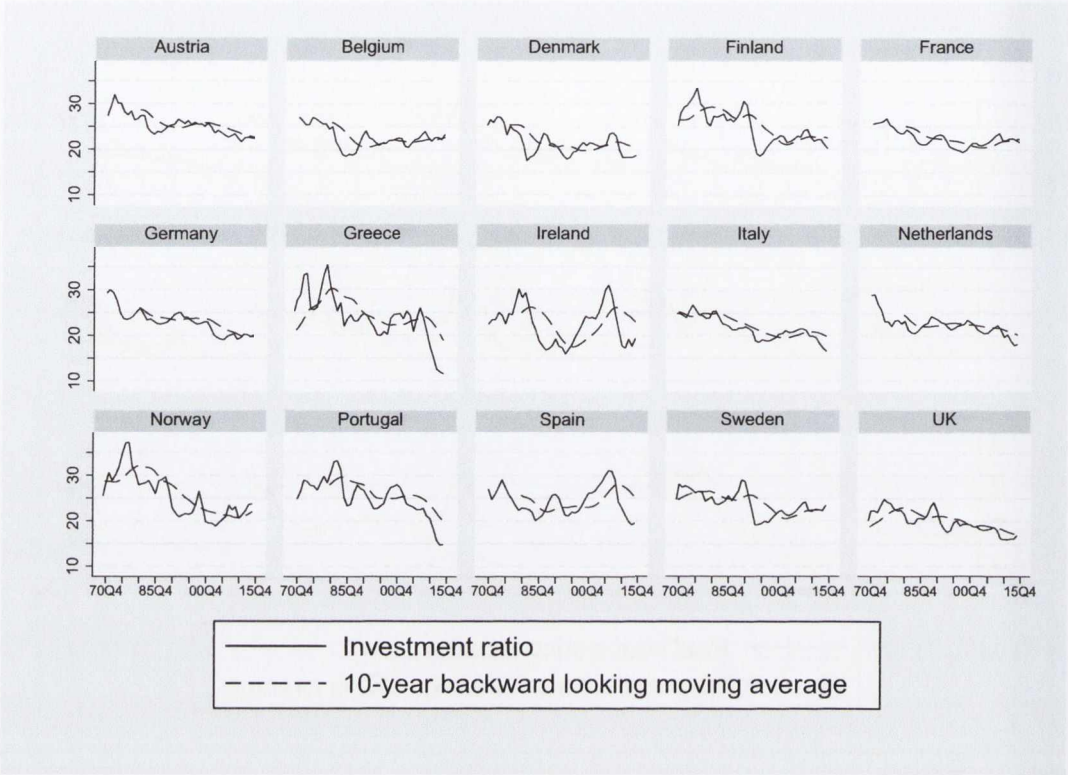
Note: Derived from GDP deflator. Annual rate, per cent.

Figure 3.5: Real house price index, 1970Q1 to 2014Q4.



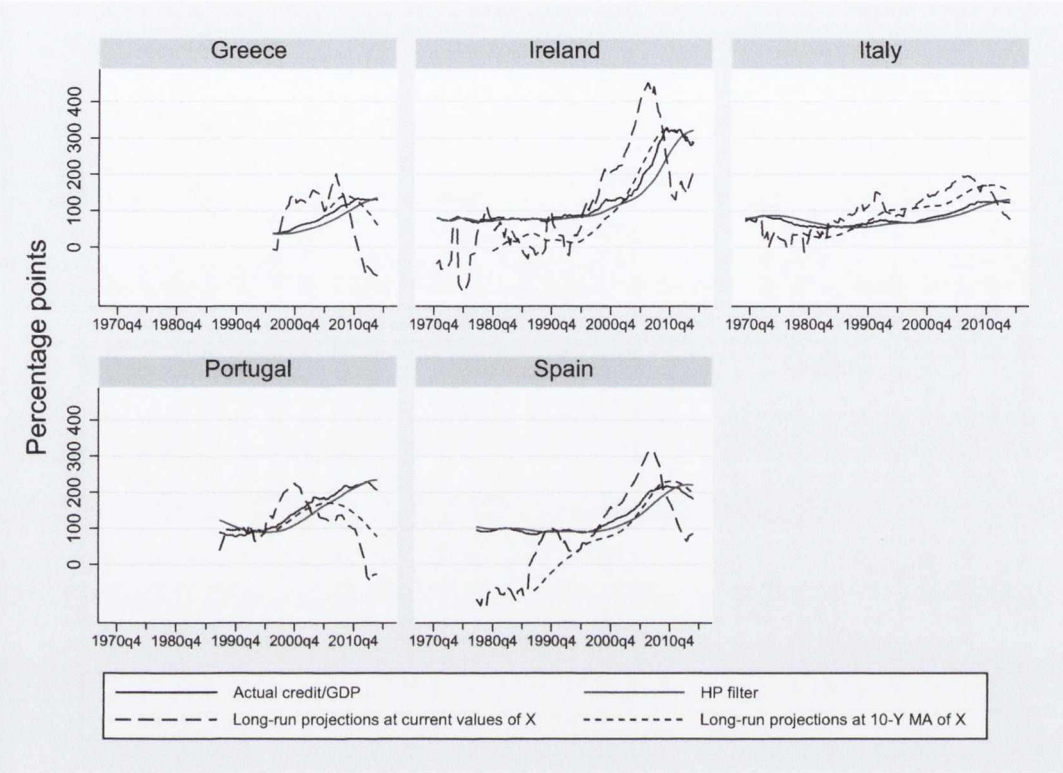
Note: Base year 2010.

Figure 3.6: Investment ratio, 1970Q1 to 2014Q4.



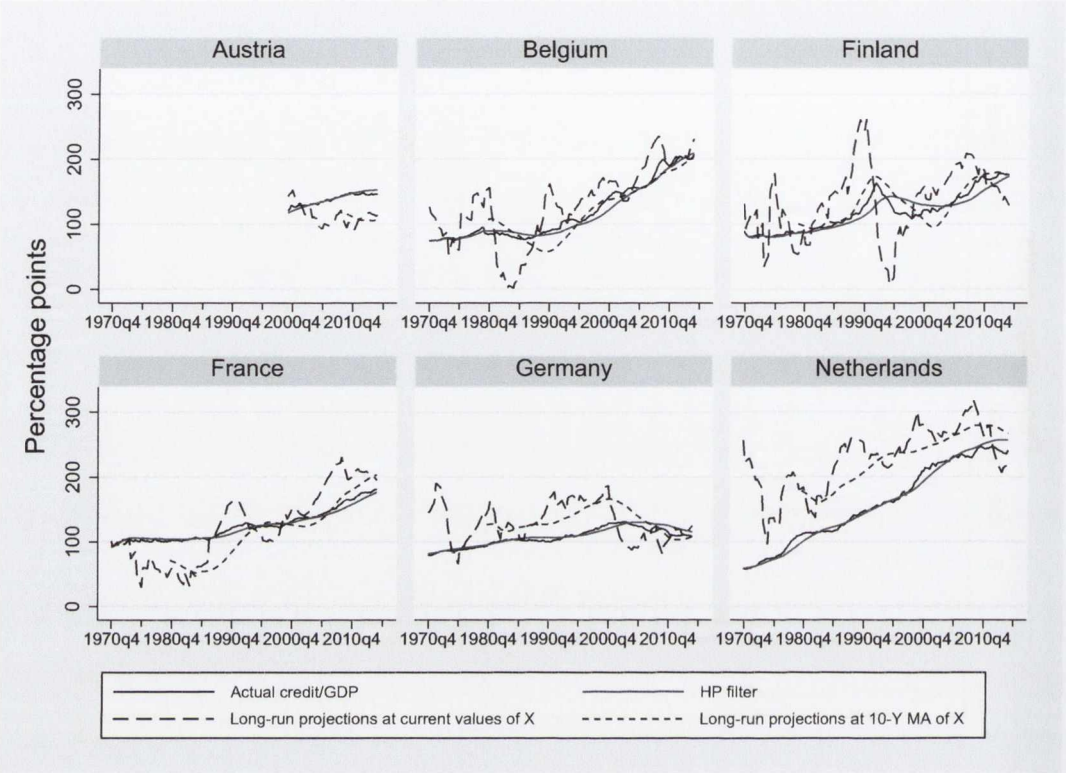
Note: Ratio of gross fixed capital formation to GDP, percentage points.

Figure 3.7: Actual non-financial private sector credit-to-GDP ratio, model projections and HP filter. EMU crisis countries.



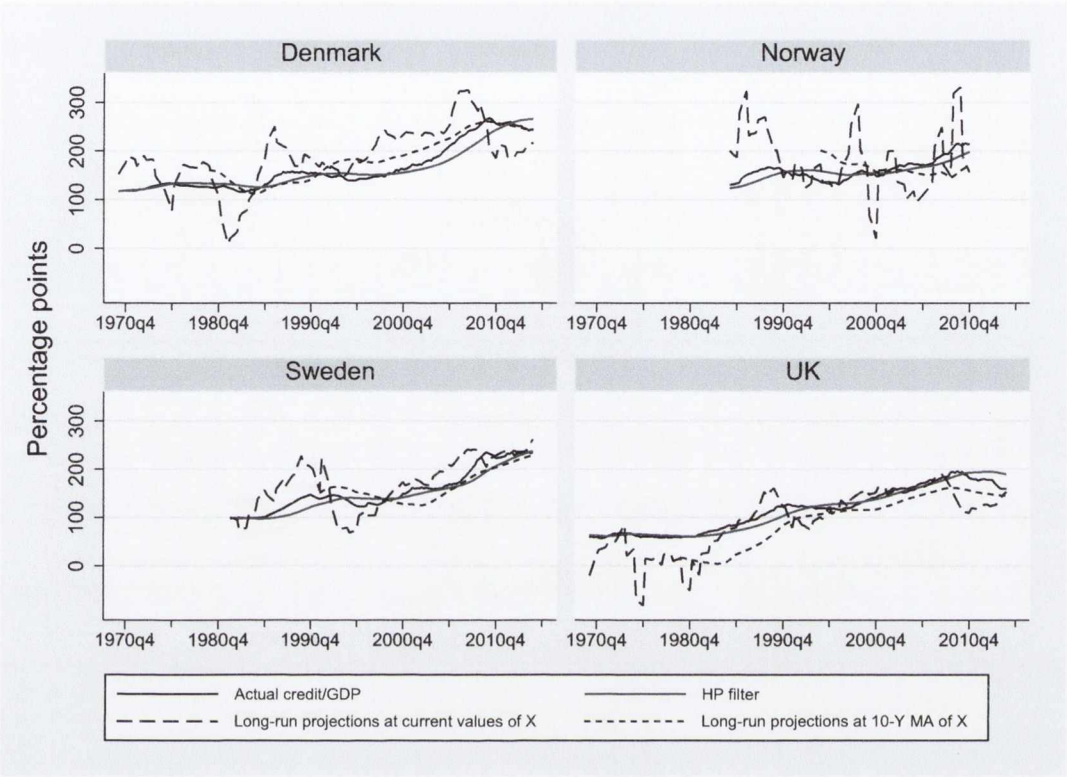
Note: Projections are based on the equation in column 6 of Table 3.8. Long-dashed lines use actual values of right-hand side variables; short-dashed lines use ten-year backward-looking moving averages of right-hand side variables. Grey lines are the trend component of the credit ratio, extracted with Hodrick-Prescott filter with a lambda parameter of 400,000.

Figure 3.8: Actual non-financial private sector credit-to-GDP ratio, model projections and HP filter. EMU non-crisis countries.



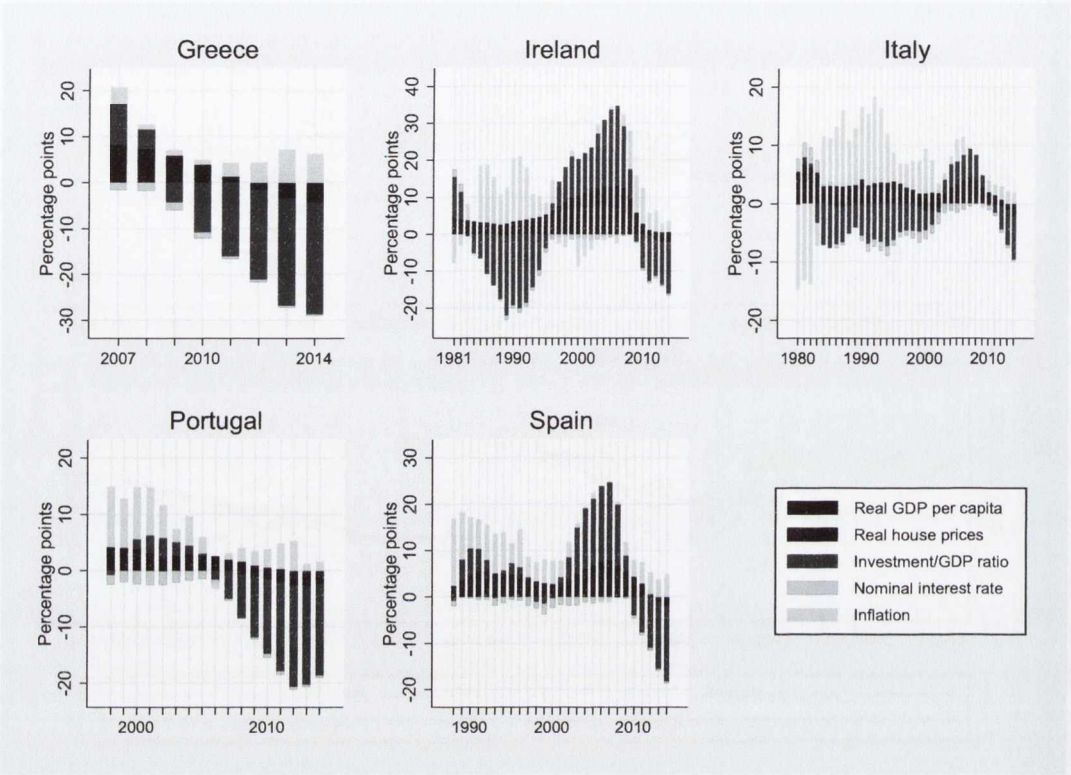
Note: Projections are based on the equation in column 6 of Table 3.8. Long-dashed lines use actual values of right-hand side variables; short-dashed lines use ten-year backward-looking moving averages of right-hand side variables. Grey lines are the trend component of the credit ratio, extracted with Hodrick-Prescott filter with a lambda parameter of 400,000.

Figure 3.9: Actual non-financial private sector credit-to-GDP ratio, model projections and and HP filter. Non-EMU countries.



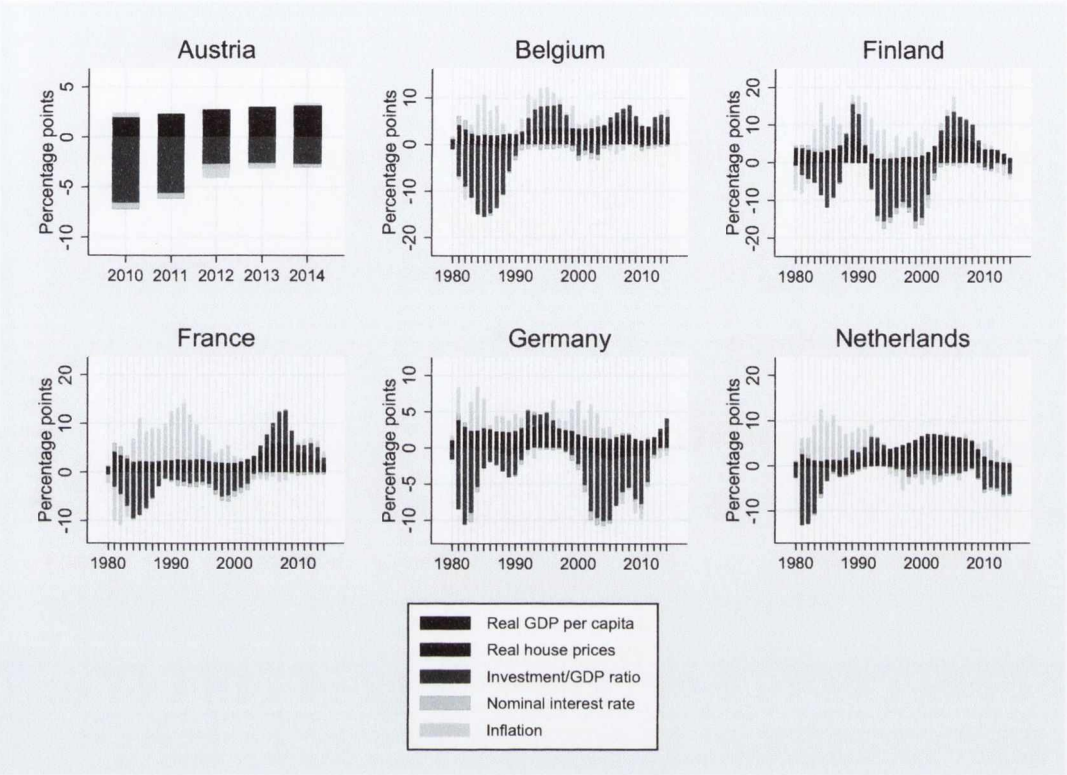
Note: Projections are based on the equation in column 6 of Table 3.8. Long-dashed lines use actual values of right-hand side variables; short-dashed lines use ten-year backward-looking moving averages of right-hand side variables. Grey lines are the trend component of the credit ratio, extracted with Hodrick-Prescott filter with a lambda parameter of 400,000.

Figure 3.10: Changes in 10-year moving average multiplied by respective long-run coefficients. EMU crisis countries.



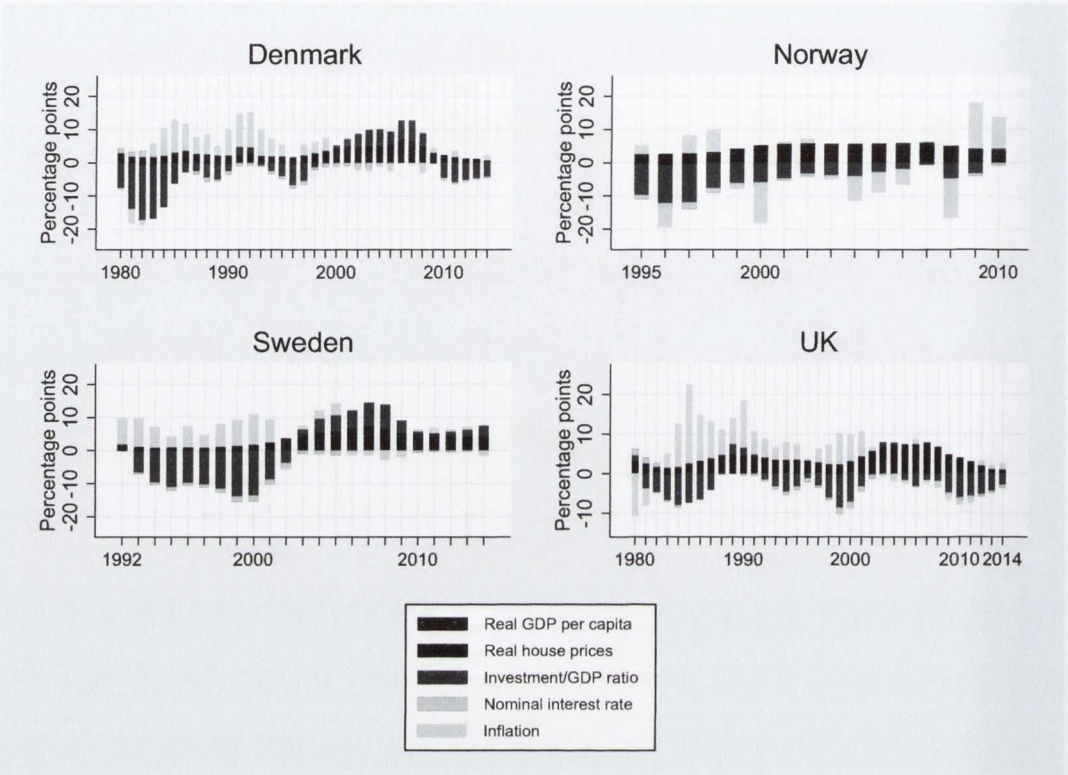
Note: For each variable, the yearly change in ten-year backward-looking moving average is multiplied by the coefficient of the respective variable from the equation in column 6 of Table 3.8.

Figure 3.11: Changes in 10-year moving average multiplied by respective long-run coefficients. EMU non-crisis countries.



Note: For each variable, the yearly change in ten-year backward-looking moving average is multiplied by the coefficient of the respective variable from the equation in column 6 of Table 3.8.

Figure 3.12: Changes in 10-year moving average multiplied by respective long-run coefficients. Non-euro countries.



Note: For each variable, the yearly change in ten-year backward-looking moving average is multiplied by the coefficient of the respective variable from the equation in column 6 of Table 3.8.

Table 3.1: Summary statistics.
Real GDP *per capita*.

Country	Mean	SD	Min	Max
Austria	39002	1952	35247	41230
Belgium	29152	6636	17257	38636
Denmark	38369	8240	24910	50695
Finland	29813	7541	18511	42415
France	28301	5754	17381	36074
Germany	28978	6539	17473	39892
Greece	20441	2353	16603	24219
Ireland	30082	14744	12178	53918
Italy	26566	4716	17189	32831
Netherlands	32840	7715	21061	45043
Norway	56144	9202	41118	69095
Portugal	17115	2069	12148	19489
Spain	21073	4522	14654	27661
Sweden	36633	6393	26966	46067
UK	29505	7987	17486	41543

Note: Constant 2005 US dollars. Statistics refer to the sample used in regressions on non-financial private sector. For regressions on household and non-financial corporation sectors, samples are shorter for some countries; the resulting summary statistics are slightly different, and available upon request.

Source: World Bank.

Table 3.2: Summary statistics.
Nominal short term interest rate.

Country	Mean	SD	Min	Max
Austria	2.3	1.5	.21	4.6
Belgium	6.2	4	.21	16
Denmark	7.3	4.6	.27	17
Finland	7.3	4.9	.21	16
France	6.5	4	.21	15
Germany	5	3	.21	12
Greece	4.2	4.1	.21	14
Ireland	7.7	5	.21	18
Italy	8.7	6	.21	20
Netherlands	5.1	2.9	.21	12
Norway	7.3	3.9	2	15
Portugal	6.2	5.5	.21	18
Spain	8.4	6.1	.21	20
Sweden	6.5	4.4	.66	14
UK	7.8	4.2	.51	17

Note: 3-month interbank rate in percent. Statistics refer to the sample used in regressions on non-financial private sector. For regressions on household and non-financial corporation sectors, samples are shorter for some countries; the resulting summary statistics are slightly different, and available upon request. Source: AMECO database.

Table 3.3: Summary statistics. Inflation.

Country	Mean	SD	Min	Max
Austria	1.8	.4	1	2.6
Belgium	3.7	2.7	.47	12
Denmark	4.9	3.8	.49	14
Finland	4.8	4.3	-.11	20
France	4.5	4	.1	13
Germany	2.7	2	-.48	7.7
Greece	2.4	2.4	-2.9	6.8
Ireland	5.9	6	-4.7	20
Italy	7	6	.33	20
Netherlands	3.3	2.9	-1.1	13
Norway	3.9	4.1	-5.7	14
Portugal	4.5	3.7	-.44	13
Spain	6	4.9	-.41	19
Sweden	3.6	3	.45	10
UK	6.1	5.1	1.1	24

Note: Derived from GDP deflator, in percent. Statistics refer to the sample used in regressions on non-financial private sector. For regressions on household and non-financial corporation sectors, samples are shorter for some countries; the resulting summary statistics are slightly different, and available upon request. Source: AMECO database.

Table 3.4: Summary statistics.
Real house price index.

Country	Mean	SD	Min	Max
Austria	95	9.1	82	114
Belgium	59	22	34	102
Denmark	70	21	43	126
Finland	72	18	46	101
France	62	22	38	105
Germany	113	7.5	98	127
Greece	90	17	61	118
Ireland	62	33	29	143
Italy	82	14	59	108
Netherlands	63	26	34	108
Norway	61	21	34	102
Portugal	108	11	82	123
Spain	59	27	24	117
Sweden	65	23	41	120
UK	57	29	23	115

Note: Base year is 2010. Statistics refer to the sample used in regressions on non-financial private sector. For regressions on household and non-financial corporation sectors, samples are shorter for some countries; the resulting summary statistics are slightly different, and available upon request.

Source: OECD Analytical House Price database.

Table 3.5: Summary statistics. Investment ratio.

Country	Mean	SD	Min	Max
Austria	23.3	1.02	21.6	25.7
Belgium	22.6	2.21	18.5	27
Denmark	21.5	2.61	17.5	27.2
Finland	24.7	3.56	18.6	33.5
France	22.5	1.81	19.4	26.8
Germany	23	2.63	19.1	30
Greece	21	4.52	11.6	26
Ireland	22.4	4.16	15.9	31
Italy	21.4	2.23	16.6	26.8
Netherlands	22.3	2.07	17.9	29.1
Norway	22.9	3.05	18.9	29.7
Portugal	23.5	3.61	14.8	28
Spain	24	3.06	19.2	31.1
Sweden	23	2.4	19.2	29.2
UK	20	2.39	16	24.9

Note: Ratio of gross fixed capital formation to GDP, in percentage points. Statistics refer to the sample used in regressions on non-financial private sector. For regressions on household and non-financial corporation sectors, samples are shorter for some countries; the resulting summary statistics are slightly different, and available upon request.
Source: World Bank.

Table 3.6: Long-run within correlations.

	Pr CR	RGDP PC	Int rate	Inflation	RHP	Inv R
Pr CR	1					
RGDP PC	.78	1				
Int rate	-.77	-.78	1			
Inflation	-.63	-.76	.79	1		
RHP	.70	.73	-.65	-.45	1	
Inv R	-.48	-.53	.49	.60	-.09	1

Note: Within correlation of ten-year non-overlapping averages. Pr CR, is non-financial private sector credit-to-GDP ratio; RGDP PC is real GDP *per capita*; Int rate is nominal short-term interest rate; Inflation is annual percentage change in production prices, derived from GDP deflator; RHP is a real house price index with base year 2010; Inv R is gross fixed capital formation over GDP.

Table 3.7: Unit Root Tests.

	IPS		Fisher							
	Stat	Pr	F1	Pr	F2	Pr	F3	Pr	F4	Pr
<i>Private credit/GDP</i>	4.43	0.99	10.11	0.99	4.44	0.99	4.58	0.99	-2.57	0.99
Δ <i>Private credit/GDP</i>	-11.33	0.00	218.27	0.00	-11.71	0.00	-15.54	0.00	24.31	0.00
<i>Log of Real GDP PC</i>	-4.97	0.00	135.91	0.00	-8.59	0.00	-9.67	0.00	13.67	0.00
<i>Interest rate</i>	2.23	0.99	12.23	0.99	2.59	0.99	2.43	0.99	-2.29	0.98
Δ <i>Interest rate</i>	-17.28	0.00	384.88	0.00	-17.39	0.00	-27.57	0.00	45.81	0.00
<i>Inflation</i>	-1.59	0.06	38.81	0.13	-1.48	0.07	-1.45	0.07	1.13	0.12
<i>Real house prices</i>	2.70	0.99	17.34	0.97	2.64	0.99	2.91	0.99	-1.63	0.95
Δ <i>Real house prices</i>	-8.68	0.00	152.14	0.00	-9.08	0.00	-10.76	0.00	15.77	0.00
<i>Investment ratio</i>	-2.46	0.00	46.60	0.03	-2.40	0.01	-2.40	0.01	2.14	0.02

Note: The table presents results of unit-root tests based on Im-Pesaran-Shin (IPS) test and a number of Fisher-type tests. The null hypothesis is that all panels are non-stationary; the alternative hypothesis is that at least one panel is stationary. The tests are based on Augmented Dickey Fuller (ADF) regressions with 4 lags and allow for both panel-specific rho and means. Fisher-type tests estimate separate ADF regressions for each panel and then combine the results. F1 combine P values using the inverse chi-squared, F2 using inverse-normal, F3 using inverse-logit, and F4 using a modification of the inverse chi-squared transformation that assumes N tends to infinity. The Im-Pesaran-Shin statistic is predicated on T going to infinity, followed by N going to infinity. The Fisher test asymptotics are in T only except for F4.

Table 3.8: Long run equations.

<i>Private credit/GDP</i>	(1)	(2)	(3)	(4)	(5)	(6)
<i>Real GDP PC</i>	2.30*** (0.46)	1.54*** (0.25)	1.53*** (0.24)	1.42*** (0.23)	0.18 (0.20)	1.17*** (0.35)
<i>Interest rate</i>		-3.82*** (0.89)		-0.65 (1.16)	2.01* (1.06)	1.88 (1.21)
<i>Inflation</i>			-5.67*** (1.37)	-5.03*** (1.73)	-5.62*** (1.25)	-11.23*** (2.51)
<i>Real house prices</i>					1.99*** (0.26)	0.76*** (0.25)
<i>Investment ratio</i>						18.70*** (4.23)
Adjustment coeff	-0.01*** (0.003)	-0.02*** (0.003)	-0.01*** (0.003)	-0.02*** (0.003)	-0.02*** (0.003)	-0.02*** (0.004)
Observations	2,749	2,559	2,529	2,439	2,188	2,181
R-sq EC model	0.06	0.08	0.10	0.10	0.16	0.25
Pedroni panel-t stat	3.70	3.23	4.39	3.74	3.85	4.21

Note: Dependent variable is the ratio of non-financial private sector credit to GDP. *Real GDP PC* is (log of real GDP per capita)*100, *Interest rate* is nominal short term interest rate, *Inflation* is percentage change in production prices, measured by GDP deflator, *Real house prices* is an index with base year 2010, *Investment ratio* is gross fixed capital formation over GDP, Adjustment coeff is the coefficient on the lag of the credit ratio in the error correction specification. R-sq EC model is the variance of the change in the credit ratio explained by the variables in error-correction form. Pedroni Panel-t stat is a cointegration test statistic distributed as a standard normal distribution; the null hypothesis is no cointegration. ***, **, * denote significance at 1, 5 and 10 percent levels respectively. Standard errors in parentheses.

Table 3.9: Long run equations. Long time series countries.

	DK	GB	IT	BE	DE	FI	FR	NL
<i>Real GDP PC</i>	1.27*** (0.36)	1.08*** (0.35)	1.17*** (0.33)	1.14*** (0.37)	1.19** (0.46)	1.14*** (0.39)	1.13*** (0.35)	1.20*** (0.40)
<i>Interest rate</i>	4.30*** (1.66)	3.53** (1.62)	4.21*** (1.50)	4.49*** (1.74)	4.70*** (1.81)	4.85** (2.06)	4.14** (1.65)	3.96** (1.95)
<i>Inflation</i>	-11.78*** (3.09)	-11.11*** (3.14)	-10.74*** (2.75)	-12.44*** (3.32)	-12.45*** (3.34)	-13.37*** (3.88)	-11.98*** (3.14)	-12.06*** (3.75)
<i>Real house prices</i>	0.70*** (0.25)	1.10*** (0.25)	0.98*** (0.23)	0.97*** (0.25)	0.97*** (0.34)	0.98*** (0.27)	1.00*** (0.25)	0.76*** (0.27)
<i>Investment ratio</i>	19.45*** (4.98)	18.11*** (4.85)	16.89*** (4.33)	20.25*** (5.44)	20.48*** (5.46)	22.16*** (6.31)	18.89*** (4.93)	19.84*** (6.03)
<i>Real GDP PC * D</i>	0.06 (1.37)	0.19 (0.88)	-0.35 (0.59)	2.05* (1.16)	-0.88 (0.54)	2.34 (1.43)	-0.75 (0.91)	0.25 (1.04)
<i>Interest rate * D</i>	0.69 (3.04)	5.29 (3.40)	-2.84 (1.78)	-4.45 (3.67)	-3.69 (2.38)	-1.31 (4.33)	-2.63 (2.26)	0.07 (3.39)
<i>Inflation * D</i>	1.26 (4.91)	-4.63 (2.82)	-0.90 (2.46)	4.89 (4.17)	-3.20 (3.36)	-0.22 (4.29)	3.55 (2.82)	1.07 (3.88)
<i>Real house prices * D</i>	1.70* (0.89)	-0.19 (0.74)	-0.87 (0.56)	-1.92 (1.25)	-0.03 (0.86)	-2.00 (1.59)	-0.36 (0.68)	0.48 (0.84)
<i>Investment ratio * D</i>	-0.20 (5.61)	8.09 (6.45)	7.56 (4.78)	1.26 (4.72)	-5.74 (3.62)	7.69 (7.33)	-3.50 (6.04)	1.56 (5.28)
<i>Adjustment coeff</i>	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.01)
Observations	1,720	1,720	1,720	1,720	1,720	1,720	1,720	1,720
R-sq EC model	0.28	0.28	0.28	0.28	0.27	0.28	0.28	0.27

Note: Dependent variable is the ratio of non-financial private sector credit to GDP. *Real GDP PC* is (log of real GDP per capita)*100, *Interest rate* is nominal short term interest rate, *Inflation* is percentage change in production prices, measured by GDP deflator, *Real house prices* is an index with base year 2010, *Investment ratio* is gross fixed capital formation over GDP. In the second half of the table, each variable is multiplied by a dummy, *D*, which in each column indicates the country indicated in the first row of the table. Adjustment coeff is the coefficient on the lag of the credit ratio in the error correction specification. R-sq EC model is the variance of the change in the credit ratio explained by the variables in error-correction form. ***, **, * denote significance at 1, 5 and 10 percent levels respectively. Standard errors in parentheses.

Table 3.10: Long run equations. Non-linearities.

<i>Private credit/GDP</i>	(50 pct)	(70 pct)	(80 pct)
<i>Real GDP PC</i>	1.36*** (0.42)	1.28*** (0.31)	1.14*** (0.29)
<i>Interest rate</i>	0.42 (1.07)	1.41 (0.97)	0.65 (0.92)
<i>Inflation</i>	-8.85*** (2.21)	-9.08*** (1.87)	-9.08*** (1.95)
<i>Real house prices</i>	0.32 (0.27)	-0.05 (0.26)	0.18 (0.24)
<i>Investment ratio</i>	15.21*** (4.03)	15.24*** (3.30)	15.17*** (3.30)
<i>Real GDP PC * High</i>	-0.23*** (0.07)	-0.20*** (0.06)	-0.11 (0.08)
<i>Interest rate * High</i>	5.79** (2.48)	7.42** (3.25)	32.99*** (8.70)
<i>Inflation * High</i>	-8.53** (3.37)	-2.80 (4.36)	-9.30 (7.07)
<i>Real house prices * High</i>	1.42*** (0.36)	2.34*** (0.55)	0.65 (0.73)
<i>Investment ratio * High</i>	5.11** (2.44)	0.62 (2.37)	1.79 (3.31)
Adjustment coeff	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)
Observations	2,181	2,181	2,181
Rsqr EC model	0.271	0.275	0.288

Note: Dependent variable is the ratio of non-financial private sector credit to GDP. *Real GDP PC* is (log of real GDP per capita)*100, *Interest rate* is nominal short term interest rate, *Inflation* is percentage change in production prices, measured by GDP deflator, *Real house prices* is an index with base year 2010, *Investment ratio* is gross fixed capital formation over GDP. In the second half of the table, each variable is multiplied by a dummy, *High*, equal to one when the credit ratio is higher than a threshold. In the first column, the dummy equals one when the credit ratio is higher than the median; in the second column, when the ratio is higher than the 70th percentile; in the third, when the ratio is higher than the 80th percentile. Adjustment coeff is the coefficient on the lag of the credit ratio in the error correction specification. R-sqr EC model is the variance of the change in the credit ratio explained by the variables in error-correction form. ***, **, * denote significance at 1, 5 and 10 percent levels respectively. Standard errors in parentheses.

Chapter 4

The European CCP ecosystem¹

4.1 Introduction

The growth of financial systems meant not only larger exposures towards the real economy, but also larger exposures amongst actors within the financial sector. In parallel to the new prudential regulation for banks which motivated the analysis in the previous chapter, the reform of the financial system has encompassed other aspects of the financial system. The build-up of exposures amongst financial traders has placed Financial Market Infrastructures (FMIs) reform on top the agenda for policy makers, as it became clear that FMIs are key to the resilience of the markets served and play a critical role in fostering financial stability.

One important change in the international framework for FMIs was the publication, by the Committee on Payments and Market Infrastructures (CPMI) and the International Organization of Securities Commissions (IOSCO), of a set of international standards for good practices in FMI. The CPMI-IOSCO Principles for Financial Market Infrastructure extend, harmonise and strengthen the standards previously in place, covering a range of FMI operations, including, among other things, credit and liquidity management, default

¹This chapter has been written in co-authorship with Angela Armakolla.

management, general business and operational risk management, with a focus on transparency (CPSS-IOSCO, 2012).

This paper is concerned with Central Clearing Counterparties (CCPs), also called clearing houses, the FMIs that facilitate the clearing of financial transactions, including over-the-counter (OTC) derivatives. The centrally cleared market has grown in size since the global financial crisis. At the global level, the percentage of notional amounts outstanding of interest rate and credit derivatives which are centrally cleared has increased from approximately 27% to over 52% between 2009 and 2014 (Domanski et al., 2015). Regulatory reforms imposing mandatory clearing of certain types of interest rate and credit derivatives are likely to contribute to the continuation of this trend in the future (Rahman, 2015). In the European Union, certain categories of interest rate derivatives and Credit Default Swaps (CDS) are already subject to the clearing obligation, whereas the implementation of other categories is due to take place gradually until 2019.²

Against this background, the goal of this paper is to construct a dataset to study the European CCP ecosystem using publicly available information. The main contribution of the paper consists in documenting aspects of CCP operations, including the number of traders served by each CCP (clearing members), the asset classes cleared and the amounts of transactions, the default resources raised by the CCPs to protect from counterparty risk, and the liquid resources maintained to settle payment obligations.

On the policy side, we provide an assessment of the extent to which the public disclosures required of CCPs by international standard-setting bodies and analysed in the paper allow an assessment of the risks posed by CCPs, for the clearing members and the financial system at large. We propose a number of policy actions aimed at improving the reliability of the data disclosed and their helpfulness for systemic risk assessment.

The chapter is organised as follows. In the next section we outline the functioning of a CCP. In section 3, we describe the dataset. In section 4, we provide a conceptual framework

²The dates from which the clearing obligations take effect, and the categories of assets to which they apply are detailed in the Regulatory Technical Standards supplementing the European Market Infrastructure Regulation (Regulation (EU) No. 648/2012).

to the analysis of the data. In section 5, we present stylised facts on the markets served by European CCPs and the resources held for credit risk management. Liquid resources are the focus of section 6. We conclude with a set of policy recommendations, including possible actions to improve the usefulness of the public data.

4.2 The functioning of a CCP

When the counterparties to a financial trade clear the transaction centrally in a CCP, the CCP interposes itself between the contracting parties; by novating the contract, the CCP becomes counterparty to both the seller and the buyer, taking on the risk of default. The book of a CCP is said to be matched, because it contains both legs of a financial trade. The CCP collects resources from the clearing members against the risk of losses incurred in case of default by a clearing member. When this happens, the book of the CCP becomes unmatched, since the obligations towards the non-defaulting members have to be met without the corresponding payments from the defaulting leg.

After a default, the CCP has to find a replacement for the contracts where the defaulting clearing member was the original counterparty, thus rebalancing the book. CCPs typically manage clearing members defaults by hedging the open positions and auctioning the underlying contracts. The default risk for a CCP is thus the risk of losses incurred while replacing the defaulting clearing member in all the contracts underlying its open positions.

To reduce replacement risk, CCPs estimate the cost of closing out the portfolio of each clearing member under two scenarios: normal and extreme market conditions. Clearing members are required to post as collateral an amount equal to the estimated loss from their portfolio under normal market conditions. This is called initial margin. Any loss in excess of this estimate is covered by a fraction of CCP's capital, and by a fund collected from all clearing members. The size of this default fund has to be by regulation at least as large as the estimated loss, in excess of initial margin, which would be incurred upon default of the

two clearing members to which the CCP has the largest exposure under extreme market conditions.

When initial margin is not sufficient to cover replacement cost, the excess loss is covered by a sequence of dedicated resources, called the default waterfall. First, the contribution of the defaulted member to the fund is drawn. Second, a fraction of capital of the CCP is used, called the *Skin in the game*. Third, when the first two resources are depleted, the CCP taps the rest of the default fund, mutualising the losses across the remaining clearing members. CCPs usually require clearing members to agree to replenish the default fund when this is not sufficient to cover the default losses, up to a multiple of the original contribution to the fund. The purpose of the *Skin in the game* is to ensure an incentive structure that guarantees the CCP will set initial margin levels which minimise the risk of tapping the resources of surviving clearing members.

CCPs can choose whether to mutualise losses across all the asset classes they clear, or to put in place distinct default funds, limiting mutualisation to a set of the products. Whereas mutualisation reduces transaction costs by allowing lower initial margin, and also reduces the individual burden of losses, it poses moral hazard and adverse selection issues (Gregory, 2014). For example, traders may be induced to increase risky positions, since the loss given default is capped for the defaulting member at the amount posted as initial margin and default fund contribution.

The clearing of transactions in a central counterparty also means that the netting of positions bilaterally between each pair of traders is replaced with multilateral netting of the positions vis-à-vis the CCP. This means that a clearing member can net offsetting positions taken on trading with different clearing members. Whether a central counterparty allows more netting than a bilateral world depends on the riskiness and correlation between asset classes. Cont and Kokholm (2014) shows that under plausible assumptions on the relative riskiness and correlation across asset classes, multilateral netting is more efficient than bilateral netting. Considering the case where multiple CCPs clear different asset classes, Duffie and Zhu (2011) shows that a single CCP reduces counterparty exposures compared to clearing different asset classes in different CCPs.

In the past, CCPs were mainly used to clear exchange-traded (ET) derivatives such as futures and options. The relatively recent increase in centrally cleared OTC derivatives may pose different risks compared to the traditionally cleared contracts: OTC derivatives are typically longer-dated and more complex than exchange traded products. Longer contracts increase the importance of counterparty risk, whereas complexity makes risk-management design more difficult. Moreover, OTC markets are larger than ET markets; mandatory clearing of OTC derivatives has been accompanied by an expansion of the aggregate size of CCPs, which is expected to increase further (Rahman, 2015; FSB, 2015). As a result, the extensive use of central clearing transformed CCPs into nodes of systemic importance within the financial system (European Systemic Risk Board, 2013; Wendt, 2015).

The risk management system of CCPs has worked well during the crisis. While the non-centrally cleared OTC derivatives market was significantly impaired during the financial crisis, central counterparties were able to manage defaults of their members without losses. For example, the interest rate derivatives portfolio of Lehman Brothers and affiliates at the London CCP LCH.Clearnet Ltd, consisting of 66,390 trades with a notional value of \$9 trillion, was closed out using only 35 per cent of the initial margin posted (Norman, 2012; Fleming and Sarkar, 2014).

4.3 Conceptual framework

In this section, we provide a conceptual framework to guide the analysis. Our dataset covers several aspects of CCP operations; we focus on the following concepts. First, we review general characteristics of the member base: number of members by CCP, proportion of domestic and foreign members, and memberships in multiple CCPs. Second, we provide an overview of markets served, and whether and when CCPs segregate default funds, by asset class or ET/OTC. The size of market segments by transaction volume and the amount of resources available for default is also studied. Third, we investigate liquidity strategies of CCPs. By their very nature, CCPs hold considerable amounts of resources posted by members, and need to readily avail of liquid resources in the event a member defaults. We

investigate liquidity management of CCPs, including the re-investment of cash received from participants.

A clear view of member bases, in terms of size and degree of interconnectedness of participants, is crucial to understanding possible channels of contagion. CCPs replace a network of bilateral exposures with a new set of interconnections. Whereas risk management systems of CCPs are designed to insulate clearing members from other members' default, contagion may occur when a default event depletes the default fund, or in the case of default of the CCP (Wendt, 2015). Furthermore, the interconnectedness of member bases of different CCPs bears contagion risks. Under extreme market conditions, the default of a trader holding clearing memberships in several CCPs may transmit liquidity pressures to otherwise healthy clearing members, for example by triggering the replenishment of default fund of several CCPs where another member is also active (Domanski et al., 2015).

Accordingly, the literature has studied the structure of member bases of CCPs from several points of view. Armakolla and Laurent (2016) focus on credit quality of CCP users. The paper provides an estimate of the deterioration in the creditworthiness of surviving clearing members after two average clearing members default. In the context of CCP interconnectedness through multiple memberships, the European Securities and Markets Authority considers the issue of common members in its first EU-wide stress test (ESMA, 2016). On interconnections between market participants, Braithwaite (2015) highlights issues related to recent changes in the structure of member bases, focusing on the relationship between direct clearing members and their clients, which in this context are traders who use the CCP through a direct clearing member. Also, the geographical distribution of clearing members has received attention, in terms of the average share of domestic and foreign clearing participants, or the distribution of initial margin requirements by location of clearing members (Domanski et al., 2015; Rahman, 2015).

In addition to the number of clearing members, the size of CCPs by notional amounts determines netting efficiency and single point of failure risk. Duffie and Zhu (2011) shows that, under some conditions, the highest degree of netting is obtained when a single, global

CCP clears all asset classes. However, Pirrong (2014) and Gregory (2014) point out that netting redistributes risk, not necessarily reducing it. Netting benefits are reaped mostly by members with largest portfolios, and in case of default, netting redistributes losses at the expense of non-member creditors. Moreover, the benefits of multilateral netting from a higher concentration of the clearing market have to be weighed against the increased concentration of risk associated with large CCPs (Cont and Kokholm, 2014).

The netting benefits of a CCP depend on its default management strategy, of pooling or segregating the asset classes cleared into a single or multiple default funds. Pooling many asset classes within one default fund has advantages and disadvantages. On the positive side are diversification of risk and margin efficiency. In the futures market, Gemmill (1994) shows that the benefits from diversification can be large; the size of benefits depends on the correlation between products cleared, which can be difficult to predict in case of market disruptions. On the negative side, mutualisation of losses across asset classes results in a subsidy to riskier asset classes, which could increase risk-taking by clearing members (Gregory, 2014).

Moreover, the size of a CCP determines its substitutability. If a CCP is in resolution, or in any other situation where members can no longer clear at a CCP, the transfer of transactions to another CCP can be challenging and lead to legal disputes. Although the European Market Infrastructure Regulation (EMIR) provides a legal framework for the EU, there are still differences between EU member states in insolvency laws and tax regimes. Moreover, the initial clearing agreement would have to be amended (Duffie, 2014). In the case of a large CCP, substitutability issues may lead to a systemic event.

In addition to legal issues, transferring all positions from a large CCP may give rise to technical difficulties. If only that CCP is in the market for a specific product, it may take time for new entrants to acquire product-specific know-how, set up the necessary internal structures, and implement risk management strategies. Should more than one CCP be in the market, clearing members can obtain membership at another CCP. On the one side, differences in membership criteria and possibly higher costs may prevent some clearing

members from continuing to centrally clear that product. On the other side, the addition of new clearing members necessitates documentation and due diligence work by the CCPs taking over the market share. If the size of the exiting CCP is large, the remaining ones may be put under significant resource constraints, and clearing members may temporarily lose access to central clearing for certain products.

The last aspect investigated in this study is liquidity management. The matched book of a CCP means that if a member defaults, liquid resources are needed to meet the obligations towards the other leg of the contract (Gregory, 2014; Hughes and Manning, 2015). When liquidating the initial margin of the defaulted member, CCPs face liquidation risk. For this reason, CCPs apply haircuts to non-cash collateral posted by members, to account for possible adverse price movements at the time of liquidation. However, CCPs also re-invest cash collateral, and retain exposure to credit and liquidity risk from such investments (CPSS-IOSCO, 2004).³ The risk that re-investment poses is similar to margin wrong-way risk: if the price of the asset used as collateral is positively correlated with the creditworthiness of the member posting it, the value of initial margin tends to decrease when the member defaults. Similarly, re-investment wrong-way risk occurs if the price of the securities purchased by the CCP tends to drop when they need to be liquidated, that is when the member whose cash has been invested defaults.

A fall in price of the re-invested instrument may be due to credit or liquidity risk, for example if the CCP buys corporate bonds of the clearing member from which it received cash collateral. When the clearing member defaults, the bond price will reflect the decrease in creditworthiness; if bonds are illiquid, liquidation will further decrease the price. To avoid this, EMIR requires CCPs to invest participants' cash in assets with minimal market and credit risk.

Margin wrong-way risk also occurs if the risk premium applied to instruments held as collateral increase under stressed market conditions. The European sovereign debt crisis showed that government bond prices are more sensitive to weak fundamentals, such as

³The only resource available to CCPs to cover losses stemming from investment (non-default losses) is own capital (Rehlon and Nixon, 2013).

domestic financial sector health, in periods of financial turmoil (similar to chapter 2). In section 6, we will show that CCPs invest non-negligible amounts in sovereign bonds, domestic bonds in particular; if risk premia were to spike as they did during the European sovereign debt crisis, a CCP may incur losses if it has to sell those bonds at market price when a member bank defaults. Whereas the banking union and the European Stability Mechanism were developed to limit the negative feedback between banks and sovereigns which generates this wrong-way risk, their effectiveness under stress has not yet been tested.

4.4 Data

The main source of our data is the Public Quantitative Disclosure (PQD) framework for central counterparties. In accordance with the principle of transparency from the Principles for Financial Market Infrastructures developed by the CPMI-IOSCO, CCPs are encouraged to publish a set of standardised data intended to enable stakeholders to compare risk control strategies, understand the risks associated with the CCP, assess the systemic importance of the CCP and its impact on systemic risk, and understand the risks involved in becoming a member (CPMI-IOSCO, 2015).

To our knowledge, this is the first paper to have assembled and analysed the information in the PQDs for European CCPs. One of our contributions is highlighting a number of issues encountered while studying the PQD, and suggesting possible improvements to enhance CCP transparency and extend the scope of analyses which can be done using this source of data.

The PQDs are provided at quarterly frequency and contain information on several aspects of CCP operations. The variables are grouped according to the Principles for Financial Market Infrastructure: Credit risk (Principle 4), Collateral (Principle 5), Margin (Principle 6), Liquidity risk (Principle 7), Exchange of value settlement systems (Principle 12), Default rules and procedures (Principle 13), Segregation and portability (Principle 14),

General business risk (Principle 15), Custody and investment risks (Principle 16), Operational risk (Principle 17), Access and participation requirements (Principle 18), Tiered participation arrangements (Principle 19), FMI links (Principle 20), and Disclosure of rules, key procedures, and market data (Principle 23). In this chapter, we analyse a subset of the disclosures and present a high-level picture of the actors in the clearing landscape, including size and aspects of their risk management strategies. Appendix A summarises the variables used and the modifications to the original disclosures, implemented to correct mistakes and ensure consistency.

The disclosures are provided by CCPs at three levels: CCP level, when data refer to the whole CCP; default fund level, when data refer to operations relating to products covered by a segregated default fund, and clearing service level, when there are clearing services that are not delimited by a segregated default fund (for instance, when there is more than one clearing service covered by a default fund). If a CCP uses an integrated default fund covering all products cleared, CCP level and default fund level coincide. If a default fund covers all products cleared in a clearing service, default fund level and clearing service level coincide.⁴

Table 4.1 lists the CCPs included in the sample and the respective country of domicile. Three additional European CCPs have published PQD data following a template different to the one used by most CCPs and are excluded; future work aims to fill the gap. The PQD are available since January 2016, and are disclosed with a three-month lag. At the time of writing (September 2016), information for three quarters is available, ending on 30 September 2015, 31 December 2015, and 31 March 2016, respectively.

In addition, we extend the dataset with publicly available information on clearing members and assets cleared. The member lists were retrieved from CCPs' websites and matched

⁴There is a slight difference between the provisions set out in CPMI-IOSCO (2015) and the scheme that CCPs follow in the templates used for reporting, in terms of the names for reported levels. The template has been developed in a collaboration between the CPMI-IOSCO and associations of CCPs, to ensure consistency and standardisation of reporting. The difference has caused some confusion regarding the reporting level; we have homogenised the naming of the level of statistical units, using the definition described above: CCP level, default fund level, and clearing service level. Information available on the websites of CCPs has been used to identify the correct level of reporting for each CCP.

with information on domestic or foreign residency of the members. We also gathered the list of products cleared in each CCP, when relevant by segregated default fund.

4.5 The European CCP ecosystem

In this subsection, we show stylised facts from our dataset, including information on the member base; the size of CCPs operations by asset class; and size and composition of default resources. Table 4.1 defines the abbreviations used for the names of CCPs.

4.5.1 The member base

We start by looking at the member base. Table 4.2 shows the total number of clearing members, the proportion of domestic and foreign participants, and the average number of memberships in other CCPs. Nasdaq OMX has the largest participation with 247 clearing members, followed by Eurex with 192 and LCH.Clearnet Ltd with 153 members. ICE Clear NL serves three members, which are financial institutions with large trading activity among themselves, mostly on behalf of their clients. The CCPs with the largest proportions of domestic members are KDPW, BME and CC&G.

The shares of domestic and foreign participants in Table 4.2 do not give a complete picture of the international relevance of CCPs. For one, they do not capture interoperability agreements;⁵ for instance, the international activity of CC&G arising from Table 4.2 may be underestimated by not accounting for the interoperability agreement with LCH.Clearnet SA, which enables members of LCH.Clearnet SA to clear transactions with members of CC&G. Moreover, the residency of clearing members' clients is not represented in the table. In the case of ICE Clear NL, the residence of clearing members carries little information on the residence of the ultimate counterparties of the trades cleared. This can be seen from the PQD: the proportion of initial margin posted by the clients of ICE Clear NL is 93.6

⁵Interoperability arrangements are links between CCPs whereby members of each CCP can clear trades with members of the other CCP without becoming a member of the other CCP.

per cent of total initial margin. Whereas two of the three clearing members are domestic, this is not necessarily the case for their clients.

In addition to the size of the member base, it is instructive to consider members' participation in other CCPs. This is important to understand the potential for contemporaneous stress in multiple CCPs, which could occur as a result of the default of a common member. Consistent with the definition of interconnectedness applied by ESMA (2016), in the fourth column of Table 4.2 we show, for each CCP, the average number of memberships in other CCPs.⁶

ICE Clear NL has the highest degree of interconnectedness per clearing participant. One of the clearing members of ICE Clear NL has 11 clearing memberships in the 12 CCPs we consider—the largest number of multiple memberships per member in our sample. This is a financial institution specialised in client clearing services; by being a member in several CCPs, it offers a wide set of clearing opportunities. In contrast, the members of KDPW have no memberships in other CCPs. Given the high proportion of domestic members in this CCP, its degree of interconnectedness with the rest of the European system is likely to be small. Overall, our sample comprises 726 clearing members; of these, 564 entities clear at only one CCP, representing about 78 per cent of the overall number of clearing members. This is not far from the findings of ESMA (2016) EU-wide stress test.⁷

4.5.2 The Products Cleared and Default Fund Segregation

Tables 4.3 to 4.8 list, for each default fund, the asset classes covered, the types of contract, and the underlying assets. Being at the default fund level, the tables show the degree of mutualisation across asset classes. We grouped the default funds on the basis of similarities in the composition of the asset classes cleared; a residual group contains default funds covering a wide range of asset classes.

⁶The average is on a locational basis. If data were consolidated at the group level, the average number of memberships would be higher.

⁷In their dataset, 85 per cent of the members of the 17 CCPs considered clear at only one CCP. ESMA (2016) also reports that 11 individual clearing participants clear at 10 or more CCPs, whereas in our sample we identify one.

Five CCPs in our sample have a single default fund covering all products they clear. EuroCCP and ICE Clear NL clear equity, derivative and cash; LME clears commodity derivatives traded in the London Metal Exchange; CCP A and Eurex clear a mix of asset classes, including equity and bond derivatives, interest rate derivatives, and other securities. The extent of mutualisation within these CCPs varies, owing to differing degrees of heterogeneity in the type of transactions cleared, and also different loss allocation rules.

Given a mixed default fund, loss allocation rules can mitigate mutualisation across asset classes. Generally, pooling different asset classes in the same default fund means that the mutualisation of losses occurs regardless of the markets where the defaulting clearing member is active. In this way, clearing members trading in less risky markets are exposed to losses caused by riskier-trading clearing members. To avoid this, Eurex clusters the trades cleared according to the risk characteristics of the underlying products (Liquidation Groups); each Liquidation Group is assigned to a segment of the default fund. Losses arising from trades in each Liquidation Group are distributed first among the clearing members active in that Liquidation Group. Mutualisation is thus prioritised among traders with similar trading profiles.

The remaining eight CCPs in our sample limit mutualisation within completely segregated segments, defined by the asset class cleared. In four CCPs there are default funds specific to fixed income products (Table 4.3). Of these, BME has a segment exclusively for repurchase agreements (repo), whereas CC&G, LCH.Clearnet SA and LCH.Clearnet Ltd cover both cash bonds and repurchase agreements within the same default fund. LCH.Clearnet SA has also a separate default fund for tri-party repurchase agreements (€CG plus).

In the equities market, four CCPs have a segregated default fund, which in several cases also covers certain types of bond transactions.⁸ The origin of the underlying stock relates to the residency of the CCP in two cases: BME clears mostly ET Spanish equity derivatives and futures on government bonds; CC&G clears cash equities and ET equity derivatives in the Italian market. Other CCPs have more geographically dispersed operations: LCH.Clearnet

⁸LCH.Clearnet SA also covers ET commodity derivatives in this default fund.

SA covers stock issued in several European countries, including ET equities and bonds, and transactions traded in a multilateral trading facility;⁹ LCH.Clearnet Ltd covers bonds and equity products issued in several countries (Table 4.4).

In Table 4.5, six default funds cover the energy and commodity markets. Futures and options traded in regulated markets are the financial product typically cleared in this segment.

Only two CCPs have a segregated segment for interest rate derivatives (Table 4.6). BME started a new segment in November 2015 covering the interest rate derivatives for which the EU clearing obligation entered into force in June 2016.¹⁰ LCH.Clearnet Ltd holds two segments in this market, segregating ET from OTC interest rate derivatives.

In Table 4.7, there are only two CCPs which offer segregated default funds for credit default swaps (CDS): ICE Clear EU and LCH.Clearnet SA. The clearing obligation for this type of products is not in place at the time of writing (September 2016), but will take effect gradually for different categories of CDS between February 2017 and May 2019.

4.5.3 Size of Segments and Waterfalls

We now look at CCP size and waterfall resources in each segment (Figures 4.1 to 4.6). Size is measured by average daily transactions cleared, in nominal (or principal) amounts. All contracts covered by a default fund are summed up, regardless of the product type. Because segments contain a mix of products, often with varying relations between notional amounts and financial obligations, this is a rough measure of CCP activity. Yet, with this caveat in mind and considering the product mix described in the previous section, this measure allows comparing the activities of CCPs in a market segment.

⁹Multilateral trading facilities are non-exchange trading venues operated by financial firms in order to facilitate retail trades.

¹⁰Other types of interest rate derivatives will be subject to mandatory clearing in the future; the clearing obligation for last category will take effect in 2019.

The juxtaposition of notional amounts and waterfall in Figures 4.1 to 4.6 is not meant to inform an assessment of risk management practices of CCPs. In fact, the transactions cleared may increase without increasing exposures. Conversely, the same amount of transactions in the exact same product may be associated with different levels of exposure, depending for example on the time to maturity of the contracts and the frequency of trades. For instance, a two-day contract is less risky than a two-year contract with the same notional amount; a two-year contract traded out after two days is less risky than an identical contract kept until maturity. The figures are intended to show the size of the markets served by CCPs in each segment and the corresponding default resources.

The connected scatter plots in Figures 4.1 to 4.6 show average daily volumes of OTC products and ET derivatives at the default fund level (right-hand-side scale). The stacked bars show the amount and composition of the pre-funded default resources: total initial margin required, own CCP capital, and default fund, recorded at the end of the quarter (left-hand-side scale).

From the PQDs, data on initial margin and default fund contributions reflect exposures at different points in time. Initial margin is calculated at least daily, so it tracks exposures relatively well; the default fund is calculated monthly. Rather than assessing whether these resources are appropriate, which is outside the scope of this paper, we use them as a measure of exposure; by comparing waterfall and CCP size, then, it is possible to relate the evolution of the cleared market with the evolution of exposures.

In LCH.Clearnet SA and CC&G, average daily transactions cleared in the fixed income segment increased between the third quarter of 2015 and the first quarter of 2016, and so did exposures (Figure 4.1). For LCH.Clearnet Ltd and BME, the data show a decrease in both transactions and exposures in the same period. Cash bond and repo transactions cleared at LCH.Clearnet Ltd 'Fixed Income' dropped at the same rate, by around 12 per cent between the third and the fourth quarter of 2015, and increased by around 6.7 per cent in the following quarter. More recent monthly data published by LCH.Clearnet Ltd shows that the drop in repo transactions has been more than recovered by June 2016.¹¹ On the

¹¹(see <http://www.lch.com/asset-classes/repoclear/volumes>)

contrary, in the case of BME, the timing of the PQD framework somewhat hides the plunge in cleared repo transactions that occurred after June 2015, with average daily transactions falling by nearly 30 per cent monthly in July 2015 and 50 per cent year-on-year in June 2016.¹²

The composition of the waterfall resources for fixed income products is related to the type of transactions. CCPs clearing traditional repurchase agreements only, such as BME, or in large proportions, such as LCH.Clearnet SA ('Bonds and Repos'), have a low percentage of default fund in the total waterfall compared to segments where the share of cash bonds cleared is higher.

Figure 4.2 charts the evolution of volumes and exposures for default funds covering mostly equity transactions, cash and derivatives. Only CC&G, ICE Clear NL and EuroCCP report notional amounts in this segment. In four CCPs, exposures decreased in the period considered. In LCH.Clearnet Ltd 'Equities' and EuroCCP, exposures increased between the third quarter of 2015 and the first of 2016, although in both cases a significant decrease was observed in the preceding quarter. The temporary drop in waterfall resources is due to a decrease, and a subsequent increase, in initial margin. Whereas in LCH.Clearnet Ltd 'Equities' the initial relative size of default fund is restored in the last quarter, for EuroCCP the default fund increases more than proportionally to 25 per cent of the waterfall resources. In the most recent quarter, the weight of the default fund in total waterfall ranges between 3 per cent for BME 'Financial derivatives' and 39 per cent at ICE Clear NL. Segments with a larger proportion of equities cleared have a larger proportion of the default fund.

In the Energy and Commodities segment, depicted in Figure 4.3, transaction volumes reported by Nasdaq OMX, CC&G, and LME have decreased in the observed period. Default waterfalls have shrunk in all segments with the exception of Nasdaq 'Commodities' and BME 'Power'. BME nearly doubled its waterfall resources in this segment, in stark contrast to the decrease by 80 per cent in default waterfall resources observed for LCH.Clearnet

¹²(see <http://www.bmeclearing.es/ing/asp/MeffREPO/EstadisticasDiarias.aspx>)

Ltd. Excluding CC&G, the composition of the waterfall in this segment is relatively homogeneous: the default fund represents between 4 per cent and 12 per cent of the total. In CC&G, the default fund constitutes more than half of the default waterfall resources in all quarters.

Five CCPs in our sample offer clearing services for interest rate derivatives: LCH.Clearnet Ltd, BME, KDPW, Nasdaq OMX and Eurex. The latter three CCPs do not segregate a specific default fund for this product. LCH.Clearnet Ltd has two segregated default funds, for ET and OTC derivatives, respectively. BME is a new entrant, having started a new default fund in November 2015. The segment started to be used effectively in the first quarter of 2016. Monthly notional volumes increased from 20 million euro in January to 1,623 million euro in March.¹³ In Figure 4.4, the process of implementation of the waterfall for the new segment is visible. Since the size of a default fund depends on exposures, when members do not yet have open positions, calibration of default fund depends on estimated clearing activity. After the CCP operates the segment for a sufficient time, the actual clearing volume will be used for calibration; the waterfall composition might then adjust in the coming months.

LCH.Clearnet Ltd 'OTC interest rates' transactions increased in the three quarters (Figure 4.4). The sample period does not include the start of the clearing obligation; the complete adjustment of the market will be visible from the PQD when data when the third quarter of 2016 will be available.

Only ICE Clear EU and LCH.Clearnet SA are active in the OTC CDS clearing market (Figure 4.5). Volumes increased between the first and the last quarter in the sample for ICE Clear EU, while default waterfall size decreased slightly. In contrast, volumes decreased for LCH.Clearnet SA while the waterfall increased dramatically. Notional amounts in LCH.Clearnet SA 'OTC CDS' increased four-fold in the first quarter of the sample, dropping ten-fold in the following quarter. Without knowing the characteristics of the specific

¹³Statistics on monthly notional volumes are available at <http://www.bmeclearing.es/ing/asp/MEFFPower/Comunicados.aspx?tipo=3427>

contracts, it is difficult to determine the descriptive ability of these numbers. The percentage of default fund in total waterfall oscillates between 12 and 14 per cent for ICE Clear EU, and between 31 and 38 per cent in LCH.Clearnet SA.

In Figure 4.6, we collect all segments that do not have a comparable product mix in other CCPs in the sample, along with segments (or CCPs) covering many asset classes in the same default fund.¹⁴ Eurex stands out as the largest segment in terms of waterfall amounts in this group, as well as compared to any other segment. The total waterfall of Eurex is on a decreasing path, from 50 billion euro in 2015Q3 to just above 40 billion euro in the first quarter of 2016. ICE Clear US ‘Futures and Options’ is the second largest waterfall. The product mix cleared in ICE Clear US ‘Futures and Options’ is more homogeneous than in Eurex. Nasdaq OMX ‘Seafood’ is the third largest in the group as per waterfall amounts, clearing derivatives on salmon.

4.6 Liquidity and liquidation risk

According to EMIR, CCPs have to hold enough qualifying liquid resources (QLR) to withstand the default of any two clearing members, at the CCP level. Whereas the segregation of default funds is implemented for solvency reasons, to isolate members clearing one asset class from members clearing in a different asset class, there is no similar rationale to segregate liquidity at the default fund level. It is therefore appropriate to consider the amount of liquid resources CCPs hold relative to the total resources at their disposal, across all default funds.

Table 4.9 reports the total amount of QLR held in any currency, total amount of default resources across all segments, and the ratio between the two. A ratio greater than 1 means that the amount of qualifying liquid resources is greater than the pre-funded default resources.¹⁵ While looking at QLR relative to the overall default resources is informative

¹⁴CCP A starts reporting PQD in the first quarter of 2016.

¹⁵The liquid resources could also be used by the CCP to pay variation margins when a member delays on its obligation. The default resources include both those provided by clearing members (initial margin and default fund contributions) and by the CCP itself (*Skin in the game*).

as to the potential availability of default resources in case of a default, the actual liquidity needs will depend on the size of the exposure vis-à-vis the members in default. All else being equal, a CCP where exposure is concentrated in a small number of members will need more liquid resources than a CCP where exposures are dispersed across the members. To address this issue, in Table 4.9 we also show the percentage of initial margin posted by the largest 5 clearing members.¹⁶

The ratio of QLR over default resources tends to be higher in CCPs with more concentrated exposures; the correlation is 0.5. For example, the QLR ratio of Eurex is amongst the lowest, but the largest 5 members account for only 39% of total initial margin. The QLR ratio of EuroCCP is higher, and so is the concentration of initial margin. This is to be expected: were concentration of exposures is high, a larger portion of default resources have to be liquidated when large members default.

To complete the picture, the table also reports total QLR and total default resources. When a default event extinguishes the available QLR, the CCP will need to raise additional liquid resources. The size of the CCP's exposure then determines the additional liquidity needs. Whereas the ability of CCPs to raise funds in stressed market conditions depends on the resilience of liquidity providers and the CCP's access to central bank liquidity, the level of emergency liquidity needs is a function of exposures.

Two CCPs with similar QLR and concentration ratios are Nasdaq OMX and LCH.Clearnet Ltd. If the default of the five largest clearing members depletes the QLRs of both CCPs, then assuming the same percentage of exposure remains uncovered, the liquidity crisis of LCH.Clearnet Ltd will be more severe. This is because the exposure of LCH.Clearnet Ltd is 17 times the exposure of Nasdaq OMX.

The discussion so far assumes that QLR are homogeneously liquid resources. However, not all types of qualifying liquid resources share the same degree of liquidity. For instance, central bank deposits are the only instrument to be virtually 100 per cent reliable in stressed market conditions. Commercial bank deposits, committed lines of credit and

¹⁶The PQDs contain data on concentration in the largest 5 and largest 10 clearing members.

‘Highly marketable collateral held in custody and investments that are readily available and convertible into cash with prearranged and highly reliable funding arrangements even in extreme but plausible market conditions’ (European Union, 2012), on the other hand, are liquid insofar as the liquidity provider is able to fulfil its obligations when the resources are needed.¹⁷

Figure 4.7 shows the composition of QLR. Eight CCPs hold central bank deposits; three of which in amounts larger than half the total waterfall resources. Overall, there is high reliance on commercial bank secured deposits, which include reverse repo. Also important is the reliance on highly marketable collateral and secured committed lines of credit and, to a smaller extent, unsecured committed lines of credit. Unsecured deposits at commercial banks and other QLRs are less common liquidity instruments.

In summary, in this section we exposed the information on the liquid resources of CCPs which is available from the Public Quantitative Disclosures. This is a valuable source of information which allowed us to give a bird-eye view of the liquid resources of CCPs. In the next section, we zoom in the disclosures in order to assess whether it is possible to use the information provided to draw conclusions on liquidity risk.

4.6.1 Reinvestment of participant cash

The initial margin and default fund contributions of clearing members may be posted in cash or securities, in accordance with collateral rules specific to each clearing house. Typically, CCPs require members to post a percentage of collateral in cash; the CCPs are allowed to reinvest this cash in highly liquid resources. According to EMIR, a *‘CCP shall invest its financial resources only in cash or in highly liquid financial instruments with minimal market and credit risk. A CCP’s investments shall be capable of being liquidated rapidly with minimal adverse price effect’* (European Union (2012)). This section describes the management of the cash received from participants.

¹⁷Liquidity providers of CCPs are often clearing members; since initial margin and default resources are needed when clearing members are under stress, it is possible that the liquidity providers are not able to meet their obligations towards the CCP when needed.

Figure 4.8 shows that five CCPs deposit the majority or all of participants' cash in central banks. Five other CCPs deposit the majority or all cash in other financial institutions. The remaining two CCPs have a mixed reinvestment policy, whereby a significant part of the cash is invested in securities. Focusing on the most recent quarter, CC&G invested 66 per cent of participants' cash in securities. Of this, 48 per cent were invested in Italian government bonds (5.4 billion euro), 40 per cent in foreign government bonds (4.5 billion euro), and 12 percent in agency or municipal bonds (1.3 billion euro). Nasdaq OMX reinvested a third of participant's cash in government bonds (the equivalent of 1 billion euro), a third in central bank deposits, and the remaining third in commercial bank deposits and other securities. Other CCPs with non-negligible investments in government bonds are LCH.Clearnet Ltd, ICE Clear EU, LCH.Clearnet SA, LME, and KDPW.

While for securities received by CCPs directly from clearing members, haircuts are applied to account for liquidation risk, securities bought by a CCP with members' cash do not have a haircut applied to them, even though they are often the same securities. However, CCPs have 'prearranged and highly reliable funding arrangements' to liquidate collateral even in extreme but plausible market conditions. We now turn to comparing the amount of reinvested securities with the amount of highly reliable funding arrangements that are available to convert securities into cash even in extreme but plausible market conditions.

Figure 4.9 shows securities holdings of CCPs. The first two bars illustrate securities held as initial margin and default fund, respectively. This includes both securities posted by clearing members (post haircut) and securities purchased by the CCP with member's cash posted as initial margin and default fund, respectively.¹⁸ The third bar is participants' reinvested cash, for which the PQD does not provide the allocation along the waterfall. The fourth bar is the QLR item 'highly marketable collateral held in custody and investments that are readily available and convertible into cash with prearranged and highly reliable funding arrangements even in extreme but plausible market conditions' (European Union, 2012).

¹⁸Bond holdings are based on concepts 4.3 and 6.2 of the PQD, which require CCPs to report the composition of prefunded default resources and initial margin held, as opposed to posted.

According to PQD standards, the third bar should be *at most* equal to the sum of the first two bars, since securities held as initial margin or default fund include reinvested cash. This is not the case for CC&G; this CCP may not be following PQD standards closely. Cross-checking PQD data with information from the collateral rules of CC&G, we concluded that initial margin composition is reported by CC&G as it is posted by members, rather than held by CC&G. For the other CCPs, figures are consistent with the other information available and in what follows we will assume they follow PQD standards precisely.

Comparing the third and fourth bars in Figure 4.9 allows us to determine whether the highly reliable funding arrangements are sufficient to liquidate the securities in which the CCP reinvested members' cash.¹⁹ This is not the case for CC&G and KDPW: if these CCPs need to liquidate all the securities bought with members' cash, they may face the risk of selling at market price.

Furthermore, the member bases of CC&G and KDPW are mostly domestic, and both invest significant amounts of the cash received in securities issued by the domestic public sector. This means that there may be a positive correlation between the price of collateral and the default probabilities of clearing members, if for example there is a public guarantee on bank deposits. Therefore, if these CCPs have to sell domestic government bonds at market price when a domestic member defaults, they will be exposed to margin wrong-way risk. Future data requirements, for instance on the arrangements in place with the liquidity providers, could help shed light on the magnitude of such risk.

To sum up, the public quantitative disclosures provide useful data to understand liquidity management of CCPs. However, we believe this is not sufficient to appropriately assess the adequacy of liquidity strategies.

¹⁹While it is not possible to ascertain whether the contracts to which the QLR item refers apply to the securities reinvested in by the CCP, it is still true that, if the fourth bar is lower than the third, there are not enough prearranged and highly reliable contracts to cover all reinvested cash.

4.6.2 Composition of initial margin and defaults funds

In order to complete the picture describing liquidity management, Figures 4.10 and 4.11 show the composition of initial margin and default fund held. As is often the case with the PQD, some CCPs do not respect requirements fully and report at a lower level of detail, which makes comparison difficult.²⁰

The way CCPs can hold initial margin and default fund resources is regulated in EMIR. Every CCP sets rules on the specific assets and currencies that clearing members can post as collateral. CCPs also impose restrictions on the composition of posted collateral, such as concentration limits, rules on the proportion of cash, exclusion of own assets, and the like. CCPs also decide the haircut to apply to each specific asset. For a comparison of collateral eligibility frameworks across asset classes, see ECB (2013) and ECB (2014).

As shown in Figure 4.10, most CCPs in our sample hold a large portion of initial margin as a mix of central bank deposits, commercial banks deposits, and sovereign bonds. Holdings of initial margin in more risky assets, such as corporate bonds, represents a lower, although in some cases non-negligible, portion.

Figure 4.11 shows that the resources in the default fund are held in more liquid assets than initial margin. This is due to the stressed market conditions under which the default fund is typically tapped.

4.7 Conclusion and policy recommendations

After the global financial crisis, central clearing has been placed at the heart of the new financial regulatory framework. The introduction of mandatory clearing has reinforced the recent trend followed by market participants to clear financial trades through CCPs.

²⁰The composition of initial margin should be reported for each currency in which the margin is posted. The composition of default resources should be reported at the default fund level.

At the same time, risk management strategies of CCPs have been strengthened by the application of the Principles for Financial Market Infrastructures.

An important aspect of the PMFI is the importance assigned to transparency: ‘*Transparency helps ensure that relevant information is provided to an FMI’s participants, authorities, and the public to inform sound decision making and foster confidence.*’ (see CPSS-IOSCO (2012), p.121). The public quantitative disclosures (PQD) for central counterparties are the application of this principle to CCPs; the disclosures should enable all interested parties to compare risk controls and to have a clear, full and accurate understanding of the risks associated with CCPs, to assess CCPs systemic relevance and the impact on systemic risk (CPMI-IOSCO, 2015).

The contribution of this chapter is twofold. First, we assemble a dataset which comprises the public quantitative disclosures as well as other publicly available information. Whereas the disclosures are meant to follow standards that ensure comparability, the data is provided in different formats, which made compiling the dataset non-trivial. Moreover, the raw data was not always comparable; we used further publicly available information to fill the gaps and ensure consistency.

Second, we provide stylised facts on the European landscape of central clearing. European CCPs are heterogeneous in terms of number of clearing members, type of assets cleared and size of markets served. Moreover, CCPs have differing risk management strategies. This is reflected in the size and structure of the default resources and the size and structure of the liquid resources. In our analysis, we encountered a number of issues which reduce the usefulness of the data from a risk assessment perspective.

Our analysis shows that the PQD data can be used to monitor the evolution of the CCP landscape across various aspects, including risk management strategies—a very important step towards full understanding of the central clearing environment. However, data quality is not constant across CCPs, and data are not provided at the high frequency needed to construct indicators of systemic risk. These would also need to account for differences in margining models and stress test methodologies, which are only marginally covered. In the

remainder of this section, we provide a number of suggestions which could help improve the usefulness of PQD data.

The PQD framework is voluntarily followed by CCPs. There is no legal requirement for CCPs in the EU to provide these data; therefore, there are CCPs not reporting, or publishing data in different formats to the template agreed on by the majority of EU CCPs. Regulatory authorities may wish to make the provision of PQD data mandatory and fully standardised for all CCPs.

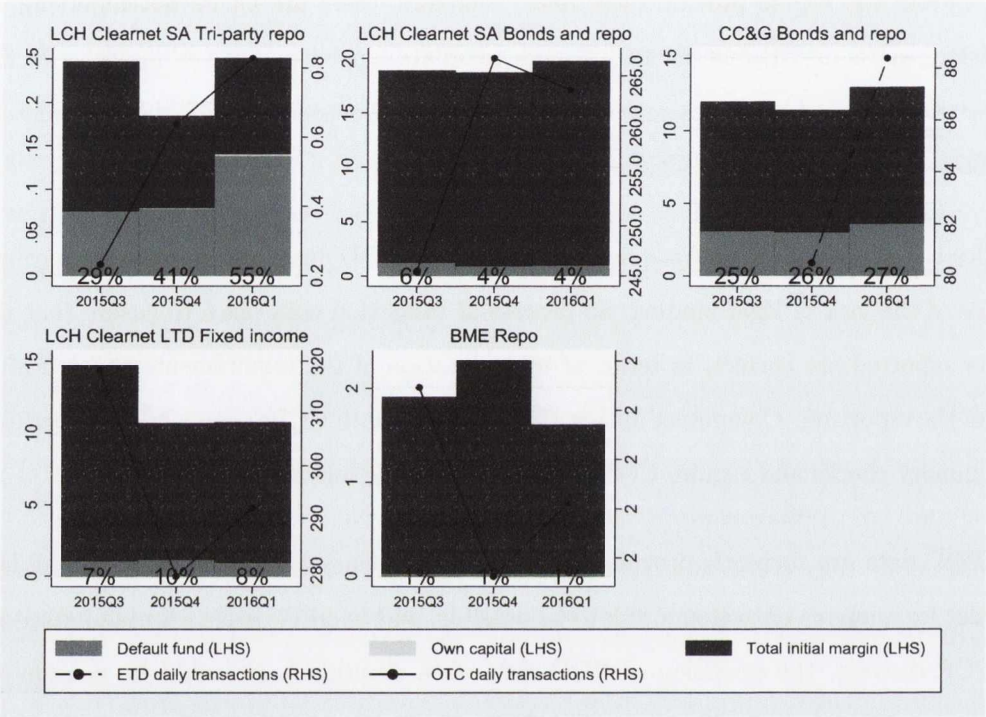
Besides the absence of a legal requirement to publish PQD data, and possibly as a consequence of the lack of legal binding, no process of validation is in place to ensure that the figures reported are correct, in terms of interpretation of the requirements and truthfulness of the reporting. Competent authorities mandated with CCPs oversight could perform data quality checks and require CCPs to correct possible mistakes.

The PQD data are currently provided at quarterly frequency and with a three-month lag. In order for analyses on systemic risk to be possible, and to create early warning indicators for CCP distress, the provision of PQD data on a monthly basis could be considered. A one-month lag in reporting may be sufficient to increase the signalling properties of indicators based on PQD.

To conclude, the Public Quantitative Disclosures for CCP are a welcome first step towards a clear, full and accurate description of the operations of CCPs. Further work is needed to enable stakeholders to fully understand the risks they pose.

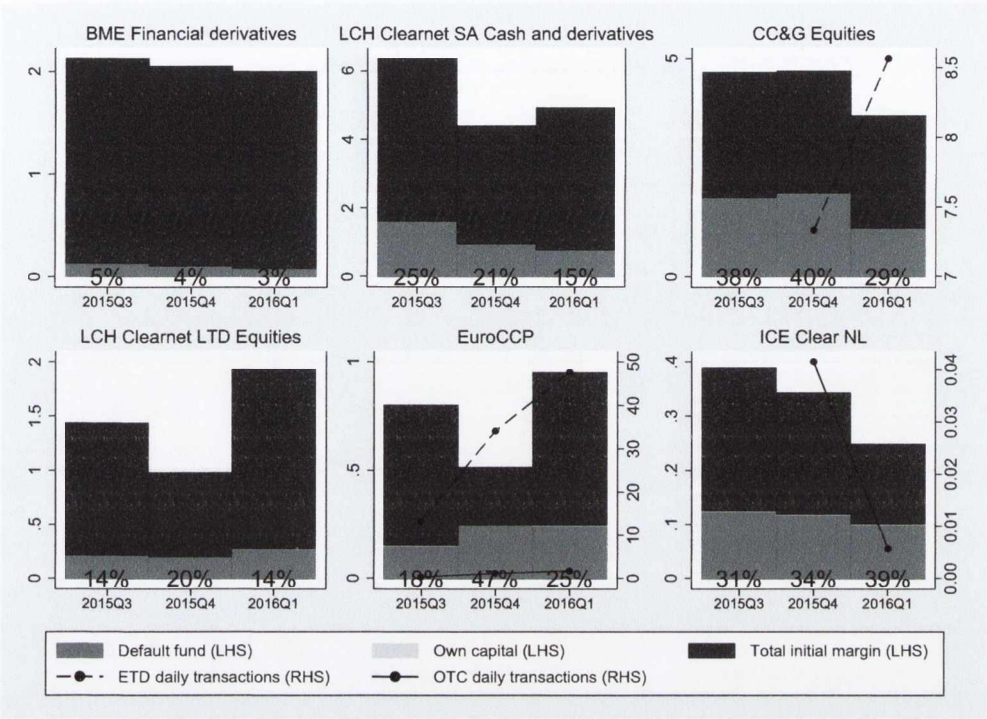
4.8 Tables and Figures

Figure 4.1: Average daily volumes and waterfall. Fixed Income segment.



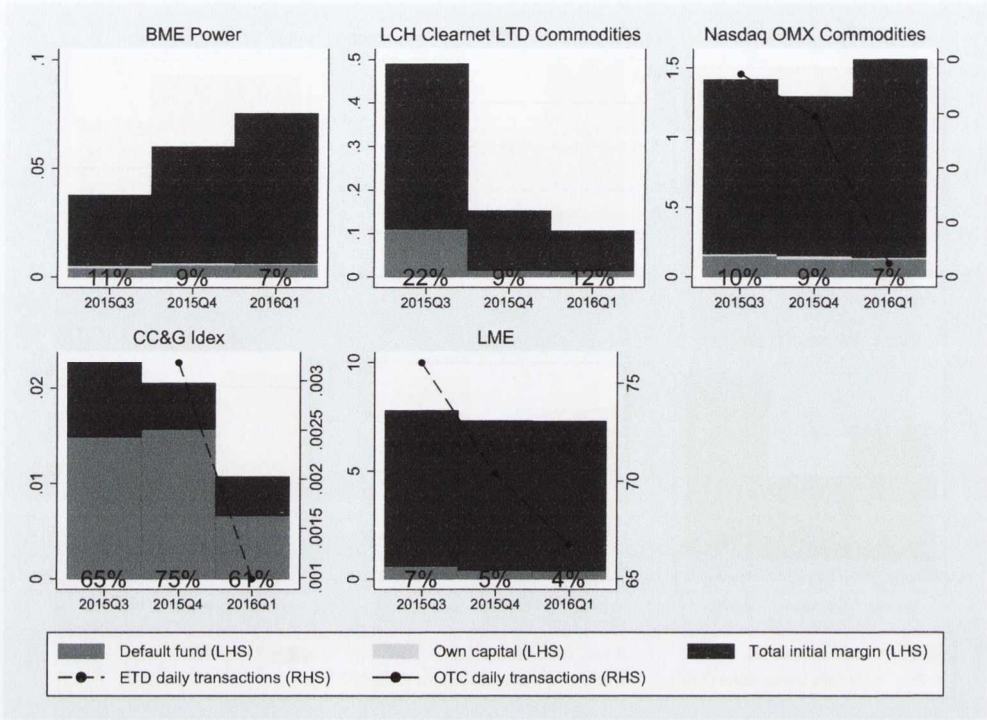
Note: Transaction volumes are notional (or principal) amounts, right-hand side scale (RHS), billion euro. Initial margin, default fund and own capital are also in billion euro, left-hand side scale. Percentages are share of the default fund in total waterfall. CC&G does not provide split by ET and OTC transactions.

Figure 4.2: Average daily volumes and waterfall. Equity segment.



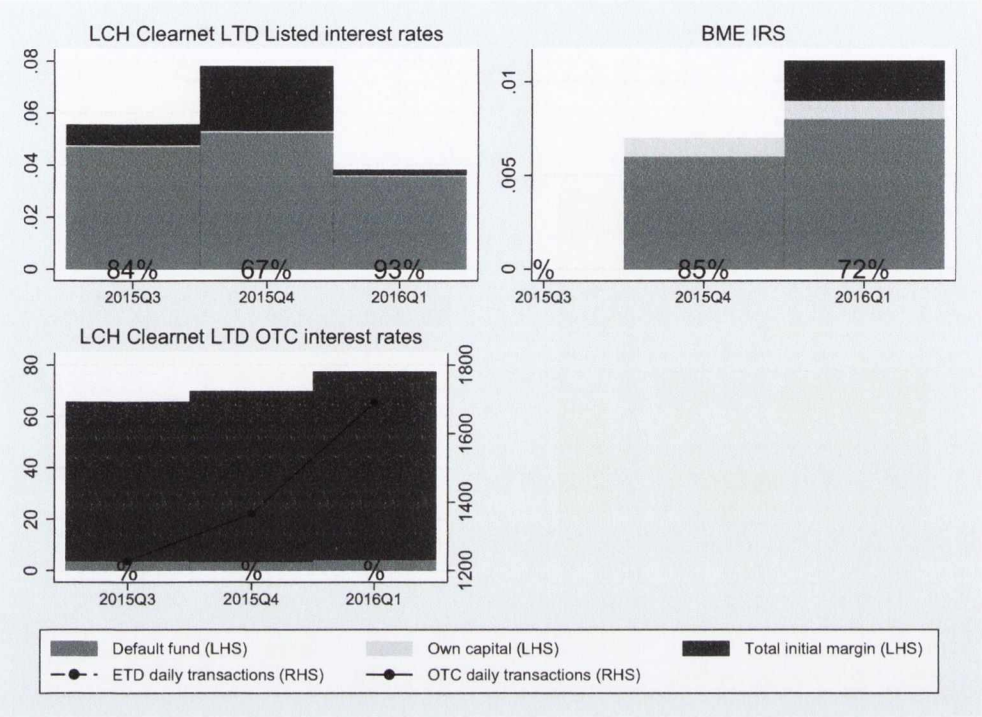
Note: Transaction volumes are notional (or principal) amounts, right-hand side scale (RHS), billion euro. Initial margin, default fund and own capital are also in billion euro, left-hand side scale. Percentages are share of the default fund in total waterfall. CC&G does not provide split by ETD and OTC transactions. BME, LCH.Clearnet SA and LCH.Clearnet Ltd also clear non-equity products in this segment. See Table 4.4

Figure 4.3: Average daily volumes and waterfall. Energy and commodity segment.



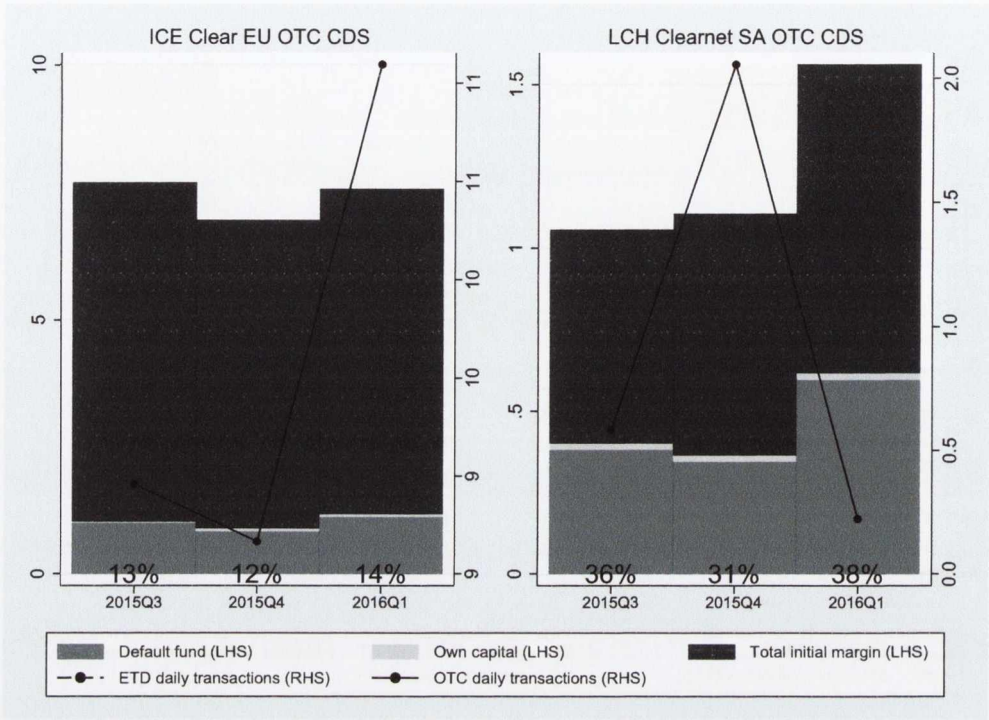
Note: Transaction volumes are notional (or principal) amounts, right-hand side scale (RHS), billion euro. Initial margin, default fund and own capital are also in billion euro, left-hand side scale. Percentages are share of the default fund in total waterfall. CC&G does not provide split by ET and OTC transactions.

Figure 4.4: Average daily volumes and waterfall. Interest rate derivatives segment.



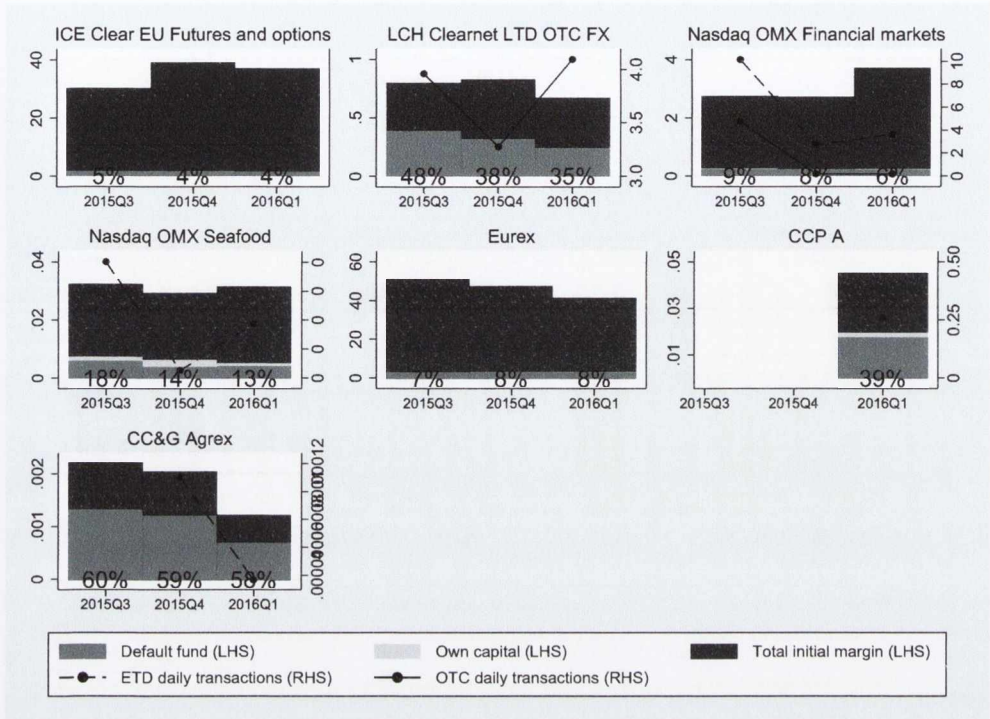
Note: Transaction volumes are notional (or principal) amounts, right-hand side scale (RHS), billion euro. Initial margin, default fund and own capital are also in billion euro, left-hand side scale. Percentages are share of the default fund in total waterfall.

Figure 4.5: Average daily volumes and waterfall. OTC CDS segment.



Note: Transaction volumes are notional (or principal) amounts, right-hand side scale (RHS), billion euro. Initial margin, default fund and own capital are also in billion euro, left-hand side scale. Percentages are share of the default fund in total waterfall.

Figure 4.6: Average daily volumes and waterfall. Mixed segments.



Note: Transaction volumes are notional (or principal) amounts, right-hand side scale (RHS), billion euro. Initial margin, default fund and own capital are also in billion euro, left-hand side scale. Percentages are share of the default fund in total waterfall. For a description of the products cleared, see Table 4.8

Figure 4.7: Ratio of QLR to total waterfall at CCP level

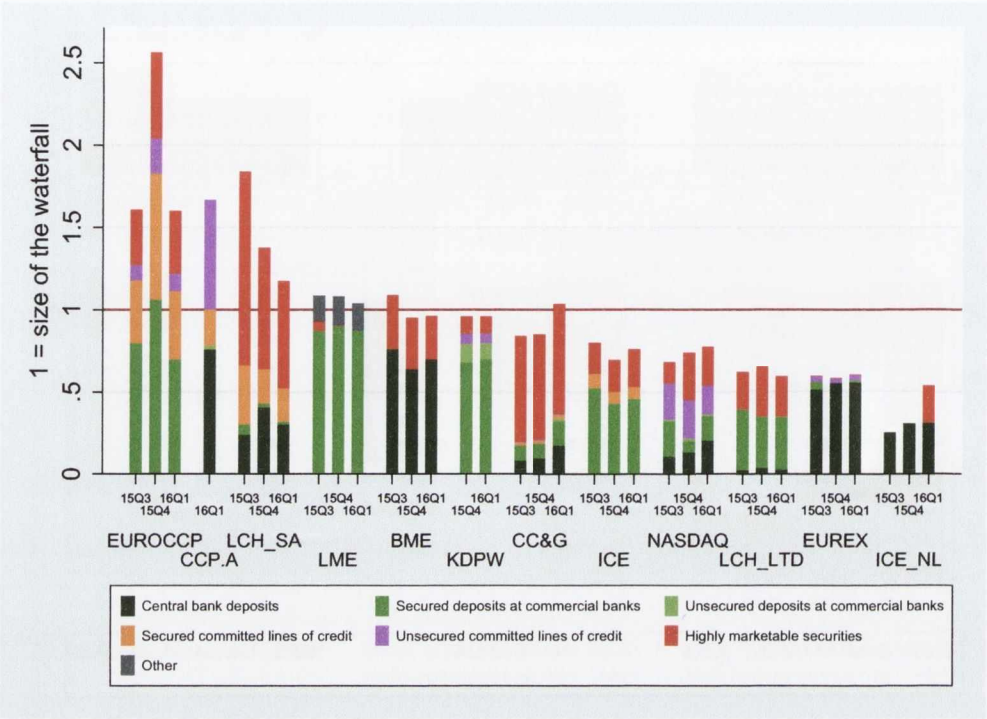
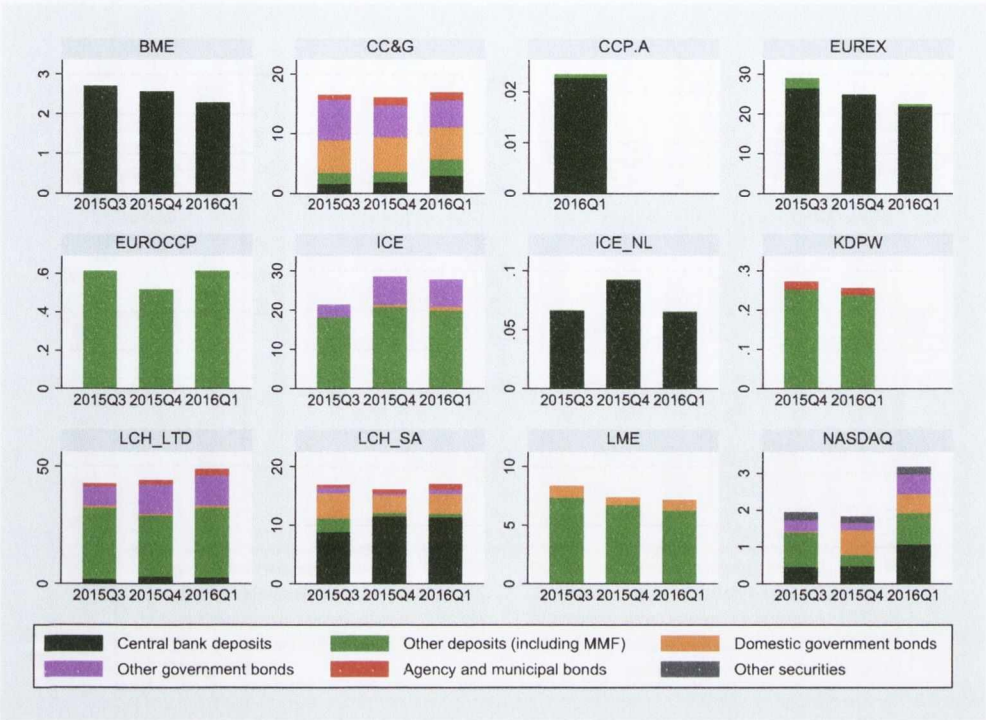
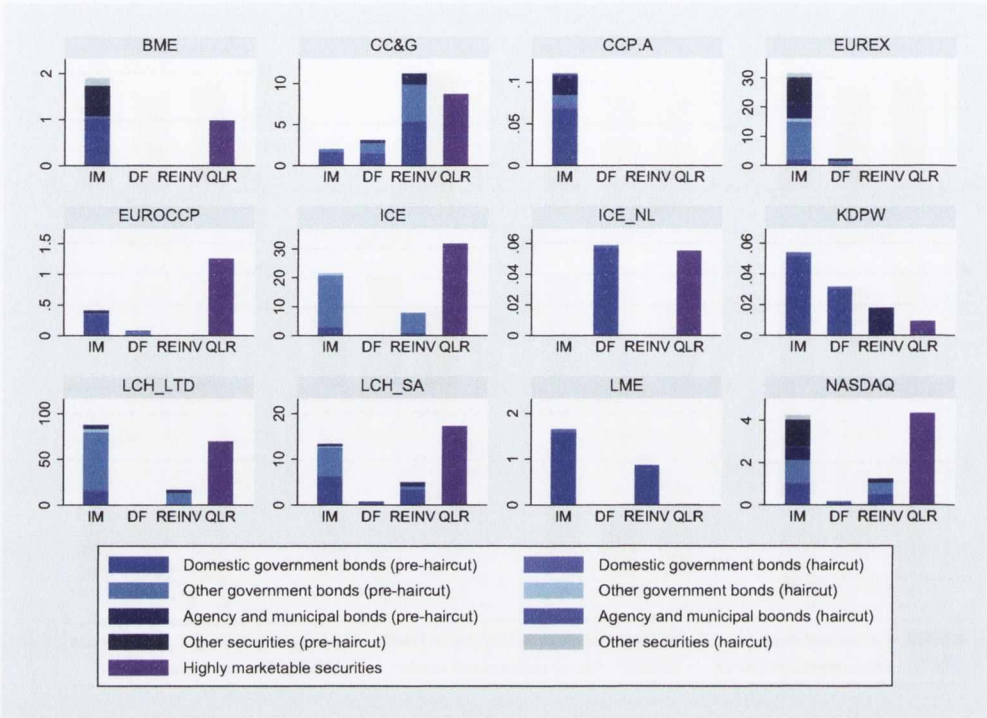


Figure 4.8: Reinvestment of participant cash



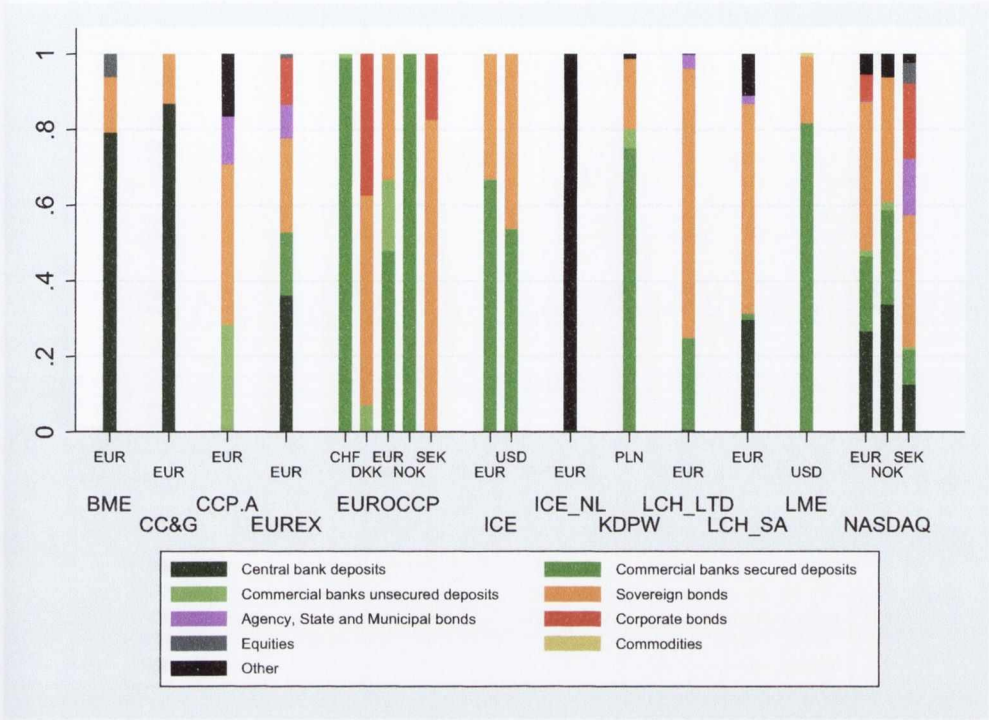
Note: Values in billion euro.

Figure 4.9: Focus on securities held



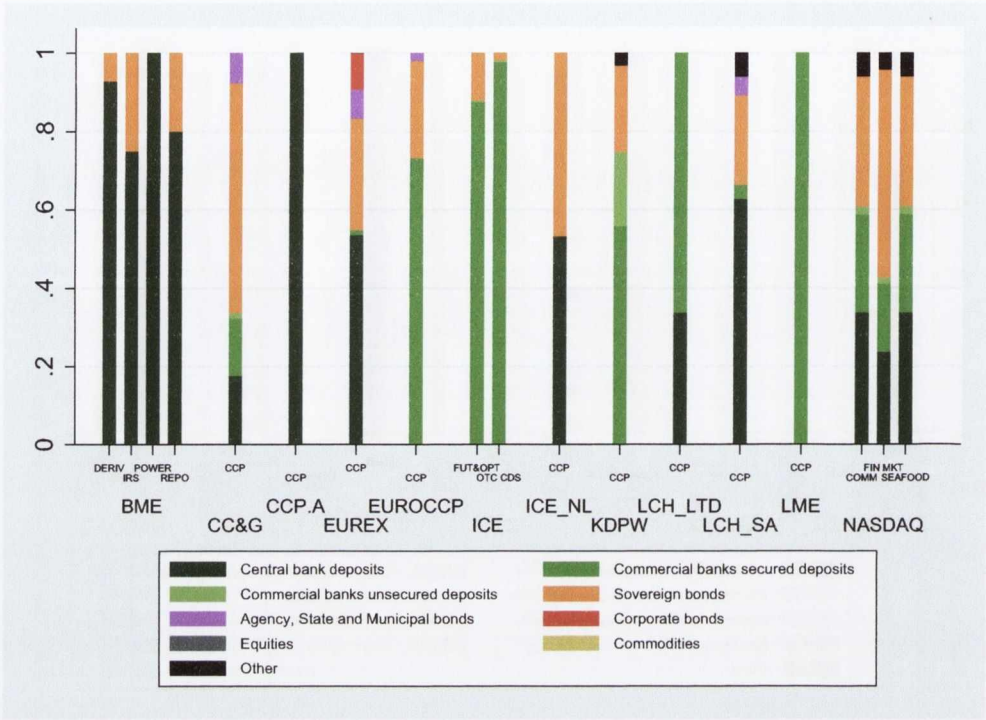
Note: Values in billion euro.

Figure 4.10: Composition of initial margin



Note: ICE is ICE Clear EU. ICE_NL is ICE Clear NL. LCH.LTD is LCH.Clearnet Ltd. LCH_SA is LCH.Clearnet SA.

Figure 4.11: Composition of default funds



Note: ICE is ICE Clear EU. ICE_NL is ICE Clear NL. LCH.LTD is LCH.Clearnet Ltd. LCH_SA is LCH.Clearnet SA.

Table 4.1: Overview of CCPs in the sample

Group	CCP	Abbreviation	CCP domicile
BME Group	BME Clearing	BME	Spain
London Stock Exchange Group	Cassa di Compensazione e Garanzia SpA	CC&G	Italy
	CCP Austria Abwicklungsstelle für Börsengeschäfte GmbH	CCP A	Austria
Deutsche Börse Group	Eurex Clearing AG	Eurex	Germany
	European Central Counterparty NV	EuroCCP	Netherlands
Intercontinental Exchange INC	ICE Clear Europe LTD ICE Clear Netherlands BV	ICE Clear EU ICE Clear NL	Netherlands Netherlands
	KDPW CCP	KDPW	Poland
LCH.Clearnet Group LTD	LCH.Clearnet Ltd LCH.Clearnet SA	LCH.Clearnet Ltd LCH.Clearnet SA	United Kingdom France
London Metal Metal Exchange	LME Clear LTD	LME	United Kingdom
Nasdaq INC	Nasdaq OMX Clearing AB	Nasdaq OMX	Sweden
	OMIClear-C.C., S.A.	OMI Clear	Portugal

Note: The table summarises the official names, the group to which the company belongs, the abbreviations, and the country of residence.

Table 4.2: Number of clearing members by residency and average memberships per participant

CCP	Clearing Members	Domestic (Per Cent)	Foreign (Per Cent)	Other memberships
BME	71	76	24	1.7
CC&G	84	75	25	1.8
CCP A	51	51	49	2.3
Eurex	192	33	67	1.6
EuroCCP	46	4	96	3.2
ICE Clear EU	77	38	62	2.7
ICE Clear NL	3	67	33	6.3
KDPW	43	98	2	0.3
LCH.Clearnet Ltd	153	31	69	2.2
LCH.Clearnet SA	102	19	81	2.8
LME	44	75	25	3.5
Nasdaq OMX	247	27	73	0.9

Note: Data retrieved from websites of CCPs in July 2016. The first column reports the total number of clearing members; the second and third column report the percentage of domestic and foreign clearing members, respectively; the fourth column reports the average number of clearing memberships in other CCPs in our sample.

Table 4.3: Products per fixed income default funds

CCP	Segregated default fund	Products covered	Contract type	Underlying
LCH.Clearnet SA	€GC Plus	Fixed income	Triparty Repo	ECB Collateral baskets
LCH.Clearnet SA	Fixed income	Fixed income	Cash trades and repo	Government bonds
CC&G	Bond	ETD Bonds and repo	Bonds and repo	Government bonds corporate bonds
LCH.Clearnet Ltd	Fixed Income	Fixed income products	Cash bond and repo trades	Government bonds, German Jumbo bonds, Agency, supranational, regional, government guaranteed bonds, liquid bonds baskets
BME	Fixed Income Securities	Repo	ETD and OTC	Government bonds

Note: Data retrieved from websites of CCPs in September 2016.

Table 4.4: Products covered by equity default funds

CCP	Segregated default fund	Products covered	Contract type	Underlying
BME	Financial derivatives	Listed derivatives	Futures Options	Stock index, 10-yr government bonds, single stock dividend, single stock index American and European style stock, index
LCH.Clearnet SA	Cash and derivatives	Equity cash and derivatives (also bonds and commodities)	Government and corporate bonds Single company equities Cash equities Equities ETFs ETCs REITs Securities Stocks Warrants Certificates Funds UCITS	NA
			trackers and structured funds ET commodity derivatives	
			Shares, warrants, convertible bonds, closed-end funds, ET funds, exchange traded commodities Futures Options	Index, single stock Index, single stock
LCH.Clearnet Ltd	Equity	Equity products and Equity derivatives	Single company equities Cash equities ETFs ETCs REITs ccCFDs	equity, index, securities
			NA	NA
EuroCCP	EuroCCP NV	ETD and OTC cash equity	Futures Options	Index American-style stock, European-style index
ICE Clear NL	Futures and options	European equity derivatives		

Note: Data retrieved from websites of CCPs in September 2016.

Table 4.5: Products covered by energy and commodity default funds

CCP	Segregated default fund	Products covered	Contract type	Underlying
BME	Power derivatives	OTC electricity derivatives	Futures Swaps	Electricity Electricity
LCH.Clearnet Ltd	Commodities	Derivatives	Block Futures	Fertilizer
			Forward Freight Agreements	Dry time charter, dry voyage, dry trip
			Forward Freight Agreement options	Dry timecharter basket routes
Nasdaq OMX	Commodities	Derivatives	Iron Ore contract	TSI index
			Iron Ore option	European-style, TSI Iron Ore contract
			Steel contracts	Hot Rolled Coil, Northern Europe Hot Rolled Coil, Southern Europe Turkish Import Scrap
CC&G	Commodities	Derivatives	Futures	Power, gas, renewables, freight, fuel oil, ferrous products.
			Options	Power, gas, freight, ferrous products
			Electricity Price Area Differentials	Power, Electricity
LME	Commodities	Commodities	Electricity Certificate futures	Carbon
			EU Allowance futures	Carbon
			EU Allowance options	Energy
LME	CCP level	Commodities	Futures	Energy
			Futures	Metal, index, steel
			Options	Metal
LME	CCP level	Commodities	Traded average price options	Future
			Monthly average futures	Metal

Note: Data retrieved from websites of CCPs in September 2016.

Table 4.6: Products covered by interest rate default funds

CCP	Segregated default fund	Products covered	Contract type	Underlying
BME	IRS	Interest rate swaps	Swaps OIS FRA	EURIBOR EONIA EURIBOR
LCH.Clearnet Ltd	Listed Interest Rates	Listed interest rate derivatives	Futures	EURIBOR, short Sterling, long Gilt, German government bonds
			IRS	BBR-BBSW, BBR-FRA, BA-CDOR, LIBOR, PRIBOR, CIBOR, EURIBOR, BUBOR HIBOR, NIBOR, WIBOR, STIBOR SOR, JIBAR
			Forward rate agreement	LIBOR, PRIBOR, CIBOR EURIBOR, BUBOR, NIBOR WIBORS, TIBOR
			OIS	AONIA, CORRA, TOIS EONIA, TONA, FEDFUNDS
			Variable Notional Swaps	BBR-BBSW, BA-CDOR, EURIBOR, LIBOR, LIBOR-BBA LIBOR-SONIA, LIBOR-USD, LIBOR-FedFunds, LIBOR-H15, LIBOR-BBA
			Basis overnight	
LCH.Clearnet Ltd	OTC Interest Rates	OTC interest rate products	Inflation ZCIIIS	HICPxT, CPIdxT, RPI, CPI

Note: Data retrieved from websites of CCPs in September 2016.

Table 4.7: Products covered by OTC CDS default fund

CCP	Segregated default fund	Products covered	Contract type	Underlying
ICE Clear EU	CDS	European CDS	Swaps	Index, corporate single names, Sovereign single names
LCH.Clearnet SA	OTC CDS	Credit default swaps	Swaps	Index, single names

Note: Data retrieved from websites of CCPs in September 2016.

Table 4.8: Products per mixed default funds

CCP	Segregated default fund	Products covered	Contract type	Underlying
ICE Clear EU	Futures and options	Energy, agricultural, interest rates, equity derivatives	Futures	Oil, natural gas, power, coal, Emissions, cocoa, coffee, sugar Wheat, index, dividend index Stock index, government bonds
LCH.Clearnet Ltd	OTC FX	OTC non-deliverable FX transactions	Options Index	Oil, natural gas, emissions, cocoa, coffee Oil, natural gas, emissions, cocoa, Coffee, sugar, wheat, index, stock Government bonds, bond future
Nasdaq OMX	Financial Markets	ET and OTC equity derivatives OTC rates Fixed income derivatives Repo products	Forwards Futures Options Forwards IRS OIS FRA Futures Options Repos	Currency pairs Single stock, index Single stock, index, fixed income Single stock STIBOR, CIBOR, EURIBOR, NIBOR STIBOR STIBOR, CIBOR, EURIBOR, NIBOR Government and mortgage bonds, rates Government and mortgage bonds, rates
Nasdaq OMX Eurex	Seafood Integrated default fund	Salmon derivatives All products cleared Equity market	Futures	Bonds Nasdaq Salmon Index NA
CCP A	Integrated default fund	Bond market Structured products Other securities	Stocks Government bonds, federal treasury certificates, Treasury notes, interest rate and government strips, Corporate and banking bonds, convertible bonds. Certificates, exchange traded funds, warrants Profit-sharing rights, UCITS shares, stocks	NA
CC&G	AGREX	Agricultural Derivatives	Futures	Durum Wheat

Note: Data retrieved from websites of CCPs in September 2016.

Table 4.9: QLR, Default Resources, and concentration of IM

CCP	QLR (€m)	DR (€m)	QLR/DR	IM5/IM
BME	3,550	3,700	0.96	0.56
CC&G	13,600	13,100	1.03	0.61
CCP A	75.3	45.2	1.67	0.55
Eurex	24,700	41,200	0.60	0.39
EuroCCP	1,520	948	1.60	0.73
ICE Clear EU	33,800	44,500	0.76	0.46
KDPW	378	394	0.96	0.56
LCH.Clearnet Ltd	53,600	90,800	0.59	0.6
LCH.Clearnet SA	31,000	26,400	1.17	0.7
LME	7,580	7,300	1.04	0.39
Nasdaq OMX	4,100	5,290	0.77	0.55

Note: Data from Public Quantitative Disclosures at the first quarter of 2016. QLR is Qualified liquid resources; DR is default resources; IM5/IM is the portion of initial margin posted by the largest 5 clearing members. The latter is a simple average of concentrations at the default fund level. Concentrations are taken at the peak over the quarter.

Appendix

4.A Overview of PQD variables used per figure

In Tables 4.10 and 4.11 we give an overview of the variables extracted from the PQD data files provided by CCPs. The figures were converted to euro using either end-of-period or period-average exchange rates, depending on the PQD snapshot type, as appropriate.

Table 4.10: Overview of PQD variables used

Figure reference	Measure of	PQD reference variable(s) used	Variable description	Data unit
4.1 to 4.6	Default waterfall size and	4.1.1	Prefunded CCP capital (SIG)	EUR, GBP, HUF, JPY, NOK, PLN, SEK, USD
		4.1.2	Prefunded CCP capital alongside default fund	EUR, GBP, HUF, JPY, NOK, PLN, SEK, USD
		4.1.3	Prefunded CCP capital after default fund	EUR, GBP, HUF, JPY, NOK, PLN, SEK, USD
		4.1.4	Required prefunded participants' default fund contributions	EUR, GBP, HUF, JPY, NOK, PLN, SEK, USD
	structure	6.1.1	Total initial margin required split by house, client gross, client net and total (if not segregated)	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
4.7	Ratio of qualifying liquid resources to total waterfall resources	7.1.2	Cash deposited at a central bank of issue of the currency concerned	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
		7.1.3	Cash deposited at other central banks	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
		7.1.4	Cash Secured cash deposited at commercial banks (including reverse repo)	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
		7.1.5	Unsecured cash deposited at commercial banks	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
		7.1.6	Secured committed lines of credit including foreign exchange swaps and committed repos	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
		7.1.7	Unsecured committed lines of credit	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
		7.1.8	Highly marketable collateral held in custody and investments that are readily available and convertible into cash with prearranged and highly reliable funding arrangements even in extreme but plausible market conditions	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
		7.1.9	Other	CHF, DKK, EUR, GBP, NOK, PLN, SEK, USD
4.8	Reinvestment of cash received from members	16.1.1	Total cash (but not securities) received from participants as IM	DKK, EUR, GBP, NOK, PLN, SEK, USD
		16.1.2	Total cash (but not securities) received from participants as default fund contribution	EUR, GBP, NOK, PLN, SEK, USD
		16.2.1	Percentage of total participant cash held as cash deposits	Percentage
		16.2.2	Percentage of total participant cash held as cash deposits at central banks of issue of the currency deposited	Percentage
		16.2.3	Percentage of total participant cash held as cash deposits at other central banks	Percentage
		16.2.4	Percentage of total participant cash held as cash deposits at commercial banks	Percentage
		16.2.5	Percentage of total participant cash held as cash deposits at commercial banks	Percentage

Table 4.11: Overview of PQD variables used (continued)

Figure reference	Measure of	PQD reference of variable(s) used	Variable description	Data unit
4.8		16.2.6	Percentage of total participant cash held as cash deposits in money market funds	Percentage
		16.2.7	Percentage of total participant cash held as cash deposits in other forms	Percentage
		16.2.10	Percentage of total participant cash invested in securities; Domestic sovereign government bonds	Percentage
		16.2.11	Percentage of total participant cash invested in securities; Other sovereign government bonds	Percentage
		16.2.12	Percentage of total participant cash invested in securities; Agency bonds	Percentage
		16.2.13	Percentage of total participant cash invested in securities; State or municipal bonds	Percentage
		16.2.14	Percentage of total participant cash invested in securities; Other instruments	Percentage
4.9	Focus on bonds	4.3.5	Non-Cash Sovereign Government Bonds-Domestic ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.6	Non-Cash Sovereign Government Bonds-Other ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.7	Non-Cash Agency Bonds ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.8	Non-Cash State/municipal bonds ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.9	Non-Cash Corporate bonds ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.10	Non-Cash Equities ^{2,3}	EUR, NOK, PLN, SEK, USD
		6.2.5	Non-Cash Sovereign Government Bonds - Domestic ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.6	Non-Cash Sovereign Government Bonds - Other ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.7	Non-Cash Agency Bonds ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.8	Non-Cash State/municipal bonds ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
4.10	Com-position of IM	6.2.9	Non-Cash Corporate bonds ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.10	Non-Cash Equities ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.1	Cash deposited at a central bank of issue of the currency concerned ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.2	Cash deposited at other central banks ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.3	Secured cash deposited at commercial banks ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.4	Unsecured cash deposited at commercial banks ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.5	Non-Cash Sovereign Government Bonds-Domestic ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.6	Non-Cash Sovereign Government Bonds-Other ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.7	Non-Cash Agency Bonds ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.8	Non-Cash State/municipal bonds ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.9	Non-Cash Corporate bonds ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.10	Non-Cash Equities ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.11	Non-Cash Commodities-Gold ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.12	Non-Cash Commodities-Other ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
4.11	Com-position of DF	6.2.13	Non-Cash Mutual Funds OR UCITS ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.14	Non-Cash-Other ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		6.2.15	Total initial margin held ^{2,4}	CHF, DKK, EUR, NOK, PLN, SEK, USD
		4.3.1	Cash deposited at a central bank of issue of the currency concerned ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.2	Cash deposited at other central banks ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.3	Secured cash deposited at commercial banks ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.4	Unsecured cash deposited at commercial banks ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.5	Non-Cash Sovereign Government Bonds-Domestic ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.6	Non-Cash Sovereign Government Bonds-Other ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.7	Non-Cash Agency Bonds ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.8	Non-Cash State and municipal bonds ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.9	Non-Cash Corporate bonds ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.10	Non-Cash Equities ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.11	Non-Cash Commodities-Gold ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.12	Non-Cash Commodities-Other ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.13	Non-Cash Commodities-Mutual Funds and UCITS ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.14	Non-Cash Commodities-Other ^{2,3}	EUR, NOK, PLN, SEK, USD
		4.3.15	In total ^{2,3}	EUR, NOK, PLN, SEK, USD

Since PQD data is not completely standardised, and there are mistakes in reporting, in building the figures in the paper we made the following modifications.

Volumes of transactions: CC&G, LCH.Clearnet Ltd, and LCH.Clearnet SA report transaction volumes at the clearing service level. When the name of clearing service and default fund do not coincide, we allocate the clearing services to default funds according to the following:

Table 4.12: Assignments of clearing service to default fund

CCP	Clearing Service as specified in PQD file	Assigned default fund
CC&G	Wholesale Retails Derivatives Equities	Bonds and repo Equities
LCH.Clearnet Ltd	EnClear LSEDM RepoClear NLX ForexClear SwapClear	Commodities Equities Fixed Income Listed Interest Rates OTC FX OTC Interest Rates
LCH.Clearnet SA	EquityClear Listed Derivatives Tri-party Repo Bonds and Repos CDSClear	Cash and Derivatives €GC Plus (Tri-party repo) Fixed Income (Bonds and repo) OTC CDS

Note: Names of clearing services and default funds as they appear in the PQD. In parentheses are the names used in Figures 4.1 to 4.6, if different from those in the disclosures.

Additionally, the double reporting of repo — as repo and reverse repo — reported by LCH.Clearnet Ltd and LCH.Clearnet SA was rectified. Finally, it was assumed that LCH.Clearnet Ltd reported in millions of euro for the clearing service RepoClear in the first quarter of 2016, due to the inconsistency of the reported numbers with other disclosures.

CCP own capital: The PQD variables 4.1.2 and 4.1.3 refer to the own capital of the CCP to be used alongside and after the non-defaulting clearing members contributions to the default fund, respectively. Whereas own capital to be used before the non-defaulting clearing members contributions to the default fund (variable 4.1.1) is allocated to the segregated default funds, for regulatory reasons this is not the case for the rest of CCP own capital. In other words, variables 4.1.2 and 4.1.3 are at the CCP level, not at the default fund level. To build the default fund-level waterfalls, we allocate variables 4.1.2 and 4.1.3 to each default fund using the same proportion with which variable 4.1.1 is allocated to the segregated default funds by the CCPs.

Ratio of Qualifying Liquid Resources to total waterfall: The QLR concept (numerator), covering PQD reference variables 7.1, refers to how financial resources are held

by the CCP. The pre-funded waterfall resources (denominator) are required amounts (default fund, variable 4.1.4, and initial margin, variable 6.1.1). This approach was chosen in order to compare the liquid resources to the resources available to the CCP, excluding any over-collateralisation, which is not available to the CCP.

Composition of securities held as initial margin and default fund: For initial margin, ‘Domestic government bonds’ and ‘Other government bonds’ refer to PQD variables 6.2.5 and 6.2.6, respectively. ‘Agency and Municipal bonds’ is the sum of PQD variables 6.2.7 and 6.2.8. ‘Other securities’ covers corporate bonds (PQD variable 6.2.9) and equities (PQD variable 6.2.10). Similarly, for default fund we use concept 4.3 or ‘Value of pre-funded default resources (excluding initial and retained variation margin)’, split into the same buckets as for initial margin (PQD variables 4.3.5 to 4.3.10). All figures are converted to euro at end-of period exchange rates before being summed up in order to get totals.

Reinvestment of participants’ cash: Total cash received as initial margin or default fund is obtained by summing variables 16.1.1 and 16.1.2: ‘Total cash (but not securities) received from participants, regardless of the form in which it is held, deposited or invested, received as’ initial margin (16.1.1) and default fund (16.1.2). The reinvestment buckets are the same as the securities holdings buckets described above; we used PQD variables 16.2.10 to 16.2.14 on ‘Percentage of total participants cash invested in securities’.

Figure 4.9 aims at showing CCPs’ holdings of securities in the default waterfall, and the extent to which the securities held have been invested in by the CCP using cash posted by clearing members or they have been posted by members directly. Concepts 4.3 and 6.2 refer to how the CCP holds initial margin and default fund, rather than how members posted resources. Therefore, according to the PQD standards, the sum of the first and second sets of stacked bars (sum of PQD variables 4.3.5 to 4.3.10 and 6.2.5 to 6.2.10) should be at most equal to the third set of stacked bars, because holdings cannot exceed re-investment. Equality holds when the CCP receives all initial margin and default fund contributions in cash, and the securities held as initial margin and default fund are only those in which

the CCP has reinvested participant cash. Conversely, when the reinvestment bar is zero, all the securities held as initial margin and default fund are those posted by members. The difference between the sum of the first two bars and the third bar in the chart is the collateral posted in securities by participants. However, in Figure 4.9, the reinvestment bar is greater than the sum of initial margin and default fund bars for CC&G. From cross checking the figures reported on the website, it appears CC&Greports initial margin posted, as opposed to held.

Chapter 5

Conclusion

This thesis contains three studies relating to the financial systems of European countries. The three essays cover different aspects, although they are linked by the study of factors affecting the probability and impact of turmoil in financial markets.

The first essay focuses on the time series variation of risk premia on sovereign risk fundamentals. In particular, countries with large and negative net international investment positions saw large increases in sovereign bond spreads when the European debt crisis unfolded; the paper shows that this can be explained by a different perception of the meaning of such negative external positions for sovereigns, depending on the prevailing level of uncertainty in financial markets.

Because the price of sovereign risk depends on uncertainty and is low in expansions, governments might downplay the risks that the private sector is building up in calm periods, and the acquired weakness can abruptly manifest when expectations turn uncertain. When this happens, the stabilising role of fiscal policy is limited by the high financing rate required by investors, in the moment when government intervention is more needed and fiscal revenues low. In light of this, it is appropriate for governments to monitor not only fiscal, but also external variables; in boom periods, scenarios more pessimistic than the expected one should be assigned a higher probability.

The second essay discusses the non-trivial separation between financial deepening and excess credit to the non-financial private sector. Our approach considers the evolution of a system of macroeconomic variables relevant for the sustainability of the credit, in conjunction with changes in the credit-to-GDP ratio. The proposed approach can be used to assist policy makers in the analysis that informs the decision to activate the counter-cyclical capital buffer.

We find that using our approach to analyse the data, a number of patterns are visible before the crisis for the countries where credit contracted the most after the crisis, such as Ireland and Spain. Similar patterns are currently present in France and Sweden, which suggests that vulnerabilities may be building up in these countries. Whereas additional qualitative and quantitative information should be considered before activating the counter-cyclical capital buffer, the current application of the buffer in Sweden confirms the result of our analysis.

The third essay studies a type of financial market infrastructure which has been studied relatively little in the literature, despite having become a central node in financial systems, and despite covering a key role in reducing systemic risk. Central clearing counterparties interpose between counterparties of a financial transaction, becoming counterparty to both the seller and the buyer, and assuming all the risks involved in the transaction. CCPs have a number of risk management strategies in place to manage the default of participants and other risks they face.

This essay is the first study to map the structure of the clearing market in Europe. First, we construct a dataset using publicly available information, mostly composed of disclosures which international standard setting bodies encourage CCPs to publish. One of the contributions of the chapter is to suggest a number of policy actions to increase the extent to which these disclosures allow an assessment of the risks posed by CCPs to the clearing members and the economy at large (the stated goal of the disclosures).

We document the structure of the European central clearing landscape. This includes the type of financial transactions cleared by each CCP, the size of the markets served, the

resources held against default, and liquidity management. We find significant re-investment in sovereign bonds of the cash posted by clearing members as collateral. Such re-investment may expose central counterparties to liquidation risk, if the value of sovereign bonds tends to decrease when the cash is needed—when the member who posted the cash defaults. Since the members are typically banks, CCPs where the members are domestic and reinvestment in domestic sovereign bonds is large are more exposed to this risk, because the correlation between creditworthiness of the domestic bank and the price of domestic sovereign bonds is more likely to be positive.

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