Essays in Financial Economics

A thesis submitted to Trinity College Dublin in fulfilment of the requirements for the degree of Doctor in Philosophy

by

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Supervised by

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Declaration

I declare that this thesis, submitted to Trinity College Dublin for the degree of Doctor in Philosophy (Ph.D.), has not been submitted as an exercise for a degree at this or any other university. I declare that I was the lead author for each of the co-authored chapters in the thesis. All research contained herein is entirely my and my co-authors' work.

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Katharina Bergant

Summary

This thesis comprises five papers in *Financial Economics*. The first part contains three essays in *International Finance* followed by two essays in *Empirical Banking*.

The *International Finance* chapter focuses on the determinants of international capital flows. It starts with an analysis of the increasing divergence of the net international investment position in the post-crisis period. By decomposing the change in the net international investment position into capital flows and valuation effects, I show that the increasing stock imbalances are driven by the former. However, valuation changes show a stabilising pattern. Countries with the largest net foreign liabilities experienced the greatest valuation gains. Analysing this effect across different asset classes indicates that this stabilising pattern was driven by a change in the value of portfolio equity. The pro-cyclical movement of domestic stock markets during the post-crisis period improved international risk sharing through foreign portfolio equity liabilities. In the second paper, I take the analysis of valuation effects to the micro level. Martin Schmitz and I use confidential data on security holdings of all euro area investors to review portfolio rebalancing patterns in response to valuation changes. Our empirical findings provide evidence for "momentum investment" as investors carry out larger net purchases of securities which experience relatively higher valuation gains. For securities denominated in foreign currency (i.e. non-euro), momentum investment is significantly stronger and driven by valuation gains from exchange rate dynamics rather than changes in market prices. The chapter ends with an analysis of international capital flows during the European Central Bank's (ECB) Asset Purchase Programme in the third essay. We show that euro area investors actively rebalanced away from securities targeted under the ECB's Public Sector Purchase Programme and other euro-denominated debt securities, towards foreign debt instruments, including 'closest substitutes', i.e. certain sovereign debt securities issued by non-euro area advanced countries. This rebalancing was particularly strong during the first six quarters of the programme with marked differences across sectors as well as country groups within the euro area, suggesting that quantitative easing has induced heterogeneous portfolio shifts.

The second part of the dissertation contains two papers on *Empirical Banking* that focus on patterns of bank lending to households and firms. In the first paper, Thore Kockerols

and I use supervisory loan-level data on corporate loans to show that banks facing high levels of non-performing loans relative to their capital and provisions were more likely to grant forbearance measures to the riskiest group of borrowers. Moreover, we find that none of the forbearance measures significantly reduce the probability of default in the long run. As high shares of forbearance are negatively correlated with new lending to the same group of borrowers, our evidence also suggests that forbearance and new lending are substitutes for banks. In the second paper, my co-authors Viral Acharya, Matteo Crosignani, Tim Eisert, Fergal McCann, and I examine the impact on bank lending and risk-taking of loan-to-income and loan-to-value limits on the issuance of residential mortgages. We show that banks play an important role in the transmission of macroprudential policies aimed at limiting household leverage. In response to these limits, banks reallocate credit from low- to high-income borrowers and from counties where borrowers are close to the limits to counties where borrowers are more distant from the limits. This mortgage reallocation is effective in slowing down house price growth in "hot" housing markets from above 20% to 4% year over year. However, banks try to maintain a stable risk exposure by increasing their risk-taking in asset classes not targeted by the regulation – such as credit to firms and holdings of securities – and reallocating mortgage credit to borrowers more likely to default during real estate busts.

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The first quote of this dissertation should come from Father George Salzmann, Harvard University's Postgraduate Chaplain: *"Thank you, God. For Everything. Amen!"*.

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Chapter 1

General Introduction

This dissertation is a collection of five essays that relate to topics at the intersection of finance and macroeconomics. The objective of the research is to answer questions that are important for the macro economy by using newly available microeconomic data.

The thesis can be split in two overarching topics. Chapter 2 contains three essays in *International Finance*, which take the reader on a journey from macro to micro data for the purpose of analysing the determinants of international capital flows. The first paper looks at the increasing divergence of the net international investment position in the post-crisis period. While the contraction of current account imbalances that followed the Global Financial Crisis is well documented, the distortions of international stock positions have been less explored in the literature. Decomposing the change in the net international investment position into capital flows and valuation effects, I find that the increasing stock imbalances are driven by the former. However, valuation changes show a stabilising pattern. Countries with the largest net foreign liabilities experienced the greatest valuation gains. Analysing this effect across different asset classes shows that this stabilising pattern was driven by a change in the value of portfolio equity. The pro-cyclical movement of domestic stock markets during the post-crisis period improved international risk sharing through foreign portfolio equity liabilities. In the second paper, I analyse valuation effects at the micro level. My co-author Martin Schmitz and I use confidential microdata on security holdings of all euro area investors to analyse portfolio rebalancing patterns in response to valuation changes. Our empirical findings provide evidence for "momentum investment" as investors show larger net purchases of securities which experience relatively higher valuation gains. This pattern is stronger for institutional investors (banks, investment funds, and insurance companies and pension funds) than for households or non-financial corporations and particularly pronounced in euro area countries less affected by the Great Financial Crisis. For securities denominated in foreign currency (i.e. non-euro), momentum investment is significantly stronger and driven by valuation gains from exchange rate dynamics rather than changes in market prices. Our finding is consistent

with a decreasing share of home currency holdings in euro area investors' portfolios, albeit from high levels, driven by rebalancing towards the US dollar and other foreign currencies over the past five years. In the final paper of this chapter, we use the same micro data to analyse portfolio investment during the ECB's Asset Purchase Programme. Based on net transactions of domestic and foreign securities, we observe euro area sectors' capital flows into individual securities, cleaned from valuation effects. Our empirical analysis – which accounts for security-level characteristics – shows that euro area investors (in particular investment funds and households) actively rebalanced away from securities targeted under the Public Sector Purchase Programme and other euro-denominated debt securities, towards foreign debt instruments, including 'closest substitutes', i.e. certain sovereign debt securities issued by non-euro area advanced countries. This rebalancing was particularly strong during the first six quarters of the programme. Our analysis also reveals marked differences across sectors as well as country groups within the euro area, suggesting that quantitative easing policies have induced heterogeneous portfolio shifts.

Chapter 3 of the dissertation contains two papers on *Empirical Banking* that focus on patterns of bank lending to households and firms which could pose risks to financial and macroeconomic stability. In the first paper, Thore Kockerols and I use supervisory loan-level data on corporate loans to show that banks facing high levels of non-performing loans relative to their capital and their provisions were more likely to grant forbearance measures to the riskiest group of borrowers. More specifically, we find that risky borrowers are more likely to get an increase in the overall limit or the maturity of a loan product from a distressed lender. As a second step, we analyse the effectiveness of this practice in reducing the probability of default. We show that the most common measure of forbearance is effective in the short run but no forbearance measure significantly reduces the probability of default in the long run. Our evidence moreover suggests that forbearance and new lending are substitutes for banks, as high shares of forbearance are negatively correlated with new lending to the same group of borrowers. In the second paper, my co-authors Viral Acharya, Matteo Crosignani, Tim Eisert, Fergal McCann, and I analyse investment decisions of banks after introduction of household lending limits in 2015. We show that banks play an important role in the transmission of macroprudential policies aimed at limiting household leverage. Combining granular house price data with loan-level residential mortgage and firm credit data, we examine the impact on bank lending and risk-taking of loan-to-income (LTI) and loan-to-value (LTV) limits on the issuance of residential mortgages – a policy adopted by 41 countries between 2000 and 2013. Our empirical context is the introduction of these limits in February 2015 on residential mortgages in Ireland, a country that experienced a severe real estate boom-bust cycle from 2000 to 2010. In response to these limits, banks reallocate credit from low- to high-income borrowers and from counties where borrowers are close to the limits to counties

where borrowers are more distant from the limits. Banks more constrained by the limits reduce their mortgage issuance to borrowers in the bottom quintile of the income distribution by 10% and increase their issuance to borrowers in the top quintile by 15%, controlling for local economic conditions and credit demand. High-income borrowers obtain larger loans and increase their leverage. This mortgage reallocation is effective in slowing down house price growth in "hot" housing markets from above 20% to 4% year over year. However, banks try to maintain a stable risk exposure by increasing their risk-taking in asset classes not targeted by the regulation – such as credit to firms and holdings of securities – and reallocating mortgage credit to borrowers more likely to default during real estate busts.

Finally, chapter 4 summarises the overall findings and provides general conclusions and policy recommendations of this thesis, along with suggestions for future research.

Chapter 2

Essays in International Finance

2.1 The Role of Stock-Flow Adjustment in the post-crisis Period [1]

2.1.1 Introduction

In the last two decades, increasing financial integration has been of great importance in international macroeconomics. Before the crisis, rapidly increasing cross-border financial flows led to easier external financial conditions and credit booms which were accompanied by rising asset prices. While volatility as well as risk aversion was low, implications of those developments were hard to assess. In the absence of strong policy responses to these changes, foreign investment positions could grow inexorably (Lane, 2013). Consequently, the beginning of the global crisis was characterized by a reversal of financial conditions and limited external finance. Flow imbalances contracted and the crisis worked as a correction of excessive pre-crisis imbalances (Lane and Milesi-Ferretti, 2012, 2014).

While flow imbalances decreased sharply in the post-crisis period, stock imbalances are still increasing (Figure 2.1, 2.2). This is seen as possible systemic risk, making large debtors vulnerable to changes in the market (International Monetary Fund, 2014b). Therefore, I argue that it is necessary to shed more light on the dynamics of the increasing divergence of stock positions in the post-crisis period, i.e. accompanying the sharp flow contractions. Absent large valuation effects, for stock imbalances to reduce, a reversal and not just a contraction of flow imbalances would be required. Thus, remaining flow imbalances have contributed significantly to growing stock imbalances.

This paper focuses on the role of valuation effects of the net international investment position in the post-crisis period. Thereby, the crucial question arises whether those valuation changes were able to stabilise the net international investment position. While ignored in much of the earlier literature, more recent work show that the importance of stock-flow adjustment has grown tremendously in importance since 1980 (see e.g. Lane and Milesi-Ferretti (2001, 2007), Balli et al. (2011)). In some cases, valuation changes dominated capital flows easily.

I find that the stock-flow adjustment moved in a stabilising direction in the post-crisis period. Countries with the lowest net international investment position experienced the most positive changes in valuation. In terms of magnitude, countries with a 1 percent of GDP lower net international investment position in 2007 experienced higher capital gains in the size of 0.23 percent of GDP on average. Therefore, the accumulation of foreign stock imbalances was significantly decelerated by the stabilising effect of changes in valuation. Analysing these effects by each asset class separately, I find that this pattern was driven by stabilising changes in the valuation of portfolio equity liabilities. This emphasises the role of the domestic stock market for international risk sharing. I show that because stock markets moved in a

[1] This is a slightly revised version of the Working Paper version published in Trinity Economic Papers *tep1317*, Trinity College Dublin, Department of Economics.

pro-cyclical direction in the post-crisis period, countries with a lower output were able to generate relatively more valuation gains through their portfolio equity liabilities.

The risk of financial distress due to large net external positions is documented in the literature (see, for example, Obstfeld, 2012a; 2012b). More specifically, Catão and Milesi-Ferretti (2013) present a model including the net international investment position which - if estimated with data from 1970-2006 - would have predicted most of the 2008-2011 crisis. While external imbalances might not have triggered the recent crisis, external debt liabilities increase the probability of an external crisis. Looking further back, Milesi-Ferretti and Razin (2000) present evidence that countries with low reserves and long persistent deficits in the past are more likely to experience a sharp reduction in their current account. Calvo et al. (2004) find that the intensity and the duration of financial turmoils once a sudden stop has occurred positively depend on total debt, especially when combined with a high domestic liability dollarisation. Summing up, several surveys like the World Economic Outlook (International Monetary Fund, 2014b) and External Sector Report (International Monetary Fund, 2014a) warn that the development regarding growing stock imbalances is unlikely to reverse during the rest of this decade which imposes systemic risk to the international financial system.

Accordingly, the goal of this paper is to shed light on the dynamics behind the increasing imbalances of net international investment positions with a focus on the driving factors of the stabilising stock-flow adjustment. In subsection 2, I explain the conceptual framework whereas in subsection 3 I present some stylized facts. subsection 4 shows an empirical analysis and subsection 5 concludes.

2.1.2 Conceptual Framework

The relationship between the flow and the stock position is usually studied in the following form:[2]

$$\begin{aligned} NIIP_t - NIIP_{t-1} &= NETFLOW_t + SFA_t && (2.1)\\ &= CA_t + EO_t + SFA_t && (2.2)\\ &= FA_t + SFA_t && (2.3) \end{aligned}$$

where $NIIP$ refers to a country's net international investment position and SFA is the stock-flow adjustment. I measure the $NETFLOW$ with CA as the current account, FA as the financial account, and EO including errors and omissions in order to equal out these measures. Therefore, the increase in imbalances can be due to flow imbalances ($CA + EO$ or FA) or the stock-flow adjustment (SFA). In more detail, the financial account can be

[2]For simplicity, I ignore the capital account due to its small magnitude.

divided by asset classes:

$$FA_t = FDI_{Nt} + PEQ_{Nt} + PD_{Nt} + OI_{Nt} + DERIV_{Nt} + RES_{At} \tag{2.4}$$

where FDI_{Nt} is foreign direct investment, PEQ_{Nt} and PD_{Nt} correspond to portfolio equity and portfolio debt respectively, OI_{Nt} is other investment, $DERIV_{Nt}$ measures foreign derivatives, and RES_{At} corresponds to holdings of foreign reserves on the asset side. Except for the latter, all values are net terms.
On the other hand, the stock-flow adjustment can be expressed as

$$SFA_t = VAL_t + OTH_t \tag{2.5}$$

where VAL_t measures changes in the valuation of the net international investment position due to changes in market prices or the exchange rate. The "residual" is captured in OTH_t which contains e.g. new measurement techniques, data revisions, or reclassifications.

In this subsection, I want to outline the rationale for dissecting the evolution of the net international investment position, especially in the post-crisis period.

2.1.2.1 The Flow Dimension

What is casually known as *Financial Globalisation* was the sharp increase in cross-border financial flows that allowed exorbitant debt levels between countries accompanied by a substantial widening of global current account imbalances in the years before the crisis. This seems surprising considering that risks attached to international financial integration are widely discussed in the literature (e.g. Edwards (2004) ; Obstfeld (2012a); Freund and Warnock (2007)). Using the case of the United States, Obstfeld and Rogoff (2005, 2007) argue that the adjustment process of an excessive deficit country's current account itself would bear considerable risks to general economic stability and financial markets, especially if the adjustment is stemming from a loss of confidence by foreign investors in the U.S. economy. Not just excessive deficit levels, but also persistent surplus balances can be signs of macroeconomic distortions such as unfair competition advantages, failures in financial regulation, or the global demand in case of a liquidity trap. In addition, exceptionally low investment can be due to an inefficiency of markets such as a lack of competition. Therefore, the literature agrees that persistent excessive imbalances, regardless of the sign, should be reduced (Milesi-Ferretti and Blanchard, 2010, 2011).

It was thus crucial to observe the unravellings of flow imbalances following the recent global financial crisis. Although these flows were most likely not the trigger for the crisis, in 2007/2008, a sudden stop in capital flows caused a contraction of flow imbalances. With

the exception of a "relapse" in 2010, current account imbalances decreased ever since the crisis started in 2008. Figure 2.1 shows that not just total dispersion but also configuration of flow imbalances have changed markedly. China and Japan reduced their surplus through expansionary fiscal policy, lower demand for the countries' exports and a higher demand for imports. On the other side, European deficit countries adjusted quickly, turning the euro area into a surplus area as a whole. Most importantly, the United States deficit shrank by almost two-thirds as a percentage of world GDP which represents the largest adjustment of all countries (around 400 billion USD). Consequently, the concentration of deficits also decreased dramatically.

Lane and Milesi-Ferretti (2012, 2014) show that this contraction in current account imbalances from 2008-2012 is significantly correlated to imbalances that emerged in the pre-crisis period. Extending this analysis, I find that the peak of current account adjustment in the post-crisis period was reached in 2013 where 90 percent of the deviation from fundamental values of the current account was reversed.[3] Regarding the macroeconomic developments during the adjustments, countries with the greatest negative pre-crisis current account gap experienced slower growth of real output, a greater decline of inflation, and a stronger improvement of the structural fiscal balance. According to forecasts (International Monetary Fund, 2015), the adjustment process will slow down but resulting in levels far below pre-crisis current account imbalances. This is in line with recent literature which suggests that the current adjustment process is mostly permanent rather than solely due to cyclical factors like the exchange rates or changes in output growth (Cerra and Saxena, 2008; Eichengreen, 2014; Cheung et al., 2013).

2.1.2.2 The Stock Dimension

In the absence of dominating stabilising valuation effects, large flow imbalances before the crisis have added up to more divergence in the overall net international investment position. In theory, the key economic significance of a country's foreign stock position is that at any point in time, it represents the limit of the present value of its future net export deficits (excluding international investment income). This national constraint describes a country's feasible transactions with foreigners and can be viewed as a combination of three more basic relationships: the households's budget constraint, the government's budget constraint, and the present value of future profits generated by domestic capital (Obstfeld, 2012a).[4]

The empirical literature, however, calls for models with fully fledged optimizing behavior

[3]Results available upon request. This finding is also the rational for using 2008 - 2013 as the years of the adjustment of global imbalances during the post-crisis period in the empirical specification in this paper.

[4]In more detail, the theory outlined in Obstfeld (2012a) shows that for a deficit to be sustainable, expenditure has to fall or output has to rise when the net international investment position is decreasing so that the private and public sectors both remain solvent (in the absence of changes in the valuation of net foreign assets). Borrowing beyond present value of net export surplus would ultimately lead to a solvency crisis somewhere in the economy.

compatible with the data. The most evident question thereby is as to why the rest of the world would finance a persistent current account deficit country such as the United States (Gourinchas and Rey, 2007). In general, the empirical work has focused on countries with high deficits. The idea behind this is that excessive debtor countries face the risk of abrupt reversal of capital flows in contrast to creditor countries. The crucial issue thereby is whether and how good a net international investment position can predict any kind of crisis. Most recently, Catão and Milesi-Ferretti (2013) show that their model with net foreign liabilities as their main explanatory variable would have forecasted most of the 2008-2011 crisis. Regarding asset classes, the authors identify debt liabilities as the driving force for this effect.

If we bear in mind those risks of excessive stock imbalances, the increasing divergence of stock positions ever since the late 1990s should be alarming. With the literature mostly focusing on the contraction of flow imbalances and the accompanying macroeconomic adjustment, International Monetary Fund (2014b) warns of ignoring the growing imbalances of net international investment positions. With excessive flow imbalances in the pre-crisis period, net foreign stock imbalances increased dramatically since the beginning of the 2000s (see Figure 2.2). Among very few countries, European periphery countries did reverse their flow balances to surpluses which is theoretically necessary in order to reduce external debt. However, this is an exception. Most of the rest of the world reduced but did not reverse flow imbalances which - absent large changes in valuation - accumulates to a larger imbalance of a country's net international investment position (Fidora et al., 2017).

2.1.2.3 Stock-Flow Adjustment

However, not only flows determine the evolution of the stock position as shown in equation (3). The difference between the change in the net international investment position and the capital flows is recognized as the so-called stock-flow adjustment. While ignored in earlier literature, this effect has recently gained considerable attention (Lane and Milesi-Ferretti, 2001, 2007; Balli et al., 2011). In some cases, stock-flow adjustment dominated capital flows easily. The effect as a whole consists of the change in the valuation of foreign assets and liabilities and an *other* category (OTH) which absorbs remaining possible changes, e.g. data revisions or reclassification of assets. As there is no existing evidence that the latter might drive an overall effect of stock-flow adjustment through a specific pattern, the natural interpretation of the total effect can be a change in valuation.[5] This change, in turn, can be due to changes in the price of an asset or a change in the exchange rate. Theoretically, the exchange rate channel could cushion the size of the exchange rate correction that would typically come with an adjustment of external imbalances. In the case for the United States, a dollar depreciation could generate valuation gains by boosting the dollar value of much of its foreign-currency-denominated

[5]In addition, due to scarce provision of granular data, the effects can only be disentangled for the United States, Australia and for the Euro Area since 2013.

assets (Cavallo and Tille, 2006). However, Bénétrix et al. (2015) show that there is limited evidence that the exchange rate channel by itself can contribute significantly to financial stabilization. This is in line with the large literature on the disconnection between macro fundamentals and the exchange rate (Obstfeld and Rogoff (2000), Lane and Milesi-Ferretti (2012, 2014)). Therefore, it is clearly an interaction of the exchange rate and the price channel that creates wealth effects through the stock-flow adjustments.

In addition, the composition of the net international investment position in terms of asset classes seems to have very different implications for a country (see e.g. Catão and Milesi-Ferretti (2013); Gourinchas and Rey (2007) and most recently Forbes et al. (2017)). Not only the amount of net foreign liabilities but also its (gross) composition plays a significant role (Bénétrix, 2009). This has been much discussed for the case of the United States and its compositionally asymmetric balance sheet. After a period of deregulation of cross border flows at the end of the last century, the country has increased its net foreign debt up to 42 percent of GDP in 2014. However, up to the crisis, the United States have traditionally been able to gain excess returns of gross assets over gross liabilities having to pay foreigners less than what the country was able to gain on its foreign assets. Gourinchas and Rey (2005) show that this results from a "composition effect" created by the short borrowing and the long lending position, thereby supplying liquidity to foreign asset holders and loans to foreign enterprises. For the United States, not just asset classes but also the analysis of the currency composition of gross positions shows that the "exorbitant privilege" of the United States results from the ability to run large direct investment surpluses which were financed by the issuance of the own currency by foreign central banks. A country naturally benefits from a depreciation of its currency if it is a net creditor in assets denominated in foreign currency. In that context, Tille (2008) emphasized the important stabilising effects of a dollar depreciation for the United States where almost all debt is issued in dollars while most of the assets are denominated in foreign currency. Adler and Garcia-Macia (2018) combine effects stock-flow adjustment with the net investment income and show that this sum of returns works in a stabilising way across countries.

In this paper, I want to look at the stock-flow adjustment as a device for international risk sharing. According to standard models, increasing financial integration can lead to perfect consumption risk sharing, whereby fluctuations in consumption are disconnected from idiosyncratic fluctuations in output (Obstfeld and Rogoff, 1996). However, the literature shows that this does not hold in the data (Backus et al., 1993; Lewis, 1996). More recent work has confirmed that the degree of risk sharing remains imperfect, but has increased over time. While international risk sharing was traditionally achieved through savings and factor income from international financial flows, capital gains have become increasingly and significantly important. Balli et al. (2011) show that changes in the valuation of foreign assets have outperformed gains from factor income flows for European Union countries and OECD

since 1999. Overall, empirical work has been scarce and/or focused on the United States due to data availability. However, the more general question is if the change in valuation moved in a stabilising direction across countries, especially during stark current account contractions which we experienced in the post-crisis period from 2008-2013. If this is the case, stock-flow adjustment has the potential to achieve risk sharing when countries need it the most.[6]

2.1.3 Stylised Facts

For completeness, I start by shortly summarising several important characteristics of increasing financial integration in the last 25 years in Figure 2.3. Regarding the overall evolution of gross international investment position, we can see that for industrial as well as emerging/developing countries, the main increase happened in the decade preceding the crisis. Industrial countries subsequently experienced two sharp drops in 2008 and 2011. In addition, the graphs show differences in the composition of net international investment positions of industrial countries and emerging and developing countries, most importantly the much higher importance of reserve assets for emerging countries.[7] On the liabilities side, foreign direct investment liabilities represent the lion share for emerging countries. While bank loans were primary source before 2000, portfolio equity liabilities increased sharply, even throughout the crisis. This combination of an increase in liquid foreign reserves and the shift from debt to equity funding put emerging and developing countries in a relatively better position when the crisis hit in 2008. Finally, one should note the different size of balance sheets, i.e. most foreign assets (liabilities) are still held (issued) by advanced economies.

So far, I have analyzed the evolution of the value of (gross) stock position. These developments are influenced by capital flows but also by the change in the valuation of foreign assets and liabilities. As the latter is difficult to grasp directly, it is usually derived from the difference of flows and the change in the stock position. From equation (3) we can derive:

$$NIIP_t - NIIP_{t-1} = Flow_t + SFA_t \tag{2.6}$$

$$SFA_t = (NIIP_t - NIIP_{t-1}) - Flow_t \tag{2.7}$$

In Figure 2.4 shows the evolution of the net international investment position and cumulated flows for the Unites States, the United Kingdom, China, and Germany. I use the financial account for the cumulated flows with the value of the 1996 net international investment position as a starting value.[8] Comparing the two time series, we can find big discrepancies.

[6] I derive this potential mechanism in Appendix B.

[7] While those seem to play a very limited role for the developed world, they represent the biggest share for the rest of the sample. A prime example is China with reserves representing 67 percent of total assets (43 percent of GDP) before the crisis in 2008.

[8] I did the same using the current account and the graphs look almost identical which is reassuring regarding the data. In theory, the current account balance should be equal and "opposite" the capital and financial account. In practice, the balance of payments only accounts to zero through a term called net errors and

At some points in time, the net international investment position and cumulated flows evolve in opposite directions which means that the stock-flow adjustment outweighed the direction of flows with the opposite sign. We can see that the United States represent an exception as the two lines moved closer together in the post-crisis period. This is in line with Gourinchas et al. (2010) who describe the special role of the United States as a "global insurer": the country enjoys the exorbitant privilege in good times while wealth flows to the rest of the world during a crisis.

Looking closer at the mechanisms of changes in valuation, I analyze different asset classes separately. Thereby, we have to take into account the accounting principles regulated in the Balance of Payments (BOP) manual which serves the consistency of the reporting of the individual countries. Bank loans are reported in their nominal value while portfolio equity must be recorded in market value. Therefore, without looking at the actual values of foreign liabilities or holdings, the easiest value to observe is the valuation of equity which is listed on the stock market. Given that a country sells its portfolio equity to foreign investors, the domestic stock market index can reflect changes in a country's liabilities towards these investors. If those changes in valuation were stabilising in the post-crisis period, a country that accumulated more net foreign liabilities during the crisis would experience a relative bigger decrease in their stock market, thus reducing liabilities to foreign investors and improving the overall net international investment position. This is what we can observe in Figure 2.5: surplus countries such as Germany, Japan, or Switzerland experienced an overall gain in their stock market in the post-crisis period. Thus, the value of their liabilities rose which represents a valuation loss. The contrary happened in countries with high net foreign liabilities such as Iceland and Greece where the stock market dropped relatively more in the years over the crisis.

At this point, the relative share of portfolio equity is also worth mentioning. Table 2.1 shows that the importance of this asset class measured as a percentage of total assets and total liabilities grew significantly. This is especially the case for emerging and developing countries where the share of portfolio equity liabilities increased by around 600% to almost a quarter of total liabilities in the 20 years proceeding the crisis. Based on findings by Catão and Milesi-Ferretti (2013) and Calvo et al. (2004) who find only foreign debt instruments to be a significant predictor for crises, I argue that this shift to equity funding put emerging and developing countries in a relatively better position when the crisis hit in 2007.

2.1.4 Empirical Analysis

In this subsection, I analyse the behavior of capital flows and the stock-flow adjustment in the post-crisis period and how they contributed to the increasing divergence of the net

omissions which contains statistical discrepancy resulting from imperfections in source data and compilation of the balance of payments accounts.

international investment position.

2.1.4.1 Data and Sample

I use estimates of foreign assets and liabilities and their asset classes from an extended version of the External Wealth of Nations dataset (Lane and Milesi-Ferretti, 2001, 2007). The estimates are based on stock measures, supplemented by cumulative capital flows including appropriate valuation adjustments. Therefore, the estimated stock positions for equity and foreign direct investment based on flow data are adjusted to reflect the effect of exchange rates and changes in market prices. For flow measures, I use the Balance of Payments Statistics of the International Monetary Fund. Data on the current account are drawn from the April 2016 database of the World Economic Outlook, stock market data are drawn from the World Bank database, and Central Bank Policy Rates are obtained from Reuter's Datastream.

There are several limitations concerning data on capital flows. First, Balance of Payments data on flows are not available on the level of asset classes for all the 60 countries of the sample.[9] Another well known caveat is "round tripping" where flows from one country to another may just be part of a chain of transactions. Investors might want to channel his investment abroad through a third country or even make a domestic investment involving cross-border intermediaries (Zucman, 2013). If a transaction is only recorded by one side, this might increase the errors and omissions of the BOP. Finally, with these data sources, sectoral data is missing or incomplete. This would be a valuable addition to this analysis as the consequences of valuation gains or losses can have different implications depending on the holding sector of the asset. While banks (or other leveraged institutions) could generate amplification effects, this is not likely to be the case for poorly connected investors.

I use a sample of 60 advanced and developing countries (see Appendix C). Oil exporters are excluded due to the strong dependence of their trade balance on oil. Also, very small countries are excluded as their current accounts are strongly influenced by transfer payments, debt forgiveness, and other irregularities. I exclude Iceland due to its extreme stock-flow adjustment. While the mean stock-flow adjustment of the sample is around 3 % of 2013 GDP, Iceland experienced valuation losses of over 240% of 2013 GDP in the post-crisis period.[10] As a final step, I exclude Hong Kong and Singapore as major financial centers with outlier values for their net international investment positions. Lane and Milesi-Ferretti (2014) argue that the measurement error is more likely to be a significant contributor to the stock-flow adjustment term for international financial centers considering the high ratios of gross foreign assets and liabilities to GDP.

[9] I run all regressions with the largest available sample. For robustness, I also re-run the regressions with the smallest available sample within different specifications of a regression but results do not change.
[10] Due to this very extreme value, regression results are not robust to the exclusion of Iceland.

2.1.4.2 The Driving Forces of the Divergence of the Stock Positions

While the recent contraction of flow imbalances is well documented (WEO, October 2014), I analyse the increasing divergence of the net international investment position (see Figure 2.2). The first question is the break down in equation (1): whether flow imbalances or the stock-flow adjustment was driving the growing divergence of net international investment positions in the post-crisis period. The most intuitive way to test this correlation is to see whether post-crisis flows and stock-flow adjustment are positively or negatively correlated to the pre-crisis stock position:

$$CumFlows_{i,0813} = \alpha + \beta_{Fl} NIIP_{i,07} + \epsilon \tag{2.8}$$

where $CumFlows_{0813}$ is the cumulated capital flows in the years 2008-2013 divided by nominal GDP in 2013 and $NIIP_{07}$ is the pre-crisis net international investment position in percent of GDP.[11] A $\beta_{Fl} > 0$ would mean that flows are causing further divergence in stock positions. This might be due to the fact that flow imbalances contracted but in the absence of significant stock-flow adjustment a reversal would be needed for imbalances to decrease. On the other hand, $\beta_{Fl} < 0$ would mean that capital flows reversed across countries, thereby stabilising the net international investment position.

To look at the stock-flow adjustment, I estimate

$$SFA_{i,0813} = \alpha + \beta_{SFA} NIIP_{i,07} + \epsilon \tag{2.9}$$

where SFA_{0813} are cumulated stock-flow adjustments from 2008 - 2013 divided by nominal GDP in 2013. While capital flows are recorded directly by the Balance of Payments Statistics, I can derive the stock-flow adjustment from equation (3):

$$SFA_{i,0813} = (NIIP_{i,13} - NIIP_{i,07}) - \sum_{08}^{13} Flows_i \tag{2.10}$$

Again, I want to point out that SFA hereby also captures the "residual" (see OTH in equation 5) which contains for instance new measurement techniques, data revisions, or reclassifications. A subdivision of those two components is only published for Australia and the United States for my time period which is why empirical work has been scarce so far.[12] There is empirical work on the foreign position of the United States where the "residual adjustment" in OTH_t are analyzed separately from capital gains (Gourinchas and Rey, 2007; Lane and Milesi-Ferretti, 2009; Curcuru et al., 2007). However, I deliberately want to adopt a

[11] As mentioned before, I use the years 2008-2013 as I find the current account adjustment in the post-crisis to peak in 2013. Results of this extension of work by Lane and Milesi-Ferretti (2012, 2014) are available upon request.

[12] The Euro Area reports data for the years after my sample period (starting in 2013).

broader approach by examining the dynamics of the stock-flow adjustment in the post-crisis period in the cross-sectional dimension. As there is no existing evidence that the residual might drive an overall effect of stock-flow adjustment through a specific pattern, the natural interpretation of the total effect can be a change in valuation.[13]

Regarding the regression in equation (9), I can find international risk sharing through the net international investment position if $\beta_{SFA} < 0$ so that the countries with the largest net foreign liabilities experienced the largest positive stock-flow adjustment. At this point, I want to point out that this is a descriptive analysis of correlations. The risk sharing obtained through the stock-flow adjustment is consistent with some international risk sharing from endogenous prices so I stop well short of doing any analysis of causality.

We can find the results in Table 2.2. Column (1) applies to the flow dimension: the positive correlations shows that countries with the highest net international investment position in the pre-crisis period also experienced the highest positive flow imbalances in the post-crisis period. This causes further divergence of international stock positions. In line with existing literature, I have used the current account as a measure for flows. However, there are also reasons to use the financial account as it is a more direct measure of capital flows, i.e. cleaned for *EO*. Therefore, as a robustness test, I also use the financial account as a measure for flows in column (3) and the coefficient remains highly significant. In terms of magnitude, the coefficient in column (1) means that a country with a 1 percent higher net international investment position in 2007 experienced higher capital outflows in the amount of 0.48 percent of 2013 GDP in the post-crisis period.

In column (2) we can see that stock-flow adjustment overall worked in a stabilising direction which confirms the hypothesis about international risk sharing through the net international investment position: countries with the highest net international investment position experienced the lowest capital gains. In terms of magnitude, countries with a 1 percent of GDP lower net international investment position in 2007 experienced on average a 0.23 percent of 2013 nominal GDP higher capital gains. Again, the coefficient remains significant using the financial account in column (4).[14]

The differences using the financial or the current account might let us derive a pattern for the term "errors and omissions". The effect of stock-flow adjustment is greater and more significant if I use the current account instead of the financial account. This means that "errors and omissions" might be - on average - negative for surplus countries and positive for deficit countries. Figure 2.6 shows that this is the case for the sample where I split surplus and deficit countries. The image is in line with findings by Lane and Milesi-Ferretti (2007) and Zucman (2013) and might reflect unrecorded capital flows.

[13] In addition, Lane and Milesi-Ferretti (2009) argue that the residual is unlikely to reflect mismeasured capital gains which is reassuring concerning my approach.

[14] For robustness, we also divide the flows and stock-flow adjustment by the nominal GDP of other years to make sure the result is not driven by levels of nominal GDP in 2013. However, the finding that the divergence of stock positions is driven by flow imbalances while stock-flow adjustment is stabilising remains significant.

In Table 2.3 I want to make sure the results are not driven by specific country groups or might even be contrary for subsamples. I split into countries with floating and pegged exchange rate regimes (column 2 and 3) as the latter group is restricted in individual monetary policy on country level which could contribute to capital gains through the exchange rate channel. In addition, I have pointed out that the composition of the net international investment position of advanced and emerging countries is considerably different which is why I split the group accordingly in column (4) and (5). However, the coefficient has the expected sign for all subsamples and the effect turns out to be most significant for the entire sample (column 1).

Robustness We purposely used this univariate regression as it is not the purpose of this paper to describe everything that influenced flows and stock-flow adjustment. More so, I want to establish patterns of correlations for the post-crisis period which I consider important for macroeconomic stability. However, to make sure those correlations are not purely driven by other factors, we include the real GDP growth, the change in the stock market, and the change in the central bank policy rate in the regressions as a robustness test (see Appendix A, Tab 1). However, with those controls, the significance of the coefficients remains at almost identical levels which is reassuring regarding the robustness of the correlations.
In addition, I want to test whether the composition of a country's portfolio might drive the overall valuation effect. Therefore, we look at correlations of each asset class as a ratio of the gross position. However, I show that none of the relative shares of each asset class in 2007 are significantly related with the subsequent stock-flow adjustment.[15]

2.1.4.3 Analysis of Individual Asset Classes

Regarding stabilising effects of returns on the NFA, Darvas and Huettl (2017) call for more research on the drivers of this mechanism. In this subsection, I want to see which types of assets drive the stabilising effect of the stock-flow adjustment. Again, I measure this by subtracting the flow from the change in the stock position of each asset class. This is especially important since the literature has pointed out significant differences between asset classes and implications of their imbalances (e.g. Rogoff, 1999 and Lane and Milesi-Ferretti, 2001b). At a first glance, in Table 2.4, we can see that all asset classes have the expected sign except for reserves. Countries with the highest net international investment position also experienced the highest capital gains from reserve assets. This is driven by European surplus countries: above all, Switzerland, followed by Scandinavian countries and Germany. Also China, as a main creditor, has received capital gains from reserves. This effect is most likely due to the appreciation of the USD, especially in the first two years after the crisis. However, reserves show the smallest coefficient among the significant classes and the effect is outweighed by the stabilising effect the equity components the net international investment position. In the

[15] Due to space constraints, results are available upon request.

following, I describe the mechanism behind the effect of these significant asset classes.

2.1.4.4 Other Investment

I do not find a significant effect for this asset class which contains everything that does not belong to the other categories, i.e. other equity, currency and deposits, loans (including IMF credit), life and non-life insurance (reserves), trade credit and advances, SDR allocations, and other accounts receivable/payable.[16] In Figure 2.7, we see the composition of this asset class when the crisis hit in 2008.[17] I offer several explanations as to why I think that this asset class did not contribute to the stabilizing effect of the changes in valuation. First, we can see that the biggest part of this asset class are loans in the form of traditional credit (including IMF loans) and currency and deposits. Together with other accounts payable/receivable, those belong to the group of nonnegotiable instruments which means that the registered value is the nominal value of an asset, not adjusted for expected losses or for changes in interest rates.[18] This implies that the nominal value we have can only be reduced by write-offs, restructuring, or debt forgiveness which happens less frequently than changes in valuation of other asset categories, such as portfolio equity. Furthermore, parts of these loans are not even subject to debt forgiveness due to regulation or bilateral agreements. For instance, some country programs during the crisis, such as the one in Greece, prohibits a write-off of loans from creditors, such as the IMF. Secondly, another factor that could influence a change in the value of non-negotiable instruments is the exchange rate. For example, if the USD appreciates and country holds bank loans in USD, e.g. most of the emerging countries in the sample, this would be a valuation loss as their liabilities increase in value. If this mechanism were at play, then I should find a significant effect for countries which can adjust their exchange rate freely. This is what we can see in Table 2.5. While pegged countries show a significant destabilizing effect, floating countries are in line with the overall stabilizing role of stock-flow adjustments.

2.1.4.5 Portfolio Equity

Portfolio equity includes cross-border equity securities other than foreign direct investment or reserves. In contrast to other investment, the valuation of those securities is at market and not at nominal value. This is straight forward for listed portfolio equity securities where market prices can be obtained from the stock market. When the security is not listed, an estimation has to be made. This can be e.g. the recent transaction price, a discount of future profits, or a derivation from the company's net asset value at market price. It seems clear that changes in the valuation of securities can influence the value of stocks considerably. The

[16] SDR holdings are included in reserve assets

[17] For a reference, this asset class represented on average 30 percent (32 percent) of total assets for advanced (emerging) and 35 percent (40 percent) of total liabilities for the countries in the high quality sample (Appendix C).

[18] This method is influenced by concerns about data availability and consistency in reporting.

crucial question therefore is whether these dynamics contribute to international risk sharing. The significant coefficient for portfolio equity in Table 2.4 shows that this is the case for the post-crisis period. Therefore, stock-flow adjustment moved in a stabilising direction: countries with the lowest net international investment position experienced the greatest valuation gains from portfolio equity.

Due to its potential for international risk sharing, I look at this pattern more closely. The first question is whether this effect comes from gross assets or gross liabilities. This is especially interesting in the case of portfolio equity as liabilities are issued on the domestic stock market while assets can be bought abroad. Therefore, assets could contribute to the stabilising effect through the exchange rate mechanism. If the domestic currency depreciates in a crisis, assets denominated in foreign currency will appreciate relatively. On the other hand, if a crisis comes with a significant decrease in the stock market, the risk can be shared with foreign creditors through a decrease in the value of liabilities. Table 2.6 shows that the latter was the case in the recent crisis: liabilities significantly contributed to the stabilising stock-flow adjustment of portfolio equity overall, e.g. countries with the highest (lowest) net international investment position experienced the greatest valuation losses (gains) from portfolio equity liabilities.

However, this effect can come from two facts: (1) portfolio equity experienced a relatively homogeneous overall decrease in its value and countries with larger deficits simply issued relatively more liabilities or (2) countries with lower net international investment position experienced a greater decrease in their domestic stock market. In Figure 2.9, we can see that the latter is the case. The left graph shows that the absolute amount of portfolio equity liabilities (as a ratio of nominal GDP) seems to be unrelated to valuation gains in the post-crisis period. This indicates heterogeneous stock market movements during this period. The graph on the right confirms that the stabilising stock-flow adjustment from portfolio equity liabilities was driven by movements in prices of portfolio equity securities on the domestic stock market.

Summing up my findings so far, we can see that the stabilising effect from stock-flow adjustment from portfolio equity overall came from a relatively greater decrease of the stock market in the post-crisis period in countries with bigger net foreign liabilities. This indicates that portfolio equities, especially liabilities, can contribute significantly to international risk sharing which is in line with findings for earlier periods by Schmitz (2010).

With these facts in mind, I want to proceed by having a closer look at the stock market. The literature suggests that portfolio equity (alongside with foreign direct investment) is the main asset category through which cross-country risk sharing takes place (Kose et al., 2007).[19] For this analysis whether international equity holdings acted as a (consumption) risk sharing device during the crisis, I want to follow the approach of Schmitz (2010) and Bracke and

[19] Data on portfolio equity are rather reliable and robust which was also an essential reason for the literature to focus on this category.

Schmitz (2011). Therefore, as a first step, I test if capital gains on the domestic stock market moved in a pro-cyclical direction in the post-crisis period. This is the prerequisite for foreign portfolio equity liabilities to provide the potential for hedging against domestic output and wealth fluctuations, i.e. the value of foreign liabilities would decrease in times of an economic downturn. For the high-quality sample, I estimate

$$\Delta StockMarket_{i,0813} = \alpha + \beta \Delta realGDP_{i,0813} + \epsilon \tag{2.11}$$

where $StockMarket_{i,0813}$ is the log change of the domestic stock market index and $\Delta realGDP_{i,0813}$ is the log change of the domestic real GDP, both over the period from 2008 to 2013. We can see in Table 2.7 that those variables are highly positively correlated, i.e. capital gains on the stock market are significantly pro-cyclical. In the first two columns, real GDP growth in USD is used while in column 3 and 4, I used the growth of real GDP in domestic currency to make sure the effect is not driven by the bilateral exchange rate with the USD. This is in line with the findings by Schmitz (2010) who tested this relation up to 2006. While it did not hold for the short-term (using yearly data), it was significant for the medium term.[20] As I find this pattern also for the post-crisis period 2008-2013, the necessary cyclical properties of the stock market are satisfied in order to generate economic or wealth stabilization through foreign positions as described above.[21]

As a second step, I test if stock-flow adjustment from foreign portfolio equity contributed to international risk sharing within this pattern. If this is the case, stock-flow adjustment should be significantly negatively correlated with real GDP growth relative to the world average. Following Bracke and Schmitz (2011), I look at the following correlation[22]:

$$SFA^{PEQ}_{i,0813} = \alpha + \beta \Delta realGDP_{i,0813} + \epsilon \tag{2.12}$$

where $SFA^{PEQ}_{i,0813}$ is the stock-flow adjustment of portfolio equity and $\Delta realGDP_{i,0813}$ is the log change of the domestic real GDP in USD. In Table 2.8, we can see that overall, stock-flow adjustment from foreign net portfolio equity holdings improved international risk sharing as countries with the relatively smallest real GDP growth experienced the greatest positive valuation gains. We can also see that this is driven by the portfolio liabilities (i.e. the domestic stock market) rather than by assets which is in line with the findings above.[23]

Running this regressions for specific country groups, I find that the risk sharing through

[20] Cumulative 5-year rates of financial market capital gains and real GDP growth.

[21] To make sure results are not driven by extreme values of real GDP growth, I exclude China from the regression but results remain unchanged.

[22] Schmitz used annual real rate of capital gains on the respective domestic stock whereas I use the (log) change in the actual stock market index from International Financial Statistics (International Monetary Fund)

[23] In 2.9 we can see that Switzerland and Finland are outliers in terms of stock-flow adjustment from portfolio equity. However, excluding those observations from the regressions above I obtain almost identical results in terms of size of the coefficient as well as level of significance.

foreign portfolio equity is not significant for emerging and developing countries. This is in line with Bracke and Schmitz (2011) and also with Kose et al. (2007) who finds that emerging countries were completely shut out of the benefit of risk sharing through foreign positions up to the crisis.[24] Within this group, even countries that experienced large increases in international capital flows have been unable to enjoy the risk sharing benefits of financial globalisation. The authors suggest that this is due to the relatively stronger effect of portfolio debt for those countries which cannot be shown to be stabilising. On the other hand, risk sharing through the portfolio equity market in the euro area shows to be the strongest. I argue that international risk sharing is especially important for the functioning of the currency union because monetary policy is unable to address asymmetric shocks.[25]

2.1.4.6 Foreign Direct Investment

This asset class is often analyzed in combination with portfolio equity securities as they together form the equity share in a country's net foreign assets. Equity investment is considered direct investment if ownership of 10 percent or more of the voting power in an enterprise is obtained by a foreign investor. From a macroeconomic point of view, it should therefore create more stable and long-lasting links between economies than portfolio equity. However, it is also the most problematic series from the point of view of measurement as some countries report it at book value while others report it at market value (International Monetary Fund, 2003).[26] As most securities are not traded at the domestic stock market, the link of the valuation of foreign direct investment and the domestic stock market index is not as direct as for portfolio equity.[27] In addition, Blanchard and Acalin (2016) add concerns based on counterintuitive stylized facts looking at FDI data from the BOP. Most importantly, inflows and outflows are highly correlated, even at high frequencies. This raises the question why a domestic investors would want to invest more abroad while their own country is perceived as relatively more attractive by foreign investors. Combining this finding with data on existing tax treaties, the authors suggest that "measured" FDI flows may merely reflect flows through rather than to the country in some cases. This has crucial implications for policy makers. In addition, it makes findings based on BOP measured FDI hard to interpret.

However, despite those caveats, we assume that (the largest) part of FDI should still be intended to serve as a final investment where decisions are based on economic long-run factors. When I split the net position in gross assets and liabilities, we can see that the

[24] They find a stabilising pattern for portfolio equity for 1970 - 2005 but significantly weaker for emerging and developing countries.

[25] These results are robust when I use the real GDP growth in national currency.

[26] As for every category, I use data from the extended version of the External Wealth of Nations (Lane and Milesi-Ferretti, 2007) Thereby, existing stock estimates are complemented with cumulative flows, with valuation changes designed to capture shifts in relative prices across countries.

[27] For instance, an increasingly important component is foreign property investment (Lane and Milesi-Ferretti, 2007)

stabilising effect is again driven by gross liabilities (see table 2.6). However, the mechanisms behind the stock-flow adjustment from direct investment liabilities seem to be different from portfolio equity. Again, the stabilising effect can come from two factors: (1) direct investment experienced a relatively homogeneous overall decrease in its value and deficit countries issued relatively more liabilities or (2) the value of direct investment decreased relatively more in deficit countries. While the latter is the case for portfolio equity, the first seems to be the pattern for foreign direct investment. The mean as well as the median of stock-flow adjustment of liabilities is significantly negative which means that on average, the value of direct investment decreased across countries. This is stabilising for countries with larger liabilities which means that deficit countries can generate relatively more valuation gains simply by issuing relatively more direct investment equity. The left graph in Figure 2.10 shows that the the amount of stabilising stock-flow adjustment from foreign direct investment liabilities is significantly related to the amount of liabilities held in relation to GDP. Although this hints more to a "magnitude effect" more than a pro cyclical valuation effect from prices of foreign direct investment, it still contributes to consumption risk sharing (see right graph in Figure 2.10, regression output see Table 2.9).

Summing up the analysis of the different asset classes, I conclude that the findings about the post-crisis period are clearly in line with the literature. I show that the stabilising stock-flow adjustment was driven by equity component of net invernational positions. Thereby, pro-cyclical movements of domestic stock markets enabled stabilising valuation movements through portfolio equity liabilities. This means that countries with lower growth in output experience a relatively greater devaluation of their debt towards foreign creditors. The findings therefore emphasize the potential of the domestic stock market to contribute to international risk sharing through foreign investors.

On the other hand, I do not find a stabilising valuation effects of the debt components. This is intuitive as most values, such as bank loans, are non-negotiable which implies that only write-offs and restructuring can cause a significant change in the prices of this asset class. Furthermore, I look at potential role of the exchange rate for this asset class. The results show that the insignificant finding is caused by countries with an exchange rate peg which even show a destabilising pattern for valuation effects of debt. This calls for more attention of policy makers to possible limitations of a pegged exchange rate regime.

2.1.4.7 Magnitude of the Effect

As a last step of the empirical analysis, I want to show how big effects were for each individual country. I first calculate a "counterfactual" net international investment position for 2013 which should reflect the value if there had not been any stock-flow adjustment in the post-crisis

period:

$$\text{NIIP } Counterfactual_{i,13} = (NIIP_{07} + \sum_{08}^{13} Flows_i) \tag{2.13}$$

where $\sum_{08}^{13} Flows_i$ is the sum of the current accounts of the years 2008-2013.[28] From this, I take the difference to the actual net international investment position to calculate the stock-flow adjustment:

$$SFA_{i,0813} = NIIP_{i,13} - \text{NIIP}Counterfactual_{i,13} \tag{2.14}$$

Table 2.10 shows an excerpt from the results. Going straight to the magnitude of stock-flow adjustment in column (3) and (4), we can see that absolute effects as well as values in percent of GDP are economically significant. For instance, Greece experienced the highest valuation gains in terms of GDP of almost 60% whereas in absolute terms, Canada experienced the largest valuation gains of USD 450 billion. On the other hand, Germany experienced valuation losses of almost USD 700 billion (over 18.5 % of GDP) from 2008 - 2013. As Greece and Canada are debtor countries while Germany is a creditor country, I argue that a stock-flow adjustment of this size helped to stabilize the net international investment position significantly.

With the equations above, I can also look at the "Counterfactual $NIIP_{2013}$" which I construct with equation 13. In column (2), we can see the values as a percentage of 2013 GDP. The European Commission Macroeconomic Imbalances Procedure considers net international investment positions above 35% of GDP as a major source of macroeconomic imbalances. I note that without valuation gains, Italy would be far above the threshold of the European Commission Macroeconomic Imbalances Procedure. In the same manner, Germany would have experienced a NIIP of 51% of GDP as opposed to 34.6% which would have also activated the monitoring by the European Commission.[29]

Therefore, I suggest that the accumulation of net foreign imbalances was significantly decelerated by the stabilising effect of changes in valuation while the continuing divergence in stock positions was driven by cross-border capital flows. Absent stock-flow adjustment, some countries would have (more) alarming levels of their net international investment positions.

2.1.5 Conclusion

In this paper, I analyse the divergence of the net international investment position accompanying the stark current account adjustment in the post-crisis period. As a first step, I find that the increasing divergence is driven by remaining flow imbalances. Although current accounts

[28] I do the same with the financial account but non of the results change significantly.

[29] Macroeconomic Imbalances Scoreboard of the European commission: `https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/macroeconomic-imbalance-procedure/scoreboard_en`

are below pre-crisis levels, only very few countries have reversed their current account so that external debt or credit could have been reduced.

On the other hand, I find a significant effect of changes in valuation. In contrast to flow imbalances, these went into a stabilising direction: countries with the lowest net international investment position experienced the highest valuation gains while creditor countries such as Germany experienced significant losses through the valuation of their foreign assets. I suggest that without these capital gains and losses, stock imbalances would be at significantly higher levels.

Anlaysing this effect of valuation further, I look at asset classes separately. The empirical results show that the stabilising effect of changes in valuation was exclusively driven by the equity component of net international investment positions. In contrast to the debt components, portfolio equity is recorded at the market price of a security where values can change significantly. Within this asset class, I find that the stabilising effect comes from gross liabilities, i.e. the domestic stock market. A relatively greater decrease of the stock market in countries with a more negative net international investment position significantly contributed to international risk sharing. For foreign direct investment, its value decreased across countries so that countries with a greater absolute amount of gross liabilities experienced relatively more gains from valuation. As this is the case for countries who also experienced the smallest relative real GDP growth in the post-crisis period, portfolio equity and foreign direct investment improve consumption risk sharing.

This paper contributes to a better understanding of cross country links that emerged with increasing financial integration in the last two decades. With changes in valuation moving in an overall stabilising direction during the recent global financial crisis, the question remains whether countries can "engineer" capital gains and hence actively improve international risk sharing through their foreign stock positions.

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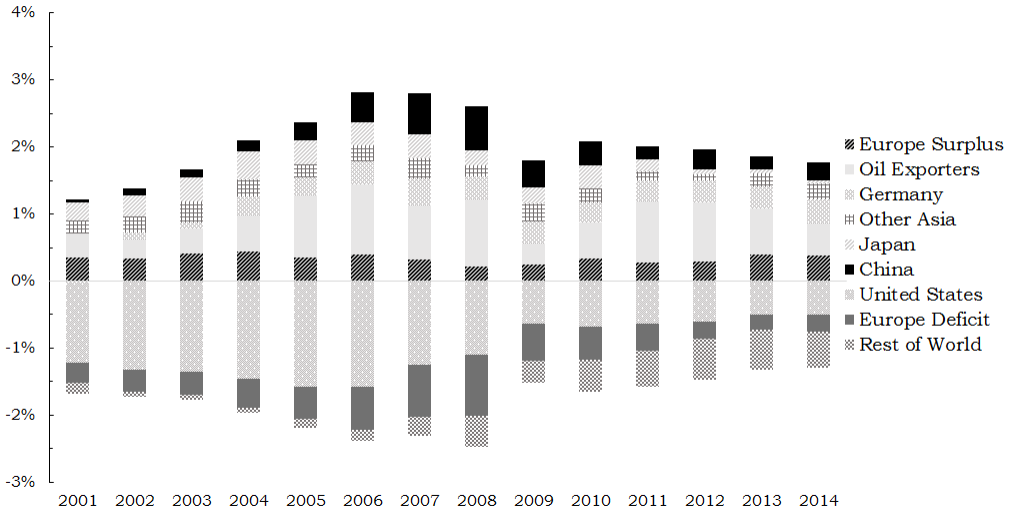
2.1.6 Figures

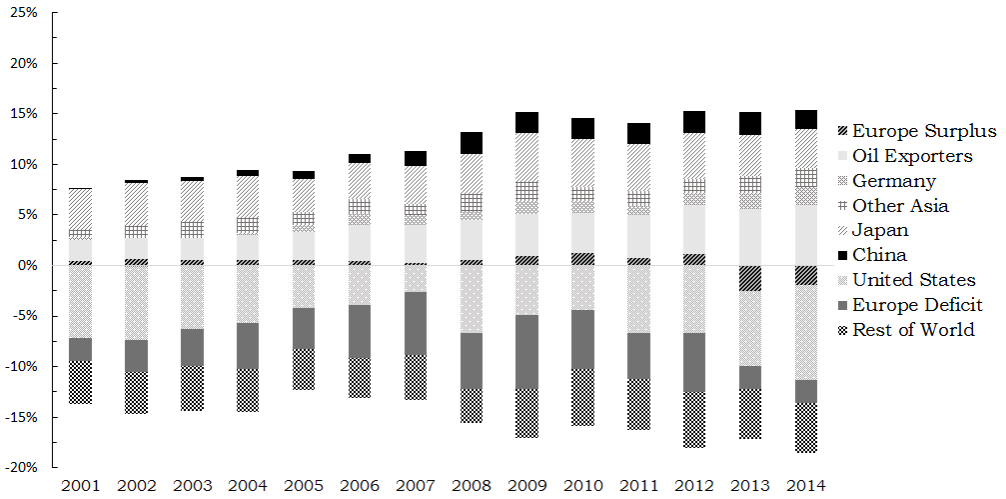
Figure 2.1: Evolution of Flow Imbalances



Current Account in Percent of World GDP; Author's calculations;
Data Source: WEO April 16 database

Note: Oil exporters = Algeria, Angola, Azerbaijan, Bahrain, Bolivia, Brunei, Darussalam, Chad, Republic of Congo, Ecuador, Equatorial Guinea, Gabon, Iran, Kazakhstan, Kuwait, Libya, Nigeria, Norway, Oman, Qatar, Russia, Saudi, Arabia, Trinidad and Tobago, Turkmenistan, United, Arab Emirates, Venezuela, Yemen; Other Asia = Hong Kong SAR, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan Province of China, Thailand. European economies (excluding Germany and Norway) are sorted into surplus or deïňĄcit each year by the signs (positive or negative, respectively) of their current account balances.

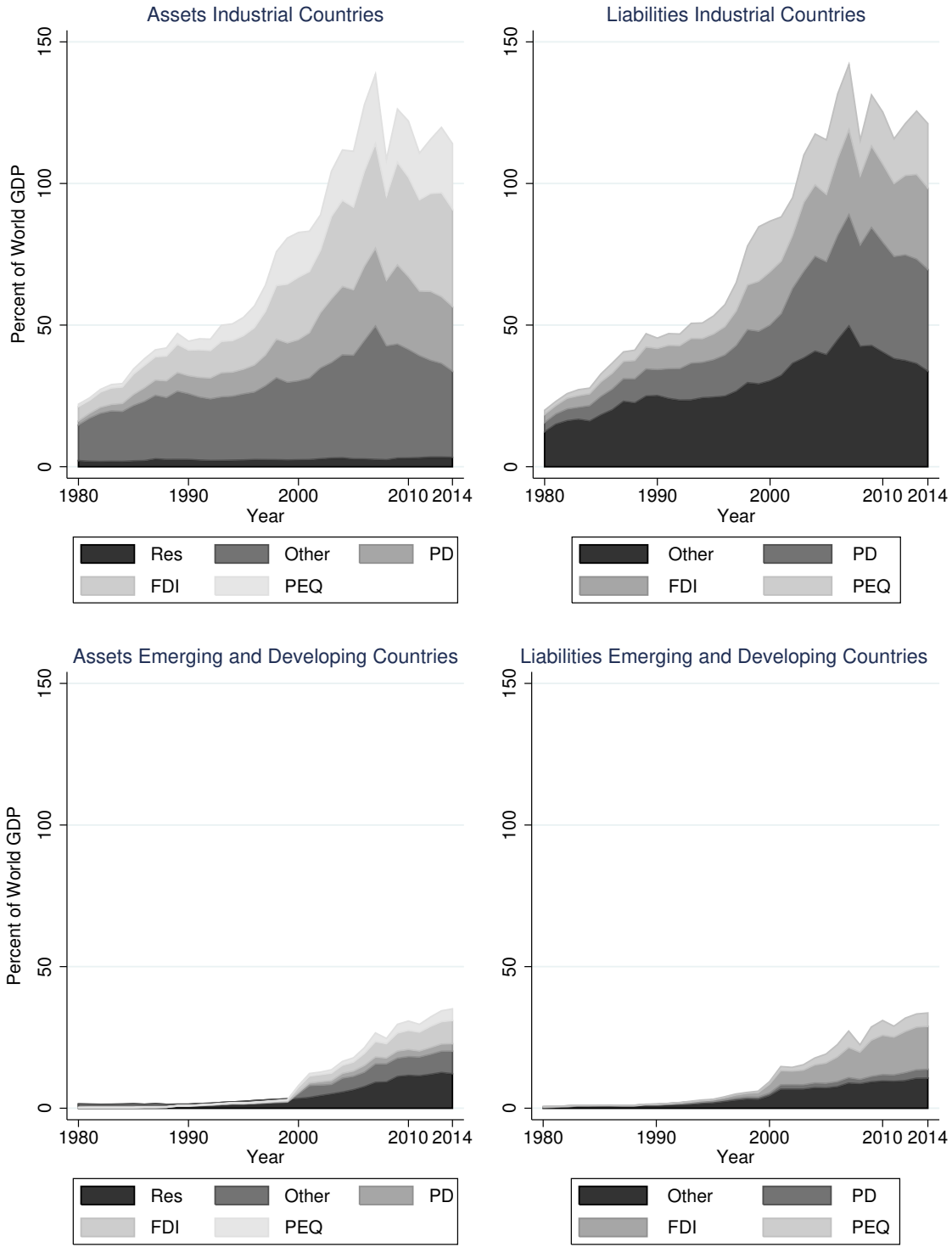
Figure 2.2: Evolution of Stock Imbalances



Net International Investment Position in Percent of World GDP; Author's calculations; Data Source: EWN (Lane and Milesi-Ferretti, 2007)

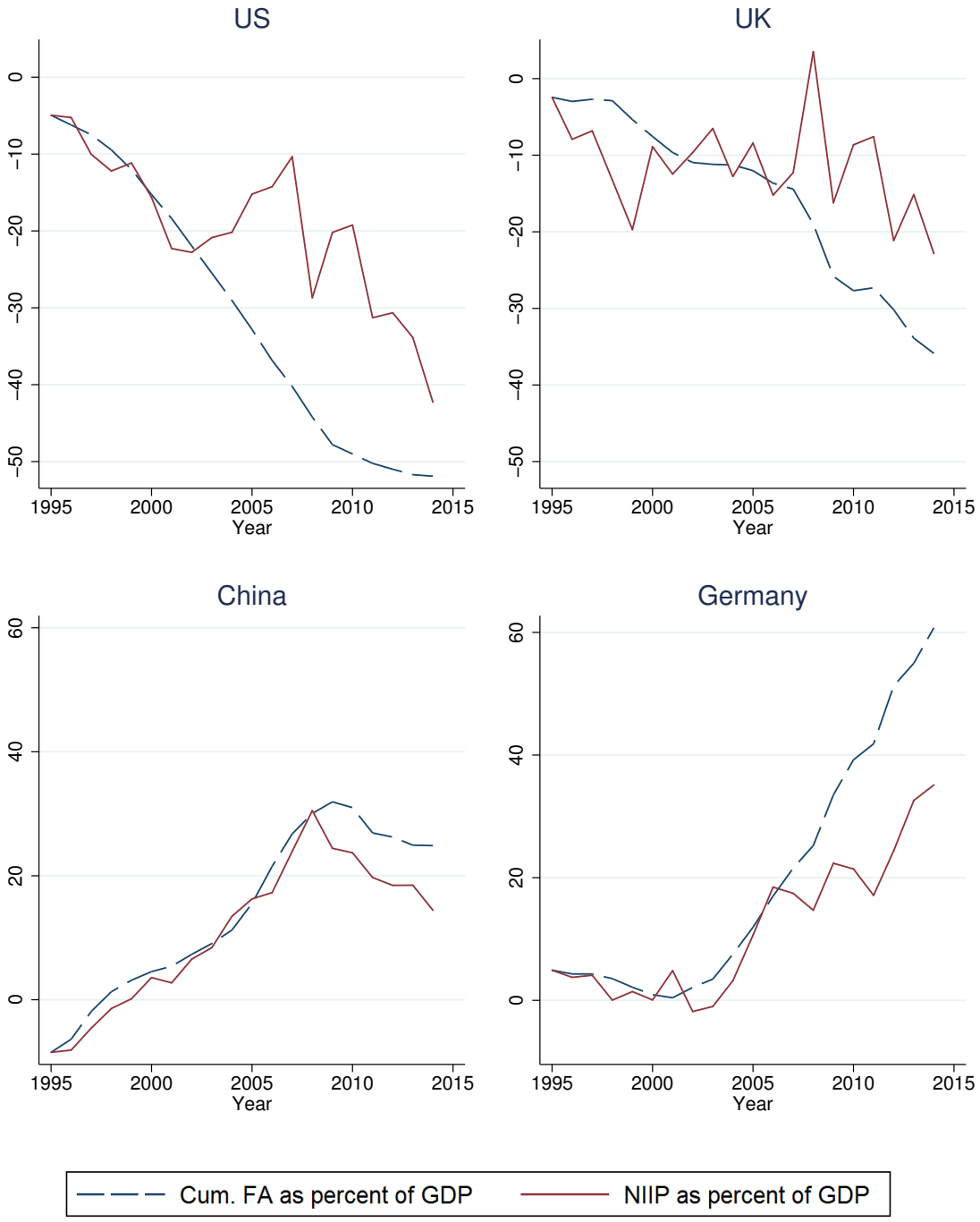
Note: Country groups as in Figure 1

Figure 2.3: Evolution of Gross International Investment Positions by Asset Class



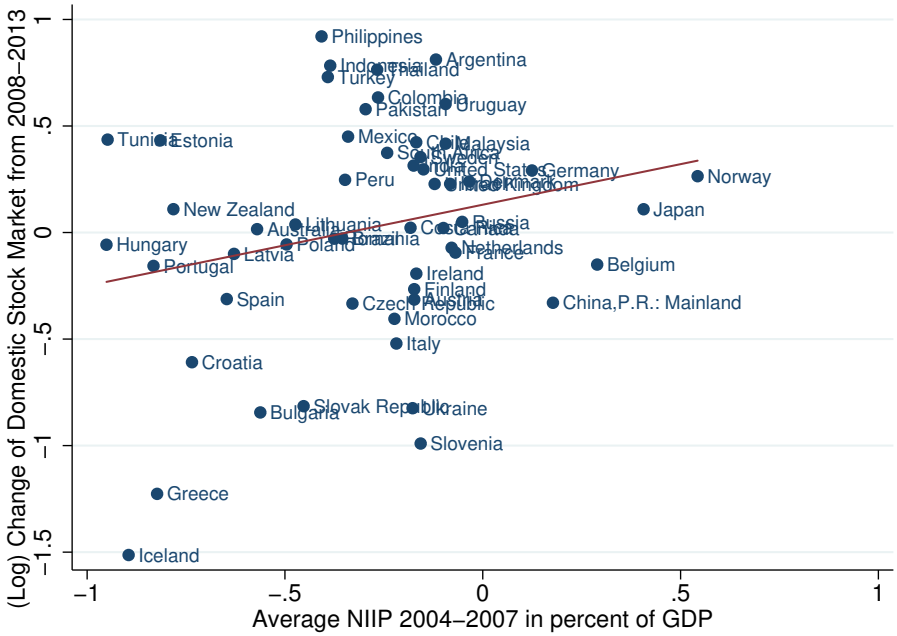
Author's calculations; Data Source: External Wealth of Nations Sample see Appendix B. Abbreviations are as follows: *Other*: Other Investment;*PD*: Portfolio Debt; *PEQ*: Portfolio Equity; *FDI*: Foreign Direct Investment; *Res*: Reserves;

Figure 2.4: Net International Investment Position vs. Cumulative Financial Account



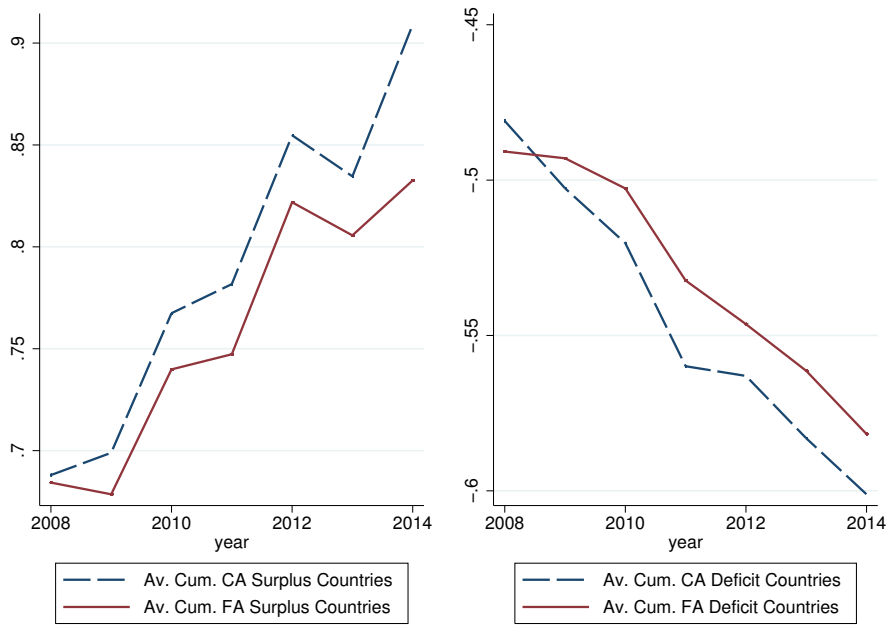
Author's calculations; Data Source: External Wealth of Nations The cumulative flow positions are calculated as the net international investment position in 1995 plus the financial account in the years following up to 2014.

Figure 2.5: Net International Investment Position and the domestic Stock Market



Author's calculations; Data Source: External Wealth of Nations, Reuter's Datastream.
The cumulative flow positions are calculated as the net international investment position in 1995 plus the cumulative flows in the years following up to 2014.

Figure 2.6: Average cumulated Current Account and Financial Account for Deficit Countries



Author's calculations; Data Source: External Wealth of Nations, Balance of Payments Statistics

Sample see Appendix C. Surplus (Deficit) countries are countries with a positive (negative) net international investment position in the corresponding year. Average is unweighted.

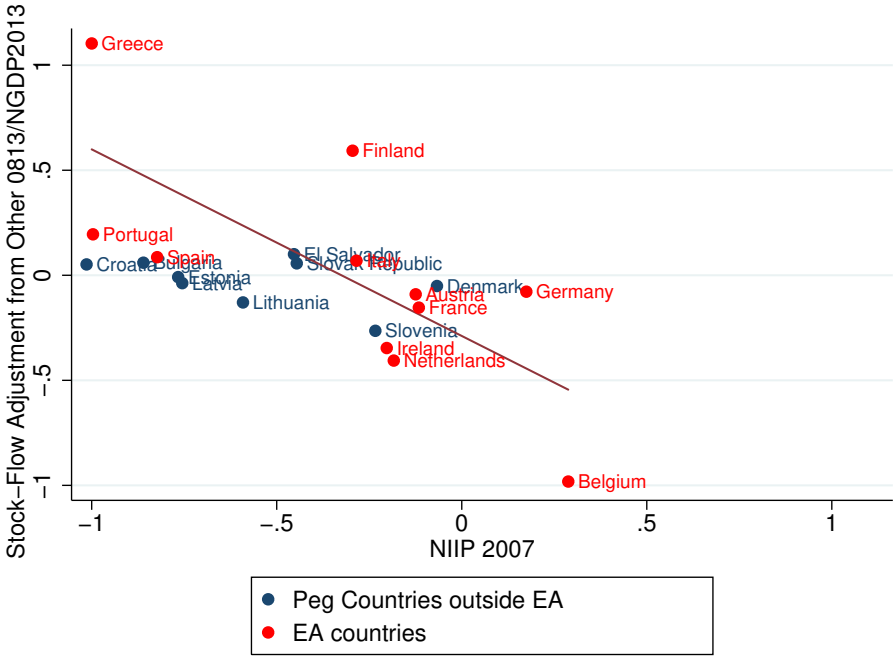
Figure 2.7: Composition of Other Investment Position in 2008

Composition of Other Investment Position in 2008.

Author's calculations; Data Source: External Wealth of Nations, Balance of Payment Statistics

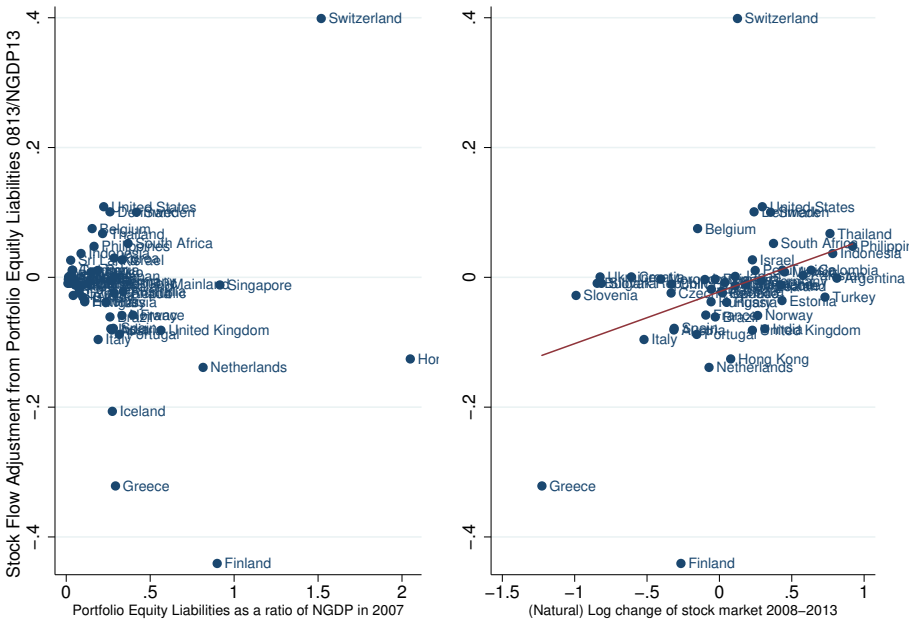
Sample see Appendix C.

Figure 2.8: Stock-Flow Adjustment from Other Investment in (floating Exchange Rates)



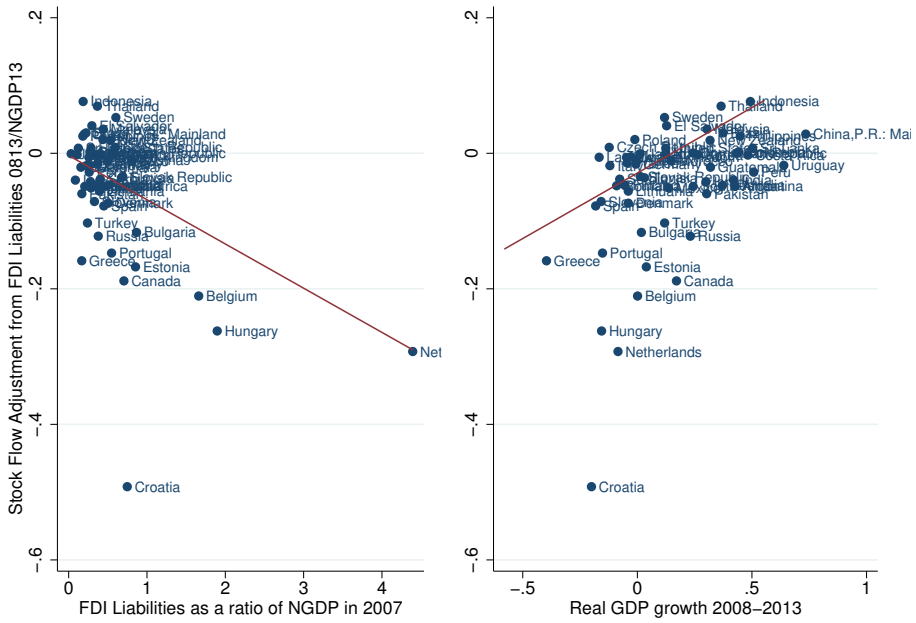
Author's calculations; Data Source: External Wealth of Nations
Sample see Appendix C.

Figure 2.9: Stock-Flow Adjustment from Portfolio Equity Liabilities



Author's calculations; Data Source: External Wealth of Nations, World Bank Database
Sample see Appendix C.

Figure 2.10: Stock-flow Adjustment from Foreign Direct Investment Liabilities



Author's calculations; Data Source: External Wealth of Nations
Sample see Appendix C.

2.1.7 Tables

Table 2.1: Share of Portfolio Equity

	Year	PEQ Assets % of Total Assets	PEQ Liabilities % of Total Liabilities
Advanced	1987	6.11 %	7.56%
Advanced	1997	14.73 %	14.56%
Advanced	2007	16.69 %	14.59%
Emerging and Developing	1987	2.45%	4.64%
Emerging and Developing	1997	4.76%	12.01%
Emerging and Developing	2007	7.01%	26.98%

Weighted Average of Country Sample see Appendix B (High Quality Sample)
Data Source: External Wealth of Nations .

Table 2.2: Flows and Stock-Flow Adjustment 2008-13 as a Ratio of NGDP 2013

	(1) CA	(2) SFA CA	(3) FA	(4) SFA FA
NIIP 2007	0.43***	-0.23***	0.37***	-0.17**
	(6.97)	(-3.64)	(6.31)	(-2.57)
Constant	0.06*	-0.04	0.03	-0.02
	(1.74)	(-1.24)	(1.16)	(-0.70)
Observations	60	60	60	60
Adjusted R^2	0.45	0.16	0.39	0.12

FA and CA are the cumulated Financial Account and Current Account from 2008-2013 as a ratio of 2013 NGDP. $SFA\ FA$ and $SFA\ CA$ correspond to the change in the NIIP minus the cumulated FA and CA from 2008-2013 as a ratio of 2013 NGDP. Estimated with robust standard errors, t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.3: Stock-Flow Adjustment 2008-13 as a Ratio of NGDP 2013

	(1) All	(2) PEG	(3) FLOAT	(4) Adv	(5) EmDev
NIIP 2007	-0.23***	-0.32*	-0.16***	-0.25**	-0.23***
	(-3.64)	(-1.98)	(-2.71)	(-2.75)	(-2.86)
Constant	-0.04	-0.06	-0.04	-0.01	-0.06
	(-1.24)	(-0.60)	(-1.14)	(-0.18)	(-1.46)
Observations	60	20	40	22	38
Adjusted R^2	0.16	0.15	0.11	0.15	0.17

SFA correspond to the change in the NIIP minus the cumulated CA from 2008-2013 as a ratio of 2013 NGDP.
Estimated with robust standard errors, t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.4: Net Stock-Flow Adjustment 2008-13 as a Ratio of NGDP 2013

	(1) PI	(2) PEQ	(3) PD	(4) FDI	(5) Other	(6) Res
NIIP 2007	-0.107*	-0.102*	-0.042	-0.085**	-0.381	0.025***
	(-1.69)	(-2.00)	(-1.15)	(-2.16)	(-0.63)	(3.76)
Constant	-0.002	-0.018	-0.004	0.005	0.349	-0.002
	(-0.09)	(-0.79)	(-0.38)	(0.28)	(0.65)	(-1.00)
Observations	57	45	52	59	61	60
Adjusted R^2	0.092	0.210	0.044	0.102	-0.015	0.127

$SFA\ NET$ of each asset class correspond to the change in the stock position minus the respective flow position from 2008-2013 as a ratio of 2013 NGDP
Estimated with robust standard errors, t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.5: Net Stock-Flow Adjustment from Other 2008-13 as a Ratio of NGDP 2013

	(1) Peg	(2) Floating
NIIP 2007	0.875**	-1.906*
	(2.60)	(-1.78)
Constant	-0.013	0.451
	(-0.08)	(0.58)
Observations	21	40
Adjusted R^2	0.222	0.00

t statistics in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.6: Stock-Flow Adjustment Gross Positions 2008-13 as a Ratio of NGDP 2013

	(1)	(2)	(3)	(4)
	Portfolio Equity		Foreign Direct Investment	
	Assets	Liabilities	Assets	Liabilities
NIIP 2007	0.03**	0.13***	0.11	0.20**
	(2.32)	(2.81)	(1.48)	(2.60)
Constant	0.02*	0.03	0.02	0.02
	(1.68)	(1.68)	(0.76)	(0.60)
Observations	45	45	58	58
Adjusted R^2	0.07	0.36	0.18	0.34

SFA Gross Position of each asset class correspond to the change in the gross stock position (assets and liabilities) minus the respective flow position from 2008-2013 as a ratio of 2013 NGDP
Estimated with robust standard errors, t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.7: Log Change of the Stock Market 2008-13

	(1)	(2)
Δ rGDP USD	1.23***	
	(4.41)	
Δ rGDP NatCur		1.15***
		(5.44)
Constant	-0.14**	-0.24***
	(-2.11)	(-3.18)
Observations	57	57
Adjusted R^2	0.35	0.28

Δ rGDP USD is the (log) change in the real GDP 2008-2013 in USD.
Δ rGDP NatCur is the (log) change in the real GDP 2008-2013 in National Currency.
Estimated with robust standard errors
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.8: Stock-Flow Adjustment from Portfolio Equity 2008-13

	(1) Net	(2) Assets	(3) Liabilities
ALL (g_i)	-0.12**	0.033	0.15**
EUR (g_i)	-0.58**	0.01	0.58**
ADV (g_i)	-0.36**	0.11**	0.47***
EM & DEV (g_i)	-0.01	0.01	0.03

(g_i) is the real GDP growth
Country Samples see Appendix C
t statistics in parentheses
Estimated with robust standard errors
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.9: Stock-Flow Adjustment from FDI 2008-13

	(1) SFA Liabilities	(2) SFA Net	(3) SFA Assets	(4) SFA Liabilities
FDI LIAB/GDP 2007	-0.07**			
	(-2.64)			
(g_i)		-0.12**	0.07**	0.19***
		(-2.32)	(2.47)	(3.54)
Constant	0.00	0.05**	-0.02	-0.06***
	(-0.34)	(2.55)	(-1.37)	(-3.31)
Observations	59	59	58	59
Adjusted R^2	0.08	0.07	0.02	0.11

SFA NET is the stock-flow Adjustment from the net FDI position *SFA Assets* and *SFA Liabilities* is the stock-flow adjustment from gross FDI positions *FDI LIAB/GDP* 2007 are FDI Liabilities in 200 7 as a ratio of 2007 NGDP. (g_i) is the real GDP growth
Estimated with robust standard errors, t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.10: Counterfactual Calculations as in Equation 2.14

		$NIIP_{2013}$ % of GDP	Counterfactual % of GDP	SFA_{08-13} % of GDP	SFA_{08-13} USD million
	US	-33.9	-25.8	-8.1	-1341558
Largest	Germany	32.6	51.1	-18.5	-694109
Valuation	China	18.5	23.6	-5.2	-490468
Losses	Sweden	-16.1	34.7	-50.8	-294622
	Switzerland	102	140.8	-38.8	-265564
	Italy	-34.6	-40.9	6.2	133224
	Taiwan	170.5	138.8	31.7	162402
Largest	Greece	-129.6	-198.7	69.1	165619
Valuation	Turkey	-50.1	-72.9	22.8	187687
Gains	UK	-15.1	-31.5	16.4	444497
	Canada	1.2	-23.3	24.5	449376
	Average	-24.5	-24.0	-0.5	-16035

Stock-Flow Adjustment calculated as the difference of the net international investment position and the cumulated flows of 2008-2013:
$SFA_{i,0813} = NIIP_{i,13} - (NIIP_{07} + \sum_{08}^{13} Flows_i)$.
We use the current account as the flow variable.

2.1.8 Appendix

Appendix A

Table 2.11: Flows and Stock-Flow Adjustment 2008-13 as a Ratio of NGDP 2013

	(1) Flows	(2) SFA	(3) Flows	(4) SFA	(5) Flows	(6) SFA
NIIP 2007	0.45***	-0.20***	0.43***	-0.21***	0.41***	-0.19***
	(6.77)	(-3.15)	(6.88)	(-3.21)	(6.33)	(-2.95)
Δ Real GDP 0813	-0.08	-0.13	-0.24*	-0.09	-0.25*	-0.09
	(-0.78)	(-1.04)	(-1.93)	(-0.73)	(-1.95)	(-0.68)
Δ StkMarket 0813			0.14**	-0.02	0.14**	-0.01
			(2.10)	(-0.22)	(2.14)	(-0.18)
Δ PolRate CB 0813					0.01	-0.01
					(1.21)	(-1.12)
Constant	0.07*	-0.02	0.09**	-0.02	0.12**	-0.05
	(1.68)	(-0.34)	(2.26)	(-0.38)	(2.47)	(-0.74)
Observations	60	60	54	54	54	54
Adjusted R^2	0.44	0.16	0.49	0.14	0.50	0.13

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Estimated with robust standard errors

Δ Real GDP 0813 is the (log) change of real GDP 2008 - 2013 (in USD)

Δ StkMarket 0813 is the (log) change of the domestic Stock Market Index 2008-2013

Δ PolRate CB 0813 is the change of the Policy Rate of the Central Bank 2008-2013

Appendix B

We define

$$SFA_t = NIIP_t - NIIP_{t-1} - CA_t$$

In this paper, we are essentially interested in the correlation of $NIIP_{t-1}$ and SFA_t. The potential for SFA to move in a stabilising direction is given as we can show the following:

$$\begin{aligned}
\sigma(SFA_t, NIIP_{t-1}) &= E((NIIP_t - NIIP_{t-1} - CA_t - (E(NIIP_t) - E(NIIP_{t-1}) - E(CA_t))) \\
&* \ (NIIP_{t-1} - E(NIIP_{t-1})) \\
&= E((NIIP_t - E(NIIP_t)) - (NIIP_{t-1} - E(NIIP_{t-1})) - (CA_t - E(CA_t)) \\
&* \ (NIIP_{t-1} - E(NIIP_{t-1})) \\
&= \sigma(NIIP_t, NIIP_{t-1}) - \sigma(CA_t, NIIP_{t-1}) - \sigma^2(NIIP_{t-1})
\end{aligned}$$

Dividing everything by the $\sigma^2(NIIP_{t-1})$ gives

$$\frac{\sigma(SFA_t, NIIP_{t-1})}{\sigma^2 NIIP_{t-1}} = \frac{\sigma(NIIP_t, NIIP_{t-1})}{\sigma^2 NIIP_{t-1}} - \frac{\sigma(CA_t, NIIP_{t-1})}{\sigma^2 NIIP_{t-1}} - 1$$

Now we can assume that $\frac{\sigma(NIIP_t, NIIP_{t-1})}{\sigma^2 NIIP_{t-1}}$ is equal to 1.[30]
This leaves us with two possible values for the $\sigma(SFA_t, NIIP_{t-1})$:

1. if $\sigma(CA_t, NIIP_{t-1}) > 0 \Rightarrow \sigma(SFA_t, NIIP_{t-1}) < 0$
2. if $\sigma(CA_t, NIIP_{t-1}) < 0 \Rightarrow \sigma(SFA_t, NIIP_{t-1}) > 0$

As explained in the paper, international capital flows contracted but did not reverse in the post-crisis period. Therefore, we assume $\sigma(CA_t, NIIP_{t-1}) > 0$ which means that creditor countries experienced net capital outflows and most debtor countries still experienced net capital inflows in the post-crisis period. Therefore, SFA can help stabilize the NIIP through $\sigma(SFA_t, NIIP_{t-1}) < 0$ so that countries with large net foreign liabilities (assets) i $t-1$ can earn positive (negative) SFA in t.

Appendix C - Country Sample and Data

Country Samples A. 64 High Quality Sample

Argentina; Australia; Austria; Belgium; Brazil; Bulgaria; Canada; Chile; China, People's Rep. of; Hong Kong, China; Colombia; Costa Rica; Croatia; Czech Republic; Denmark; Dominican Republic; El Salvador; Estonia; Finland; France; Germany; Greece; Guatemala; Hungary; Iceland; India; Indonesia; Ireland; Israel; Italy; Japan; Korea, Republic of; Latvia; Lithuania; Malaysia; Mexico; Morocco; Netherlands; New Zealand; Norway; Pakistan; Peru; Philippines; Poland; Portugal; Romania; Russian Federation; Serbia, Republic of; Singapore;

[30] For our 64 country high-quality sample where $NIIP_{t-1}$ is NIIP in 2007 a $NIIP_{t-1}$ is NIIP in 2013 this value is 1.18.

Slovak Republic; Slovenia; South Africa; Spain; Sri Lanka; Sweden; Switzerland; Taiwan Prov. of China; Thailand; Tunisia; Turkey; Ukraine; United Kingdom; United States; and Uruguay.

Subsamples

Euro Countries: Austria; Belgium; Finland; France; Germany; Greece; Ireland; Italy; Netherlands; Portugal; Spain.

Pegged Countries: All Euro countries; Bulgaria; China, P.R.: Hong Kong; Croatia; Denmark; El Salvador; Estonia; Latvia; Lithuania; Slovac Republic; Slovenia; Taiwan.

No Peg Countries: Argentina; Australia; Brazil; Canada; Chile; China, P.R.:Mainland; Columbia; Costa Rica; Czech Republic; Dominican Republic; Guatemala; Hungary; Iceland; India; Indonesia; Israel; Japan; Korea; Malaysia; Mexico; Morocco; New Zealand; Norway; Pakistan; Peru; Philippines; Poland; Romania; Russian Federation; Serbia; Singapore; South Africa; Sri Lanka; Sweden; Switzerland; Thailand; Tunisia; Turkey; Ukraine; United Kingdom; United States; Uruguay.

Advanced Countries: Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Greece; Iceland; Ireland; Israel; Italy; Japan; Netherlands; New Zealand; Norway; Portugal; Singapore; Spain; Sweden; Switzerland; United Kingdom; United States.

Emerging Countries: Argentina; Brazil; Bulgaria; Chile; China, P.R.: Hong Kong; China, P.R.: Mainland; Colombia; Costa Rica; Croatia; Czech Republic; Dominican Republic; El Salvador; Estonia; Guatemala; Hungary; India; Indonesia; Korea; Latvia; Lithuania; Malaysia; Mexico; Morocco; Pakistan; Peru; Philippines; Poland; Romania; Russian Federation; Serbia; Slovak Republic; Slovenia; South Africa; Sri Lanka; Taiwan; Thailand; Tunisia; Turkey; Ukraine; Uruguay.

B. World sample

Industrial countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Other countries: Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bahrain, Bangladesh, Belarus, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Cambodia, Cameroon, Chad, Chile, China, Colombia, Dem. Rep. of Congo, Rep. of Congo, Costa Rica, CÃŧte d'Ivoire, Croatia, Cyprus, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Ethiopia, Fiji, Gabon, Georgia, Ghana, Guatemala, Guinea, Haiti, Honduras, Hong Kong S.A.R., Hungary, India, Indonesia, Iran, Islamic Republic of, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Kyrgyz Republic, Laos, Latvia, Lebanon, Libya, Lithuania, Macedonia, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritius, Mexico, Moldova, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Serbia and Montenegro, Singapore, Slovak Republic, Slovenia, South Africa, Sri Lanka, Sudan, Swaziland, Syrian Arab Republic, Taiwan Province of China, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, Uruguay, Uzbekistan, Venezuela, Rep. Bol., Vietnam, Yemen, Zambia, Zimbabwe.

Data

- Flow positions: Balance of Payments Statistics (IMF)
- Stock Positions: External Wealth of Nations dataset (Lane and Milesi-Ferretti, 2007).
- The current account data: World Economic Outlook April 2016 database
- The real GDP: International Financial Statistics (IMF)
- Domestic Stock Market indices: World Bank database
- Central Bank Policy Rates: Monetary and Financial Statistics (IMF) and Reuter's Datastream

2.2 Valuation Effects and Capital Flows - Security Level Evidence from Euro Area Investors [31]

2.2.1 Introduction

Increasing financial integration has become of great importance in international macroeconomics as external assets and liabilities have risen from around 60% of world GDP in 1995 to approximately 200% in 2015 (Lane and Milesi-Ferretti, 2018). This development reflects (1) the accumulation of foreign assets, but also (2) the valuation of these instruments. The growth in cross-border financial integration goes in tandem with an increased role of returns on external portfolios. While ignored in much of the earlier literature, more recent work shows that the importance of valuation changes as determinants of external investment positions has grown tremendously (see e.g. Lane and Milesi-Ferretti (2001, 2007b, 2018, 2007a); Tille (2008); Gourinchas and Rey (2007); Fratzscher et al. (2010)).[32] Many countries experience valuation effects which exceed capital flows in a given period. Hence, the question arises as to how investors react to increasing valuation effects on foreign assets and in particular on those which are denominated in foreign currency. Do they rebalance their portfolios towards constant security weights in order to maintain fixed exposures to certain types of assets? Or do they invest with the momentum to reach for higher returns?

We use sectoral microdata on security holdings and transactions of all euro area investors collected by the European Central Bank (ECB) since 2013 to test these hypotheses.[33] Recent theoretical literature in international economics predicts that investors will repatriate earnings on foreign securities after experiencing excess returns in order to maintain an optimal trade-off between exchange rate exposure and international asset diversification (Camanho et al., 2018; Hau and Rey, 2006). On the other hand, empirical and theoretical work from the finance literature shows that investors often adjust their targets pro-cyclically and buy more of assets that are increasing in value (e.g. Cox (1967) for banks, Bohn and Tesar (1996) for international investment in the US, or Becker and Ivashina (2015) for insurance companies). These investment patterns are better known as “momentum investment", “return chasing", or “reaching for yield".

Our empirical analysis provides evidence for exactly this type of investment behaviour, i.e. “momentum investment". We show that euro area investors buy more (less) of a security when it yields a relatively higher (lower) valuation gain. We use a standard international intertemporal capital asset price model (IICAPM) by Bohn and Tesar (1996) to show the intuition for this result. The model predicts that investors will indeed target specific weights

[31] Co-authored with Martin Schmitz (DG-Statistics, European Central Bank).

[32] For a special focus on exchange rate valuations and currency composition of external assets see Lane and Shambaugh (2010); Benetrix et al. (2015); Corte et al. (2012); Maggiori et al. (2018).

[33] Our dataset does not contain the security holdings and transactions of euro area monetary authorities, i.e. of the Eurosystem consisting of the European Central Bank and the national central banks.

for assets in their portfolio. Facing the standard trade-off between mean return and variability, however, they will adjust these weights according to their expectations on the performance of the corresponding asset. This naturally decomposes the investor's decision on net transactions into those (i) to maintain a portfolio of constant security shares and those (ii) triggered by time-varying investment opportunities.

Our results suggest that euro area investors' transactions since 2013 are primarily driven by the latter effect. We further investigate the patterns of momentum investment in a detailed empirical analysis. We find that the overall pattern is significantly stronger for institutional investors (banks, investment funds, and insurance companies and pension funds) compared with retail investors, i.e. non-financial corporates (NFC) and households (HH). Moreover, we observe significantly stronger momentum investment for investors located in euro area countries that were less affected by the recent financial crisis. For non-euro denominated securities, the effect from valuation changes due to exchange rate dynamics strongly dominates the effect from changes in market prices. This is consistent with a decreasing share of home currency holdings in euro area investors' portfolios, driven by rebalancing towards the US dollar and other foreign currencies over the past five years. While the main focus of the paper lies on international investment, we also include domestic securities held by euro area investors. Since we find momentum investment also for euro-denominated assets, we can exclude that investors chase returns only abroad, while investing more conservatively at home.

While the financial globalization of the last two decades resuscitated interest in portfolio balance models (see e.g. Blanchard et al. (2005), Hau and Rey (2006), Bacchetta and van Wincoop (2010), and Gabaix and Maggiori (2015)), the empirical literature on portfolio rebalancing using microdata is rather scarce and limited to specific countries or sectors. For instance, Calvet et al. (2009) use Swedish data to examine portfolio rebalancing of households for which they find that especially educated and wealthy households are likely to sell securities after an increase in prices. Maggiori et al. (2018) use security positions of international mutual funds to show the importance of the currency home bias combined with a strong portfolio shift away from the euro and towards the US dollar since the global financial crisis. Most closely related to our research are two recent working papers by Camanho et al. (2018) and Ammer et al. (2018). The former use microdata of internationally invested equity funds and show how differential returns on the foreign and domestic segments of their portfolios determine the rebalancing behavior and capital flows. They find that investors repatriate gains on foreign securities after experiencing excess returns in order to maintain an optimal trade-off between exchange rate exposure and international asset diversification.[34] Conversely, Ammer et al. (2018) present empirical evidence that investors shift their portfolio into riskier US corporate

[34]This is in line with the broader concept of Uncovered Equity Parity (UEP). It predicts that when foreign equity holdings outperform domestic holdings, domestic investors are exposed to higher relative exchange rate exposure and decide to repatriate some of the foreign equity to decrease exchange rate risk (Cappiello and De Santis (2007); Kim (2011); Curcuru et al. (2014)).

bonds in response to low interest rates in their domestic markets. Our findings are in line with Ammer et al. (2018), illustrating investors' appetite for higher returns abroad when domestic assets offer relatively lower returns.

We contribute to the literature in several ways: our broad coverage of euro area sectors allows to shed light on sector heterogeneity which we deem especially important due to different degrees of investor sophistication, informational frictions, or varying asset and liability management strategies as well as regulatory constraints. These factors may imply heterogeneous responses across sectors to changes in valuation (Timmer, 2018). As our data are at the security level, we can further decompose valuation changes very precisely into those emanating from exchange rate dynamics or other price effects. Moreover, we analyze heterogeneity across different asset classes (equity compared to debt instruments) as well as across the residence countries of holders and issuers of a given security. By using a micro-econometric approach, we can circumvent the endogeneity often affecting country-level macro-data studies. We argue that movements in the exchange rate are reasonably exogenous to the investment patterns of our unit of observation, i.e. a specific sector of given euro area country. This is in contrast to much of the existing literature that analyzes international investment at the country level, which makes it more likely that capital flows influence the evolution of asset prices and exchange rates. Finally, the granularity of the data enables us to control for country-sector fixed effects as well as for all security-level characteristics that could possibly obscure our analysis.

The rest of the paper is organized as follows: in Section 2.2.2, we motivate our research question with a theoretical framework. Our dataset is introduced in Section 2.3.2.1 and we present descriptive evidence on the (international) portfolio rebalancing of euro area investors in Section 2.3.3. Section 2.2.5 explains our identification strategy, Section 2.2.6 presents our estimation results including robustness exercises, while Section 2.3.5 concludes.

2.2.2 Conceptual Framework

Before we present extensive empirical evidence from security level data on investment of euro area investors, we present the research question in a theoretical framework. We follow Bohn and Tesar (1996) and Cox et al. (1985) and use a standard international intertemporal capital asset price model (IICAPM) in order to be able to benchmark our empirical results.

We start by defining the investment decisions as transactions T_{at} of asset a in quarter t:[35]

$$T_{at} = w_{at}P_t - (1 + v_{at})(w_{at-1}P_{t-1}) \tag{2.15}$$

[35] Positive transactions are net purchases while negative transactions are net sales of a security a in quarter t. For simplicity, we drop the index for the holder country usually used in international CAPM models in order to focus on the effects at the security level.

where w_{at} represents the weight of asset a in quarter t of the total portfolio of the investor P_t and v_{at} is the change in the valuation of asset a at the security level.
Mechanically, the value of the portfolio at time t is a function of the return on the portfolio between $t-1$ and t so that we approximate

$$T_{at} = (w_{at} - w_{at-1})P_{t-1} + (\overline{v_t} - v_{at})w_{at-1}P_{t-1} \tag{2.16}$$

where $\overline{v_t}$ is the average valuation change of the investor's portfolio in time t.
The right hand side of this equation now splits the determinants of investors' transactions of asset a into two components:

1. $(\overline{v_t} - v_{at})w_{at-1}P_{t-1}$: Transactions for the purpose of portfolio rebalancing towards a given portfolio weight. Hence, if capital gains v_{at} exceed the average capital gain on the portfolio $\overline{v_t}$, net sales of security a are required to bring w_{at} back into balance. For the contrary case, if the average valuation gain of the portfolio exceeds the individual gain on asset a, the resulting gains will be distributed across the portfolio, including asset a, leading to net purchases of asset a.

2. $(w_{at} - w_{at-1})P_{t-1}$: Transactions in response to the change of the portfolio weight between $t-1$ and t. If investors would want to increase the weight of a certain security in their portfolio, this would translate to a net buy (sale) of that asset.

It is assumed that euro area investors face a standard trade-off between mean return and variance. According to the framework by Cox et al. (1985), the solution to this problem yields the following first-order condition, linking the valuation of asset a to its corresponding portfolio weight:

$$w_{at} = \alpha e_a \sum_{t}^{-1} \overline{\mu_t} \tag{2.17}$$

where α represents the coefficient for relative risk aversion, e_a is a 0-1 vector which selects asset a, $\sum_t^{-1} \overline{\mu_t}$ is the covariance matrix of returns.[36]
Therefore, we can substitute equation (3) in our process of interest, namely transactions defined in equation (2):

$$T_{at} = e_a \sum_{t}^{-1} (\overline{\mu_t} - \overline{\mu_{t-1}})\alpha P_{t-1} + (\overline{v_t} - v_{at})w_{at-1}P_{t-1} \tag{2.18}$$

[36] We ignore the component of the portfolio that is used to hedge against risk that are not priced in the equity valuation. Adler and Dumas (1983) show that this term represents the covariance of capital gains with state variable (time varying investment opportunities) and with inflation. As we ignore second moments of the driving processes for returns and the state variables, we would obtain a constant hedge term which cancels out when we consider the change of w_{at}.

Again, this splits the right hand side into two processes which lay out a perfect playground for our empirical analysis:

Portfolio Rebalancing Hypothesis: $(\overline{v_t} - v_{at})w_{at-1}P_{t-1}$ mainly determines active investment. Investment patterns are characterized by rebalancing towards constant target weights in order to offset excess returns (losses) by net sales (purchases) of that security. This would be in line with the recent work by Camanho et al. (2018). Their model predicts portfolio rebalancing through the repatriation of excess returns on foreign equity securities in order to maintain an optimal trade-off between international asset diversification and exchange rate exposure.[37]

Momentum Investment Hypothesis: $e_a \sum_t^{-1}(\overline{\mu_t} - \overline{\mu_{t-1}})$ mainly determines active investment. This term reflects the adjustment of the portfolio weights in accordance with portfolio optimization over time. If risk aversion and the variance-covariance matrix of returns are fixed, investors can adjust their weights if they expect higher returns for a given security.

The rest of the paper investigates empirically which of the two hypotheses best describe the investment decisions of euro area investors' since 2013.

2.2.3 Data

We use data on security-level portfolio holdings and transactions of all 19 euro area Member States from the European System of Central Banks (ESCB) Securities Holding Statistics by Sector (SHSS).[38] The data are collected by National Central Banks from (i) financial investors and (ii) custodians. It covers all short-term and long-term debt securities, listed shares, as well as investment fund shares that are identified with an unique International Securities Identification Number (ISIN). This split into financial instruments is in line with the instruments contained in National Accounts or Balance of Payments Statistics. The data are collected on a quarterly basis since the fourth quarter of 2013 and we use releases until the fourth quarter of 2017Q4 for this analysis. For our period of observation, the data comprise holdings of EUR 25 trillion in the first quarter of 2014 gradually growing to EUR 30 trillion in the fourth quarter of 2017 (see 2.13).[39] The SHSS data consist of *directly* and *indirectly* reported securities. A financial institution resident in the euro area is obliged to report securities that it holds as its own investment ("direct reporting") as well as securities

[37] Camanho et al. (2018) also find empirical evidence for such portfolio rebalancing. They use a sample focusing on equity positions of mutual funds, while we have a broader range of investors and securities in our sample. Furthermore, in order to capture active portfolio rebalancing, we follow Bohn and Tesar (1996) and use transactions as the dependent variable, rather than changes in positions.

[38] This dataset is collected according to Regulation ECB/2012/24, see The Official Journal of the European Union.

[39] Revised versions of our data are available with a significant time lag and we plan to update our analysis with new releases.

that it holds in custody ("indirect reporting"). In order to avoid double reporting, only assets held in custody for non-financial investors are included in the SHSS.[40] Investors in the data are defined by their country of residence and sector. In line with the IMF's Balance of Payments Manual (BPM6), our data rely on the residency principle. Therefore, it records all holdings and transactions by investors resident in a country, independent of their nationality.[41] We follow the European System of Accounts (2010)[42] and aggregate the data to five main sectors: monetary and financial institutions excluding monetary authorities (MFIs), insurance companies and pension funds (ICPFs), other financial institutions (OFIs)[43], non-financial corporations (NFCs), and households. Using the ISIN for each security, we merge SHSS data to individual asset characteristics obtained from the ESCB's Centralised Securities Database (CSDB) which contains information on more than six million debt and equity securities issued globally. Therefore, we are able to use information at the security-level, such as the instrument type, market prices, or the currency of denomination.

Table 2.12 shows the summary statistics of the main variables of our empirical analysis for the sectors mentioned above. The average holdings of a single security are significantly heterogeneous, ranging from 4.3 million euro for households to 29.1 million euro for ICPFs. NFCs do not only hold the smallest amount of different securities (3 million) but also trade less often than the other sectors. Households and OFIs are the most active traders (in terms of numbers of trades in our period of observation), while MFIs show the largest trading volumes of individual securities, increasing their holdings on average by 22% and reducing their holdings on average by 46%. ICPFs yield the highest returns from valuation (average Total Val at .824% per quarter) which is driven by returns from prices (particularly of non-euro denominated securities) as returns from the exchange rate are negative for this sector. All institutional investors experience higher returns from market price dynamics from non-euro denominated securities compared to securities denominated in euro.

2.2.4 The Development of Euro Area Portfolios

Before we present the empirical framework and results, we give an overview of broad developments in the portfolios of euro area investors during the time period of our analysis. Table 2.13 shows snapshots of the first and the latest release of the sectoral securities holdings data. In this period, portfolios of euro area investors have increased from around EUR 25 trillion in 2014Q1 to 30 trillion in 2017Q4 which corresponds to 245 and 263 percent of annual euro area GDP, respectively. This strong portfolio growth was driven by the increased holdings of OFIs

[40] Double counting would happen if there are several intermediate financial institutions between the final non-financial investor and the financial institution holding assets in custody.

[41] E.g. Citi's subsidiary in Frankfurt would be considered as holdings of the German banking sector. On the other hand, Deutsche Bank's holdings through its subsidiary in New York are not captured.

[42] Link to European System of Accounts (2010).

[43] These include important intermediaries such as mutual funds which represent the largest subgroup of this sector.

(mainly investment funds), followed by ICPFs and – to a significant lesser extent – NFCs and households. This trend was only partly offset by the decrease in security holdings of MFIs, which partly reflects the continued deleveraging in the euro area banking sector during this period. Households are the most important retail investors in the euro area, with a portfolio twice and three times as large as those of NFCs and governments. Security holdings in the latter two sectors remain relatively small (accounting for less than 10% of total euro area holdings).

In terms of investors' residency, most securities are held by residents of Germany and France, followed by the two financial centres Luxembourg and Ireland. The split by asset class suggests a portfolio shift by euro area investors from debt to equity, mainly towards investment fund (IF) shares. However, this interpretation has to be taken with caution. The increased amount of investment in IF shares coincides with an increased investment by investment funds in non-euro debt. Thus, we suggest that the shift towards equity partly reflects a channelling of investment into non-euro debt securities via IFs, rather than a rebalancing of portfolios from debt to 'pure' equity. An analysis of the issuer location shows that the holdings of euro area issued securities (measured as a share of the overall portfolio) have decreased significantly. This was mainly driven by a decrease in holdings of securities issued in the investor's country of residence, suggesting a declining home bias. In contrast, investment in securities issued by non-euro area countries has increased markedly. Notably, there has been a 70% increase with respect to securities issued in the US (measured in EUR).

We observe a decrease in the share of euro denominated securities in our period of observation in Figure 2.11. This was mirrored in an increase in holdings in foreign currencies, most importantly US dollar and British pound. As this trend has proven steady, events such as the Brexit referendum in June 2016 or the Swiss National Bank's decision to discontinue the peg of the franc against the euro in January 2015 seem to have had a limited effect on holdings of securities denominated in the respective foreign currencies. A major event during our period of observation has been the ECB's Quantitative Easing (Asset Purchase Programme (APP)) which absorbed EUR 2.3 tn of euro-denominated (mainly sovereign) debt assets. However, Figure 2.11 suggests that the shift towards foreign currency was not only driven by the APP, as the largest decline in the share of euro-denominated securities occurred before the programme started at the end of the first quarter of 2015.[44] The high share of US dollar holdings is significantly driven by IFs located in the financial centres Ireland and Luxembourg (close to 30% of portfolio are US dollar denominated at the end of 2017). At the same time, 95% of securities held by NFCs were denominated in euro between 2013 and 2017, which exceeds the share held by households and even government institutions (87% and 92%, respectively). The decreasing share of euro-denominated holdings is in line with recent

[44] In addition, the decline in the share of euro-denominated securities can be observed across all asset classes and not just for debt securities which is the only asset class targeted under the APP. These charts are available upon request.

findings by Maggiori et al. (2018) for international mutual funds. The authors show that the share of euro-denominated cross-border holdings of corporate debt declined from 35% in 2004 to 20% since 2008 across countries.

Until now, we only presented evidence on stock positions and shares thereof. The change in the holdings of a security can be due to (i) net sales or purchases of that security, (ii) a change in the market price, and/or (iii) a change in the value of the foreign currency for non-euro denominated securities. In Figure 2.12, we aggregate the development of these values for each quarter. In the upper left graph, we see that overall valuation changes, be them from prices (dotted bars) or the exchange rate (striped bars), exceeded transactions (grey bars) and, therefore, played a bigger role in explaining the total changes in euro area investors' portfolios (line).[45] Overall, valuation effects of euro area investors were driven by market price developments. This reflects the fact that over 80% of euro area investors' portfolio is denominated in euro. Hence, valuation effects caused by exchange rate fluctuations for this large part of the portfolio are mechanically zero (upper right graph). This is in contrast to the bottom graphs where we show the developments for all foreign currency securities on the left and US dollar denominated securities on the right. Here, effects from the exchange rate largely dominate those stemming from dynamics in market prices. Regarding sectoral heterogeneity, these graphs imply that sectors holding mainly euro denominated securities, such as households and NFCs, show negligible valuation effects from the exchange rate compared to OFIs, where valuation changes stemming from the exchange rate can exceed the effect of price changes.

We continue with descriptive evidence on the development of valuation effects and investment patterns over time. In Figure 2.13, we plot the average difference in quarterly valuation effects of non-euro vs. euro-denominated securities (foreign excess return) as well as the share of non-euro denominated securities. If investors were to maintain constant security weights, aggregates of non-euro denominated assets would stay constant, independent of the development of their valuation. However, we see that the share of non-euro denominated assets (solid red line) increased drastically in the last five years for both institutional and retail investors. This shift is correlated with the excess return earned on non-euro denominated securities (dashed blue line). As we plot this for institutional investors separately from retail investors, we find that that the former (i) show a stronger correlation with the excess returns (0.84 unconditional for the change in foreign currency shares) and (ii) achieve higher excess returns on non-euro denominated securities than retail investors. This suggests that institutional investors invest not only more pro-cyclically but are also able to achieve a higher return from valuation with this strategy.

In Figure 2.14, we shed more light on this pattern as we zoom in on the exchange rate component of the valuation effect, more specifically for the US dollar as the most important

[45] Possible discrepancies between the sum of valuation and net purchases and the change in holdings are due to statistical innovations such a a larger population of investors or compilation errors in case investors report holdings, but no transactions of the same security.

currency of denomination of non-euro denominated securities. We plot the share of US dollar denominated securities (dashed blue line) against the evolution of the EUR/USD exchange rate (solid red line). Again, if investors wanted to keep the exposure to the US dollar fixed, the share of US dollar denominated assets should be flat, independent of the development of the exchange rate. However, we find that the share of US dollar securities in euro area investors' portfolios has risen by around 50% during our time period of observation. This evolved in line with developments of the EUR/USD exchange rate: when the US dollar appreciated against the euro from 2013 to 2015, shares of US dollar holdings were increasing in euro area investors' portfolios. This development only stalled in 2017, when the US dollar depreciated against the euro and investors were decreasing their US dollar share somewhat. Part of this strong correlation is mechanical as the value of the securities is recorded in euros, i.e. the share of US dollar denominated securities will naturally rise when the US dollar appreciates against the euro. However, the magnitudes shown in the graph are far larger than the mechanical adjustment under *ceteris paribus* conditions, as euro investors were heavily investing in the US dollar in times of its appreciation. This picture is in line with models that account for investment behavior based on expected interest rate differentials and/or the time series of valuation changes (e.g. Frankel and Froot (1990)). It is also in line with empirical evidence by (i) Bohn and Tesar (1996) who show that US investors were seeking valuation gains with international investment abroad from 1980-1994 and (ii) Ammer et al. (2018) who show that investors look for yield abroad when interest rates at home are at low levels.

2.2.5 The Role of Valuation - Identification Strategy

In this section, we present our empirical framework to identify how investors react to valuation changes at the security level. We recall the result of the IICAPM model laid out above:

$$T_{at} = e_a \sum_{t}^{-1} (\overline{\mu_t} - \overline{\mu_{t-1}}) \alpha P_{t-1} + (\overline{v_t} - v_{at}) w_{at-1} P_{t-1}$$

where the first part of the right hand side $e_a \sum_t^{-1} (\overline{\mu_t} - \overline{\mu_{t-1}}) \alpha P_{t-1}$ represents the adjustment of the weight of an asset in the course of a portfolio optimization, whereas the latter part represents portfolio rebalancing towards a given weight ($(\overline{v_t} - v_{at}) w_{at-1} P_{t-1}$). The *Portfolio Rebalancing* Hypothesis of the IICAPM therefore predicts that $(\overline{v_t} - v_{at}) w_{at-1} P_{t-1}$ determines investment patterns which correspond to net transactions in our data. We test this accordingly with the corresponding part of the model in the equation above. Hence, if all investments happen only for the purpose of portfolio rebalancing towards a constant weight of each asset, we are left with the following equation at the security level:

$$T_{at} = (\overline{v_t} - v_{at}) w_{at-1} P_{t-1} \tag{2.19}$$

so that

$$\frac{T_{at}}{w_{kt-1}P_{t-1}} = (\overline{v_t} - v_{at}) + \epsilon_t \quad (2.20)$$

$$= -(v_{at} - \overline{v_t}) \quad (2.21)$$

Therefore, we find portfolio rebalancing towards constant targeted portfolio weights if the coefficient on $(\overline{v_t} - v_{at})$ is significantly negative. This means that net transactions would be lower (or negative, implying net sales) if the valuation gains on asset a are above those of portfolio P.

Translating this to our data, we define the dependent variable capturing net investment flows as

$$\frac{T_{at}}{w_{kt-1}P_{t-1}} = t_{a,j,t} = \frac{Transactions_{a,j,t}}{Holdings_{a,j,t-1}} \quad (2.22)$$

which are the transactions of asset a by country-sector j in quarter t scaled by holdings of this asset in $t-1$.

In order to calculate the nominal valuation changes of an asset $v_{a,j,t}$, we use the asset specific characteristics of each security to calculate three types of valuation changes at the security level:

1. $v^{pr}_{a,j,t}$ from prices: $\Delta marketprice_{a,j,t} = \frac{price_{a,j,t}}{price_{a,j,t-1}} - 1$
2. $v^{fx}_{a,j,t}$ from the exchange rate: $\Delta exchangerate_{a,j,t} = \frac{fx_{a,j,t}}{fx_{a,j,t-1}} - 1$ [46]
3. $v^{tot}_{a,j,t}$: $= \Delta marketprice_{a,j,t} + \Delta exchangerate_{a,j,t}$

As laid out in the IICAPM above, we argue that an investor is concerned about changes in the valuation of an asset in relative terms, i.e. compared to the overall valuation dynamics of her portfolio. In empirical international macroeconomics, the terms “push and pull" factors are used, implying that investors are attracted to foreign markets by the prospect of high returns (pull factor), which have to be evaluated against the returns on the domestic portfolio of the investor (push factor). In our model, this idea corresponds to the concept of “excess valuation". The decisive explanatory variable should therefore not only consider the valuation dynamics of a security, but also the evolution of the valuation of the rest of the portfolio. To calculate these relative changes in valuation, we split the securities into three financial asset classes c in line with macroeconomic statistics: debt securities, listed equities, and investment fund shares and calculate an average $\overline{v_t}_{j,c,t}$ valuation change for the portfolio of each country-sector j in one the three asset classes c at a given time t. With these averages of the different asset classes, we calculate three measures of excess valuation gains $val_{a,j,t}$ at the security level to

[46] For instance, in the case of the exchange rate of the euro against the US dollar, we define $\frac{EUR}{USD}$ so that an increase in the exchange rate means an appreciation of the US dollar

obtain excess valuation from prices $val^{pr}_{a,j,t}$, excess valuation from exchange rate dynamics $val^{fx}_{a,j,t}$, and the total excess valuation $val^{tot}_{a,j,t}$ for each asset a held by country-sector j in time t relative to the average valuation of the portfolio of asset class c:

1. $val^{pr}_{a,j,t} = v^{pr}_{a,j,t} - \overline{v^{pr}_t}_{j,c,t}$
2. $val^{fx}_{a,j,t} = v^{fx}_{a,j,t} - \overline{v^{fx}_t}_{j,c,t}$
3. $val^{tot}_{a,j,t} = v^{tot}_{a,j,t} - \overline{v^{tot}_t}_{j,c,t}$

In our baseline specification, we relate these measures of excess valuation to investment, i.e. net transactions:

$$t_{a,j,t} = \beta_1 * val^{tot}_{a,j,t} + \beta_2 * val^{tot}_{a,j,t} * EUR + FE_a + FE_j \tag{2.23}$$

where $val^{tot}_{a,j,t}$ is the total relative valuation change for asset a, held by country-sector j in time t as described above. FE_a are *Security Fixed Effects* to absorb time-invariant security characteristics, such as original maturity or currency denomination, while FE_j are *Country-Sector Fixed Effects* to control for any country-sector specific factors that could possibly drive investment behaviour over the time frame of our analysis, such as the portfolio growth of a county-sector.[47] An interaction of the total relative valuation change $val^{tot}_{a,j,t}$ with a EUR Dummy is included in order to estimate a differential effect of valuation changes of euro-denominated vs. foreign currency denominated securities.

For the sample of foreign currency denominated securities, we can furthermore disentangle the effect of the relative valuation from price vs. exchange rate dynamics:

$$t_{a,j,t} = \beta_1 * val^{pr}_{a,j,t} + \beta_2 * val^{fx}_{a,j,t} + FE_a + FE_j \tag{2.24}$$

where $val^{pr}_{a,j,t}$ are the relative valuation changes from prices and $val^{fx}_{a,j,t}$ are the relative valuation changes from the exchange rate as described above. For all regressions, we cluster standard errors at the *issuer country * quarter* level in order to account for correlation of valuation within an issuer country, e.g. co-movement of market prices on the same stock market. In a robustness test, we also include time fixed effects to confirm that our results are not purely driven by unobserved time-specific factors (see Table 13 in the Appendix).

Relating this specification to our hypotheses outlined in Section 2.2.2, we would find evidence for our *Portfolio Rebalancing* Hypothesis if $\beta_1 < 0$. This would mean that investors sell (buy) a security if the value of the asset increases (decreases) in order to maintain a targeted share of

[47] The importance of portfolio growth in driving overall capital flow developments has recently been documented by Ahmeda et al. (2016) and Meng and van Wincoop (2018).

this asset in their portfolio. On the other hand, $\beta_1 > 0$ would reject the *Portfolio Rebalancing* Hypothesis and would therefore suggest *Momentum Investment* as investors buy more (less) of an asset that is appreciating (depreciating) in value compared with the rest of the portfolio. As our data are at quarterly frequency, we suggest that the contemporaneous effect, i.e. $beta_1$, is the correct one to consider for our regression and its interpretation.[48]

2.2.6 Estimation Results

In this section, we present the results of our baseline specification including an analysis by sector, asset class, as well as country heterogeneity. Furthermore, we identify several investment patterns underlying our main result as well as robustness tests of our baseline specification.

2.2.6.1 Baseline specification

We present the results of our baseline estimation in Table 2.14 where we consider the contemporaneous conditional correlation of valuation changes and net transaction for all securities in our sample in column (1). We observe that our variable of interest is significantly positive. This rejects our *Portfolio Rebalancing* Hypothesis and at the same time presents evidence for "momentum investment" as investors show higher net purchases of a security when they experience higher gains from valuations relative to the rest of their portfolio. If a security's excess valuation gain (relative to the rest of the sector's portfolio in t) increases by one percentage point, net purchases of this security (expressed as a percentage of holdings in $t-1$) are estimated to increase by about 7 percentage points. This holds controlling for country-sector as well as security fixed effects.[49] In column (2), we introduce an interaction effect with the euro dummy as we argue that investors differentiate their investment strategy between domestic and foreign currencies.[50] We observe that the coefficient on the interaction term is significantly negative, although not outweighing the base coefficient which suggests that there is less pro-cyclical investment in euro-denominated assets as compared to foreign currency assets, which hence drive our strong positive coefficients overall. This is consistent with Meng and van Wincoop (2018) who document for US international capital flows that there is no rebalancing at the quarterly frequency. Column (3) differentiates once more between euro denominated vs. foreign currency denominated assets. As there is no valuation effect coming from the exchange rate for the former group, we compare only the valuation effects due to market prices between the two groups. We find that investors purchase securities with an equal price momentum in euro and non-euro denominated securities. This suggests that the

[48] Following Camanho et al. (2018), we reproduce all our results where we also control for the lagged value of $v_{a,j,t-1}$ which leaves our coefficients almost identical in terms of size as well as in significance.

[49] We also run all of the regressions in this table without and with either one of the set of fixed effects alone and we obtain results that are at least equally significant. Available upon request.

[50] The base coefficient of the currency of denomination is captured by the security-level fixed effects.

stronger overall result from non-euro denominated securities is driven by valuation effects due to exchange rate movements. To explore this further, columns (4) - (8) only include non-euro denominated securities. We find the overall coefficient to be significantly positive and larger in magnitude compared to the overall sample, which again shows that euro area investors react in a more pro-cyclical way to valuation changes in foreign currencies as compared to euro-denominated assets. In column (5), we divide the overall excess valuation effect in price and exchange rate components. We find that the coefficients on price and exchange rate movements are significantly positive, with the latter being five times larger. This implies that investors are more likely to invest in securities where the valuation changes from the exchange rate outperform those emanating from the exchange rate in the rest of the foreign currency portfolio. As we observed strong rebalancing towards assets denominated in USD as well as GBP, we interact the valuation effect from exchange rate movements with a USD and a GBP dummy, respectively. This test is not just interesting because those are the two major foreign currencies for euro area investors, but also because their value moved for fundamentally different reasons. While movements in the exchange rate of the USD mainly co-moved with monetary policy announcements by the Federal Reserve Bank and ECB, the GBP experienced its greatest valuation movements after political announcements around Brexit. We can see that both interactions turn out to be significantly positive. Therefore, we suggest that (i) our results are not only driven by the USD and (ii) our results are not restricted to valuation changes due to certain type of events, such as a monetary policy announcement.[51]

2.2.6.2 Heterogeneity by Asset Class

Debt securities In Table 2.15 we repeat the above analysis for debt securities only. While the overall coefficient in column (1) remains significantly positive, the interaction with the euro in column (2) shows that there is no pro-cyclical investment in euro denominated debt assets as the negative interaction weighs out the positive base effect.[52] In addition, we find in column (3) and (4) that the overall dynamics are driven by long term securities, rather than short term debt securities (i.e. with an original maturity of less than a year).[53] As column (2) shows clearly that the positive coefficient on valuation changes is driven by foreign currency denominated securities, we focus on these securities in columns (5) - (7). In line with our findings for all asset classes, column (5) shows that the overall effect from valuation is significantly stronger for non-euro denominated debt securities. Column (6) reveals again that

[51] These results hold when we exclude fixed effects (all or iteratively). In addition, the results are robust to the inclusion of time fixed effects which control for time-specific factors. These results are available upon request

[52] This result could be driven by the ECB's Asset Purchasing Programme (APP) as euro area investors sold significantly more assets eligible to be bought under the APP (Bergant et al., 2018). These assets were appreciating in the course of the programme. We further test this hypothesis in the Robustness section.

[53] The sample of short-term debt securities is much smaller, partly reflecting our scaling of transactions by holdings in $t-1$. We therefore carry on by focusing our analysis on long-term debt securities.

this is driven by the exchange rate, while the effect from prices is also significantly positive, but much smaller than the coefficient on the exchange rate (in line with Table 2.14). In column (7), we observe that for debt, this relatively stronger result of the exchange rate dynamics applies to foreign currency denominated debt securities in general, as the base effect remains positive when including an interaction effect with the USD or the GBP. While the interaction effect with the latter remains insignificant, the interaction with the USD is again significantly positive. This implies that investors behave even more pro-cyclically with regard to exchange rate valuation changes in US dollar denominated debt securities, while this is not observed for the Pound.

Listed Equities and Investment Fund Shares We turn to equity in Table 2.16 which we split into listed equities in column (1) - (4) and investment fund shares in column (5) - (8). We find coefficients on valuation changes to be the smallest for listed equities across all asset classes, which is – as for debt securities – even outweighed by the negative euro interaction term. In addition to this, column (4) shows that listed equity is the only asset class where the effect of the exchange rate shows to be insignificant which causes the overall smaller result for this asset class. We suggest that the intuition for this result is that listed equity is more driven by real investment concerns (i.e. into tangible or intangible parts of a company), while the currency denomination of the security matters.
In contrast, the coefficients for relative valuation changes on investment fund shares are around ten times larger and considerably more significant. Column (6) shows that this strong pro-cyclical investment applies to euro denominated securities as much as for non-euro denominated securities. Looking at foreign currency investment fund shares, we also observe that price effects have almost as large effects on net transactions as exchange rate changes. The mechanism for this relatively stronger effect for investment fund shares is likely simple: investors invest in appreciating investment funds which beat their peers. A deeper analysis of these results would be possible with granular information on the ultimate investments of investment funds which is difficult to identify.[54]

2.2.6.3 Sector Heterogeneity

Sector Heterogeneity for Debt Securities In Tables 5 to 7, we report our main specifications across asset classes with heterogeneous coefficients for each sector. In Table 5, our main finding for debt securities is that institutional investors (MFIs, ICPFs and OFIs) behave significantly different compared to NFCs and households. First, institutional investors show significantly stronger pro-cyclical patterns which are, however, more than offset by the interaction with the euro dummy. This suggests that euro area institutional investors cash out

[54] We did collect data on the main mandate of each investment fund. However, a large share of investment funds is identified as “mixed" funds which means they can invest in bonds, equity, as well as other instruments. It is therefore hard to trace the investment behaviour to the ultimate securities of the investment funds.

on euro denominated bonds after recording valuation gains. This is also consistent with these investors chasing higher yields, which are inversely related to bond prices. Thus, euro area institutional investors behave only pro-cyclically with regard to non-euro denominated debt securities which is driven by relatively larger coefficients on exchange rate-induced valuation gains for MFIs and OFIs and market price-induced valuation gains for ICPFs (column (6) to (10)).[55] Retail investors, i.e. NFCs and households, show smaller overall coefficients which are mainly driven by the exchange rate dynamics of foreign currency denominated assets (columns (9) and (10)).

Sector Heterogeneity for Listed Equities and Investment Fund Shares Similarly to debt, we find institutional investors to be significantly different than retail investors when rebalancing their portfolio of listed equity. The former group shows again stronger overall momentum chasing (column (1)-(3)). Households exhibit even counter-cyclical behaviour by selling assets that are relatively appreciating in value. These results persist for euro-denominated securities, although pro-cyclicality is much less pronounced, in particular for MFIs, while NFCs exhibit counter-cyclicality for euro-denominated securities. Column (6)-(8) show for non-euro denominated securities that the pattern for institutional investors is not driven by the exchange rate for this asset class, but by market price movements. This is in line with our previous assertion that investors see equities as a more "real" asset so that the currency of denomination is less important. The counter-cyclical behaviour of households is driven by the negative coefficient on price dynamics which also holds for the sample of non-euro denominated securities (column (10)).
In line with the overall finding above, we observe the strongest positive effects for investment fund shares. Again, the coefficients are stronger for institutional investors, but all coefficients are in line with the baseline results. The euro interaction effect is only significant for MFIs (with a negative sign, but not outweighing the positive base coefficient), while all sectors invest pro-cyclically following both price as well as exchange rate movements for non-euro denominated securities.

2.2.6.4 Country Heterogeneity

The euro area sovereign debt crisis exposed significant country-differences in terms of macroeconomic and financial stability within the euro area. Accordingly, when analyzing financial investment in the post-crisis period, the literature finds significantly different results for more and less vulnerable euro area countries (e.g. for recent portfolio rebalancing the euro area Bergant et al. (2018); Koijen et al. (2018); Albertazzi et al. (2018)). The intuition is that

[55] We are cautious to speak of portfolio rebalancing for banks as security holdings only reflect a part of their overall assets.

(formerly) stressed countries might be constrained in optimally allocating their portfolio or reaching for yield, as a legacy from the recent crisis. In our case, investors could refrain from rebalancing towards more holdings in foreign currencies when they are reluctant to take on more risk in the form of foreign currency exposure, possibly due to tighter regulatory constraints.

In Table 2.20, we split our sample between formerly stressed countries – Greece, Italy, Portugal, Spain – and the rest of the euro area. We see in columns (1) and (2) that the coefficients on valuation effects for non-stressed countries is more than twice as large and more significant. Similarly, we also observe that the baseline results for the regression including the euro dummy is mainly driven by non-stressed countries (columns (3) and (4)). For stressed countries, the baseline coefficient is barely significant and this effect is not significantly different for euro-denominated securities. In column (5) and (6), we only consider non-euro denominated securities where we find that (i) momentum investment in response to price changes is only significant for non-stressed countries and (ii) the coefficient on valuation changes due to exchange rate dynamics is smaller as well as less slightly significant for stressed countries. Notably, Table 2.20 includes Luxembourg and Ireland in the non-stressed group. In order to test whether the results for this group are driven by these financial centers, we re-run the same specifications excluding them and the results are identical in significance and very similar in terms of magnitude.[56] Summing up, the findings are in line with our intuition outlaid above, namely that stressed countries might have tighter constraints to follow “momentum investment" as a legacy from the recent crisis.

2.2.6.5 Patterns of Momentum Investment

Expectations of Macroeconomic Performance Now that we have rejected the *Portfolio Rebalancing* Hypothesis, the theory laid out in Section 2.2.2 suggests that expectations of future returns determine the portfolio weights of securities and therefore return chasing behaviour. This can be perfectly in line with portfolio optimization if investors adjust their desired exposure to an issuing country according to the economic outlook. Rather than entering a more complex area of asset pricing regressions, we stay on a macro level in the following analysis. In Table 2.21, we test whether return-chasing might be correlated with an adjustment in expectations on the macroeconomic performance of the issuer country. We use changes in the five-year ahead GDP forecasts from different vintages of the World Economic Outlook (WEO) database of the IMF for all issuer-countries of securities to test whether the investment response to valuation changes is driven by changes in the economic outlook for the issuer country of a security.[57]

[56] These results are available upon request.

[57] Specifically, changes in the WEO forecast can materialize with the April (second quarter) and October (fourth quarter) releases each year. For the two quarters without WEO releases, we interpolate the changes to the forecast. In using the WEO forecasts, we do not argue that investors (for instance board members of

Our results in Table 2.21 show two main effects. While the interaction of excess valuation effects with changes in the five-year ahead forecast of real GDP growth (measured in percentage points) is insignificant for the whole sample, there is indeed a significantly positive coefficient for foreign currency denominated securities (column 3). This suggests that changes in the economic outlook of the issuer country is highly important for euro area investors when making investment decisions on foreign currency securities. One explanation for this result could be that investors need to rely on broad macroeconomic forecasts or similar information for foreign (currency) securities due to larger informational frictions. As before, we split the valuation into changes resulting from price dynamics and from exchange rate changes in column (4). We find that the interaction effect with the change in the macroeconomic forecast is driven by the valuation effect coming from exchange rate dynamics. Therefore, for two securities where currencies appreciate equally, euro area investors invest significantly more in securities issued in a country where they experience a positive change in the expectation of the country's macroeconomic performance. In column (5) and (6), we split the sample according to whether the forecast of the issuer country of a security has been revised upwards or downwards as this should directly reflect changes in expectations. We find that our baseline effect for the overall sample is driven by securities where expectations on projected GDP growth for the issuing country are higher than in the previous quarter. Therefore, investors reach for return from valuation only for those securities that are issued by countries with an improving economic outlook.

Other Patterns of Momentum Investment In the following section, we address several alternative interpretations as well as underlying mechanisms of our findings in Table 2.22. First, we analyze whether we observe different investment patterns for high quality (column (1)) and low quality (column (2)) assets. It is considered a key principle in finance that return is only meaningful on a risk-adjusted basis. When investors face a trade-off between and appreciating asset and its risk, they should prefer to invest more (less) in a relatively safer appreciating (depreciating) asset, all else equal. We acknowledge that risk is hard to measure and use a quality classification based on official ratings from the four biggest rating agencies to separate assets in high quality and low quality assets. The former group consist of all debt securities that are labelled with the highest quality step in the ECB harmonised rating scale[58] for more than half of the time of our observation while all other securities are in the latter group.[59] This provides us with a standardized proxy for an asset's risk which is not

investment funds) follow specifically these numbers when adjusting their portfolio shares of securities, but we use this variable as a proxy for general shifts in investor sentiment towards a country. To the best of our knowledge, the WEO forecast is the richest database for economic forecast for a global range of countries with a publicly available history of forecast vintages.

[58] Long term debt securities are labelled with the highest quality step if they obtain one of the following ratings: DBRS:AAA/AAH/AA/AAL, Fitch Ratings:AAA/AA+/AA/AA-; Moody's:Aaa/Aa1/Aa2/Aa3; Standard& Poor's:AAA/AA+/AA/AA-. For a more detailed description, see ECB (2015), page 20.

[59] The groups of high and low quality debt securities are approximately of the same size.

affected by liquidity or overall market conditions. In line with our intuition above, we find that momentum-investment patterns are significantly stronger for highly rated securities. We interpret this as good news for policy makers regarding the risk taking of institutions. The finding is moreover in line with Becker and Ivashina (2015) who show that reaching for yield by insurance companies in the US is less appealing for lower rated compared to higher rated securities.
In column (3) and (4) we divide the sample depending on whether the valuation experienced is a loss or a gain. Effects might be asymmetric for many reasons, such as loss aversion or pressure from investors. We find that our baseline results are driven by positive valuation changes (i.e. gains), while the coefficient on valuation losses turns out to be insignificant.[60] In column (5) and (7), we test non-linearities regarding the size of valuation gains and losses. The idea is that investors might react stronger to extreme movements in prices or exchange rates. We find in column (5) that the reaction to extra strong movements in prices[61] is insignificant for gains so that investors seem to react linearly to valuation gains. For losses, this interaction is significantly negative which even outweighs the base effect. This means that investors would buy securities after especially big price decreases. A reason for this could be that they take the chance to acquire a certain asset at a low price, which might signal a possible undervaluation of the security.

For exchange rate dynamics, we find stronger effects for especially large movements in the exchange rate which are in line with momentum investment. The interaction with stark positive exchange rate movements shows that investors buy dis-proportionally more of a security if the appreciation in the respective exchange rate is relatively stronger. One of the reasons for this behaviour might be that they expect large exchange rates to mirror the development of macroeconomic fundamentals. In the same vein, investors are selling securities that experience large valuation losses due to exchange rate movements.

Finally, in the last column, we analyze whether investors that are relatively more exposed to a currency react stronger to changes in valuation of a security denominated in that currency. We define a dummy that is equal to 1 if the sector is within the top 10% of the most exposed sectors in a given time period. We observe that the interaction is insignificant which means higher and relatively lower exposed investors react similar to valuation changes due to exchange rate movements.

Persistence of investment patterns In Table 2.23, we analyze another dimension of return chasing, namely persistence. The idea is that investors should react differently to temporary vs. longer-term movements in valuation. For gains, it might also be rational to

[60] We show in our next table (Table 2.23), however, that this result reverts as soon as the loss is more persistent.
[61] Stark movements (prices or exchange rate) are indicated by a dummy which is equal to one if the valuation was within the largest 10% of the valuation movements for that time period.

speculate on price increases so that prices are pushed away from fundamentals (DeLong et al., 1990; Abreu and Brunnermeier, 2003). On the other hand, it can be risky to keep depreciating securities as asset prices have shown to continue price trends for several quarters before a reversion (see for instance Cutler et al. (1990, 1991) or more recently Moskowitz et al. (2012)). To test these hypotheses, we interact valuation effects with the number of consecutive quarters of the same type of valuation change (i.e. gains vs. losses). Overall, we find that the momentum chasing effect is generally stronger when more persistent (column(1)) and larger for gains than for losses (column (2)). This overall effect is in line with our idea on expectations: investors are more likely to shift their targeted portfolio share when changes (in valuation) are persistent and not just outliers. More detailed insights come from column (3) and column (4) where we find different narratives for gains and losses. For a better overview, these results are presented in Figure 2.15. For valuation gains, the return chasing behavior peaks at two quarters of consecutive gains for a security and decreases afterwards. This could be driven by expectations of mean reversion after a persistent price increases. However, the negative interaction terms in a given quarter never outweigh the strong positive base effect, implying that we observe return chasing for temporary as well as persistent valuation gains, albeit much smaller for the latter. For losses (column (4)), we see that the baseline effect is negative and therefore in contrast to our general results. Investors might be tempted to buy securities where they see a temporary price decrease in order to purchase them at a relatively lower price. However, if the loss is persistent, this effect is outweighed by the interaction term so that investors sell securities for which they experience a persistent loss in valuation. This can be driven by leveraged institutional investors, such as banks and investment funds, that might be forced to sell depreciating assets due to margin calls (Shleifer and Vishny, 1992).

2.2.6.6 Robustness Tests

We conduct several robustness tests to our main specification. Data availability restricts us to analyze a special time period for the euro area when the ECB introduced various measures of unconventional monetary policy. Thus, one could suggest that our results are only driven by the ECB's asset purchases of euro denominated securities. However, we already showed in Section 2.3.3 descriptively (particularly Figure 2.11) that our results are unlikely to be only driven by only by the APP for several reasons. First, the greatest decline in the share of euro denominated securities happened already before the APP started in the first quarter of 2015. Secondly, we can observe a decline in euro denominated securities in all assets classes, while only debt securities were targeted under the APP. In this section, we test this formally by splitting the sample in the first quarter of 2015 when the largest component of the programme – the Public Sector Asset Purchase Programme (PSPP) including large-scale purchases of public sector securities – was announced and introduced. In column (1) and (2) of Table 2.24, we run our main specification for debt securities and find that the coefficient on valuation

effects is indeed larger for the period after APP was announced (in column (2)). However, the coefficient for valuation changes before the programme (column (1)) also turns out to be highly significant and positive despite the short time span considered which means that the momentum investment patterns are not entirely driven by the introduction of the APP. More likely, during this period of unconventional monetary policy measures overall, euro area investors felt "behind the cycle" of other countries, such as the U.S.. This is in line with our model in section 2.2.2 which predicts higher investment in countries where the expected return on assets is higher.

In a second robustness test, we follow Camanho et al. (2018) and we include the lag as a control of reverse causality. The idea is that if a sector in the euro area buys (sells) significant amounts of a specific security, this may increase (decrease) the market price and therefore generate a generate a relatively higher (lower) return and drive our positive coefficient on the contemporaneous valuation changes. This logic does not apply to the lagged change in valuation changes. We find that all the results hold for our main findings and that size and significance stay almost identical. We can confirm that even when we control for the lagged value of the relative valuation change there is a positive relationship between contemporaneous relative return and net purchases (column (3)) and a smaller, but still positive coefficient for euro-denominated securities (column (4)). The strong positive coefficient for foreign currency securities continues to be driven by the exchange rate component (column (5)). Looking just at the coefficients from the lagged values, we can say that the main findings on foreign securities in column (4) and (5) can also be found in the lagged values of our variables.

2.2.7 Conclusion

The empirical findings presented in this paper provide robust evidence for momentum investment by euro area investors in the period 2013 to 2017. Rather than rebalancing assets towards constant portfolio shares, net purchases of a given security were larger (smaller) when a relatively higher (lower) valuation gain was recorded. Overall, this pattern is driven by securities denominated in foreign currency where the effect from exchange rate dynamics is significantly stronger than the effect from price movements. For these assets, momentum investment is stronger and significantly correlated with the expectations about the issuer country's economic outlook. Thus, our findings suggest that investors shift their targeted portfolio shares according to their expectations of the future economic performance of the group of issuers. Due to the granularity of the micro data used in this paper, we can also document that momentum investment is particularly strong for institutional investors as well as in countries less affected by the recent global and euro area financial crises.

Behind this overall mechanism, we provide evidence for several interesting patterns of momentum investment. We show that the baseline effect is driven by gains rather than losses and by investment in high quality debt securities. The rebalancing towards appreciating securities is

significantly stronger when exchange rate movements are relatively large, but uncorrelated to the investors' initial exposure to the specific currency. Finally, we analyze the dynamics of temporary vs. persistent movements of prices. Investors strongly invest in assets where they experience a short-to-medium term gain, albeit this effect weakens over time. On the other hand, investors buy securities where they experience a short term loss while this effect reverses if losses last more than one quarter.

Our findings are important for policy makers as well as for issuers of securities. Knowing the investor base and their investment patterns of different asset classes improves the ability to predict reactions to changes in the financial environment. Investors who conduct momentum investment can increase the probability of sudden stops and surges in capital flows with repercussions to the real economy (Forbes and Warnock, 2012), for instance by reinforcing the procyclicality of domestic credit growth. We suggest that these considerations are currently important for several reasons. First, euro area monetary policy is expected to normalize over the next years which is very likely to affect the conditions on financial markets. Second, we recently observed turmoil in several emerging markets where euro area investors hold a significant share of outstanding debt.

In this regard, we emphasize that our findings indicate that momentum investment is driven by periods of valuation gains, rather than losses, and targeted at countries with an improving economic outlook. Thus, while our period of observation was largely characterized by increasing asset prices, our results indicate that in periods of falling asset prices, euro area investors may not automatically reverse their investments. Following the intuition of the work by Ahmeda et al. (2016) and Meng and van Wincoop (2018) who break down capital flows into portfolio growth and portfolio reallocation components, we argue that the role of portfolio growth is also an important factor. Euro area investors experienced strong portfolio growth of approximately 20 percent in the last five years. In line with our findings for the euro area, Meng and van Wincoop (2018) show that portfolio growth and reallocations from domestic to foreign securities account for most of US capital flows to individual countries, while portfolio growth proves very persistent. Therefore, portfolio growth and its persistence are additional reasons why the normalization of euro area monetary policy or turmoil in foreign markets may not automatically entail large readjustments in euro area investors' portfolios.

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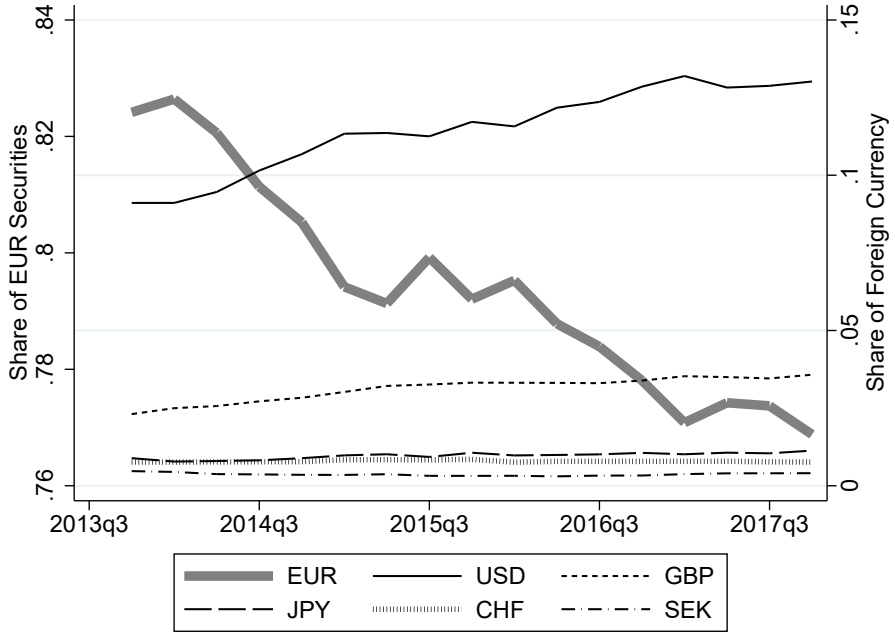
2.2.8 Figures

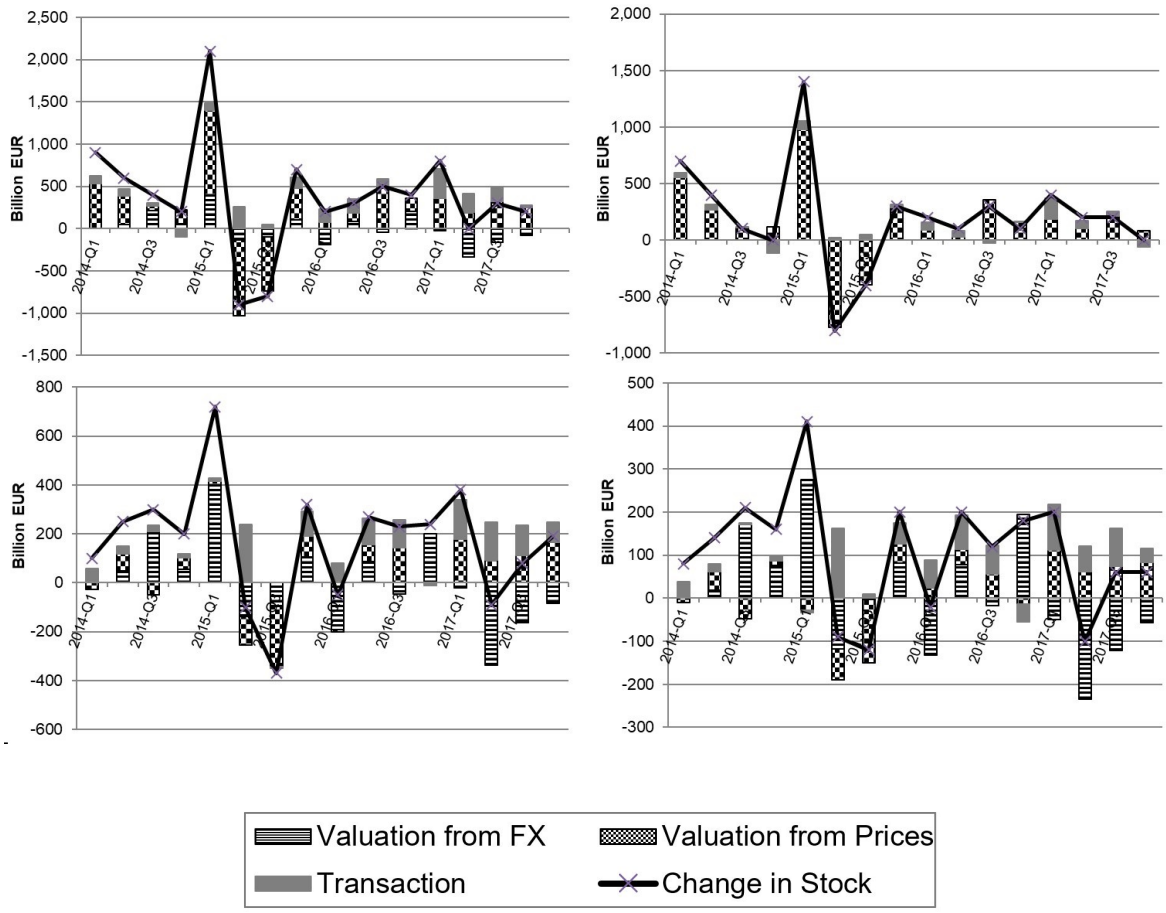
Figure 2.11: Currency Shares in Euro Area Portfolios



Source: Authors' calculation; Data: European Central Bank

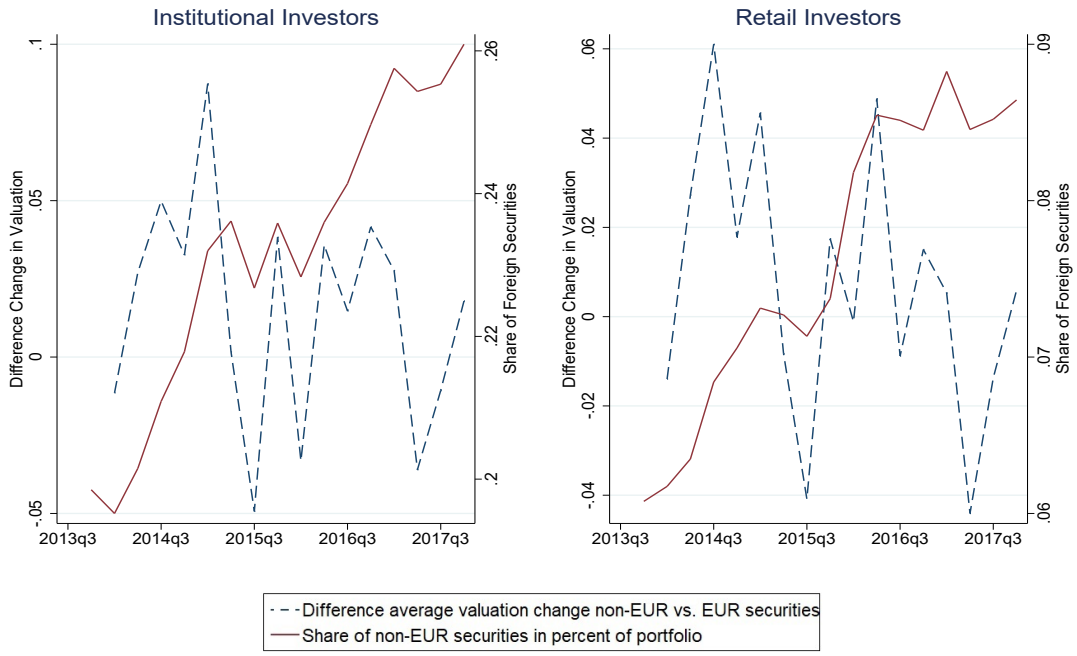
Notes: All values for the calculation of shares are measured in EUR.

Figure 2.12: Capital Flows and Valuation Changes



Source: Authors' calculation; Data: European Central Bank
Notes: The top left graph includes all securities; the top right graph includes only euro denominated securities; the bottom left graph includes all non-euro denominated securities; the bottom right graph includes only US dollar denominated securities.
All values are in billion EUR. The small discrepancies between the change in the stock (line) and the sum of the bars results from changes in coverage or compilation errors, in line with the "Other Flows" category in the BoP.

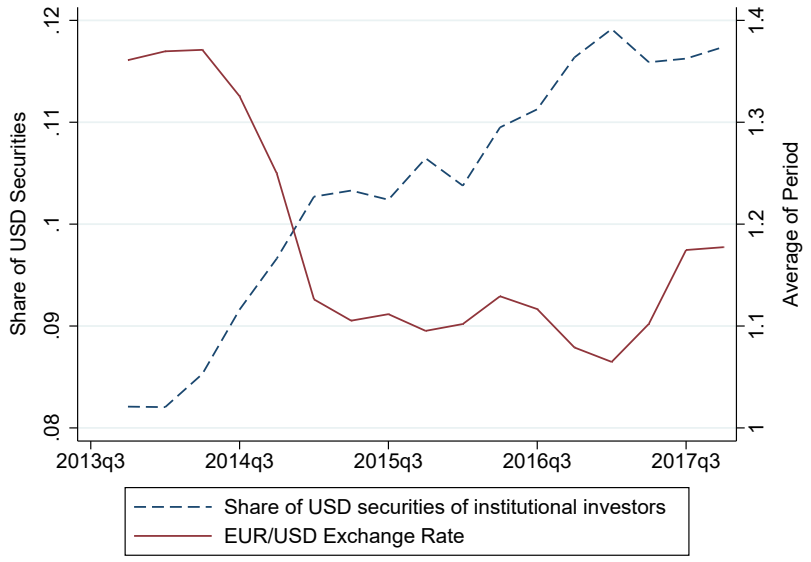
Figure 2.13: Excess Valuation and the Share of non-euro denominated Securities



Source: Authors' calculation; Data: European Central Bank

Notes: The blue line shows the difference of the weighted average valuation changes of non-euro denominated securities and the weighted average valuation changes of euro denominated securities (in percent). When the blue line is above 0, investors experienced higher valuation gains from non-euro denominated securities compared to euro denominated securities on average. The red line shows the share of non-euro denominated securities in the portfolio.

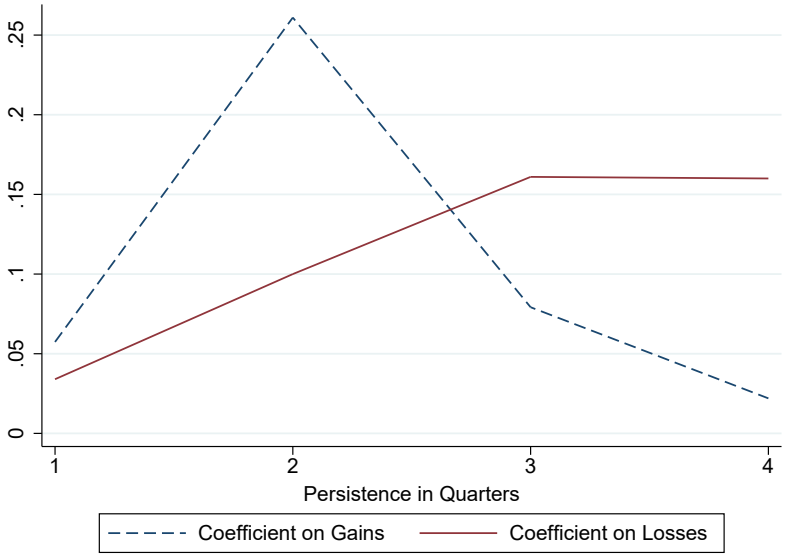
Figure 2.14: Share US Dollar Securities and EUR/USD Exchange Rate



Source: Authors' calculation; Data: European Central Bank

Notes: The blue line shows the share of US dollar denominated securities in the total portfolio. The red line is the EUR/USD exchange rate. Therefore, a decrease in the line means an appreciation of the USD.

Figure 2.15: Coefficients from Table 2.23



Source: Authors' calculation

Notes: Coefficients from regressions displayed in Table 2.23.

2.2.9 Tables

Table 2.12: Summary Table: Stocks, Flows, and Changes in Valuation

	Holdings	Buy	Sell	Total Val	Val(Pr)	Val(Pr)	Val (FX)
	All Securities				only EUR	only non-EUR	
	Panel A: Monetary and Financial Institutions*						
Mean	24.10	9.43	-11.20	.54%	.39%	0.44%	.31%
Std.	225.00	79.70	87.80	7.79%	5.29%	10.46%	4.58%
Obs.	4.17	1.76	1.58	3.19	2.14	1.11	1.39
	Panel B: Other Financial Institutions						
Mean	17.50	4.49	-3.79	.77%	.48%	0.53%	.38%
Std.	154.00	40.50	38.50	8.63%	5.96%	9.67%	4.74%
Obs.	8.84	3.21	3.31	7.02	3.37	3.86	4.30
	Panel C: Insurance Companies and Pension Funds						
Mean	29.10	3.54	-3.55	.82%	.64%	1.00%	-.05%
Std.	1,320.00	41.10	42.30	7.43%	5.49%	9.01%	4.40%
Obs.	3.65	1.47	1.22	3.11	1.90	1.25	1.42
	Panel D: Non-Financial Corporations						
Mean	8.87	1.63	-1.81	.59%	.56%	0.19%	.37%
Std.	272.00	40.20	36.60	8.98%	6.58%	12.31%	4.69%
Obs.	2.99	1.02	.87	2.42	1.70	0.75	.89
	Panel E: Households						
Mean	4.27	.65	-.73	.47%	.47%	0.03%	.35%
Std.	9.20	15.90	14.20	9.44%	7.13%	13.01%	4.57%
Obs.	13.41	4.20	3.89	9.93	7.09	2.96	3.44

Notes: Holdings is the market value of a security held (in million euros). Buy and sell refers to the amount bought and sold in million euros in one quarter. Total Val refers to the change in valuation of a security per quarter. This consists of the change in the market price of the security (Val(Pr)) but also the change in the exchange rate Val(FX) for securities not denominated in euro. Obsevations are in million.
Source: Authors' calculations; Data: European Central Bank

Table 2.13: Summary Table on Holdings

		2014Q1		2017Q4	
		bn EUR	**%**	**bn EUR**	**%**
ALL		**24 460**	**100%**	**29 314**	**100%**
Sector	MFI	6 227	25%	5 298	18%
	OFI	7 365	30%	10 664	36%
	ICPF	5 275	22%	7 166	24%
	NFC	1 504	6%	1 746	6%
	HH	3 273	13%	3 488	12%
	GOV	816	3%	953	3%
Country	DE	5 336	22%	6 559	22%
	FR	5 393	22%	5 804	20%
	LU	2 774	11%	4 139	14%
	IE	1 403	6%	2 470	8%
Asset Class	Debt	14 014	57%	14 418	49%
	Equity	5 113	21%	7 065	24%
	IF shares	5 333	22%	7 831	27%
Issuer Location	All EA	19 606	80%	21956	75%
	of which domestic	13 212	54%	13787	47%
	US	1 630	7%	2 771	9%
	UK	997	4%	1 430	5%
	Emerging	507	2%	761	3%

Source: Authors' calculations; Data: European Central Bank
Notes: Descriptive Table. Values are in bn EUR.

Table 2.14: Baseline Specification

	All Securities			Non-euro denominated Securities		
	(1)	(2)	(3)	(4)	(5)	(6)
$val^{tot}_{a,j,t}$	0.0712***	0.0938***		0.0911***		
	(7.98)	(12.08)		(12.22)		
$val^{tot}_{a,j,t}$*EUR		-0.0630***				
		(-2.94)				
$val^{p}_{a,j,t}$			0.0561***		0.0646***	0.0825***
			(7.89)		(8.72)	(10.96)
$val^{fx}_{a,j,t}$					0.352***	0.0452
					(6.95)	(0.85)
$val^{p}_{a,j,t}$*EUR			0.0255			
			(1.33)			
$val^{fx}_{a,j,t}$*USD						0.580***
						(7.16)
$val^{fx}_{a,j,t}$*GBP						0.303***
						(3.44)
N	22190248	22190248	22190248	8144163	8144163	8144163
Country-Sector FE	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in t − 1: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ *is the total change in valuation of asset a in time t relative to the rest of the portfolio.*
$val^{p}_{a,t}$ *is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.*
$val^{fx}_{a,t}$ *is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.*
EUR, USD, and GBP are dummies for denomination in euro, US dollar, and the GB pound, respectively.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.15: Debt Securities

	All Securities				Non-Euro denominated Securities		
	All		Long-term	Short-term			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$val^{tot}_{a,j,t}$	0.068**	0.240***	0.062**	0.200	0.234***		
	(2.54)	(8.50)	(2.52)	(1.40)	(8.60)		
$val^{tot}_{a,j,t}$*EUR		-0.271***					
		(-5.97)					
$val^{p}_{a,j,t}$						0.081***	0.081***
						(4.74)	(4.50)
$val^{fx}_{a,j,t}$						0.510***	0.263***
						(8.11)	(6.26)
$val^{fx}_{a,j,t}$*USD							0.517***
							(5.22)
$val^{fx}_{a,j,t}$*GBP							0.178
							(1.41)
N	13230264	12291680	12291680	936984	3630769	3630769	3630769
Country-Sector FE	x	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$*:* $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ *is the total change in valuation of asset a in time t relative to the rest of the portfolio.*
$val^{p}_{a,t}$ *is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.*
$val^{fx}_{a,t}$ *is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.*
EUR, USD, and GBP are dummies for denomination in euro, US dollar, and the GB pound, respectively.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.16: Equity Securities

	Equity				**IF Shares**			
	All Securities		Non-Euro Securities		All Securities		Non-Euro Securities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$val^{tot}_{a,j,t}$	0.038***	0.049***	0.048***		0.266***	0.285***	0.287***	
	(6.78)	(6.99)	(6.85)		(13.89)	(13.19)	(13.05)	
$val^{tot}_{a,j,t}$*EUR		-0.055***				-0.034		
		(-6.09)				(-0.90)		
$val^{p}_{a,j,t}$				0.046***				0.238***
				(6.45)				(11.75)
$val^{fx}_{a,j,t}$				0.066				0.314***
				(0.85)				(5.72)
N	3630790	3630790	2825933	2825933	5328918	5328918	1601033	1601033
Country-Sector FE	x	x	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$

$val^{tot}_{a,t}$ is the total change in valuation of asset a in time t relative to the rest of the portfolio.

$val^{p}_{a,t}$ is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.

$val^{fx}_{a,t}$ is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.

EUR is a dummy for denomination of asset a in euro.

t-values in brackets.

** significant at 10% level; ** significant at 5% level, *** significant at 1% level*

*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.17: Sector Heterogeneity for Debt Securities

	ICPF (1)	**OFI** (2)	**MFI** (3)	**NFC** (4)	**HH** (5)	**ICPF** (6)	**OFI** (7)	**MFI** (8)	**NFC** (9)	**HH** (10)
$val^{tot}_{a,j,t}$	0.307***	0.251***	0.442***	0.186***	0.091***					
	(7.44)	(7.83)	(5.10)	(4.96)	(3.76)					
$val^{tot}_{a,j,t}$ * EUR	-0.407***	-0.403***	-0.570***	-0.152***	-0.035					
	(-8.16)	(-4.62)	(-3.84)	(-2.85)	(-0.72)					
$val^{p}_{a,j,t}$						0.205***	0.120***	-0.037	0.023	-0.045*
						(5.81)	(6.24)	(-0.62)	(0.74)	(-1.81)
$val^{fx}_{a,j,t}$						0.304***	0.551***	1.309***	0.427***	0.372***
						(3.57)	(5.86)	(8.10)	(8.40)	(7.82)
N	13230264					3717117				
Country-Sector FE	x	x	x	x	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x	x	x	x	x
SECTOR * EUR	x	x	x	x	x					

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ is the total change in valuation of asset a in time t relative to the rest of the portfolio.
$val^{p}_{a,t}$ is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.
$val^{fx}_{a,t}$ is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.
EUR is a dummy for denomination of asset a in euro.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.18: Sector Heterogeneity for Listed Equity Securities

	ICPF (1)	**OFI** (2)	**MFI** (3)	**NFC** (4)	**HH** (5)	**ICPF** (6)	**OFI** (7)	**MFI** (8)	**NFC** (9)	**HH** (10)
$val^{tot}_{a,j,t}$	0.214***	0.168***	0.165***	0.006	-0.081***					
	(13.41)	(19.07)	(3.33)	(0.69)	(-10.52)					
$val^{tot}_{a,j,t}$ * EUR	-0.124***	-0.028*	-0.163***	-0.054***	-0.012					
	(-5.92)	(-1.92)	(-2.61)	(-3.98)	(-1.19)					
$val^{p}_{a,j,t}$						0.212***	0.168***	0.166***	0.001	-0.084***
						(14.58)	(20.63)	(3.79)	(0.14)	(-10.71)
$val^{fx}_{a,j,t}$						0.039	-0.007	-0.050	0.164**	0.116**
						(0.33)	(-0.06)	(-0.10)	(2.04)	(2.39)
N	3630790					2825933				
Country-Sector FE	x	x	x	x	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x	x	x	x	x
SECTOR * EUR	x	x	x	x	x					

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ is the total change in valuation of asset a in time t relative to the rest of the portfolio.
$val^{p}_{a,t}$ is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.
$val^{fx}_{a,t}$ is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.
EUR is a dummy for denomination of asset a in euro.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.19: Sector Heterogeneity for Investment Fund Shares

	ICPF (1)	**OFI** (2)	**MFI** (3)	**NFC** (4)	**HH** (5)	**ICPF** (6)	**OFI** (7)	**MFI** (8)	**NFC** (9)	**HH** (10)
$val^{tot}_{a,j,t}$	0.374***	0.439***	0.322***	0.287***	0.196***					
	(16.13)	(15.61)	(4.70)	(10.33)	(6.94)					
$val^{tot}_{a,j,t}$ * EUR	-0.047	-0.089	-0.234***	-0.041	0.020					
	(-1.02)	(-1.51)	(-3.10)	(-1.02)	(0.50)					
$val^{p}_{a,j,t}$						0.342***	0.377***	0.196***	0.247***	0.159***
						(14.49)	(13.71)	(4.19)	(8.52)	(6.21)
$val^{fx}_{a,j,t}$						0.184***	0.409***	0.930***	0.253***	0.260***
						(3.20)	(4.59)	(3.95)	(2.74)	(4.79)
N	5328918					1601033				
Country-Sector FE	x	x	x	x	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x	x	x	x	x
SECTOR * EUR	x	x	x	x	x					

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ is the total change in valuation of asset a in time t relative to the rest of the portfolio.
$val^{p}_{a,t}$ is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.
$val^{fx}_{a,t}$ is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.
EUR is a dummy for denomination of asset a in euro.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.20: Country Heterogeneity

	Non-Stressed	Stressed	Non-Stressed	Stressed	Non-Stressed	Stressed
$val^{tot}_{a,j,t}$	0.077***	0.037**	0.104***	0.025*		
	(8.25)	(2.53)	(13.82)	(1.66)		
$val^{tot}_{a,j,t}$*EUR			-0.078***	0.031		
			(-3.35)	(1.40)		
$val^{p}_{a,j,t}$					0.073***	-0.010
					(10.46)	(-0.72)
$val^{fx}_{a,j,t}$					0.422***	0.348***
					(8.05)	(7.24)
N	22190248		22190248		8148734	
Country-Sector FE	x		x		x	
ISIN FE	x		x		x	

Notes: Stressed countries are Greece, Italy, Portugal, Spain, the rest is in the Non-Stressed group.
The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ is the total change in valuation of asset a in time t relative to the rest of the portfolio.
$val^{p}_{a,t}$ is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.
$val^{fx}_{a,t}$ is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.
EUR is a dummy for denomination of asset a in euro.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.21: Macroeconomic Outlook

	All	EUR	FOREIGN		Pos. Dummy	Neg. Dummy
$val^{tot}_{a,j,t}$	0.071***	0.033	0.105***		0.106***	0.028
	(6.565)	(1.517)	(10.146)		(6.842)	(1.324)
$\Delta GDPForecast_t$	0.023	0.032	0.009	0.010		
	(1.597)	(1.494)	(0.897)	(1.287)		
$val^{tot}_{a,j,t} * \Delta GDPForecast_t$	0.036	0.019	0.118***			
	(1.125)	(0.284)	(4.089)			
$val^{p}_{a,j,t}$				0.059***		
				(6.159)		
$val^{fx}_{a,j,t}$				0.505***		
				(11.597)		
$val^{p}_{a,j,t} * \Delta GDPForecast_t$				0.052*		
				(1.851)		
$val^{fx}_{a,j,t} * \Delta GDPForecast_t$				0.448***		
				(5.421)		
N	20,364,381	13,782,544	6,580,963	6,583,700	10,332,088	9,631,246
Country-Sector FE	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ is the total change in valuation of asset a in time t relative to the rest of the portfolio.
$\Delta GDPForecast_t$ is the percentage change in 5 year annual GDP growth forecast (WEO) for the issuing country of asset a in time t.
Column (2) and (3) only include euro denominated and foreign currency denominated securities, respectively.
Column (4) and (5) only include the sample where the 5 year annual GDP growth forecast (WEO) has been revised upwards and downwards, respectively.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.22: Investment Patterns and Non-Linearities

	DEBT		ALL ASSET CLASSES				
	All Securities		All Securities			Non-euro Securities	
	High Quality	Low Quality	$val^{tot}_{a,j,t} > 0$	$val^{tot}_{a,j,t} < 0$	All		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$val^{tot}_{a,j,t}$	0.219***	0.078***	0.103***	-0.062	0.228*	0.084***	0.094***
	(4.52)	(4.15)	(2.59)	(-1.48)	(1.96)	(10.55)	(10.70)
$val^{tot}_{a,j,t}$ * Stark Pr Movement>0					-0.108		
					(-0.97)		
$val^{tot}_{a,j,t}$ * Stark Pr Movement<0					-0.234*		
					(-1.76)		
$val^{tot}_{a,j,t}$ * Stark FX Movement>0						0.092***	
						(3.81)	
$val^{tot}_{a,j,t}$ * Stark FX Movement<0						0.050**	
						(2.49)	
$val^{tot}_{a,j,t}$ * High Curr Exp							0.012
							(0.84)
N	1905725	2031215	9447198	12166206	22190248	8144163	8144163
Country-Sector FE	x	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ is the total change in valuation of asset a in time t relative to the rest of the portfolio.
High Quality Securities are rated on the highest step of the ECB harmonised rating scale for ECAIs (Description on page 20)
EUR and USD are dummies for denomination in euro and US dollar, respectively.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.24: Robustness Tests

	Debt		All Assets		
	Pre-APP	APP	Including Lag Values		
	(1)	(2)	(3)	(4)	(5)
$val^{tot}_{a,j,t}$	0.090***	0.271***	0.073***	0.101***	
	(3.62)	(7.26)	(5.84)	(11.20)	
$val^{tot}_{a,j,t}$*EUR	-0.202***	-0.332***		-0.080***	
	(-2.71)	(-3.50)		(-2.61)	
$val^{p}_{a,j,t}$					0.072***
					(7.82)
$val^{fx}_{a,j,t}$					0.304***
					(6.04)
$val^{tot}_{a,j,t-1}$			-0.009	0.016**	
			(-0.72)	(2.55)	
$va^{tot}_{a,j,t-1}$*EUR				-0.071**	
				(-2.27)	
$val^{p}_{a,j,t-1}$					0.003
					(0.59)
$val^{fx}_{a,j,t-1}$					0.121***
					(3.22)
N	2469327	9752109	18269733	18269733	6912047
Country-Sector FE	x	x	x	x	x
ISIN FE	x	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in $t-1$*:* $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ *is the total change in valuation of asset a in time t relative to the rest of the portfolio.*
$val^{p}_{a,t}$ *is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.*
$val^{fx}_{a,t}$ *is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.*
EUR and USD are dummies for denomination in euro and US dollar, respectively.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

Table 2.23: Persistence

	(1)	(2)	only gains (3)	only losses (4)
$val^{tot}_{a,j,t}$	0.014	0.015	0.143***	-0.186***
	(1.41)	(1.41)	(5.05)	(-5.04)
$val^{tot}_{a,j,t}$ * Quarters of same VAL	0.057***			
	(7.84)			
$val^{tot}_{a,j,t}$ * Quarters of VAL gains		0.063***		
		(7.17)		
$val^{tot}_{a,j,t}$ * Quarters of VAL losses		0.048***		
		(5.54)		
$val^{tot}_{a,j,t}$ * Dummy (Gain 1 Quarter)			-0.086***	
			(-4.56)	
$val^{tot}_{a,j,t}$ * Dummy (Gains 2 Quarters)			0.118***	
			(4.15)	
$val^{tot}_{a,j,t}$ * Dummy (Gains 3 Quarters)			-0.064*	
			(-1.83)	
$val^{tot}_{a,j,t}$ * Dummy (Gains >4 Quarters)			-0.121***	
			(-3.15)	
$val^{tot}_{a,j,t}$ * Dummy (Loss 1 Quarter)				0.220***
				(6.28)
$val^{tot}_{a,j,t}$ * Dummy (Losses 2 Quarters)				0.286***
				(7.65)
$val^{tot}_{a,j,t}$ * Dummy (Losses 3 Quarters)				0.347***
				(8.50)
$val^{tot}_{a,j,t}$ * Dummy (Losses >4 Quarters)				0.346***
				(7.72)
N	22190248	22190248	9817164	11775445
Country-Sector FE	x	x	x	x
ISIN FE	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in t − 1: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ *is the total change in valuation of asset a in time t relative to the rest of the portfolio.*
$val^{p}_{a,t}$ *is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.*
$val^{fx}_{a,t}$ *is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.*
EUR and USD are dummies for denomination in euro and US dollar, respectively.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

2.2.10 Appendix

Table 2.25: Baseline Specification with Time Fixed Effects

	All Securities			Non-euro denominated Securities		
	(1)	(2)	(3)	(4)	(5)	(6)
$val^{tot}_{a,j,t}$	0.063***	0.068***		0.069***		
	(0.009)	(0.010)		(0.007)		
$val^{tot}_{a,j,t}$*EUR		-0.013				
		(0.017)				
$val^{p}_{a,j,t}$			0.066***		0.062***	0.061***
			(0.008)		(0.007)	(0.007)
$val^{p}_{a,j,t}$*EUR			-0.015			
			(0.017)			
$val^{fx}_{a,j,t}$					0.183***	0.048
					(0.040)	(0.046)
$val^{fx}_{a,j,t}$*USD						0.364***
						(0.064)
$val^{fx}_{a,j,t}$*GBP						0.134*
						(0.069)
Observations	22,190,248	22,190,248	22,586,222	8,144,162	8,148,733	8,148,733
Country-Sector-Time FE	x	x	x	x	x	x
ISIN FE	x	x	x	x	x	x

Notes: The dependent variable is transactions of asset a in time t scaled by its holdings in t − 1: $\frac{Transactions_{a,t}}{Holdings_{a,t-1}}$
$val^{tot}_{a,t}$ *is the total change in valuation of asset a in time t relative to the rest of the portfolio.*
$val^{p}_{a,t}$ *is the change in valuation due to price changes of asset a in time t relative to the rest of the portfolio.*
$val^{fx}_{a,t}$ *is the change in valuation due to exchange rate changes of the currency of denomination of asset a in time t relative to the rest of the portfolio.*
EUR, USD, and GBP are dummies for denomination in euro, US dollar, and the GB pound, respectively.
t-values in brackets.
** significant at 10% level; ** significant at 5% level, *** significant at 1% level*
*All regressions are at the security level. Standard errors are clustered at the issuer country * quarter level.*

2.3 International Capital Flows and the ECB's Asset Purchase Programme [62]

2.3.1 Introduction

Large scale asset purchase programmes (LSAPs) by central banks have become a popular tool of unconventional monetary policy since the global financial crisis to stimulate economic growth and fulfil inflation objectives in a zero lower bound environment. A major transmission channel of these policies to the real economy is portfolio rebalancing towards higher yielding domestic as well as foreign assets.

The European Central Bank's (ECB) unconventional monetary policy measures, covering the large scale Asset Purchase Programme (APP), a negative deposit rate, and targeted longer-term refinancing operations (TLTROs), reduced euro area long-term risk-free rates by around 80 basis points since June 2014 (ECB, 2017b). The resulting yield differentials between euro area and foreign government bonds have played an important role for euro area capital flows since then (ECB, 2017a). Evidence from the euro area balance of payments shows that the introduction of the main component of the APP – namely the Public Sector Purchase Programme (PSPP) – was followed by significant net capital outflows (Figure 2.16).[63] At their peak in mid-2016, net outflows of portfolio investment reached an all-time high of nearly 5% of euro area GDP (Coeure, 2017). While non-residents account for a sizable share of bond sales to the Eurosystem, euro area investors have been a major driving force behind the observed net outflows (Figure 2.17). Since the start of the PSPP in March 2015, net purchases of foreign securities by domestic investors took place almost entirely in the form of long-term bonds suggesting that domestic investors partly rebalanced their portfolios towards the closest substitute to PSPP eligible assets outside the euro area. In addition, the APP triggered substantial intra-euro area liquidity flows related to portfolio rebalancing which were partly reflected in rising TARGET balances (Eisenschmidt et al., 2017).

This macro-based evidence shows that LSAPs can trigger substantial cross-border capital flows by way of the portfolio rebalancing channel. In an integrated international financial system, monetary policy impacts both domestic investment patterns and international capital flows. The growing complexity and interconnectedness of the international financial system as well as sector heterogeneity provide a strong case for incorporating micro data for policy analysis (Lane, 2015). Limitations of macro data pertain for instance to the limited extent of sectoral information on holders and issuers of assets, both in a domestic and cross-border

[62] Co-authored with Martin Schmitz (DG-Statistics, European Central Bank). Michael Fidora was my designated supervisor during my research visit at the European Central Bank. This is a slightly revised version of the CEPS ECMI Working Paper published under the title *"International Capital Flows at the Security Level - Evidence from the ECB's Asset Purchase Programme"* as the paper received the CEPS ECMI Best Paper Award 2018.

[63] The PSPP accounts for approximately 80% of the entire APP

context. Consistent country-level data on capital *flows* are usually only available unilaterally, while bilateral data merely cover investment *positions*, are available at low frequencies, and do not include the holdings of domestic securities (e.g. the IMF's Coordinated Portfolio Investment Survey, CPIS). Finally, only security-by-security data allow identifying important asset specific characteristics such as the issuing entity, the yield and market prices, as well as the currency denomination, rating, or the maturity.

The objective of this paper is to analyse the capital outflows observed during the APP programme at a very granular level . In doing so, we seek to answer the question whether euro area investors did rebalance away from the very same securities that were targeted by the ECB during the APP. Moreover: what securities did euro area investors buy outside the euro area (i.e. securities issued by which countries and sectors), thereby creating global spillovers from the ECB's policies? What were the determinants of these capital flows? Were there heterogeneous investment patterns across euro area sectors and countries?

To answer these questions, we use security-by-security data from the European System of Central Banks' (ESCB) Securities Holding Statistics by sector (SHSS) which offers a comprehensive, fully integrated, granular dataset of the security holdings of euro area residents. Our dataset allows for providing a detailed account of euro area portfolio rebalancing over the first eight quarters of the PSPP period (2015Q1 to 2016Q4) – both at the country and sector level, incorporating domestic, euro area and global capital flows of euro area residents.[64]

Our paper is the first – to the best of our knowledge – to analyse actual capital flows (i.e. net purchases or net sales) at the security level in a bilateral cross-country-sector setting.[65] With our empirical specification of sectoral, bilateral capital flows at the security level, we are able to test several hypotheses with regard to the impact of the APP on portfolio rebalancing. Moreover, as our dataset includes holdings as well as transactions of individual securities, we are able to decompose the overall portfolio rebalancing of euro area investors into 'active' (i.e. capital flows) and 'passive' components (i.e. valuation changes due to fluctuations in security prices and exchange rates), following the intuition of Tille and van Wincoop (2010).

The SHSS data encompass security holdings and transactions of all economic sectors in euro area countries (with the exception of the monetary authorities), rather than singling out a specific country or sector. Exploiting this allows for examining heterogeneity among investors along various dimensions. We argue that it is crucial to consider sectoral heterogeneity, especially when analysing the PSPP, due to differing initial positions at the start of the programme (most notably in terms of exposure to public sector bonds, ECB (2017c)), different degrees of investor sophistication, informational frictions, or different asset and liability management strategies as well as regulatory constraints which may imply heterogeneous

[64] As such we are able to integrate the analysis of domestic and international sectoral portfolios, similar to Heipertz et al. (2016) who use data on French sectoral portfolios to estimate how different sectors are affected by balance sheet contagion.

[65] While Boermans and Vermeulen (2016) also use information on positions from the SHSS data, their analysis focuses on the cross-sectional determinants of security holdings before the APP, rather than on transactions.

responses.

Our paper contributes to the literature on the cross-border impact of LSAPs, which was initially triggered by the first rounds of the Federal Reserves' quantitative easing (QE). Neely (2010) shows that the Fed's QE significantly reduced not only domestic, but also foreign long-term bond yields, while Moore et al. (2013) find that QE also resulted in a significant increase in the foreign ownership of emerging market debt securities. The channels through which QE affects international portfolio rebalancing emerge from the transmission channels of unconventional monetary policy in the domestic economy. Beyond pure 'scarcity' effects, LSAPs can work through the signalling effect, the extraction of duration risk, as well as confidence and inflation channels (Krishnamurthy and Vissing-Jorgensen, 2011).

In general, international portfolio rebalancing will occur in response to an absorption of the supply of safe long-term bonds by the central bank under QE. If unconventional monetary policy is successful in raising the price and lowering the yields of such assets, investors will seek higher yielding assets abroad. These effects may be reinforced via the duration risk channel as the reduced supply will induce investors to accept a smaller term premium for long-term bonds which further lowers their yields and increases their incentives to invest in higher yielding foreign assets (Chari et al., 2017). In particular, rebalancing may happen towards bonds with similar characteristics via "preferred-habitat investors" (Vayanos and Vila, 2009).

Moreover, under the signalling channel, investors may perceive a credible commitment by the central bank to keep also short-term rates (despite not directly targeted by QE) low for a considerable period of time. This gives rise to persistent interest rate differentials which in turn could incentivise cross-border carry trades (Neely, 2010). Related to the former, under the inflation channel, investors may expect higher inflation rates in the future and – under the purchasing power parity hypothesis – a depreciation of the currency which would further trigger appetite for foreign assets.

Furthermore, unconventional monetary policy may affect international capital flows via the confidence channel. If financial markets extract private information from QE on the central bank's economic outlook, this may affect investor sentiment and risk aversion. The sign of the correlation of capital flows and LSAPs thereby depends on the interpretation given to the central banks' motivation behind QE. If asset purchases are interpreted as the central bank pointing to a less favourable economic outlook in the domestic economy than abroad, the confidence channel implies a positive relationship between QE and capital outflows. On the contrary, Chari et al. (2017) argue that a tapering by the Fed may be interpreted as a sign of an improving global outlook and thereby trigger capital flows to emerging economies. In this example, the confidence channel would imply that QE is negatively related to capital outflows.

There is a broad consensus that the ECB's APP persistently reduced euro area long-term

bond yields, both of targeted and other debt securities, while also boosting equity prices via the signalling channel (Altavilla et al. (2015), Andrade et al. (2016), and Fratzscher et al. (2016)). Event-studies focusing on the ECB's APP announcement show that the effect on investor sentiment had significant spillovers to the rest of the European Union (EU) and global equity markets (Falagiarda et al. (2015); Georgiadis and Graeb (2016)). Examining the impact of monetary policy surprises associated with the ECB's APP, Bubeck et al. (2017) present high-frequency event-study evidence on the investment behaviour of mutual funds based in Luxembourg. They distinguish between an active channel (transactions) and a passive channel (changes in the value), of which they find only the latter to be a significant driver of portfolio rebalancing at the daily frequency.

Our paper also contributes to the literature on portfolio rebalancing using microdata. This strand has grown over time, but usually focuses only on a particular sector or country: Calvet et al. (2009) examine the portfolio rebalancing of Swedish households and Hau et al. (2017) find that international equity funds rebalance from foreign investment after making excess returns relative to their domestic equity investment. While we follow this literature and use fixed effects for the holder and issuer country pairs to control for incomplete asset markets and transaction costs in international asset trade, we also contribute to the broader literature analysing the determinants of international capital flows by incorporating the concept of "push" and "pull" factors in our analysis. Since seminal papers have shown evidence of their significance as drivers of international capital flows (Calvo et al. (1993, 1996), Fernandez-Arias (1996), Chuhan et al. (1998), Griffin et al. (2004)), push and pull determinants have received significant attention, especially in the aftermath of the global financial crisis (Fratzscher (2012), Forbes and Warnock (2012), and more recently Cerutti et al. (2017)) and McQuade and Schmitz (2019).

In contrast to other contributions using the SHSS dataset, we are the first to use actual data on net transactions at the euro area level: Koijen et al. (2018) assess rebalancing by using information on changes in security holdings and show for the period 2015Q2 until 2016Q4 that foreign investors rebalanced most in response to the ECB's PSPP purchases, followed by euro area banks and mutual funds. Albertazzi et al. (2018) find that portfolio rebalancing played a relevant role in the transmission of the ECB's APP, but with important differences across countries. Boermans and Vermeulen (2018) suggest that euro area investors' preference for holding bonds with certain characteristics ("preferred habitat") remained stable during the APP. Analysing net transactions by Irish investment funds, Bua and Dunne (2017) find significant evidence of portfolio rebalancing away from euro area government bonds, but only after the PSPP was scaled up in June 2016.

The rest of the paper is organised as follows: In Section 2.3.2, we introduce our dataset and the empirical framework. We provide descriptive evidence on the portfolio rebalancing of euro area investors since the launch of the APP in Section 2.3.3. Section 2.3.4 presents our

econometric results and Section 2.3.5 concludes.

2.3.2 Empirical Framework

2.3.2.1 Data

We use data on security-level portfolio holdings and transactions of all 19 euro area countries from the ESCB Securities Holding Statistics (SHSS).[66] The data are collected by national central banks from (i) financial investors and (ii) custodians.

It covers all short-term and long-term debt securities, listed shares, as well as investment fund shares that are identified with a unique International Securities Identification Number (ISIN). This split into financial instruments is in line with those included in national accounts or balance of payments statistics. The data are collected on a quarterly basis since 2013Q4 and we use releases until 2016Q4 for this analysis. The SHSS data consist of *directly* and *indirectly* reported securities. A financial institution resident in the euro area is obligated to report securities that it holds as its own investment ("direct reporting") as well as securities that it holds in custody ("indirect reporting"). In order to avoid double reporting, only assets held in custody for non-financial investors (mainly households and non-financial corporations) are included in the SHSS.[67] Investors in the data are defined by their country of domicile and sector. We follow the European System of Accounts (2010) and aggregate the data to six sectors: monetary and financial institutions (MFI) excluding monetary authorities, insurance companies and pension funds (ICPF), other financial institutions (OFI)[68], non-financial corporations (NFCs), general government and households.[69] Using the ISIN for every security, we merge the SHSS data to individual asset characteristics obtained from the ESCB's Centralised Securities Database (CSDB) which contains information on more than six million debt and equity securities issued globally. Therefore, we can use information at the security-level, such as the instrument type, issuer country and institutional sector, currency of denomination, yields and original maturity.

2.3.2.2 Econometric approach

Our paper builds on the literature estimating the determinants of international investment patterns and extends it by analysing the drivers of euro area investors' international capital

[66] This dataset is collected according to Regulation ECB/2012/24, see `http://www.ecb.europa.eu/ecb/legal/pdf/l_30520121101en00060024.pdf`

[67] Double-counting could occur if there are several intermediate financial institutions between the final non-financial investor and the financial institution holding assets in custody.

[68] These include important intermediaries such as mutual funds which represent the largest subgroup of this sector.

[69] As for Balance of Payments statistics, one potential shortcoming of the dataset is the incomplete coverage of securities held in custody outside the euro area by the non-financial sector.

flows at the security-level for the APP period. We specify the model

$$ln(flow_{a,i,j,t}) = \beta_d^0 ln(A_{a,i,j,t-1}) + \beta_d^1 * x_{a,t}^1 + ... + \beta_d^k * x_{a,t}^k + \gamma_{h,s} + \alpha_i + \alpha_j + \epsilon_{a,i,j} \quad (2.25)$$

where $ln(flow_{a,i,j,t})$ represents the log of country-sector i's net transactions (i.e. net sales or purchases) accumulated over t (i.e. the PSPP period 2015Q1-2016Q4) of security a issued by country-sector j.[70] The dependent variable is regressed on pre-PSPP holdings of a security $ln(A_{a,i,j,t-1})$, defined as holdings at the end of 2014Q4, which are included in order to control for the pre-existing 'level' of a sectors' investment in a specific security.[71] Due to the granularity of our dataset, we are able to control for asset specific characteristics ($x_{a,t}^k$) that may influence investment behaviour directly. Our main variables of interest are (i) *PSPP Eligible* which is a dummy variable equal to one if the security is eligible to be bought under PSPP and (ii) *PSPP Substitute* which is a dummy variable equal to one for sovereign debt securities issued by advanced countries outside the euro area as defined in 2.3.2.3. As control variables at the security level, we also include the change in the outstanding amount of a security (at market prices) which signifies to what extent investors follow shifts in the market-portfolio. This should be the case under the assumptions of identical investor preferences, no financial frictions, and efficient asset pricing. If investors follow the theoretical predictions of the CAPM, the estimated coefficient should be equal to unity. Moreover, our specification comprises the currency denomination of a security using a binary variable for euro-denominated securities and the original maturity of a security (in log days). In additional estimations, we include the average yield and rating of a security over the PSPP period.

Following recent papers using microdata for the analysis of portfolio rebalancing (e.g. Calvet et al. (2009) or Camanho et al. (2018)), we use fixed effects for the holder country-sector (α_i) and the issuing country-sector (α_j). We further employ bilateral fixed effects $\gamma_{h,s}$ between holder country h and issuer country s to capture all bilateral factors affecting capital flows. This controls for incomplete asset markets and transaction costs in international asset trade as proposed by Martin and Rey (2004) and Okawa and van Wincoop (2012). The bilateral fixed effects thereby absorb gravity variables often used in the empirical literature (e.g. see Galstyan and Lane (2013) for rebalancing during the financial crisis or Boermans and Vermeulen (2016) using microdata on security holdings in the euro area). In all regressions, we cluster the standard errors at the holding country*sector level as the residual might be correlated with country and sector specific demand factors.

Another approach to explain the determinants of international capital flows in the literature

[70] If net transactions over 2015Q1-2016Q4 are negative (indicating net sales of a security by a sector), we take the logarithm of the absolute value and multiply it with -1 to allow for a log distribution also in the case of net sales.

[71] Galstyan and Lane (2013) find that during the Global Financial Crisis bilateral cross-border positions were reduced most where pre-crisis bilateral holdings were the largest which they interpret as a "reversion to the mean".

encompasses "push" and "pull" factors. Early papers using this concept show evidence that external "push" factors are more important drivers of international capital flows (Calvo et al. (1993), Fernandez-Arias (1996), Chuhan et al. (1998)), while Griffin et al. (2004) argue that domestic "pull" factors are also significant in explaining international transactions. Since these seminal papers, push and pull determinants have received significant attention, especially in the aftermath of the global financial crisis (Fratzscher (2012) and Forbes and Warnock (2012)), and more recently (Cerutti et al. (2017) and McQuade and Schmitz (2019)). In supplementary estimations, we employ the push and pull concept by using bilateral differences of established drivers of capital flows. In particular, we include the following bilateral push and pull factors instead of the bilateral fixed effect $\gamma_{h,s}$: (1) the average difference in a news-based policy uncertainty index from Baker et al. (2016);[72] (2) the difference in GDP forecast revisions as a proxy for relative changes in macroeconomic expectations;[73] (3) the change in the yield differential at the country-level.[74]

Our empirical set-up allows for assessing heterogeneity between different groups of investors by estimating varying (β_d^1,...,β_d^k) coefficients across sectors or country groups. The advantage of this approach is that it simultaneously estimates the heterogeneous coefficients so that one can directly infer statistical differences between the various coefficients.

2.3.2.3 Empirical implementation

Main hypotheses Our econometric approach allows for isolating the role of security-specific drivers of euro area capital flows since the launch of the PSPP, for which we specify a set of testable hypotheses:

1. *We expect euro area investors to be net sellers of the assets targeted by the Eurosystem under the PSPP and to rebalance into the closest substitutes, in line with the preferred habitat hypothesis.* As the price of bonds targeted in the PSPP increased significantly since the start of the programme, with the Eurosystem absorbing sizeable volumes of these securities, investors 'searching for yield' are expected to rebalance into debt securities that allow them to achieve a certain average yield in their portfolios.[75] Moreover, investors also consider the risk profile of their portfolios which – apart from

[72] This index can be downloaded at `http://www.policyuncertainty.com/`.It is available for seven euro area countries and we use the index for a âĂIJEuropeanâĂİ aggregate for the rest of the euro area countries. The index is also available for the 16 most important counterpart countries for euro area investors. We take the average quarterly difference between news-based policy uncertainty (in logs) of the issuer country and the holder country from 2015Q1 to 2016Q4.

[73] We compute the average difference of revisions in the semiannual forecast (five years ahead) between issuer and holder country from 2015Q1 to 2016Q4. Forecast revisions are calculated from the respective vintages of the IMF's World Economic Outlook.

[74] Using the change in the 10 year government bond yield differential between issuer and holder country between 2014Q4 to 2016Q4. Data are retrieved from the IMF's International Financial Statistics.

[75] By December 2016, the stock of securities purchased by the Euosystem under PSPP summed up to 1.25 trillion EUR.

individual investment strategies – may also be influenced by regulatory constraints, such as risk weights or eligibility for collateral. The security-level of our dataset allows to construct two exogenous variables which enable us to directly investigate our hypothesis, namely *PSPP eligibility* and *PSPP substitute*. The former is equal to 1 for those debt securities which are eligible to be purchased by the Eurosystem under the PSPP. These are (i) securities issued by euro area governments or (ii) securities of international or supranational institutions. In addition, the assets need fulfil certain requirements, e.g. a maturity between 2 and 30 years, ratings above credit quality step 3 in the Eurosystem's harmonised rating scale (i.e. at least a rating *BBB-* from Standard&Poor's or Fitch, *BBBL* from DBRS, or *Baa3* from Moody's), and the yield to maturity has to be above the deposit facility rate, which was equal to -20bp at the time of the launch of the programme in January 2015.[76] The dummy variable *PSPP substitute* equals 1 for securities issued by the public sector in non-euro area advanced economies which otherwise fulfil all the requirements of the PSPP, e.g. a 10-year United States (US) treasury bond.[77] Hence, we do not impose any priors on the definition of *PSPP substitutes*, but use the exogenously-defined characteristics of PSPP-eligible assets at the security level to test whether there has been a shift from eligible (euro area) assets to assets with the same characteristics outside the euro area, which in turn would have important implications for monetary policy spillovers via international capital flows. If this mechanism is at play, we should find a significantly negative coefficient for *PSPP eligible* and a positive coefficient for *PSPP substitute*. Figure 2.18 illustrates that the average yield of *PSPP eligible* securities started to decline sharply in mid-2014 when the ECB's credit easing packages were announced and in anticipation of the announcement of a QE programme. At the same time a growing yield differential between *PSPP eligible* bonds and *PSPP substitutes* emerged, which peaked in early 2015 after the announcement of the PSPP programme. During the period 2015 to 2016, i.e. the period of our analysis, this yield differential remained persistently large.

2. *We expect investors to rebalance into securities with longer maturities.* As the euro area yield curve shifted downwards and flattened, but did not invert during the APP period (ECB (2017b), De Santis (2016)), we suggest that investors need to buy additional duration risk (in order to compensate for its removal by the central bank) and thus increase the average maturity of their debt securities in order to achieve a certain yield.

3. *We expect a weakening of the euro-denomination bias in debt securities.* For the period before 2014, Boermans and Vermeulen (2016) show that there is a significant home as

[76] More detailed information and the full list of eligible international or supranational institutions can be found at `https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html`.

[77] These include sovereign debt securities issued by Australia, Canada, Czech Republic, Denmark, Hong Kong, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, United Kingdom, and the United States

well as euro denomination bias in the euro area holdings of debt securities. During the PSPP period, euro area yields declined not only for those debt securities targeted under the PSPP, but also more broadly for euro-denominated debt securities issued by the private sector, in line with the signalling channel associated with QE. In the case of euro area NFCs, yields were also impacted by the Corporate Sector Purchase Programme (CSPP) in the last six months of our period of observation.[78]

4. *More broadly and mirroring hypothesis 3, we expect euro area portfolio shifts towards other foreign debt securities, including securities issued in emerging economies.* Such rebalancing was observed for US investors following the introduction of QE (Moore et al., 2013). However, if investors want to maintain a certain risk profile, a shift towards debt issued by other advanced economies may be more likely than a rebalancing towards emerging economies' debt. As a number of advanced countries outside the euro area were "ahead of the cycle" during the period analysed, higher yields could be achieved by substituting securities issued by certain euro area sectors (other than the government) with foreign securities of the same sectors.

5. *We expect heterogeneity across sectors* within the euro area for several reasons.

   First, sectors vary in their degree of professionalism with regard to portfolio allocations which implies a larger role for information asymmetries for certain sectors, in particular in changing financial market conditions as observed during the APP period. Second, theory suggests that accommodative monetary policy that boosts the prices of assets held by balance sheet-impaired sectors relaxes their financial constraints and allows them to increase their lending activity Brunnermeier and Sannikov (2016). Different investment behavior can also be due to regulatory restrictions, such as risk weights attached to particular securities (such as sovereign bonds) or eligibility for collateral. Finally, different sectors might manage assets heterogeneously depending on the business models, e.g. due to different restrictions on the liability side of their balance sheet in terms of maturity or currency denomination. Timmer (2018) shows for German financial institutions that cyclical investment behaviour can be explained by differences in sectors' balance sheet structure.

   Therefore, we propose the following sector-specific hypotheses:

   - Regarding the hypothesis of net sales of PSPP-eligible assets, we expect retail investors, such as households, to be significant sellers of these bonds. For them, there is no regulatory "price" of shifting from these assets to higher yielding

[78] Net sales of debt securities issued by MFIs may reflect partly negative net issuance due to the broad-based deleveraging in the euro area banking sector as well as funding substitution towards the Eurosystem's targeted longer-term refinancing operations. Under this open market operation, the ECB had offered long-term funding at attractive conditions to banks since June 2014.

"substitutes" abroad. This substitution may happen via investment funds (part of the OFI sector) which has the additional benefit of avoiding direct foreign currency exposure, which is particularly important for sectors that face higher information frictions (such as households). Banks on the other hand may be limited in their ability to sell eligible assets due to their low (zero) risk weight and their frequent use for collateral in repo transactions.

- We expect the rebalancing into longer term maturities to be driven by ICPFs. Domanski et al. (2017) show that the combination of long-term liabilities and risk regulation leads ICPFs to hold long-term bonds, in particular when interest rates are low. The long-term liabilities are often independent of the state of economy which gives ICPFs more autonomy in their portfolio choice. Thus, when the yield curve shifts downwards, they can buy duration risk by purchasing longer term securities. Banks on the other hand have a need for liquid assets as deposits are easily redeemable.

6. *We expect heterogeneity across euro area countries* as the euro area sovereign debt crisis exposed significant country-differences in terms of macroeconomic and financial stability within the euro area. Accordingly, Albertazzi et al. (2018) and Koijen et al. (2018) analyse the impact of the PSPP focusing on a potential difference in the transmission between the (formerly) stressed and the other 'non-stressed' euro area countries.[79] We hence refine our hypotheses for these country groups:

   - Stressed countries might take more advantage of the opportunity to sell eligible assets given their opportunities to rebalance their portfolio towards higher yielding securities at home and abroad. This mechanism is reinforced by the fact that the PSPP led to positive wealth effects which relaxed in particular the financial constraints of stressed countries (in line with Brunnermeier and Sannikov (2016)) as banks in stressed countries had purchased significant amounts of domestic public debt during the sovereign debt crisis (Altavilla et al., 2017).
   - Following a similar argument as for sector heterogeneity, we expect mainly non-stressed countries to be able to rebalance their portfolio towards longer-term securities due to looser financial constraints. Moreover, such rebalancing is further induced by the low yields recorded on domestic debt securities in these countries.

Extensions of baseline approach In order to shed more light on the mechanisms of international portfolio rebalancing, we provide two extensions to our baseline approach: (i) we focus on different time horizons and (ii) we isolate not only the active part of portfolio rebalancing (i.e. net purchases and sales), but also consider passive rebalancing (i.e. changes

[79]The group of (formerly) stressed countries consists of Cyprus, Greece, Italy, Portugal and Spain.

in holdings due to valuation). In order to grasp time dynamics, we vary the time frame of the analysis. While our baseline approach covers the 8 quarters since the start of the PSPP, we also analyse short term (2 quarters) and medium-term (6 quarters) rebalancing. Most empirical studies on the financial impact of unconventional monetary policies argue that the largest movements in yields take place upon announcement (e.g. see Krishnamurthy and Vissing-Jorgensen (2011) for the US or Altavilla et al. (2016) and De Santis (2016) for the euro area). Therefore, we investigate whether portfolio rebalancing occurred instantaneously, or with a time lag, and whether it has been maintained throughout the duration of the programme. Moreover, we test whether our analysis yields different results for the period before the PSPP was launched (2014Q3 and 2014Q4), which includes the ECB's credit easing package of June 2014 and potential anticipation effects for an LSAP in the euro area following the speech of Draghi (2014) at Jackson Hole.

Furthermore, we distinguish the *active* (i.e. net purchases) and the *passive* (i.e. valuation changes) channels of portfolio rebalancing. We substitute our dependent variable $ln(flow_{a,i,j,t})$ with (i) $\Delta ln(stock_{a,i,j,t})$ which represents the change in the stock of the holding and (ii) $[\Delta ln(stock_{a,i,j,t}) - ln(flow_{a,i,j,t})]$ which are the passive changes in holdings that are not due to transactions, but due to valuation changes resulting from fluctuations in asset prices. With this, we follow the intuition of Ahmeda et al. (2016) who apply this concept to US capital flows targeting EMEs and Bubeck et al. (2017) who implement this idea in an event study analysis for Luxembourg-based mutual funds following ECB monetary policy announcements.

2.3.3 Descriptive evidence on euro area rebalancing during the PSPP period

We provide descriptive evidence on the 'active' portfolio rebalancing (i.e. in terms of net transactions) of euro area investors since the launch of the PSPP. By constructing these statistics from the security-level SHSS dataset we are able to provide additional insights compared to analysis which rests entirely on aggregate statistics such as the balance of payments statistics presented in Figures 2.16 and 2.17 (see also Bergant and Schmitz (2019)).

2.3.3.1 Debt securities

Starting with transactions in debt securities, Figure 2.19 shows that euro area investors were net sellers of securities eligible to be bought by the Eurosystem under the PSPP in the period 2015Q1-2016Q4, which is in line with our hypothesis 1. In fact, more than EUR 250 billion PSPP eligible securities were sold in net terms by euro area investors in the period 2015Q1-2016Q4. However, even larger net sales by euro area residents were recorded for other debt securities issued in the euro area, of which the largest share was those issued by euro area banks. These net sales can be mainly attributed to negative net issuance of bonds by the euro area banking sector and spillovers from the PSPP under the signalling channel. Thereby,

a commitment by the central bank to keep short-term rates low for a considerable period of time has a negative effect on the yields of all debt securities – including those that are not PSPP eligible – via the expectations hypothesis of interest rates (Krishnamurthy and Vissing-Jorgensen, 2011).

Net sales of euro area debt instruments were mirrored in sizeable net purchases of foreign debt securities by euro area residents, as can be expected under the signalling channel to the extent that it results in an increase of the interest rate differential. In line with hypothesis number 1, we observe in particular significant net purchases (around EUR 350 billion) of foreign sovereign debt securities, of which around 40% qualify as the closest substitutes for PSPP eligible assets, consistent with the preferred habitat hypothesis. Moreover, net purchases of foreign debt securities issued by the private sector were even slightly higher, thus closely matching the net sales of private euro area area debt securities.

Figure 2.20 shows which sectors drove these overall patterns: MFIs, households and OFIs (mainly investment funds) accounted for the largest net sales of PSPP eligible and other euro area debt securities, while ICPFs were net buyers of both types of euro area debt securities. OFIs bought the largest amounts of PSPP substitutes as well as foreign debt securities in general, followed by MFIs and ICPFs. In terms of investors' country of residence, the rebalancing towards non-euro area debt securities was driven by the financial centres Ireland and Luxembourg – hosting many of the euro area investment funds – as well as to a lesser extent Germany and France. Spanish investors sold the largest amount of PSPP eligible securities, followed by the Netherlands, Germany, France, and Italy (see Figure 2.21). Italy stands out as resident investors were the largest net sellers of other euro area debt securities, followed by Germany and France.

2.3.3.2 Beyond debt securities

Figure 2.22 also includes equity securities, i.e. investment fund shares and listed shares, to investigate the transmission of quantitative easing from targeted securities towards other instruments. In our analysis, securities are split into those issued by euro area residents and foreign securities in Figures 2.22-2.24. Euro area investors were overall net sellers of euro area debt securities and mainly rebalanced their portfolios towards euro area investment fund shares, debt securities issued outside the euro area, and to a lesser extent to euro area and foreign listed shares. Figure 2.23 provides important insights into the sectoral 'flow of funds' behind these aggregate flows: the net sales of euro area debt securities were driven by MFIs and households, while ICPFs, households and OFIs bought the largest amounts of euro area investment fund shares as shown on the left hand side of Figure 2.23. On the right hand side, we observe that OFIs were by far the largest net buyers of foreign debt securities, followed by MFIs and ICPFs. The increased investment of OFIs in foreign debt instruments goes in hand with increased funding that OFIs receive from other euro area

investors, such as households. This suggests that MFIs and to a lesser extent also ICPFs were buying foreign debt securities directly, while in particular households channelled their investments into overseas debt securities via investment funds. Figure 2.24 shows that the largest net purchases of euro area investment fund shares originated from Germany, Italy, Spain and France.[80]

Figure 2.25 sheds more light on euro area flows into investment fund shares. Based on security-level information from the ESCB's Centralised Securities Data Base (CSDB), we differentiate investment funds by their main investment mandate. The graph shows that the largest net inflows by euro area residents went into 'mixed' investment funds, followed by investment funds with explicit mandates to invest in bonds. Particularly households and ICPFs were large net buyers of 'mixed' funds, while for OFIs bond funds constituted the largest type. Aggregate ECB investment fund statistics in turn show that euro area investment funds mainly bought shares of other investment funds, debt securities and listed shares in our period of analysis. Combining the evidence contained in Figures 2.23 and 2.25 confirms that at the end of the investment chain, OFIs channelled large funds towards the acquisition of non-euro area debt securities.

2.3.3.3 Geography, currency, and maturity

In terms of geographical composition, Figure 2.26 shows that euro area residents were net sellers of debt securities issued in their home countries, while they invested heavily into US debt securities, followed by those issued in the United Kingdom (UK) and in the residual country group "rest of the world". Large net purchases of US debt securities can be explained by the substantial yield differentials between the euro area and the US since the start of the start of the ECB's unconventional monetary policy. Indeed, the largest net purchases of debt securities by euro area residents were recorded for those issued by the US government sector, followed by US NFCs (see also Bergant and Schmitz (2019)). MFIs and households in particular sold domestic securities, while OFIs' net purchases focused almost entirely on extra-euro area debt securities, with the US and UK accounting for the largest shares. On the right hand side of Figure 2.26, we see that the majority of net equity purchases consisted of those issued by domestic and other euro area residents, which mainly reflect investment fund shares.

The geographic composition is mirrored in changes in currency exposures. Figure 2.27 shows sizeable net sales of euro-denominated debt securities – in line with our third hypothesis, suggesting a reduced euro preference in debt securities. Furthermore, one can observe an increase in the exposure to debt securities denominated in US dollars, and also British pounds, while net purchases of equities were to a large extent euro-denominated. Strikingly, all sectors

[80] The large purchases of euro area investment fund shares were driven by ICPFs in Germany and France and by households in Italy and Spain. In turn, Luxembourg-based OFIs accounted for 86% of all euro area OFI net purchases of extra-euro area government bonds.

were net buyers of US dollar-denominated debt, with more than half of net purchases being conducted by OFIs as shown in Figure 2.28. ICPFs and to a much smaller extent also OFIs were net buyers of euro-denominated debt securities.

With regard to our second hypothesis, i.e. that under the duration risk channel investors will rebalance their portfolio to longer-term securities, Figure 2.29 reveals that the majority of net purchases of debt securities fell within the bucket of assets with an original maturity of more than 10 years. Moreover, the vast majority of net sales consisted of assets with a maturity between 2 to 5 years after origination. Figure 2.30 shows that the large net purchases of assets with a minimum maturity of 10 years is driven by ICPFs and OFIs. In particular for ICPFs, these purchases are likely due to their need to match longer-term liabilities with longer-term assets. The large net sales of 2-5 year securities were – just like the sales of PSPP eligible assets – mainly driven by MFIs and households.

Summing up, we find strong support for our hypotheses by looking at descriptive evidence. Euro area investors rebalanced their portfolios from euro area debt securities to foreign debt. As large net purchases of euro area investment fund shares were also recorded, the acquisition of foreign debt appears to have been partly channelled – in particular for households – through mutual funds. Overall, this confirms that investors were "searching for yield" and investing partly in the "closest substitutes" to securities targeted under the PSPP, i.e. sovereign debt of advanced countries outside the euro area. We also find evidence for portfolio rebalancing towards longer-term maturities as more than 50% of net purchases consisted of securities with a maturity exceeding 10 years. Moreover, we also observe strong sector heterogeneity as for instance ICPFs were net buyers of PSPP eligible assets and other euro area debt securities since the launch of the PSPP.

2.3.4 Econometric evidence on euro area rebalancing during the PSPP

2.3.4.1 Overall results

Table 2.26 presents the overall estimation results for equation (3) focusing on euro area country-sectors' net transactions in individual debt securities, summed over the PSPP period 2015Q1 to 2016Q4. We observe in column (1) that the *PSPP eligibility* variable is significant with a negative sign. This confirms hypothesis number 1, i.e. that euro area investors significantly rebalanced their portfolios away from those individual securities targeted under the PSPP, controlling for a vast array of security-specific as well as country and sector specific factors. In column (2), we add the *PSPP substitute* variable which turns out to be positive, though insignificant. Our descriptive evidence suggests that this might be because euro area investors gained exposure to *PSPP substitutes* through an indirect channel, i.e. via net purchases of investment fund shares, which we will analyse in the next subsection.

Across Table 2.26, we also confirm hypothesis number 2, as the coefficient on the original maturity variable is significantly positive. This indicates that euro area investors were net

buyers of relatively more long-term securities which might be driven by the general decrease in yields, enticing investors to shift to longer-term securities in order to achieve a certain yield within one asset class. The euro currency denomination variable turns out insignificant, which is in line with hypothesis 3 and suggests an increased rebalancing towards foreign-currency denominated debt securities, especially considering that Boermans and Vermeulen (2016) find evidence for a strong preference for holdings of euro-denominated debt securities in the pre-APP period.

We further obtain a negative coefficient for the pre-PSPP holding variable, confirming the "mean reversion" found by Galstyan and Lane (2013). This means that investors sold (bought) assets that they held relatively large (small) amounts of before the programme started, i.e. in 2014Q4. For the change in the outstanding amount (at market prices) over the PSPP period, we observe a significantly positive coefficient of around 0.5 which is in line with the predictions of the CAPM as investors were partly following developments of the overall market portfolio.[81]

In columns (3) to (8), we perform various modifications to the baseline results. In column 3, we exclude all domestic securities (i.e. the net purchases of those securities issued in an investor's country of residence), which shows similar results, but a slightly lower coefficient on *PSPP eligibility*. This indicates that euro area investors were selling in particular those securities to the Eurosystem that were issued by governments of their country of residence. In column (4), we exclude all observations that feature Ireland and Luxembourg – both as investor or issuing countries – due to their financial centre role in the euro area. The results show a more negative coefficient on *PSPP eligibility* and a larger coefficient for the maturity variable. In column (5), we include only long-term debt securities (i.e. those with an original maturity of more than 12 months), which delivers very similar results, likely driven by their large share in overall debt securities (around 95% in our sample).

Next, we explore evidence with regard to the question whether the PSPP has led to increased risk-taking by euro area investors in terms of purchases of debt securities. In column (6), we introduce a dummy variable that takes the value one if the average yield of a security over the PSPP period was within the highest decile of yields. The variable turns out to be insignificant and remains insignificant if we replace it – in unreported regressions available upon request – with a dummy for the upper 25% of yields or with the yield itself. In column (7), we define a dummy variable for those securities rated within the worst rating category (out of four standardised categories in the Eurosystem's harmonised rating scale). This corresponds to a credit rating of $BB+$ and below for Standard & Poor's and Fitch.[82] As this variable also turns out to be insignificant, we do not observe any evidence that euro area investors were

[81] Boermans and Vermeulen (2016) find similar (or lower) coefficients for cross-sectional holdings before APP. The authors suggest that an explanation for these relatively low values – compared to a theoretical coefficient of 1 derived from the CAPM – might be that individual bonds may have several substitutes.

[82] The worst rating across the four major rating agencies is used.

taking significantly more risk by investing into lower-rated, high-yield debt securities.[83]

Finally in column (8), we use a set of push and pull variables described in Section 2.3.2.2, rather than country-pair dummies, which leaves our results intact. Using the entire sample, the only significant variable is the average difference in news-based policy uncertainty measured following Baker et al. (2016). Euro area investors show significantly lower net purchases of debt securities issued by economies in which economic policy uncertainty is higher than in the investors' euro area country of residence. When we restrict the sample to securities issued by countries outside the euro area, the bilateral yield differential turns significantly positive (in unreported estimations).[84] We thus find that euro are investors bought larger amounts of debt securities issued by non-euro area countries with higher aggregate yields during the PSPP programme, in line with a push-pull framework.

2.3.4.2 Sector heterogeneity

In Table 2.27, we report our main specification but estimated with heterogeneous coefficients across sectors. As put forward in the sector-specific hypotheses in Section 2.3.2.3, we expect heterogeneity across sectors due to different regulatory restrictions, asset management strategies, and sophistication regarding information on financial market developments. This heterogeneity is clearly reflected in our results, especially when considering the coefficients which respond to our main hypotheses.

In particular, with regard to hypothesis 1, we find a significant negative coefficient on PSPP eligibility for OFIs, while at the same time OFIs are found to invest in *PSPP substitutes*, in line with preferred habitat motives.[85] Combining this with our descriptive evidence (see Figures 2.22-2.24) and taking into account the "flow of funds" within the euro area, these investment patterns reflect to a large extent the "channelling" of the underlying ultimate investors' preferences via investment funds. This also implies that the insignificance of the closest substitute in Table 2.26 is likely to be driven by the fact that other sectors are channelling their investments into closest substitutes via mutual funds rather than investing directly into foreign sovereign debt. In line with this mechanism, we find that NFCs and households were significant net sellers of PSPP eligible assets and euro denominated assets more generally.

For MFIs and ICPFs on the other hand, the PSPP eligible coefficient is insignificant, while the one for euro-denomination is significantly positive. This reflects banks' incentive to hold PSPP eligible assets because of the zero risk weight attached to them and due to their role

[83] Our sample size shrinks by more than 50% in the estimations displayed in columns (6) and (7) due to limited data availability. In further unreported estimations, we include a dummy variable controlling for securities maturing during the PSPP period. As anticipated, this variable is significant with a negative sign, but leaves our main results unchanged.

[84] These results are available upon request.

[85] In unreported estimations, we find evidence that OFIs rebalanced even stronger away from those PSPP eligible securities which exhibited average negative yields during the PSPP period.

as collateral in monetary policy operations. The fact that the PSPP eligibility coefficient is not significant for MFIs, even though Figure 2.20 showed that MFIs were the sector with the largest net sales of PSPP securities, may be puzzling at first glance. However, it is important to note that the regression analysis controls for a vast array of factors, such as the pre-PSPP level of PSPP-eligible assets which were the largest for MFIs. Moreover, the regression results are further underpinned by the fact that MFIs' net sales of other euro area debt securities were three times larger than those of PSPP eligible debt securities (Figure 2.20).

Consistent with our sector hypothesis, we also observe a strong preference for net purchases of longer-term securities for ICPFs, in line with the duration risk and preferred habitat channels. This is particularly large for this sector, followed by NFCs and households. Finally, the negative coefficient on pre-PSPP holdings and the positive sign on changes in the outstanding amounts of a security remain significant across all sectors, confirming their general validity.

2.3.4.3 Geography

To answer the question to what extent euro area investors' portfolio shifted towards foreign bonds other than closest *PSPP substitutes*, we add additional variables to our baseline estimation that track which country-sectors received relatively larger inflows from euro area investors during the PSPP period. This exercise also serves as a robustness test with regard to our key findings on PSPP eligibility and substitutes.[86]

We split the geography of euro area investors' capital flows into different sectors focusing on three country groups: euro area (EA), other advanced (ADV) and emerging (EME) economies.[87]

In Table 2.28, we observe that PSPP eligibility remains significant overall (column 1), while net investment by euro are OFIs into closest substitutes remains significant, too. Our analysis further reveals several interesting patterns with regard to securities issued by euro area residents: we find significant net purchases of debt securities issued by OFIs (driven by the household and NFC sectors). These securities are largely bonds issued by financial intermediaries that are linked to euro area NFCs (or MFIs) as well as entities engaged in securitisation.

Moreover, we observe that all euro area sectors invested significantly in bonds issued by banks and OFIs resident in advanced countries outside the euro area, while euro area ICPFs and households also invested to a significant extent in bonds issues by advanced

[86] Since we include dummy variables for securities issued by other country-sectors (including for the euro area), we test that our baseline findings are not resulting from an omitted variable bias. Specifically, to avoid multicollinearity problems due to the presence of issuer-sector fixed effects, we define the country-group-sector dummies for long-term debt securities.

[87] Countries classified as advanced include Australia, Canada, Czech Republic, Denmark, Hong Kong, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, United Kingdom, and the United States. Our definition of EMEs – which is broadly consistent with the IMF's definition – includes Argentina, Bangladesh, Brazil, Chile, China, Columbia, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Russia, South Africa, South Korea, Thailand, Turkey, Uruguay and Venezuela.

economies' NFCs. These results show that euro area investors did not only rebalance into closest substitutes, but conducted broad-based purchases of debt securities issued in advanced economies. This is in line with the evidence presented by Ammer et al. (2018) who find that non-US investors faced with low interest rates at home rebalanced towards riskier US corporate bonds.

We also investigate whether the PSPP has led to increased investment into emerging market debt securities as observed for US investors following the introduction of QE (Moore et al., 2013). In line with (Coeure, 2017), we do not find evidence of broad-based euro area net purchases of debt securities issued by EMEs. However, we observe significant net buying of EME sovereign bonds by euro area MFIs.

Overall, our results show that euro area investor's shift towards foreign debt was broad-based across sectors, but mainly targeted at other advanced economies, in contrast to the patterns observed for US investors following QE.

2.3.4.4 Country heterogeneity

Table 2.29 reports the estimation results with heterogeneous coefficients across the (formerly) stressed and non-stressed euro area country groups.[88] Confirming our hypotheses, we observe that both country groups were significant net sellers of PSPP eligible securities. However, the coefficient is almost three times as large for stressed countries indicating that investors from such countries had a larger propensity to rebalance away from PSPP-eligible assets. As financial constraints were more binding in the formerly stressed countries, the finding suggests that positive wealth effects enticed investors from these countries to realise capital gains made on PSPP eligible securities. These capital gains were particularly sizable for banks in stressed countries as they had purchased significant amounts of domestic public debt during the sovereign debt crisis reflecting "moral suasion" by governments as well as "carry trade" motives as these banks used cheap funding by the Eurosystem to invest in high-yielding sovereign debt (Altavilla et al., 2017). Our findings are also in line with Albertazzi et al. (2018) who report evidence of portfolio rebalancing towards riskier securities in the (formerly) stressed economies where risk-premia remained relatively higher.

As regards our second hypothesis, only investors of non-stressed countries were significant net buyers of longer-term maturity bonds, which is likely driven by the fact that yields were lower in these countries, resulting in a stronger pressure to shift into longer-term maturities, compounded by looser financial constraints that allow investors to expand their investment horizon.

[88]The group of (formerly) stressed countries consists of Cyprus, Greece, Italy, Portugal and Spain. We exclude Ireland and Luxembourg from these estimations due to their large financial intermediation role.

2.3.4.5 Time dynamics

Next, we consider the time dynamics in euro area portfolio rebalancing for debt securities during the PSPP period in Table 2.30. In column (1), we analyse the period before the announcement of the PSPP (2014Q3-2014Q4) which includes the implementation of the ECB's credit easing package of June 2014 to account for potential anticipation effects for an LSAP in the euro area following the speech of Draghi (2014) at Jackson Hole. In contrast to our benchmark results for the whole PSPP period (column 4), euro area investors were significant net buyers of PSPP eligible assets in the two quarters before the programme was announced, which hints at the game-changing nature of the PSPP for euro area financial flows. The net purchases before the PSPP were likely driven by the growing expectation of an impending quantitative easing programme in the euro area, suggesting that investors were betting on valuation gains in the run-up to the PSPP. This is in line with Lemke and Werner (2017) who argue that the decline in yields of German sovereign debt before the PSPP points to a portfolio rebalancing towards eligible assets in anticipation of the programme.[89]

Column (2) considers the determinants of 'short-term' rebalancing (in the two quarters since the start of the PSPP, 2015Q1-2015Q2), for which we observe a significantly negative coefficient on PSPP eligible assets and euro-denominated debt securities. Thus, already immediately after the launch of the programme, euro area investors started to rebalance in line with our hypotheses. Moreover, for net purchases in this short-term period, we find a relatively strong positive coefficient on changes in the outstanding amount of a security – suggesting that investors generally follow the market portfolio – and a less pronounced reversion to the mean.

In the third column we analyse net purchases cumulated over the medium-term (6 quarters), in which the negative coefficients on PSPP eligibility and euro-denomination turn out larger than in the short term, suggesting that in this period the rebalancing forces of euro area investors were the strongest. Importantly, net sales of euro denominated assets were only significant in the short and medium term, but not in column 4, which might reflect the strong announcement effects of the programme (Georgiadis and Graeb, 2016). Moreover, the need of certain sectors to hold euro-denominated securities might have prevented a protracted rebalancing away from those securities. The coefficient on the original maturity of a security exhibits a larger positive sign over time, suggesting that investors gradually switched to longer-term maturities, likely reflecting the extended low yield environment.

To explore the time dynamics across sectors we zoom in on the PSPP eligibility coefficients for each sector (Table 2.31). The phenomenon of "loading up" eligible assets before the start of the programme is driven by investment funds (column 1), suggesting that these relatively more sophisticated investors were speculating on valuation gains before the start of PSPP. In the short term (column 2), MFIs and household exhibit significant negative coefficients.

[89] Interestingly, this period is also associated with (marginally) significant net purchases of *PSPP substitutes*.

Thus, while MFIs do not appear as significant net sellers of PSPP eligible assets over the entire period considered, this was different in the early days of the programme. The observed strongest rebalancing in the medium term (6 quarters, column 3) is driven by households, OFIs and NFCs, which also holds true for the baseline period in column 4.

2.3.4.6 Active vs. passive rebalancing

Motivated by the theoretical model of Tille and van Wincoop (2010), we shed light on the different dynamics of the *active* (i.e. net purchases) and the *passive* channels of portfolio rebalancing.[90]

In Table 2.32 column (1), our dependent variables are, respectively, the cumulative net purchases of debt securities over the period 2015Q1-2016Q4 $ln(flow_{a,h,s})$, the corresponding change in holdings between 2014q4 and 2016q4 $\Delta ln(stock_{a,h,s})$ in column (3) and in column (2) the difference between the latter and the former, i.e. $[\Delta ln(stock_{a,h,s}) - ln(flow_{a,h,s})]$ which correspond to valuation changes. While running a full regression analysis, we zoom in on hypothesis 1 and observe – as in our baseline estimation – a negative coefficient on PSPP eligibility for transactions. Moreover, we obtain a positive coefficient in the 'passive' rebalancing estimation implying that euro area investors recorded significant positive valuation gains in PSPP eligible assets relative to all other debt securities held during this period. For changes in overall holdings, we do not find a significant coefficient for PSPP eligible asset during our period of analysis (column 3). This emphasises the importance of analysing actual transactions rather than proxying these with changes in holdings.

Across sectors, the second panel of Table 2.32 shows that the observed aggregate patterns are driven by OFIs, MFIs and households, albeit to varying degrees. Significant net sales and positive valuation gains in PSPP-eligible securities are found for all three sectors, while a significant (and negative) coefficient in the overall change in holdings estimation is only obtained for households.[91]

Descriptive evidence on the aggregate volumes of the active and passive rebalancing components by sector (Figure 2.31) highlights that sizeable valuation gains in PSPP eligible assets were achieved by ICPFs, i.e. the sector that continued to be a net buyer of these assets, while MFIs and households recorded large net sales of these assets and only small valuation gains during the PSPP period. OFIs on the other hand, generated more sizeable valuation gains, while selling PSPP eligible assets, thereby offsetting part of the net sales.

The results in this subsection highlight that the *active* (i.e. net purchases) and *passive* channels of portfolio rebalancing in PSPP eligible securities were working in opposite directions

[90] A subsample is used as this analysis is only feasible for those securities that were held by a certain sector both before the launch of the PSPP (i.e. at the end of 2014Q4) and at the end of our sample period (i.e. 2016Q4) and for which holdings as well as transactions were reported. This restriction is necessary as in case a security is only held at the beginning of the sample period or only at the end of the period, no change in the market value of the holdings ("passive rebalancing") of this security can be computed.

[91] In this subsample, significant (at the 10% level) net sales of PSPP-eligble securities are recorded for MFIs.

during the PSPP period. Thereby, overall net sales of these securities by euro area investors were only partly offset by positive valuation gains.

2.3.5 Conclusion

Our paper is – to the best of our knowledge – the first to analyse international capital *flows* (i.e. net purchases or net sales) at the security level. Using a model of these flows, we are able to test several hypotheses with regard to the impact of the APP on portfolio rebalancing, for which we emphasize significant sector and country heterogeneity within the euro area:

First, we expected euro area investors to be net sellers of the assets targeted by the Eurosystem under the PSPP and to rebalance into "closest substitutes." Descriptively, we observe that euro area investors rebalanced their portfolios from domestic and other euro area debt securities towards foreign debt. Our regression analysis confirms that euro area investors significantly rebalanced away from individual securities targeted under the PSPP. In particular, OFIs show rebalancing as they invested significantly in assets defined as closest substitute to the PSPP-eligible securities, in line with preferred habitat motives, underlining the impact of the PSPP on international capital flows. Moreover, we find that NFCs and households were significant net sellers of euro denominated assets and especially PSPP eligible assets. Households in particular made use of investment funds to gain exposure to foreign sovereign debt. MFIs and ICPFs on the other hand are not found to be significant net sellers of PSPP eligible assets and were significant net buyers of euro denominated securities, reflecting regulatory and balance sheet management reasons. We find that both the (formerly) stressed and non-stressed euro area countries were significant net sellers of PSPP eligible securities, but the impact was larger for stressed countries.

Second, we expected investors to rebalance into securities with longer maturities, for which we find significant evidence as euro area investors were net buyers of relatively more long-term securities. This was particularly pronounced for ICPFs, in line with the duration risk and preferred habitat channels. Overall, net purchases of securities with a maturity exceeding 10 years made up 50% of net debt purchases.

Third, we expected a weakening of the euro-denomination bias in debt securities. Indeed, we observe overall evidence for a rebalancing away from euro-denominated debt securities, in line with the signalling channel associated with QE. Our results show that euro area investor's shift towards foreign debt was broad-based across sectors, thereby creating global spillovers from the ECB's policies, but mainly targeted at other advanced economies, in contrast to the patterns observed for US investors following QE.

We also investigated potential anticipation effects of the PSPP following Draghi (2014) speech at Jackson Hole and find that euro area investors were indeed net buyers of PSPP eligible securities in anticipation of the programme.

Finally, as our dataset also comprises the holdings of individual securities, we are able to

decompose overall portfolio rebalancing of euro area investors into 'active' (i.e. capital flows) and 'passive' components (i.e. valuation changes due to fluctuations in asset prices). This analysis reveals the importance of analysing actual transactions rather than proxying these with changes in holdings. Moreover, we find that active net sales of PSPP-eligible securities by euro area investors were only partly offset by positive capital gains.

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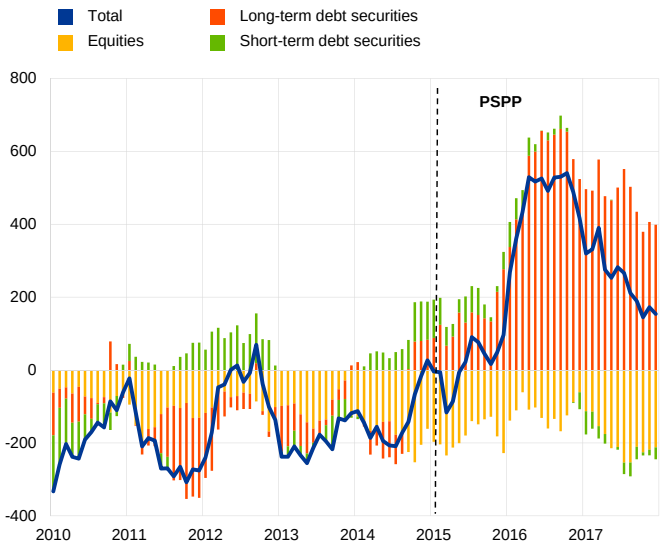
2.3.6 Figures

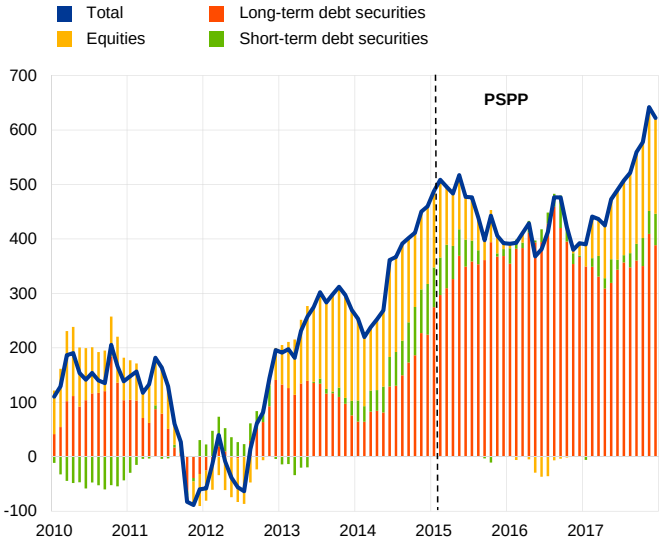
Figure 2.16: Breakdown of Euro Area net Portfolio Investment Flows



Source: ECB.

Notes: A positive (negative) number indicates net outflows (inflows) from (into) the euro area. Equity includes investment fund shares. Last observation is December 2017. 12-month cumulative sums in bn EUR.

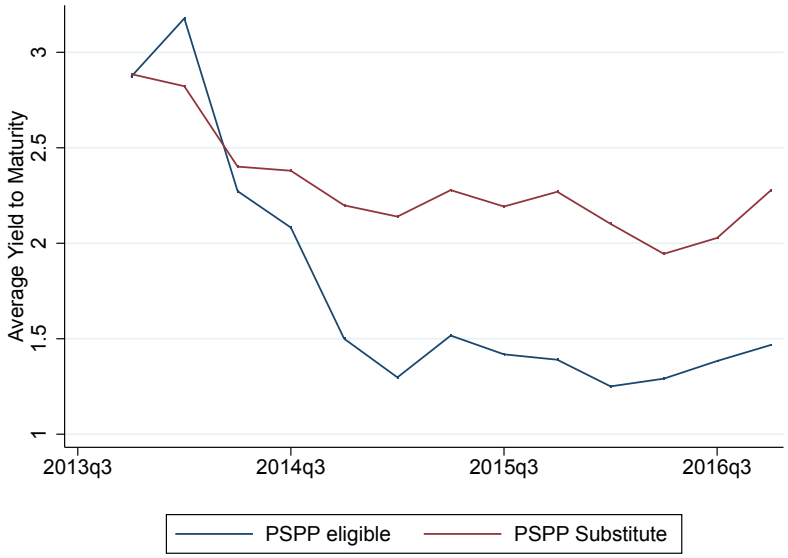
Figure 2.17: Breakdown of Euro Area Portfolio Investment Outflows



Source: ECB.

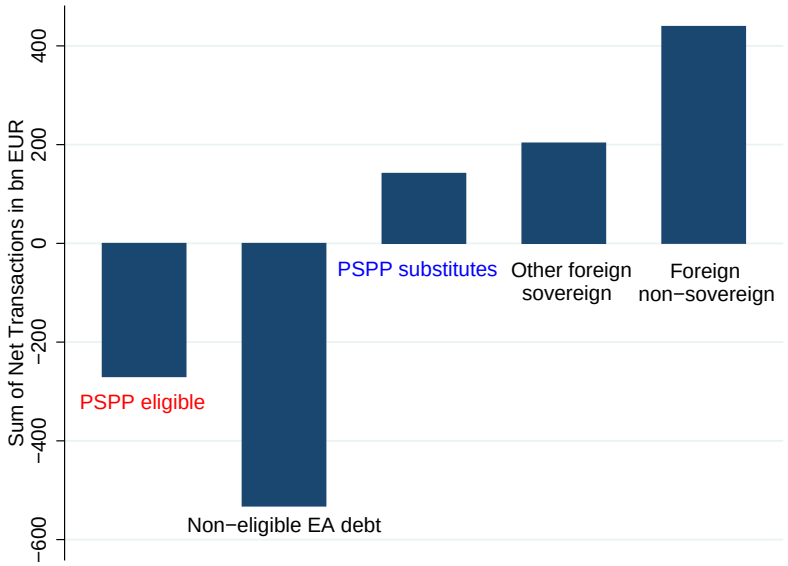
Notes: A positive (negative) number indicates net purchases (sales) of non-euro area securities by euro area investors. Equity includes investment fund shares. Last observation is December 2017. 12-month cumulative sums in bn EUR.

Figure 2.18: Average Yield to Maturity



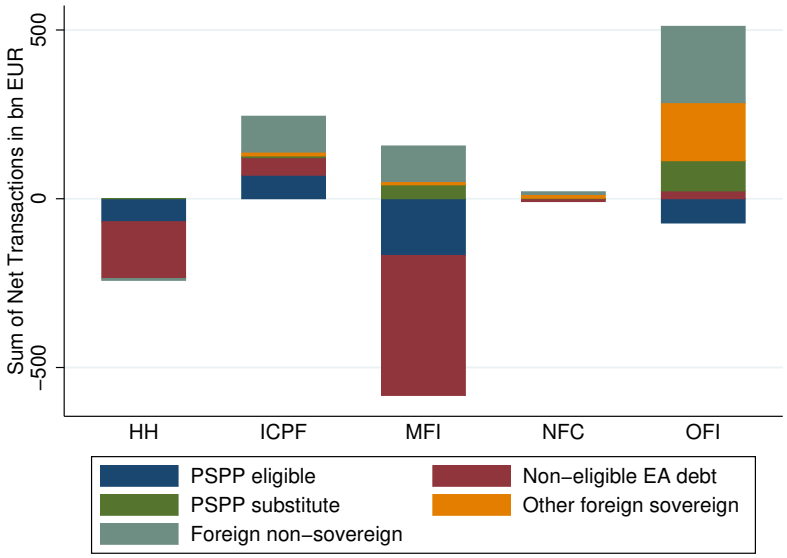
Source: ECB.
Notes: Unweighted average yield to maturity of securities eligible to be bought under PSPP (*PSPP eligible*) vs. comparable securities outside the euro area (*PSPP substitutes*). PSPP eligible and PSPP substitute as defined in 2.3.2.3.

Figure 2.19: Euro Area net Debt Transactions



Source: ECB
Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. PSPP eligible and PSPP substitute as defined in 2.3.2.3.

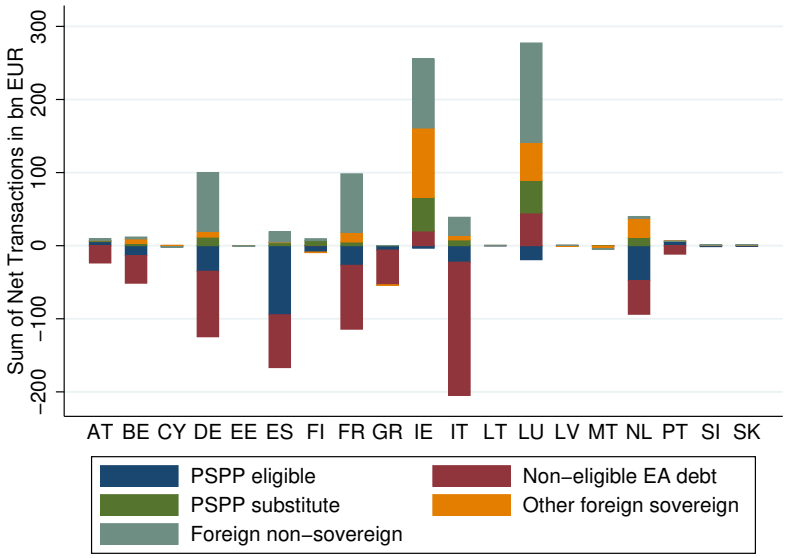
Figure 2.20: Euro Area net Debt Transactions by Sector



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. PSPP eligible and PSPP substitute as defined in 2.3.2.3.

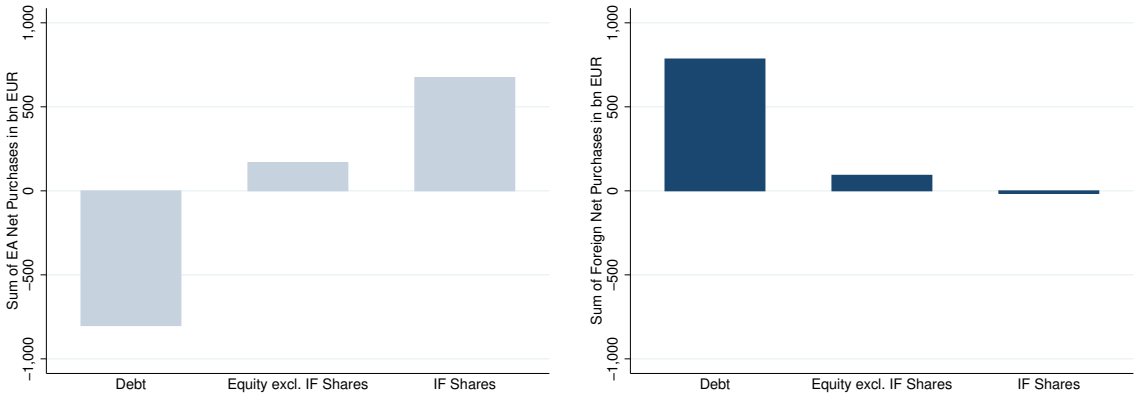
Figure 2.21: Euro Area net Debt Transactions by Country



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. PSPP eligible and PSPP substitute as defined in 2.3.2.3.

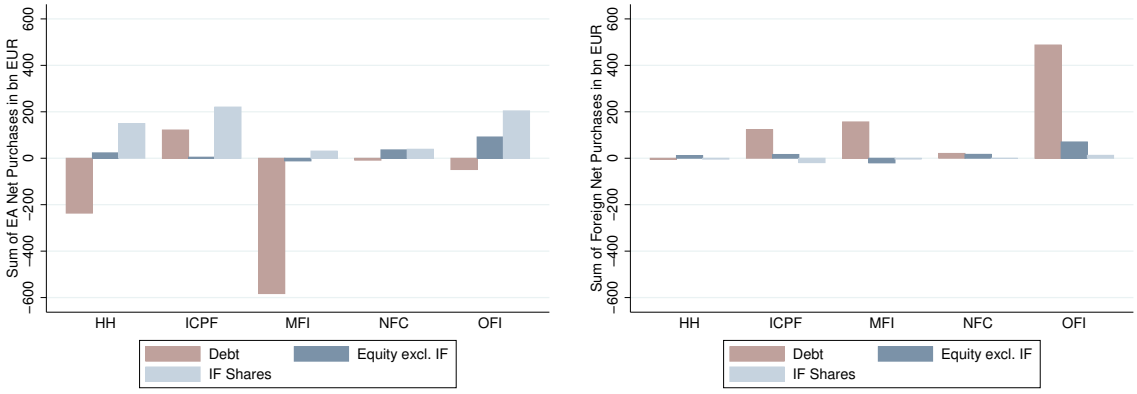
Figure 2.22: Euro Area net Transactions: intra-(LHS) and extra-euro area (RHS)



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. Securities on the left (right) issued in (outside) the euro area.

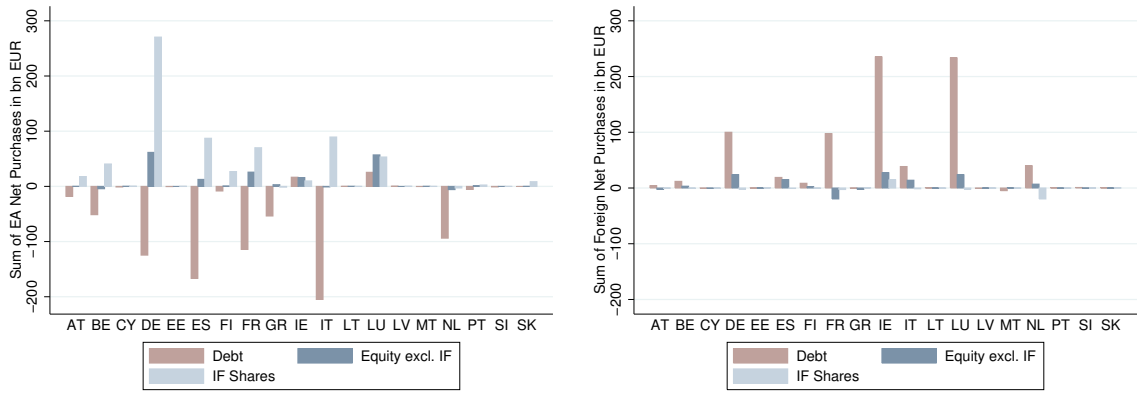
Figure 2.23: Euro Area net Transactions by Sector: intra-(LHS) and extra-euro area (RHS)



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. Securities on the left (right) issued in (outside) the euro area.

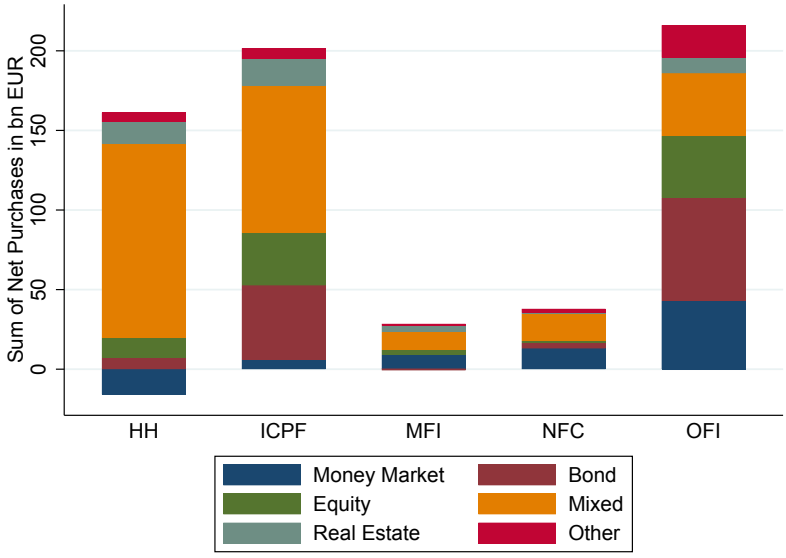
Figure 2.24: Euro area net transactions by country: intra-(LHS) and extra-euro area (RHS)



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. Securities on the left (right) issued in (outside) the euro area.

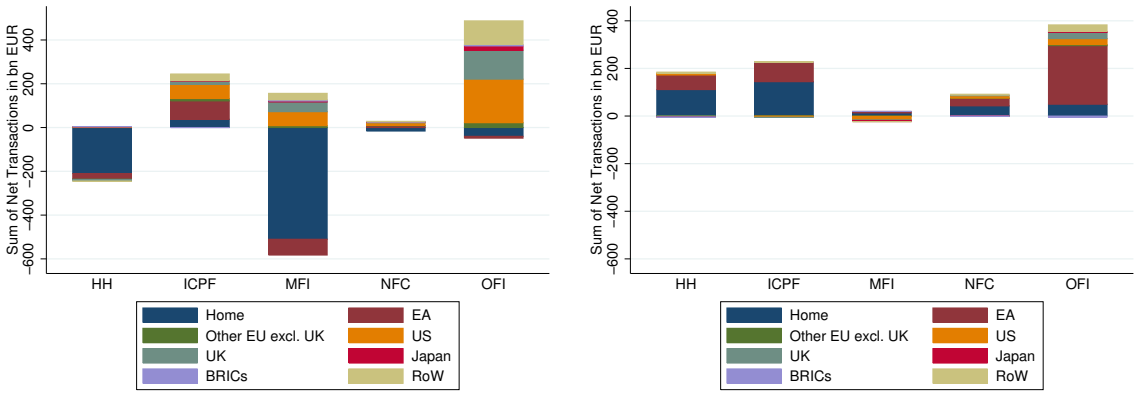
Figure 2.25: Euro Area net Transactions of Investment Fund Shares split by main Mandate



Source: ECB

Notes: Cumulated net purchases of investment fund shares from 2015Q1-2016Q4 split by their respective main mandate of investment in bn EUR. Data on the mandates are from an extract of the CSDB on 31/01/2018.

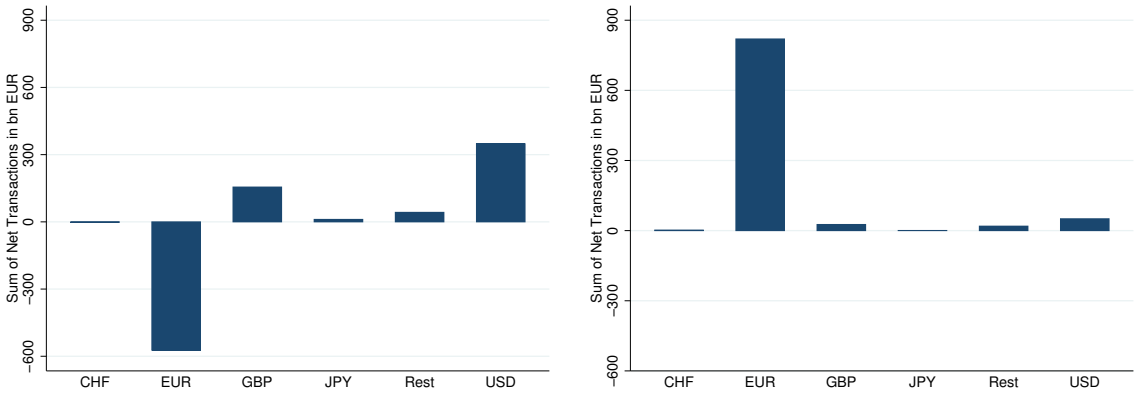
Figure 2.26: Euro Area net Transactions by Geography: Debt (LHS) and Equity (RHS)



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. Debt securities on the left and equity securities on the right hand side.

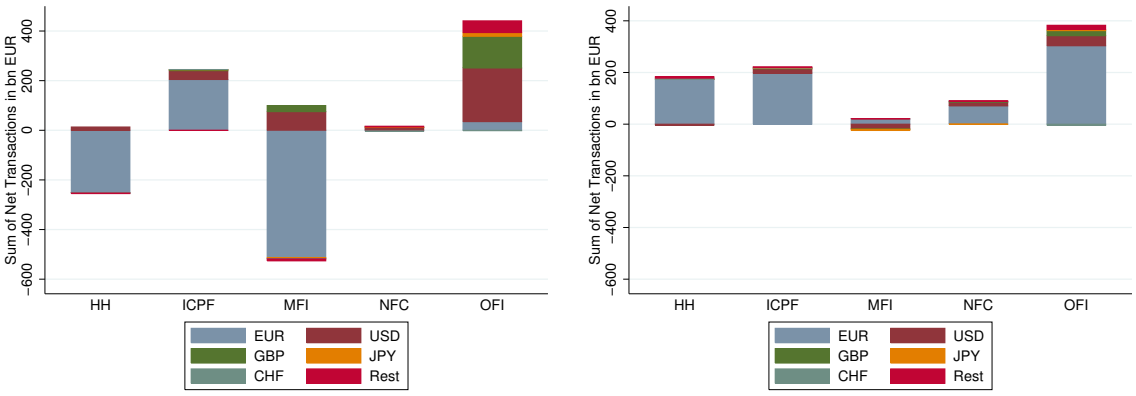
Figure 2.27: Euro Area net Transactions by Currency: Debt (LHS) and Equity (RHS)



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. Debt securities on the left and equity securities on the right hand side.

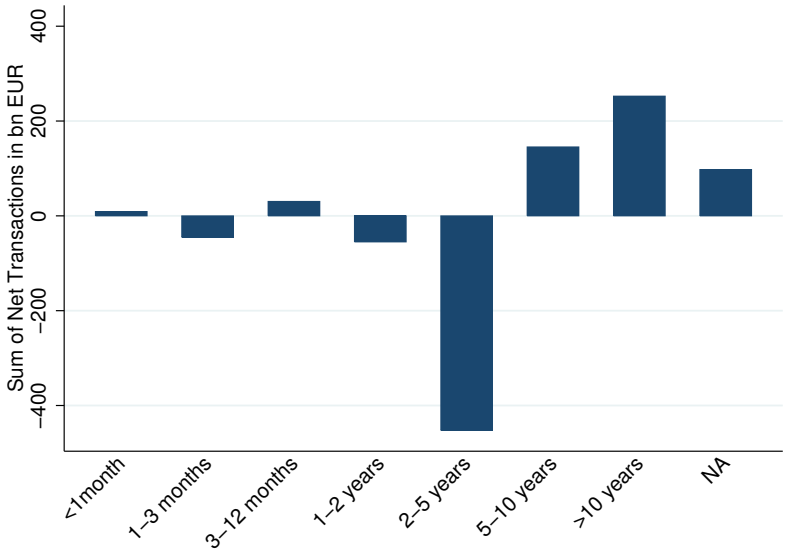
Figure 2.28: Euro Area net Transactions by Currency: Debt (LHS) and Equity (RHS)



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn. Debt securities on the left and equity securities on the right hand side.

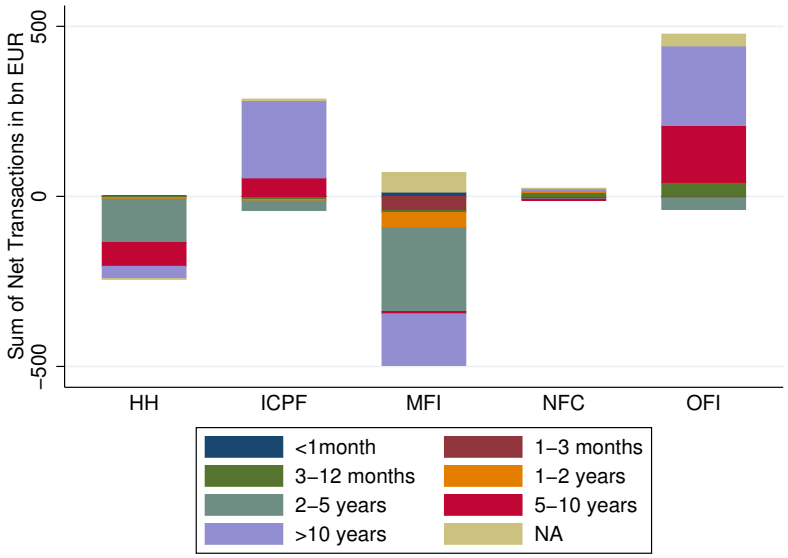
Figure 2.29: Euro Area net Debt Transactions by Maturity



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn.

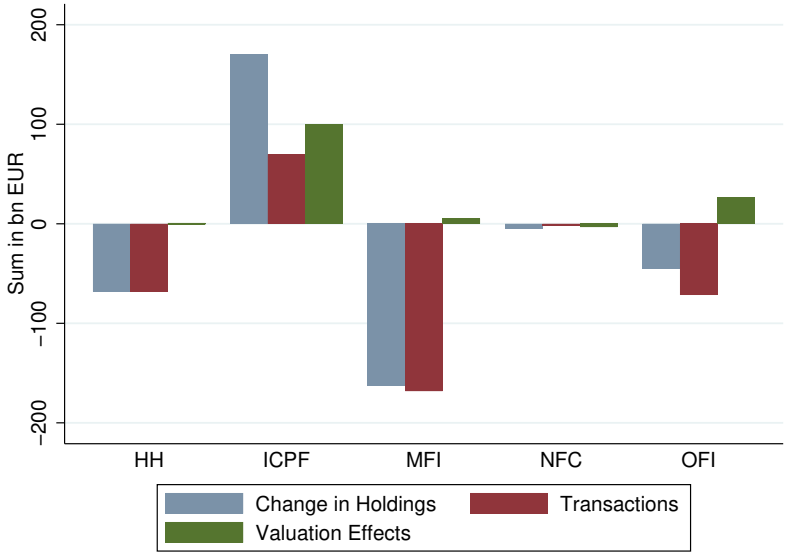
Figure 2.30: Euro Area net Debt Transactions by Maturity and Sector



Source: ECB

Notes: Cumulated net purchases by euro area residents from 2015Q1-2016Q4 in EUR bn.

Figure 2.31: Euro Area net Transactions, Changes in Holdings, and Valuation Effects



Source: ECB

Notes: Cumulative values from 2015Q1-2016Q4 of PSPP eligible assets by sector in EUR bn.

2.3.7 Tables

Table 2.26: Baseline Estimation: Debt Securities

	(1) All	(2) All	(3) Foreign	(4) no IE&LU	(5) only long-term	(6) All	(7) All	(8) Push-Pull
ln(Hold$_{pre}$)	-0.652***	-0.652***	-0.653***	-0.751***	-0.657***	-0.744***	-0.771***	-0.553***
	(-10.71)	(-10.71)	(-8.42)	(-13.61)	(-10.44)	(-9.53)	(-15.84)	(-7.47)
Δ Amount Out	0.505***	0.505***	0.471***	0.506***	0.507***	0.540***	0.479***	0.509***
	(26.80)	(26.79)	(31.26)	(23.35)	(26.78)	(26.47)	(25.57)	(25.45)
EUR	-0.327	-0.327	-0.210	-0.284	-0.324	-0.219	0.0139	-0.481
	(-1.22)	(-1.22)	(-0.81)	(-0.85)	(-1.15)	(-0.72)	(0.05)	(-1.542)
ln(original maturity)	0.564***	0.565***	0.350**	0.825***	0.468**	0.352	0.195	0.771***
	(3.60)	(3.59)	(2.42)	(7.03)	(2.25)	(1.65)	(1.45)	(5.072)
PSPP Eligibility	-0.808***	-0.808***	-0.681**	-0.959***	-0.816***	-0.925***	-0.632**	-0.581*
	(-3.00)	(-3.00)	(-2.39)	(-3.36)	(-3.24)	(-3.27)	(-2.46)	(-1.821)
PSPP Substitute		0.293	0.141	0.482	0.493	0.119	-0.475	0.520
		(0.58)	(0.29)	(1.06)	(0.68)	(0.19)	(-0.81)	(0.972)
High Yield						0.0125		
						(0.08)		
Low Quality							-0.132	
							(-0.48)	
Diff. Policy Uncertainty$_{s-h}$								-1.546**
								(2.050)
Diff. Δ GDP Forecast$_{s-h}$								-0.477
								(0.331)
Diff. Δ Yield$_{s-h}$								0.542
								(0.905)
Observations	683007	683007	460687	566399	651402	306654	290771	613093
Holder country-sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Issuer country-sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Country-pair FE	yes	yes	yes	yes	yes	yes	yes	no

Notes: The dependent variable is the (adjusted) logarithm of cumulative net purchases of debt securities during the PSPP period (2015q1-2016q4). The independent variables are holdings *ln(Hold$_{pre}$)* in 2014Q4, the change in the outstanding amounts Δ *Amount Out*, a dummy variable for euro denomination *EUR*, and the original maturity *ln(original maturity)*. PSPP eligible and PSPP substitute as defined in 2.3.2.3. *High Yield* is a dummy variable equal to 1 if the yield is in the highest decile. *Low Quality* is a dummy variable equal to 1 if the security is rated on the lowest out of four categories defined by the ECB. *Diff. Policy Uncertainty$_{s-h}$* is the average quarterly (log) difference between news-based policy uncertainty of the issuer country s and holder country h. *Diff. Δ GDP Forecast$_{s-h}$* is the average difference of revisions in the semiannual forecast (five years ahead) between issuer country s and holder country h. *Diff. Δ Yield$_{s-h}$* is the change in the 10 year government bond yield differential between issuer country s and holder country h. All differences refer to 2014Q4 to 2016Q4. T-statistics in brackets. * significant at 10% level; ** significant at 5% level, *** significant at 1% level.

Table 2.27: Sectoral Estimation: Debt Securities

	(1) MFI	(2) ICPF	(3) OFI	(4) NFC	(5) HH
ln(Hold$_{pre}$)	-0.709***	-0.556***	-0.526***	-0.658***	-0.830***
	(-7.20)	(-5.88)	(-4.88)	(-8.58)	(-8.55)
Δ Amount Out	0.640***	0.513***	0.487***	0.476***	0.445***
	(9.37)	(11.09)	(19.86)	(26.29)	(20.88)
EUR	1.085***	0.970	-0.112	-0.454*	-2.550***
	(2.99)	(1.37)	(-0.40)	(-1.87)	(-13.18)
ln(original maturity)	-0.166	1.258***	0.290	0.877***	1.081***
	(-0.56)	(3.58)	(1.17)	(10.33)	(11.37)
PSPP eligibility	-1.370	-0.0993	-1.189***	-0.908*	-1.549***
	(-1.34)	(-0.25)	(-3.14)	(-1.92)	(-4.07)
PSPP substitute	-0.0952	-0.741	1.725***	-1.026	-0.0372
	(-0.09)	(-0.90)	(2.90)	(-1.13)	(-0.05)
Observations			683007		
Holder country-sector FE			yes		
Issuer country-sector FE			yes		
Country-pair FE			yes		

Notes: The dependent variable is the (adjusted) logarithm of cumulative net purchases of debt securities during the PSPP period (2015q1-2016q4). The independent variables are holdings *ln(Hold$_{pre}$)* in 2014Q4, the change in the outstanding amounts Δ *Amount Out*, a dummy variable for euro denomination *EUR*, and the original maturity *ln(original maturity)*. PSPP eligible and PSPP substitute as defined in 2.3.2.3. T-statistics in brackets. * significant at 10% level; ** significant at 5% level, *** significant at 1% level.

Table 2.28: Geography Estimations

	(1) ALL	(2) MFI	(3) ICPF	(4) OFI	(5) NFC	(6) HH
PSPP Eligibility	-0.827***	-0.573	0.045	-1.359***	-0.758	-1.776***
	(0.267)	(1.004)	(0.440)	(0.442)	(0.458)	(0.365)
Issuer = EA MFI	0.256	1.988***	0.464	0.111	0.689***	-0.152
	(0.259)	(0.351)	(0.336)	(0.284)	(0.259)	(0.199)
Issuer = EA NFC	-0.068	1.019	0.492	0.192	0.700*	0.510
	(0.356)	(0.912)	(0.432)	(0.497)	(0.420)	(0.471)
Issuer = EA OFI	0.587**	0.517	-0.044	0.319	0.509**	0.583**
	(0.256)	(0.382)	(0.302)	(0.247)	(0.234)	(0.259)
Issuer = EA ICPF	-0.073	1.039	0.074	-0.424	-0.595	0.735
	(0.705)	(2.401)	(1.103)	(1.457)	(0.926)	(1.310)
PSPP Substitute	0.435	0.628	-0.047	1.704***	-0.596	0.521
	(0.489)	(1.071)	(0.795)	(0.632)	(0.898)	(0.737)
Issuer = ADV MFI	1.554***	2.422***	2.111***	1.254**	1.240***	1.157***
	(0.359)	(0.396)	(0.467)	(0.515)	(0.409)	(0.337)
Issuer = ADV NFC	0.969	0.933	1.675***	1.026	0.693	1.627***
	(0.603)	(0.802)	(0.594)	(0.692)	(0.700)	(0.566)
Issuer = ADV OFI	3.846***	4.123***	4.864***	2.687***	4.090***	4.995***
	(0.336)	(0.540)	(0.459)	(0.355)	(0.542)	(0.469)
Issuer = ADV ICPF	1.280	-2.262	-0.590	1.954**	-2.087	0.357
	(0.784)	(1.660)	(1.251)	(0.859)	(1.873)	(0.915)
Issuer = EM Corp	-1.243	-1.131	-1.116	-1.425	-0.783	0.411
	(0.808)	(0.928)	(0.810)	(0.919)	(1.005)	(0.829)
Issuer = EM Sov	0.954*	2.126***	1.425	0.757	-1.602**	-0.294
	(0.569)	(0.568)	(0.952)	(0.717)	(0.734)	(0.615)
Observations	683,007	683,007				
Holder country-sector FE	yes	yes				
Issuer country-sector FE	yes	yes				
Country-pair FE	yes	yes				

Notes: The dependent variable is the (adjusted) logarithm of cumulative net purchases of debt securities during the PSPP period (2015q1-2016q4). The independent variables are holdings *ln(Hold$_{pre}$)* in 2014Q4, the change in the outstanding amounts Δ *Amount Out*, a dummy variable for euro denomination *EUR*, and the original maturity *ln(original maturity)*. PSPP eligible and PSPP substitute as defined in 2.3.2.3. ADV stands for advanced countries which include Australia, Canada, Czech Republic, Denmark, Hong Kong, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, United Kingdom, and the United States. EM stands for emerging market economies. T-statistics in brackets. * significant at 10% level; ** significant at 5% level, *** significant at 1% level.

Table 2.29: Country-group Estimation

	(1) Debt Stressed	(2) Debt Non-stressed
ln(Hold$_{pre}$)	-0.904***	-0.712***
	(-9.89)	(-13.45)
Δ Amount Out	0.547***	0.495***
	(9.55)	(24.03)
EUR	0.178	-0.407
	(0.28)	(-1.08)
ln(original maturity)	0.385	0.908***
	(1.46)	(8.63)
PSPP eligibility	-1.750**	-0.685*
	(-2.31)	(-1.86)
PSPP substitute	0.728	0.300
	(1.08)	(0.65)
Observations	566399	
Holder country-sector FE	yes	
Issuer country-sector FE	yes	
Country-pair FE	yes	

Notes: The dependent variable is the (adjusted) logarithm of cumulative net purchases of debt securities during the PSPP period (2015q1-2016q4). The independent variables are holdings *ln(Hold$_{pre}$)* in 2014Q4, the change in the outstanding amounts Δ *Amount Out*, a dummy variable for euro denomination *EUR*, and the original maturity *ln(original maturity)*. PSPP eligible and PSPP substitute as defined in 2.3.2.3. The group of (formerly) stressed countries consists of Cyprus, Greece, Italy, Portugal and Spain. Ireland and Luxembourg are not included in these estimations. T-statistics in brackets. * significant at 10% level; ** significant at 5% level, *** significant at 1% level.

Table 2.30: Extension of the baseline Estimation: Time Dimension

	(1) From 14Q3 until 14Q4	(2) From 15Q1 until 15Q2	(3) From 15Q1 until 16Q2	(4) From 15Q1 until 16Q4
$\ln(\text{Hold}_{pre})$	-0.431***	-0.298***	-0.589***	-0.652***
	(-4.79)	(-3.50)	(-9.50)	(-10.71)
Δ Amount Out	0.578***	0.661***	0.542***	0.505***
	(21.08)	(19.00)	(28.22)	(26.79)
EUR	-0.543	-0.577**	-0.626**	-0.327
	(-1.52)	(-2.45)	(-2.40)	(-1.22)
ln(original maturity)	0.307*	0.328*	0.444**	0.565***
	(1.70)	(1.68)	(2.55)	(3.59)
PSPP eligibility	1.226***	-0.425*	-1.047***	-0.808***
	(3.42)	(-1.69)	(-4.64)	(-3.00)
PSPP substitute	0.899*	0.0452	0.101	0.293
	(1.88)	(0.12)	(0.21)	(0.58)
Observations	347851	689561	684168	683007
Holder country-sector FE	yes	yes	yes	yes
Issuer country-sector FE	yes	yes	yes	yes
Country-pair FE	yes	yes	yes	yes

Notes: The dependent variable is the (adjusted) logarithm of cumulative net purchases of debt securities during the period specified on top of the column.The independent variables are holdings $ln(Hold_{pre})$ in 2014Q4, the change in the outstanding amounts Δ *Amount Out*, a dummy variable for euro denomination *EUR*, and the original maturity *ln(original maturity)*. T-statistics in brackets. PSPP eligible and PSPP substitute as defined in 2.3.2.3. * significant at 10% level; ** significant at 5% level, *** significant at 1% level.

Table 2.31: Time Dimension and PSPP Eligibility: overall and by Sector

	(1) From 14Q3 until 14Q4	(2) From 15Q1 until 15Q2	(3) From 15Q1 until 16Q2	(4) From 15Q1 until 16Q4
I. Overall specification				
	1.226***	-0.425*	-1.047***	-0.808***
	(3.42)	(-1.69)	(-4.64)	(-3.00)
II. Sectoral specification				
MFI	0.760	-1.243*	-1.525	-1.370
	(0.69)	(-1.67)	(-1.61)	(-1.34)
ICPF	1.285	-0.305	-0.499	-0.0993
	(1.54)	(-0.72)	(-1.11)	(-0.25)
OFI	1.435***	-0.111	-1.035***	-1.189***
	(3.78)	(-0.31)	(-3.21)	(-3.14)
NFC	-0.0304	-0.896	-1.046*	-0.908*
	(-0.06)	(-1.44)	(-1.73)	(-1.92)
HH	0.768	-0.627*	-1.519***	-1.549***
	(1.50)	(-1.73)	(-4.09)	(-4.07)
Observations	347851	689561	684168	683007
Holder country-sector FE	yes	yes	yes	yes
Issuer country-sector FE	yes	yes	yes	yes
Country-pair FE	yes	yes	yes	yes

Notes: Excerpts from full regression tables as in Table 5: coefficients of PSPP Eligibility. The same number of observations is used in both specifications. The dependent variable is the (adjusted) logarithm of cumulative net purchases of debt securities during the period specified on top of the column. T-statistics in brackets. * significant at 10% level; ** significant at 5% level, *** significant at 1% level.

Table 2.32: Extension: active vs. passive Rebalancing and PSPP Eligibility

	(1) Net transactions	(2) Passive rebalancing	(3) Δ Holdings
I. Overall specification			
	-1.541***	1.492***	-0.0485
	(-4.61)	(4.78)	(-1.37)
II. Sectoral specification			
MFI	-2.505*	2.541**	0.0358
	(-1.96)	(2.19)	(0.28)
ICPF	-0.351	0.379	0.0278
	(-0.75)	(0.83)	(0.69)
OFI	-1.963***	1.961***	-0.00162
	(-3.34)	(3.51)	(-0.04)
NFC	-0.920	0.906	-0.0138
	(-1.29)	(1.33)	(-0.27)
HH	-1.950***	1.738***	-0.212***
	(-3.30)	(3.23)	(-2.92)
Observations	331356	331356	331356
Holder country-sector FE	yes	yes	yes
Issuer country-sector FE	yes	yes	yes
Country-pair FE	yes	yes	yes

Notes: Excerpts from full regression tables: coefficients of PSPP Eligibility. The same number of observations is used in both sets of estimations. The dependent variable is for column (1) the (adjusted) logarithm of cumulative net purchases of debt securities during the PSPP period (2015q1-2016q4), for column (3) the log change in holdings from end of 2014Q4 until 2016Q4, and for column (2) the difference between (3) and (1). T-statistics in brackets. * significant at 10% level; ** significant at 5% level, *** significant at 1% level.

Chapter 3

Essays in Empirical Banking

3.1 Forbearance Patterns in the post-crisis Period [92]

3.1.1 Introduction

In the recent financial crisis, the banking sector was simultaneously both the trigger as well as one of the most affected sectors in many countries. Corporate defaults, a crash in house prices, and high unemployment threatened the health of banks' balance sheets. Under these circumstances, lenders and borrowers found it in their interest to keep otherwise non-performing loans alive by preventing a risky borrower's default. Terms such as "evergreening", "zombie lending", or banks "gambling for resurrection" emerged in the economic literature to describe the practice of granting concessions to troubled borrowers. Whilst this can be economically useful under some circumstances, it can be used by banks to conceal potential losses. This can cause systemic risk, increase uncertainty about the quality of banks' assets, and undermine trust in the banking sector's solvency, which calls for regulators to monitor and prevent the establishment of this practice.

Using loan-level data on the commercial loans of all Irish banks, we study the patterns and the effectiveness of forbearance after the recent Global Financial Crisis and provide evidence for several correlations observed in banks under stress. In our empirical setting, we distinguish between extensions in the overall credit limit or the maturity of the loan, a stop in amortisation, a relative decrease in the interest rate, and a rollover of the exposure. Using a standard logit model saturated with various fixed effects, we find that the riskiest borrowers are more likely to be granted a forbearance measure if the lender is facing high levels of non-performing loans (NPLs) relative to its capital and provisions. For the positive relationship between banks' stress levels - measured by the Texas Ratio - and a higher probability of granting forbearance, we offer an explanation through the current regulatory framework. When the reporting of default is seen as a conscious decision of the bank and the firm, banks face an incentive not to flag loans as non-performing but to grant forbearance because of the impact on their profitability and ultimately their capital ratios (Eisfeldt and Rampini, 2008). Furthermore, since banks do not know the persistence of the shock hitting firms it is rational to practice forbearance under the assumption that it might help the firm survive. Besides the incentives, forbearance can be one way of releasing stress on borrowers and banks if it is effective in bringing down the probability of default and thereby helping the overall economy.

As a second step, we look at the effectiveness of forbearance as a mean of preventing default. We show that a limit extension is effective in reducing the probability of default up to one year ahead. For a longer time horizon and other forbearance measures we find that treated borrowers are in fact more likely to default compared to their peers within the same risk category. While this can be due to several mechanisms (e.g. selection bias within

[92] Co-authored with Thore Kockerols (Norges Bank). This is a slightly revised version of Norges Working Paper No. 11/2018.

a risk category), we show that forbearance did not prevent default in the long run after the Global Financial Crisis. Finally, the question arises over whether or not new lending is subdued because capital and other resources within the bank are allocated to forborne loans. We present evidence that lending and forbearance might be treated as substitutes by banks. Within buckets of similar loans, we find that the share of forbearance is negatively related with the issuance of new credit.
A significant caveat of our administrative data is that we do not observe the borrowers identity across banks[93]. This brings identification challenges when trying to single out supply factors and to properly account for substitution of credit from one bank to another bank.

Therefore, we contribute to a strand of literature focused on forbearance techniques of banks which has emerged in the last two decades. For Japan, empirical evidence shows that troubled banks allocated credit to severely impaired borrowers to avoid the realisation of losses on their own balance sheets (e.g. Peek and Rosengren (2005), Sekine et al. (2003), and Watanabe (2010)). Analysing the driving mechanism of forbearance during the country's "lost decade", Caballero et al. (2008) use the term "zombie lending" for credit to unprofitable firms at interest rates below market values. Besides the hazard for banks themselves, the authors show that this misallocation of credit towards otherwise insolvent borrowers had significant negative effects on the real economy. The presence of zombie firms was found to depress job creation, deter the entry of healthy firms, and to decrease employment and investment of healthy firms. Using the effects following capital injections for Japanese financial institutions, Giannetti and Simonov (2013) show that troubled banks that remained under-capitalized were more likely to engage in "evergreening" by maintaining relationships with weak borrowers.

More recently, it became clearer that Japan was not an exception (Acharya et al., 2016a). Homar et al. (2015) look at European banks and find that weak banks are more likely to grant concessions to weak borrowers. The authors call for more empirical work regarding patterns of forbearance as an important factor in the slow recovery after the Global Financial Crisis. Using the Italian credit registry, Schivardi et al. (2017) show that Italian banks with relatively low capital levels were less likely to cut credit to non-viable firms after the Global Financial Crisis. While they show that measures of real effects, such as TFP growth, were not significantly affected by the misallocation, it did lead to an increase in the failure rate of healthy firms while it reduced the failure rate of non viable firms. Using the same data, Accornero et al. (2017) confirm the negative correlation between NPL ratios and credit growth but show that for the Italian case, this was caused by constrained demand. Acharya et al. (2016b) use the announcement of the Outright Monetary Transactions (OMT) as an event on which to identify "zombie lending" patterns for European banks. Institutions which were not sufficiently recapitalised in the wake of the OMT announcement were more likely to extend loans to weak firms instead of their more creditworthy peers who would have been able to

[93]We do observe borrower IDs within a bank so we can link one borrower with several loan products.

invest credit more profitably. This resulted in significant real effects, most notably a slowdown of the economic recovery in the post-crisis period.

Our analysis is also motivated by existing work focused on the incentives for banks to engage in forbearance and therefore relatively risky lending. Keuschnigg and Kogler (2017) present a theoretical model showing that weak banks try to avoid writing off non-performing loans in order to prevent a violation of regulatory requirements or even insolvency. This literature also emphasises possible negative consequences of these patterns for the financial stability when banks do not "clean up their balance sheets" (Diamond and Rajan, 2011). Analysing the case of China, Zhang et al. (2016) show that high NPL ratios are associated with riskier lending, potentially increasing individual institutions credit risk and threatening financial stability. Huizinga and Laeven (2009) show that distressed banks in the US used discretion in accounting during the Global Financial Crisis in order to inflate the book value of their assets which results in a distorted view of the financial health of these institutions. In addition, Bonaccorsi di Patti and Kashyap (2017) show that banks are able to recover significantly faster from large adverse shocks if they manage risky clients more aggressively and thereby reduce credit risk.

With our analysis we reach some novel results. First, we argue that capitalisation is not the only determinant factor of forbearance for banks. As can be seen in recent stress tests (EBA, 2016b), some of the banks in our sample have been sufficiently re-capitalised since the crisis through a public bailout, so that they now comfortably exceed regulatory requirements. However, NPLs are at very high levels by any standards, which can pose a threat to capitalisation levels under even moderate economic stress (IMF, 2016). Therefore, we argue that the quality of a lender's loan book must be considered when analysing the determinants of "zombie lending". Secondly, we exploit the quality of the loan level data to measure forbearance techniques using more definitions than are common in the literature. We suggest that financial pressure in times of crises creates incentives for different types of forbearance other than subsidised lending through a lower interest rate. More specifically, we analyse whether banks extend credit limits or maturities, or opt to grant other measures such as a stop in amortisation or a rollover of a loan product. Furthermore, the granular loan-level data allow us to suggest that a limit extension has been effective in bringing down the probability of default up to one year but no forbearance measure has been effective in the long run for the banking system. Using a standard logit-hazard model, we show the relationship between the different forbearance measures and the probability of default across various time horizons. Finally, the evidence suggests that forbearance ties up banks' resources that might have been used for new lending. We conclude our empirical analysis with a correlation analysis that reveals the negative relationship between forbearance and new lending.

In Section 3.1.2, we explain the conceptual framework, the different forbearance measures and offer an explanation as to why banks face an incentive to engage in forbearance within

the current regulatory framework. Section 3.1.3 introduces the data and lays out our analysis of the forbearance patterns. Section 3.1.4 elaborates on the effectiveness of the different forbearance measures in avoiding default, and Section 3.1.5 looks at possible correlations between forbearance and new lending. Finally, Section 3.1.6 concludes.

3.1.2 Conceptual Framework

3.1.2.1 The Crisis and the Irish Case

Ireland experienced one of the worst banking crises in the aftermath of the recent Global Financial Crisis. It originated from a devastating boom-bust cycle in the domestic property market which was financed by bank loans. While the economic growth in the years leading up to 2000 can be interpreted as a healthy convergence of the "Celtic Tiger" with the rest of the European Union, the surge in output in 2003-2007 turned out to be of a different kind: a construction boom (Honohan, 2010). Banks became highly exposed to the housing market through the extremely rapid credit expansion to home owners and property developers. As a consequence of the shift in international financial markets in 2007/2008, Irish banks faced difficulties to maintain funding while domestic investors pulled back from the property market. After prices declined sharply and construction activities collapsed, banks faced an unprecedented increase in NPLs. Finally, public funds had to be used in order to recapitalise the most significant credit institutions in Ireland (Lane, 2011). The banks' recovery was then shaped by two stylised facts: (i) a fast recapitalisation of banks due to the public bail-out but (ii) threatening levels of NPLs on their balance sheets. We show these two developments for Irish banks in Figure 3.1. On the left side, we look at Tier 1 capital as an indicator of the health of an institution's balance sheet.[94] We can see that after the public bailouts of banks in response to the crisis, the ratio of Tier 1 capital to risk weighted assets (Tier 1 Capital Ratio) has levelled off well above the regulatory requirement of 8% and the European average of 14.1%.[95] On the right side, we analyse the NPL ratio which is at very high levels throughout and peaks only in 2013 and descends thereafter. In the middle panel of Figure 3.1, we analyse the Texas Ratio, which indicates how close the bank is to the regulatory constraints due to credit risk.[96] The measure is defined as:

$$\text{Texas Ratio} = \frac{\text{Impaired Loans + Loans 90 days past due but not impaired}}{\text{Tangible Equity + Loan Loss Provisions}}.$$

Intuitively, a value above 100% is widely considered to be critical and we can see that the Irish banking sector only recovered to below this threshold in 2014. It is clear from Figure

[94] Tier 1 capital is composed of Common Equity Tier 1 and Additional Tier 1 capital, which is available to the institution for unrestricted and immediate use to cover risks or losses as soon as these occur.

[95] Through the public bank bailouts, 99.9% of Allied Irish Banks and 15% of Bank of Ireland became state-owned.

[96] Developed by Gerard Cassidy and others at RBC Capital Markets, the Texas Ratio got its name from its use to analyse weak banks in Texas during the 1980s.

3.1 that the development of the Texas Ratio is driven by the NPL ratio. Evidently, Ireland continues to suffer from high levels of impaired loans as a legacy from the Global Financial Crisis. Besides the decline in house prices and resulting wealth effects, unemployment and contractionary fiscal policy have made it impossible for some borrowers to pay back their loans. Hence, NPL ratios have risen to approximately four times the European average, driving the Texas Ratio to critical levels throughout our period of observation.

The high levels of the Texas Ratio suggest a threatening sensitivity to credit risk, which has been confirmed by recent stress tests, such as the latest Financial Sector Assessment Program of the International Monetary Fund and European Banking Authority's stress tests (IMF (2016); EBA (2016a)). In Figure 3.2, we use data from EBA (2016a) to illustrate this risk: although Irish banks seem well capitalised in normal economic conditions, the stress test points out that regulatory requirements may not be reached under the adverse scenario. In addition, compared to other Euro Area countries, the difference of Tier 1 capital levels between the baseline and adverse scenario turns out to be the largest for Ireland.

A breakdown of the drivers behind this large gap, shown in Figure 3.3, reveals that credit risk is the main contributor and accounts for a 6 percentage point difference in the Tier 1 capital ratio between the two scenarios.[97] More specifically, credit risk is explaining a 6 percentage point difference. For this case, losses from credit are projected to decrease the Tier 1 capital ratio by around 6 percentage points between 2015 and 2018.

Data We use the commercial loan level data from the Central Bank of Ireland provided by Irish banks in biannual frequency from 2011 Q4 up to 2016 Q2. This covers all loans to large corporates, small and medium enterprises (SMEs), and Micro SMEs including loan-specific as well as borrower-specific characteristics. Therefore, while most of the previous literature considered only listed firms, we are able to analyse lending to any type of firm that borrows from Irish Banks in Ireland. The loan-specific characteristics contain information on product type, maturity, interest rate, the repayment schedule, whether the loan is securitised, and a mapped rating of the risk of the loan. The latter come from the banks' internal Probability-of-Default (PD) models but are homogenized by the Central Bank of Ireland by ensuring that the rating classes correspond to similar probabilities of default. The borrower-specific characteristics include information about the firm's sector and segment.

We have 1,686,325 observations (loan $\times$ time) and 244,908 borrowers in our sample. Once a loan defaults, the borrower and all of the related loans are no longer included in the sample. The data covers the 26 Irish counties, 8 sectors, 3 segments (Corporate, SME and micro SME), and 4 product types (leasing/hire purchase, overdraft, term loan and other).

A caveat of this confidential data is that we do not obtain the firms' names. This has two consequences: first, we cannot enrich the data with balance sheet information in order

[97] In comparison, Italy is less affected by credit risk and is projected to have higher profits under the adverse scenario.

to control for firm characteristics. Secondly, we cannot identify the same firm across banks. While the data allow us to identify a borrower having several loan products within a bank, we cannot control for the fact that the firm might have a relationship to another bank. However, Albertazzi and Marchetti (2010) use the Italian credit registry to show that the ability of borrowers to compensate through substitution across banks appears to have been limited after Lehman's collapse.

3.1.2.2 Forbearance

Types of Forbearance In this section, we define and explain the different forbearance measures that we construct from our data. We exploit the quality and granularity of the Irish commercial loan level data to measure forbearance techniques along several definitions. The first definition of forbearance we consider is when banks (temporarily) suspend instalments and allow borrowers to only make interest payments. This measure, referred to as an "amortisation stop", ensures that the outstanding amount on the loan remains constant until further agreement or maturity. This is straight-forward to detect since banks report any changes in the amortisation status of each loan.[98] Furthermore, a bank can grant two types of loan extensions. First, loans can be extended by increasing the total limit that can be drawn down by the borrower. This measure is especially common for overdrafts. In the framework of forbearance, the idea is that a borrower needs more credit, e.g. to cover current expenses or even to fulfil payments that are outstanding on another existing loan product. We define this measure as a positive change in the total limit that can be drawn by a borrower. Second, the loan's maturity can be extended by pushing back the due date of the loan. Non-amortising loans therefore become due at a later date. For loans with constant repayments, this can result in smaller instalments and therefore a lighter financial burden for the company over time. In a similar manner, the bank can "rollover" a loan. This measure is less straight forward to extract from loan-level data. We consider a loan "rolled-over" if for a given borrower one of its significant loans disappears from the sample (expired or concordantly ended) but the borrower limit does not decrease by more than half of the discontinued loan's amount. This implies that limits on other products were increased or new products were issued. Finally, we follow Caballero et al. (2008) and look at subsidised lending via a comparably lower interest rate. We extend this idea to account for the environment of decreasing interest rates for our sample period. Therefore, we analyse whether banks grant specific borrowers significantly greater interest rate decreases compared to their peers. We define an advantageous change in the interest rate if the decrease in a borrower's interest rate is greater than the decrease for the safest borrowers within the same sector, segment, and product type.[99]

[98] Under Capital Requirements Regulation Article 178 (3) a) non-accrual status amounts to a default of a loan. Here, we rely on banks internal indicators of an amortisation stop which does not correlate with default, both before and after CRR/CRD IV took effect.

[99] An extensive description of how we measure forbearance can be found in the Appendix.

These measures are very heterogeneous. A limit extension can be requested for very different purposes by very diverse borrowers. Safe borrowers might apply for more credit in order to finance projects with net positive returns. In contrast, a stressed borrower might apply for further credit when he is unable to cover due payments and expenses. However, other measures, such as an amortisation stop, might be the most necessary, but also the riskiest, when a borrower is in distress. In order to account for this, we split borrowers in three risk categories: safe, average, and risky.[100] Figure 3.4 shows the share per borrower rating of the different treatments across time. We find that the share of treated loans is the highest for the riskiest borrowers for every forbearance measure. The most commonly applied measure within the group of risky borrowers is a limit extension, followed by an interest rate change. A rollover and an amortisation stop are the least commonly applied measures. The fact that risky borrowers have higher shares of forborne loans goes against banks' risk aversion, but this phenomenon is intuitive when considering that borrowers in distress are most in need of additional financial support. In the following sections we will focus the banks' incentives to prevent default and test this hypothesis empirically.

The Banks' Incentives and Constraints In the context of our research question it is important to understand how the constraints and incentives of banks influence their credit supply to the economy. Banks maximise their profits while staying solvent and holding enough liquid assets to meet their obligations. At the same time, they are subject to the capital and liquidity regulation set out in the Basel II and III framework.

Let us consider the case of a commercial loan close to default (low rating). The bank has an incentive to prevent default because of the impact on its capital ratio. NPLs have a negative impact on capital both now and in the future. First, a provisioning shortfall is deducted from Tier 1 capital[101] in case of default under the Foundation Internal Ratings Based (F-IRB) approach.[102] This shortfall might occur because of the discretionary nature of provisions. Banks have an incentive to "underprovision" and only realise the loss at default. Second, a default leads to higher future provisions since these are based on historical observed default rates. International Financial Reporting Standards (IFRS) 9, in place from January 2018 on, will lead to an earlier recognition of expected losses and thereby mitigate the issue of underprovisioning.

Intuitively, banks have a strong incentive to prevent this potential decrease of capital and adopt forbearance measures in order to support the borrower in difficulty. Nonetheless, forbearance measures themselves might also impact regulatory capital ratios. First, a maturity

[100] These ratings come from the banks' internal models but are homogenized by the Central Bank of Ireland by ensuring that the rating classes correspond to similar probabilities of default.

[101] Excess provisions are added to Tier 2 capital.

[102] The majority of corporate, SME and micro SME portfolios are held under the Foundation Internal Ratings Based approach. Minor parts are accounted for using the Standardised Approach and one bank has a small part of their portfolio with the Retail Internal Ratings Based approach.

extension mechanically increases the risk weight as maturity is part of the risk weight formula.[103] Second, an increase of the overall borrower limit translates directly into an increase of the exposure at default and thereby risk weighted assets. Third, reducing the interest rate will lead to lower capital because of the lower future interest earnings but risk weights are unaffected. Fourth, an amortisation stop is a temporary stop/reduction of the regular payments. The effect on capital depends on whether missed payments are repaid in full once the loan becomes amortising again. Lastly, a rollover can be seen as a maturity extension with regards to risk weights, because a considerable amount of the exposure stays on the book of the bank.

Having laid out the motivation for using forbearance measures, the question that arises is whether or not new lending is subdued because capital and other resources within the bank are allocated to forborne loans. New lending mechanically increases risk weighted assets with risk weights being dependent on observed default rates of comparable loans. This explains why, after the Global Financial Crisis, commercial lending had very high-risk weights.

One could argue that these considerations only hold once the constraints become binding (low capital ratios). Thus, high-risk weighted capital ratios should allow the bank to focus on profitability. We argue that capital ratios alone are not sufficient to capture the pressure for banks to optimise their risk weighted assets. Credit risk poses a significant risk to capital levels as could be seen in the stress test results (see Figure 3.3). As the risk of a bank's loan portfolio changes over the economic cycle, seemingly prudent provisioning levels can turn out to be insufficient during an economic downturn. This uncertainty around the credit risk and its provisions casts doubt on capital levels. This effect is even more relevant if the overall quality of a bank's book is inferior.[104] A deterioration of the economic environment can potentially lead to a significant average downgrade and would increase risk weighted assets and decrease capital. Therefore, the Texas Ratio defined in Section 3.1.2.1 is a more informative measure taking into account the uncertainty surrounding capital levels and credit risk.

3.1.3 Forbearance Patterns

3.1.3.1 Descriptive Analysis

Before we turn to our empirical analysis, we give some insights into our loan level data described in 3.1.2.1. Table 3.1 shows a split of the sample by rating, segment, and product type. Starting with rating, we observe not just a high share of defaulted loans (32.3% weighted by outstanding balance) but also a significant share of loans in the riskiest category (26.1% weighted by outstanding balance). This supports the hypothesis that a high number of NPLs

[103] See Capital Requirements Regulation Article 153 (1) for the F-IRB approach.

[104] One bank in our sample has around 50% of it's commercial loans in default throughout the sample. Accordingly, another 25% of this banks' commercial loan book is close to default.

indicates an overall stressed loan portfolio. Furthermore, only 6.4% of loans weighted by outstanding balance are in the safe category. Comparing these shares by volume and number of loans, we can see that loans in the safe category are relatively smaller whereas defaulted loans are considerably larger on average. This difference is even more evident turning to the split by segment. We can see that the largest amount outstanding is towards the SME segment but the majority of loans go to micro SMEs. Even more extreme, corporate lending makes up for 18.9% of outstanding balance but only 0.3% of loans. Finally, we look at different product types where term loans represent the largest share by volume as well as number of loans. Furthermore, we see a larger amount outstanding for this product type (120,000 € on average) which is only surpassed by the "Other" category with an average loan size of 265,000 €.[105]

Table 3.2 shows how many borrowers are affected by different forbearance measures across the whole sample. 89,255 borrowers receive any kind of measure, with the most frequent being a limit extension, followed by an interest rate change. This means that more than a third of all borrowers in our sample were granted forbearance measures. This split by the individual measures confirms what we show in Figure 3.4: limit extension is the most popular measure, followed by interest rate changes, term extensions, an amortisation stop and finally a rollover. As even the latter has been applied to 11,353 borrowers in our sample, we argue that none of the measures are negligible.

3.1.3.2 Empirical Approach

In a first step, we want to estimate the probability of any or one of the five forbearance measures indexed by i being applied for a given borrower j in the next six months with the following logit model:

$$Pr(forb_{i,j,t+1}) = \alpha + \beta_1 X_{l,t} + \beta_2 T_{k,t} + \beta_3 Rating_{l,t} * T_{k,t} + forb.\ before_{j,t} + fixed\ effects + \epsilon \quad (3.1)$$

where $X_{l,t}$ contains the time varying characteristics per loan l: rating and ln(Outstanding Balance), $T_{k,t}$ corresponds to the time varying Texas Ratio of bank k, and $forb.\ before_{j,t}$ is a dummy if borrower j received any forbearance measure before. Finally, we include various fixed effects: *loan age* fixed effects control for the influence of the loan age on the estimated probability of forbearance, *sector* × *time* fixed effects attempt to control for the macroeconomic environment, *bank* × *segment* × *product type* fixed effects control for the variation between different loan products of different sizes at a given bank, and *county* fixed effects consider geographical variation. In order to control for other bank and time varying characteristics that might correlate with the Texas Ratio, we also include *bank* × *time* fixed effects. Once we do include *bank* × *time* fixed effects the Texas Ratio drops out of the regression and we consider the differential impact of the Texas Ratio combined with borrower

[105] The significantly higher average in the "Other" category is due to large loans to corporates, such as syndicated loans.

riskiness. Given that borrowers do not leave the sample once they received a treatment, the dummy whether any loan by borrower j was modified before t, *forb. before*$_{j,t}$, tests if it is more likely for a loan to be forborne if another measure has already been granted. Contrary to forborne loans which stay in the sample, non-performing loans are excluded from the sample once default occurs. Thus, our specification does not suffer from endogeneity problems which would arise if we had NPLs on the left hand side and the Texas Ratio - including NPLs - on the right. Regarding the dependent variable, we start by testing the probability of receiving any of the five different forbearance measures: an extension in the overall credit limit or the maturity of the loan, a stop in amortisation, a change in the interest rate, or a rollover of the loan product. As a second step, we then test the specification for each measure individually in order to identify the patterns driving our results.

3.1.3.3 Results

Overall Forbearance In Table 3.3, we show the results of our logit model regressions. From column (1) to (7) we include fixed effects and lastly the forbearance before dummy up to the full specification of equation (3.1). The interpretation of the results only becomes relevant once we load in at least fixed effects controlling for the demand side (*sector* $\times$ *time*). On the other hand, the supply side fixed effects (*bank* $\times$ *time*) are important because the Texas Ratio of a bank is likely to be correlated with other time varying bank characteristics. Nonetheless, *bank* $\times$ *time* fixed effects do not allow us to make a statement about the influence of the Texas Ratio on the probability of forbearance in absolute terms but only in relative terms. Therefore, we add fixed effects in the following order in columns (2-6): *loan age*, *sector* $\times$ *time*, *bank* $\times$ *time*, *bank* $\times$ *segment* $\times$ *product type*, and *county*. In order to gauge whether risky borrowers are more or less likely to receive forbearance we have to add up the difference in probabilities for the different ratings and the differential slopes with respect to the Texas Ratio and ratings. When controlling for *loan age* and *sector* $\times$ *time* we find that for the average Texas Ratio of 105%, the probability of receiving forbearance is higher for risky borrowers than for safe borrowers. The coefficient for risky loans (having safe borrowers as the reference group) is significantly negative in column (3) but the effect is outweighed by the significantly positive interaction term for risky borrowers with the Texas Ratio (again with safe borrowers as the reference group). Therefore, we can say that a stressed borrower paired with a stressed bank has a higher probability of agreeing on forbearance than a risky borrower with a less stressed bank and a safe borrower with a stressed bank.

We present this main result in a more intuitive way in Figure 3.5, which is based on the regression in column (7) without *bank* $\times$ *time* fixed effects. In order to calculate the actual probabilities of receiving forbearance, we vary the Texas Ratio and keep all other values (e.g. segment, bank, ln(Outstanding Balance)) at mean or mode. We can see that for the average Texas Ratio of 105%, the probability of a risky loan receiving forbearance is 5 percentage

points higher than for a safe loan and at an absolute value of about 52%. For a risky loan, the difference in predicted probability is around 60 percentage points between a bank with a Texas Ratio at the 95th percentile (134%) and a bank at the 5th percentile (70%). Given the higher Texas Ratio a representative borrower of a risky loan has a 70% probability of receiving any forbearance measure within the next six months. Therefore, we show two main results. Our first result, increasing probability of receiving a forbearance measure with decreasing borrower rating, is driven by two mechanisms: first, only borrowers in need will ask for forbearance. Secondly, borrowers have an informational advantage over their lenders which they might exploit in a situation where default is unavoidable. This strategic motive can play a role if the borrower knows that the bank believes forbearance is effective and that the bank has an incentive to help because it cannot afford to let the borrower default. Our second result is the increasing probability of receiving a forbearance measure with the increasing Texas Ratio of the lender. This is in line with the incentives for constrained banks to preserve their capital ratios by forbearing loans, outlined in Section 3.1.2.2. Furthermore, we find that larger loans are more likely to receive a forbearance measure.

Turning back to Table 3.3, in column (4) we add *bank* × *time* fixed effects which are crucial to control for anything correlated with the bank's Texas Ratio. We find the interaction effect of the risky borrower's rating (with the safe rating as the reference category) and the bank's Texas Ratio to be significantly positive. In other words, for a risky borrower, the probability of receiving forbearance increases more with respect to bank level stress than for a safe borrower. One has to bear in mind that the base probability of receiving forbearance is lower but insignificant for risky borrowers as can be seen in column (4). The coefficient is significant and negative once we control for *bank* × *segment* × *product type* and *county* fixed effects. For the average value of the Texas Ratio, 105%, the coefficient on the interaction term outweighs the difference in the baseline probability. Therefore, for the average value of the Texas Ratio and above, the probability of receiving forbearance is higher for risky borrowers compared to safe borrowers. This result is robust throughout columns (4-6).

Another way of interpreting the results is to look at odds-ratios.[106] Summing up the coefficients of interest in column (7), we can say that at an average Texas Ratio of 105%, the odds of a risky loan receiving forbearance are 28.5% higher than for a safe loan, ceteris paribus. With regards to the second result we compare the odds of receiving forbearance for a risky loan with a bank at times of very low and very high values of the Texas Ratio. At the 95th percentile (Texas Ratio of 134%), the odds of receiving forbearance for a risky loan are 67% higher than at the 5th percentile (Texas Ratio of 70%), ceteris paribus. The other important factor in explaining the probability of receiving forbearance is if the loan already received another forbearance measure. The odds are 224% higher to receive forbearance if the borrower already received forbearance.

[106] As we run a logit model we look at e^{β} to get the odds-ratio.

The previously presented results are robust given the saturation with fixed effects. Furthermore, we cluster standard errors at *bank* × *time* level to tackle the problem of heteroskedasticity. Another concern could be that at high levels of the Texas Ratios, banks have an additional incentive to forbear the most important borrowers by loan size as they are concerned about the exposure at default. Although we already control for the loan size in our regression, we conduct another robustness test, shown in Table 3.11 in the Appendix, where we add a double interaction effect: ln(Outstanding Balance$_{l,t}$):Texas Ratio$_{k,t}$. We can see that the additional effect of the loan size at high Texas Ratios is not significant and that our main results hold.

We argue for the use of the Texas Ratio in Section 3.1.2.1 and use it for our regressions. Moreover, we test a range of bank level variables, such as: loan to deposits ratio, total gross loans, operating profit to average assets next to the Tier 1 and NPL[107] ratio, in order to isolate the single most important driver of forbearance. Table 3.13 shows the same regression we previously interpreted for the Texas Ratio instead of the other bank level regressors. The results suggest that the NPL ratio is the most important driver of forbearance after adding *loan age* and *sector* × *time* fixed effects. The Tier 1 capital ratio does not appear to have a significant impact when including all the other bank level characteristics (columns 1-3). We find that the results for the Texas Ratio can be confirmed for the NPL Ratio. In column (8), we add the Tier 1 ratio interacted with the borrower rating and it turns out to be insignificant. Once we include both, the interaction of the NPL Ratio and the Tier 1 Ratio with the borrower rating in column (9), it is only the NPL Ratio interaction term that remains significant. Therefore, we conclude that the level of NPLs is driving our results when we use the Texas Ratio as a measure for bank stress in determining the granting of forbearance.

Different Measures of Forbearance In Table 3.4, we look at the different forbearance measures[108] individually so that the dependent variable is equal to one if a specific forbearance measure was granted within the following 6 months. For policy makers, it is indispensable to know which measure exactly the mechanism found in our previous results.

Column (1) shows the results for any forbearance measure which can be found in column (7) of Table 3.3 in order to contrast the individual forbearance measures results. The two main results laid out in the previous section can be confirmed for Term and Limit extensions. For these two measures, the interaction term of the borrower's rating and the bank's Texas Ratio is significantly positive (with the safe rating as the base category). The baseline probability of receiving a limit extension is significantly lower for a risky borrower than for a safe borrower. This effect is outweighed by the interaction for values of the Texas Ratio of greater than 120%. One has to bear in mind that we define limit extension as a forbearance measure only for borrowers in distress (risky). A limit extension for a safe borrower is not necessarily forbearance but more likely growth financing. Therefore, the probability of receiving a limit

[107] The NPL Ratio is defined as: $\frac{\text{Non-Performing Loans (Impaired or 90 days past due)}}{\text{Total Loans}}$.
[108] See Section 3.1.2.2 for the definitions of each forbearance measure.

extension, in the sense of growth financing, is naturally higher for a safe borrower paired with a not stressed bank, than receiving a limit extension as a forbearance measure for a risky borrower paired with a similar bank. The significantly positive coefficient on the interaction term in column (5) confirms that the probability of agreeing a limit extension increases more strongly with the Texas Ratio of the bank for risky borrowers than for safe borrowers. For term extensions the argument is the same, whereas in this case the baseline coefficient in column (3) is negative but insignificant.

Turning to the other three forbearance measures, the results differ. For an amortisation stop - column (2), an interest rate change - column (4) or a rollover - column (5) we do not find a significant influence of neither the bank's nor the borrower's risk. The interaction term for rollover and amortisation stop is positive but insignificant given our very conservative standard error clustering at *bank* × *time* level. The size of the loan is the only variable with a significant coefficient. This is to say that an amortisation stop and an interest rate change is more likely for larger loans and the contrary holds for a rollover. For all the individual forbearance measures the probability of receiving it is higher if the borrower received a forbearance before.

Sequencing of forbearance measures Forbearance is not necessarily a one-off treatment and we observe that banks and borrowers often agree to more than just one measure over time. The question arises if there is an observable pattern in the sequencing of measures. Having established that there is a significant share of borrowers who received more than one forbearance measure, we complete this analysis by looking at sequences. We want to check if certain types of forbearance are typically applied first while others might be predominantly used as a "measure of last resort", after other measures were deemed insufficient. A simple descriptive analysis can be found in Table 3.5. Among all borrowers who received more than one measure, we measure how many times each forbearance type has been applied as a first, second, or third measure. The first column describes what measures were taken first, given that two or more measures were taken for a given borrower. Because a borrower can have multiple loan products, there can be more than one forbearance measure per borrower. The distribution of measures taken first resembles that of the overall distribution presented in Figure 3.4 and Table 3.2. Limit extensions are the most common, followed by an interest change, whereas a rollover is the least common measure. Furthermore, out of the 244,908 borrowers in our sample, 52,255 receive two or more forbearance measures and 33,342 receive three or more. For the distribution of the measures applied second, for all cases where there were at least two measures applied, we find that limit extensions are less often applied as a second measure compared to being employed as the first measure. All other forbearance measures are employed more frequently as a second measure than as a first measure. As for the third measure we find that the relative shares differ from those of the first and second measure. A limit extension is much less likely to be taken as a third measure compared to a first and amortisation stop and interest rate changes are more likely. To conclude, a limit

extension seems to be a measure more often applied at first, whereas interest rate changes and an amortisation stop become more important as a second and third measure.

3.1.4 Effectiveness of Forbearance

3.1.4.1 Empirical Approach

Having shown that banks under stress are more likely to forbear risky borrowers we now turn to the effectiveness of forbearance. This question is important for the overall economy as effective forbearance means lower default rates of firms and higher bank capital. Therefore, we estimate the probability of default for a given borrower with the following logit hazard model:

$$Pr(Def_{j,t}) = \alpha + \beta_1 X_{l,t} + \beta_2 F_{j,t} + \beta_3 Rating_{l,t} * F_{j,t} + \beta_4 forb.\ before_{j,t} + fixed\ effects + \epsilon \quad (3.2)$$

where $Pr(Def_{j,t})$ is the probability of default on any loan held by borrower j in different periods in the future, $X_{l,t}$ consists of the time varying characteristics of loan l: rating and ln(Outstanding Balance), $F_{j,t}$ is a dummy for (any) forbearance measure for any loan held by borrower j within the last six months, and $forb.\ before_{j,t}$ is the dummy for any previous forbearance measure towards borrower j. Again, we include *loan age*, *bank* $\times$ *time*, *bank* $\times$ *segment* $\times$ *product type*, and *county* fixed effects and we cluster standard errors at *bank* $\times$ *time* level. *Sector* $\times$ *time* fixed effects control for the macroeconomic environment in a given sector at a given point in time.

We let $Pr(Def_j)$ vary over periods in order to analyse the timing of default. Given that only forbearance measures to risky borrowers should be of concern, we look at β_3 where the $Rating_{l,t}$ is *Risky*. If forbearance was effective, this should lead to a lower probability of default of the borrower, hence β_3 would be negative for any time period. However, if forbearance is just used to conceal "short-term" threats to a bank's balance sheet, β_3 might be significant only in the short term, i.e. lowering the probability of default for short periods.

3.1.4.2 Results

The regression results of the logit model can be found in Table 3.6. We first analyse if the granting of any forbearance measure is associated with a lower probability of default in the future (infinite horizon). As the ratings are defined by the ex-ante probability of default, the increasing coefficients with riskiness across all columns are reassuring. However, even controlling for the rating, the interaction of the dummy for any forbearance with the rating is positive for all ratings when controlling at least for *loan age* and *sector* $\times$ *time*. In other words, a risky borrower who received forbearance is more likely to default than a risky borrower who did not receive forbearance. This result is robust when loading in more fixed effects.

We suggest that these results could be driven by two different mechanisms. First, a selection bias might cause a bank to choose to give forbearance to the "worst" borrowers (closest to default) within the group of risky borrowers in an attempt to prevent default where it is most likely. Secondly, borrowers might act strategically and demand forbearance knowing that they are going to default even with forbearance. The intuition is that it might be profitable for firms to keep business alive even just for a limited period of time. We cannot disentangle these two effects. However, we can conclude that they outweigh the positive impact of forbearance as a financial support for struggling borrowers in order to prevent default. Using the regression results in column (6), with all fixed effects loaded in, we find that the odds of default for a borrower having received any forbearance measure in the last six months are 20% higher than if the borrower was not treated. In column (7), we add the forbearance before dummy but we find no significant effect for this variable. Outstanding balance has a significantly positive coefficient, which means that larger loans are more likely to default. In Figure 3.6, we show our result graphically. The graph shows the probability of default for risky borrowers who received a forbearance measure and those who did not receive a measure in time t. In order to calculate the actual probabilities, we keep all variables at mean or mode and change only the dummy for any measure. If no measure was taken during the last six months, the probability of default is around 8.7%. The probability for a risky borrower who received forbearance in the last six months is significantly higher at around 9.25%. The default probabilities are significantly lower if we do not condition the results on the riskiness of the borrower. Again, it is crucial for policy makers to know which measures of forbearance are associated with a higher probability of default. In Table 3.7, we can see the results for the different measures. In column (1), we see the result for any measure as a benchmark for the results of the individual measures. All regressions control for the full set of fixed effects. The findings outlined regarding the negative impact of any measure on subsequent default are confirmed for term extensions, interest rate changes, and amortisation stops. The probability of default is higher given that a risky borrower has received these three different forbearance measures. The overall finding cannot be confirmed for limit extensions or rollovers. For these two, the coefficients are negative but insignificant. However, only a negative coefficient could be interpreted as a positive effect of this forbearance measure. Therefore, also for those measures, we cannot show that they effectively lower default rates for stressed borrowers.

In a last step, we want to analyse the timing of default. We just showed that β_3 is positive for *Rating - Risky*$_{l,t} * F_{j,t}$ which means that risky borrowers who received forbearance were subsequently more likely to default than other risky borrowers. This would be an additional loss (of the forbearance) for the bank and would not be in line with banks' profit optimizing behaviour. However, if forbearance is just used to conceal (short-term) threats to a bank's balance sheet, β_3 might be significant only in the short term, i.e. lowering the probability of

default for short periods.

Comparing Table 3.6 and Table 3.8, where the dependent variables are *Probability of default in any period in the future* and *Probability of default in the next six months* we can evaluate the effectiveness in the short and long run. Again, we focus on $Risky_{l,t} * F_{j,t}$ where we see that overall, the coefficient is significantly positive for both specifications, i.e. forbearance is associated with a higher probability of default both in the short and in the long term.

However, looking at measures individually reveals surprising results. Besides the importance for policy, we argue that the different measures also impose different risks for banks. E.g. if a banks grants a limit extension, it increases its exposure and would therefore suffer a greater loss in the case of default. On the other hand, a bank increases its risk relatively less through a small change in the interest rate or a term extension. In line with this reasoning, we find the coefficient on Limit Extension to be significantly negative in the short term in Table 3.9 while it is insignificant in the long term (Table 3.7). As Limit Extension is the most common measure of forbearance this lets us conclude that the most common form of forbearance decreases the probability of default in the short term but remains uncorrelated to default for longer horizons and is therefore not effective in ultimately preventing default. In a final specification in Table 3.12, we show the effectiveness for every period after each forbearance measure was granted for all risky borrowers. We can see that Limit Extensions are significantly negatively related with defaults up to two periods after the measure was taken while borrowers are equally as probably to default as borrowers within the same risk category thereafter. On the other hand, Amortisation Stops are always associated with higher probabilities of default at any point in the future. This could be due to a "selection bias" where this measure is only given to the riskiest borrowers among those with a "risky" rating. This reasoning is in line with our findings in section 3.1.3.3 where we highlight that Amortisation Stop is relatively more often applied as a second or third measure and could therefore be interpreted as a "measure of last resort".

3.1.5 Correlation with new Lending

3.1.5.1 Empirical Approach

Existing literature shows that when stressed banks keep relationships with risky borrowers alive, they issue significantly lower volumes of new lending compared with their peers (e.g. Caballero et al. (2008); Acharya et al. (2016b)). This literature strongly emphasises the negative real effects this behaviour can have for the economy. The presence of zombie firms was found to depress job creation, deter the entry of healthy firms, and to decrease employment and investment levels in healthy firms (Giannetti and Simonov, 2013).

The empirical evidence from this literature suggests a relationship between credit supply

and lower volumes of new credit . In Figure 3.7, we analyse seasonally adjusted[109] quarterly new lending to Irish firms. While Irish banks were under stress due to their high NPL levels, their new lending to the SME sector was subdued. Accornero et al. (2017) also find a negative relationship of outstanding loans and NPLs but show that this was due to constrained credit demand for the Italian case. In order to shed more light on this mechanism for Ireland, we look at survey data on SME credit applications during that time.[110] The dotted (dashed) line in Figure 3.7 shows the application (rejection) rate for Irish SMEs over time. The application rate for new products and thereby demand for new credit was high in 2012 and continuously dropped throughout the sample. The coincidence of the period of low new lending volumes and high credit demand suggests that the low volumes were driven by banks credit supply. The dashed line confirms the high rejection rate for new product applications around the time of low new lending volumes. In our empirical analysis, we want to see if this is correlated with forbearance patterns which might tie up capital so that supply for new loans remains suppressed.

In the following, we test this correlation of forbearance and new lending for Ireland. First, we set up buckets of borrowers, b, by *bank*, *segment*, *time*, and *county* because we suggest that lending decisions are made separately for these groups. Then, we estimate the following OLS regression:

$$Share(New\ Lending)_{b,t} = \alpha + Share(Forbearance)_{b,t-1} + fixed\ effects + \epsilon \tag{3.3}$$

where $Share(New\ Lending)_{b,t}$ is the sum of lending to new borrowers over the total lending in bucket b in time t and $Share(Forbearance)_{b,t-1}$ is the sum of loans to forborne borrowers over the total lending in $t-1$ in bucket b. Again, we add fixed effects to control for the macroeconomic environment (*county* $\times$ *time*) and variation between banks (*bank*), and between banks over time (*bank* $\times$ *time*).

3.1.5.2 Results

The results in Table 3.10 confirm a negative correlation between forbearance and new lending in the same bucket and across all specifications. This means that the higher the share of forbearance within a certain segment and county by a specific bank, the lower the share of new loans. This result holds when saturating the regression with fixed effects (see columns 1-4). In terms of magnitude, a 1% higher share of forborne loans is correlated with a 0.076% lower share of new lending, as can be seen in our most conservative specification in column (4).

[109] New lending exhibits significant seasonality, which we treat using the X13-ARIMA-SEATS procedure.

[110] We obtain these data from the RedC Reports on SME lending provided by the Department of Finance of Ireland. As SMEs are by far the largest borrower group, we argue that it is representative to look at this group in order to get an overview of the lending market.

We test the robustness of this result in two ways: first, we use contemporaneous new lending in column (5). As our unit of time is relatively large (six months) the decision to "substitute" new lending with forbearance could happen within the same time period. Second, instead of using the share of new lending and forbearance, we use the natural logarithm of new lending and forbearance instead of shares in column (6). However, for both robustness checks, results remain highly significant even in our most conservative specification. Combining this with our previous results and the literature we can suggest that forbearance - which occurs mostly for risky borrowers - is a trade-off for new loans, which are potentially safer.

3.1.6 Conclusion

In this paper, we analysed the forbearance patterns of stressed banks in the post-crisis period. More specifically, our analysis presents five measures: an extension in the credit limit or maturity, a pause in amortisation, a comparably lower interest rate change, and a rollover of a loan product. We find that risky borrowers are more likely to receive a limit or maturity extension when banks are facing high levels of NPLs relative to their capitalisation and provisions. As a second step, we evaluate the effectiveness of this practice. Using a logit-hazard model, we find that a limit extension is effective in reducing the probability of default up to one year. For longer horizons and other forbearance measures we find a higher probability of default of the risky borrower. While we cannot conclude that the forbearance measures themselves caused defaults, we argue that credit might have been misallocated to the weakest borrowers which were subsequently not "rescued" from default. In the last part of our empirical analysis, we show that banks with a high share of forborne loans issue lower volumes of new credit. This could result in tighter financial conditions for new firms who might potentially be more productive.

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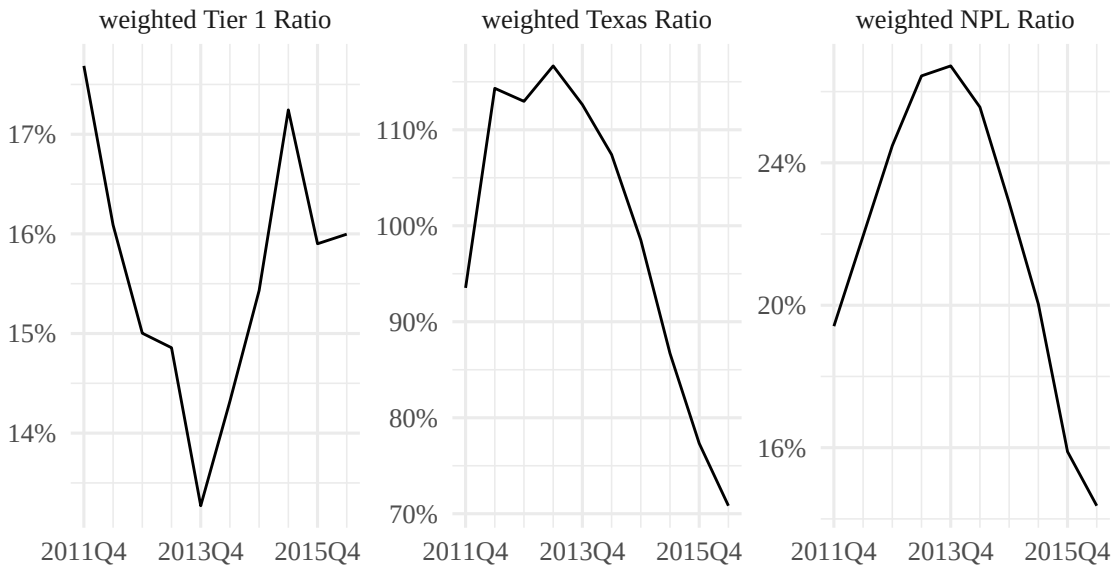
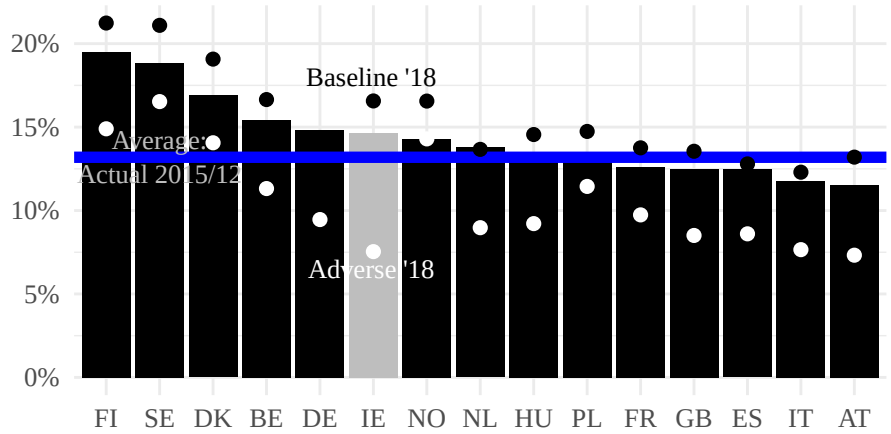
3.1.7 Figures

Figure 3.1: Weighted Tier 1 Capital Ratio and Texas Ratio of Irish Banks



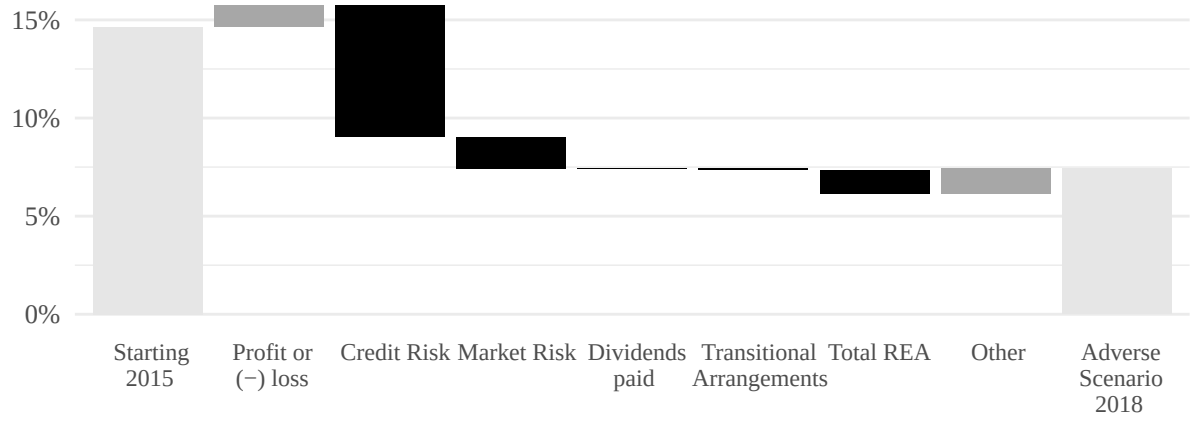
Weighted by Total Assets of respective bank.
Source: Author's calculations; Data: SnL

Figure 3.2: Tier 1 Ratio under different Scenarios



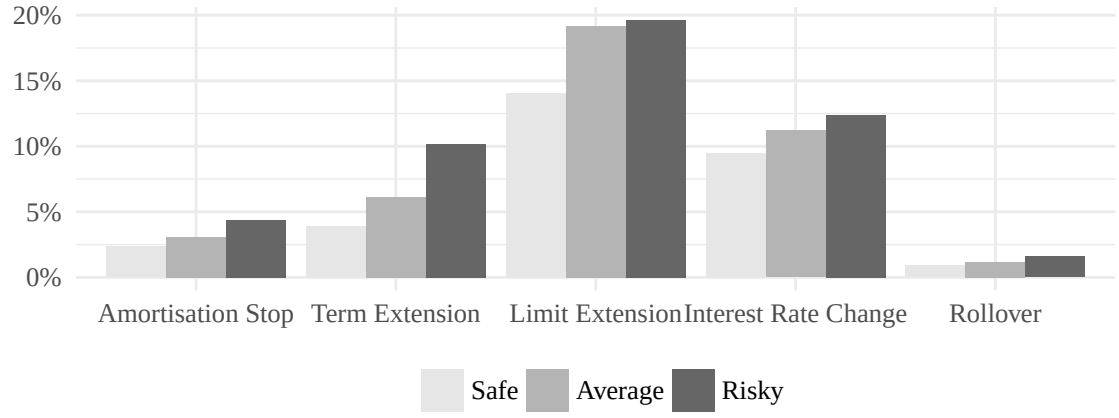
The y-axis measures the Tier 1 Ratios for banks residing in the respective countries under different scenarios. The black (white) dot represents the Tier 1 Ratio under the baseline (adverse) scenario in 2018. The blue line shows the European average.
Source: Author's calculations; Data: EBA (2016a)

Figure 3.3: Drivers of Changes in the Tier 1 Capital (different Scenarios)



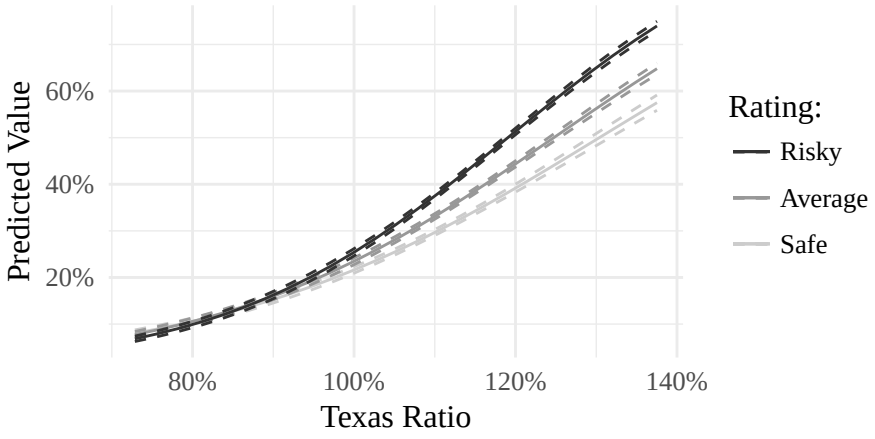
Credit Risk refers to: Impairment or (-) reversal of impairment on financial assets. Profit or (-) loss refers to: profit or (-) loss before tax from continuing operations before credit risk and market risk losses.
Source: Author's calculations; Data: EBA (2016a)

Figure 3.4: Frequency Forbearance Measures



Forbearance measures taken by borrower classification [% of loans per risk class and forbearance measure].

Figure 3.5: Predicted Probability of any Forbearance Measures



Predicted probability of any measure taken by borrower rating class and Texas Ratio. All other variables at mean or mode.

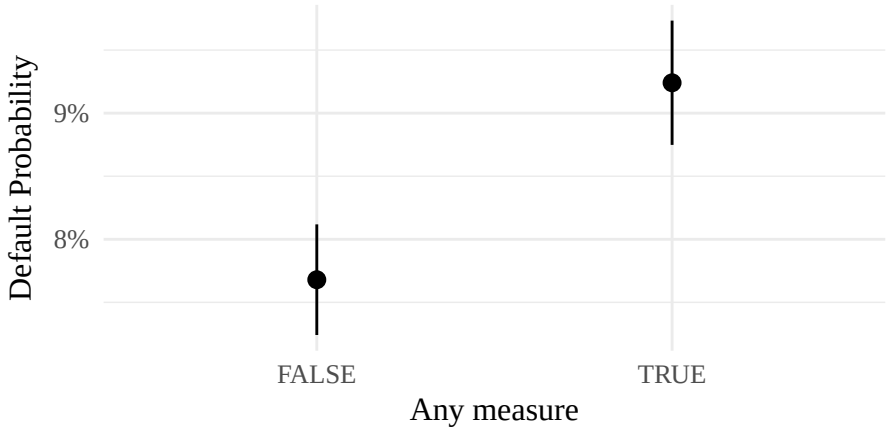


Figure 3.6: Probability of Default - risky Loans

Predicted probability of default for a risky loan, depending on any measure being taken. All other variables at mean or mode.
Source: Author's Calculations; Data: CBI

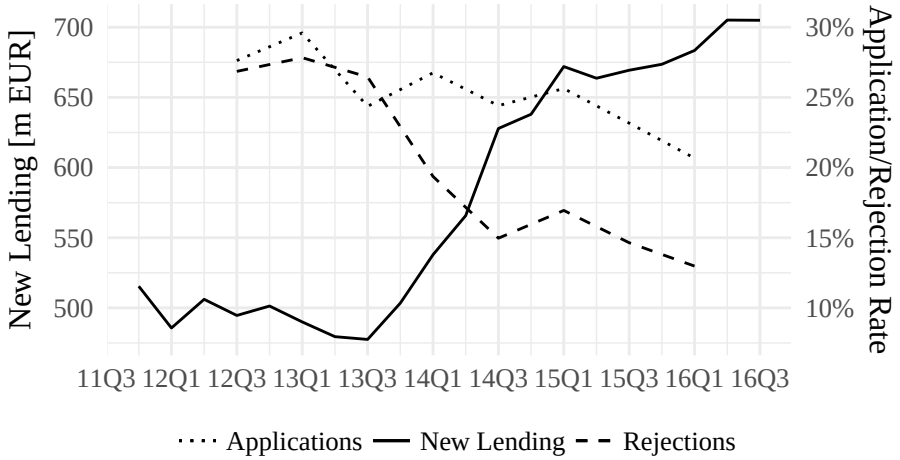


Figure 3.7: New Lending

The left y-axis shows the quarterly new lending to Irish SMEs (seasonally adjusted in m EUR). *Source: Author's Calculations; Data: CBI*
The right y-axis shows application rate for new products (% of firms) and rejection rate for new products (% of applications) for Irish SMEs. *Data: RED-C SME Market Report*

3.1.8 Tables

Table 3.1: Summary statistics by Segment, Rating, and Product Type

Split by:	Sample share by outstanding balance	Sample share by number of loans
Rating		
Safe	6.4%	8.7%
Average	35.2%	40.0%
Risky	26.1%	32.5%
Default	32.3%	18.9%
Segment		
Corporate	18.9%	0.3%
SME	61.6%	30.7%
Micro SME	19.4%	69.0%
Product Type		
Term Loan	81.8%	49.6%
Overdraft	6.9%	34.3%
Leasing/Hire Purchase	4.6%	14.3%
Other	6.7%	1.7%

Note: Ratings are based on underlying ex-ante probabilities of default for individual loans, segments relate to the size of the firm, and product type describes the type of loan held by the borrower. These summary statistics are averages over 1,686,325 observations (loan × time) held by 244,908 borrowers in our sample.

Table 3.2: Number of Borrowers who received Forbearance Measures

	Number of borrowers
Rollover	11,353
Amortisation Stop	14,087
Term Extension	17,377
Interest Rate Change	27,837
Limit Extension	69,209
Any measure	89,255
All borrowers	244,908

Note: The numbers presented here are across time, which means that borrowers can obtain more than one measure.

Table 3.3: Probability any Forbearance Measure

	Dependent variable:						
	Any measure$_j$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rating - Average$_l$	−0.152	−0.136	−0.202	0.029	−0.153	−0.162	−0.094
	(0.296)	(0.295)	(0.237)	(0.120)	(0.113)	(0.112)	(0.172)
Rating - Risky$_l$	−0.843	−0.856	−0.887***	−0.408	−0.565**	−0.578**	−0.589**
	(0.585)	(0.589)	(0.338)	(0.268)	(0.263)	(0.263)	(0.273)
ln(Outstanding Balance$_l$)	0.218***	0.213***	0.207***	0.212***	0.132***	0.130***	0.096***
	(0.012)	(0.012)	(0.013)	(0.013)	(0.009)	(0.008)	(0.009)
Texas Ratio$_k$	−0.014	−0.014	−0.052*				
	(0.009)	(0.009)	(0.027)				
Rating - Average$_l$:Texas Ratio$_k$	0.009	0.009	0.012***	0.001	0.003**	0.003**	0.002
	(0.008)	(0.008)	(0.004)	(0.001)	(0.001)	(0.001)	(0.002)
Rating - Risky$_l$:Texas Ratio$_k$	0.014	0.014	0.017***	0.006*	0.008***	0.008***	0.008**
	(0.009)	(0.009)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
Loans/Deposits$_k$	0.016	0.017	−0.019				
	(0.021)	(0.021)	(0.014)				
Rating - Average$_l$:Loans/Deposits$_k$	−0.011	−0.012	0.006				
	(0.019)	(0.019)	(0.008)				
Rating - Risky$_l$:Loans/Deposits$_k$	−0.022	−0.022	−0.004				
	(0.020)	(0.020)	(0.009)				
ln(Gross Loans$_k$)	1.655	1.773	0.126				
	(1.895)	(1.899)	(1.515)				
Rating - Average$_l$:ln(Gross Loans$_k$)	−1.247	−1.351	−1.803*				
	(1.731)	(1.735)	(1.031)				
Rating - Risky$_l$:ln(Gross Loans$_k$)	−2.099	−2.246	−2.222**				
	(1.787)	(1.798)	(1.107)				
Op. Profit/Avg. Assets$_k$	0.404	0.412	1.509**				
	(0.272)	(0.270)	(0.719)				
Rating - Average$_l$:Op. Profit/Avg. Assets$_k$	−0.186	−0.194	0.028				
	(0.224)	(0.224)	(0.094)				
Rating - Risky$_l$:Op. Profit/Avg. Assets$_k$	−0.473*	−0.490*	−0.178				
	(0.263)	(0.264)	(0.118)				
Forbearance Before$_j$							1.178***
							(0.098)
Fixed Effects:							
Loan age		Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time			Yes	Yes	Yes	Yes	Yes
Bank x Time				Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type					Yes	Yes	Yes
County						Yes	Yes
Observations	1,393,284	1,393,284	1,393,284	1,393,284	1,393,284	1,393,284	1,324,317

*Note: Logit Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of receiving forbearance in $t+1$ whereas the independent variables are measured in t. A Texas Ratio of 100% corresponds to a value of 100 in the regression. We split the borrowers in Safe, Average and Risky based on their ex-ante probability of default. Forbearance Before is a dummy which is one if a borrower has ever received forberance before $t+1$. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.4: Probabilities of different Forbearance Measures

	Dependent variable:					
Measure$_i$:	Any measure$_j$	Amortisation Stop$_j$	Term Extension$_j$	Interest Rate Change$_j$	Limit Extension$_j$	Rollover$_j$
	(1)	(2)	(3)	(4)	(5)	(6)
Rating Average$_l$	−0.094	0.099	−0.614	0.050	−0.184*	−0.445
	(0.172)	(0.665)	(0.473)	(0.193)	(0.103)	(0.386)
Rating Risky$_l$	−0.589**	0.851	−0.512	0.073	−0.483**	−0.102
	(0.273)	(0.592)	(0.470)	(0.331)	(0.225)	(0.441)
ln(Outstanding Balance$_l$)	0.096***	0.030*	0.029	0.240***	0.008	−0.112***
	(0.009)	(0.015)	(0.021)	(0.025)	(0.008)	(0.014)
Rating Average$_l$:Texas Ratio$_k$	0.002	0.001	0.009**	−0.001	0.003***	0.001
	(0.002)	(0.006)	(0.005)	(0.002)	(0.001)	(0.004)
Rating Risky$_l$:Texas Ratio$_k$	0.008**	0.0005	0.014***	−0.002	0.004*	0.0005
	(0.003)	(0.006)	(0.005)	(0.004)	(0.002)	(0.005)
Forbearance Before$_j$	1.178***	1.184***	0.676***	1.667***	0.728***	0.291***
	(0.098)	(0.186)	(0.146)	(0.226)	(0.085)	(0.111)
Fixed Effects:						
Loan age	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type	Yes	Yes	Yes	Yes	Yes	Yes
County	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,324,317	1,321,654	972,779	1,304,003	1,181,047	1,285,117

*Note: Logit Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of receiving a specific forbearance measure i in $t+1$ whereas the independent variables are measured in t. A Texas Ratio of 100% corresponds to a value of 100 in the regression. We split the borrowers in Safe, Average and Risky based on their ex-ante probability of default. Forbearance Before is a dummy which is one if a borrower has ever received forbearance before $t+1$. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.5: Number of Occurrence of each Measure granted in a Sequence of Measures

	First Measure of 2 or more		Second Measure of 2 or more		Third Measure of 3 or more	
Term Extension	5,370	8.6%	6,506	10.4%	3,598	8.8%
Limit Extension	34,201	55.1%	32,109	51.1%	19,860	48.6%
Interest Rate Change	14,271	23.0%	15,119	24.1%	11,186	27.4%
Amortisation Stop	5,102	8.2%	5,687	9.0%	4,341	10.6%
Rollover	3,179	5.1%	3,438	5.5%	1,840	4.5%
Total number of borrowers	52,255		52,255		33,342	

Note: Among all borrowers who received more than one measure, we measure how many times each forbearance type has been applied as a first, second, or a third measure.

Table 3.6: Probability of Default (any Forbearance Measure)

	Dependent variable:						
	Probability of Default$_j$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rating Average$_l$	1.199***	1.204***	1.370***	1.380***	1.280***	1.281***	1.281***
	(0.181)	(0.185)	(0.111)	(0.116)	(0.118)	(0.118)	(0.118)
Rating Risky$_l$	2.895***	2.898***	3.001***	3.061***	3.010***	3.010***	3.010***
	(0.291)	(0.286)	(0.151)	(0.152)	(0.155)	(0.155)	(0.154)
ln(Outstanding Balance)$_l$	0.131***	0.132***	0.102***	0.100***	0.127***	0.128***	0.127***
	(0.026)	(0.026)	(0.026)	(0.026)	(0.019)	(0.019)	(0.018)
Rating Safe$_l$:Any Measure$_j$	−0.061	−0.021	0.378**	0.409**	0.397**	0.400**	0.387**
	(0.450)	(0.450)	(0.172)	(0.164)	(0.189)	(0.188)	(0.178)
Rating Average$_l$:Any Measure$_j$	−0.274	−0.244	0.151*	0.176**	0.225***	0.231***	0.217***
	(0.254)	(0.254)	(0.081)	(0.076)	(0.077)	(0.076)	(0.079)
Rating Risky$_l$:Any Measure$_j$	−0.234	−0.210	0.190***	0.169***	0.192***	0.197***	0.184***
	(0.176)	(0.171)	(0.054)	(0.047)	(0.034)	(0.033)	(0.035)
Forbearance Before$_j$							0.019
							(0.031)
Fixed Effects:							
Loan age		Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time			Yes	Yes	Yes	Yes	Yes
Bank x Time				Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type					Yes	Yes	Yes
County						Yes	Yes
Observations	1,563,456	1,563,456	1,563,456	1,563,456	1,563,456	1,563,456	1,563,456

*Note: Logit Hazard Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of default of any loan held by borrower j in any period in the future whereas the independent variables are measured in t. We split the borrowers in Safe, Average, and Risky based on their ex-ante probability of default. Forbearance Before is a dummy which is one if a borrower has ever received forbearance before t. The loan exits the sample once a default occurs. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.7: Probability of Default (different Forbearance Measures)

	Dependent variable:					
	Probability of Default$_j$					
Measure$_i$:	Any Measure$_j$	Term Extension$_j$	Interest Rate Change$_j$	Limit Extension$_j$	Rollover$_j$	Amortisation Stop$_j$
	(1)	(2)	(3)	(4)	(5)	(6)
Rating Average$_l$	1.281***	1.298***	1.294***	1.312***	1.271***	1.235***
	(0.118)	(0.068)	(0.079)	(0.063)	(0.074)	(0.080)
Rating Risky$_l$	3.010***	3.195***	3.140***	3.161***	3.067***	2.921***
	(0.155)	(0.072)	(0.071)	(0.062)	(0.064)	(0.090)
ln(Outstanding Balance$_l$)	0.128***	0.099***	0.144***	0.126***	0.126***	0.131***
	(0.019)	(0.020)	(0.020)	(0.017)	(0.017)	(0.020)
Rating Safe$_l$:Measure$_i$	0.400**	0.462***	1.535***	0.400***	0.419***	0.402*
	(0.188)	(0.157)	(0.176)	(0.102)	(0.087)	(0.229)
Rating Average$_l$:Measure$_i$	0.231***	0.344***	1.085***	0.231***	0.237**	0.517***
	(0.076)	(0.126)	(0.116)	(0.086)	(0.116)	(0.109)
Rating Risky$_l$:Measure$_i$	0.197***	0.744***	0.266***	−0.015	−0.038	0.326***
	(0.033)	(0.062)	(0.073)	(0.051)	(0.034)	(0.056)
Fixed Effects:						
Loan age	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type	Yes	Yes	Yes	Yes	Yes	Yes
County	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,563,456	956,718	1,326,984	1,304,332	1,304,332	1,561,260

*Note: Logit Hazard Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of default of any loan held by borrower j in any period in the future whereas the independent variables are measured in t. We split the borrowers in Safe, Average, and Risky based on their ex-ante probability of default. Measure on loan l is specified by the heading of each column. The loan exits the sample once a default occurs. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.8: Probability of Default in next Period (any Forbearance Measure)

	Dependent variable:						
	Probability of Default$_{t+1,j}$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rating Average$_l$	0.926***	0.940***	1.026***	1.033***	0.980***	0.981***	0.980***
	(0.208)	(0.212)	(0.192)	(0.198)	(0.197)	(0.196)	(0.196)
Rating Risky$_l$	3.268***	3.267***	3.279***	3.322***	3.295***	3.294***	3.293***
	(0.353)	(0.353)	(0.316)	(0.326)	(0.325)	(0.325)	(0.325)
ln(Outstanding Balance)$_l$	0.015	0.018	0.003	0.003	0.011	0.012	0.011
	(0.022)	(0.021)	(0.022)	(0.022)	(0.017)	(0.017)	(0.016)
Rating Safe$_l$:Any Measure$_j$	0.145	0.203	0.333	0.323	0.256	0.261	0.214
	(0.419)	(0.429)	(0.351)	(0.355)	(0.370)	(0.369)	(0.352)
Rating Average$_l$:Any Measure$_j$	−0.219	0.258	0.450***	0.446**	0.441***	0.446***	0.401***
	(0.226)	(0.231)	(0.173)	(0.176)	(0.166)	(0.165)	(0.149)
Rating Risky$_l$:Any Measure$_j$	0.091	0.128	0.307***	0.283***	0.274***	0.281***	0.234***
	(0.125)	(0.124)	(0.101)	(0.104)	(0.077)	(0.077)	(0.073)
Forbearance Before$_j$							0.069
							(0.066)
Fixed Effects:							
Loan age		Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time			Yes	Yes	Yes	Yes	Yes
Bank x Time				Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type					Yes	Yes	Yes
County						Yes	Yes
Observations	1,292,685	1,292,685	1,292,685	1,292,685	1,292,685	1,292,685	1,292,685

*Note: Logit Hazard Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of default of any loan held by borrower j in any period in the future whereas the independent variables are measured in t. We split the borrowers in Safe, Average, and Risky based on their ex-ante probability of default. Forbearance Before is a dummy which is one if a borrower has ever received forbearance before t. The loan exits the sample once a default occurs. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.9: Probability of Default in next Period (different Forbearance Measures)

	Dependent variable:					
	Probability of Default$_{t+1,j}$					
Measure$_i$:	Any Measure$_j$	Term Extension$_j$	Interest Rate Change$_j$	Limit Extension$_j$	Rollover$_j$	Amortisation Stop$_j$
	(1)	(2)	(3)	(4)	(5)	(6)
Rating Average$_l$	0.981***	1.209***	1.153***	1.151***	1.157***	1.053***
	(0.196)	(0.130)	(0.152)	(0.119)	(0.142)	(0.184)
Rating Risky$_l$	3.294***	3.655***	3.642***	3.638***	3.536***	3.242***
	(0.325)	(0.153)	(0.172)	(0.133)	(0.152)	(0.253)
ln(Outstanding Balance$_l$)	0.012	−0.023**	0.029*	−0.001	−0.001	0.015
	(0.017)	(0.011)	(0.017)	(0.009)	(0.009)	(0.018)
Rating Safe$_l$:Measure$_i$	0.261	1.793***	0.414***	0.290	0.250	1.006*
	(0.369)	(0.324)	(0.099)	(0.205)	(0.528)	(0.539)
Rating Average$_l$:Measure$_i$	0.446***	1.319***	0.444***	0.335*	0.708**	0.762***
	(0.165)	(0.246)	(0.161)	(0.186)	(0.335)	(0.220)
Rating Risky$_l$:Measure$_i$	0.281***	0.114	−0.005	−0.251***	0.077	1.166***
	(0.077)	(0.130)	(0.062)	(0.076)	(0.125)	(0.092)
Fixed Effects:						
Loan age	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type	Yes	Yes	Yes	Yes	Yes	Yes
County	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,292,685	799,152	1,109,815	1,100,091	1,100,091	1,291,121

*Note: Logit Hazard Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of default of any loan held by borrower j in any period in the future whereas the independent variables are measured in t. We split the borrowers in Safe, Average, and Risky based on their ex-ante probability of default. Measure on loan l is specified by the heading of each column. The loan exits the sample once a default occurs. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.10: OLS regression: Forbearance and new Lending by Borrower Buckets

	Dependent variable:					
	Share(New Lending$_t$)					ln(New Lending$_t$)
	(1)	(2)	(3)	(4)	(5)	(6)
Share(Forbearance)$_{t-1}$	-0.034^{***}	-0.053^{***}	-0.066^{***}	-0.076^{***}		
	(0.007)	(0.007)	(0.007)	(0.008)		
Share(Forbearance)$_t$					-0.045^{***}	
					(0.011)	
ln(Forbearance)$_t$						-0.160***
						(0.042)
Fixed Effects:						
Bank		Yes	Yes			
County x Time			Yes	Yes	Yes	Yes
Bank x Time				Yes	Yes	Yes
Observations	754	754	754	754	873	872
R^2	0.033	0.136	0.383	0.419	0.290	0.597
Adjusted R^2	0.032	0.134	0.144	0.185	0.011	0.438

*Note: OLS Regressions saturated with fixed effects. The dependent variable is the volume-weighted share of new lending (1)-(5) or the ln of new lending (6) per bucket of borrowers within a bank, segment, and county. The independent variable is the volume-weighted share of forborne loans in $t-1$ or t (first two lines) or the ln of the sum of forborne loans in t (last line). Significance levels: *p<0.1; **p<0.05; ***p<0.01*

3.1.9 Appendix

Additional Tables

Table 3.11: Robustness: Additional double Interaction Term Texas Ratio × Outstanding Balance

	Dependent variable:						
	Any Measure$_j$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rating Average$_l$	−0.149	−0.132	−0.199	0.031	−0.149	−0.158	−0.088
	(0.299)	(0.298)	(0.241)	(0.124)	(0.115)	(0.115)	(0.173)
Rating Risky$_l$	−0.845	−0.857	−0.888***	−0.409	−0.565**	−0.579**	−0.597**
	(0.587)	(0.590)	(0.339)	(0.271)	(0.263)	(0.264)	(0.275)
ln(Out. Bal.$_l$)	0.271**	0.264**	0.261**	0.244**	0.180**	0.178**	0.185**
	(0.105)	(0.107)	(0.108)	(0.109)	(0.083)	(0.083)	(0.086)
ln(Out. Bal.$_l$):Texas Ratio$_k$	−0.001	−0.001	−0.001	−0.0003	−0.0005	−0.0005	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Rating Average$_l$:Texas Ratio$_k$	0.003	0.003	0.003	0.001	0.003**	0.003**	0.002
	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)
Rating Risky$_l$:Texas Ratio$_k$	0.009	0.009	0.011***	0.006*	0.008***	0.008***	0.008**
	(0.006)	(0.006)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Forbearance Before$_k$							1.179***
							(0.098)
Fixed Effects:							
Loan age		Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time			Yes	Yes	Yes	Yes	Yes
Bank x Time				Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type					Yes	Yes	Yes
County						Yes	Yes
Observations	1,393,284	1,393,284	1,393,284	1,393,284	1,393,284	1,393,284	1,324,317

*Note: Logit Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of receiving forbearance in $t+1$ whereas the independent variables are measured in t. A Texas Ratio of 100% corresponds to a value of 100 in the regression. We split the borrowers in Safe, Average and Risky based on their ex-ante probability of default. Forbearance Before is a dummy which is one if a borrower has ever received forbearance before $t+1$. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.12: Probability of Default in one to six periods ahead for any loan by borrower - Influence of different measures taken by borrower

	Dependent variable: Probability of Default$_j$					
Time:	t+1	t+2	t+3	t+4	t+5	t+6
	(1)	(2)	(3)	(4)	(5)	(6)
Rating - Risky$_l$:Any measure$_j$	0.281***	0.246***	0.269***	0.273***	0.274***	0.284***
	(0.077)	(0.050)	(0.043)	(0.040)	(0.039)	(0.020)
Observations	1,292,685	1,082,965	888,638	721,261	556,138	407,507
Rating - Risky$_l$:Term extension$_j$	0.114	0.218**	0.212***	0.202***	0.196***	0.233***
	(0.130)	(0.090)	(0.073)	(0.060)	(0.057)	(0.038)
Observations	799,152	657,785	526,096	410,257	296,674	194,008
Rating - Risky$_l$:Interest rate change$_j$	−0.005	−0.013	0.052	0.057	0.150***	0.148***
	(0.062)	(0.054)	(0.048)	(0.061)	(0.051)	(0.011)
Observations	1,109,815	919,948	741,435	586,613	432,833	294,974
Rating - Risky$_l$:Limit extension$_j$	−0.251***	−0.133***	−0.050	−0.049	−0.031	−0.041
	(0.076)	(0.050)	(0.042)	(0.044)	(0.036)	(0.052)
Observations	1,100,091	915,549	740,629	587,655	435,649	298,885
Rating - Risky$_l$:Rollover$_j$	0.077	0.329***	0.434***	0.493***	0.491***	0.417***
	(0.125)	(0.062)	(0.047)	(0.041)	(0.044)	(0.089)
Observations	1,100,091	915,549	740,629	587,655	435,649	298,885
Rating - Risky$_l$:Amortisation Stop$_j$	1.166***	1.019***	0.911***	0.858***	0.771***	0.674***
	(0.092)	(0.082)	(0.077)	(0.075)	(0.068)	(0.072)
Observations	1,291,121	1,081,726	887,638	720,434	555,471	406,982
Fixed Effects:						
Loan age	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Segment x Product Type	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes

*Note: Logit Hazard Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of default of any loan held by borrower j in one to six periods in the future whereas the independent variables are measured in t. We split the borrowers in Safe, Average, and Risky based on their ex-ante probability of default. The loan exits the sample once a default occurs. Significance levels: *p<0.1; **p<0.05; ***p<0.01*

Table 3.13: Probability of application of any forbearance measure - NPL Ratio and Tier 1 Ratio

	Dependent variable: Any measure$_j$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Rating Average$_l$	−0.150	−0.134	−0.138	0.032	−0.051	−0.055	−0.036	0.136	−0.828*
	(0.218)	(0.220)	(0.177)	(0.076)	(0.060)	(0.059)	(0.100)	(0.427)	(0.435)
Rating Risky$_l$	−0.829***	−0.844***	−0.568***	−0.400***	−0.400***	−0.412***	−0.344**	0.219	−0.875*
	(0.309)	(0.311)	(0.198)	(0.124)	(0.109)	(0.108)	(0.149)	(0.563)	(0.466)
ln(Outstanding Balance$_l$)	0.219***	0.214***	0.208***	0.213***	0.133***	0.132***	0.098***	0.096***	0.098***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)
NPL Ratio$_k$	−0.029	−0.030*	−0.048***						
	(0.018)	(0.018)	(0.018)						
Rating Average$_l$:NPL Ratio$_k$	0.017	0.019	0.017**	0.002	0.006**	0.006**	0.004		0.008***
	(0.013)	(0.013)	(0.007)	(0.003)	(0.003)	(0.002)	(0.003)		(0.003)
Rating Risky$_l$:NPL Ratio$_k$	0.030**	0.032**	0.028***	0.020***	0.022***	0.023***	0.019***		0.024***
	(0.014)	(0.014)	(0.008)	(0.005)	(0.005)	(0.005)	(0.006)		(0.006)
Tier 1 Ratio$_k$	−0.030	−0.029	0.161						
	(0.041)	(0.041)	(0.111)						
Rating Average$_l$:Tier 1 Ratio$_k$	0.040	0.041	0.023					−0.001	0.041*
	(0.034)	(0.035)	(0.027)					(0.026)	(0.024)
Rating Risky$_l$:Tier 1 Ratio$_k$	0.067*	0.067*	0.041					−0.003	0.023
	(0.039)	(0.040)	(0.031)					(0.034)	(0.027)
ln(Gross Loans$_k$)	1.338	1.475	0.264						
	(1.589)	(1.598)	(1.110)						
Rating - Average$_l$:ln(Gross Loans$_k$)	−1.004	−1.116	−1.166						
	(1.472)	(1.479)	(0.870)						
Rating - Risky$_l$:ln(Gross Loans$_k$)	−1.677	−1.828	−1.392						
	(1.459)	(1.470)	(0.864)						
Loans/Deposits$_k$	0.002	0.001	−0.039**						
	(0.026)	(0.026)	(0.015)						
Rating - Average$_l$:Loans/Deposits$_k$	−0.004	−0.003	0.013						
	(0.023)	(0.023)	(0.012)						
Rating - Risky$_l$:Loans/Deposits$_k$	−0.004	−0.003	0.011						
	(0.024)	(0.024)	(0.013)						
Op. Profit/Avg. Assets$_k$	0.332	0.339	1.249**						
	(0.271)	(0.267)	(0.585)						
Rating - Average$_l$:Op. Profit/Avg. Assets$_k$	−0.179	−0.180	0.055						
	(0.198)	(0.196)	(0.096)						
Rating - Risky$_l$:Op. Profit/Avg. Assets$_k$	−0.372	−0.378	−0.082						
	(0.235)	(0.234)	(0.120)						
Forbearance Before$_j$							1.175***	1.177***	1.175***
							(0.099)	(0.098)	(0.098)
Fixed Effects:									
Loan age		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Time			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank x Time				Yes	Yes	Yes	Yes	Yes	Yes
Bank x Segment x Prod. Type					Yes	Yes	Yes	Yes	Yes
County						Yes	Yes	Yes	Yes
Observations	1,393,284	1,393,284	1,393,284	1,393,284	1,393,284	1,393,284	1,324,317	1,324,317	1,324,317

Note: Logit Regression with standard errors clustered at Bank x Time level. The dependent variable is the probability of receiving forbearance in $t+1$ whereas the independent variables are measured in t. A value of 100% of any ratio in this table corresponds to a value of 100 in the regression. We split the borrowers in Safe, Average and Risky based on their ex-ante probability of default. Forbearance Before is a dummy which is one if a borrower has ever received forbearance before $t+1$. Significance levels: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Description of variables

All of our forbearance measures are dummy variables that switch to 1 if the forbearance measure i has been applied in time t. In the following, we provide the exact definition for each measure.

Rollover A loan is considered rolled over if for a given borrower one of its significant loans disappears from the sample (expired or concordantly ended) but the borrower limit does not decrease by more than half of the expired loan's amount. This implies that limits on other products were increased or new products issued to increase the borrower limit. A loan is considered significant if it makes up for at least half of the total borrower limit.

Change in interest rate In essence, we use the definition of "zombie lending" by Caballero et al. (2008) which we extend to account for the environment of decreasing interest rates for the our sample period. Therefore, we first calculate the percentage change in the interest rate per loan across time, Δr_l followed by the average change in the interest rate for buckets, Δr_b, by: Sector, Segment, Product Type, and Rating. Next, we take the deviation of an individual loan from its bucket mean, $\Delta r_{l,b} = \Delta r_l - \Delta r_b$. Finally, we define an advantageous change in the interest if this decrease in deviation from the bucket mean is larger than that of the lowest decile of the two best rating categories, $\Delta r_{l,b} < \Delta r_{l,b} \| \textit{lowest decile of best rating categories}$.

Amortisation stop We extract this information on the basis of the banks' reports whether a loan is amortising or not. Therefore, this dummy variable is 1 if a loan switches from amortising to non amortising and 0 otherwise.

Limit extension This dummy variable is 1 if we observe an increase in the borrower's total limit (sum of all loans).

Term extension This variable is defined by whether we see a positive change of the maturity of a loan product.

Overall forbearance dummy The overall forbearance dummy switches to 1 if any loan of a borrower received any of the these forbearance measures in a given period.

Abbreviations

EBA	European Banking Authority
F-IRB	Foundation-Internal Ratings Based
IFRS	International Financial Reporting Standards
IMF	International Monetary Fund
NPL	Non-performing Loans
OMT	Outright Monetary Transactions
REA	Risk Exposure Amount
SME	Small Medium Enterprise

3.2 The Anatomy of the Transmission of Macroprudential Policy [111]

3.2.1 Introduction

Policymakers have recently proposed, designed, and implemented macroprudential policies to limit household leverage so as to slow down the feedback loop between credit and house prices and preserve financial stability. The rationale for these interventions, adopted by 41 countries between 2000 and 2013, is based on the observation that build-ups of household leverage have historically led to busts, accompanied by lower output growth and higher unemployment (Mian et al., 2017).

In this paper, we analyze the impact on bank lending and risk-taking of most widely used type of macroprudential regulations, namely, policies that limit household leverage in the residential mortgage market. In particular, we study the introduction in 2015 of loan-to-value (LTV) and loan-to-income (LTI) limits for residential mortgages issued by Irish banks.[112] Ireland offers a prime laboratory setting for our inquiry because it recently experienced a dramatic boom-bust cycle: The household debt-to-GDP ratio almost doubled (from 55% to 101%) from 2002 to 2007, followed by a collapse in GDP growth (-10%) and a jump in the unemployment rate (+8%) over the next three years. In this context, we collect data on loan-level residential mortgages, county-level house prices, loan-level bank credit to firms, and bank security-level holdings.

We examine microscopically how macroprudential policies transmit to the banking sector. We document that, whereas the lending limits affect 43% of the residential mortgage market, mortgage issuance keeps growing after the policy introduction as the market "moves" to conform with the newly imposed limits. Our analysis of this reallocation provides three main findings: (i) In response to the policy, banks reallocate credit from low- to high-income borrowers and from counties where borrowers are close to the lending limits to counties where borrowers are more distant from the lending limits; (ii) this bank mortgage credit reallocation is effective in slowing down house price growth in "hot" housing markets; however, (iii) banks try to maintain a stable risk exposure by increasing their risk-taking in asset classes not targeted by the regulation, such as credit to firms and holdings of securities, and reallocating mortgage credit to borrowers more likely to default during real estate busts.

Next, we describe these results in detail. First, we show that the lending limits affect a large part of the market, because 43% of the mortgage issuance in the year before the policy

[111] Co-authored with Viral Acharya (New York University and Reserve Bank of India), Matteo Crosignani (Michigan Ross), Tim Eisert (Erasmus University Rotterdam), and Fergal McCann (Central Bank of Ireland). This paper is currently under review at the American Economic Review.

[112] Cerutti et al. (2015) collected data from 2000 to 2013 on 119 countries, 107 of which have implemented at least one type of macroprudential regulation. Limits on LTV and LTI are the most widely used tool, adopted by 34 and 27 countries, respectively.

would have been affected if the rules had been in place during this period. Nevertheless, originations seem almost unaffected by the policy in the aggregate, because the increase in "conforming" issuance offsets the collapse in the issuance of those mortgages that exceed the newly imposed limits. Not everyone is, however, affected in the same way. In the cross-section of counties, urban counties that experienced a high house price appreciation before the policy are closer to lending limits ("low-distance" counties) than rural counties with modest pre-policy house price appreciation ("high-distance" counties). In the cross-section of borrowers, high-income borrowers are more distant from the limits than low-income borrowers. We show that residential mortgage issuance moves from low- to high-income borrowers and from low- to high-distance counties after the policy. In particular, high-income borrowers obtain larger loans and increase their leverage.

We show that active bank portfolio choice drives this credit reallocation. We exploit *bank-level* heterogeneity by calculating the share of bank mortgage issuance that would have been affected if the rules had been in place in the year before the policy. After confirming that more-exposed banks drive the aggregate reallocation, we find that more-exposed banks reduce their mortgage issuance to borrowers in the bottom quintile of the income distribution by 10% and increase their issuance to borrowers in the top quintile by 15%, controlling with fixed effects for local economic conditions and credit demand. More-exposed banks reduce mortgage rates more than less-exposed banks, inducing high-income borrowers to take out larger loans and increase their leverage.

Second, we show that the evolution of house prices is consistent with the observed credit reallocation. House price growth, around 14% year-on-year (YoY) and rapidly increasing at the time of the policy announcement, decreased and stabilized below 10% post-regulation. This evolution is driven by low-distance counties where house price growth, well above 20% YoY and rapidly increasing at the time of announcement, collapsed to reach around 4% post-regulation. The evolution of house prices is also consistent with the credit reallocation across the income distribution, because the differential evolution of house price growth across counties is more pronounced for larger properties, usually purchased by high-income borrowers.

Third, we show that banks try to maintain stable risk exposure by analyzing banks' holdings of securities, credit to firms, and residential mortgage credit, capturing approximately 80% of banks' assets. We find that more-exposed banks increase their holdings of high-yield securities (buy more and sell less) more than less-exposed banks, relative to the pre-policy period. Our estimates include stringent security-time and bank-time fixed effects to control for time-varying confounding factors at the bank and security level. Similarly, we find that more-exposed banks increase their corporate lending (higher volumes and lower rates), targeting mostly risky borrowers. Finally, in the residential mortgage space, we find that banks reallocate their credit to borrowers more likely to default in bad times. Given that we do not observe mortgage defaults on post-policy originations (the policy is recent), we use machine

learning techniques to estimate loan-level default probabilities exploiting characteristics at origination of loans that defaulted during the 2007-10 bust. Modulo the caveat that there might be differences in mortgage default patterns in the future relative to 2007-10, we find the conditional probability of mortgage defaults increased right after the policy. Of course, our results on house prices strongly suggest the recurrence of a similar bust became presumably less likely.

The rationale for macroprudential policies is based on the observation that agents overborrow in good times, not internalizing all the costs of their financing choice (Lorenzoni, 2008; Bianchi, 2011; Bianchi and Mendoza, 2010, 2018; Farhi and Werning, 2016; Bianchi et al., 2012; Jeanne and Korinek, 2017). In the U.S., the increase in mortgage credit contributed to the rapid appreciation of house prices (Favara and Imbs, 2015; Mian and Sufi, 2009; Adelino et al., 2015). Their collapse, channeled through the balance sheets of households (Mian et al., 2013; Mian and Sufi, 2014; Hall, 2011; Eggertsson and Krugman, 2012; Midrigan and Philippon, 2018) and intermediaries (Gertler and Kiyotaki, 2011; He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014; Chodorow-Reich, 2014; Moreira and Savov, 2017), contributed, in turn, to the Great Recession.

We contribute to the growing literature on macroprudential regulation aimed at limiting household leverage by (i) showing that banks play an important role in the transmission, and (ii) jointly analyzing, for the first time, mortgage credit, house prices, and bank risk exposure.[113] A few other papers analyze some aspects of LTV/LTI limits and find results consistent with ours.[114] In the U.S., DeFusco et al. (2019) show how the Dodd-Frank "Ability-to-Repay" rule (similar to a LTI limit) successfully reduced borrower leverage, but with limited effect on default rates in a crisis scenario. Although not analyzing the role of banks, Tzur-Ilan (2017) and Igan and Kang (2011) show that borrowers move away from hot real estate markets, slowing down house price growth in Israel and Korea, respectively.[115]

[113] See Aikman et al. (2019), Freixas et al. (2015), Claessens et al. (2013), Claessens (2015), and Gambacorta and Murcia (2017) for excellent overviews of macroprudential policies. Our paper is also related to the literature, theoretical (Landvoigt and Begenau, 2017; Elenev et al., 2018; Begenau, forthcoming; Kashyap et al., 2014; Malherbe and Bahaj, 2018) and empirical (Aiyar et al., 2014; Jimenez et al., 2017; Gropp et al., 2019; Benetton et al., 2017; De Marco and Wieladek, 2015; Dassatti Camors et al., 2015; Ayyagari et al., 2019), on macroprudential policies (mostly capital requirements) aimed at limiting bank risk taking.

[114] In our same empirical setting, Kinghan et al. (2017) show that, following the introduction of the limits, LTV fell for first time buyers and second and subsequent buyers. Compared with their paper, we focus on the reallocation of mortgage credit across the income and geographical distributions, as well as house prices and bank risk exposure.

[115] Auer and Ongena (2019) and Basten and Koch (2015) show that countercyclical capital buffers on Swiss residential lending led to higher growth in commercial lending and shifted mortgages from less to more resilient banks, respectively. Using Singaporean data, Agarwal et al. (2018) show that policies that impose limits on only LTV cause an increase in high-LTI mortgage issuance. These papers do not analyze house prices or banks' overall risk exposure.

3.2.2 Setting and Data

In Section 3.2.2.1, we provide some background on the Irish residential mortgage market. In Section 3.2.2.2, we describe the policy introduced in February 2015. In Section 3.2.2.3, we describe our data set.

3.2.2.1 Residential Mortgage Credit in Ireland

In the years leading up to 2000, Ireland experienced a period of steady economic growth often interpreted as a healthy convergence of the "Celtic Tiger" with the rest of the European Union. However, the surge in output from 2003 to 2007 was of a different type, fueled by a construction boom financed through bank credit extended to home owners and property developers (Honohan, 2010). In Figure 3.8, we show the issuance of residential mortgages (dashed line) from 2000 to 2016 and observe a stark increase in new mortgages from 2002 to 2007. Issuance then collapsed and started increasing again in 2013. House prices (solid line) followed a remarkably similar pattern.

During the bust of 2007-10, prices declined sharply and construction activities collapsed. The fall in quarterly Gross National Product (GNP) is estimated to be about 17%.[116] In addition to the sharp decrease in real estate prices, an increase in unemployment from 4.6% in 2007 to 13.3% in 2010 left many households unable to service their debt burden. This increase in non-performing mortgage credit led to losses for banks that consequently experienced severe funding dry-ups. In September 2008, public funds had to be used to recapitalize almost all large domestic credit-taking institutions, which needed further government assistance in March 2011 (Lane, 2011; Acharya et al., 2014).

3.2.2.2 The February 2015 Mortgage Lending Limits

To avoid a recurrence of this boom-bust cycle in the property market, the Central Bank of Ireland introduced new macroprudential rules aimed at increasing the resilience of households and banks to financial shocks and dampening the pro-cyclical dynamics between property lending and house prices.[117] In the words of Patrick Honahan in January 2015, at that time Governor of the Central Bank of Ireland, "What we are trying to prevent is another psychological loop between credit and prices and credit. If we avoid that, we can keep banks safe, we can keep borrowers safe."

The lending limits were first discussed in October 2014 (our "announcement" date) and

[116] Irish economic performance is better measured in relation to GNP rather than GDP, because the latter is inflated by profits of international companies, which are transferred to Ireland because of low corporation tax.

[117] Almost all mortgages in Ireland are held on banks' balance sheets. There is no active securitization market in Ireland. More specifically, securitization is solely used to create collateral eligible to be pledged at the European Central Bank. Risk transfer off banks' balance sheets is not common.

introduced on February 9, 2015 (our "implementation" date).[118] In Table 3.14, we provide an overview of the limits on loan-to-value (LTV) and loan-to-income (LTI) ratios on new originations of residential mortgages. The LTI limit is 3.5. The LTV limit depends on the type of borrowers. Lending for primary-dwelling housing (PDH) is limited to 80% LTV. For first-time buyers (FTB), a more generous LTV limit of 90% is imposed for houses up to €220,000.[119] For any amount exceeding €220,000, the excess amount over €220,000 faces an LTV limit of 80%. The measures impose a stricter threshold for buy-to-let (BTL) properties, requiring banks to apply an LTV limit of 70%.[120]

3.2.2.3 Data

In this section, we describe the data set construction and the empirical work. The core of our final data set is the result of combining loan-level information on residential mortgages and credit to firms, bank security-level holdings, and county-level house prices. The loan-level data and security register are proprietary data sets obtained from the Central Bank of Ireland.

First, we observe loan-level data on the issuance of residential mortgages to households at a daily frequency from January 2013 to June 2016.[121] We observe all outstanding residential mortgages by the most significant institutions that have to submit loan-level data to the Central Bank of Ireland.[122] This sample consists of the five largest banks and covers more than 90% of the domestic mortgage market. The data set also contains household-month demographic (age, marital status), income, and residential mortgage credit characteristics (first-time or subsequent-time buyer, buy-to-let).

Second, we observe loan-level data on bank credit to firms at a semi-annual frequency from June 2013 to June 2016. At the bank-firm-period level, we observe credit granted and drawn and the rate charged by bank b to firm f at time t. We match this information with firm characteristics such as county of incorporation, industry, and asset class (very small/SME/large). We observe the borrower rating assigned to each loan from internal rating

[118] The lending limits were first proposed in a paper (Consultation Paper 87) published to stimulate discussion by the central bank on October 7, 2014 and available on the Central Bank of Ireland website (link). Mortgages issued after February 9, 2015 could exceed the lending limits if approved before February 9, 2015.

[119] First-time buyers are four percentage points or 30 per cent relatively less likely to default than subsequent-time buyers in Ireland (Kelly et al., 2015).

[120] In addition to loans that are exempted from the rule, banks can issue loans exceeding the limits to a small share of borrowers, as shown in the last column of the table. In November 2016, the rules were relaxed, extending the LTV limit for FTBs to 90%. The analysis of this subsequent period goes beyond the scope of this paper.

[121] These data are a combination of two sources: We use the *loan-level data* until 2015 and the *Monitoring Template Data* after 2015. The latter has to be submitted to the Central Bank of Ireland for regulatory purposes as prescribed by the macroprudential regulations introduced on February 9, 2015. More information is in the Appendix.

[122] Irish banks that received a public bailout are required to report loan-level data. The rest of the significant mortgage issuers in Ireland submit loan-level data following the encouragement from regulators and in accordance with data submissions required by the ECB-SSM Comprehensive Assessment in 2013.

models of each lender.[123] The data have one main limitation. In contrast to most credit registries, our borrower identifier is consistent within a bank over time, but not across banks.

Third, we observe bank security-level holdings at a quarterly frequency from January 2011 to June 2016. At the security-bank-quarter level, we observe each security s identified by an International Securities Identification Number (ISIN) held by bank b at time t. We match this information with security characteristics (rating and yield) from Datastream.

Fourth, at the bank-month level, we observe monthly balance sheet items from the European Central Bank Individual Balance Sheet Statistics (IBSI).

Fifth, at the county-period level, we observe quarterly house prices from the Irish property website Daft.ie. This data set is publicly available and regularly updated with quarterly reports published on the website.

3.2.3 Some Facts

In this section, we present three aggregate facts. In Section 3.2.3.1, we show the pace of originations of residential mortgages seems almost unaffected by the lending limits even if these limits affect more than one third of the market. In Section 3.2.3.2, we show that counties and borrowers are differentially exposed to the lending limits, with urban counties and low-income borrowers being more affected than rural counties and high-income borrowers. In Section 3.2.3.3, we show that after the policy, mortgage credit is reallocated from low- to high-income borrowers and from counties where borrowers are closer to the limits to counties where borrowers are further away from the limits.

3.2.3.1 Evolution of Residential Mortgage Issuance

The lending limits announced in October 2014 and implemented in February 2015 prevented banks from originating high-LTV and high-LTI residential mortgages. These rules affected a large fraction of the mortgage market, because 43% of the volume of residential mortgage issuance (35% of mortgages issued) from October 2013 to September 2014 would have been affected if the policy had been in place during that period. Out of the total €1.6 billion mortgages in our sample in that period, non-conforming (i.e., not complying with the new rules) mortgages accounted for €0.7 billion. The LTV limits affected the largest fraction of the market. LTV-non-conforming mortgages accounted for €0.5 billion and LTI-non-conforming mortgages accounted for €0.3 billion. Moreover, approximately half of the LTI-non-conforming mortgages were also LTV-non-conforming.

Whereas the lending limits affected more than one third of the typical residential mortgage issuance, the pace of originations and the build-up of mortgage credit risk exposure seem

[123] The Central Bank of Ireland internal mapping scales are used to classify each internal rating into a consistent categorization between 1 and 6. It ranges from 1 (highest-quality borrower) to 5 (very risky borrower) for non-defaulted loans and equals 6 for defaulted loans.

almost unaffected by the policy. In the top-left panel of Figure 3.9, we show the evolution of mortgage issuance from January 2013 to June 2016. We find that mortgage credit growth – high since the beginning of 2014 – did not stop after the implementation of the lending limits. This aggregate evidence suggests an increase in the issuance of *conforming* mortgages might have compensated the mechanical reduction of the issuance of *non-conforming* mortgages, as banks followed the new rules. In the top-right panel, we show the evolution of originations of conforming (solid line) and non-conforming (dashed line) mortgages and confirm the two time-series diverge starting in February 2015.[124] In the bottom panels, we show that mortgage originations keep increasing even when weighted by LTV and LTI, suggesting the lending limits do not affect the build-up of residential mortgage risk exposure of our sample banks is unaffected by the lending limits.[125]

3.2.3.2 Exposure to the Lending Limits

We now show that counties and borrowers are differentially exposed to the lending limits. First, we define a county-level variable *Distance*, which measures the average distance of borrowers in county c from the lending limits in the year prior to the policy announcement.[126] In Figure 3.10, we show the county-level distance from the lending limits. Darker colors indicate counties that are closer to the lending limits. Perhaps not surprisingly, urban counties – and the Dublin area in particular – are closer to the lending limits. These are the counties that experienced a larger house price increase before the policy and where households were therefore more likely to borrow close to the to-be-imposed limits. Substantial heterogeneity exists in the distance from the lending limits across counties: The average distance is 0.21, the median distance is 0.23, and the standard deviation is 0.15.[127]

Second, in Table 3.15, we divide households who obtain a mortgage in the year prior to the policy in five quintiles based on their income.[128] The income distribution is negatively skewed, because the average income of the top quintile is almost double the average income of the fourth income quintile. High-income borrowers also have lower LTV and lower LTI and tend to be older and less likely to be single or first-time buyers than lower-income borrowers.

Borrowers across the income distribution are differentially exposed to the LTI and LTV

[124] The issuance of non-conforming mortgages is still strictly positive after the policy implementation as the new rules allow banks to exceed the limits for a limited fraction of their issuance.

[125] While the figure suggests that the volume and riskiness of mortgage issuance was increasing around the policy introduction, borrower leverage and originations were low compared with historical levels.

[126] We proceed in three steps. First, for each mortgage, we measure the distance from the respective LTV and LTI limits. Second, given the very different scale of LTV and LTI, we rescale both distances to have a mean of zero and a standard deviation of one. Third, we average these two distances at the county level. See the Appendix for details.

[127] In Figure 3.16 in the Appendix, we show that counties closer to the limits are more densely populated and experienced a sharper house price appreciation before the policy than more distant counties. In the Appendix, we show the county-level distance from the LTV and LTI limits, separately.

[128] Income quintiles are based on the January 2014 income distribution and adjusted monthly for Irish wage inflation using OECD data.

limits. Somewhat mechanically, the distance from the LTI limit increases monotonically with income. Low-income borrowers are the closest and high-income borrowers are the furthest from the limit. This monotonicity does not apply to the distance from the LTV limit: Borrowers in the bottom quintile of the income distribution are on average further away from the LTV limit than borrowers in the second to fourth quintiles, whereas borrowers in the top quintile are the furthest from the limit.[129] In sum, the LTV and LTI limits do not seem to be most binding for the same type of household. To measure how tight the regulation is for households based on their income, we create a standardized measure of the distance from both the LTV and LTI limit. This measure shows that borrowers in the top income quintile are by far the most distant from the lending limits compared with other borrowers.

3.2.3.3 Reallocation of Residential Mortgage Credit

We now document a mortgage credit reallocation from counties where borrowers are closer to the lending limits ("low-distance" counties) to counties where borrowers are further away from the lending limits ("high-distance" counties) and from low-income to high-income borrowers.

We show this reallocation, non-parametrically, in Figure 3.11. On the x-axis, the 26 counties are ordered based on their distance from the lending limits: high-distance counties on the left and low-distance counties on the right. On the y-axis, borrowers are grouped and ordered in 20 ventiles based on their position in the income distribution: low-income borrowers on the bottom and high-income borrowers on the top. In sum, a point in the heatmap is an income group-county group pair. For each pair, we compute the change in mortgage origination from the pre-policy period (February 2013 to January 2014) to the post-policy period (February 2014 to January 2015). Darker colors indicate higher growth.

We observe darker colors on the left, toward the top, and especially in the top-left corner. In sum, this figure documents that the growth in mortgage issuance after the policy implementation has been driven by high-distance counties and high-income borrowers.[130]

3.2.4 Bank Credit Reallocation

In this section, we show the reallocation of mortgage credit from low-distance to high-distance counties and from low-income to high-income borrowers is driven by bank portfolio choice.

[129] On the one hand, high-income borrowers tend to face stricter LTV limits because they are often second- or subsequent-time buyers. On the other hand, low-income borrowers tend to face laxer LTV limits because they are often first-time buyers.

[130] In the Appendix, we show a version of this heatmap where the post-period is from February 2014 to January 2015 and the pre-period is from February 2013 to January 2014. In this "placebo" period, we do not observe a reallocation to high-income borrowers and high-distance counties.

3.2.4.1 Mortgage Credit Reallocation

The bank credit reallocation channel is based on the idea that banks react to the policy by reallocating their mortgage issuance to keep their risk exposure unchanged. This transmission mechanism has a clear cross-sectional implication: Banks with a larger fraction of non-conforming issuance in the pre-regulation period should reallocate their mortgage credit more aggressively than banks with less non-conforming issuance.

Following this intuition, we measure banks' differential exposure to the policy based on the relative importance of non-conforming issuance relative to a bank's total mortgage issuance during the year before the policy announcement. In particular, for each bank b, we define the following variable:

$$Exposure_b = \frac{\sum_{t=Oct13}^{Sep14} \text{Non-Conforming Mortgage Issuance}_{bt}}{\sum_{t=Oct13}^{Sep14} \text{Total Mortgage Issuance}_{bt}} \tag{3.4}$$

where the numerator is the sum of total non-conforming mortgage issuance between October 2013 and September 2014 by bank b, and the denominator is the sum, over the same period, of total mortgage issuance by bank b. Constructing this measure solely for the period before the announcement allows us to capture a bank's typical mortgage issuance without any temporary effects caused by the announcement of the lending limits.

We validate our measure in Figure 3.12, where we show the evolution of conforming mortgages issued by high-exposure banks (exposure above median, blue line) and low-exposure banks (exposure below median, red line). The thin dashed lines show non-conforming mortgage issuance, collapsing for both groups of banks after the policy implementation. This figure documents that high-exposure banks experience a greater drop in non-conforming mortgage issuance and a greater increase in conforming mortgage issuance than low-exposure banks.

Having shown non-parametric evidence of cross-sectional variation in bank credit reallocation, we now estimate the following difference-in-differences specification:

$$Y_{bcht} = \alpha + \beta Post_t \times Exposure_b + \gamma X_{b,t-1} + \nu_b + \eta_{ct} + \theta_{ht} + \epsilon_{bcht} \tag{3.5}$$

where our unit of observation is bank b, county c, household income bucket h, and month t. We divide households into 20 income buckets to ensure households are similar enough to properly capture mortgage demand. The sample period includes 24 months and runs from February 2014 to January 2016. The key independent variable is the interaction term between a $Post_t$ dummy equal to 1 from February 2015 to January 2016 and the bank-level $Exposure_b$ variable defined in (3.4). We saturate the specification with county-time fixed effects to capture time-varying geographical heterogeneity (e.g., county-specific demand for credit), bank fixed effects to capture bank time-invariant heterogeneity (e.g., specialization in mortgage issuance), income bucket-time fixed effects, and lagged bank time-varying controls

(logarithm of total assets, equity capital ratio, and loans/total assets).

We run our specification in subsamples based on borrower income quintiles. We show the estimation results in Table 3.16 where each column corresponds to an income quintile. In Panel A and Panel B, the independent variables are total loan volume and mortgage size, respectively. We find that more-exposed banks increase the total loan volume issued to high-income (Q5) borrowers, whereas they reduce the total loan volume to low-income (Q1) borrowers more than less-exposed banks. Moreover, the top income quintile households also obtain larger loans than other quintiles after the policy. More precisely, a one standard deviation higher $Exposure_b$ leads to a 10% decrease in total new mortgage issuance to low-income (Q1) borrowers and to a 15% increase in total new mortgage issuance to high-income (Q5) borrowers. These results are consistent with more-affected banks reallocating credit to richer households that are further away from the lending limits and thus have potentially more room to increase their LTV and LTI, while still conforming with the newly imposed limits.

In Panel C, we consider the (loan volume-weighted) LTV as a dependent variable. We find that banks more exposed to the policy reduced their LTV compared with less-exposed banks in income quintiles Q1 and Q2, consistent with the lending limits affecting exposed banks more and with lower income households being more constrained. For households in the bottom income quintile, a one standard deviation higher $Exposure_b$ implies a reduction in the LTV of 6.6 percentage points. However, in the top income quintile (column (5)), more-affected banks *increased* their LTV compared with less-exposed banks. Borrowing from banks with a one standard deviation higher $Exposure_b$ leads to a 4.9 percentage points higher LTV in the top income quintile. Hence, by issuing larger loans to high-income households, banks can (partially) make up for the lost business caused by the introduction of the lending limits.

In Panel D, the independent variable is the (loan volume-weighted) LTI. Similar to the finding for the LTV, we document a significant increase in the LTI for high-income households borrowing from more-exposed banks. More precisely, a one standard deviation higher $Exposure_b$ implies an increase in the loan-to-income ratio of high-income borrowers by 0.3 percentage points.[131]

3.2.4.2 Mortgage Rates

Having shown evidence consistent with bank portfolio choice driving mortgage credit reallocation, we now analyze mortgage rates to understand why high-income borrowers and borrowers located in high-distance counties take out larger loans and increase their leverage after the policy introduction.

We first examine the time-series evolution of mortgage rates for each quintile of the borrower income distribution. In Panel A of Table 3.17, we document that, although mortgage

[131] In Figure 3.18 in the Appendix, we show non-parametric evidence consistent with exposed banks driving high-income borrowers' LTV and LTI increase in the post-regulation period.

rates are falling for all borrowers during our sample period, high-income borrowers experience the largest reduction.[132] Borrowers in the top income quintile (Q5) experience a reduction of 46 whereas borrowers in the bottom income quintile (Q1) experience a reduction of 29 basis points.

Having shown that high-income borrowers experience the largest reduction in mortgage rates around the introduction of the lending limits, we resort again to the cross-section of banks to capture the bank portfolio choice channel. In particular, we re-estimate specification (3.5), using the mortgage rate as a dependent variable.

We show estimation results in Panel B of Table 3.17, where columns correspond to income quintiles. We find that (i) households in the top quintile of the income distribution were charged significantly lower rates if they borrowed from banks more affected by the lending limits, consistent with more-exposed banks offering favorable interest rates to high-income households who take larger loans.[133] Conversely, low-income households borrowing from more-affected banks faced relatively higher interest rates after the introduction of the lending limits. The results in this section are therefore consistent with more-exposed banks offering lower interest rates to attract high-income households to take out larger loans, thus trying to make up for the lost business due to the introduction of the lending limits.

One obvious question is why were high-income borrowers, and especially those located in high-distance counties, not borrowing as much *before* the lending limits? Two explanations are possible. First, banks suffered large losses exactly from high-income borrowers during the 2008-10 bust and therefore might have been reluctant to increase credit to this types of borrower when the housing market started to pick up again.[134] Second, banks might have a risk-shifting incentive to tilt their mortgage issuance toward low-distance counties such as the Dublin area, because the payoffs of mortgages in these counties are more correlated with banks' legacy assets (Malherbe and Bahaj, 2018; Landier et al., 2015).

3.2.4.3 Geographical Reallocation

In this subsection, we investigate whether the geographical reallocation of mortgage credit is consistent with the bank credit reallocation channel, i.e., whether more-exposed banks drive the change in credit reallocation across counties. To this end, we rerun the model in (3.5) separately for high- and low-distance counties.

Results are presented in Table 3.18. In column (1) of Panel A, we show that households in the bottom quintile of the income distribution receive significantly less credit if they are located in a low-distance county and are borrowing from more-exposed banks. More precisely,

[132] Irish banks do not offer mortgage rates based on the income of borrowers. Banks typically offer an interest rate-LTV schedule, allowing borrowers to self-select into the product they prefer.

[133] Banks have several ways to influence the rates charged to clients, including offering more fixed- or non-fixed-rate mortgages.

[134] In Figure 3.19 in the Appendix, we show that our sample banks experienced the largest losses from high-income high-LTV borrowers during the 2007-10 bust.

a one standard deviation higher $Exposure_b$ leads to a 13% reduction in new mortgage issuance in low-distance counties. Conversely, high-income households see a significant increase in the loan volume coming from more-exposed banks, especially if they are located in high-distance counties (column (5)). Here, a one standard deviation higher $Exposure_b$ leads to a 19% increase in new mortgage issuance. Moreover, these high-income households again take out larger loans from more-exposed banks, especially in high-distance counties (Panel B).

We also find that low-income households face a significant reduction in their LTV both in high- and low-distance counties (Panel C). However, the magnitude of the reduction is larger for low-income households in low-distance counties (a one standard deviation higher $Exposure_b$ leads to a 6.9 percentage points lower LTV in low-distance counties versus 6.0 percentage points in high-distance counties). Focusing on the top income quintile, we find that high-income households in high-distance counties receive mortgages with a significantly higher LTV after the introduction of the lending limits (for a one standard deviation higher $Exposure_b$, LTV increases by 7.2 percentage points). Similarly, the LTI of these households increases by 0.6 percentage points.

More affected banks thus seem to reallocate mortgage credit from low-income households in low-distance counties to high-income households in high-distance counties, which have the largest distance from the lending limits. This group of borrowers represents the segment of the market with the greatest opportunities for conforming credit expansion after the introduction of the regulations. More precisely, whereas high-income households in low-distance counties have an average distance of 0.3 from the lending limits, high-income households in high-distance counties have an average distance of 0.7 from the lending limits.

3.2.5 House Prices

In this section, we show the time-series evolution of house prices is consistent with the mortgage credit reallocation documented in the previous sections.

First, we show non-parametric evidence consistent with the credit reallocation across counties. In the left panel of Figure 3.13, we show yearly growth in house prices from January 2011 to June 2017. We observe that house price growth stopped increasing at the time of the policy announcement and then stabilized around 10% after the policy implementation.[135] In the right panel, we plot house price growth separately for high-distance (solid line) and low-distance (dashed line) counties. We find that low-distance counties experienced a stark contraction of house price growth after the policy implementation, whereas house price growth remained stable at the pre-policy level in high-distance counties.

Second, we show non-parametric evidence consistent with the credit reallocation across the

[135] House prices reacted at the time of the policy announcement, anticipating the credit reallocation at the time of the policy implementation. In Figure 3.17 in the Appendix, we show, using survey data, that households expected a decline in house prices after the announcement, exactly because of the imminent implementation of the lending limits.

income distribution. In Figure 3.14, we the show yearly growth in house prices from January 2011 to June 2017 separately for one-bedroom, two-bedroom, and three-or-more-bedroom apartments in low-distance counties (left panel) and high-distance counties (right panel). To the extent that property size is correlated with the income of the buyers, this figure is consistent with the mortgage credit reallocation documented in the previous section: The slow-down in house price growth in low-distance counties is driven by small apartments, and the relative stability of house price growth in high-distance counties is driven by large apartments.[136]

We complement these graphs with parametric evidence. In particular, we estimate the following specifications at the county (c) level and at the county-property type (c, p) level:

$$\Delta HP_{c}^{14Q3-16Q4} = \alpha + \beta Distance_{c} + \epsilon_{c} \tag{3.6}$$

$$\Delta HP_{cp}^{14Q3-16Q4} = \alpha + \beta_1 Distance_{c} \times Size_{p} + \beta_2 Distance_{c} + \beta_3 Size_{p} + \epsilon_{cp} \tag{3.7}$$

where the dependent variable is the change in house prices from 2014Q3 to 2016Q4, *Distance* is the county-level distance from the lending limits, and *Size* is an integer equal to the number of bedrooms.[137] We interact *Distance* with the measure of property size to check whether the effect of the lending limits changes depending on the type of property.

We show the estimation results in Table 3.19. The county-level estimation (3.6), in column (1), confirms the positive correlation between changes in house price growth after the policy and county-level distance from the lending limits. In columns (2)-(5), we show the county-property size-level estimation. We confirm that house price growth increased more in high-distance counties than in low-distance counties, and this different evolution is more pronounced for larger properties. These results are consistent with the documented reallocation of mortgage credit across counties and – to the extent that property size is correlated with the income of the buyers – across the distribution of incomes of borrowers.

3.2.6 Bank Risk Exposure

In the previous section, we showed that, thanks to their effect on house prices, the lending limits likely reduced the probability of a bust like the 2007-10 one. In this section, we analyze

[136] Table 3.15 shows that borrower income is strongly correlated with the price of the property purchased. In the Appendix, we attempt to map the number of bedrooms to the income of buyers by regressing the price of the residential property collateralizing the residential mortgage (from the credit registry data) on property size-county-level house price data. We find these loadings are consistent with high-income (low-income) borrowers predominantly buying large (small) properties. Of course, this mapping is not perfect, because, for example, high-income borrowers might buy a one-bedroom property to rent it out.

[137] The geographical breakdown of the house price data is more granular than the mortgage-level data. In particular, we observe data for each of the 22 Dublin postal districts. Given that we cannot compute the distance from the lending limits at this more granular level, we are forced to assume the distance is constant within a county. We then cluster our standard errors at the county-level to take into account that standard errors might be correlated within counties.

the risk exposure of banks should the economy fall again in that – now less probable – state of the world. We combine security-level holdings, loan-level credit to firms, and loan-level residential mortgages, capturing approximately 80% of banks' assets. We find that banks increased their risk exposure in asset classes not targeted by the policy (holdings of securities and credit to firms) and reallocated their residential mortgage credit to borrowers more likely to default during busts.[138] In Section 3.2.6.1 and Section 3.2.6.2, we analyze banks' holdings of securities and credit to firms, respectively. In Section 3.2.6.3, we analyze residential mortgages.

3.2.6.1 Security Holdings

We use security-level holdings data and examine whether banks changed their risk exposure in this asset class. In particular, we use the yield of a security to measure its exposure to events like the 2007-10 bust. Following Davis and Haltiwanger (1992), we define the "net buys" of security s by bank b from time $t-1$ to time t as follows:

$$NetBuys_{s,b,t} = \frac{Holdings_{s,b,t} - Holdings_{s,b,t-1}}{0.5(Holdings_{s,b,t} + Holdings_{s,b,t-1})} \in [-2, 2] \tag{3.8}$$

where *Holdings* is the euro value of holdings of security s by bank b at time t. Compared with simple percentage changes, this measure also captures final sales and initial purchases. Its value is always between -2, corresponding to final sales, and 2, corresponding to initial purchases.

We exploit again the cross-sectional heterogeneity in bank exposure to the lending limits. In particular, we estimate the following specification:

$$NetBuys_{sbt} = \alpha + \beta Exposure_b \times Post_t \times Yield_{st} + \gamma_{bt} + \eta_{st} + \epsilon_{sbt} \tag{3.9}$$

where the unit of observation is security s, bank b, quarter t.[139] Our independent variable of interest is a triple interaction term between bank exposure to the lending limits defined in (3.4), a *Post* dummy equal to 1 in the post period, and the yield of the security. We saturate our specification with several fixed effects. In our most conservative estimation, we include bank-time fixed effects to capture any time-varying bank heterogeneity and security-time fixed effects to capture eventual changes in price and amounts outstanding of specific securities.

We show estimation results in Table 3.20. We progressively saturate the regression with more stringent fixed effects. Column (4) includes all the pairs of two-way fixed effects. The coefficient of interest, stable across specifications, indicates that more-exposed banks increase their holdings of risky securities compared with less-exposed banks after the policy implementation than before it. Moreover, in columns (5) and (6), we explicitly distinguish

[138] We do not observe substantial reallocation across asset classes. In the Appendix, we show the evolution of the aggregate balance sheet of our sample banks.

[139] We observe security-level holdings at a quarterly frequency.

between the buying and selling behavior of banks. *Buys* are defined as the logarithm of the amount of security s bought by bank b at time t, and zero otherwise. Similarly, *Sells* are defined as the logarithm of the amount of security s sold by bank b at time t, and zero otherwise. We find that more-exposed banks buy more and sell less high-yield securities than less-exposed banks.

3.2.6.2 Credit to Firms

We now use the corporate loan-level data and analyze whether banks changed their credit supply to firms. To this end, we adapt specification (3.5) and estimate the following specification:

$$Y_{bclqt} = \alpha + \beta Post_t \times Exposure_b + \gamma X_{bt-1} + \delta_{bc} + \eta_{clqt} + \epsilon_{bclqt} \tag{3.10}$$

We measure the credit provided by bank b to firms in county c, industry l, of quality q in semester t, i.e., we group firms into clusters based on their county, industry, and quality at time t and investigate the lending behavior of banks to a cluster of firms (Acharya et al., 2018).[140] Forming clusters based on county and industry is motivated by the fact that firms in a particular industry in a particular county share many characteristics and are thus likely affected in a similar way by macroeconomic developments that might influence credit demand.

Note that because we do not have a unique firm identifier across loans, we are unable to analyze credit extended to the *same* firm by different banks (Khwaja and Mian, 2008). To determine the quality of a firm that receives a loan, we use the ratings obtained by the Central Bank of Ireland.[141] More precisely, the Central Bank of Ireland employs a rating scale from 1 (best) to 5 (worst). We use these rating categories to divide firms into three quality buckets: high quality (rating 1-2), medium quality (rating 3-4), and low quality/high risk (rating 5).

The dependent variable is either the change in log (stock of) credit granted ($\Delta VOLUME$) or the change in the interest rate charged ($\Delta RATE$). Similar to the previous section, we are interested in the coefficient of the interaction term between the *Post* dummy and the bank exposure to the intervention. We include industry-county-quality-time fixed effects to control for credit demand of firms and other variables that are shared by firms of similar quality operating in the same county and industry. We also include bank-county fixed effects to capture time-invariant bank-county heterogeneity (e.g., time-constant heterogeneity in the geographical preference of banks).

We show estimation results in Table 3.21. In Panels A and B, the dependent variable is the change in volume of credit and change in interest rate charged, respectively. Column (1) considers the full sample of firms. The estimates document that more-exposed banks increase their lending volume to firms and decrease the price of corporate loans more than less-exposed

[140] We observe loan-level credit to firms at a biannual frequency.

[141] These ratings come from the banks' internal models but are homogenized by the Central Bank of Ireland to ensure the rating classes correspond to similar probabilities of default.

banks. In a next step, we split our sample firms into risky (rating 5) and non-risky (rating 1-4) firms and re-run our specification (3.10) separately for these two groups of borrowers. The estimation results in columns (2) and (3) show that, although a credit expansion in the corporate sector occurs for both risky and non-risky firms, the effect is economically and statistically more pronounced for risky firms relative to the pre-period. A one standard deviation higher *Exposure* leads to a 10 percentage points higher credit supply to firms and a 20 percentage points higher credit supply to risky firms. These results are confirmed in the last column of Panel A, where we employ a triple interaction of our bank exposure variable with a *Post* dummy and a dummy for whether the borrowing firms are risky. The coefficient shows the increase in loan volume is mostly driven by an increase toward risky firms relative to the pre-period. Similarly, in Panel B, we find the decrease in the cost of bank loans is mostly benefiting risky firms.

3.2.6.3 Residential Mortgage Lending

The analysis of the risk exposure of residential mortgage credit is particularly delicate because we do not observe mortgage-level ratings or have data on ex-post defaults (the lending limits were introduced very recently). Hence, we use machine learning techniques to predict mortgage-level default probabilities using loan characteristics at origination.[142] Our goal is to exploit patterns of loan and/or borrower characteristics that predict defaults (Mullainathan and Spiess, 2017) using the cross-section of all outstanding mortgages in December 2013.[143] Given that the majority of mortgage defaults in Ireland occurred during the 2007-10 real estate bust, our predicted default probabilities should be interpreted as conditional on a similar bust in the housing market.[144] More specifically, we follow Liberman et al. (2018) and estimate these conditional default probabilities with a random forest model. This supervised algorithm consists of various regression trees where each tree uses a random selection of standard loan and borrower characteristics at origination. The algorithm chooses a combination of explanatory variables (branches) to maximize in-sample prediction power. At the end of each tree, the values of variables are used to determine whether or not a loan is predicted to default. The final prediction of the model is obtained by calculating the average of all trees in the forest.[145]

In Figure 3.15, we plot the evolution of the (value-weighted) conditional default probability of newly issued mortgages by our sample banks. The top-left panel shows the bank credit reallocation in the mortgage book seems to have led to an increase in the average default

[142]The intuition underlying this approach is that we let past data tell us which predictors are significant for mortgage default. We do not manually pick variables as we would for standard OLS or logit hazard models.
[143]December 2013 is the earliest date on which we have a well populated data set on all outstanding mortgages.
[144]Because houses are hard to repossess in Ireland, a portion of defaults in the crisis was likely strategic. McCann (2017) shows that 40% of borrowers who are in long-term arrears have never engaged with their lender for a renegotiation, suggesting some of them might have been strategic defaulters.
[145]In the Appendix, we provide a detailed description of this machine learning exercise.

probability of newly issued mortgages.[146] The top-right panel confirms this increase is driven by more-affected banks, whereas the two bottom panels show this increase is concentrated in the high-income household segment of the mortgage market.

We confirm this graphical evidence by re-running specification (3.5) using default probabilities as the dependent variable. The results, presented in Table 3.22, show that more-exposed banks issue mortgages with a higher default probability to high-income households than do less-exposed banks. Consistent with the results in the previous sections, this effect is strongest in counties that are further away from the lending limits. More precisely, a one standard deviation higher *Exposure* in counties that are more distant from the lending limits leads to a 2.7 percentage points higher default probability for mortgages issued to high-income households.

The higher default probability in a bust for high-income households is consistent with data from past real estate busts. In the U.S., Adelino et al. (2016) document that middle class and high-income borrowers were responsible for a high share of mortgage dollars in delinquency during the bust. In Ireland, in Figure 3.19 in the Appendix, we show our sample banks experienced the largest losses from high-income high-LTV borrowers.[147] Consistent with DeFusco et al. (2019), these results suggest that limits to household leverage have a limited effect in reducing mortgage default rates in bad times.

Of course, these findings have to be considered in the context of the changes in the evolution of house prices documented in Section 3.2.5. On the one hand, the lending limits induced banks to issue mortgages more likely to default in case of a bust like the 2007-10 one. On the other hand, given the decrease in house price growth rates, especially in low-distance counties, the lending limits made the recurrence of a bust like the 2007-10 one less likely. In sum, we cannot conclude the risk of banks' mortgage book actually increased, because two opposing effects need to be considered.

3.2.7 Conclusion

We provide a comprehensive micro-level analysis of the transmission of macroprudential policies aimed at limiting household leverage in the residential mortgage market. Combining loan-level data on residential mortgages with data on bank credit to firms, county-level house prices, and security-level bank holdings of securities, we examine the impact of the February 2015 introduction of LTV and LTI limits in Ireland.

We find that banks played a key role in the transmission. In response to the lending limits, banks reallocate credit from low- to high-income borrowers and from counties where borrowers

[146] These relatively high default probabilities should again be interpreted conditional on a severe real estate bust. In particular, during the 2007-10 bust, unemployment rose from 4% to 13% and house prices collapsed by more than 50%, in a context where household debt was among the highest in world.

[147] Kelly et al. (2015) show that Irish first-time buyers, which are primarily low-income households, are four percentage points less likely to default than second and subsequent home buyers, which tend to be higher-income households.

are close to the limits to counties where borrowers are more distant from the limits. Banks more constrained by the limits reduce their mortgage issuance to borrowers in the bottom quintile of the income distribution by 10% and increase their issuance to borrowers in the top quintile by 15%, controlling for local economic conditions and credit demand. Our effects are consistent with the evolution of house price growth, which stopped increasing at the time of the policy announcement, driven by a collapse in low-distance counties. Consistent with the goal of keeping their risk exposure unchanged, banks increased their risk exposure in credit to firms and holdings of securities, the two largest asset classes not targeted by the regulation.

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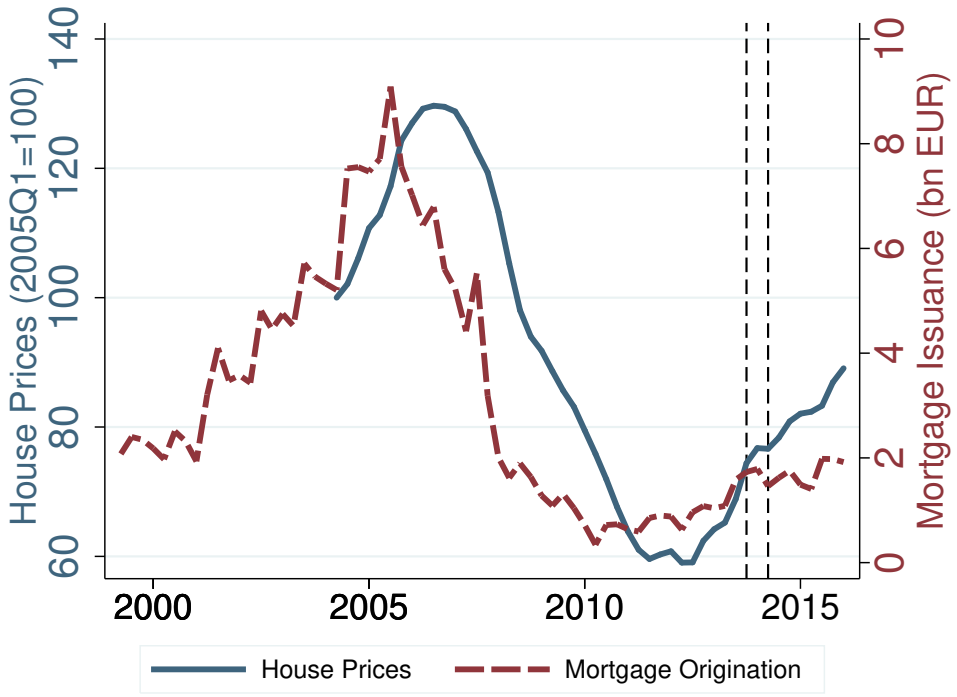
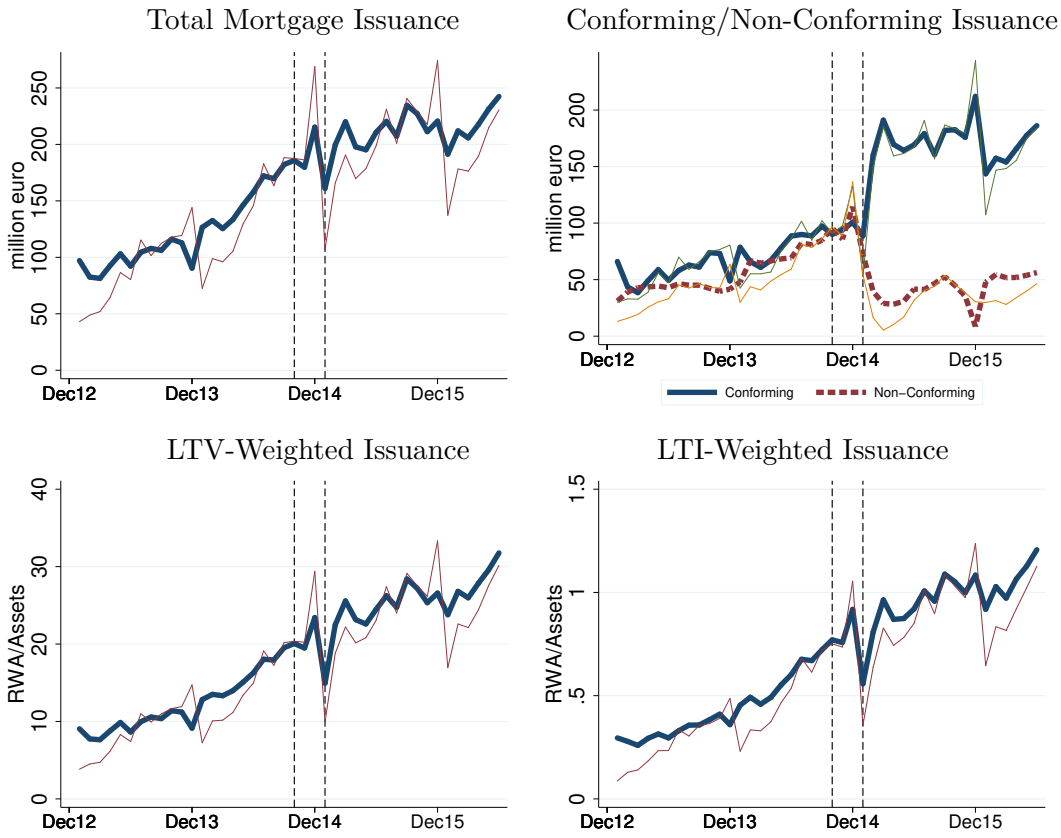
3.2.8 Figures

Figure 3.8: Ireland Real Estate Boom-Bust Cycle



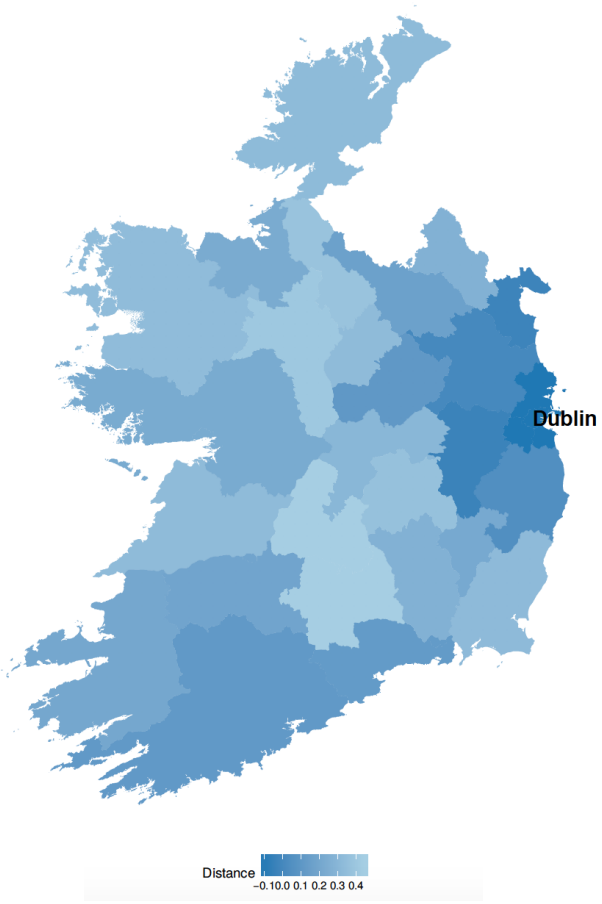
This figure shows the evolution of real estate prices from 2005Q1 to 2016Q4 (left axis, index is 100 in 2005Q1) and residential mortgage issuance from 2000Q1 to 2016Q4 (right axis, billion euros). The two vertical dashed line indicate the announcement and the implementation of the lending limits, respectively. Sources: Department of Housing, Planning and Local Government and Central Statistics Office.

Figure 3.9: Aggregate Residential Mortgage Issuance



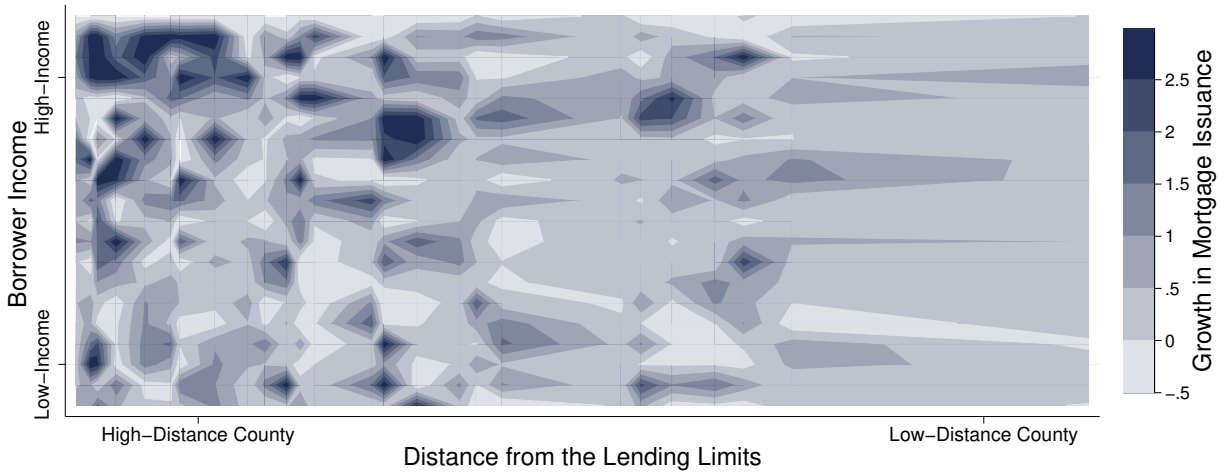
This figure shows the evolution of residential mortgage issuance of our sample banks from January 2013 to June 2016. The top-left panel shows total mortgage issuance (million euro). The top-right panel shows issuance of conforming (solid line) and non-conforming (dashed line) mortgages. The bottom-left panel shows LTV-weighted monthly mortgage issuance divided by total assets (percentage). The bottom-right panel shows LTI-weighted monthly mortgage issuance divided by total assets (units). Thick lines are seasonally adjusted and thin lines are not seasonally adjusted. The vertical dashed lines indicate the announcement and the implementation of the lending limits. Source: Central Bank of Ireland.

Figure 3.10: Counties and Lending Limits



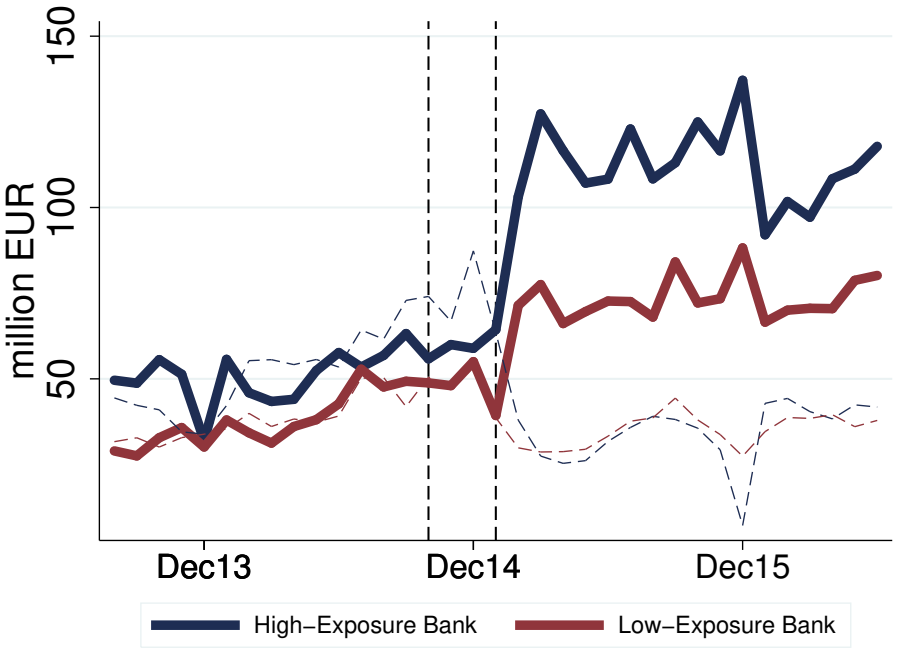
This figure shows county-level distance from the lending limits. Darker colors indicate counties that are less distant. Source: Central Bank of Ireland.

Figure 3.11: Reallocation of Mortgage Credit



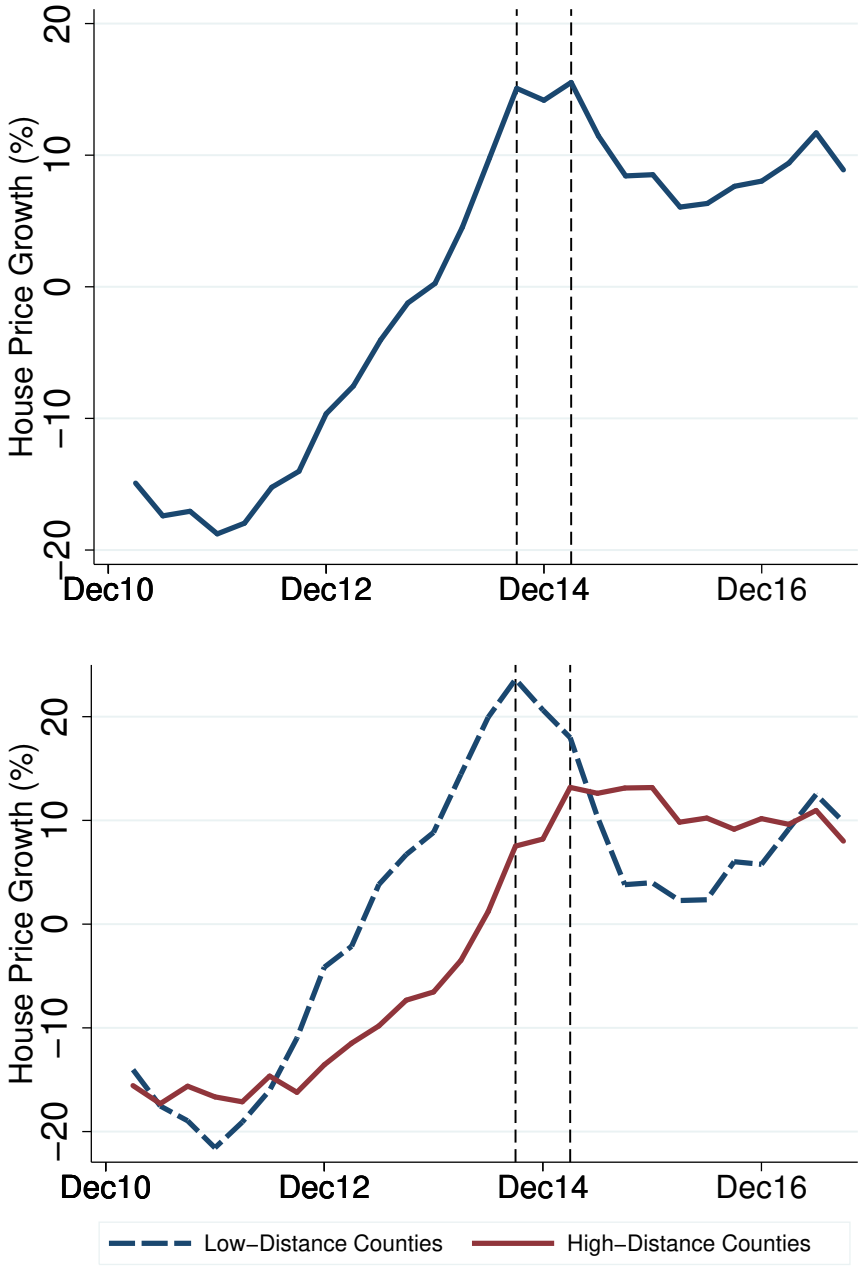
This figure shows the reallocation of mortgage credit across counties and the across the income distribution of borrowers. The x-axis shows counties ranked according to their distance from the lending limits. The y-axis shows borrowers ranked according to their position in the income distribution (20 ventiles). Each point in the map indicates the change of mortgage issuance in the post-period (February 2015 to January 2016) compared with the pre-period (February 2014 to January 2015). Darker colors indicate higher growth of mortgage issuance, as indicated by the legend on the right.

Figure 3.12: Residential Mortgage Issuance, High- vs. Low-Exposure Banks



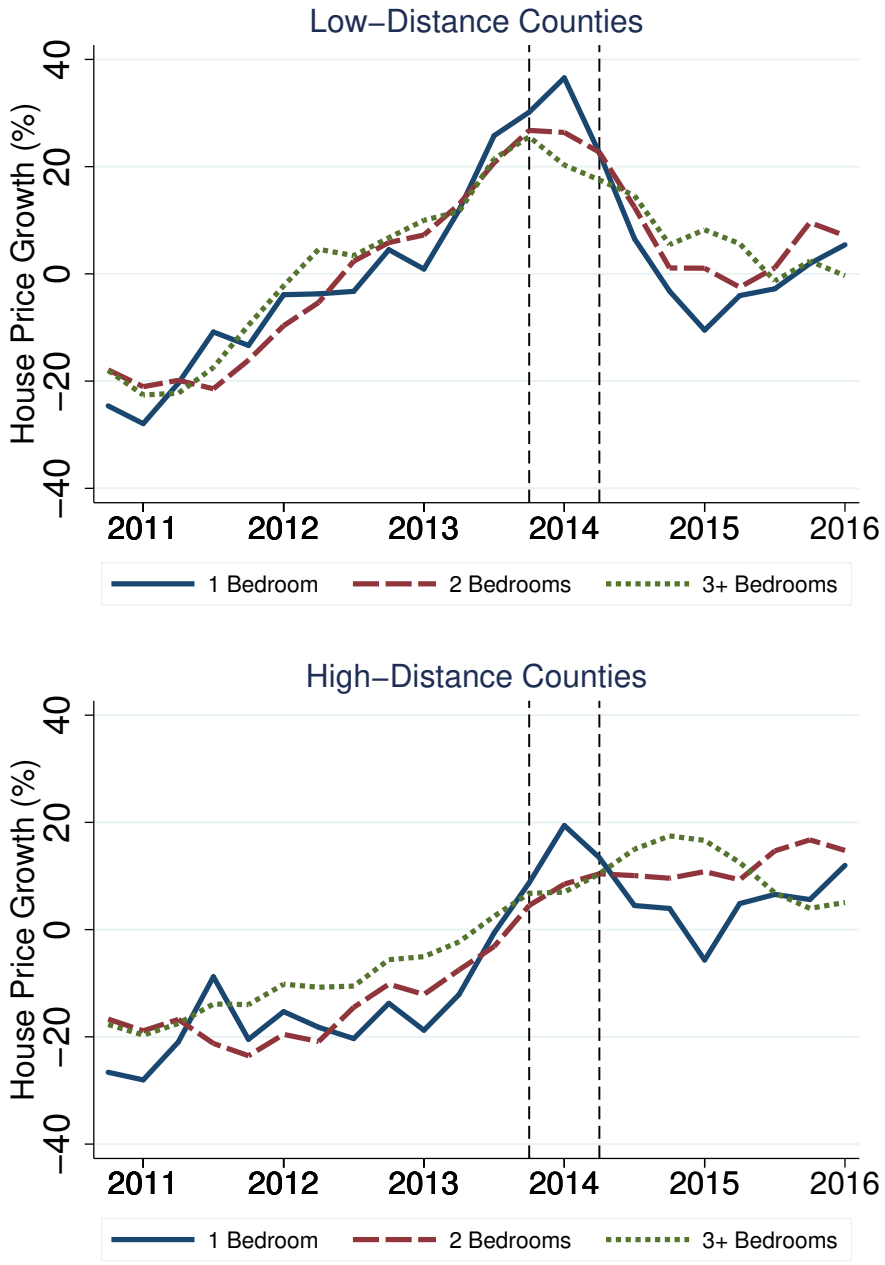
The figure shows the issuance of conforming (solid thick lines) and non-conforming (dashed thin lines) mortgages for high-exposure (above median exposure) and low-exposure (below median exposure) banks from January 2013 to June 2016. The vertical lines indicate the announcement date and the implementation date of the lending limits. All time series are seasonally adjusted. Source: Central Bank of Ireland.

Figure 3.13: House Price Changes



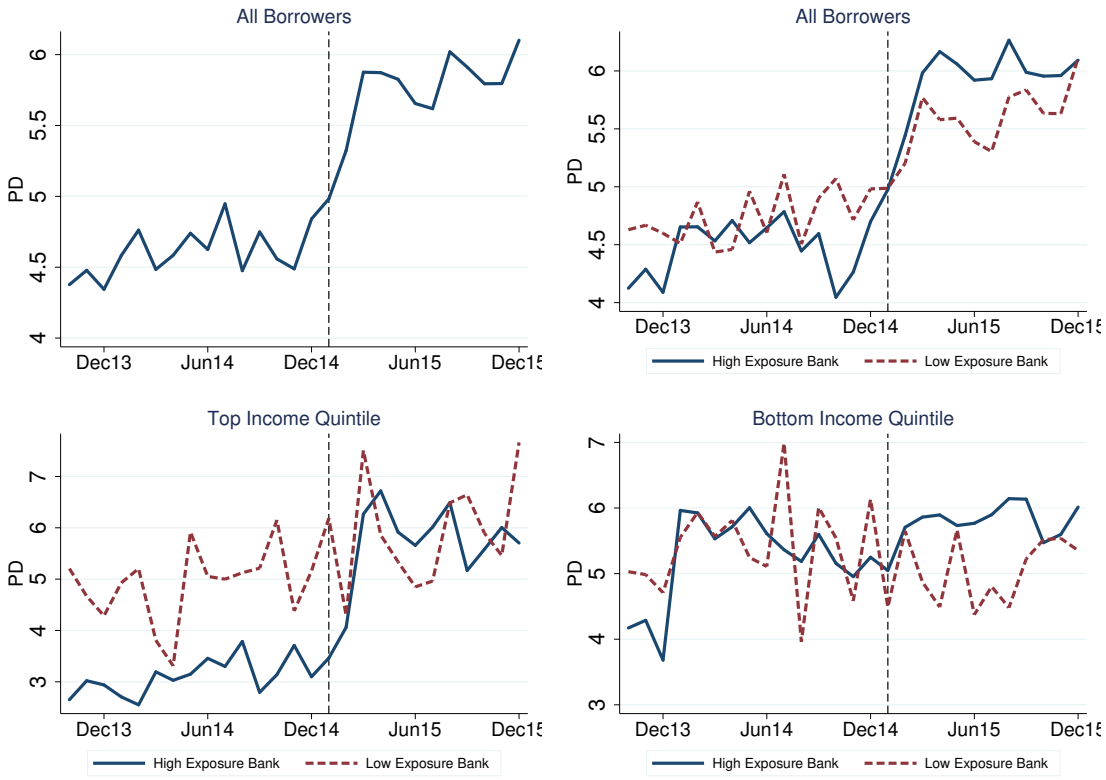
The top panel of this figure shows the evolution of yearly house price growth. The bottom panel shows the evolution of yearly house price growth for high-distance and low-distance counties separately. The vertical dashed lines indicate the announcement and the implementation date of the lending limits. The sample period runs from January 2011 to June 2017. Source: Central Bank of Ireland, Daft.ie.

Figure 3.14: House Price Changes and Property Type



These figures shows the evolution of yearly house price growth for 1-bedroom properties (solid line), 2-bedroom properties (dashed line), and 3-bedroom or larger properties (dotted line). The top (bottom) panel shows data for low-distance (high-distance) counties. The vertical dashed lines indicate the announcement and the implementation date of the lending limits. The sample period runs from January 2011 to June 2017. Source: Central Bank of Ireland, Daft.ie.

Figure 3.15: Mortgage Probability of Default



This figure shows the evolution of mortgage probability of default from October 2013 to February 2016. Panel A shows the default probability of newly issued mortgages by all Irish banks. Panel B shows the default probability of newly issued mortgages separately for high- and low-exposure banks. Panel C (D) shows the default probability of newly issued mortgages in the top (bottom) income quintile separately for high- and low-exposure banks. The vertical dashed lines indicate the implementation of the lending limits. Source: Central Bank of Ireland.

3.2.9 Tables

Table 3.14: Lending Limits

Regulation	Target Group	Limits	Allowances for each bank
LTV limits	For primary dwelling homes:	**First-Time Buyers**: Sliding LTV limits from 90%* **Subsequent Buyers**: 80%	15% of all new lending limits
	For Buy-to-Let:	70% LTV limit	10% of new lending above the buy-to-let limit is allowed
LTI limits	For primary dwelling homes:	3.5 times income	20% of new lending above the limit is allowed
Exemptions	**From LTV limit** Borrowers in negative equity	**From LTI limit** Borrowers for investment properties	**From both limits** * Switcher mortgages * Restructuring of mortgages in arrears

*A limit of 90% LTV applies to the first €220,000 of the value of a residential property and a limit of 80% LTV applies to any value of the property thereafter.

This table provides a summary of the lending limits. Source: Central Bank of Ireland.

Table 3.15: Summary Statistics by Household Income

		Income Quintiles				
	Unit	Q1	Q2	Q3	Q4	Q5
Borrower Characteristics						
Income	€	32,635	47,659	64,899	91,756	168,129
Married	%	16.5	36.2	49.0	66.8	65.1
Age	Years	34.2	35.3	36.2	37.7	40.0
First-Time Buyer	%	82.7	78.1	65.1	41.7	27.0
Buy-to-Let	%	1.7	2.3	3.2	4.3	8.4
No. Borrowers	Units	1,559	2,023	2,378	1,977	2,664
Loan Characteristics						
Size	€	95,030	127,008	168,902	215,070	235,801
LTV	%	77.2	77.2	78.3	76.7	71.8
LTI	Units	3.2	3.0	3.0	2.7	2.3
House Value	€	133,518	177,142	230,458	298,620	385,940
Term	Months	326	328	326	314	286
Fixed Rate	%	44.9	41.8	40.3	34.9	24.4
Rate	%	4.15	4.26	4.25	4.26	4.27
Distance from LTI Limit	Units	0.54	0.75	0.73	1.00	1.28
Distance from LTV Limit	Units	6.73	5.92	3.64	4.22	10.00
Stand. Distance from Limits	Units	-0.13	-0.10	-0.09	-0.02	0.45

This table shows household and loan characteristics by household income quintile during the 12-month period before the policy implementation from February 2014 to January 2015. Income quintiles are adjusted monthly for wage inflation. Source: Central Bank of Ireland.

Table 3.16: Credit Reallocation, Residential Mortgages, Household Heterogeneity

	Income Quintiles				
	Bottom Q1	**Q2**	**Q3**	**Q4**	**Top Q5**
Panel A: Loan Volume					
Post×Exposure	-1.311	-0.570	-0.307	-0.773	2.085
	(0.553)	(0.552)	(0.642)	(0.615)	(0.928)
Observations	2,404	2,786	2,947	2,512	1,929
R-squared	0.496	0. 505	0.582	0.590	0.655
Panel B: Loan Size					
Post×Exposure	-0.546	-0.773	-1.050	-1.856	4.591
	(0.386)	(0.273)	(0.469)	(0.476)	(1.250)
Observations	2,404	2,786	2,947	2,512	1,929
R-squared	0.446	0.359	0.360	0.369	0.476
Panel C: LTV					
Post×Exposure	-91.148	-30.657	-0.421	-6.747	67.309
	(14.915)	(14.100)	(16.285)	(12.749)	(26.549)
Observations	2,363	2,755	2,896	2,466	1,866
R-squared	0.389	0.264	0.242	0.265	0.372
Panel D: LTI					
Post×Exposure	-4.855	3.548	5.461	2.357	4.453
	(6.830)	(4.521)	(4.001)	(4.193)	(1.579)
Observations	1,396	1,775	1,929	1,743	1,267
R-squared	0.426	0.419	0.484	0.492	0.538
Bank Controls	✓	✓	✓	✓	✓
Bucket-Time FE	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓
County-Time FE	✓	✓	✓	✓	Âť✓

This table shows regressions at the bank-county-income bucket level separately for each quintile of the income distribution. Income quintiles are adjusted monthly for wage inflation. The dependent the logarithm of total mortgage volume to an income bucket (Panel A), the logarithm of the average loan size to an income bucket (Panel B), the value-weighted LTV (Panel C), and the value-weighted LTI (Panel D). *Exposure* is defined in (3.4), and *Post* is a dummy equal to 1 from February 2015 to January 2016. Time-varying bank-level controls include the logarithm of total assets, equity capital ratio, and the ratio of loans to total assets. All control variables are lagged by one period. Standard errors are double clustered at the bank-county and month level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Central Bank of Ireland.

Table 3.17: Mortgage Interest Rates

Panel A		Pre	Post	Difference
Bottom	Q1	4.12	3.84	-0.29
	Q2	4.24	3.85	-0.39
	Q3	4.21	3.81	-0.40
	Q4	4.21	3.80	-0.40
Top	Q5	4.24	3.78	-0.46

	Income Quintiles				
	Bottom				**Top**
Panel B	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Post×Exposure	0.628	0.668	-0.224	-0.205	-1.427
	(0.607)	(0.501)	(0.573)	(0.842)	(0.641)
Bucket-Time FE	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓
County-Time FE	✓	✓	✓	✓	✓
Observations	2,366	2,666	2,717	2,220	1,682
R-squared	0.482	0.538	0.491	0.472	0.516

Panel A shows (value-weighted) mean interest rates paid by households in different quintiles of the income distribution from February 2014 to January 2015 and from February 2015 to January 2016. Panel B shows estimation results from specifications (3.5) separately for each income quintile. Each column refers to an income quintile. The unit of observation is month-income bucket-bank. The dependent variable is the mortgage rate. *Exposure* is defined in (3.4), and *Post* is a dummy equal to 1 from February 2015 to January 2016. Standard errors clustered at the bank-time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Central Bank of Ireland.

Table 3.18: Bank Credit Reallocation, Residential Mortgages, Geographical Reallocation

	Income Quintiles				
	Q1	Q2	Q3	Q4	Q5
	Income Quintiles				
	Q1	Q2	Q3	Q4	Q5
PANEL A: TOTAL VOLUME					*Low Distance Counties*
Post×Exposure	-1.763	-1.231	-0.101	-0.306	1.327
	(0.954)	(0.991)	(0.529)	(0.811)	(0.661)
Observations	664	850	981	933	795
R-squared	0.531	0.564	0.660	0.623	0.715
					High Distance Counties
Post×Exposure	-0.840	-0.204	-0.372	-0.439	2.664
	(0.575)	(0.646)	(0.823)	(0.689)	(1.519)
Observations	1,739	1,936	1,965	1,579	1,134
R-squared	0.432	0.372	0.397	0.421	0.425
PANEL B: LOAN SIZE					*Low Distance Counties*
Post X Exposure	-1.118	-1.036	-0.486	-1.729	2.642
	(0.611)	(0.426)	(0.267)	(0.488)	(1.289)
Observations	664	850	981	933	795
R-squared	0.410	0.290	0.365	0.343	0.385
					High Distance Counties
Post×Exposure	-0.237	-0.691	-1.296	-1.860	6.706
	(0.460)	(0.489)	(0.659)	(0.679)	(1.410)
Observations	1,739	1,936	1,965	1,579	1,134
R-squared	0.446	0.330	0.303	0.360	0.493
PANEL C: LTV					*Low Distance Counties*
Post X Exposure	-95.156	-34.655	12.483	-12.752	26.131
	(32.174)	(28.343)	(14.928)	(23.987)	(21.635)
Observations	655	849	976	924	785
R-squared	0.453	0.312	0.241	0.239	0.311
					High Distance Counties
Post×Exposure	-83.793	-30.936	-7.822	3.152	99.522
	(17.870)	(19.919)	(23.212)	(11.624)	(34.871)
Observations	1,707	1,906	1,919	1,542	1,080
R-squared	0.412	0.287	0.277	0.295	0.434
PANEL D: LTI					*Low Distance Counties*
Post×Exposure	-1.167	3.838	4.893	2.669	2.345
	(10.739)	(5.222)	(4.555)	(4.352)	(2.099)
Observations	398	587	706	689	590
R-squared	0.451	0.394	0.461	0.421	0.541
					High Distance Counties
Post×Exposure	-6.045	-1.345	6.755	0.899	8.516
	(6.901)	(7.612)	(6.265)	(6.182)	(3.436)
Observations	993	1,188	1,223	1,054	676
R-squared	0.426	0.383	0.417	0.468	0.519
Time Varying Bank Controls	✓	✓	✓	✓	✓
Bucket-Time FE	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓
County-Time FE	✓	✓	✓	✓	Âţ✓

This table presents the results from specification (3.5), separately for mortgages issued in high- and low-distance counties. The sample period includes 24 months and runs monthly from February 2014 to January 2016. The unit of observation is county-month-bank-income bucket. Income quintiles are adjusted monthly for wage inflation. The dependent variables are logarithm of total mortgage volume to an income bucket (Panel A), the logarithm of the median loan size to an income bucket (Panel B), the value-weighted LTV (Panel C), and the value-weighted LTI (Panel D). *Exposure* is defined in (3.4), and *Post* is a dummy equal to 1 from February 2015 to January 2016. Time-varying bank-level controls include the logarithm of total assets, equity capital ratio, and the ratio of loans to total assets. All control variables are lagged by one period. Standard errors are double clustered at the bank-county and month level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Central Bank of Ireland.

Table 3.19: House Prices and Lending Limits

LHS: ΔHP	(1)	(2)	(3)	(4)	(5)
Distance × Size		0.007	0.007	0.007	0.007
		(0.003)	(0.003)	(0.003)	(0.003)
Distance	0.296	0.276		0.276	
	(0.072)	(0.076)		(0.077)	
Size		0.012	0.012		
		(0.000)	(0.000)		
Country FE			✓		✓
Size FE				✓	✓
Observations	54	270	270	270	270
R-squared	0.360	0.281	0.736	0.468	0.924

This table shows estimation results from specification (3.7) in column (1) and estimation results from specification (3.7) in columns (2)-(5). The dependent variable is the change in house prices between 2014Q3 and 2016Q4. *Distance* is the county-level distance from the lending limits. *Size* is the number of bedrooms (1 to 5). Standard errors clustered at the county-level in parentheses. Source: Central Bank of Ireland, Daft.ie.

Table 3.20: Bank Portfolio Reallocation, Holdings of Securities

	Net Buys				Buys	Sells
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure×Yield×Post	0.021	0.019	0.057	0.067	0.290	-0.251
	(0.008)	(0.009)	(0.016)	(0.022)	(0.098)	(0.102)
Time FE	✓					
Security FE	✓	✓				
Bank-Time FE		✓		✓	✓	✓
Security-Time FE			✓	✓	✓	✓
Observations	7,707	7,707	7,707	7,707	7,707	7,707
R-squared	0.247	0.281	0.943	0.949	0.919	0.915

This table shows the estimation results from specification (3.9). The unit of observation is security-bank-quarter. The sample runs at a quarterly frequency from 2013Q1 to 2016Q2. The dependent variable is defined in (3.8). *Exposure* is defined in (3.4), *Post* is a dummy equal to 1 from 2015Q2 onwards, and $Yield$ is the yield of the security. Double-interaction terms and uninteracted terms (when not absorbed by fixed effects) are not shown for brevity. Standard errors clustered at the security-level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Central Bank of Ireland.

Table 3.21: Bank Portfolio Reallocation, Credit to Firms

Panel A

	Sample			
LHS: $\Delta VOLUME$	Total	Risky	Non-Risky	Total
Exposure × Post	1.382	2.761	0.740	0.697
	(0.401)	(0.659)	(0.435)	(0.449)
Exposure × Post × Risky				2.253
				(0.547)
Exposure × Risky				-0.182
				(0.307)
Time-Varying Bank Controls	✓	✓	✓	✓
Industry-County-Quality-Time FE	✓	✓	✓	✓
Bank-County FE	✓	✓	✓	✓
Observations	10,092	3,227	6,865	10,092
R-squared	0.525	0.569	0.493	0.527

Panel B

	Sample			
LHS: $\Delta RATE$	Total	Risky	Non-Risky	Total
Exposure × Post	-0.719	-1.677	-0.234	-0.187
	(0.195)	(0.557)	(0.268)	(0.262)
Exposure × Post × Risky				-1.753
				(0.674)
Exposure × Risky				0.058
				(0.367)
Time-Varying Bank Controls	✓	✓	✓	✓
Industry-County-Quality-Time FE	✓	✓	✓	✓
Bank-County FE	✓	✓	✓	✓
Observations	10,007	3,183	6,823	10,007
R-squared	0.478	0.508	0.463	0.479

This table shows the estimation results of specification (3.10). The unit of observation is bank-industry-county-quality-time. The sample runs at a bi-annual frequency from 2013H1 to 2016H1. *Exposure* is defined in (3.4) and *Post* is a dummy equal to 1 from 2015H1 to 2016H1. A risky loan has a rating equal to 5. The dependent variables are the change in log (stock of) credit granted in Panel A and the (value weighted) change in the interest rate charged in Panel B. Standard errors clustered at the bank-county level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Central Bank of Ireland.

Table 3.22: Bank Credit Reallocation, Residential Mortgages, Default Probability

	Income Quintiles				
	Q1	Q2	Q3	Q4	Q5
PANEL A. Sample Counties: Full Sample					
Post×Exposure	0.041	-0.031**	-0.027	0.073***	0.253***
	(0.030)	(0.013)	(0.021)	(0.025)	(0.056)
Observations	2,366	2,666	2,717	2,220	1,682
R-squared	0.501	0.527	0.475	0.438	0.472
PANEL B. Sample Counties: Low Distance					
Post×Exposure	0.012	-0.040*	0.026	0.099***	0.113**
	(0.041)	(0.019)	(0.032)	(0.029)	(0.044)
Observations	648	785	850	778	651
R-squared	0.527	0.626	0.509	0.408	0.505
PANEL C. Sample Counties: High Distance					
Post×Exposure	0.063*	-0.031	-0.056*	0.051	0.386***
	(0.034)	(0.018)	(0.031)	(0.039)	(0.070)
Observations	1,717	1,881	1,866	1,442	1,031
R-squared	0.511	0.514	0.488	0.469	0.535
Time Varying Bank Controls	✓	✓	✓	✓	✓
Bucket-Time FE	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓
County-Time FE	✓	✓	✓	✓	Âŧ✓

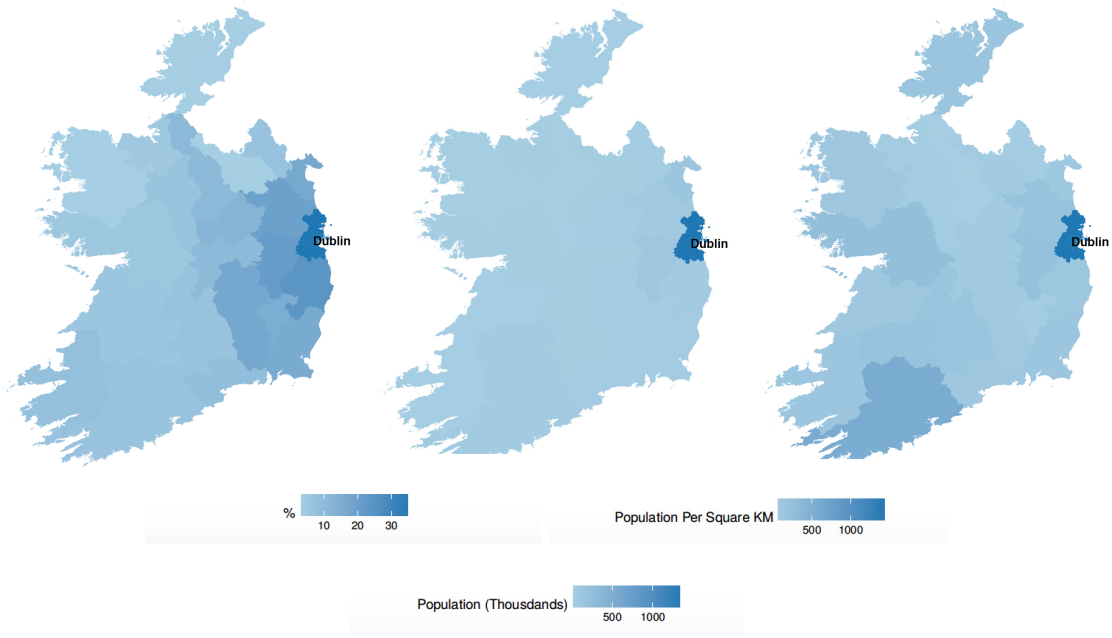
This table presents the results from specification (3.5) using the value-weighted default probability as the dependent variable. The sample period includes 24 months and runs monthly from February 2014 to January 2016. The unit of observation is county-month-bank-income bucket. Income quintiles are adjusted monthly for wage inflation. *Exposure* is defined in (3.4), and *Post* is a dummy equal to 1 from February 2015 to January 2016. Time-varying bank-level controls include the logarithm of total assets, equity capital ratio, and the ratio of loans to total assets. All control variables are lagged by one period. Standard errors double clustered at the bank-county and month level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Central Bank of Ireland.

3.2.10 Appendix

Additional Figures

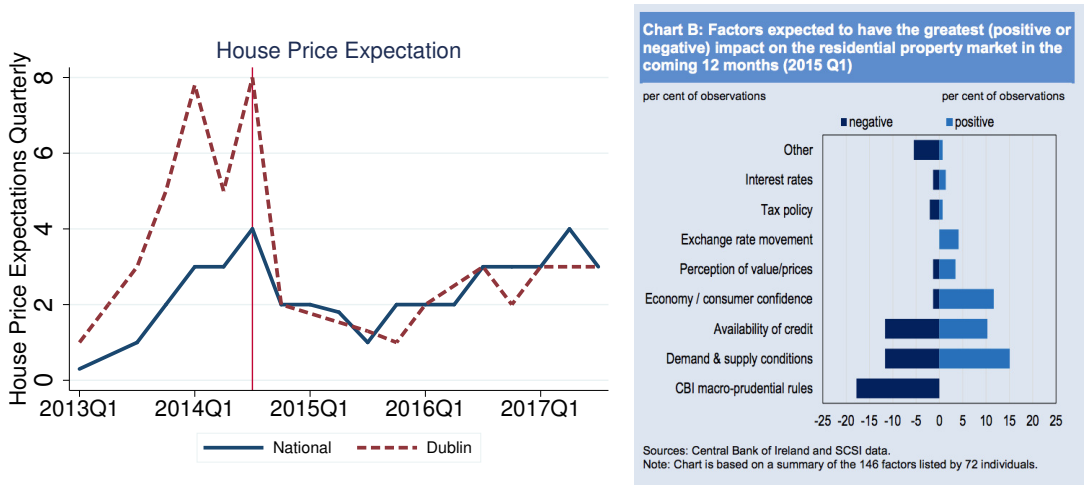
Figure 3.16: Demographics and House Price Appreciation Across Counties

Pre-Policy House Price Appreciation Population Density Distribution of National Population



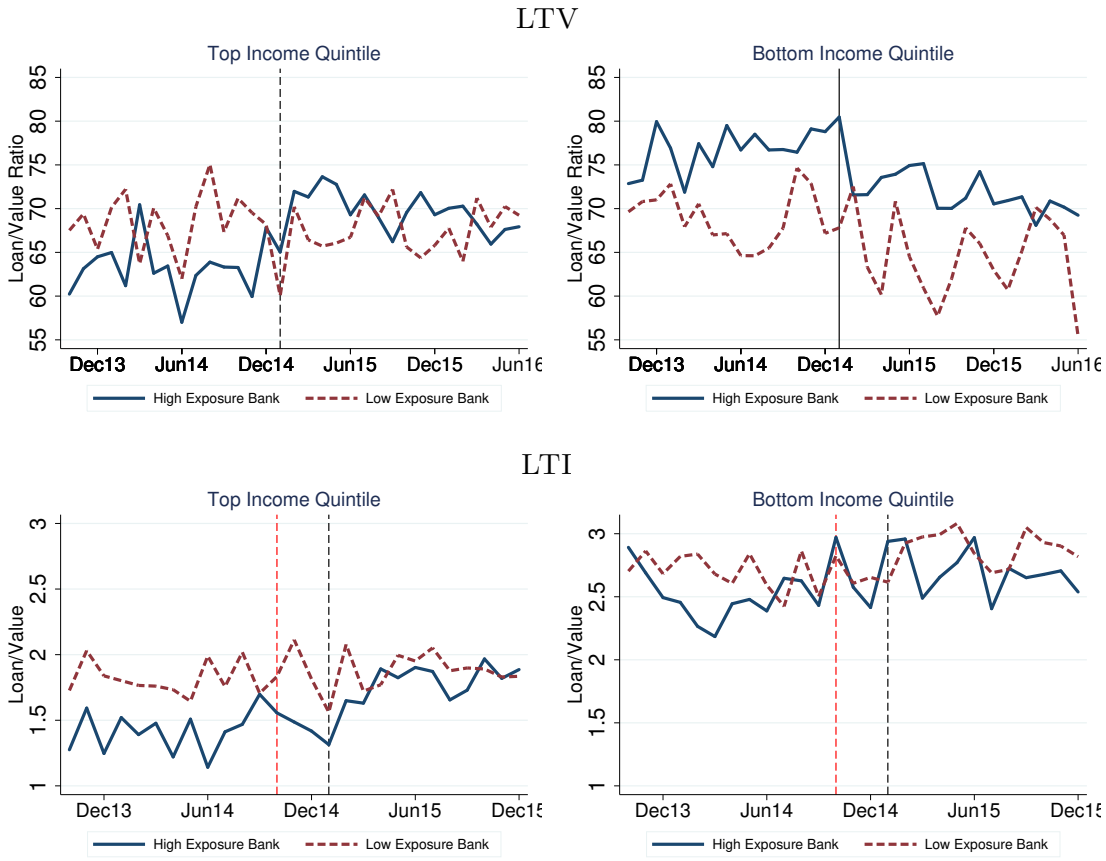
The left panel of this figure shows county-level population. Darker colors indicate more densely populated counties. The right panel shows county-level increase in house prices from their lowest point after the bust to September 2014. Darker colors indicate sharper a larger increase in house prices. Source: Central Bank of Ireland, Daft.ie

Figure 3.17: House Price Expectations



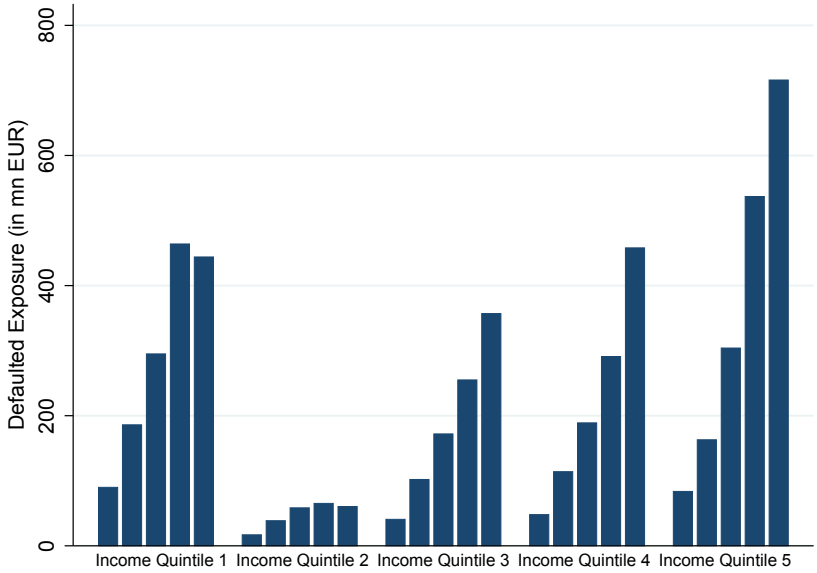
This figure shows survey evidence suggesting that the announcement of the lending limits caused households to revise their expectations about house prices downward, especially in low-distance counties. The left panel shows the evolution of house price expectations in Dublin (dashed line) and at the national level (solid line) at a quarterly frequency. The right panel shows a breakdown of factors affecting expectations in 2015Q1. Source: Central Bank of Ireland.

Figure 3.18: LTV and LTI, High and Low Exposure Banks, Top Income Quintile Vs. Bottom Income Quintile



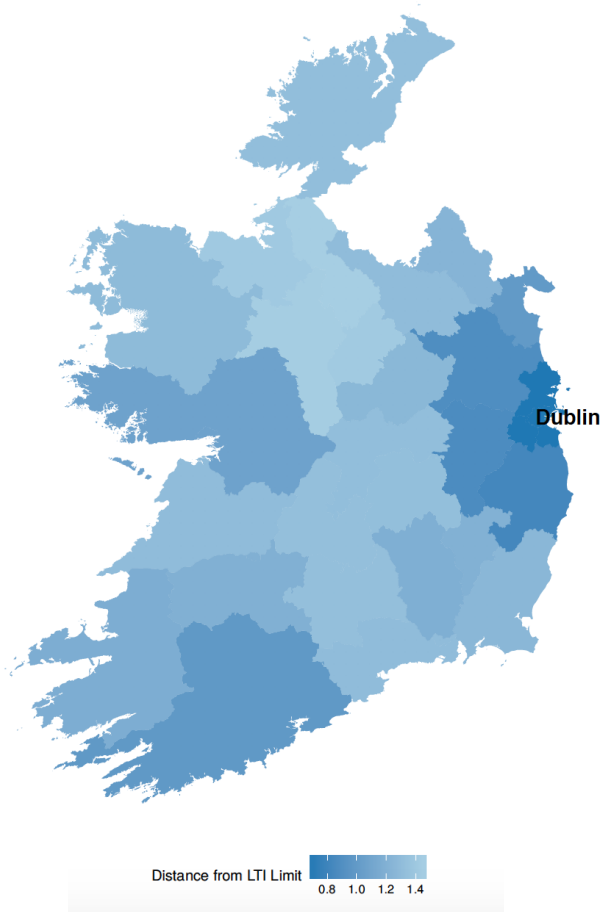
This figure shows the evolution of LTV (top panel) and LTI (bottom panel) of mortgage issuance by high-exposure (solid line) and low-exposure (dashed line) banks from October 2013 to June 2016. Blue lines corresponds to high exposure banks (exposure above median). Red lines corresponds to low exposure banks (exposure below median). Income quintiles are obtained from the January 2014 income distribution and adjusted monthly for Irish wage inflation. Source: Central Bank of Ireland.

Figure 3.19: Defaulted Exposure accumulated during the run-up to the Financial Crisis



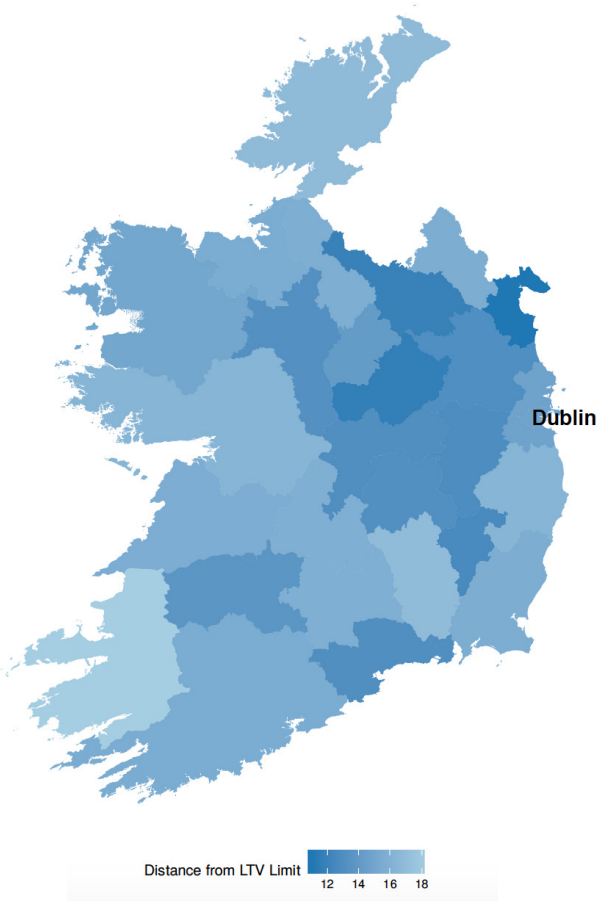
This figure shows the defaulted exposure of Irish banks from 2000-2012. The bars represent the loss of the individual LTV Quintiles which are shown in an ascending order from left to right within each income quintile. It is calculated by multiplying the default intensity for a bucket with the total original exposure of the bank in that bucket. We create 25 buckets based on income and LTV quintiles where the former is scaled according wage growth figures. Source: Central Bank of Ireland.

Figure 3.20: Counties and LTI Lending Limits



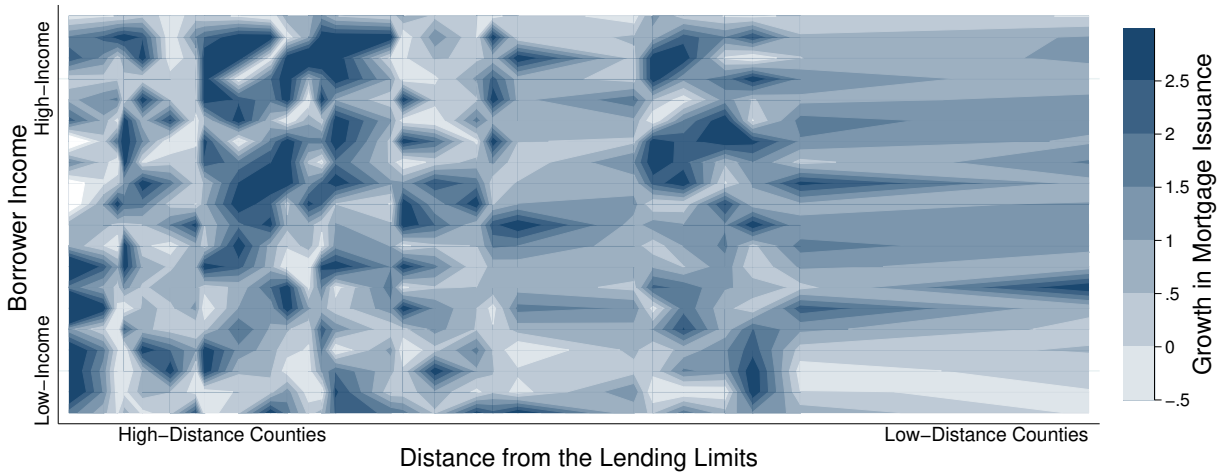
This figure shows county-level distance from the LTI lending limits. Darker colors indicate counties that are less distant. Source: Central Bank of Ireland.

Figure 3.21: Counties and LTV Lending Limits



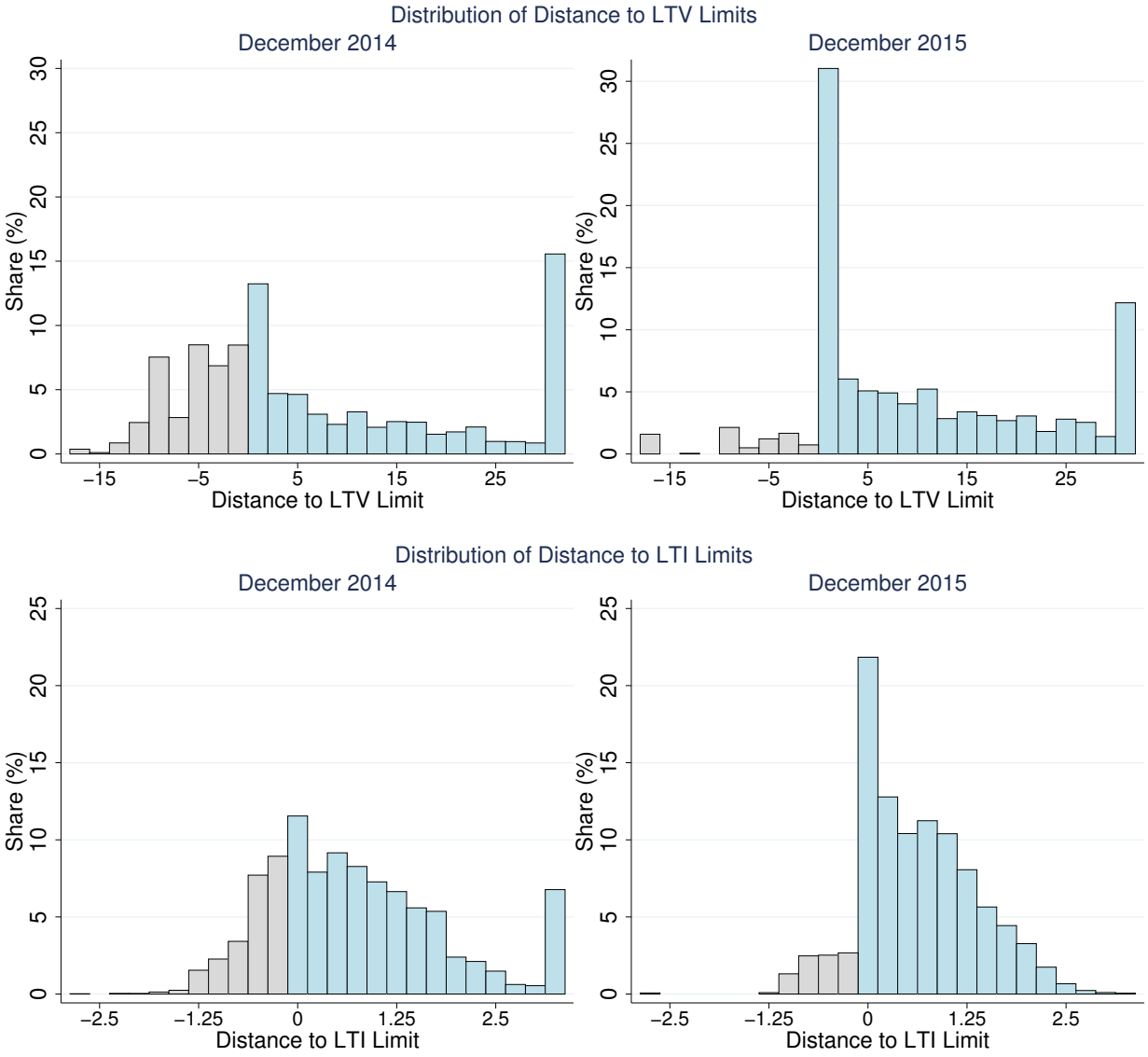
This figure shows county-level distance from the LTV lending limits. Darker colors indicate counties that are less distant. Source: Central Bank of Ireland.

Figure 3.22: Reallocation of Mortgage Credit, Placebo



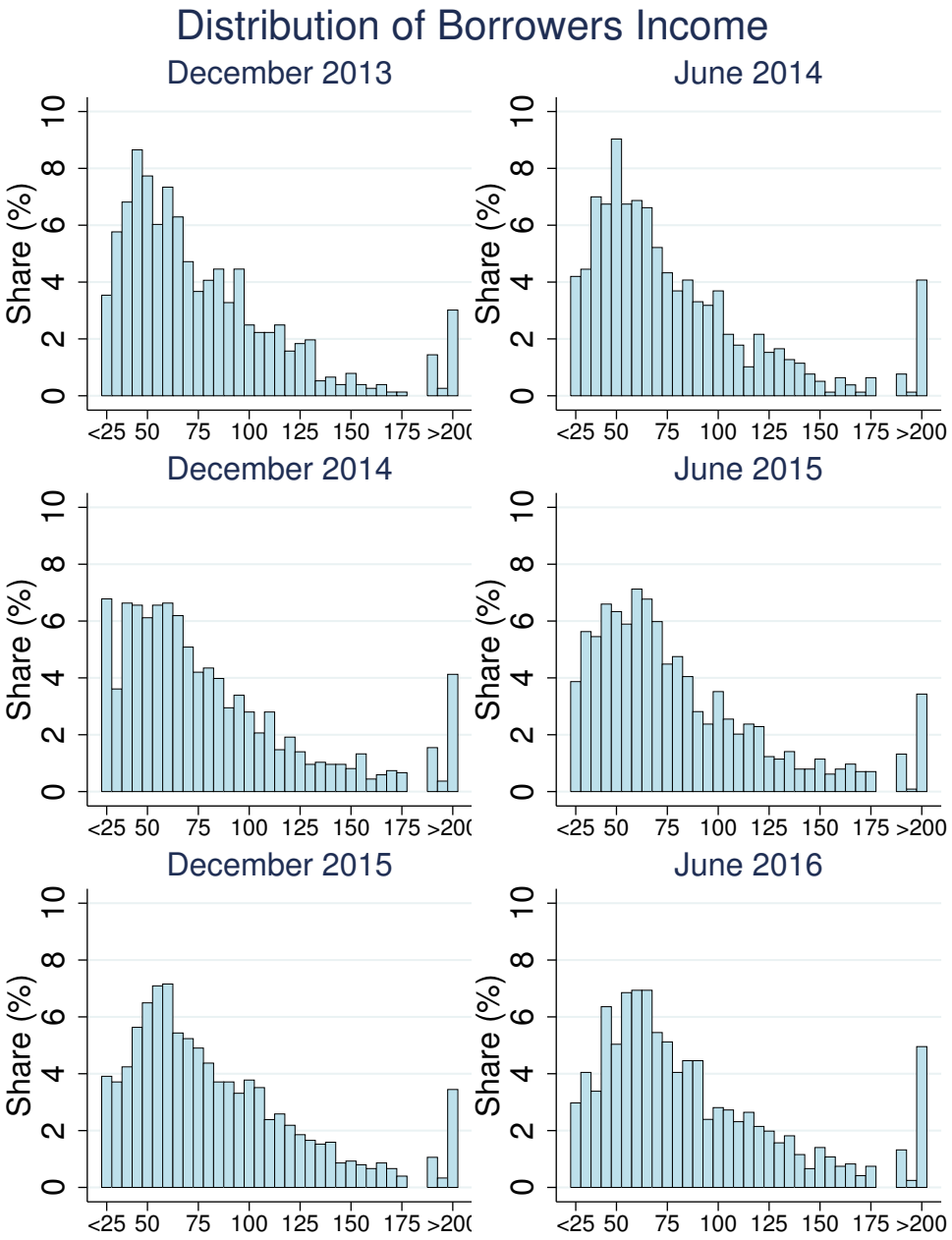
This figure shows the growth of mortgage credit across counties and the across the income distribution of borrowers before the policy implementation. The x-axis shows counties ranked according to their distance from the lending limits. The y-axis shows borrowers ranked according to their position in the income distribution (20 ventiles). Each point in the map indicates the change of mortgage issuance in the post-period (February 2014 to January 2015) compared with the pre-period (February 2013 to January 2014). Darker colors indicate higher growth of mortgage issuance, as indicated by the legend on the right.

Figure 3.23: Distribution of Distance to Lending Limits



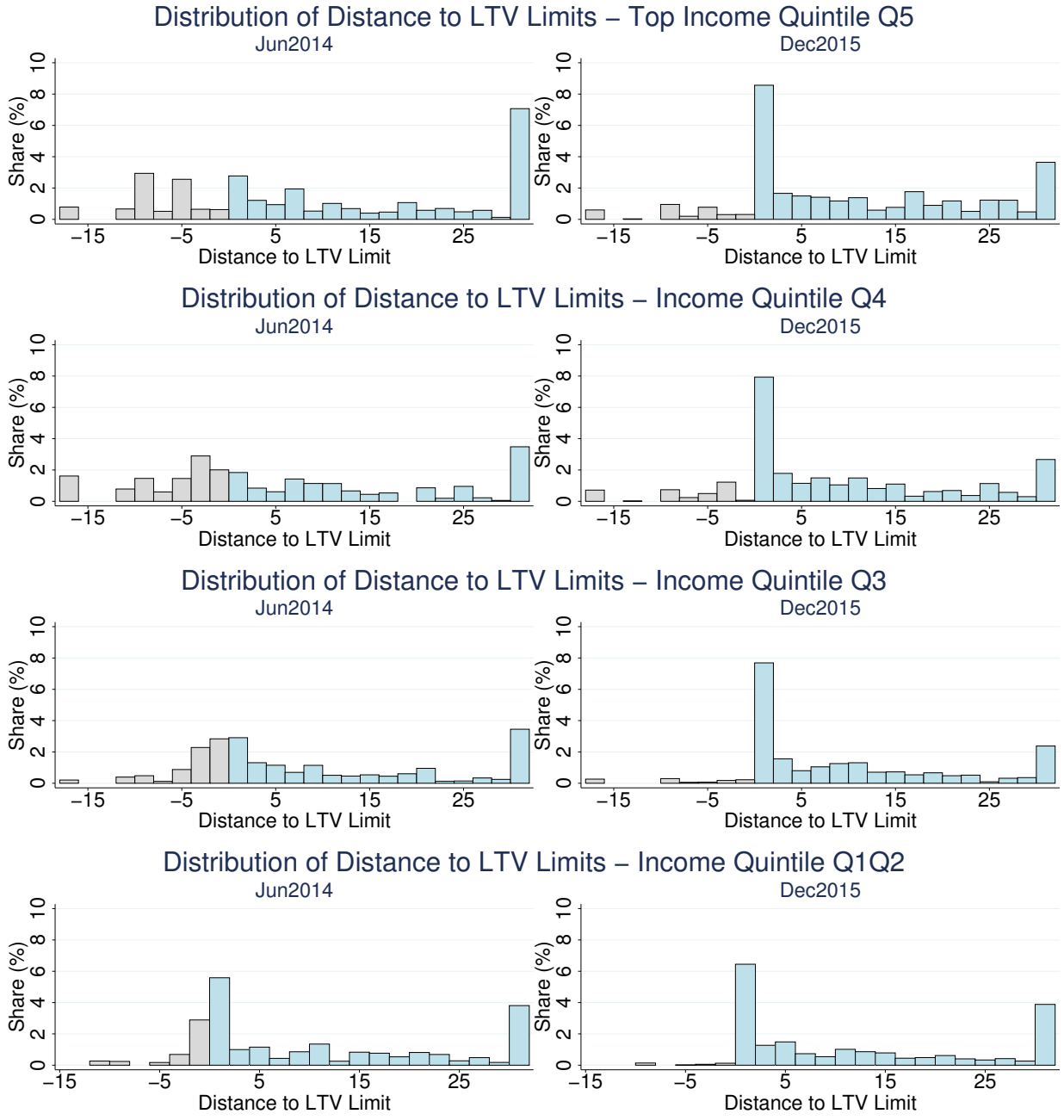
This figure shows the distribution of the distance to the lending limits. The top panel shows the distribution of the distance to the LTV limits. The bottom panel shows the distribution of the distance to the LTI limit. The left figures are the share of total mortgage issuance volume. The right panels are the share of total number of mortgages issued. Grey bars indicate non-conforming mortgages. Blue bars indicate conforming mortgages. Source: Central Bank of Ireland.

Figure 3.24: Evolution of Distribution of Borrowers' Income



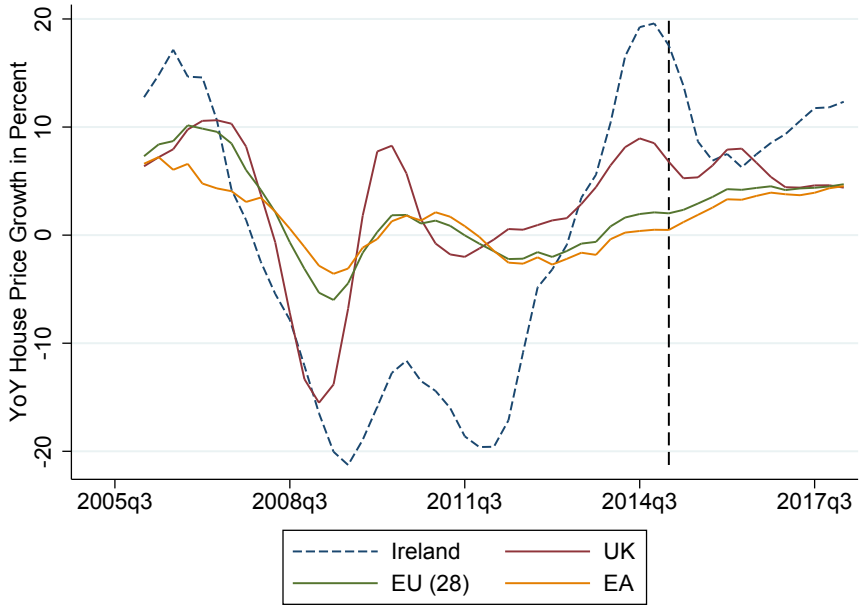
This map shows the evolution of the distribution of borrowers' income at a semi-annual frequency from December 2013 to June 2016. We group households who receive a mortgage at time t in buckets of €5,000 from €25,000 to €200,000 on the x-axis. The y-axis shows the share of total issuance at time t in each bucket. *Source: Central Bank of Ireland.*

Figure 3.25: Distribution of Distance to LTV Lending Limits, by Borrower Income



This figure shows the distribution of the distance to the LTV lending limits. Each row corresponds to an income quintile, except the last row that combines the two bottom quintiles. Income quintiles are adjusted monthly for wage inflation. The distributions on the left (right) panel are measured in June 2014 (December 2015). Grey bars indicate non-conforming mortgages. Blue bars indicate conforming mortgages. Source: Central Bank of Ireland.

Figure 3.26: House Price Growth Outside Ireland



This figure shows house price growth (YoY) for Ireland, the U.K., the Euro Area, and the European Union (28). The vertical dashed line indicates the introduction of the lending limits. Source: Eurostat.

Additional Tables

Table 3.23: House Prices, Number of Bedrooms, Borrower Income

	Income Quintiles				
	Q1	Q2	Q3	Q4	Q5
LHS: House Price					
$HP1BR$	0.632	0.779**	1.131**	0.0431	-0.796
	(0.399)	(0.394)	(0.439)	(0.657)	(1.030)
$HP2BR$	-1.315***	-1.568***	-2.492***	-2.280***	-2.441*
	(0.391)	(0.379)	(0.449)	(0.736)	(1.266)
$HP3BR^{+}$	0.593***	0.717***	1.070***	1.496***	2.314***
	(0.156)	(0.154)	(0.184)	(0.299)	(0.519)
Observations	1,862	2,356	2,752	2,339	3,323
R-squared	0.155	0.206	0.183	0.178	0.189

This table shows the estimation results for the following specification: $CollateralPrice_{lct} = \alpha + \beta_1 1BRHP_{ct} + \beta_2 2BRHP_{ct} + \beta_3 3BR^{+}HP_{ct} + \epsilon_{lct}$. The unit of observation is loan l, county c, and quarter t. The dependent variable is the price of the residential property used as collateral (from the credit registry data). The independent variables are the house prices (from the county-level house price data) for one-bedroom properties, two-bedroom properties, and three-or-more-bedroom properties. The specification is estimated separately in each quintile of the borrower distribution. Source: Central Bank of Ireland, Daft.ie.

Table 3.24: Aggregate Balance Sheet

Balance Sheet Item	**Unit**	**Jun14**	**Dec14**	**Jun15**	**Dec15**	**Jun16**
Total Assets	billion €	344	336	325	298	281
Liquid Assets	billion €	118	118	114	108	103
Dom. Govt Bonds	billion €	18	19	16	17	15
Loans	billion €	190	184	176	168	160
Households	billion €	79	81	78	77	73
NFC ($<$ 1Y)	billion €	19	17	14	10	9
NFC ($\geq$ 1Y)	billion €	40	38	34	32	32
MFI	billion €	38	36	39	38	37
ICPF	billion €	14	11	11	10	10

This table shows the aggregate balance sheet of our sample banks from June 2014 to June 2016. Source: Central Bank of Ireland.

Data Sources

- Data on Lending including loan and borrower characteristics
  - Data on mortgages in Ireland and abroad:
    - up to Jan 2015: Loan Level Data from the Central Bank of Ireland (Financial Stability Division)
    - Jan 2015 - June 2016: Monitoring Templates from the Central Bank of Ireland (Financial Stability Division)
  - Data on commercial lending in Ireland and abroad: Central Bank of Ireland (Financial Stability Division)
- Quarterly Security Holdings: Central Bank of Ireland (Statistics Division)
- Monthly Balance Sheets: Individual Balance Sheet Items (IBSI) survey from the ECB
- County-level house prices from daft.ie (`https://www.daft.ie/report`).
- Regional house prices from Central Statistics Office (CSO) of Ireland

The loan specific characteristics include

- Date of loan origination
- Amount outstanding (current and at origination)
- Interest rate and interest type (current and at origination)
- Data on collateral (location, type, purpose, and value; all at origination)

The borrower specific characteristics (all measured at origination of the loan) include

- Type of Borrower (FTB, SSB, BTL)
- Age, marital status, occupation
- Total household income. For one of our banks, this is missing from 2010-2014 but is available before and after this period. As we expect heterogeneity in the risk taking of the different banks in our sample, we cannot just assume that income will be the same for similar borrowers across banks. Therefore, we use the period where we do obtain all the data to construct a scalar that measures how income of costumers of this specific bank behaves differently from all other borrowers. For the period we do not have income data for this specific bank, we then take the average income of a similar borrower in terms of loan- and borrower characteristics and multiply it with the scalar.

Calculation of County-level Distance

To calculate the average distance from the lending limits in a county we proceed in several steps:

1. For each mortgage in our sample during the 12 months before the announcement of the macroprudential regulation (October 2013 - September 2014) we calculate the distance of the mortgage from both the LTV and the LTI limit that applies to this mortgage.

2. If the mortgage was exceeding the limit (i.e., would have violated the lending limits, had they already been in place), we set the distance equal to zero.

3. This leads to an average distance in our sample of 14.69 for the LTV limit and 0.94 for the LTI limit. In order to compute the average distance across both limits for each mortgage, we have to rescale the distances.

4. We rescale both the distance from the LTV and the distance from the LTI limit to have a mean of zero and a standard deviation of one. The average distance (across both limits) of a particular mortgage is then calculated as the average of the rescaled LTV distance and the rescaled LTI distance for any given mortgage.

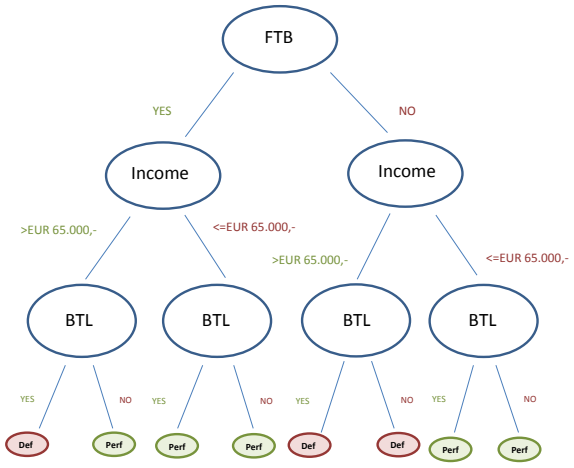
5. In a last step we calculate the mean of the mortgage-level average distance at the county level (measured from October 2013 - September 2014) to arrive at our measure of how distant a county is from the lending limits in the pre-regulation period ($Distance_c$).

Machine Learning Technique

We follow Mullainathan and Spiess (2017) and use a machine learning approach for the evaluation of the risk, i.e. the probability of default, of new loans issued after the start of the macroprudential regulation. The intuition is that we let past data tell us which predictors are significant for mortgage default instead of manually picking variables to include in standard stress testing, like it is the case for standard OLS or logit hazard models. Thus, we hope to be able to uncover generalizable patterns which can be used for default predictions on the on current loan book of banks.

More specifically, we estimate the determinants of default with a random forest model. This supervised algorithm can be used for classification, in our case to determine whether is performing or not. As our data provides the standard loan and borrower characteristics, the random forest will then consist of various regression trees where each one will use a random selection of the available variables (see Figure 3.27).

Figure 3.27: Example of a Tree



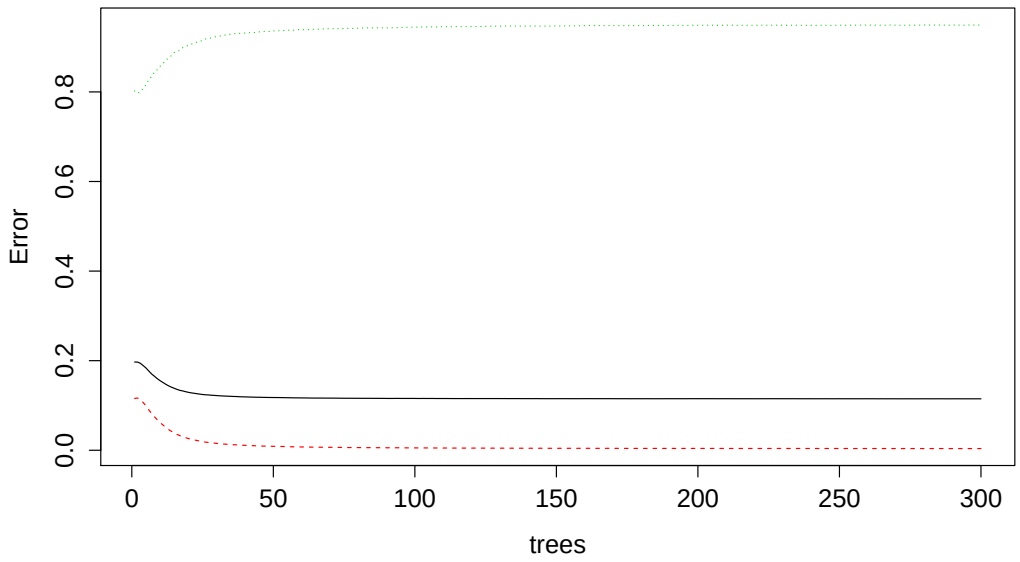
More specifically, our analysis itself involved 3 steps

1. **Fine-Tuning of the model** where we supervise the algorithm in order to get the highest accuracy possible for the prediction of default
2. **Estimating the model** using the resulting optimal model on data covering past loans where we have data on default
3. **Predicting default** of new loans issued after the start of the macroprudential regulation including a short analysis of the determinants of default in this model

(1) Fine Tuning of the Model

One of the reasons why random forest is often referred to as the most popular algorithm for econometricians is that the supervisor only has to decide on two characteristics of the process: (i) the number of trees and (ii) the number of variables (nodes) in each tree. We use straight forward measures in order to establish the optimal choice for these two determinants. In order to find the optimal number of trees, we run our model with a large number of trees (500) and check graphically where the error does not decrease significantly anymore. As can be seen in Figure 1, our model almost stops to improve at around 100 trees. As there is a trade-off of the number of trees and the computational power needed to estimate our model, we choose to use 100 trees for our model.

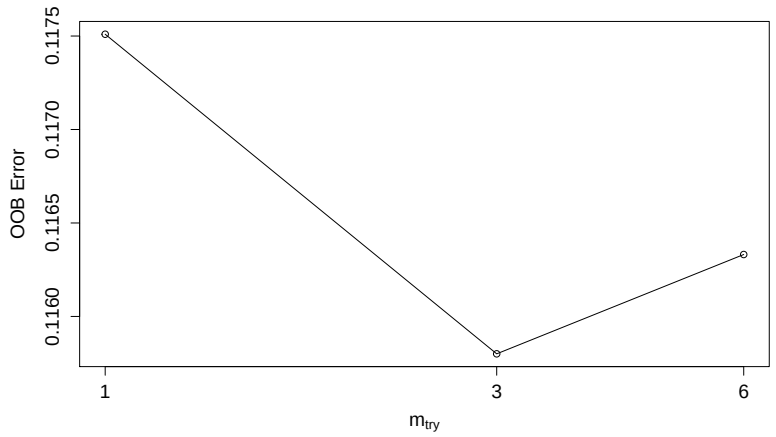
Figure 3.28: Optimal Number of Trees



This graphs whose the average error for the different amounts of trees planted in the forest.

As a second step, we use a fine tuning mechanism embedded in the R-package *RandomForest* in order to determine the optimal number of variables. Figure 3.29 shows that the Out-Of-Bag Error is the smallest when we use 3 variables for each tree. This graph is the result when we fine-tune our forest with 100 trees according to our findings in Figure 3.28, but is robust to the same fine tuning mechanism for bigger forests (300 or 500 trees).

Figure 3.29: Optimal Number of nodes for each Regression Tree



This graph shows the average OOB (Our of Bag) Error for the different amounts of variables randomly selected for each Regression Tree.

(2) Estimating the Model

For the second step, we use data on loans defaulted in the past to estimate the model. Our data consists of a snapshot of all outstanding loans in June 2012 and its characteristics. As this is the earliest snapshot available, we capture the maximum amount of loans where we have information on whether default happened or did not happen. Therefore, we capture a significant part of mortgage issuance from 1995 onwards. [148]
We feed the algorithm with the following

- **Loan Characteristics**: Loan-to-Value Ratio, Value of Collateral, Loan Amount, Loan-to-Income Ratio, Interest Rate, Interest Rate Type, Year of Issuance;
  and
- **Borrower Characteristics**: Household Gross Income, Age, County, Marital Status, First-Time-Buyer, Buy-To-Let;

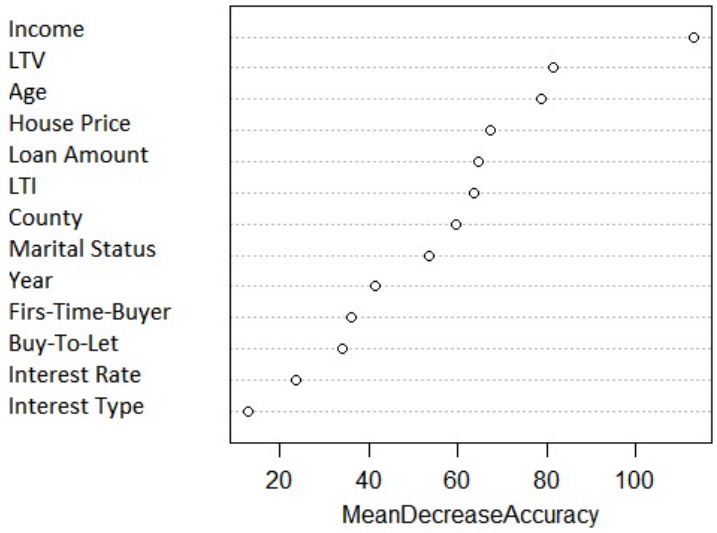
[148] We also have information whether a loan issued after the introduction of macroprudential policies is performing or not. However, we use the earlier data as default is a protracted process which is unlikely to be determined until the end of our data sample (June 2016) if loans are issued after January 2015. We argue that by using data that includes a significant part of mortgage issuance from 1995, we can be more confident about the precision of our NPL variable.

(3) Predicting Default

Finally, we use the estimated trees to predict default for newly issued loans based on their characteristics. In both datasets we standardize all variables with a (strong) time trend[149]. This is necessary in order to get precise coefficients which will only be possible if the value of a variable is comparable over the two data sets.

In contrast to a simple OLS or a logit hazard model, it is not usual to interpret coefficients and their signs as every tree represents different versions of regressions and interaction terms. What we can show, however, is the importance of variables, i.e. which characteristics are determining default and which attributes are only weakly correlated with default. Figure 3.30 shows how much the accuracy[150] of the model would decrease if the variable were excluded from the estimation. We can see that (standardized) income has the strongest prediction power for default, followed by LTV.

Figure 3.30: Importance of Variables



This graph shows the loss of Accuracy if variables would not be included in the Model.

[149] Household Gross Income, House Price, Loan Amount

[150] This refers to a decrease in accuracy over all out-of-bag cross validated predictions, when a given variable is permuted after training, but before prediction.

Chapter 4

General Conclusions

This thesis sheds light on different questions in the fields of international finance and empirical banking that are concerned with financial as well as macroeconomic stability. The five essays contained herein examine investment patterns from an academic perspective using newly available microeconomic data.

The first part contains three essays which analyse the determinants of international capital flows. More specifically, in the first paper, I analyse the divergence of the net international investment position accompanying the stark current account adjustment in the post-crisis period. In a first step, I find that the increasing divergence is driven by remaining flow imbalances. Although current accounts are below pre-crisis levels, only very few countries have reversed their current account so that external debt or credit could have been reduced. In other words, the speed of accumulation of debt/credit has decreased but not stopped which caused stock balances to diverge further in the post-crisis period. In contrast to flow imbalances, however, changes in the valuation of international investment went into a stabilising direction: countries with the lowest net international investment position experienced the highest valuation gains while creditor countries such as Germany experienced significant losses through the valuation of their foreign assets. I argue that without these capital gains and losses, stock imbalances would be at significantly higher levels. Analysing this effect of valuation further, I show that the stabilising effect of changes in valuation was exclusively driven by the equity component of net international investment positions. A relatively greater decrease of the stock market in countries with a more negative net international investment position significantly contributed to international risk sharing. This paper contributes to a better understanding of cross country links that emerged with increasing financial integration in the last two decades. With changes in valuation moving in an overall stabilising direction during the recent global financial crisis, the question remains whether countries can "engineer" capital gains and hence actively improve international risk sharing through their foreign stock positions. The findings are relevant for policy makers as a more interconnected financial

system calls for improved risk sharing. I find two contrary mechanisms for countries with an exchange rate peg, such as Euro Area countries: while non-negotiable debt instruments such as bank loans caused destabilising valuation effects, risk sharing through portfolio equity was more significant than for any other country group in the sample. In the absence of a banking union and without independent monetary policy or a floating exchange rate, these mechanisms could represent an efficient way of risk sharing and should therefore be observed more closely. In the second paper, my co-author and I take the analysis of valuation effects and capital flows to the micro level: we use confidential data on all security holdings in the euro area to analyse the effects of valuation effects on investment patterns at the micro level. Rather than rebalancing assets towards constant portfolio shares, net purchases of a given security were larger (smaller) when a relatively higher (lower) valuation gain was recorded. This pattern is driven by securities denominated in foreign currency where the effect from exchange rate dynamics is significantly stronger than the effect from price movements. For these assets, momentum investment is stronger and significantly correlated with the expectations about the issuer country's economic outlook. Thus, our findings suggest that investors shift their targeted portfolio shares according to their expectations of the future economic performance of the group of issuers. Due to the granularity of the micro data used in this paper, we can also document that momentum investment is particularly strong for institutional investors as well as in countries less affected by the recent global and euro area financial crises. Our findings are important for policy makers as well as for issuers of securities. Knowing the investor base and their investment patterns of different asset classes improves the ability to predict reactions to changes in the financial environment. Investors who conduct momentum investment can increase the probability of sudden stops and surges in capital flows with repercussions to the real economy, for instance by reinforcing the procyclicality of domestic credit growth. We argue that these considerations are currently important for several reasons. First, euro area monetary policy is expected to normalise over the next years which is very likely to affect the conditions on financial markets. Second, we recently observed turmoils in several emerging markets where euro area investors hold a significant share of outstanding debt. In this regard, we emphasise that our findings indicate that momentum investment is driven by periods of valuation gains, rather than losses, and targeted at countries with an improving economic outlook. Thus, while our period of observation was largely characterised by increasing asset prices, our results indicate that in periods of falling asset prices, euro area investors may not automatically reverse their investments. Following the intuition of the work by Warnock et al. (2016) and Meng and van Wincoop (2018) who break down capital flows into portfolio growth and portfolio reallocation components, we argue that the role of portfolio growth is also an important factor. Euro area investors experienced strong portfolio growth of approximately 20 percent in the last five years. In line with our findings for the euro area, Meng and van Wincoop (2018) show that portfolio growth and reallocations from domestic to

foreign securities account for most of US capital flows to individual countries, while portfolio growth proves very persistent. Therefore, portfolio growth and its persistence are additional reasons why the normalisation of euro area monetary policy or turmoil in foreign markets may not automatically entail large readjustments in euro area investors' portfolios.
For the third paper, we use the event of the ECB's Asset Purchase Programme to analyse the portfolio rebalancing it induced in the euro area. Our regression analysis confirms our hypothesis that euro area investors significantly rebalanced away from individual securities targeted under the ECB's quantitative easing. In particular, OFIs show rebalancing as they invested significantly in assets defined as closest substitute to the PSPP-eligible securities, in line with preferred habitat motives, underlining the impact of the PSPP on international capital flows. Moreover, we find that NFCs and households were significant net sellers of euro denominated assets and especially PSPP eligible assets. Households in particular made use of investment funds to gain exposure to foreign sovereign debt. We also show that investors rebalanced into securities with longer maturities. This was particularly pronounced for ICPFs, in line with the duration risk and preferred habitat channels. Overall, net purchases of securities with a maturity exceeding 10 years made up 50% of net debt purchases. We also observe overall evidence for a rebalancing away from euro-denominated debt securities, in line with the signalling channel associated with quantitative easing. Our results show that euro area investor's shift towards foreign debt was broad-based across sectors, thereby creating global spillovers from the ECB's policies, but mainly targeted at other advanced economies, in contrast to the patterns observed for US investors following QE. We also investigated potential anticipation effects of the PSPP following Mario Draghi's speech at Jackson Hole (2014) and find that euro area investors were indeed net buyers of PSPP eligible securities in anticipation of the programme. Finally, as our dataset also comprises the holdings of individual securities, we are able to decompose overall portfolio rebalancing of euro area investors into 'active' (i.e. capital flows) and 'passive' components (i.e. valuation changes due to fluctuations in asset prices). This analysis reveals the importance of analysing actual transactions rather than proxying these with changes in holdings.

The second part of the dissertation contains essays in empirical banking which focus on lending patterns of banks that can potentially pose risks to financial stability. In the first paper, my co-author and I analyse forbearance patterns of stressed banks in the post-crisis period. We find that risky borrowers are more likely to receive a limit or maturity extension when banks are facing high levels of NPLs relative to their capitalisation and provisions. As a second step, we evaluate the effectiveness of this practice. Using a logit-hazard model, we find that a limit extension is effective in reducing the probability of default up to one year. For longer horizons and other forbearance measures we find a higher probability of default of the risky borrower. While we cannot conclude that the forbearance measures themselves caused defaults, we argue that credit might have been misallocated to the weakest borrowers which were subsequently

not “rescued” from default. In the last part of our empirical analysis, we show that banks with a high share of forborne loans issue lower volumes of new credit. This could result in tighter financial conditions for new firms who might potentially be more productive. Our analysis highlights the importance of the health of banks' loan books. While banks can be well-capitalised ”on paper”, they might be under pressure by high levels of non-performing loans on their balance sheets. We suggest that banks have an incentive not to recognise loans as non-performing and offer an explanation through the regulatory framework. This is crucial for policy makers as uncertainty about the real quality of the loan book, if widespread in the economy, can lead to systemic risk and undermine trust in the banking sector's solvency.
In the final essay, my co-authors and I provide a comprehensive micro-level analysis of the transmission of macroprudential policies aimed at limiting household leverage in the residential mortgage market. Combining loan-level data on residential mortgages with data on bank credit to firms, county-level house prices, and security-level bank holdings of securities, we examine the impact of the February 2015 introduction of LTV and LTI limits in Ireland.We find that banks played a key role in the transmission. Following the policy introduction, banks reallocated their mortgage issuance from low-income to high-income households and from low-distance to high-distance counties. Our effects are consistent with the evolution of house price growth, which stopped increasing at the time of the policy announcement, driven by a collapse in low-distance counties. Consistent with the goal of keeping their risk exposure unchanged, banks increased their risk exposure in credit to firms and holdings of securities, the two largest asset classes not targeted by the regulation. Our analysis of the transmission of macroprudential regulation opens up a promising area for future research. In particular, our results on bank asset allocation naturally call for the development of equilibrium models to measure how macroprudential regulation affects welfare and the the likelihood of busts. Having documented, in a partial equilibrium framework, how limits to household leverage affect bank portfolio choice and house prices, we provide a set of correlations and suggested transmission mechanisms that these equilibrium models should take into account.