Essays on Financial Intermediation and Risk

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To Constanze, Antonia, Snježana, and Michael

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Abstract

This thesis contributes to the understanding of systemic risk in the financial sector and its interrelation to the macroeconomy. The first chapter documents that misallocation of resources increased in the German manufacturing sector during the economic crisis in 2009 and that productivity would have been up to 4% higher without misallocation. Using granular data on bank-firm credit relationships, I find causal evidence that the preceding banking crisis contributed to the increase in misallocation. The second chapter shows stylized facts on interest rate risk management for the population of German banks and investment funds using transaction level data on derivatives. I find that around 50% of banks and funds use interest rate derivatives, funds predominantly use exchange-traded products, and banks manage their risk mostly with OTC contracts. On average, both sectors use interest rate derivatives to hedge their interest rate risk against a rate rise, although there is considerable heterogeneity. The third chapter provides empirical evidence that asset managers use bond futures to counteract valuation losses from physical bond holdings when yields move adversely. Analyzing supervisory mutual fund data, I find that this overlay strategy is more pronounced among funds with higher share of ex-ante longer-term bond holdings, more ex-ante riskier fixed income assets, and higher net outflows.

Resumen

Esta tesis contribuye a la comprensión del riesgo sistémico en el sector financiero y su interrelación con la macroeconomía. El primer capítulo documenta que, durante la crisis financiera de 2009, la mala asignación de recursos en el sector manufacturero alemán aumentó y sin esta mala asignación, la productividad habría sido un 4% más alta. Utilizando datos granulares sobre las relaciones crediticias entre bancos y empresas, encuentro evidencia causal de que la crisis bancaria anterior contribuyó al aumento de la asignación incorrecta. El segundo capítulo muestra hechos estilizados sobre la gestión del riesgo de tipos de interés para la población de bancos y fondos de inversión alemanes, utilizando datos a nivel de transacción sobre derivados. Encuentro que alrededor del 50% de los bancos y fondos usan derivados de tasas de interés. Los fondos usan predominantemente productos negociados en bolsa y los bancos administran su riesgo principalmente con contratos OTC. En promedio, ambos sectores utilizan derivados de tipos de interés para cubrir su riesgo de tipos de interés frente a una subida de tipos, aunque existe una considerable heterogeneidad. El tercer capítulo proporciona evidencia empírica de que los administradores de activos utilizan futuros de bonos para contrarrestar las pérdidas de valoración de las tenencias de bonos físicos cuando los rendimientos se mueven adversamente. Al analizar los datos de supervisión de fondos mutuos, encontramos que esta estrategia de superposición es más pronunciada entre los fondos con una mayor proporción de tenencias de bonos ex ante a largo plazo, más activos de renta fija riesgosos ex ante y mayores salidas netas.

Preface

The financial sector is a large contributor to economic output and has systemic relevance through its interconnectedness with other economic sectors. In its most traditional role banks and other financial institutions intermediate funds between lenders and borrowers. They facilitate investment projects and provide return to financial wealth. At the same time, various threats prone to the financial system create elevated levels of risk to the sector and the economy at large. Commercial banks are highly leveraged institutions, which make them susceptible to economic shocks. Other financial intermediaries, like mutual funds, face fierce competition in the market for funds and are therefore very vulnerable to bad performance. The financial crisis of 2007-08 is a prominent example of how risks in the financial sector can translate into adverse consequences for the broader economy.

This dissertation sets out to make a contribution by analysing risk factors to the financial system and its impact on the macroeconomy using novel datasets. In the first chapter, joint with Puriya Abbassi and Sebastian Wichert, I present new evidence on the relation between financial frictions and aggregate productivity in Germany during the global economic crisis in the late 2000s. First, I document that misallocation of resources (capital and labour) in the German manufacturing sector increased during the economic crisis and that productivity would have been up to 4% higher without this increase. Second, using granular data on bank-firm credit relationships, I provide causal evidence that a bank lending cut during the financial crisis was a driving force behind this increase in misallocation. My results have important policy implications. While previous research largely agrees that the solvency of the banking system is a crucial determinant of economic output, I show that it has an important impact on aggregate productivity as well. Thus, ensuring a resilient banking system is a first order concern for government officials.

Opacity in the derivatives market has been a major concern during the financial crisis in the United States, when policy makers decided whether to prevent the insolvency of the insurance company AIG. Authorities were forced to make critical decisions despite being uncertain about risks emanating from the derivatives market. In the second chapter, joint with Puriya Abbassi and José-Luis Peydró, I present new facts about interest rate risk management with over-the-counter (OTC) derivatives and exchange traded derivatives (ETDs) on the population of German banks and open-end investment funds.

Exploiting supervisory data on derivative contracts between 2017 and 2018, I document several new empirical findings: First, around 40% of funds and 50% of banks use interest rate derivatives (IRDs). Second, while funds predominantly use ETDs, banks manage their interest rate risk mostly with OTC contracts. Moreover, banks that also utilize ETDs tend to have a larger trading book and cash positions. Next, I quantify interest rate risk from the ETD and OTC derivatives market for the cross section of funds and banks at quarterly frequency with own model calculations. On average, both sectors use IRDs (OTC and ETD) to hedge their interest rate risk against a rate rise. Strikingly, while only few funds use OTC derivatives, I estimate that those institutes have a much higher exposure than from ETDs. Banks, as expected, have a large exposure from OTC and not ETD contracts. My research implies that macro supervisors in financial stability and monetary policy decision makers should pay close attention to interest rate derivatives when assessing interest rate risk, given their importance in the financial system.

In the third chapter, joint with Puriya Abbassi, I analyse the dynamic trading behaviour in derivatives of open-end investment funds in response to changes of long-term yields. Compared to the second chapter of my thesis, the focus is more on the incentives behind interest rate risk management with derivatives. In order to achieve a better understanding of risk factors in the financial system, it is crucial being able to predict reactions in response to macroeconomic developments and what attributes drive these changes. In this chapter, I provide evidence that asset managers use bond futures (short positions) to counteract valuation losses from physical bond holdings when yields move adversely (increase). Analyzing supervisory mutual fund data, I find that this overlay strategy is more pronounced among funds with (i) higher share of ex-ante longer-term bond holdings, (ii) more ex-ante riskier fixed income assets and (iii) higher net outflows (more illiquidity), but (iv) weaker for funds with insurance investor base. My results hold important policy implications. First, they shed light on the risk management behaviour of mutual funds, i.e., one of the most important fixed income investors in today's financial markets. They suggest dynamic and active employment of overlay strategies to offset interest rate risk exposure when yields move adversely. Thus, my results suggest that bond futures are an important tool to avoid losses in a rising rates environment. At the same time, my findings speak to the notion that bond futures may be used to augment desired interest rate exposure in the existing portfolio when yields are decreasing. The latter, in essence, is a form of leverage and should be closely monitored by macroprudential policy makers.

This dissertation is an attempt to shed light on important aspects of the functioning of our financial system. The overarching goal of writing this thesis is to make the economy safer and less vulnerable to shocks.

Lastly, let me state that the views expressed in this dissertation are solely those of the authors and do not necessarily represent the views of the institution, to which the authors are affiliated.

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CHAPTER 1

MISALLOCATION, PRODUCTIVITY, AND CREDIT SUPPLY SHOCKS: MICRO-EVIDENCE FROM THE GERMAN FINANCIAL CRISIS

Joint with Puriya Abbassi and Sebastian Wichert

1.1 INTRODUCTION

More than one decade ago, Europe and the US have experienced its worst financial crisis and recession since world war two. It is generally believed that a reduction of credit supply by banks has exacerbated the downturn in economic output (e.g. Chodorow-Reich 2014). While previous studies show that the banking crisis led to a reduction in output, its effect on productivity is less clear. In this paper, we want to analyse how a credit supply shock, induced by the German banking crisis of 2007/08, affected the country's productivity and allocation of production factors.[1]

There are, in principle, two ways how the productivity at the country level can be affected by credit market frictions. First, a firm that loses access to funding might be forced to cut on its R&D investment, which leads to a reduction in the productivity growth of the individual company (e.g. Aghion, Angeletos, Banerjee, and Manova 2010). Hence, if a sizeable amount of companies cannot borrow, this can lead to aggregate productivity losses in the whole economy through the accumulation of productivity losses at the individual firm level. Second, imagine the country is populated only by a total of two companies. One of them is highly productive, while one has low productivity. In an ideal world, the high productivity firm has relatively many resources (capital and labour), that

[1] Total Factor Productivity decreased by 4.1% in Germany during 2009, marking the biggest decline since the 1950s (University of Groningen and University of California, Davis 2020).

is, it is large, whereas the low productivity firm is kept small in size. However, taking capital or labour from the high productivity firm and giving it to the low productivity firm can harm the total productivity of the country. We define the optimal allocation of resources formally later, but intuitively speaking resource misallocation occurs whenever productivity losses result from capital and labour not being distributed to its most productive use (Hsieh and Klenow 2009).

In this paper, we will focus on aggregate productivity losses emanating from misallocation of resources across firms instead of productivity losses of individual companies. Our hypothesis is, that a contraction in lending reduced resource accumulation of productive firms and this harmed aggregate productivity of Germany during and after the financial crisis. More precisely, we establish that certain banks cut credit supply due to financial problems during 2007/08. Based on bank – firm credit relationships before the crisis, we then assess the degree of credit fallout during the crisis for the individual company. In order to analyse the effect of the credit shock on misallocation, we follow the model of Hsieh and Klenow (2009), which builds upon a Krugman type model of monopolistic competition. All estimates of productivity and our understanding of misallocation is guided by this model. For implementation we make use of the German credit register, provided by Deutsche Bundesbank (the German central bank) and several vintages of the firm level dataset Amadeus, provided by the private company Bureau van Dijk.

Our research has two primary results. First, we document that misallocation of resources increased in the German manufacturing sector during the financial and economic crisis between 2008 and 2009 and that this increase induced productivity losses. More precisely, following Hsieh and Klenow (2009), we measure misallocation of resources as the standard deviation of within sector revenue TFP (TFPR). We find that the standard deviation increased, with a peak in 2009, by around 4% and model calculations suggest this resulted into aggregate productivity losses of around 2 – 4%. Put differently, without misallocation we estimate that aggregate productivity of German manufacturing would have been 2 – 4% higher during the economic crisis in 2009. Interestingly, both misallocation and productivity losses sharply reduce to pre crisis levels by 2011. Thus, the reason for the inefficiency seems solely contained to the financial and economic crisis in 2008 and 2009. In order to shed light on the source of friction causing this misallocation, we decompose the variation in TFPR into its two components marginal revenue product of capital (MRPK) and marginal revenue product of labour (MRPL). We find that the standard deviation of both MRPK and MRPL increases during the crisis in similar magnitudes. Thus, the increase in misallocation is not the result of a certain friction affecting only the labour or capital market. But rather it is the effect of an output friction, a friction affecting the labour and capital market, or several frictions at once. We also analyse the correlation of productivity and firm size (labour and capital) as well as the correlation of productivity and capital/labour market frictions. Both results likewise point to allocative inefficiencies during the crisis in Germany: The correlation of productivity and firm size (labour and capital) decreased, with a trough in 2009, by 2 – 3%; the correlation of productivity and the inverse of MRPK also decreased, with a trough in 2009, by 2 – 3%. Where the latter can be interpreted as saying, that more productive firms are the once being financially constrained. We do not find a decrease in the correlation of productivity and the inverse of MRPL. In summary, all results show that misallocation increased during the crisis and this increase reversed afterwards.

Second, we find firm level evidence that a credit supply shock, induced by the German banking crisis, caused an increase in misallocation and therefore harmed aggregate productivity during the economic crisis. More precisely, we identify a credit supply shock by selecting nine large German banks that had big exposures to the US housing market and financial crisis. These banks were all rescued by the German government due to solvency and liquidity concerns about their losses in the US. Together they comprise around 30% of lending to non-financial firms and therefore have aggregate implications. Previous research shows that bank – firm relationships are sticky over time and firms cannot easily switch their lenders. Thus, firms with ex-ante (before the shock/ financial crisis) relationships to our *crisis banks* (the nine banks) were likely to be credit constrained during the financial crisis. We can confirm this finding from the literature and show that our crisis banks differentially reduce lending to firms, even when comparing lending of crisis banks and unaffected banks to the same company, exploiting multiple firm – bank relationships. In order to analyse productivity losses we categorize firms according to their pre-crisis relationships with the “bad” banks. For each company we calculate the percentage of credit supplied by bad banks before the crisis. This is our shock variable at the firm level and indicates the exposure to a reduction in credit supply during the crisis.

The main finding of our paper is that treated (shocked) firms differentially increase TFPR during the economic crisis. Thus, under our model assumptions, we empirically show a direct relation between the banking crisis and an increase in misallocation (productivity losses). Interestingly, the increase in TFPR is solely driven by a rise in MRPK; MRPL is not affected. We interpret this as a sign that the banking crisis particularly affected capital market efficiency. This is reasonable as borrowing decisions are traditionally driven by investment opportunities rather than employment decisions. Also, notice the positive sign. As predicted by theory, companies that face borrowing constraints will have larger MRPKs as they cannot accumulate enough resources to equalize their marginal return to the cost of borrowing. The results are robust to including sector-, regional-, and size-bin fixed effects. We also analyse the relation of credit supply and firm TFP. Interestingly, we estimate that TFP of treated firms either increases or stays constant. This is in contrast to other studies that mainly find a negative relation between credit shocks and productivity. In our case, a positive relation is interesting, as it also implies a positive relation between productivity and MRPK. Intuitively, it means that especially productive firms tend to be financially constrained, giving further evidence for misallocation. We also analyse the relation of productivity, TFPR, firm size, and other firm observables with our shock variable in the cross section of 2006 before the financial and economic crisis. It would have important implications if the financial shock were positively related to firm productivity ex-ante. However, we cannot find any robust results supporting this claim. In contrast, we find that our shock variable is unrelated to other firm observables in 2006. And, thus giving support to the exogeneity of our financial shock to other time varying variables.

To the best of our knowledge, this is the first paper to emphasize that Germany experienced a stark increase in misallocation and productivity losses during the financial and economic crisis in 2008/09. Moreover, this is the first paper to link this increase in productivity losses to the German banking crisis. By analysing granular data on bank – firm relationships, this paper provides new evidence on the effects of credit supply shocks on misallocation and productivity.

This paper is very closely related to two recent strands of literature that have mainly evolved during and after the financial crisis. The first strand, motivated by the findings of Hsieh and Klenow (2009), emanates from the macroeconomic productivity literature. This area of research is mostly concerned with the question whether financial frictions can account for cross-country and within industry productivity losses through the misallocation of resources. On the more theoretical front, Midrigan and Xu (2014) argue that financial frictions, in the form of borrowing constraints, are unlikely to cause misallocation in the long run as firms can “outsave“ themselves through internal capital accumulation. Moll (2014) acknowledges that capital frictions are unimportant in long run, but tend to matter in the short run and analyzing steady states is misleading. Other important contributions have focused on the sources of misallocation. Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) suggest that large capital inflows to Spain during the Euro convergence process have caused an oversupply of funding to high net worth firms. Larrain and Stumpner (2017) find that bank dependent firms profited comparatively more during capital account liberalizations in Eastern European countries. Thus driving down misallocation and increasing aggregate productivity. Other contributions on the theoretical side include David, Hopenhayn, and Venkateswaran (2016) and Gilchrist, Sim, and Zakrajsek (2013). Furthermore, there is a growing (and slightly more empirical) literature documenting misallocation around the world: For Spain, see Garcia-Santana, Moral-Benito, Pijoan-Mas, and Ramos (2020); for Portugal, see Dias, Robalo-Marques, and Richmond (2016); for Italy, see Calligaris, Del Gatto, Hassan, Ottaviano, and Schivardi (2016); for other European countries, see Gamberoni, Giordano, and Lopez-Garcia (2016). Although the productivity literature is mainly concerned with long-run effects, several studies have investigated the role of misallocation in lowering aggregate productivity during a crisis. Indeed, aggregate productivity declines sharply during a financial crisis (see Calvo, Izquierdo, and Talvi 2006). Also during 2009 Germany experienced its largest and sharpest decline in productivity since at least the second world war. Kahn and Thomas (2013) show in a quantitative model that financial shocks can lead to aggregate productivity losses through resource misallocation. Oberfield (2013) finds that within sector misallocation did not increase during the Chilenean crisis in 1981. Libert (2016) shows that misallocation can explain roughly half of the decline in productivity in France during the Great Recession (post 2008). Ziebarth (2015) finds that misallocation can account for a large fraction of productivity losses during the Great Depression in the 30s.

A second strand of literature related to this study emanates from the empirical finance literature. The financial crisis of 2007/08 and the subsequent sovereign debt crisis in Europe in the early 2010s have motivated the study of financial shocks to the banking system and its transmission to the real sector. For the US, using loan data at the firm-bank level, Chodorow-Reich (2014) finds that bank lender health following the Lehman Brothers crisis can account for large employment losses at companies. Acharya, Eisert, Eufinger, and Hirsch (2018) investigate, using data from the European syndicated loan market, whether the sovereign debt crisis in Portugal, Italy, and Spain had adverse consequences for employment, investment, and sales. In line with this paper, studies using credit registry data (see Cingano, Manaresi, and Sette 2016 for Italy and Bentolila, Jansen, and Jimenez 2018 for Spain) find that the financial and sovereign debt crisis negatively impacted investment and employment. Thus there is a growing literature that establishes detrimental consequences of the recent banking crisis. Furthermore, the persistent problem of non-performing loans in southern European countries and sluggish productivity growth before and after 2008, have led to an increased interest into the relation of credit markets and productivity. Acharya, Eisert, Eufinger, and Hirsch (2019) find that the additional liquidity provided by the ECB in its unconventional monetary policy program in 2012 was predominantly given to Zombie firms (firms receiving subsidized credit that would otherwise be insolvent) by weakly capitalized banks. In addition, creditworthy firms appeared to suffer from these credit subsidies and thus harm productivity. Schivardi, Sette, and Tabellini (2017), on the other hand, do not find large negative effects on productivity. In addition, they estimate whether Zombie lending is associated to resource misallocation, in the sense established before, at the sector-province level. There have also been studies focusing on the relation of credit shocks and productivity (see for example Manaresi and Pierri 2018). These, however, analyze the relation of credit and individual firm level productivity. An exception here from is Lenzu, Rivers, and Tielens (2019), who also analyze with firm level data the relation of credit supply and misallocation.

To conclude one can highlight that since the crisis of 2008, a large literature has been analyzing misallocation of resources and real effects of the banking crisis, but not in conjunction. The productivity literature is still debating about whether financial frictions can cause resource misallocation. The ongoing sluggish growth and financial stability concerns of southern European countries have motivated the empirical finance literature to start analyzing the productivity consequences of an impaired banking sector. This paper makes a major contribution by analyzing granular data and bringing together two seemingly detached strands of literature.

The remainder of the paper is structured as follows. In the next section, we describe our datasets and basic data manipulation. Section 1.3 discusses the German banking crisis and associated lending shock. Section 1.4 introduces our economic model and descriptive results on misallocation around the economic crisis. Section 1.5 empirically evaluates the effect of the banking crisis on misallocation at the firm level. Section 1.6 concludes.

1.2 DESCRIPTION OF THE DATA

This study makes use of four different datasets: The Amadeus firm database compiled by the company Bureau van Dijk (BvD); the German credit register and monthly bank balance sheet statistics from regulatory fillings at Deutsche Bundesbank; and industry business statistics from Eurostat.

Our company financial data comes from BvD’s database product Amadeus. Amadeus contains information on financial statements of more than 20 million European companies. Administrative data are initially collected by local chambers of commerce and, in turn, relayed to BvD through roughly 40 different information providers including business registers. A big advantage of Amadeus compared to other datasets of German manufacturing is its large coverage of small and medium sized companies and coverage of key variables for productivity analyses, such as fixed assets, operating income, wage bill, or cost of material at a yearly frequency. In order to achieve maximum possible coverage of companies and variables, we meticulously follow an extensive data compilation process as outlined, in detail, in Kalemli-Ozcan et al. (2015) and briefly discussed here.

One problem with Amadeus is that BvD only keep companies if they reported during the last five years at least once.[2] Therefore, later versions of Amadeus lose information of previously reporting companies, creating an artificial survival bias in the sample. Further, there is a reporting lag of around two years and later versions update and expand their information on companies over time. To accommodate these problems, we merge several different vintages of Amadeus ("Amadeus Disk July 2017", "Amadeus Disk July 2015", "Amadeus Disk July 2013", "Amadeus Disk July 2012", and "Amadeus Disk July 2010"). We start with the earliest vintage and then update and replace missing information with later vintages through a unique BvD company identifier. Changes in identifiers over time are accounted for by using the official BvD identifier correspondence table.[3] After merging the raw data and accounting for Amadeus specific data issues, we follow an extensive cleaning process as outlined in Appendix A. Afterwards we deflate wage bill and value added with the two digit output price deflators from Eurostat. Fixed assets are deflated with the country investment inflation estimates from World Bank. For the purpose of our study, we focus on the subset of German companies in the manufacturing industry.

The final dataset contains yearly observations on roughly 21,000 firms between 2006 and 2012 in the German manufacturing industry. Table 1 compares the coverage of our sample across wage bill, gross output, and employment relative to the whole population of manufacturing firms in Germany. The census data is retrieved from Eurostat's Structural Business Statistics. Table 1 shows that our sample accounts for roughly 25 to 30 percent of the aggregate for all variables in all years. Table A1 in the appendix gives summary statistics. We distinguish two samples here. The *full sample* includes all 21,000 firms, and the *permanent sample* includes all companies that are continuously present between 2006 and 2012 (around 2,700 firms).

For the credit analysis of our paper, we use the proprietary credit register and bank balance sheet information from the Deutsche Bundesbank, which is the micro- and macro-prudential supervisor of the German Banking system. From the bank balance sheets we

[2] Note that Amadeus keeps at maximum the past ten years of each company. Thus, current versions of Amadeus would likely not be sufficient to cover studies on the financial crisis.
[3] The data is downloaded from each vintage in small buckets to account for downloading capacity. We use the relative years option to achieve bigger time coverage. And we download all variables in the same units.

retrieve information on aggregate outstanding credit to German non-financial firms, non-banks, and all borrowers. The credit register keeps record of quarterly credit exposures at the individual bank – firm level. It covers nearly 70% of the total credit volume of all German banks.[4] Both datasets (credit register plus balance sheet information) are used at a quarterly frequency between 2006 and 2010. This period saw a high frequency of M&A activity within the banking sector. Thus, we account for all takeovers by treating the involved parties as a single entity. We aggregate credit across two banks to a single observation before the takeover took place and leave it unchanged afterwards. The final dataset for credit analysis contains around 18,000 firms, 1,800 banks, and 24,000 Bank – Firm credit relations. More than 50% of firms receive credit from multiple banks.

For analysing misallocation at the firm level, we need to match the companies in the credit register with Amadeus by name of the company. For this purpose, firm names are parsed into bigrams and then matched with each other. We only keep matches that are exactly equal, because the probability of error increases rapidly with even small name deviations. The final dataset contains a panel of around 1,100 firm – bank matched companies in German manufacturing between 2006 and 2009. Table A2 gives summary statistics on the main variables.

In the following we distinguish between two samples: One is the *full sample* of Amadeus companies with roughly 21,000 companies. And one is the *permanent sample* with all companies present at each time between 2006 and 2012. Figure 1 plots the aggregate gross output of the two series compared to census data for the sample period. The Amadeus data depicts a stronger growth rate at the beginning between 2006 and 2008, but correlates very strongly with the census data throughout. Table 2 presents the share of economic activity accounted for by firms belonging to three size categories in

[4] As a general rule, all German banks have to report firm credit exposures that exceed 1.5 million in nominal value. But, there are several exceptions: First, if the firm belongs to a larger group, even small amounts of firm credit exposure already need to be reported if the group exposure exceeds 1.5 million. Second, if the exposure exceeded the threshold during a quarter, the bank needs to keep reporting even if the exposure is now below 1.5 million. Also, the term credit is interpreted very broad and also includes exposure from credit guarantees and derivatives (which are sizeable). Further, it includes both loans and debt securities and thus gives a very holistic measurement of credit exposure. The median exposure in the manufacturing industry amounts to 1.5 million.

2007.[5] Medium sized companies (50 – 249 employees) are equally represented in all three data sets. Large companies (> 249 employees) tend to be over represented compared to small firms (< 50 employees). In the full sample, for example, small firms make up 3.8 percent (1.9 percent panel) of output and 8.9 percent in Eurostat. Nevertheless, we think that our sample contains large variation in firm size and a good coverage of medium sized companies.

1.3 CREDIT SHOCK

This study aims to measure the effect of a credit supply shock on misallocation at the firm level. For identification, we want to exploit heterogeneity at the bank level during the financial crisis of 2007/08. Many previous studies have shown that bank – firm relationships are sticky over time and play a decisive role for credit access to non-financial companies (e.g. Chodorow-Reich 2014). During the financial crisis some German banks were more affected than others, irrespective of their German firm credit portfolios. The global financial crisis took its roots in the United States when the housing market lost value and households and financial institutions ran short on liquidity or even went bankrupt. The financial problems transmitted to the European banking system through two main channels. Either, banks were themselves directly invested in securities connected to the US financial crisis (like CDOs, MBSs, or other real estate investments) through their proprietary trading arms (or loans), or they were indirectly harmed by interbank connections. In the first case, German banks experienced stark losses that transmitted to non-financial firms through lending cuts beginning with the slow down in US house prices and mortgage debt crisis as shown by Ongena, Tümer-Alkan, and von Westernhagen (2018). In the second case, European banks suffered from liquidity dry-ups in wholesale borrowing, again leading to lending cuts, as shown by Iyer, Peydro, da-Rocha-Lopes, and Schoar (2014).

In this paper, we identify a credit supply shock by comparing lending of banks that took aid from the federal government to banks that didn’t make use of government support measures. We assume that the aid receiving banks were among the ones hit most by the global financial crisis and support this claim with suggestive evidence. On October

[5] We choose 2007 instead of 2006 as the employment variable has a bigger coverage for that year. Overall the distribution is pretty stable over time.

20, 2008, the German Parliament enacted *SoFFin* – Special Financial Market Stabilization Fund, to provide the banking system with guarantees of up to 400bn and equity capital of up to 80bn. In total, nine banks, henceforth *crisis banks*, made use of those measures, in addition to regional level bailouts (Deutsche Finanzagentur 2019).[6] Together they comprise around 30% of total credit to domestic non-financial firms according to balance sheet statistics. Four of those banks were almost exclusively in the mortgage business active and played a negligible role as firm lenders. The other five (responsible for 99% of credit to non-financial firms as well as manufacturing firms) were universal banks, active as investment banks and traditional lenders to households and firms. Two were private and three public banks. The German banking system has, with around 35% in total assets, a high ratio of government owned banks. Importantly, we think there is suggestive evidence that those five universal banks were substantially hit by the international financial crisis and this was unrelated to its domestic credit portfolio of firm financing. Table 3 lists exposures of 14 German banks to conduits and special purpose vehicles based on publicly available information created by Fitch Ratings. These were off-balance sheet positions in detrimental US structured financial products financed with very short-term wholesale borrowing. Both, the losses in asset values and the short-term nature of borrowing were a major strain to bank balance sheets and relates to the two channels of how banks were affected by the US financial crisis. As shown by Table 3, our crisis banks are among the seven with highest off-balance sheet exposures relative to equity capital and total assets. Furthermore, the positions of all 14 banks are substantial, amounting for up to 10 times regulatory capital. Thus, Table 3 suggest that our exposed-banks were strongly and negatively affected by the US financial crisis irrespective of their domestic firm-loan portfolio. However, the question remains, whether the shock led to a decline in credit supply. All banks are required by law to hold enough equity capital against their credit portfolio. Thus, a financial shock requires banks to reduce their asset size (equity refinancing is particularly difficult in times of crises). Furthermore, a reduction to equity can raise external costs of financing, which further incentivizes sell offs (see e.g. Huber 2018). While the financial shock was inarguably strong, suggesting credit reductions, the government measures could have in fact prevented a credit squeeze.

[6] We use the terms *crisis banks*, *exposed banks*, and *stressed banks* interchangeably.

Therefore, next we analyse the credit supply of the crisis banks (treated) relative to the rest of the banking sector (control group).

Figure 2 displays total credit, credit to non-financial firms, and credit to manufacturing companies. The first two series are created from balance sheet statistics; the latter is based on the credit register. In each case, we aggregate credit for the crisis banks and all other banks separately (by group) and normalize it to 2007q1 (2006q2 for manufacturing sector) respectively. Figure 2 shows that in all three cases, on aggregate, credit in the crisis banks grows slower than in the rest of the banking sector, starting around 2007q3. Importantly, credit behaves similar in the quarters before the crisis, suggesting parallel trends.

In Table 4, we analyse credit supply in a regression framework. We define a pre-crisis (2006:Q1 until 2007:Q1), crisis (2007:Q2 until 2008:Q4), and post-crisis (2009:Q1 until 2010:Q1) period. The financial crisis in Germany starts in summer 2007, when IKB bank announced losses related to the US real estate sector, and reaches a peak at the end of 2008 with the failure of Lehman Brothers. We follow Khwaja and Mian (2008) and take a symmetric time series average of credit positions before and after the shock/crisis. We define 2007q2 as the start and 2008q4 as the end of the financial shock. Then we take a five-quarter average before and after the financial crisis. In columns 1 - 3, we show the effect of being a crisis bank (a dummy for all nine banks) on total lending, lending to non-banks (primarily households and non-financial firms), and lending to non-financial companies relative to the rest of the banking sector. Our estimates suggest that there is a significant differential decrease of 27 - 33% for crisis banks. That is, our financial shock is associated with a decline in bank lending irrespective of the customers (all, non-banks, or only firms). In order to disentangle supply form demand effects, we now turn to analysing credit at the bank - firm level. Column 4 and 5 display the effect of being a crisis bank on change in firm credit, where in the latter we include firm fixed effects. Both estimates suggest a differential decrease of around 12%. That is, crisis banks reduce credit by 12% more on average even when lending to the same company. Finally, in column 6 and 7 we analyse total firm credit depending on exposure to crisis banks before the shock. In contrast to the previous two estimates, this also includes the extensive margin of credit growth. When analysing credit at the bank – firm level we can only use observations if there exists a relation before the shock. But this may overestimate the total effect on companies, as new banks might step in and originate new loans. We build a measure between 0 and 1, where 1 means a firm was fully financed by a crisis bank before the shock and 0 that it received no financing from crisis banks ex ante. Our estimates suggest that total credit of fully exposed firms decreased differentially between 15 and 18% even accounting for sector and local fixed effects at the three-digit industry code or three-digit postcode, respectively. Thus, our credit analysis suggests that certain firms were financially constrained during the economic crisis in 2008/09.

1.4 MISALLOCATION FACTS

In this section, we document the development of resource misallocation and its impact on aggregate total factor productivity (TFP) during the financial crisis in Germany. We follow Hsieh and Klenow (2009) and employ a model of monopolistic competition with heterogeneous firms. This is the most standard framework that has been used in the literature to study developments in productivity in the context of misallocation. The model also serves as a framework for Section 1.5, where we present and test the hypotheses for our firm level analysis.

We assume there is a single final good Y produced by a representative firm in a perfectly competitive output and input market. Final output is the aggregation of output Y_s in several industries (we refrain from time subscripts):

$$Y = \prod_{s=1}^{S} Y_s^{\theta_s} \quad with\ \theta_s > 0 \ \ and\ \ \sum_{s=1}^{S} \theta_s = 1 \tag{1}$$

In each sector s there is a representative competitive firm that solves the argument:

$$\max_{Y_{si}} \left\{ P_s Y_s \quad - \ \sum_{i=1}^{M_s} P_{si} Y_{si} \right\} \tag{2}$$

where sector output is:

$$Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{3}$$

The firm producing variety Y_{si} solves the argument:

$$\max_{L_{si}, K_{si}} \left\{ P_{si} Y_{si} - \left(1 + \tau_{L_{si}}\right) w L_{si} - \ \left(1 + \tau_{K_{si}}\right) r K_{si} \right\} \tag{4}$$

subject to output $Y_{si} = A_{si}K_{si}^{\alpha}L_{si}^{1-\alpha}$ and the demand schedule $P_{si} = \overline{Y_s}Y_{si}^{-\frac{1}{\sigma}}$ derived from industry maximization.[7] Each company chooses optimal levels of labour L_{si} and capital K_{si}. They are heterogeneous in terms of productivity A_{si} and firm specific frictions in both factor markets $\tau_{L_{si}}$ and $\tau_{K_{si}}$. That is, they differ in terms of costs faced for input factors capital and labour. Note that we assume constant labour and capital shares across industries. The maximization yields the following FOC:

$$MRPK \coloneqq \frac{\sigma-1}{\sigma}\alpha\frac{P_{si}Y_{si}}{K_{si}} = \left(1+\tau_{K_{si}}\right)r \quad (5)$$

$$MRPL \coloneqq \frac{\sigma-1}{\sigma}(1-\alpha)\frac{P_{si}Y_{si}}{L_{si}} = \left(1+\tau_{L_{si}}\right)w \quad (6)$$

These two conditions are crucial for the understanding and measurement of misallocation. In an economy without frictions, each company will accumulate resources until it equalizes its marginal products to the respective factor costs. Hence, the marginal products will be the same across firms. This shows that firm size, the level of capital and labour, will be solely determined by the amount of productivity of the individual firm. Each firm will operate at an optimal level of size depending on its productivity. Moreover, the larger its productivity, the larger will be the factor inputs. However, suppose a certain company faces a financial constraint in the credit market and therefore a higher $\tau_{K_{si}}$, then, its marginal product of capital will be higher relative to other companies. Now the firm will not operate at its optimum anymore. Thus, in this framework, the degree of frictions in the economy (sector) can be measured by the variation in marginal products of resources.

Following Hiseh and Klenow (2009), we next define the revenue-based total factor productivity (TFPR) as the product of price P_{si} and physical productivity A_{si}. This yields a measure of frictions coming from both factor markets together:

$$TFPR_{si} \coloneqq P_{si}A_{si} = \frac{P_{si}Y_{si}}{K_{si}^{\alpha}L_{si}^{1-\alpha}} = \frac{\sigma-1}{\sigma}\left(\frac{MRPK_{si}}{\alpha}\right)^{\alpha}\left(\frac{MRPL_{si}}{1-\alpha}\right)^{1-\alpha} \quad (7)$$

Firms with higher $\tau_{K_{si}}$(high costs of capital) will have lower capital and higher $MRPK_{si}$ than optimal. This translates into higher $TFPR_{si}$.

[7] Where we defined $\overline{Y_s} = (\theta_s Y)^{\frac{1}{\sigma}} P_s^{\frac{\sigma-1}{\sigma}}$

In order to get a measure of misallocation and the degree of productivity losses in this economy we need a measure of TFP at the aggregate/ sector level. Aggregating firms within a sector, we obtain sectoral output as:

$$Y_s = TFP_s K_s^{\alpha} L_s^{1-\alpha} \quad (8)$$

where the expression for sectoral TFP_s is as follows:

$$TFP_s = \left[\sum_{i=1}^{M_s} \left(A_{si} \frac{\overline{TFPR}_s}{TFPR_{si}}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}} \quad (9)$$

with $\overline{TFPR}_s$ being the weighted average of the $TFPR_{si}$ of firms in sector s. From this expression we can see that sector TFP depends on the joint distribution of firm productivity and firm $TFPR_{si}$. Without distortions $TFPR_{si}$ is equalized across firms and sectoral TFP_s is just:

$$TFP_s^* = \left[\sum_{i=1}^{M_s} (A_{si})^{\sigma-1}\right]^{\frac{1}{\sigma-1}} \quad (10)$$

This is also the maximum TFP that can be achieved in this economy, as can be shown from a social planner maximization (Gilchrist et al. (2013)). Thus, whenever TFP_s is smaller than TFP_s^*, resources are not optimally allocated due to frictions and productivity losses emerge. However, in order to measure the extent of misallocation caused by the frictions, one needs to simplify the expression for TFP_s. The most common assumption in the literature is that $TFPR_{si}$ and $A_{si}$are jointly lognormally distributed. Then the expression for TFP_s becomes

$$\log TFP_s = \frac{1}{\sigma-1} \log \sum_{i=1}^{M_s} (A_{si})^{\sigma-1} - \frac{\sigma}{2}\, var\, (\log TFPR_{si}) \quad (11)$$

In this special case, the negative effect of distortions on aggregate TFP_s can be summarized by the variance of $\log TFPR_{si}$. Thus, here our measure of misallocation is synonym with the distortions. Intuitively, what matters for productivity is only that marginal products are equalized. No matter what productivity a company has, as long as e.g. its marginal product of capital is higher compared to the peers, resources should be switched to the firm with the higher return and therefore output will be maximized for a given input in the economy.

However, it is useful to derive an expression that does not depend on distributional assumptions. Inserting the identity $cov(X,Y) = E(XY) - E(X)E(Y)$ into the definition of TFP_s yields the following expression:

$$\log TFP_s = \frac{1}{\sigma-1}\log\left[E(A_{si})^{\sigma-1}E\left(\frac{\overline{TFPR_s}}{TFPR_{si}}\right)^{\sigma-1} + cov\left((A_{si})^{\sigma-1}, \left(\frac{\overline{TFPR_s}}{TFPR_{si}}\right)^{\sigma-1}\right)\right] \quad (12)$$

Keeping the variance of $TFPR_{si}$ (or the second moment) and A_{si} constant, but increasing the correlation of productivity and the inverse of distortions reduces the productivity losses. In this case the extent of misallocation can be measured by the correlation of productivity and $TFPR_{si}$. Intuitively, if more productive firms are less constrained, then aggregate productivity will be higher. Indeed, Restuccia and Rogerson (2008) find in a very similar model, that misallocation will be highest if the more productive firms are constrained.

Next, we turn to empirically assessing the magnitude of misallocation and productivity losses during the financial crisis in Germany. Following the above two equations on sector TFP, we will analyse the dispersion in TFPR and the correlation of TFPR and firm productivity.

In panel A, C, and D of Figure III we present the evolution of the dispersion of TFPR, MRPK, and MRPL in Germany. These are computed in two steps. First, we calculate a given dispersion measure across firms i in a given industry s and year t. Second, for each year we calculate dispersion as the weighted average of dispersions across industries s. Each industry is given a time-invariant weight equal to its average share in manufacturing value added. We always use the same weights when aggregating across industries. Therefore, all of our estimates purely reflect variation within four-digit industries over time. In panel B we present the evolution of TFP relative to its efficient level normalized to 2006. Aggregates are again calculated by taking the same value added weights of sector TFP. The “full sample” includes all observations of firms irrespective of exit and entry of firms during the sample period. The “permanent sample” only includes observations if the firm data was available throughout the sample period. Panel A shows that misallocation increased by 4% during the financial crisis in Germany. Panel C and D show that this variation can be explained by a simultaneous increase in MRPK and MRPL dispersion. Although there is a downward trend in the panel sample for

MRPK dispersion, it decreases more slowly during 2008 and increases during 2009. Panel B shows that the increase in misallocation is accompanied by aggregate productivity losses of 2.5 – 6.2%.

In Figure IV, we further investigate the causes of the increase in misallocation. The dispersion of MRPK (or MRPL) can be divided into three terms:

$$Var_i\,(\log MRPK_{is}) = \gamma_1\, Var_i(\log A_{is}) + \gamma_2 Var_i(\log K_{is}) - \gamma_3 cov(\log A_{is}\,, \log K_{is}) \qquad (13)$$

This equation says that the dispersion of MRPK (or MRPL) increases if productivity becomes more uncertain, capital is more dispersed, or productivity is associated less with firm size, that is the level of capital or labour. Especially, productive uncertainty is said to increase during a crisis (see Bloom (2014) for a discussion on uncertainty including plant level shocks to TFP) and thus could be the driver of MRPK dispersion instead of resource misallocation. Panel A and C in Figure 4 show the evolution of variance of capital and wage bill. Both show signs of an increase during the crisis, although the magnitudes are far smaller than for MRPK or MRPL dispersion. Instead misallocation seems to be driven by the covariance of productivity and capital (wage bill). Panel B and D show that the correlation drops between 2 and 3 percentage points during the crisis. Although we have set correlation to 0 in 2006, it is initially positive at around 0.5. Thus, as theory suggests, more productive firms tend to be larger. However, this association gets subdued with the instance of the financial crisis. We interpret this as a sign that resources were wrongfully allocated during the crisis in the German banking sector.

In Figure 5, we follow equation (12) and analyse the correlation of TFP with the inverse of TFPR, MRPK, and MRPL respectively. The results suggest that productive firms are more associated with being constrained, in terms of TFPR and MRPK, during the financial crisis. We interpret this as a further sign that resources were wrongfully allocated during the crisis in the German banking sector.

1.5 RESULTS ON MISALLOCATION - FIRM REGRESSIONS

In this section, we estimate the effect of the financial crisis in Germany on misallocation at the firm level. We inform our regressions by the previous model and establish the following hypotheses:

Hypothesis 1: *Bank exposure increases TFPR, MRPK, and MRPL.*

The first hypothesis is based on the assumption that productivity and frictions are jointly normally distributed. For this case, a higher dispersion in frictions, measured as a wedge in TFPR, MRPK, or MRPL is directly associated with misallocation/ productivity losses. While TFPR and MRPK will be directly affected through the costs of borrowing (higher MRPK), there is no connection to the labour market in the model. However, one could assume that the hiring capabilities will be equally affected by the credit frictions.

The next two hypotheses are based on the notion that also the correlation of productivity and frictions matter (equation 12). In particular, misallocation will be higher if the more productive firms are constrained. This will hold true if the following hypotheses are satisfied in conjunction with Hypothesis 1:

Hypothesis 2 a): *Bank exposure is associated with firms that increase their productivity.*

Hypothesis 2 b): *Bank exposure is associated with more productive companies ex-ante.*

In particular, we estimate the following regression for firm i in sector s:

$$y_{is} = S_s + \beta BE_{si} + \gamma' X_f + \epsilon_{is} \qquad (14)$$

where $y_{is} = \log(Y_{s,i,2009}) - \log(Y_{s,i,2006})$ and Y is either TFPR, MRPK, MRPL, or TFP. S_s are sector fixed effects at very narrowly defined industries (4-digit Nace 2) as of 2006. S_s is key to our estimation. According to theory, firms that are close to identical should display similar patterns in TFPR (or MRPK/MRPL) independent of their productivity measured as TFP. X_f includes local and size fixed effects as of 2006. BE_{si} (bank exposure) is between zero and one, and indicates the fraction of credit financed by crisis banks in 2006. We also add a cross sectional regression to this model and estimate the relation of TFP, TFPR, size, etc. with bank exposure in 2006 before the shock arrives. Table 5 reports the main results of this section. For each variable TFPR, MRPK, MRPL, and TFP we show the results including only sector fixed effects, with sector and local fixed effects, and with sector, local, and size fixed effects. The point estimates including only sector fixed effects imply that, following the financial shock, TFPR was 8 percentage points higher for a firm fully dependent on the crisis banks. The rise in TFPR seems to be entirely driven by a differential increase in MRPK of 23 percentage points. There is no difference in MRPL. At the same time, we measure a positive effect of the financial shock on total factor productivity. TFP increases differentially by 10 percentage points for a firm fully dependent on crisis banks. The results for including local and size fixed effects stay qualitatively similar. When including all fixed effects the effect on TFPR and MRPK stay significant at the 10^{th} and 5^{th} percentile respectively. The effect on productivity stays significant at the 20^{th} percentile. Quantitatively all estimates lose in terms of size when saturating the model.

To summarize, we find tentative evidence for hypothesis one being true, except for MRPL. As suggested by theory, credit constraints tighten for firms with a high exposure to crisis banks. Consequently MRPK and TFPR increase and resources get misallocated. Strikingly, also firm level TFP increases. Thus, especially firms with higher productivity get constrained. This provides tentative evidence for Hypothesis 2 a. The identifying assumption of this section is that within very narrowly defined industries, bank exposure is unrelated to firm variables. In Table A3 of the appendix we show that there is no significant relation between the financial shock and firm observables before the crisis in 2006. This supports the notion that bank exposure is unrelated to other time varying shocks experienced by companies during the financial crisis. However, as we will show in the next table, when exploring Hypothesis 2 b, bank exposure seems to be related to TFP, TFPR, etc. ex-ante in 2006.

In Table 6, we analyse the relation of TFPR, MRPK, MRPL, and TFP with bank exposure in the cross section of 2006, before the crisis. Again we show the results including only sector fixed effects, with sector and local fixed effects, and with sector, local, and size fixed effects. The results are ambiguous. While bank exposure is positively related to TFP with sector (and local) fixed effects, the relation becomes negative in the most conservative specification with size fixed effects. This suggests, bank exposure cannot be unambiguously related to TFP ex-ante. That is, we cannot say that firms related to financial problems were more productive. Therefore, we do not find conclusive evidence that supports hypothesis 2 b.

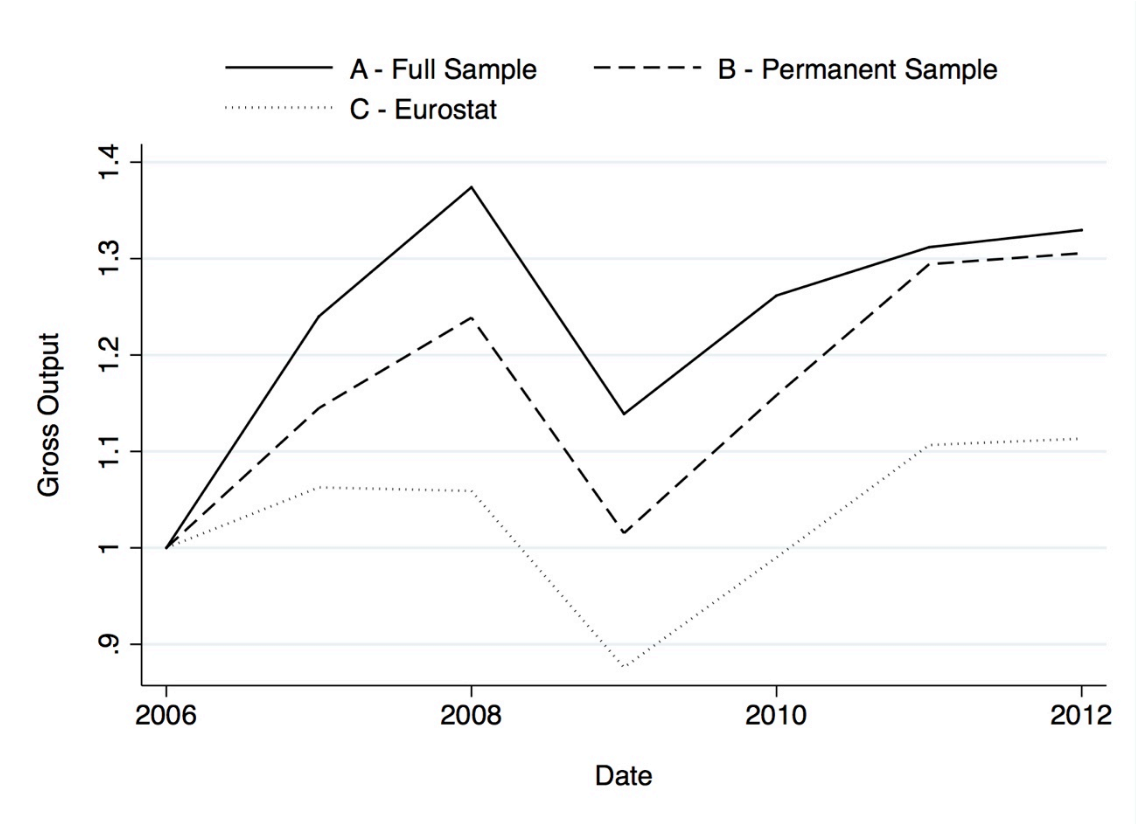
We further analyse the relation of bank exposure with MRPK, TFPR, and MRPL in Table 6. Again, as with TFP, the relation of bank exposure with MRPK and TFPR is ambiguous. While bank exposure is negatively related to TFPR and MRPK with sector (and local) fixed effects, the relation becomes positive in the most conservative specification with size fixed effects. This finding is important for the interpretation of Hypothesis 1. Assuming frictions are negatively related to bank exposure ex-ante, a differential increase (as we find) would actually decrease variation in TFPR. However, our results do not show conclusive evidence on the relation of TFPR with bank exposure in 2006. Therefore, we assume it is unrelated, while acknowledging that its relation would matter for our interpretations.

To conclude this section, we once again highlight the main findings. Our results give suggestive evidence that the banking crisis in Germany caused TFPR and MRPK to increase. This in itself, and the positive relation of the banking crisis to productivity growth, led to an increase in (measured) resource misallocation in Germany during the recession in 2009.

1.6 CONCLUSION

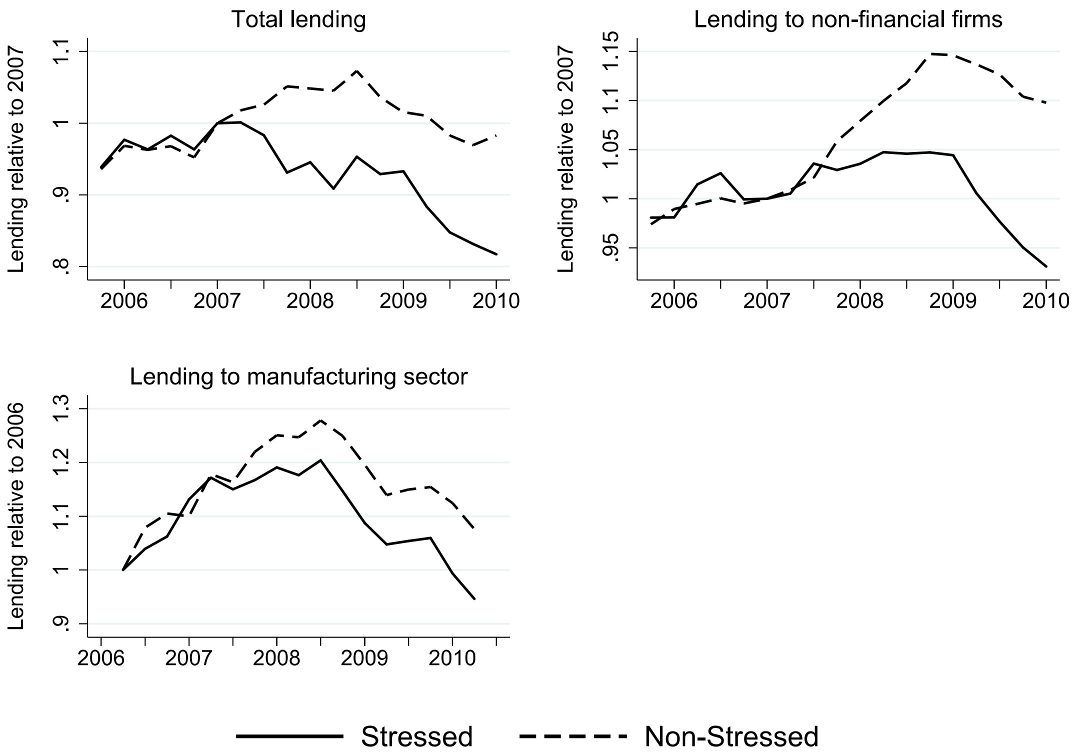
This paper presents new evidence on within-sector misallocation of production factors during an economic crisis. Using a representative firm sample of the German manufacturing sector, we find that misallocation increased sharply at the beginning of the crisis and returned sharply afterwards. More precisely, we find that the standard deviation in revenue-TFP, marginal product of capital, and marginal product of labour increased. We estimate that, without misallocation, productivity of the German manufacturing sector would have been up to 4% higher during the crisis. Therefore, misallocation had an important impact on aggregate productivity and economic output during the downturn. Our paper suggests, that financial frictions can account for part of the aggregate productivity losses. We find causal evidence that the banking crisis in Germany was a driving force behind the increase in misallocation. Starting in 2007 some of Germany's largest banks experienced liquidity and solvency issues. This shock to the financial system transmitted through a bank lending cut to the non-financial sector. We find that troubled banks differentially reduced credit supply by around 20%. This credit scarcity translated into a borrowing constraint for manufacturing companies leading to a sharp increase in the marginal product of capital and revenue productivity. The resulting wedge between firms can explain the increase in (measured) misallocation of production factors. Interestingly, the effect is only prevalent in the capital market and not in the labour market. Thus, the increase in variation of marginal products of labour cannot be attributed to the banking crisis and remains an open question for future research. Our results have important policy implications. While previous research largely agrees that the solvency of the banking system is a crucial determinant of economic output, we show that it has an important impact on aggregate productivity as well. Thus, ensuring a resilient banking system is a first order concern for government officials.

FIGURE 1: AGGREGATES IN AMADEUS AND EUROSTAT



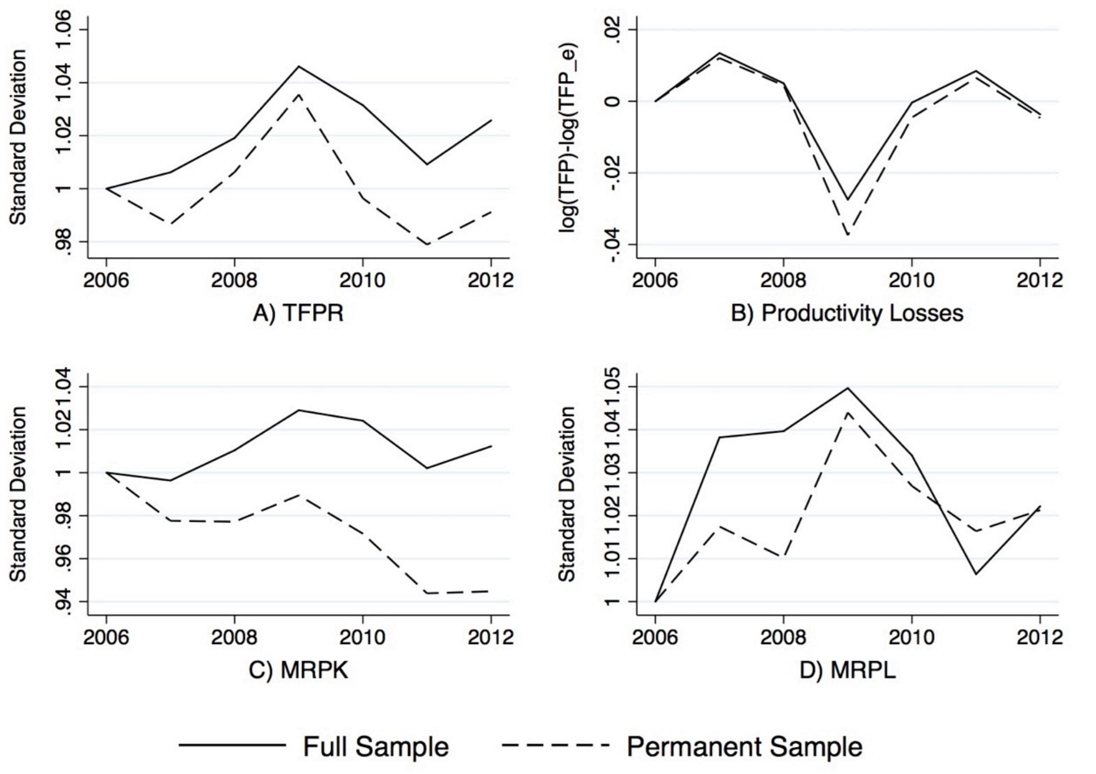
Notes: This figure plots aggregate gross output of the Amadeus data (full sample and panel) compared to Eurostat census figures. All series are relative to 2006. Full sample refers to all firms after cleaning the data. And permanent sample refers to firms that are present in all years. For detailed explanation see Section 2.

FIGURE 2: CREDIT SHOCK AND LOAN SUPPLY



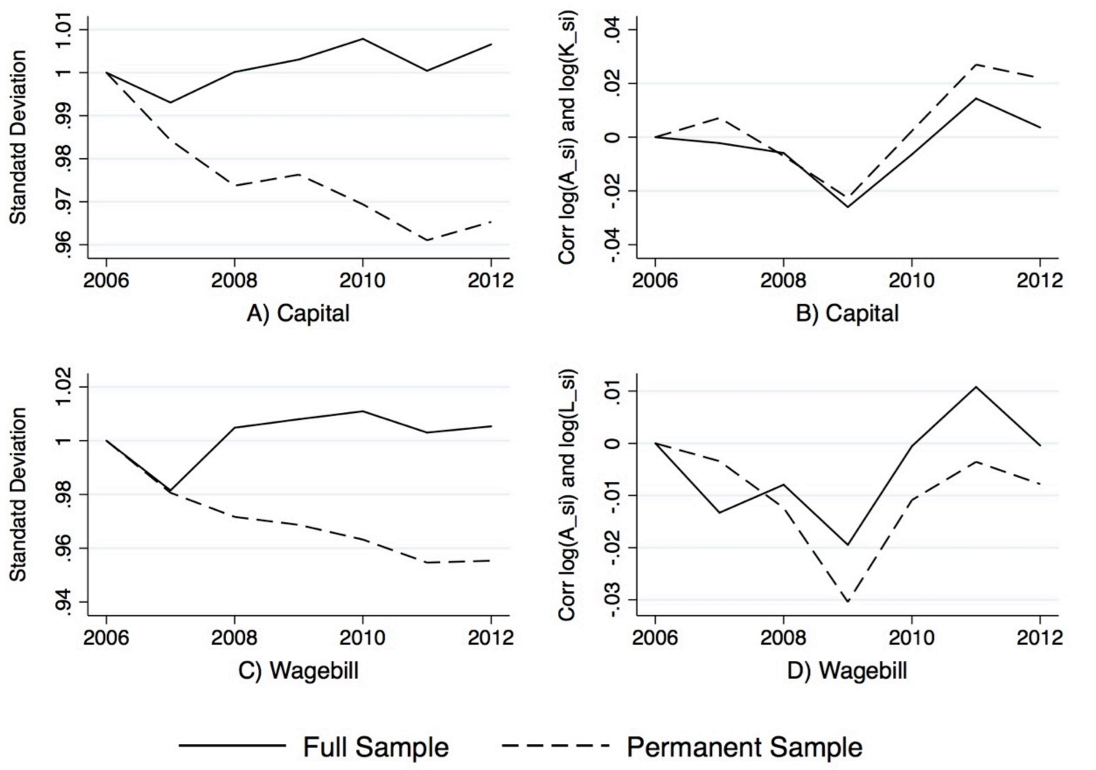
Notes: This figure displays total credit, credit to non-financial firms, and credit to manufacturing companies. The first two series are created from balance sheet statistics; the latter is based on the credit register. In each case, we aggregate credit for the stressed banks and all other banks separately (by group) and normalize it to 2007q1 (2006q2 for manufacturing sector) respectively.

FIGURE 3: MISALLOCATION AND PRODUCTIVITY DURING FINANCIAL CRISIS



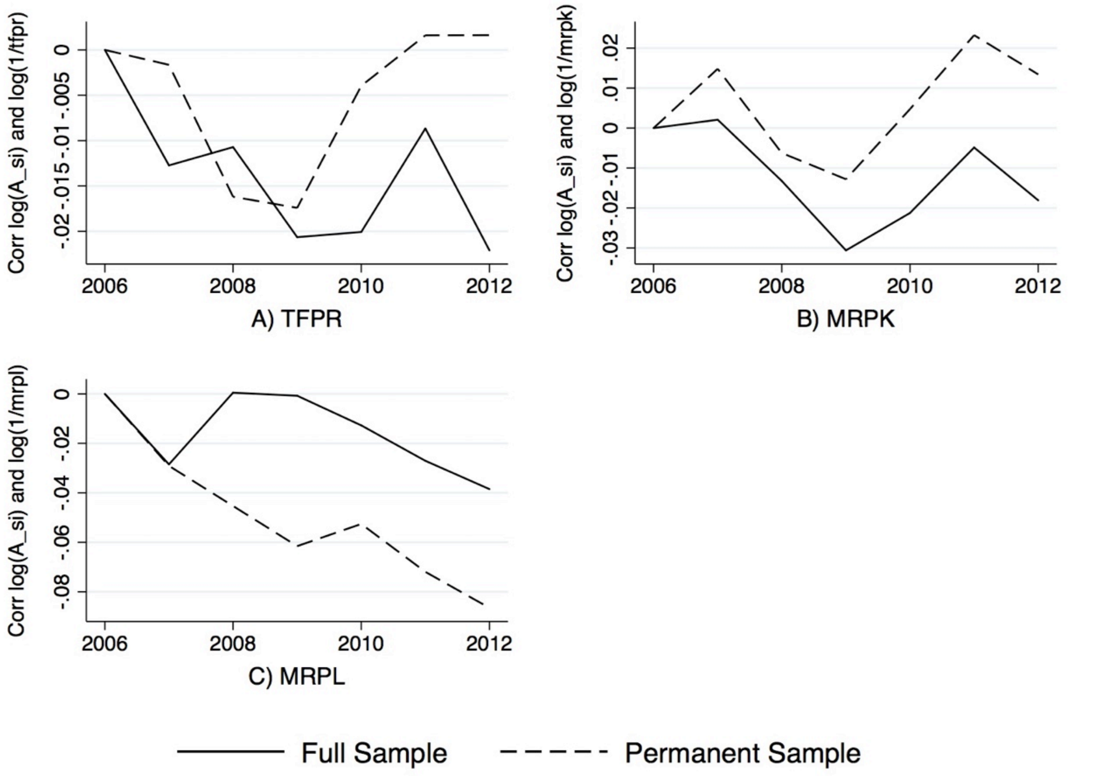
Notes: This figure plots several measures of misallocation and productivity losses from Amadeus data. *Full sample* refers to all firms present after cleaning the data. And *permanent sample* refers to firms that are present in all years between 2006 and 2012.. All values are relative to 2006. Panel A describes the standard deviation of TFPR (at the sector level). Sectors are aggregated according to the average percentage contribution in value added of the sector to the whole economy (also in other panels). The exact definition of TFPR and all other variables is described in section 4. Panel B describes the model-based deviation of total factor productivity from its efficient level due to misallocation. Panel C and D provide a break down of TFPR dispersion into variation of MRPK and MRPL.

FIGURE 4: MISALLOCATION AND PRODUCTIVITY DURING FINANCIAL CRISIS



Notes: This figure plots further measures of misallocation from Amadeus data. *Full sample* refers to all firms present after cleaning the data. And *permanent sample* refers to firms that are present in all years between 2006 and 2012. All values are relative to 2006. Panel A and C describe the standard deviation of capital and wagebill (at the sector level). Sectors are aggregated according to the average percentage contribution in value added of the sector to the whole economy (also in other panels). Panel B and D describe the correlation of firm productivity with capital and wagebill. Absolute levels of correlation are strongly positive.

FIGURE 5: MISALLOCATION AND PRODUCTIVITY DURING FINANCIAL CRISIS



Notes: This figure plots further measures of misallocation from Amadeus data. *Full sample* refers to all firms present after cleaning the data. And *permanent sample* refers to firms that are present in all years between 2006 and 2012. All values are relative to 2006. Panel A describes the correlation of productivity and TFPR (at the sector level). Panel B and C describe the correlation of firm productivity with MRPK and MRPL. Absolute levels of correlation are strongly positive. Sectors are aggregated according to the average percentage contribution in value added of the sector to the whole economy (also in other panels).

TABLE 1: COVERAGE IN AMADEUS RELATIVE TO EUROSTAT

Year	Gross Output	Employment	Wage Bill
2006	0.26	0.16	0.23
2007	0.28	0.19	0.25
2008	0.30	0.21	0.26
2009	0.29	0.22	0.26
2010	0.28	0.22	0.25
2011	0.27	0.21	0.25
2012	0.27	0.22	0.25

Notes: This table shows coverage of the German manufacturing sector in Amadeus relative to census data from Eurostat (Structural Business Statistics) with respect to three variables. The dataset was subject to extensive cleaning. Thus the estimates are very conservative. Further note that the employment variable is underrepresented for 2006/07 due to download restrictions.

TABLE 2: SHARE OF TOTAL MANUFACTURING OUTPUT BY SIZE CLASS

Size	Full Sample	Permanent Sample	Eurostat
1 - 49 employees	0.038	0.017	0.089
50 - 249 employees	0.220	0.193	0.186
> 249 employees	0.741	0.791	0.725

Notes: This table shows coverage of the Amadeus *Full Sample* and *Permanent Sample* compared to census data (Eurostat) by different size classes for the year 2008. *Full sample* refers to all firms present after cleaning the data. And *permanent sample* refers to firms that are present in all years between 2006 and 2012. We choose 2008 as 2006/07 we had restricted downloading capabilities for the employment variable.

TABLE 3: EXPOSURE OF SELECTED BANKS TO CONDUITS AND SPECIAL INVESTMENT VEHICLES

	Bank	In % of capital	In % of assets
1	Sachsen LB	1126	30
2	West LB	542	12
3	IKB	494	20
4	Commerzbank	210	6
5	Landesbank Berlin	179	2
6	Bayern LB	170	5
7	HSH Nordbank	126	4
8	Deutsche Bank	114	3
9	HVB	105	7
10	Nord LB	89	3
11	Helaba	68	1
12	DZ - Bank	61	1
13	LBBW	59	2
14	KfW	58	3

Notes: This table shows conduit and special purpose vehicle exposures of certain banks relative to total assets and accounting equity. Note that there is a limited comparability across observations due to differing definitions and different dates. Source: Fitch Ratings (2007), ABCP Concerns Trigger Liquidity Issues for German Banks, Germany Special Report, August. As throughout the paper, we also merged Commerzbank with Dresdner Bank in this statistic, by taking a weighted average in terms of total assets.

TABLE 4: THE EFFECT OF BANK STRESS ON CREDIT GROWTH

Variable	Total	Firms + Housholds	Non-Fin Firms	MF-BF	MF-BF	MF-F	MF-F
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Crisis Banks	-0.33**	-0.32**	-0.27***	-0.11***	-0.12**		
	(0.167)	(0.131)	(0.072)	(0.039)	(0.049)		
Bank Exposure						-0.19***	-0.16***
						(0.039)	(0.040)
Observations	1,819	1,819	1,796	23,428	9,557	17,880	17,867
R-squared	0.006	0.003	0.001	0.001	0.452	0.001	0.011
Constant	YES	YES	YES	YES	NO	YES	NO
Sector FE	NO	NO	NO	NO	NO	NO	YES
Local FE	NO	NO	NO	NO	NO	NO	YES
Firm FE	NO	NO	NO	NO	YES	NO	NO

Notes: Columns 1 – 3 refer to the respective credit aggregates at the bank level. In columns 4 – 5 we analyse credit in the manufacturing sector at the bank – firm level. And columns 6 – 7 are credit at the firm level. In each case we calculate the change in credit between a pre-crisis period and post-crisis period. The pre-crisis period is defined as 2006q1 – 2007q1 and the post-crisis period as 2009q1 – 2010q1. For each period we take the average quarterly outstanding credit as an observation. The variable *Crisis Banks* is a dummy variable indicating whether the bank belongs to the group of banks that experienced a financial shock. The variable *Bank Exposure* is between zero and one, and indicates the fraction of credit financed by crisis banks in 2006. All regressions are estimated with OLS. Columns 1 - 3 and 6 include a constant in the estimation. Sector FE refer to the three digit German industry classification code. Local FE are at the level of three digit postcodes. Standard Errors are clustered at the bank level (in parentheses); Significance levels are: *** p<0.01, ** p<0.05, * p<0.1.

TABLE 5: THE EFFECT OF BANK STRESS ON MISALLOCATION

Variables	TFPR			MRPK			MRPL			TFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Bank Exposure	0.0858***	0.0547#	0.0581*	0.2330***	0.1620**	0.1590**	0.0094	0.0080	0.0074	0.0961**	0,0576	0.0703#
	(0.0321)	(0.0341)	(0.0350)	(0.0667)	(0.0707)	(0.0745)	(0.0242)	(0.0257)	(0.0257)	(0.0450)	(0.0470)	(0.0481)
Observations	1,117	1,113	1,113	1,117	1,113	1,113	1,117	1,113	1,113	1,117	1,113	1,113
R-squared	0.211	0.297	0.298	0.193	0.278	0.280	0.194	0.282	0.288	0.234	0.314	0.318
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region FE	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	YES
Size FE	NO	NO	YES	NO	NO	YES	NO	NO	YES	NO	NO	YES

Notes: This table shows results from OLS firm level regressions. TFPR, MRPK, and MRPL are defined in section 4 and refer to measures of misallocation. TFP refers to total factor productivity. For each variable we calculate the log difference between 2006 (pre-crisis) and 2009 (crisis). Bank Exposure is as defined in Table IV. Sector FE are at the four digit Nace Rev. 2 classification. Regional FE are at the three digit postcode level (in Germany up to 7 digits). And Size FE are total assets divided into four size categories. Standard errors are robust in parentheses. *** p<0.01, ** p<0.05, * p<0.1, # p<0.2

Table 6: THE EFFECT OF BANK STRESS ON MISALLOCATION (CROSS SECTION 2006)

Variables	TFPR			MRPK			MRPL			TFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Bank Exposure	-0.1100***	-0.1120***	0.0936**	-0.3740***	-0.3330***	0.2300**	0.0316	0.0044	-0.0221	0.1000#	0.0965#	-0.1020*
	(0.0396)	(0.0431)	(0.0427)	(0.101)	(0.102)	(0.100)	(0.0330)	(0.0342)	(0.0348)	(0.0730)	(0.0747)	(0.0600)
Observations	1,117	1,113	1,113	1,117	1,113	1,113	1,117	1,113	1,113	1,117	1,113	1,113
R-squared	0.211	0.291	0.303	0.272	0.407	0.437	0.275	0.383	0.405	0.227	0.371	0.592
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region FE	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	YES
Size FE	NO	NO	YES	NO	NO	YES	NO	NO	YES	NO	NO	YES

Notes: This table shows results from OLS firm level regressions. TFPR, MRPK, and MRPL are defined in section 4 and refer to measures of misallocation. TFP refers to total factor productivity. We correlate all variables with our shock in the cross section of firms in 2006. Bank Exposure is as defined in table IV. Sector FE are at the four digit Nace Rev. 2 classification. Regional FE are at the three digit postcode level (in Germany up to 7 digits). And Size FE are total assets divided into four size categories. Standard errors are robust in parentheses. *** p<0.01, ** p<0.05, * p<0.1, # p<0.2.

APPENDIX TABLE A1: SUMMARY STATISTICS ON FIRM DATA

	N	Mean	SD
		Full Sample	
Revenue	68,436	51,915	364,827
Wage Bill	68,436	8,444	37,904
Value Added	68,436	22,202	102,786
Total Assets	68,436	33,255	179,561
Capital	68,436	8,231	44,941
Tang. Fix. Assets	68,436	7,320	40,429
Cash	67,649	1,803	11,927
Equity	67,878	11,473	63,957
		Permanent Sample	
Revenue	18,816	106,272	596,676
Wage Bill	18,816	16,557	53,240
Value Added	18,816	44,988	158,813
Total Assets	18,816	66,713	254,198
Capital	18,816	16,309	62,510
Tang. Fix. Assets	18,816	14,899	57,947
Cash	18,541	3,320	13,824
Equity	18,782	23,061	78,308

Notes: This table shows summary statistics on the firm data from Amadeus between 2006 and 2012. The *full sample* shows all firms that are present in at least one year. *Permanent Sample* refers to firms present in all years between 2006 and 2012.

APPENDIX TABLE A2: SUMMARY STATISTICS ON FIRM DATA

	N	Mean	SD
		Panel	
Revenue	4,612	141,410	814,879
Wage Bill	4,612	20,744	68,109
Total Assets	4,612	54,947	176,916
Value Added	4,612	80,549	284,720
Capital	4,612	20,454	62,429
Tang. Fix. Assets	4,612	18,697	57,069
Cash	4,576	3,436	18,244
Equity	4,604	25,745	73,920

Notes: This table shows summary statistics on the firm data from Amadeus between 2006 and 2009 for companies present in all years. *Panel* refers to the matched firm-bank dataset used for the firm level analysis.

APPENDIX TABLE A3: THE EFFECT OF BANK STRESS ON OBSERVABLES (CROSS SECTION 2006)

	Vadded	Cash	Equity	Revenue
Bank Exposure	-0.0149	0.0968	0.0713	0.0025
	(0.0739)	(0.237)	(0.110)	(0.0773)
Observations	1,113	1,091	1,085	1,113
R-squared	0.789	0.388	0.766	0.804
Sector FE	YES	YES	YES	YES
Region FE	YES	YES	YES	YES
Size FE	YES	YES	YES	YES

Notes: This table shows results from OLS firm level regressions. All variables are in logarithms. We correlate all variables with our shock in the cross section of firms in 2006. Bank Exposure is as defined in Table 4. Sector FE are at the four digit Nace Rev. 2 classification. Regional FE are at the three digit postcode level (in Germany up to 7 digits). And Size FE are total assets divided into four size categories. Standard errors are robust in parentheses. *** p<0.01, ** p<0.05, * p<0.1, # p<0.2

APPENDIX A

A Data Cleaning

After merging the raw data (from "Amadeus Disk July 2017", "Amadeus Disk July 2015", "Amadeus Disk July 2013", "Amadeus Disk July 2012", and "Amadeus Disk July 2010") and basic data manipulation, we follow closely Gopinath et al. (2017) and Kalemli-Ozcan (2015) in cleaning the company dataset, but apply it only to the manufacturing sector. We only make use of unconsolidated accounts. We clean the data in four steps.

A.1 Cleaning of Basic Reporting Mistakes

We start with a sample of 864,703 observations and 109,817 firms in manufacturing for Germany. At each step we provide the number of dropped observations. We implement the following steps to correct for basic reporting mistakes:

1. We drop firm-year observations that have missing information on total assets and operating revenues and sales and employment. (-113)
2. We drop firms if total assets are negative in any year, or if employment is negative, or if sales are negative in any year, or if tangible fixed assets are negative in any year. (-89)
3. We drop firm-year observations with missing, zero, or negative values for materials, operating revenue, and total assets. (-739,516)
4. We drop firm-year observations with missing information regarding their industry of activity. (-0)

The large drop at step 3 comes from missing observations in operating revenue and materials. If one would only drop missing observations in revenue less than half of observations would be lost. But a missing observation in revenue also implies a missing in materials, such that one would lose all observations just by dropping missing observations in materials.

A.2 Internal Consistency of Balance Sheet Information

We check the internal consistency of the balance sheet data by comparing the sum of variables belonging to some aggregate to their respective aggregate. We construct the following ratios:

1. The sum of fixed assets and current assets as a ratio of total assets.
2. The sum of capital and other shareholder funds as a ratio of total shareholder funds.
3. The sum of long-term debt and other non-current liabilities as a ratio of total non-current liabilities.
4. The sum of loans, creditors, and other current liabilities as a ratio of total current liabilities.
5. The sum of non-current liabilities, current liabilities, and shareholder funds as a ratio of the variable that reports the sum of shareholder funds and total liabilities.

We then exclude from the analysis extreme values by dropping observations that are below the 0.1 percentile or above the 99.9 percentile of the distribution of ratios.

A.3 Further Quality Checks

After the implementation of basic cleaning steps, we further examine the quality of the variables. Again, we provide the number of dropped observations at each step.

1. We construct the variable "age" of the firm as the difference between the year of the balance sheet information and the year of incorporation of the firm plus one. We drop firms that report dates of incorporation that imply non-positive age values. (-146)
2. We construct liabilities as the difference between the sum of shareholder funds and liabilities ("TSHF") and shareholder funds or equity ("SHFD"). We drop observations with negative or zero values. (-7)

3. We compare the value of liabilities constructed as the difference between TSHF and SHFD and the value of liabilities constructed as the sum of current and non-current liabilities. We look at the ratio of the first measure relative to the second measure and remove firm-year observations for which this ratio is greater than 1.1 or lower than 0.9. (-0)
4. We drop firm-year observations with negative values for current liabilities, non-current liabilities, current assets, loans, creditors, other current liabilities, and long-term debt. (-40). Finally, we drop observations for which long-term debt exceeds total liabilities. (-124)
5. We construct net worth as the difference between total assets ("TOAS") and total liabilities. This variable should be equal to the variable SHFD provided by the BvD. We drop extreme values at the 0.1 and 99.9 percentile. This leaves ratios with a minimum of 0.85 and maximum of 1.1. (-230)
6. We drop firm-year observations with missing, zero, or negative values for the wage bill. (-1,015)
7. We construct our measure of the capital stock as the sum of tangible fixed assets and intangible fixed assets and, therefore, we drop observations with negative values for intangible fixed assets. (-0) We drop observations with missing or zero values for tangible fixed assets. (-2,442) We drop firm-year observations when the ratio of tangible fixed assets to total assets is greater than one. (-4)
8. Next, we examine the quality of the capital to the wage bill variable. We first drop firms if in any year they have a capital to wage bill ratio in the bottom 0.1 percent of the distribution. (-119) After we remove the very high extreme values of this ratio there is a very positively skewed distribution of the ratio and, therefore, we drop observations with ratios higher than the 99.9 or lower than the 0.1 percentile. (-238)
9. We drop observations with negative SHFD. (-3,239) We drop observations in the bottom 0.1 percentile in the ratio of other shareholders funds (that includes items such as reserve capital and minority interests) to TOAS. (-0)
10. We calculate the ratios of tangible fixed assets to shareholder funds and the ratio of total assets to shareholder funds and drop extreme values in the bottom 0.1 or top 99.9 percentile of the distribution of ratios. (-216)

11. We construct value added as the difference between operating revenue and materials and drop negative values. (-130) We construct the ratio of wage bill to value added and drop extreme values in the bottom 1 percentile or the top 99 percentile. (-2,312)

The final sample has 113,337 observations with 25,371 firms.

A.4 Winsorization

We winsorize at the 1 and the 99 percentile variables such as value added, tangible fixed assets, wage bill, operating revenue, materials, total assets, shareholder funds, fixed assets, the sum of tangible and intangible fixed assets (capital), other fixed assets, and total liabilities. We winsorize at the 1 and the 99 percentile net worth, cash flow to total assets, and sales to total assets. In addition, we winsorize at the 0.1 and 99.9 percentile TFPR, MRPK, and MRPL before calculating our dispersion measures.

CHAPTER 2

STYLIZED FACTS ON INTEREST RATE RISK MANAGEMENT OF BANKS AND INVESTMENT FUNDS: EVIDENCE FROM ETD AND OTC DERIVATIVE MARKETS

Joint with Puriya Abbassi and José-Luis Peydró

2.1 INTRODUCTION

Do financial institutions use interest rate derivatives? How many of them are using derivatives? What type of interest rate derivatives are they using? And, what are the attributes associated with derivative users? Do they hedge or increase interest rate risk with derivatives and by how much? Do they adjust interest rate risk in reaction to yield changes?

To answer these questions, we employ novel supervisory data on interest rate derivatives for the population of German banks and open-end investment funds.[8] The questions that we pose are important to ensure adequate monitoring of interest rate risk in the German financial system, but extend as central questions to many other jurisdictions. The allocation of interest rate risk in the financial sector is important for at least two reasons: First, changes in interest rates affect bank net worth and through the bank balance sheet channel credit supply in the broader economy (see Bernanke and

[8] As of Mai 2020, for Germany, total assets in the open-end fund sector accumulates to 2.3 trillion Euro compared to 8.9 trillion Euro in the banking sector. Apart from insurance firms, which have a similar asset position as funds, those two sectors are the most important in terms of asset value. Furthermore, closed-end funds only make up a small fraction of total assets in the fund sector and are not using interest rate derivatives.

Gertler 1995 and Jiménez et al. 2012). Second, the allocation of interest rate risk is important for financial stability. For banks, a higher duration on the asset side of the balance sheet means that net worth declines if the yield curve shifts upwards. Thus, interest rate risk can affect the solvency of individual banks or the banking sector as a whole. Indeed, the savings and loans crisis in the US is a well-known example of bank failures caused by elevated interest rate risk (see White 1991). Moreover, interest rate risk has grown sharply over time in the German banking sector, where almost all banks experience a decrease in net worth from a rate rise (see Deutsche Bundesbank 2018) albeit equity ratios have grown concurrently. The investment fund sector is also very sensitive to interest rate risk as assets are held in (long term) securities and liabilities are redeemable at short notice. Thus, an abrupt rise in the yield curve creates losses for investment funds and more so if the duration is large. Losses can lead to a sell-off in the risk sensitive security markets and start a reinforcing price–adjustment spiral. Moreover, a negative fund performance due to rising rates could trigger fund outflows and through this force additional divestment. If funds hold considerable amounts of illiquid assets, run like behaviour among fund shareholders could emerge (see Deutsche Bundesbank 2018).

During the financial crisis in 2007/08, losses in the opaque derivatives market induced the US government to rescue the insurance company AIG (see Glasserman and Young 2016). Thus, the neglect of derivative markets in the past, has led to considerable financial stability concerns. This paper makes a contribution by analysing the role of derivatives for interest rate risk in the German financial industry. A central question after the financial crisis was whether derivatives lead to a build up of financial risk or whether they are used for hedging purposes (see Sen 2018).

Our research makes two primary contributions: First, we analyse the extensive margin of interest rate derivative usage by open-end investment funds and banks for the population of German institutes active in 2018. We find that around 50% of banks and 40% of funds are using interest rate derivatives. The share of banks is much larger compared to the US, where only 10% are using interest rate derivatives. The number is similar for investment funds in the US. Curiously, while banks use predominantly OTC derivatives (ten times as much institutes use OTC products), it is vice versa for investment funds (use ETDs ten times as much). We also relate interest rate derivative usage of banks to balance sheet variables previously analysed by the literature. In line with previous theoretical contributions and empirical research, we find evidence that size, total credit, mortgages, and deposits positively predict derivative usage of banks, while cash, securities, and equity negatively predict it. Interestingly, within derivative users, we find that bonds held-for-trading are a positive predictor of ETD usage. For investment funds, we find that the share of bonds is the strongest predictor of derivative usage.

Second, we quantify interest rate risk from Euro denominated bond futures and interest rate swaps for the banking and fund sector between 2017:Q1 and 2018:Q4 at the bank–quarter level. We calculate the interest rate risk of bond futures with position level data and market information from Bloomberg. For interest rate swaps, we employ a pricing model and calculate interest rate risk for each individual open transaction. Afterwards, we aggregate all open positions at the bank–quarter level. Our findings suggest, that banks take a negative duration on average with both interest rate swaps and bond futures. Thus, profiting when the yield curve rises. Quantitatively, they take considerable interest rate risk with OTC swaps and not with futures, both on average and in the cross section. However, assuming that most banks have positive net duration for on-balance-sheet exposures, swaps are used to mitigate interest rate risk. In addition, the distribution of swap-duration is skewed towards negative values. Thus, banks with large risk factors in swaps likely reduce their overall interest rate risk. Investment funds also take a negative duration on average with both swaps and bond futures. While average duration in futures is small, our estimates show that investment funds take large risks in the interest rate swap market both on average and in the cross section. Again swap-duration is also skewed towards negative values. Hence, derivatives (futures and swaps) are used to decrease interest rate risk of the bond portfolio, which traditionally has a positive duration. Furthermore, while future-duration is on average low, there is considerable heterogeneity and a large number of ETD users. Thus, both the interest rate swaps and bond-futures are important factors when it comes to analysing interest rate risk in the fund sector.

Lastly, we want to highlight that we cannot detect any significant (positive or negative) relation between the overall level of the ten year yield and interest rate risk for small changes in the yield at the quarterly frequency for both banks and funds. However, the exposure in derivatives seems correlated between investment funds and banks.

Overall, our research implies that macro supervisors in financial stability and monetary policy decision makers should not neglect interest rate derivatives when assessing interest rate risk given their importance in the financial system.

To the best of our knowledge, this is the first paper to empirically analyse interest rate risk management with derivatives for the population of German banks and investment funds. Moreover, we are not aware of any other research work that studies the extensive margin of (interest rate) derivative usage outside the US, especially in relation to balance sheet variables. Furthermore, to the best of our knowledge we are the first to highlight that investment funds predominantly use ETDs, banks OTC derivatives, and what observables determine ETD usage within banks. Except for Hoffmann et al. (2018), we are not aware of any other research study that quantifies interest rate risk with position level data on derivatives, especially with enough information to precisely calculate interest rate risk. Begenau et al. (2015) also measure interest rate risk of derivatives albeit indirectly. We complement the study of Hoffmann et al. (2018) along several dimensions: First, we analyse a larger cross-section of financial institutes. More precisely, we measure interest rate risk for the population of German banks and investment funds. Thus, compared to them, we also include smaller banks and investment funds into our study.[9] Second, we analyse a panel of financial institutes and therefore are able to relate interest rate risk to the time dimension of macroeconomic variables. Third, we extend their analyses by comparing interest rate risk from exchange traded with over-the-counter derivatives.

There is a large literature related to the study of interest rate risk and derivatives in the banking sector. As described by Hoffmann, Langfield, Pierobon, and Vuillemey, (2018), in the traditional view, banks act as maturity transformers by funding long-term loans and taking short-dated deposits, which makes them vulnerable to an increase in interest rates.[10] This view is supported by several empirical studies. Many papers use public data to show the negative relationship between surprise interest rate increases and stock prices of banks (see e.g. Flannery and James 1984a). The relation of equity value and interest rates can then, in a second step, be related to different balance sheet positions

[9] They also analyse investment funds, however, not in connection to on-balance sheet items.
[10] Banks will only be exposed to interest rate risk in the scenario that loans are not exclusively floating rate contracts.

to detect the sources of interest rate risk (see Flannery and James 1984b and English, Heuvel, and Zakrajsek 2018 for a relation to maturity mismatch and Ampudia and Van den Heuvel 2019 for a relation to deposits and the low interest rate environment in the Eurozone). Moreover, changes in stock prices have been related to off-balance sheet information on derivative usage (see Venkatachalam 1996 and English, Heuvel, and Zakrajsek 2018). Begenau, Piazzesi, and Schneider (2015) take a different approach and use a factor model to represent banks' fixed income positions in terms of factor portfolios. They similarly find that bank balance sheets (both banking and trading book) are negatively exposed to interest rate rises, as well as interest rate derivative positions. Deutsche Bundesbank together with the German federal financial supervisory authority (BaFin) require, as do many other central banks, banks to self-report their interest rate risk in the banking book (including derivatives of the banking book) in accordance to EU regulation and guidelines set by the European Banking Authority (see BaFin 2019). According to this measure, for Germany, more than 90% of banks report losses from an increase in interest rates, confirming the other empirical findings (see Bundesbank 2018). Di Tella and Kurlat (2020) provide a theoretical explanation for why banks are exposed to interest rate risk. According to their model banks earn a higher spread in deposit taking when interest rates are high. Therefore, they optimally hedge by being long in rate decreases.

In an alternative view on the banking system, the duration of bank assets and liabilities perfectly match. In Hellwig (1994) banks extend variable-rate loans and borrow in form of variable-rate deposits. Drechsler, Savov, and Schnabl (2018) show that due to market power in the deposit market, deposit rates effectively behave like long-term fixed rate liabilities and therefore match with assets. Hoffmann et al. (2018) analyse banks supervised by the European Central Bank and find that on average net worth changes only marginally with rates but increases in interest rates for the majority of institutes. Moreover, contrary to Begenau et al. (2015), they find that banks reduce their interest rate exposure via interest rate derivatives (swaps).

Related to interest rate risk and derivatives in the banking sector, research has also focused on the transmission of monetary policy. Both, Gomez, Landier, Sraer, and Thesmar (2020) and Beutler, Bichsel, Bruhin, and Danton (2020) find that monetary policy transmission is significantly affected by bank interest rate risk. Moreover, Purnandandam (2007) finds that derivative non-user banks adopt more conservative asset-liability (risk) management policies in response to monetary tightening.

Interest rate risk or duration management is a key concern for fixed income funds as well as the fixed income part of a multi asset fund. Generally, duration management has two broad purposes: First, market timing interest rates is a crucial strategy to achieve superior performance. Most bond fund managers are in fact believed to be market timers (see Elton, Gruber, Brown, and Goetzmann 2003). By adjusting their duration in expectation of yield changes, fund managers can make profits.[11]

Second, almost all bond portfolio managers control their interest rate risk through a Duration Targeting (DT) process (see Leibowitz and Bova 2012).[12] DT refers to bond portfolios that maintain a more or less stable duration over time. In this way, investment funds pursue a clear objective in terms of risk profile, which is a key distinction between other fund competitors.

Generally, an investor has always two options for DT or market timing purposes: Cash market instruments or derivatives. Futures have generally low transaction costs and high liquidity and are therefore a useful tool for both purposes. Indeed, Fabozzi (2012) highlights that index replication is often achieved synthetically with interest rate derivatives such as futures. Moreover, according to Fabozzi (2012), market timing is the most common use of futures.

Overall, there is not much evidence on the duration (interest rate risk) management practices of investment funds. Using security-level data on fixed income securities, Koijen, Koulischer, Nguyen, and Yogo (2020) depict the evolution of duration for the euro area mutual fund sector over the course of monetary easing. As interest rates decreased, they find a small increase in duration for the fund sector. However, as mentioned by the authors, their estimates are lacking the inclusion of interest rate derivative positions. Similarly, analyzing German institutes, estimates by Deutsche

[11] For an empirical evaluation of bond fund performance and market timing see Chen, Ferson, and Peters (2010) and Huang and Wang (2014). For the role of derivatives in market timing see Lynch and Maslar (2017).

[12] In principle, there are other measures for interest rate risk, but duration is performing well. For example, Ilmanen (1992) finds that duration measures can explain 80 to 90% of the return variance of U.S. government bonds.

Bundesbank show that portfolio duration of investment funds has increased over the last decade (see Bundesbank 2018). This has been especially the case for funds held by the insurance sector. To our knowledge, the paper by Lynch and Maslar (2017) is the only one including position level information on interest rate derivatives in their calculation of portfolio duration. Natter, Rohleder, Schulte, and Wilkens (2017) analye the risk exposure to interest rates based on the relation of fund performance, interest rates, and interest rate future use.

Lastly, another strand of literature has focused on the linkage between credit constraints, net worth, and derivatives hedging. Froot, Scharfstein, and Stein (1993) and Froot and Stein (1998) argue that firms and financial institutions face convex external financing costs and therefore are more likely to hedge when leverage is high (networth low). Similarly, the model by Diamond (1984) predicts that institutes with higher interest rate risk are more likely to hedge. Thus, ceteris paribus (regarding interest rate risk), a lower net worth is associated with higher risks and more hedging. Rampini and Viswanathan (2010), on the other hand, argue that net worth is positively related to hedging. In their model financing and risk management are linked as both involve promises to pay that are limited by collateral constraints. Rampini, Visvanathan, and Vuillemey (2020) find empirical evidence to support their theory for banks. Using detailed and long-dated information on derivative positions of US life insurers, a recent paper by Sen (2018) shows that hedging depends on whether balance sheet positions are marked-to-market and hence have implications for regulatory capital. Hedging increases for insurers that underwrite products that are risk sensitive for regulatory capital. According to Sen (2018), collateral (financial) constraints are not able to explain the differences in hedging behaviour.

The remainder of the paper is structured as follows. In the next section, we describe our datasets along with summary statistics. Section 2.3.1 shows our results on the extensive margin of derivative usage. Section 2.3.2 provides for the theoretical underpinnings of interest rate risk measurement. Section 2.3.3 shows our results on interest rate risk in the banking and fund sector. Section 2.4 concludes.

2.2 DATA DESCRIPTION AND SUMMARY STATISTICS

This study makes use of four different datasets: Granular data on interest rate derivative contracts reported under the European Markets Infrastructure Regulation; monthly bank balance sheet statistics and investment fund statistics of Deutsche Bundesbank; and Bloomberg data.

Since 2014, derivative transactions have to be reported by European legal entities under the European Markets Infrastructure Regulation. The information is transferred through several privately managed transaction repositories to Deutsche Bundesbank for all German legal entities.[13] For the purposes of this study, we restrict our dataset to interest rate derivative contracts made by financial institutions classified as open-end investment funds or banks. Institutes are selected based on Bundesbank internal bank and fund classifiers. Internal classifiers of financial institutes can be matched to the derivatives data with the global Legal Entity Identifier (LEI). We make use of end-of-day reports on open positions in interest rate derivative transactions for ETD and OTC derivative contracts. We aggregate the information of all end-of-day reports between January 2017 and December 2018 to a single file and keep all unique counterparty-transaction pairs. For each transaction, we have around 80 variables of information such as for example: counterparty identifier, quantity, or currency.

In Table 1, we show summary statistics on the different types of interest rate derivatives reported during 2018 at the institute-contract level (or counterparty-transaction level).[14] We count around 940,000 unique ETD and 500,000 unique OTC contracts held by investment funds and banks in Germany in 2018. For ETDs, around 80% of observations are futures and only 20% options. Within futures, 90% of observations are bond futures and the rest other types of interest rate futures. Around 74% of all observations are Euro denominated contracts and 19% Dollar denominated. Thus, those two currencies make up 93% of all observations. For OTC derivatives, 75% of observations are swaps, 20% forwards, and 5% options. Within swaps, 90% are plain vanilla and the rest cross-currency, basis swaps, etc. Around 52% of observations are

[13] The two repositories DTCC and REGIS cover virtually all trades of European financial institutions (see Hoffmann et al. (2018)).
[14] We show summary statistics only on the 2018 sample, because filtering by product identifier is less time consuming than for the 2017 sample.

Euro denominated and 19% Dollar denominated. Thus, while the big majority is Euro denominated, other currencies than Euro play an important role. The distribution of different types of interest rate derivatives is very similar if one looks at only Euro denominated interest rate derivatives. Note that comparing the number of OTC contracts against ETD contracts is misleading. While a trader would usually make a new OTC transaction when changing her interest rate exposure, a trader in ETDs only creates a transaction for a particular derivative once and then changes her exposure by making modifications to the original transaction. These modifications are not captured as a new contract in the data. Thus, leading to an underestimation of ETD contracts.

In Table 2, we show summary statistics on average positions of key balance sheet variables of banks and open-end investment funds for 2018. The information is retrieved from the monthly bank balance sheet and investment fund statistics gathered by Deutsche Bundesbank. We select all German banks and funds for which we have a LEI identifier. Since investment funds are reported at ISIN level, we aggregate all funds with the same LEI. Our final dataset covers around 99% of total bank sector assets and 93% of the total fund sector assets. We have in total 1,449 banks and 5,962 investment funds.

In Section 2.3.1, we analyse the relation between balance sheet variables and interest rate derivative usage based on our complete sample of financial institutions in 2018, distinguishing also between ETD and OTC users. In Section 2.3.3, we quantify interest rate risk emanating from the Euro denominated bond future market and plain vanilla swap market for the banks and funds using the respective derivatives at quarterly frequency between 2017:Q1 and 2018:Q4. As shown in Table 1, swaps and bond futures are by far the largest types of contracts traded. We focus on those two types for simplicity of risk calculation. The interest rate swaps in our sample differ based on maturity, the counterparty side (sell or buy), underlying floating rate (e.g. 6-month Euribor), swaprate, and reset frequency. The bond futures differ in the underlying bond, which is a fictive government bond with various criteria (country, maturity, coupon payment) and counterpartyside. Note that we restrict our swaps to Euribor referenced contracts, which make up around 80% of reported trades. The relevant contracts can be selected by product identifiers and declared values of several key-characterizing variables. We extensively check for quality of the dataset by for example analysing the number of reporting institutes or examining systematic changes in reported values. Our final dataset for section

2.3.3 contains in total around 1,900 reporting funds and around 700 banks. These figures are similar in magnitude to the total number of derivatives users in 2018. For summary statistics on the derivative positions see Section 2.3.2 when we outline the measurement of interest rate risk and the needed input factors.

Lastly, we enrich our proprietary datasets with market prices, duration, and conversion factors of the underlyings for bond futures from Bloomberg.

2.3 EMPIRICAL EVIDENCE

2.3.1 Derivative usage

In Table 3, we report the number of investment funds and banks that used interest rate derivatives during 2018. We find that out of 1,449 German banks around 50% use interest rate derivatives. This is in contrast to the US where only around 10% of commercial banks use interest rate derivatives out of around 8,000 banks, although 50% of bank holding companies use interest rate derivatives out of around 300 (see Rampini et al. 2020). For open-end investment funds, we find that out of 5,962 German institutes around 40% use interest rate derivatives. Natter et al. (2017) find for US bond funds that around 50% use derivatives. Given that we find a positive relation between bond securities and interest rate derivatives in Table 8, we expect a similar ratio of interest rate derivative usage for German funds compared to the US. Notice that, although we do not compare our results on the extensive margin with all types of derivatives, we expect a close match between the number of interest rate derivative users and derivative users more generally. Moreover, the number of Euro denominated derivative users is similar to the total number of derivative users. Thus, looking only at Euro denominated contracts would also likely yield similar results.

In Table 4, we differentiate OTC derivative vs. ETD usage of both banks and funds. Out of 704 banks, 71 use both OTC derivatives and ETDs, 621 use only OTC derivatives, and 12 use only ETDs. This is in contrast to investment funds where out of 2,304 interest rate derivative users, 199 use both OTC derivatives and ETDs, 2,026 use only ETDs, and 79 use only OTCs. Therefore, investment funds predominately use ETDs and banks almost exclusively OTC derivatives. To our knowledge, we are the first to highlight this difference in derivatives usage across different sectors – although previous research for banks has focused on OTC swaps and for funds on interest rate futures (see

Natter et al. 2017 and Hoffmann et al. 2018). Furthermore, it is an open question at this point, why funds predominantly use ETDs and banks OTC products. In addition, while few funds use OTC derivatives or few banks use ETDs, they could still be quantitatively important in terms of risk exposures.

In Table 5, we report the results of a linear probability model for our sample of banks. The dependent variable is '1' if the banks use an interest rate derivative (OTC or ETD) during any day in 2018 and '0' otherwise. The independent variables are various mean balance sheet figures. In column 1, we regress derivatives usage on the log of total assets. In line with previous findings for the US, size is a strong and positive predictor for derivatives usage (see Purnanandam 2007 or Rampini et al. 2020). Among all independent variables it has with 0.22 the by far largest R^2. Quantitatively, a 100% increase (doubling) of asset size leads to a 15% higher chance of using derivatives. There are several possible reasons why size is a positive determinant. Size can be interpreted as a measure of net worth and related to theories of borrowing constraints and hedging (see Rampini and Viswanathan 2010 and Rampini et al. 2020). Moreover, with size come economies of scale (lower fixed costs) or generally a higher level of sophistication. In columns 2-5, we regress derivatives usage on four asset side balance sheet items, which have been related to hedging in previous research. Consistent with the theory of Froot et al. (1993) and the empirical findings of Purnanandam (2007) cash is negatively associated to the likelihood of derivatives usage. Quantitatively, an increase from the 25^{th} percentile to the 75^{th} percentile of the cash ratio distribution (≈2 percentage points) leads to a 0.74% higher probability of derivative usage. Similarly, in line with Purnanandam (2007), we also find that securities are negatively associated to interest rate derivatives usage. Quantitatively, an increase from the 25^{th} to the 75^{th} percentile of the security ratio distribution (≈10 percentage points) leads to a 3.8% higher probability of derivative usage. The results suggest that cash or liquid assets can be viewed as substitutes to derivatives. In case of negative shocks, all three items can be sold (compared to credit). More precisely, banks can either have liquid assets or insure cash through derivatives to achieve a stable cash flow. In contrast, we find that both, the ratio of credit and mortgages to total assets are positively related to the likelihood of derivatives usage. This is in line with the model by Diamond (1984), which shows that derivatives use facilitates intermediation services. Purnanandam (2007) also finds a positive association for US data. Hoffmann et al. (2018) argue that retail mortgages predict how much banks lose with a rate rise and find a positive relation between hedging and mortgages for the large Eurozone banks supervised by the ECB. Quantitatively, an increase from the 25th to the 75th percentile of the credit and mortgage ratio distribution (both ≈15 percentage points) leads to a 5.25% and 6.45% higher probability of derivative usage respectively. In columns 6 and 7, we estimate the connection between securities held for trading and interest rate derivatives. If sophistication is a cause of derivatives usage, we would expect a positive relation. We find that the ratio of securities held for trading to total assets positively predicts derivatives usage. However, this relation becomes negative if one controls for size (see Table 6) suggesting a not very robust association. We also include the ratio of fixed income securities held for trading to total assets and come back to its interpretation when analysing Table 7. Lastly, in columns 8 and 9 we regress derivatives usage on the ratio of equity and deposits to total assets. We find that equity is negatively related. This is in line with the theory of Froot et al. (1993), which predicts more hedging with lower net worth, but in contrast to Rampini and Viswanathan (2010). At the same time, higher hedging with little equity could be the result of regulatory pressure. German banks can be demanded additional equity injections if they take excessive interest rate risk in their banking book (see Bundesbank 2018). Rampini et al. (2020), on the other hand, do no find a significant relation of accounting equity and interest rate derivatives for US data. Quantitatively, an increase from the 25th to the 75th percentile of the security ratio distribution (≈2 percentage points) leads to a 2% higher probability of derivative usage. We find that deposits are positively related to hedging. This is in contrast to the empirical findings of Purnanandam (2007) for the US. In theory, higher deposits could lead to more or less hedging. A higher ratio of deposits could be a sign of less access to international credit markets and therefore incentives hedging to keep a stable cash flow. At the same time, deposits could be a sign of stable funding and therefore dis-incentivize hedging. From the perspective of interest rate risk, a high ratio of deposits could mean that banks suffer from a rate rise due to long maturity assets and therefore decrease their asset duration with swaps. Although one could also argue the opposite and say that banks use swaps to insure themselves against a further decline of rates due to the lower bound on deposit rates. Quantitatively, an increase from the 25th to the 75th percentile of the deposit ratio distribution (≈15 percentage points) leads to a 6.6% higher probability of derivative usage. Thus, the independent variables analysed here generally appear to be economically significant predictors.

In Table 6, we corroborate the findings of columns 2-9 by controlling for size. All results are qualitatively robust except for the relation of equity and securities held for trading to derivative usage.

In Table 7, we estimate the same model as in Table 6 except that we focus on derivative users only and the dependent variable is ‘1’ for banks using ETDs and ‘0’ otherwise. Since ETD users also hold OTC products in almost all cases, we essentially compare banks that use ETDs and OTC derivatives with banks that use only OTCs. Furthermore, we control for sophistication and economies of scale in terms of size in all regressions. We find that banks using ETDs differ to OTC users along several dimensions: They have more cash, less mortgages, and less credit. Interestingly, the likelihood of ETD usage is positively predicted by the ratio of fixed income securities held-for-trading to total assets. Quantitatively, a one standard deviation increase in the ratio distribution (≈1 percentage points) leads to a 7.7% higher probability of ETD usage. Notice that both the securities and derivatives are marked-to-market. This finding is in line with Sen (2018), who empirically shows that insurance firms are more likely to use derivatives, which are marked-to-market, if the balance sheet assets are sensitive to market valuations. To the best of our knowledge, we are the first to highlight these differences among banks using different types of derivatives.

In Table 8, we report the results of a linear probability model for our sample of investment funds. As with banks, the dependent variable is ‘1’ if the funds use an interest rate derivative (OTC or ETD) during 2018 and ‘0’ otherwise. The independent variables are again various mean balance sheet figures. In line with previous findings for US banks and bond mutual funds (see Rampini et al. 2020 and Lynch and Maslar 2017), in column 1, we find that larger funds (log of total assets) are more likely to use derivatives. Quantitatively, a 100% increase (doubling) of asset size, leads to a 5% higher chance of using derivatives. Compared to banks, German investment funds hold very little debt and are almost exclusively financed by equity. Thus, models of financial constraints, which traditionally explain hedging behaviour, are not directly applicable. Intuitively as with banks, with size usually comes higher sophistication and lower fixed costs and thus could be a potential explanation for the given result. In column 2, we regress derivatives usage on the ratio of cash to total assets. We find that cash is negatively related to interest rate derivatives. In line with the model by Froot et al (1993) one could argue that, as long as fund managers are risk averse, having cash or hedging are both ways to maximize utility and therefore substitutes. Quantitatively, an increase from the 25th to the 75th percentile of the cash ratio distribution (≈6 percentage points) leads to a 1.6% higher probability of derivative usage. Lastly, we find that bond funds are more likely to use interest rate derivatives. Given that interest rate derivatives are frequently used to achieve certain duration targets (see Leibowitz and Bova 2012) or for market timing of interest rates (see Fabozzi 2012), they are more relevant to fixed income funds. Quantitatively, an increase from the 25th to the 75th percentile of the cash ratio distribution (≈80 percentage points) leads to a 43% higher probability of derivative usage. In Table 9, we corroborate the findings of Table 8 by controlling for size. All results are qualitatively robust.

2.3.2 Theory and measurement

In this section, we set out how to quantify the duration (interest rate risk) of bond futures and plain vanilla interest rate swaps. Our measurement of interest rate risk and derivatives pricing is guided by the textbook on fixed income by Fabozzi et al. (2012).

There are in principle two different measures of duration of a bond: Macaulay duration and modified duration. Macaulay duration is defined as the weighted average time to maturity and expressed in years. A hypothetical duration of 2 would thus mean that it takes on average two years until all cash flows are repaid. Modified duration, on the other hand, is defined as the approximate percentage change in value for a 100 basis point change in rates. Thus, modified duration measures the percentage losses or gains from an increase or decrease of rates respectively. In the following analysis we adhere to the modified duration (MD) definition of duration as we are interested in a direct measure of interest rate risk.

In order to calculate the interest rate risk emanating from the futures market, we calculate for each investment fund and bank in each quarter the MD as such:

$$MD_{futures} = -\frac{\sum_{f=1}^{F} \phi_f * €duration_{CTD,f} * CF_f}{TA} \quad (1)$$

where subscript 'f' refers to future, ϕ_f to the number of futures (negative for short positions), CF_f to conversion factor, $€duration_{CTD,f}$ is the loss (gain) in Euros of the cheapest-to-deliver (CTD) bond for a 100 basis points parallel upward shift in the yield curve (this position is negative for losses), and TA is total assets. The conversion factor is used to equalize coupon differences across all delivery bonds. E.g. if the fictive delivery bond has a coupon of 6%, but the CTD issue has a coupon of less, the conversion factor will be less than one. The CTD issue is the bond among all those that are deliverable to satisfy the contract that has the highest return in a cash and carry trade. This return is called the implied repo rate. For each future, we retrieve the end of quarter duration of the cheapest to deliver bond and its conversion factor from Bloomberg. In the numerator, we aggregate over all losses or gains from the futures the institute is holding. Subsequently we take the negative value and divide by total assets (TA). The final measure of duration MD_f will be negative if a fund makes gains from a upward shift in the yield curve and positive vice versa. Modified duration is defined as a positive value if the security holder experiences losses from a rate rise, which will be the case for almost all bonds. We thus manipulate the sign such that the derivative holder will also have a positive duration if it makes losses from rate rises.

In order to calculate the interest rate risk emanating from the swap market, we calculate for each investment fund and bank in each quarter the MD as such:

$$MD_{swaps} = -\frac{\sum_{s=1}^{S} PV_s(r+\Delta r) - PV_s(r)}{TA} \qquad (2)$$

where $PV_s(r)$ is a pricing model to value interest rate swap s, r is a vector of forward rates, Δr is a 100 basis points upward perturbation of the yield curve, and TA is total assets. If the swap holder is the fixed rate receiver (floating rate payer), the change in present value will be negative. If the swap holder is the floating rate receiver (fixed rate payer), the change in present value will be positive. Following the convention of the definition of duration, we again switch the sign of the expression. Thus, the final expression will be negative if the institute gains from a rise in yields. For the valuation of interest rate swaps, we use a single-curve model where both the swap payments and the discount factors are based on the relevant euro forward curves of the underlying interest rate benchmarks (e.g. 3 month Euribor).[15]

In Table 10, we show summary statistics on swap-duration and future-duration at the institute –quarter level in 2017 and 2018 for banks and funds that use at least one of the two types of contracts. In line with the previous findings, investment funds predominantly use bond futures and banks use almost exclusively interest rate swaps.

2.3.3 Interest rate risk distribution

In Figure 1, we plot the quarterly distribution of swap-duration for the German banking sector. Duration of swaps is defined at the bank level as in equation 2. Figure 1 shows that banks on average have a negative duration for interest rate swaps and that this duration does not portray a time trend. For the majority of quarters average duration is around -2%, suggesting that banks profit around 2% in terms of total assets from a 100 basis points parallel rise in the yield curve. Given an average ratio of equity to total asset of 6%, this amounts to 33% of regulatory equity and therefore is large. Furthermore, the distribution is skewed towards negative values and depicts considerable variation, with the 5th percentile being most of the time between -15% and -10% and the 95th percentile between 2.5% and 5%. Assuming that the big majority of banks have a higher duration for the asset side of their balance sheet (excluding derivatives), our results imply that banks both increase and decrease their interest rate risk with swaps. Since we do not have information on interest rate risk for non-derivative balance sheet items, we cannot tell to what extent interest rate risk is heightened or mitigated for individual banks. However, given that banks presumably have on average a net positive duration from on-balance-sheet exposures (lose from a rate rise), their average total interest rate risk will decrease from swaps. Moreover, assuming net positive duration (without derivatives) for most of the banks, would imply that the large negative positions in derivatives are likely used for mitigating interest rate risk exposure. Our findings are in line with Hoffmann et al. (2018), who show bank value is increasing in interest rates due to swaps for a sample of Euro area banks. Moreover, they also show that the distribution in interest rate risk is heterogeneous and skewed towards banks profiting from a rate rise. Similarly, English et

[15] For an explanation of the single curve approach and its relation to the newer multi-curve approach, see Wenzel (2018).

al. (2018) find that the negative effect of a rate rise on stock prices is attenuated for US banks holding derivatives. In contrast, Begenau et al. (2015), also using data on US banks, find that positions in interest rate derivatives decline in a rate rise. Quantitatively, our estimates on average risk are larger than those of Hoffmann et al. (2018). They find that banks on average profit 0.09% for a 100 basis points rise in the yield curve, while our estimates suggest 2%.

In an unreported result we also analyse the distribution of interest rate risk emanating from bond futures for German banks. The respective variable is defined in equation 1. In accordance to swaps we find that banks on average profit from a rate rise. However, the distribution is centred closely around zero and quantitatively less meaningful. The average bank profits only 0.01% from a rate rise and most of the gains or losses are within 0.1% of total assets. Furthermore, there are only very few banks active per quarter in our sample of Euro denominated bond future holders. Thus, overall OTC derivatives appear more important for the analysis of interest rate risk.

In Figure 2, we plot the quarterly distribution of futures-duration as defined in equation 1 for the German fund sector. Figure 2 shows that similar to banks the average fund has a negative duration and does not depict a time trend. For the majority of quarters average duration is around -0.2% of total assets. However, compared to the average duration of around 7% for fixed income securities in the fund sector, the values are rather small (see Bundesbank 2018). Moreover, similar to banks there is considerable variation and skewness towards negative values, with the 5th percentile being most of the time around -1% and the 95th percentile between 0.2% and 0.5%. That is, while some funds gain 1% from a 100 basis points rate rise, others lose 0.5% of total assets. Notice also that interest rate risk became more dispersed over time.

In Figure 3, we plot the quarterly distribution of swap-duration as defined in equation 2 for the German fund sector. Figure 3 shows that similar to derivative positions of banks and future positions of investment funds, the average fund has a negative duration for swaps. Furthermore, average duration has been decreasing over time. While duration was around -5% at the beginning of 2017, it fell to around -11% in 2018. Considering that average duration of fixed income securities for funds is around 7%, these are large values. We find that variation is very substantial, with the 5th percentile being most of the time around -40% and the 95th percentile at around 15%. Interestingly, similar to the future positions of funds, but more vivid, variation in interest rate risk became more dispersed over time. Thus, compared to future positions, there is more interest rate risk emanating from the swap market.

In Figure 4, we plot the yield to maturity for the ten-year German government bond between end of 2016 and end of 2018. There are three relevant features that emerge: First, at the beginning of the sample, the yield was on a rising path, increasing by a total of 25 basis points and peaking in the second quarter of 2017. Second, in the second quarter of 2018 the yield decreased by 20 basis points after only small fluctuations in the previous three quarters. Third, within the two years there was no trend and the yield level stayed basically unchanged.

Looking at Figure 1 to 3, we cannot detect any significant co-movement of interest rate risk and the trajectory of the ten-year yield. Risk positions are not significantly changed at the quarterly frequency for minor movements in yields. Neither the second quarter of 2017 nor the second quarter of 2018 were turning points in the time series of interest risk distributions. Thus, suggesting that risk positions are unrelated to the level of yields for minor movements in yields. If we look at the development of interest rate risk over the whole sample period, it is not clear to what extent interest rates play a role fore risk management. While most figures do not show any significant changes, in line with the unchanged yield level, funds investing in OTC derivatives decrease their average duration over the sample period. Therefore, while we can say that risk positions seem unrelated to rates at the quarterly frequency for minor yield changes, we cannot conclude that the level of yields and interest rate risk from derivative positions are unrelated. Overall, we want to highlight that our results seem not to be driven by the extensive margin, as the number of banks and funds active in the bond future or swap market is not associated with the relevant statistics.

Interestingly, the distribution of interest rate risk for the swap market in the banking and fund sector seem correlated. This is especially vivid in the lower tail of the distribution. While 2017:Q3 is a trough, the subsequent two quarters are a high point. Afterwards both time series are declining again. In Figure 5, we plot the total outstanding net notional of ETD positions for the banking and fund sector. In line with the findings for the swap market, both lines seem to be correlated.

To conclude this section, we want to highlight several key findings: First, banks take a negative duration on average with interest rate swaps and bond futures. Thus, profiting when the yield curve rises. Quantitatively, they take considerable interest rate risk with OTC swaps both on average and in the cross section. However, assuming that most banks have positive net duration for on-balance-sheet exposures, swaps are used to mitigate interest rate risk. Average duration and duration in the cross section from bond futures is much smaller than for swaps. Paired with the fact that only few banks use bond futures, they are not very relevant to the study of interest rate risk in the banking sector. Second, investment funds also take a negative duration on average with both swaps and bond futures. Thus, derivatives are used to decrease interest rate risk of the bond portfolio, which traditionally has a positive duration. While average duration in futures is small, there is considerable heterogeneity and the number of ETD users is large. Thus, there exists a substantial amount of funds, where bond futures play a significant role for duration. Interestingly, our estimations show that investment funds take large risks in the interest rate swap market both on average and in the cross section. However, given that the bond portfolio has positive duration, this is used mostly for risk reduction. Moreover, one needs to keep in mind that the number of OTC users is only a fraction of ETD users. Lastly, we want to highlight that we cannot detect any significant (positive or negative) relation between the overall level of the ten year yield and interest rate risk for small changes in the yield at the quarterly frequency for both banks and funds.

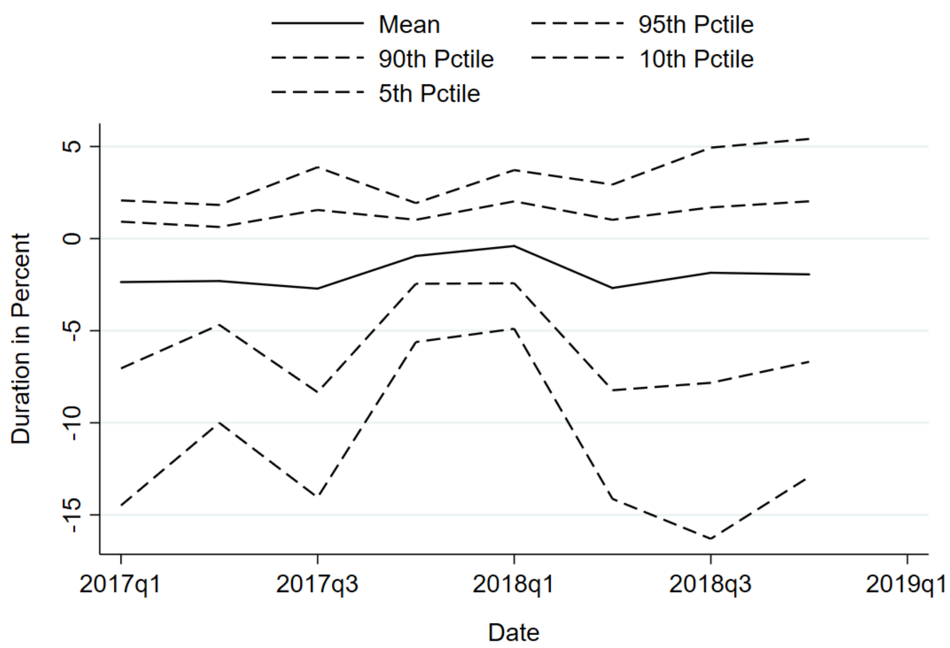
2.4 CONCLUSION

This study made a contribution by analysing the role of the derivatives market for the financial industry and interest rate risk in particular. We showed that interest rate derivatives play a large role for both the banking and investment fund sector. A large fraction of financial institutes are using interest rate derivatives. While banks predominantly use OTC derivatives, investment funds dominate the ETD market. Our evidence suggests, that both sectors on average decrease their interest rate risk with derivatives. However, while some institutes decrease their risk, others increase it. We cannot find evidence that financial institutes react to yield changes at the quarterly frequency.

Our research implies that macro supervisors in financial stability and monetary policy decision makers should not neglect interest rate derivatives when assessing interest rate risk given their importance in the financial system.

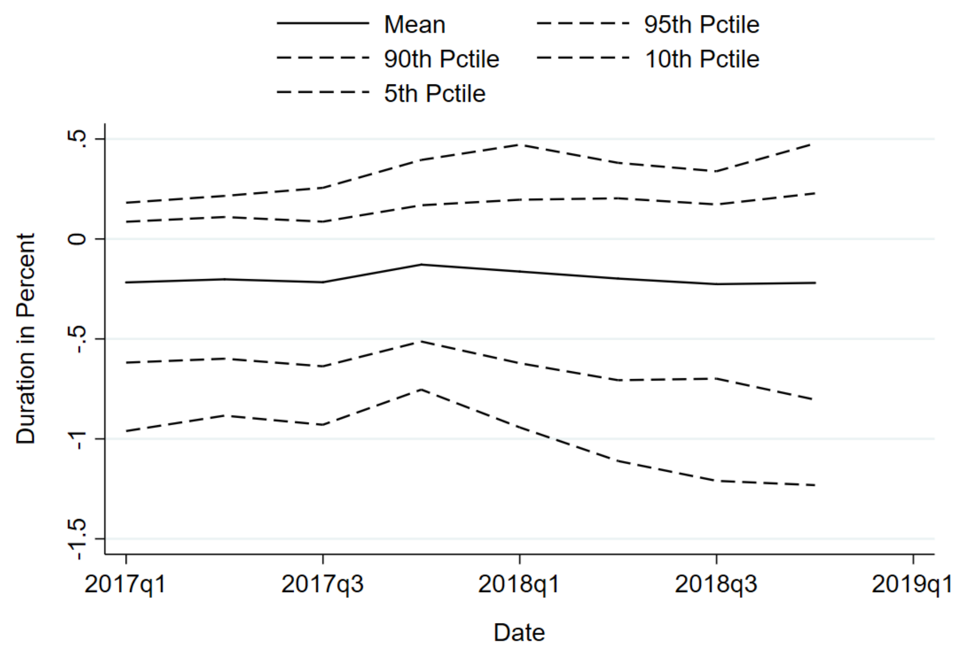
We want to conclude by making several suggestions for future research: One possible extension of our analysis would be to replace our extensive margin analysis (dummy variable) with notional values on interest rate derivatives since the extensive margin may be misleading when looking at economic magnitudes. Moreover, we are not able to quantitatively explain to what extent German banks or funds increase or decrease their risk with interest rate derivatives. Therefore, we suggest to complement the derivatives information with data on security holdings and self reported interest rate risk from the banking book of banks. Another interesting aspect would be to analyse the holding structure of investment funds in conjunction with the overall interest rate risk. Given the different balance sheet structure of insurance firms and banks, it would make a major difference for the overall financial stability implications. More generally, the analysis should be extended to the insurance sector, which is the third important sector in the German financial system.

FIGURE 1: SWAPS, INTEREST RATE RISK, AND THE BANKING SECTOR



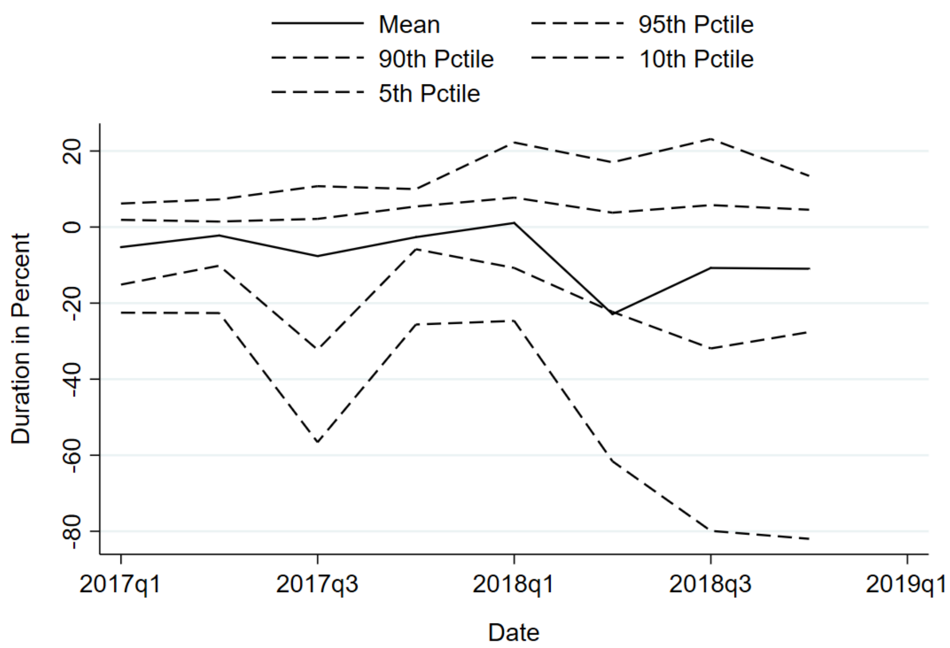
Notes: This figure displays the distribution of quarterly estimates of bank level exposure to interest rate risk from interest rate swaps from 2017:Q1 to 2018:Q4. Using proprietary transaction-level data from the EMIR on Euro denominated plain vanilla OTC interest rate swaps, we compute the present value change of each derivative at a given point of time for a 100 basis point rise in the yield curve. Swaps are priced using a single-curve model where both the swap payments and the discount factors are based on the relevant euro forward curves of the underlying interest rate benchmarks (e.g. 3 month Euribor). We aggregate all present value changes for a single institute and divide the resulting value by total assets. Our final estimate of interest rate risk will be negative if a bank profits from a rate rise and positive vice versa. We call this number duration in line with the definition of modified duration of a single security.

FIGURE 2: BOND FUTURES, INTEREST RATE RISK, AND THE INVESTMENT FUND SECTOR



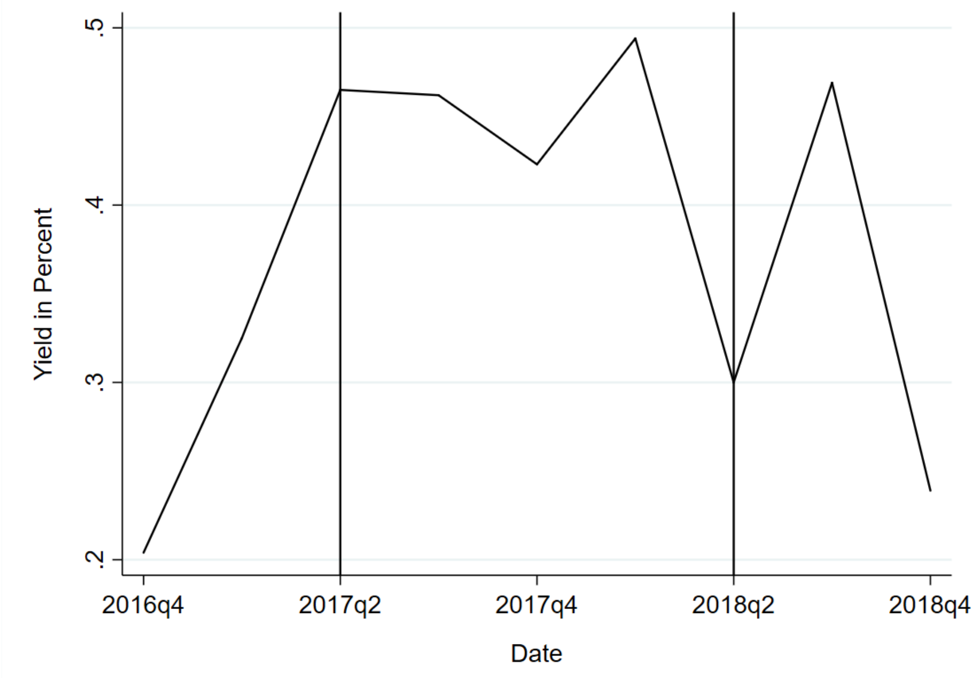
Notes: This figure displays the distribution of quarterly estimates of fund level exposure to interest rate risk from bond futures from 2017:Q1 to 2018:Q4. Using proprietary position-level data from the EMIR on Euro denominated bond futures paired with Bloomberg Analytics information, we compute the Euro duration (usually called Dollar duration) of each position, which is the absolute loss or gain from a future position for a 100 basis points rise in the yield curve. Afterwards, we aggregate the Euro duration of all positions for a single institute and divide the resulting value by total assets. Our final estimate of interest rate risk will be negative if a fund profits from a rate rise and positive vice versa. We call this number duration in line with the definition of modified duration of a single security.

FIGURE 3: SWAPS, INTEREST RATE RISK, AND THE INVESTMENT FUND SECTOR



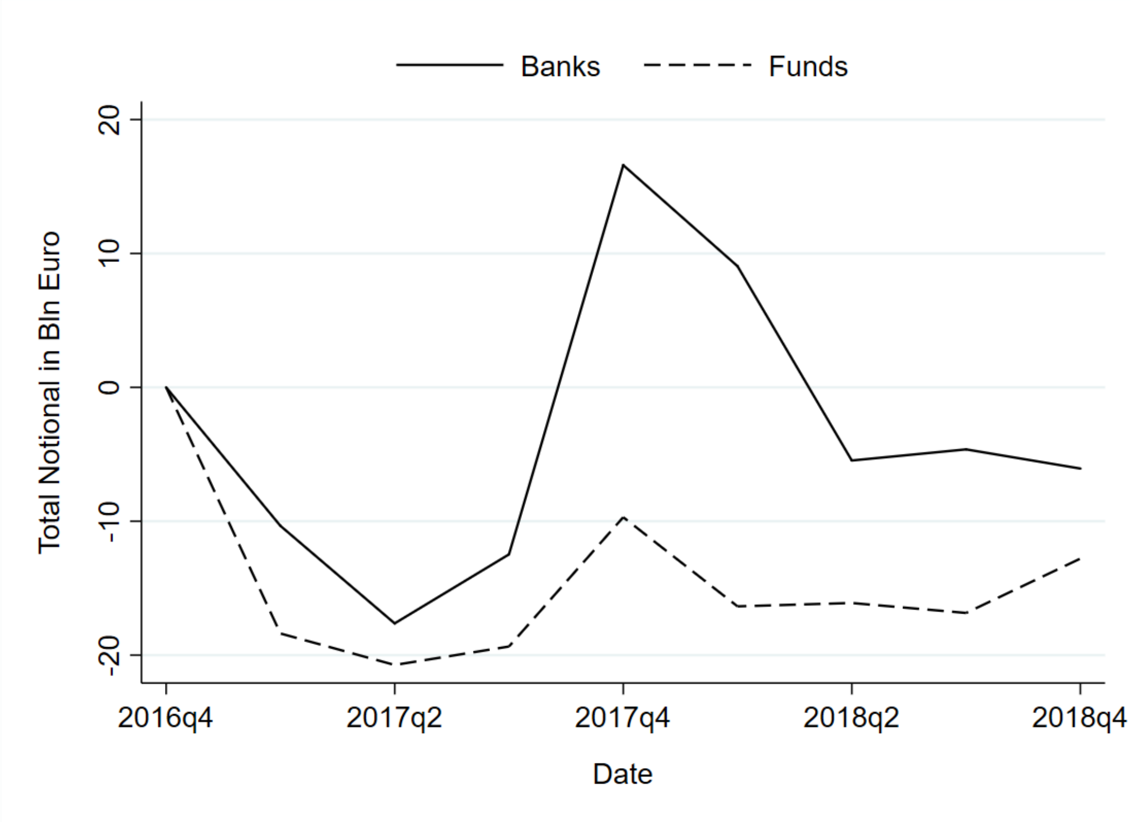
Notes: This figure displays the distribution of quarterly estimates of fund level exposure to interest rate risk from interest rate swaps from 2017:Q1 to 2018:Q4. Using proprietary transaction-level data from the EMIR on Euro denominated plain vanilla OTC interest rate swaps, we compute the present value change of each derivative at a given point of time for a 100 basis point rise in the yield curve. Swaps are priced using a single-curve model where both the swap payments and the discount factors are based on the relevant euro forward curves of the underlying interest rate benchmarks (e.g. 3 month Euribor). We aggregate all present value changes for a single institute and divide the resulting value by total assets. Our final estimate of interest rate risk will be negative if a fund profits from a rate rise and positive vice versa. We call this number duration in line with the definition of modified duration of a single security.

FIGURE 4: YIELD ON 10Y GERMAN GOVERNMENT BOND



Notes: This figure displays the path of the yield to maturity for a generic German government bond with ten-year maturity between 2016:Q4 and 2018:Q4.

FIGURE 5: AGGREGATE STATISTICS ON BOND FUTURE POSITIONS



Notes: This figure displays the aggregate net notional value in billion Euros for the bond future market in the German banking and open-end investment fund sector. Notice that we have no data in 2016q4 and thus our first observation is zero.

TABLE 1: SUMMARY STATISTICS ON DIFFERENT TYPES OF INTEREST RATE DERIVATIVES

ETD* contracts (Total=934,825)

Options	Futures	
20%	80%	
	Bonds	Miscellaneous
	90%	10%

OTC# contracts (Total=498,896)

Options	Swaps		Forwards
5%	75%		20%
	Plain Vanilla	Other	
	90%	10%	

* around 74% are Euro and 19% Dollar denominated contracts

around 52% are Euro and 19% Dollar denominated contracts

Notes: This table shows summary statistics on different types of interest rate derivatives at the institute-contract level reported during 2018. The distribution (e.g. options vs. futures) is very similar if one only looks at Euro denominated interest rate derivatives.

TABLE 2: SUMMARY STATISTICS ON BALANCE SHEET VARIABLES

Banks

	Obs.	Mean	Std.	P 10	P 25	P 50	P 75	P 90
Total Assets	1449	5334.60	40815.74	130.58	286.90	867.09	2142.01	5096.81
Cash / Total Assets (in %)	1449	4.28	9.54	0.78	1.28	1.94	3.40	6.85
Credit/ Total Assets (in %)	1449	67.90	14.84	49.48	60.24	70.07	77.73	83.70
Equity/ Total Assets (in %)	1449	7.14	7.94	4.12	4.96	5.92	7.11	8.86
Nonbank-Liab/ Total Assets (in %)	1449	71.43	15.85	58.67	69.37	75.31	79.66	83.63
Savings/ Total Assets (in %)	1449	21.98	11.60	0.20	16.04	22.95	28.93	35.27
Deposits/ Total Assets (in %)	1449	49.45	14.06	36.10	42.83	49.57	56.70	63.83

Investment Funds

	Obs.	Mean	Std.	P 10	P 25	P 50	P 75	P 90
Total Assets	5962	352.20	1651.35	13.61	32.59	84.14	229.83	665.71
Securities/ Total Assets (in %)	5899	85.44	26.71	59.72	89.83	95.47	97.70	98.86
Bonds/ Total Assets (in %)	5899	42.65	38.41	0.00	0.00	43.24	80.33	96.20
Cash/ Total Assets (in %)	5899	7.34	14.98	0.71	1.59	3.44	7.35	14.78

Notes: This table shows summary statistics on average positions of balance sheet variables of the population of German open-end investment funds and banks for 2018 (with small deviations).

TABLE 3: INTEREST RATE DERIVATIVE USAGE

IR Derivatives	No	Yes	Total
# of Funds	3,658	2,304	5,962
In %	61.36	38.64	100.00
# of Banks	745	704	1,449
In %	51.41	48.59	100.00
Total	4,403	3,008	7,411
In %	59.41	40.59	100.00

Notes: This table shows the number of investment funds and banks that reported positions in interest rate derivatives during 2018.

TABLE 4: INTEREST RATE DERIVATIVE USAGE: ETD VS. OTC

Banks

		OTC user	
		No	Yes
ETD user	No	745	621
	Yes	12	71

Funds

		OTC user	
		No	Yes
ETD user	No	3,658	79
	Yes	2,026	199

Notes: This table shows the number of institutes that reported only ETDs, only OTCs, both ETDs and OTCs, or none during 2018.

TABLE 5: THE EXTENSIVE MARGIN OF DERIVATIVE USAGE BY BANKS

	Dependent Variable: Derivatives Yes/No								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Assets	0.1520***								
	(0.0061)								
Cash / TA (in %)		-0.0037***							
		(0.0012)							
Securities/ TA (in %)			-0.0038***						
			(0.0010)						
Credit/ TA (in %)				0.0035***					
				(0.0009)					
Mortgages/ TA (in %)					0.0043***				
					(0.0009)				
Securities H-f-T/ TA (in %)						0.0111*			
						(0.0057)			
Fixed Income Securities H-f-T/ TA (in %)							0.0281		
							(0.0227)		
Equity/ TA (in %)								-0.0098***	
								(0.0011)	
Deposits/TA (in %)									0.0044***
									(0.0009)
Observations	1,449	1,449	1,449	1,449	1,387	1,449	1,449	1,449	1,449
R-squared	0.220	0.005	0.008	0.011	0.015	0.004	0.002	0.024	0.016

Notes: This table reports estimates on the likelihood of interest rate derivative usage in the cross-section of German banks on any day during the year 2018. The outcome variables are dichotomous with ‘1’ and ‘0’. The outcome variable is ‘1’ if the bank holds an interest rate ETD or OTC derivative during 2018 and ‘0’ otherwise. All independent variables are averaged over 2018. 'Total Assets' (TA) is the logarithm of total assets. 'Cash' is defined as the cash balance held at other banks and at the central bank. 'Securities' is the nominal amount of marketable equity and bonds. 'Credit' is the total amount of outstanding loans. 'Mortgages' is defined as the amount of retail credit borrowed for the procurement of housing. 'Securities H-f-T' is the nominal amount of securities held for trading. 'Fixed Income Securities H-f-T' is the nominal amount of bonds held for trading. 'Equity' is the total amount of accounting equity. And, lastly, 'Deposits' is the total amount of on-demand and short-term deposits held by non-banks. All amounts are in Euros. Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 6: THE EXTENSIVE MARGIN OF DERIVATIVE USAGE BY BANKS

	Dependent Variable: Derivatives Yes/No							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total Assets	0.152***	0.150***	0.150***	0.154***	0.152***	0.166***	0.149***	0.149***
	(0.0061)	(0.0062)	(0.0062)	(0.0063)	(0.0061)	(0.0070)	(0.0066)	(0.0062)
Cash/ TA (in %)	-0.0036***							
	(0.0010)							
Securities/ TA (in %)		-0.00172*						
		(0.0010)						
Credit/ TA (in %)			0.0024***					
			(0.0008)					
Mortgages/ TA (in %)				0.0052***				
				(0.0008)				
Securities H-f-T/ TA (in %)					-0.0062**			
					(0.0031)			
Fixed Income Securities H-f-T/ TA (in %)						-0.0053		
						(0.0116)		
Equity/ TA (in %)							-0.00151	
							(0.0011)	
Deposits/ TA (in %)								0.0029***
								(0.0008)
Observations	1,449	1,449	1,449	1,387	1,449	1,449	1,449	1,449
R-squared	0.225	0.222	0.225	0.232	0.221	0.220	0.220	0.226

Notes: This table reports estimates on the likelihood of interest rate derivative usage in the cross-section of German banks on any day during the year 2018. The outcome variables are dichotomous with '1' and '0'. The outcome variable is '1' if the bank holds an interest rate ETD or OTC derivative during 2018 and '0' otherwise. All independent variables are averaged over 2018. 'Total Assets' (TA) is the logarithm of total assets. 'Cash' is defined as the cash balance held at other banks and at the central bank. 'Securities' is the nominal amount of marketable equity and bonds. 'Credit' is the total amount of outstanding loans. 'Mortgages' is defined as the amount of retail credit borrowed for the procurement of housing. 'Securities H-f-T' is the nominal amount of securities held for trading. 'Fixed Income Securities H-f-T' is the nominal amount of bonds held for trading. 'Equity' is the total amount of accounting equity. And, lastly, 'Deposits' is the total amount of on-demand and short-term deposits held by non-banks. All amounts are in Euros. Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 7: THE EXTENSIVE MARGIN OF DERIVATIVE USAGE BY BANKS

	Dependent Variable: ETD Yes/No							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total Assets	0.0875***	0.0994***	0.0989***	0.0804***	0.0880***	0.0709***	0.0972***	0.0980***
	(0.0105)	(0.0102)	(0.0107)	(0.0112)	(0.0104)	(0.0117)	(0.0102)	(0.0103)
Cash/ TA (in %)	0.0132***							
	(0.0039)							
Securities/ TA (in %)		0.00138						
		(0.0011)						
Credit/ TA (in %)			-0.0045***					
			(0.0010)					
Mortgages/ TA (in %)				-0.0037***				
				(0.0010)				
Securities H-f-T/ TA (in %)					0.0205***			
					(0.0046)			
Fixed Income Securities H-f-T/ TA (in %)						0.0766***		
						(0.0201)		
Equity/ TA (in %)							-0.0021	
							(0.0072)	
Deposits/ TA (in %)								0.0006
								(0.0012)
Observations	704	704	704	665	704	704	704	704
R-squared	0.267	0.192	0.222	0.143	0.228	0.224	0.190	0.190

Notes: This table reports estimates on the likelihood of interest rate ETD usage in the cross-section of German banks on any day during the year 2018. The outcome variables are dichotomous with '1' and '0'. The outcome variable is '1' if the bank holds an interest rate ETD during 2018 and '0' if holds only a OTC contract. All independent variables are averaged over 2018. 'Total Assets' (TA) is the logarithm of total assets. 'Cash' is defined as the cash balance held at other banks and at the central bank. 'Securities' is the nominal amount of marketable equity and bonds. 'Credit' is the total amount of outstanding loans. 'Mortgages' is defined as the amount of retail credit borrowed for the procurement of housing. 'Securities H-f-T' is the nominal amount of securities held for trading. 'Fixed Income Securities H-f-T' is the nominal amount of bonds held for trading. 'Equity' is the total amount of accounting equity. And, lastly, 'Deposits' is the total amount of on-demand and short-term deposits held by non-banks. All amounts are in Euros. Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 8: THE EXTENSIVE MARGIN OF DERIVATIVE USAGE BY INVESTMENT FUNDS

	Dependent Variable: Derivative Usage Yes/No				
	(1)	(2)	(3)	(4)	(5)
Total Assets	0.0504***				
	(0.0035)				
Cash/ TA (in %)		-0.0026***			
		(0.0004)			
Securities/ TA (in %)			0.0040***		
			(0.0001)		
Bond Securities/ TA (in %)				0.0054***	
				(0.0001)	
Bond Securities €/ TA (in %)					0.0052***
					(0.0002)
Observations	5,899	5,899	5,899	5,899	5,899
R-squared	0.029	0.006	0.048	0.181	0.144

Notes: This table reports estimates on the likelihood of interest rate derivative usage in the cross-section of German investment funds on any day during the year 2018. The outcome variables are dichotomous with ‘1’ and ‘0’. The outcome variable is ‘1’ if the fund holds an interest rate ETD or OTC derivative during 2018 and ‘0’ otherwise. All independent variables are averaged over 2018. 'Total Assets' (TA) is the logarithm of total assets. 'Cash' is defined as the cash balance held at banks. 'Securities' is the market value of marketable equity and bonds. 'Bond Securities' is the market value of bonds. 'Bond Securities €' is the market value of all Euro denominated bonds. All amounts are in Euros. Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 9: THE EXTENSIVE MARGIN OF DERIVATIVE USAGE BY INVESTMENT FUNDS

	Dependent Variable: Derivative Usage Yes/No			
	(1)	(2)	(3)	(4)
Total Assets	0.0476***	0.0466***	0.0376***	0.0470***
	(0.0038)	(0.0035)	(0.0032)	(0.0033)
Cash/ TA (in %)	-0.0010**			
	(0.0004)			
Securities/ TA (in %)		0.0038***		
		(0.0001)		
Bond Securities/ TA (in %)			0.0052***	
			(0.0002)	
Bond Securities €/ TA (in %)				0.0051***
				(0.0002)
Observations	5,899	5,899	5,899	5,899
R-squared	0.030	0.072	0.197	0.169

Notes: This table reports estimates on the likelihood of interest rate derivative usage in the cross-section of German investment funds on any day during the year 2018. The outcome variables are dichotomous with ‘1’ and ‘0’. The outcome variable is ‘1’ if the fund holds an interest rate ETD or OTC derivative during 2018 and ‘0’ otherwise. All independent variables are averaged over 2018. 'Total Assets' (TA) is the logarithm of total assets. 'Cash' is defined as the cash balance held at banks. 'Securities' is the market value of marketable equity and bonds. 'Bond Securities' is the market value of bonds. 'Bond Securities €' is the market value of all Euro denominated bonds. All amounts are in Euros. Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 10: SUMMARY STATISTICS ON ETD AND OTC DERIVATIVE POSITIONS

Banks

	Obs.	Mean	Std.	P 5	P 25	P 50	P 75	P 95
Notional Futures	5608	-5.52	443.07	0.00	0.00	0.00	0.00	0.00
Duration Futures	5608	-0.00	0.02	0.00	0.00	0.00	0.00	0.00
Notional Swaps	5608	6230.36	158589.86	-575.50	0.00	22.00	125.00	1457.00
Duration Swaps	5608	-1.78	11.55	-11.76	-1.30	-0.10	0.08	2.84

Investment Funds

	Obs.	Mean	Std.	P 5	P 25	P 50	P 75	P 95
Notional Futures	14326	-9.09	117.84	-51.10	-6.00	-0.40	0.00	10.10
Duration Futures	14256	-0.77	47.37	-0.79	-0.20	-0.01	0.00	0.21
Notional Swaps	14326	1.80	322.57	-0.90	0.00	0.00	0.00	12.70
Duration Swaps	14256	-0.95	26.10	-0.61	0.00	0.00	0.00	0.00

Notes: This table reports summary statistics on the notional amount and duration of interest rate swap positions and bond future positions for German open-end investment funds and banks at quarterly frequency in 2017 and 2018. It takes negative (positive) values whenever the institute is net short (net long) in the derivative at the end of the quarter.

CHAPTER 3

FIXED INCOME OVERLAY STRATEGY: EVIDENCE FROM MATCHED FUND-ASSET MICRODATA

Joint with Puriya Abbassi

3.1 INTRODUCTION

With total assets of nearly 160 trillion US dollars, non-bank institutional asset managers have grown to become one of the most important participants in today's financial markets. The unusually low interest rates of the past years have considerably contributed to this rapid growth (BIS 2018). Especially major fixed income investors, whose existing investments benefited initially from the decline in interest rates, tilted their portfolios towards longer-term assets in order to generate additional returns on new investments when interest rates persisted at low levels (Hanson and Stein 2015).[16] This, in essence, has extended the duration of the portfolios suggesting an increased sensitivity of the non-bank industry sector to snapbacks in interest rates and volatility (e.g., Rajan 2005; Gennaioli, Shleifer, and Vishny 2012; Stein 2013). A natural question that arises in this context is whether and how these investors manage this vulnerability associated with spot market risk.

Addressing this question is a crucial step in understanding channels of propagation of snapback risks and similar shocks within the financial system, especially in light of recent market dynamics, where longer-term rates have reverted without notable changes

[16] Figure 1 shows that the Euro denominated market for long-term government and corporate bonds has markedly increased over the years, insinuating an overall heightened interest rate risk for financial institutions.

in short-term rates.[17] In this paper, we conjecture that overlay strategies using interest rate derivatives play a pivotal role in the way non-bank firms manage changes in value of their existing physical bond portfolio when long-term rates move adversely.[18] Despite a large theoretical literature on such overlay strategies, virtually no empirical study identifies this relation in data.[19] This paper aims to provide such empirical evidence.

We conduct our analysis using (open-end) mutual fund data. Mutual funds are highly relevant for the propagation channel as they rely on credit lines and deposits at banks, thereby creating a direct link to the banking sector and the real economy. At the same time, they face strategic complementarities that may have a profound effect on the stability of the financial system as a whole through their impact on market prices and dynamics (e.g., Edelen 1999; Coval and Stafford 2007; Chen, Goldstein, and Jiang 2010). Focusing on mutual funds has also another important advantage that is crucial to our analysis: since funds are almost exclusively funded via marketable shares, funds' net asset value decreases in the interest rate. Hence, changes in market rates have direct impact on the values of assets under management. Understanding potential overlay strategies thus restricts the focus on physical assets holdings (and their maturities) and exposures from interest rate derivatives, to both of which we have access.[20]

More precisely, we exploit transaction-level supervisory data on investor's interest rates derivatives trading for all open-end mutual funds in Germany during 2017-2018, enabling us to trace the end-of-day positions for each fund in response to adverse movements in long-term interest rates. Because we have also detailed information on funds' actual asset holdings at the security-fund-month level, we are able to compute each

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[17] Historically, interest rate shocks have been linked to monetary policy decisions, see e.g., Hanson et al (2018) for a thorough discussion.

[18] In this paper, we use the term 'overlay strategies' to denote investment strategies that use derivatives to obtain, offset, or substitute for certain risk exposures beyond the underlying physical security portfolio.

[19] The most prominent theoretical papers studying risk management practices are Froot, Scharfstein, and Stein (1993), Froot and Stein (1998), Rampini and Viswanathan (2010) and (2013), and Fabozzi (2012). Only very few papers document the interest rate exposure for banks, see e.g., Begenau, Piazzesi, and Schneider (2015) and Hoffmann et al (2018). But among these studies, the evidence is mixed: Begenau, Piazzesi, and Schneider (2015) document that most U.S. banks do not use interest rate derivatives, and the ones that do take on additional risk. For the euro area, Hoffmann et al (2018) show that banks reduce their interest rate risk, but only partially.

[20] For banks, the effective maturities of liabilities would also play an essential role in assessing the interest rate exposure associated with holdings, both on and off the balance sheet. Therefore, several papers rely primarily on market data, see e.g., Flannery and James (1984), Ampudia and van den Heuvel (2017), and English, van den Heuvel, and Zakrajsek (2018).

fund's portfolio physical asset holdings and map this to changes in interest rate derivatives positions. In addition, we have detailed monthly balance sheet information on each fund that allows us to explore across-fund heterogeneity. This exhaustive set of matched firm-asset micro data allows us to study differences across mutual funds, thereby addressing the typical reflection problem in detecting peer effects (Chen, Goldstein, and Jian 2010).

Our empirical study therefore tests differences in interest rate derivatives positions across funds depending on the ex-ante level of the physical bond portfolio when long-term interest rates change. Our main hypothesis is that funds with extended portfolio duration draw on the market of interest rate derivatives when long-term rates move adversely. Intuitively, consider investors holding large shares of long-term bonds versus investors with small shares of long-term debt. Faced with increases of long-term interest rates, the former will experience a higher valuation loss. Relative performance concerns of fund managers can induce a form of strategic complementarity among manager actions, which leads them to a coordinated shift out of high maturity assets (e.g., Feroli, Kashyap, Schoenholtz, and Shin 2014; Morris and Shin 2016). By taking countervailing positions in interest rate derivatives, funds with large shares of long-term bonds can (at least partially) offset the valuation loss associated with changes in long-term rates.

Our second prediction is based on the idea that yield-chasing investors are less willing to internalize the externalities of spot market risk. Funds that invest in relatively illiquid assets need to strike a challenging balance between selling illiquid assets and running out cash buffers when faced with performance related outflows. In addition, and consistent with strategic complementarities, yield-chasing investors are more concerned about their relative performance ranking with respect to their peers. Therefore, the prediction is that the effect of adverse yield changes on overlay strategies (i.e., usage of interest rate derivatives) is stronger in funds with more riskier profiles, i.e. more alpha-seeking behaviour (more credit risk and less liquid physical portfolios).

We find strong empirical support for our two hypotheses. Interestingly, mutual funds use primarily exchange traded (ETD) derivatives, notably bond futures, rather than over-the-counter (OTC) traded derivatives.[21] Within bond futures, our results suggest that

[21] Most of the funds (89%) in our sample are associated with ETD futures only, whereas a small number of funds trade only interest rate swaps over the counter (5%). This is consistent with Fabozzi (2012) who

mutual funds increase their net short selling positions when the long-term yield increases, thereby reducing valuation losses from systemic risk exposure (beta). Economically, a 10 basis point increase in the 10-year German government bond leads to 29% increase in net short positions. Moreover, we find that bond futures reduce the physical portfolio maturity mix (duration) on average by 5% in the cross section. At the same time, there is significant variation across funds: for 10% of funds, the overlay strategy reduces the overall interest rate risk exposure by 25%, which is economically very significant.

Importantly, however, the differential effect in net short selling positions depends on funds' ex-ante fraction of longer-dated bond securities. Economically, a fund with a one-standard-deviation higher share of longer-dated bonds is associated with 9.4% more net short positions as the long-term yield rises. In fact, we find that when the long-term rate increase, funds increase their net short selling positions particularly in futures where the fictive underlying asset is of longer-term nature. However, results using the overall level of bond holdings, i.e., without differentiating the maturity structure of the investments, are not significant. These results are consistent with the notion that funds use interest rate derivatives as an overlay strategy to offset some level of undesired systemic exposure in the existing physical bond portfolio without disrupting the existing particular asset mix strategy.

Within funds with longer-dated bonds, there is crucial heterogeneity among funds. More precisely, funds with higher duration and thus larger valuation losses from increases in the long-term yield, increase their net short selling positions in ETD-traded futures (i) more when they have a higher ex-ante fraction of lower-rated bonds, (ii) less when their investor base is the insurance sector, and (iii) more when they experience higher net outflows during the recent past. The reason for using liquid bond futures is fully consistent with the primary objective of an overlay, which is to reduce the main risk exposures of an illiquid fund investment.

Our results are all robust to the inclusion of a variety of fixed effects and fund-level time-varying controls. Overall, our findings speak to the existence of strategic complementarities among funds, especially among managers that are more concerned

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points out that interest rate futures have several key benefits, notably low transaction costs and high liquidity.

about their relative performance ranking with respect to their peers. By employing this overlay strategy, the asset manager can modify market exposure (beta) without changing security selection (alpha). Moreover, the liquidity, credit quality, and build-in leverage of bond futures allows such overlays to be implemented cheaply, safely, and with relatively small amounts of capital.

Our paper contributes to the literature in several ways. First, it adds an important insight to the growing body of research that examines financial fragilities arising from the presence of strategic complementarities among investors, notably fixed income asset managers (Chevalier and Ellison 1997; Chen, Goldstein, and Jiang 2010; Christoffersen, Musto, and Wermers 2014; Feroli et al 2014; Goldstein, Jiang, and Ng 2017).[22] These papers highlight the causal effect of illiquidity of investors' assets on payoff complementarities by showing that investors tendency to withdraw increases when they fear the damaging effect of other investors' redemptions. And it has been shown and discussed that these costs stem mostly from trades that funds face in response to outflows including both direct costs such as commissions, bid–ask spreads, price impact and indirect costs that result when redemptions force fund managers to deviate from their desired portfolio mix (Chordia 1996; Edelen 1999; Wermers 2000; Greene and Hodges 2002; Johnson 2004; Coval and Stafford 2007; Alexander, Cici, and Gibson 2007; Christoffersen, Keim, and Musto 2007). In this regard, our results also give rise to the notion that during a lengthy liquidation process, by employing an interest rate future overlay strategy, fixed income investors may keep their net exposures more in line with its original investment objectives. In this regard, Bund future overlays may also be a helpful tool to alleviate temporary imbalances and facilitate the restoration of liquidity in bond cash markets.

Second, it relates to the general understanding of amplification mechanisms in the financial sector. Recent evidence shows that financial disruptions can arise from excessive leverage on the liability side (Greenlaw, Hatzius, Kashyap, and Shin 2008; Adrian and Shin 2010) and excessive risk-taking on the asset side (Altunbas, Gambacorta, and Marquéz-Ibañez, 2014; Gambacorta, 2009; Ioannidou, Ongena, and Peydró, 2009;

[22] The idea, however, essentially traces back to traditional theories on bank runs (Diamond and Dybvig 1983), currency attacks (Morris and Shin 1998) bubbles and crashes in financial markets (Abreu and Brunnermeier 2003), among others.

Jiménez, Ongena, Peydró, and Saurina, 2014; Hanson and Stein 2015; Maddaloni and Peydró, 2011). Yet, these studies have primarily focused on on-balance-sheet activities entirely. An important aspect, however, in assessing propagation channels is the role of off-balance sheet investments, notably derivatives, which may both extend or reduce the exposure inherent to on-balance sheet activities. Empirical evidence on overlay strategies that make use of derivatives positions is, however, scarce due to the lack of microdata on both derivatives trading and balance sheet positions. We provide this evidence for one of the major fixed income investors in today's financial markets and show that open-end mutual funds take countervailing positions in futures to reduce valuation losses from existing physical bond holdings. Another, economically different, way to read our results is that higher-duration funds extend their physical bond portfolio using interest rate futures when long-term interest rates decrease. In this regard, our results suggest that this overlay strategy is also used to *expand* the investment opportunity set of the funds' strategy.

Our paper also contributes to the recent literature studying asset managers' investment behaviour during a low interest rate environment in general (Kacperczyk and Schnabl 2013; Chodorow-Reich 2014; Becker and Ivashina 2015; Hanson and Stein 2015; Choi and Kronlund 2016; Hau and Lai 2016; Di Maggio and Kacperczyk 2017; Peydró, Polo, and Sette 2017; Czech and Roberts-Sklar 2017). We show that on-balance sheet duration risks inherent to yield-chasing investment behaviour induce overlay strategies as interest rates change. In this regard, our paper also adds empirical evidence to the finance literature which argues that yield-oriented investors tend to neglect unlikely risks, in turn making financial markets more fragile (Rajan 2005 and 2010, Gennaioli, Shleifer, Vishny 2012; Guerrieri and Kondor 2012; Feroli, Kashyap, Schoenholtz, and Shin 2014; Moreira and Savov 2017). Our findings indicate that mutual funds pro-cyclically address vulnerabilities associated with spot market risk, i.e., they engage in countervaling positions when rates move adversely. At the same time, we show that overlay strategies can expand the investment opportunity set when long-term rates decrease, suggesting additional build-up of accounting and economic leverage in funds.

The remainder of the paper is organized as follows. In Section 3.2, we develop our theoretical predictions that will guide our empirical analysis. In Section 3.3, we describe our data and present first stylized facts. Section 3.4 presents our results and Section 3.5 concludes.

3.2 Fixed Income Overlay Strategies and Hypotheses Development

In light of the persistently low interest rates of the last decade, the potential for shifts in investors' asset holdings triggered by sudden yield reversals have been at the centre of concerns, given the potential to create substantial financial instability (Shin 2017; Stein 2013; Goldstein, Jiang, and Ng 2017, among others). Most investors have traditionally managed the overall interest rate exposure of their bond allocation exclusively through the physical (cash) market (Hanson and Stein 2015). We conjecture, however, that funds use interest rate derivatives to modify their market exposures. In fact, such an overlay strategy that involves interest rate derivatives may allow the investor to make asset mix shifts without disrupting specific underlying strategies that make up the asset structure. Moreover, the transaction costs, liquidity, credit quality, and build-in leverage of bond futures allow changes in market exposure to be implemented cheaply, safely, and with relatively small amounts of capital.

Our intuition regarding the implementation of such an overlay strategy is as follows. Assume an investor has a strategic asset mix of 70% long-term and 30% short-term bonds, and that the long-term interest rate increases.[23] This increase in the long-term interest rate creates, ceteris paribus, valuation losses on existing physical bond holdings, especially for investors with a higher share of long-term debt. In the traditional approach, in order to reduce the associated valuation loss the investor may wish to tilt its asset mix from long-term debt to short-term debt by selling long-term bonds and buying short-term bonds (Domanski et al 2013). An alternative approach is to implement a strategic mix through the use of an asset overlay, i.e., by taking a short position in long-term interest rate derivatives to achieve the desired market exposure.[24] This latter approach keeps the underlying physical portfolio intact, but allows to rebalance the overall exposures to ensure adherence to the investors' desired asset mix. A variation of this approach is to use

[23] For simplicity, we assume that the portfolio of the investor has no equities. However, our example also can be extended to funds with an asset portfolio that includes both bonds and equities.
[24] We interpret a short position in interest rate derivatives in line with markets terminology as a hedge against rate increases, i.e. the value of the derivative increases in interest rates.

an overlay strategy to achieve extended market exposure. Assume that the asset manager observes that long-term bonds outperform short-term bonds; to maintain the same physical portfolio allocations, the investor may want to take a long position in long-term interest rate derivatives to increase duration of the bond exposure. By altering these exposures through the use of derivatives instruments, the investor has efficiently achieved the desired tactical asset mix efficiently without disrupting the underlying investments in the physical allocations.

We conjecture that mutual funds implement such an overlay strategy to countervail valuation losses associated with physical bond holding when the long-term interest rate rises. Our motivation relies on the notion that fund managers care about relative performance in that they are averse to posting lower returns than their peers. These relative performance concerns induce a form of strategic complementarity of manager actions. Specifically, as long-term rates rise fund manager *i* is worried that other fund managers will start selling long-term assets and fund manager *i* will end up underperforming the other fund managers and finish last in the relative-performance tournament. Hence, following this line of reasoning, when the long-term yield rises we should see a coordinated shift among bond managers out of the long-term asset (or an increase of short positions in derivatives), and vice versa if rates decrease. These relative-performance-induced actions of fund managers in response to yield changes, have been discussed in previous theoretical work by e.g. Feroli et al (2014) and Morris and Shin (2016). And are in line with the empirical findings of Timmer (2018), who shows that mutual funds buy debt securities in response to higher returns. Fund managers care about relative performance, primarily for two reasons. First, career concerns play a role, as performance is positively associated with subsequent job outcomes (Chevalier and Ellison 1999). Interestingly, career concerns also have been shown to amplify price movements and lead to herding behavior (Guerrieri and Kondor 2012) and are thus in line with our presumption of cyclical trading strategies. Second, previous studies have shown a positive relation between performance and fund flows (e.g. Chevalier and Ellison 1997; Goldstein, Jiang, and Ng 2017). Given that asset managers' compensation is often a fixed share of asset size, this creates positive performance incentives. Indeed, Chevalier and Ellison (1997) discuss that this incentive mechanism directly affects risk-taking of fund managers. We do not take a stance on what precisely drives relative performance concerns (career concerns vs. fund flows). Rather, we exploit the fact that relative performance concerns incentivise fund managers to take actions.

More precisely, we conjecture that relative performance concerns of asset managers' paired with the benefits of using derivative contracts give rise to overlay strategies, whereby funds short interest rate derivatives to counteract valuation losses in affected bond holdings. Given that the performance of funds with higher duration is stronger affected by adverse long-term yield movements, we would expect them to react differentially stronger than funds with relatively lower duration. This notion forms our first hypothesis:

Hypothesis 1: *When the long-term interest rate increases, funds with higher duration short interest rate derivatives differentially more than funds with lower duration.*

Our second prediction is based on the idea that within the group of higher-duration investors, there is a differential effect depending on how strong the positive fund flow–performance relationship is. As described earlier, asset managers are motivated to achieve superior performance, because of their capacity to attract funds and the resulting higher compensation. If bad performance has a stronger effect on outflows and thus on the compensation for asset managers, they should care more about performance. Chen, Goldstein, and Jiang (2010) show that outflows are more sensitive to bad performance in illiquid funds than in liquid ones because outflows impose higher asset liquidation costs for illiquid funds and these costs are usually conveyed to the remaining investors after redemptions. Goldstein, Jiang, and Ng (2017) confirm that negative performance has a strong effect on outflows in illiquid corporate bond funds. Moreover, funds with illiquid assets will suffer also future losses if they are forced to liquidate assets on short-term notice upon bad performance and outflows. Therefore, we conjecture that within funds with larger shares of long-term debt, those with riskier profiles (e.g., more credit risk and less liquid) are differentially more inclined to sell interest rate derivatives when the long-term interest rate increases, than funds with more strategic stability. That is, we suspect the following hypothesis:

Hypothesis 2: *The pattern conjectured in Hypothesis 1 is stronger in funds that invest in less liquid assets.*

These predictions will guide us through the empirical analysis of the next section.

3.3 Data Description and Summary Statistics

We study fixed income overlay strategies employed by open-end mutual funds exploiting a unique data source that we obtain from the Deutsche Bundesbank, which, together with the European Central Bank and the German federal financial supervisory authority (BaFin), is the micro- and macroprudential supervisory in Germany. More precisely, we have access to transaction-level supervisory data on investor's interest rates derivatives trading, where at least one involved counterparty is based in Germany. Access to this data is granted to the Deutsche Bundesbank via the European Markets Infrastructure Regulation (EMIR), the European analogue to the U.S. Dodd-Frank Act. The raw data that we observe includes all interest rate derivatives contracts that were outstanding during the period January 2017 through December 2018, capturing information on the contracting parties, the initiation date, contract maturity, the type of contract, the underlying asset, the currency of the underlying, the notional value, and the price.

For our empirical analysis, we process the raw data along the following lines. First, we restrict ourselves to the most liquid and economically relevant interest rates derivatives contracts, i.e., futures and swaps, thereby considering both the exchange traded (ETD) and the over-the-counter (OTC) market segments. Within interest rates futures and swaps derivatives, we focus on euro-denominated contracts, most prominently on bond futures traded on Eurex and plain vanilla interest rate swaps referenced to the Euribor.[25] This captures around 80% of all Euro-denominated exchange-traded interest rates derivative contracts and 70% of all OTC-traded interest rate derivatives by funds in our sample.

We complement our interest rate derivatives data with confidential fund-level information, which allows us to relate derivatives trading to individual fund characteristics. To that aim, we match confidential balance-sheet information that is available at a monthly frequency, thereby capturing each fund's total assets under management, net flows, cash holdings, fixed income nominal amount investments, and

[25] Notice that all fixed-income futures are traded on a fictive underlying rather than being referenced to a specific bond. Figure 2 provides a decomposition of the different interest rate derivatives in our data.

the fund's investor base at the end of each month.[26] At the same time, this data collects funds' asset holdings at the security-fund-month level, which allows us to compute for each fund its duration associated with its investments. Using the unique security specific identifier ISIN, we further enrich this dataset with more granular information retrieved from Eurosystem's centralised securities database (CSDB) on the security's currency of denomination, its maturity, and credit rating. Finally, we use the unique identifier on the fictive underlying for our futures derivatives and obtain market information on the cheapest-to-deliver bond for each future, its future price, and the respective conversion factors from Bloomberg. Our final data set comprises information on 1,267 mutual funds over the period 2017:M1 through 2018:M12.[27] The total assets under management of all of these funds combined amounts to 577 EUR billions, which corresponds to roughly 18% of German GDP as at end of 2016.

In Table 1, we provide summary statistics for the open-end mutual funds that participate in both futures and swaps markets during our sample period, where for each fund, we present the average of the balance sheet statistic across time. The summary table reveals that there is a large heterogeneity across funds, with the mean and median of total assets of EUR 456 million and EUR 125 million, respectively, and a standard deviation of EUR 855 million. Importantly, our sample includes funds with a sizable amount of securities in fixed-income assets. While 90% of the funds hold at least 34% in bonds, 50% of our sample holds more than 73% of their securities portfolio in bond securities.

In unreported results, we show that most of the funds (89%) in our sample are associated with ETD futures only, whereas a smaller number of funds only trade interest rate swaps (5%). 7% of funds seem to be active in both markets. Table 2, therefore, provides further summary statistics on the type of ETD bond futures that we observe in our data. In total, there are eight different futures that we can observe for government bonds (see Appendix A). The FGBL, for example, is a future on the German government bond with residual maturity of 8.5 to 10.5 years and coupon rate of 6%. It has an initial

[26] Refer to Bade, Flory, and Schönberg (2018) for a thorough description of the investment fund statistic maintained by the Deutsche Bundesbank.

[27] In Germany, there are a total of 9,868 mutual funds, most of which (68%) are of open-end nature. Open-end funds also comprise more than 97% of the total net asset value (in total around 2.1 EUR trillions) in the mutual fund sector. Around 65% of open-end funds invest in bond securities (see Bundesbank 2019). Notice that funds are counted at the share-class level. We, however, aggregate data to the legal entity level.

maturity of 9 months and matures four times per year. Before maturity, a fund usually rolls over into the next contract in order to avoid delivery of the underlying and keep the exposure constant (see Figure A1). We summarize the eight futures into four different maturity buckets: short (1.75 to 3.25 years), medium (4.5 to 6 years), long (8.5 to 11 years), and ultra-long (24 to 35 years). On average, Table 2 shows that across all maturity buckets, funds are associated with a negative net notional in bond futures. The negative sign suggests that open-end mutual funds sell ETD futures more than they buy, indicating that funds decrease their overall (on-balance sheet) bond duration using interest rate futures.

To quantify the effect of the overlay strategy on the bond portfolio, we construct the following measure at the fund-month level:

$$modified\ duration \quad = -\frac{duration^{portfolio} + \sum_{f=1}^{F} \phi_f duration^{CTD-future} CF}{P(y)}$$

where ‘modified duration’ refers to the duration of bonds as part of a fund’s portfolio investments and its futures contracts. We compute the *portfolio duration* using bond-specific duration information that we retrieve from CSDB. The first term in the numerator measures the aggregate gain (loss) in Euros associated with Euro denominated bond holdings when the yields were to decline (inlcine) by 100 basis points. The second term in the numerator measures the duration (gain and loss in Euro amounts, respectively) associated with funds’ total bond future positions. For each future, we retrieve the end of month duration of the cheapest-to-deliver (CTD) bond ($duration^{CTD-future}$) and its conversion factor (CF) from Bloomberg. The Euro duration of the future portfolio is calculated by multiplying the number of futures with the CTD bond and its conversion factor and aggregating over all futures. $P(y)$ in the denominator measures the market value of the Euro denominated bond holdings. Hence, if the fund, for example, is rather long (i.e., buying) in bond holdings, but short (i.e., selling) in interest rate derivatives futures, the first term of the nominator will take a negative value and the second term will be positive, thereby reducing the overall duration of a given fund (modified duration, hereafter). In Figure 3, we show the bond portfolio duration (named ‘duration’) and the portfolio duration adjusted for futures (named ‘adjusted duration’) over time. We can see that funds are found to reduce their bond portfolio duration with futures on average by 5% and that this pattern is fairly constant over time. In unreported results, we also look at the cross sectional distribution: for 10% of funds, the decrease in overall duration amounts to 25% after accounting for interest rate futures, which is economically very large.[28]

3.4 EMPIRICAL STRATEGY AND RESULTS

3.4.1 The role of exchange-traded futures

We start our analysis by examining the role of exchange-traded futures as compared to OTC-traded swaps. That is, we intend to study whether there is a differential usage of ETD trades when market yields change, as compared to OTC contracts. To that aim, we estimate the following econometric specification:

$$Derivates\ usage_{\mathrm{i,j,t}} = \beta_1 * |\Delta i|_{t-1} + \beta_2 * \ |\Delta i|_{t-1} * ETD_c + controls + \varepsilon_{\mathrm{i,c,t}} \qquad (1)$$

where the dependent variable is an indicator variable, which takes the value of one if fund ‘i’ trades in segment ‘c’ (i.e., either ETD or OTC) during week ‘t’, and ‘0’ otherwise. $|\Delta \mathrm{i}|_{\mathrm{t-1}}$ refers to the absolute change in the one-period lagged market yield. We use the 10-year German Bund yield to capture the market yield. ‘*ETD*’ is a dummy variable that equals the value of one if the contract is an ETD, and zero otherwise (i.e., when the contract is OTC-traded). We further control for time-varying market-specific observed and unobserved heterogeneity using contract*month fixed effects and fund-contract specific characteristics using fund*contract fixed effects. Moreover, we include time-varying fund characteristics (‘controls’), notably the one-period lagged logarithm of total assets, notional amount associated with their bond holdings, nominal outflows and inflows.

Column 1 of Table 3 shows that open-end mutual funds are associated with a higher likelihood to trade derivatives contracts when market yields change (irrespective of direction). In column 2, we can see that this result is especially present for ETD contracts as opposed to OTC-traded contracts. That is, there is a 12.3% higher probability for funds to trade ETD derivatives when market yields change as compared to OTC

[28] The average fund has total assets amounting to 455 million Euros. Thereof around 85% (390 million Euros) are securities, where around 54% (210 million Euros) consist out of debt securities of which around 75% (160 million Euros) are Euro denominated and enter our calculations. Thus, an average fund in our sample with a bond portfolio of 160 million Euros and given a average portfolio duration of 5.5 (see Figure 3), will lose around 9 million Euros (0.055*160) for a 100 basis point increase in the yield curve. Thus, the total fund sector in our samle will lose around 11.4 billion Euros (9*1267) for a 100 basis point increase.

derivatives contracts. In columns 3 and 4, we replicate the analysis from columns 1 and 2, but change the dependent variable to a binary variable that equals the value of one whenever fund ‘i’ changes (increase or decrease) its derivatives position in segment ‘c’ during week ‘t’. That is, we examine whether a change in the market yield is associated with a build-up (or cutback) in derivatives positions. In column 3, we find that funds increase their derivatives positions with changing market yields. Column 4 suggests that this relationship is particularly pronounced for ETD-based contracts.

3.4.2 Overlay strategies to manage yield changes

On the basis of our finding from Table 3, we will restrict our analysis on ETD-traded futures going forward. More precisely, we intend to examine the relationship between funds’ ETD-traded futures and market yield changes. Therefore, we amend our model from equation 1 as follows

$$\text{NetLong}_{i,b,t} = \beta_1 {*} \Delta i_{t\text{-}1} + \text{controls} + \varepsilon_{i,b,t} \qquad (2)$$

where the dependent variable refers to the logarithm of the notional amount held in ETD futures by fund ‘i’ in the maturity bucket ‘b’ during week ‘t’. The dependent variable takes a negative (positive) value whenever the fund is net short (net long) in futures during a given week. Similarly, to equation 1, we use the one-period lagged change in the 10-year German government bond yield to account for changes in market yield. We further saturate the regression with fund-specific fixed effects, maturity-specific fixed effects, month fixed effects, fund-maturity bucket fixed effects, as well as time-varying fund-specific controls.

In column 1 of Table 4, we estimate our equation 2 without any fixed effects and controls. We find that an increase in the 10-year Bund yield is associated with higher net short (lower net long) positions in futures. That is, ceteris paribus, funds increase their net short positions in futures when the 10-year Bund yield increases. The results are statistically and economically significant. An increase of 10 basis points in the 10-year Bund yield is associated with a 29% increase in net short bond future positions. Moreover, the results remain both qualitatively and quantitatively unchanged, when including fund-specific and maturity-specific fixed effects as well as time-varying fund controls (column 2). In fact, while the estimated coefficient does not change, the increase in R-squared is significant (44%), suggesting that our result is independent with respect to the fixed effects added here (e.g., Altonji, et al, 2005). In column 3 and 4, respectively, we saturate the estimation with more fixed effects, notably with time-varying fund-maturity bucket specific fixed effects. While the estimated coefficient is smaller than in column 1 and 2, it remains negatively signed and highly significant (both economically and statistically). That is, mutual funds increase net short positions in futures when market yields increase.

One question that arises in this context is whether funds that have a higher duration associated with their bond holdings engage in more future sales as compared to funds with lower fraction of longer-dated fixed-income assets. The reason being that funds with higher bond duration may have a higher incentive to reduce overall duration in response to market yield changes given the larger valuation loss they face on existing physical bond holdings. Therefore, in the next step, we study fund-level heterogeneity depending on the fraction of longer-term bonds a given fund holds as part of its on-balance sheet securities portfolio. In column 1 of Table 5, we therefore replicate the estimation from column 4 of Table 4, but control for fund's fraction of longer-dated bonds at the end of each month, where longer-dated refers to remaining maturity of higher than eight years.[29] We can see that the estimated coefficient on the interaction term is negative and highly significant, suggesting that indeed funds with a larger fraction of longer-dated bonds are associated with larger net short positions when markets yields increase. This result holds true even after netting out maturity bucket-week effects (column 2). Economically speaking, a fund with a one-standard-deviation higher fraction of longer-dated bonds is associated with 9.4% more net short positions than the fund with an average share of long-term debt holdings for a 10 basis point increase in the 10-year Bund yield.

In a next step, we intend to assess how robust this result is to the inclusion of fund-level control variables that may affect this documented relationship. One may have the notion that funds only increase their short positions in response to yield increases, because they have been building up long positions in futures in the past and therefore see the necessity to counteract as yields change adversely. Therefore, in column 3, we include a binary variable that takes the value of one for each fund that is net long during the week prior the trading week, and zero otherwise. The estimated coefficient is indeed negative

[29] The results do not depend on the how we define longer-dated. In unreported results, we find that similar results can be obtained when altering the definition to longer than 10 years, for instance.

and highly significant, suggesting that funds with net long positions adjust their trading direction as yields move adversely. In economic terms, a 10 basis point increase in the 10-year Bund yield is associated with a 20% stronger increase in net short positions by funds with ex ante long positions relative to funds with no ex ante long positions. But, at the same time we find that our result remains unchanged. One concern may be that funds with a higher fraction of longer-dated bonds have higher stocks of bonds to begin with. We therefore include the logarithm of nominal amount of fund's total bond holdings in column 4. The estimated coefficient is indeed negative and significant, implying that funds with larger holdings of bonds engage in more net short positions when market yields rise. However, our result from column 1 remains also negatively, highly significant and similar in magnitude. One may have the notion that funds with higher ratios of longer-dated fixed income securities are generally more keen to pick up riskier assets and hence to generate more yield. In column 5, we therefore include each fund's fraction of bonds with non-A credit rating (i.e., lower investment grade and junk) to total bond holdings. Yet, we find that our result remains unchanged suggesting that the documented relationship is not affected by the fund's general risk-appetite.

One may have the notion that the type of the investor base may also affect our results. Therefore, we introduce a binary variable that equals the value of one, when the investor base is an insurance company, and zero otherwise. The results are presented in column 6, but indicate that our finding remains unaffected. Another issue could be that funds with higher share of longer-dated securities are less liquid and hence rely more on duration management than otherwise comparable funds. Therefore, in column 7 we include a binary variable which equals the value of one if the fund experienced a net outflow in the month prior to the week for which we observe its net short position. The estimated coefficient suggests that funds with previously larger net outflows are associated with higher net short positions in futures markets when the 10-year Bund yield increases. But, our main variable remains unchanged and highly significant. Finally, in column 8, we include all variables to ensure that neither one of these variables drives our results in a joint manner. Yet, we still find a differential effect in net short positions depending on the fraction of longer-dated bond securities when market yields increase.

Given this strong and robust result, one may raise the question as to whether there is further heterogeneity within funds with higher shares of longer-dated bond holdings.

We examine this question in Table 6. We start our analysis by examining whether the differential effect is higher for funds with overall larger bond holdings. In column 1, we do not find evidence in favour of this conjecture. Next, we include the fraction of non-A rated bonds to account for the riskiness of the bond portfolio of a given fund. The result presented in column 2 shows that indeed there is an additional differential effect stemming from the fraction of riskier fixed income securities. That is, funds with higher share of longer-dated bonds increase their net short positions in ETD-traded futures more when they have a higher fraction of lower-rated bonds as compared to funds with bonds of better credit ratings when the 10-year Bund yield increases. In economic terms, a 10 basis point increase in the 10-year Bund yield for a fund with average share of long-term bond holdings is associated with a 29% stronger increase in net short positions for a one standard deviation higher share of risky bonds. In column 3, we study the additional role that the investor base may play. The estimated coefficient presented in column 3 suggests that the differential effect is lower when the fund's investor base is the insurance sector. In fact, our estimated coefficient for 'Yield Change*Longer-Term Bonds' becomes economically more significant. However, we can also see that this differential effect is not significantly different from zero (F-test not reported) for funds held by the insurance sector. Economically, a 10 basis point increase in the 10-year Bund yield for funds with average share of long-term bond holdings is associated with a 24% weaker increase in net short positions for funds with the insurance sector as investor base. In a last step, we investigate the role of net outflows, i.e., whether there is an additional differential effect depending on how illiquid a fund is. The results is presented in column 4, where we find that, in response to an increase in the market yield, funds with higher shares of longer-term bonds are associated with even higher net short ETD-traded futures when they experienced net outflows during the recent past. Economically, a 10 basis point increase in the 10-year Bund yield for funds with average share of long-term bond holdings is associated with a 20% stronger increase in net short positions for funds that experienced net outflows relative to funds that did not. In column 5, we combine all variables and see that all results remain qualitatively and quantitatively similar. The only exception is our result on net outflows, which still has a negative signed estimated coefficient (as before), but is not statistically significant anymore (due to the large standard errors).

These results speak strongly to the fact that open-end mutual funds manage their portfolio bond duration using ETD futures as yields move adversely, thereby countervailing valuation losses from existing physical bond holdings. Yet, if the primary goal in using these derivatives contracts is to reduce valuation losses, one would assume that funds should engage in this behaviour using futures contracts with a fictive underlying that is also of longer-term nature, thereby mimicking the underlying investment in physical bonds. To that aim, in Table 7, we exploit the contract-level-maturity dimension further. More precisely, in column 1, we replicate our main result from column 4 but include an interaction term using a binary variable that equals the value of one for all positions in futures with a fictive underlying government bond of at least eight years of remaining maturity. We can see that the interaction term *Yield Change*Long-term Future* is negatively signed and highly significant (both statistically and economically). That is, when market yields increase, we find that open-end funds increase their net short positions particularly in futures where the fictive underlying asset is of longer-term nature.

All in all, these results are consistent with the notion that open-end funds use ETD-traded futures to manage their overall bond-portfolio duration when market yields move adversely. These results suggest a dynamic pattern in funds' overlay strategy, which is stronger for funds with riskier fixed income assets and higher net outflows (more illiquidity), but weaker for funds with an insurance investor base. Together, these results are consistent with the notion that funds use interest rate derivatives as an overlay strategy to offset some level of undesired systemic exposure (beta) in the existing physical bond portfolio without disrupting the existing particular asset mix strategy (alpha).

3.4.3 Event study: Draghi's Sintra speech

The previous analysis is based on a dynamic panel approach. To strengthen our results, in this section, we wish to study the relationship between fund's ETD-traded futures positions and changes in the market yield around an exogenous event that affected the 10-year Bund yield. On June 27, 2017, the president of the European Central Bank, Mario Draghi, gave an introductory speech to the ECB forum on central banking held yearly in Sintra, Portugal. During the speech, while talking about the Eurozone, he made the important comment that "deflationary forces have been replaced by reflationary ones".

This statement was widely interpreted by investors that the ECB would henceforth take a more hawkish stance on monetary policy and reduce its bond-buying programme as part of the ‘quantitative easing’ measures. During the same day, but also in the days after the speech, the yield on the 10-year German government bond increased rapidly. Other segments, e.g., the 2-year and 5-year German government bond yield reached their highest levels in over a year.[30]

In Figure 4 Subfigure A, we plot the daily yield on the 10-year German government bond both before and after Draghi’s Sintra Speech on June 27, 2017. On the day of the speech (indicated by the vertical line), the 10-year German Bund yield increased by 13 basis points, showing its largest daily change in 2017 and 2018. Within two and half weeks, the yield reached a level of 60 basis points, up with an overall increase of roughly 35 basis points compared to the day before the speech. This sudden and unexpected change in the 10-year Bund yield gives us a good quasi-natural experiment to study funds’ trading behaviour during the period of the yield increase. In Figure 4B, we plot the weekly yield on the 10-year German Bund against the average growth rates in the total notional net position in bond futures of open-end mutual funds around Draghi’s speech. While yields react immediately, the average growth rate only declines with a lag of one week. The decline in the growth rate of ETD-traded net positions suggests a build-up of short positions in the amount of 24% in response to the increase of the market yield. This unconditional result is consistent with our previous findings from the dynamic panel approach.

We study this period also more formally in Table 8, where we restrict our focus to a symmetric window of two weeks before and after Draghi’s speech and replicate our main estimations from Tables 5-7. In column 1, we start by testing the differential level in ETD-traded futures during the two weeks following the speech relative to the two weeks prior to Draghi’s statement. In columns 2 and 3, we examine the role of funds’ large share of longer-dated bond holdings and find that funds with more ex-ante long-term bonds increase their net short positions as compared to funds with a lower fraction of long-term fixed income holdings. In column 4, we include a binary variable which takes the value of one whenever the fund was net long in futures three weeks before the

[30] See the article called “Markets whipsaw after ECB recalibrates message on QE” in the Financial Times edition of June 27, 2017.

speech (i.e., had the largest exposure to the yield hike). We find that funds with an ex-ante net long position increase their net short positions more than funds with previously net short positions. Moreover, in columns 5 and 6, we find that funds with ex-ante higher long-term bond holdings increase their net short positions more in futures with an underlying asset of longer-term maturity after Draghi's speech. We consider these results to be very consistent with our prior findings suggesting that open-end mutual funds engage in a fixed income overlay strategy using ETD-traded Bond futures.

3.5 CONCLUSION

In this paper, we empirically study whether and how open-end mutual funds manage valuation losses from systemic exposure inherent to physical bond holdings. To that aim, we exploit a unique set of supervisory microdata on funds' interest rate derivatives positions matched with their asset holdings at the security-fund-month level, which allows us to track each funds' countervailing position associated with their investments. We are, therefore, able to test differences in interest rate derivatives positions across funds depending on the ex-ante level of bond portfolio duration when long-term interest rates change.

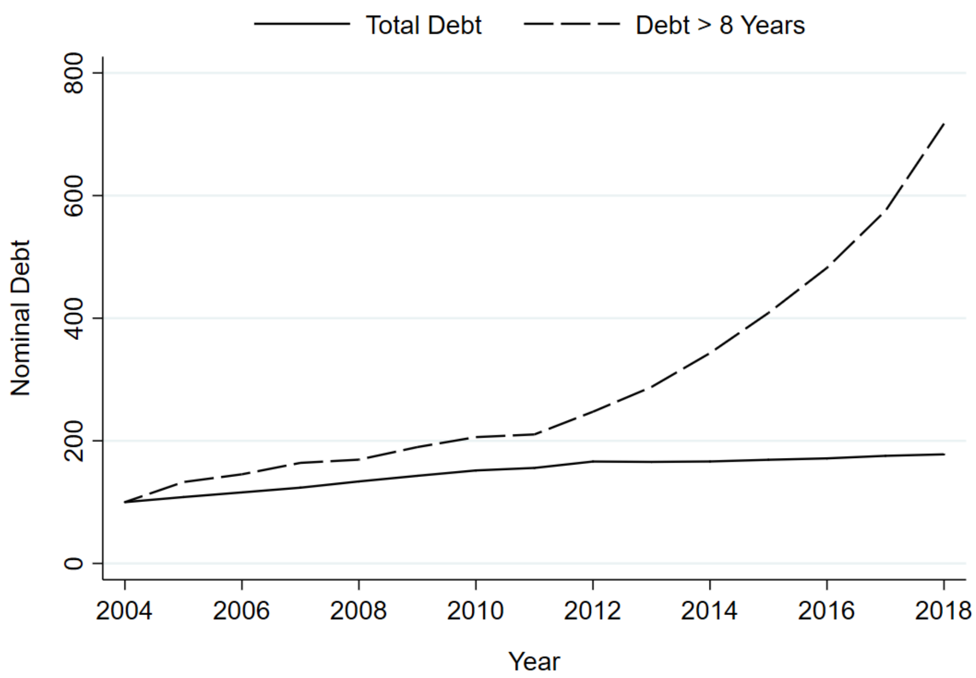
We find that funds with extended portfolio duration draw on the market of interest rate derivatives, notably interest rate futures, and thereby reduce valuation losses on existing bond holdings arising from adverse changes in the long-term interest rate. This pattern is stronger for funds with ex-ante riskier fixed income assets and higher net outflows (more illiquidity), but weaker for funds with insurance investor base.

These findings speak to existing strategic complementarities among funds, especially among alpha-seeking investors, that are more concerned about their relative performance ranking with respect to their peers. By employing this overlay strategy, the asset manager can modify market exposure (beta) without changing security selection (alpha). Moreover, the liquidity, credit quality, and build-in leverage of ETD Bund futures allows such overlays to be implemented cheaply, safely, and with relatively small amounts of capital.

Our results hold important policy implications. First, our results shed light on the risk management behaviour of mutual funds, i.e., one of the most important fixed income investors in today's financial markets. Our results suggest dynamic and active employment of overlay strategies to offset some level of undesired exposure. At the same time, our findings speak to the notion that the same strategy may be used to augment desired exposures in the existing portfolio without disrupting an existing particular strategy. The latter, in essence, is a form of leverage. Unless macroprudential policy makers monitor the overlay strategies undertaken by funds, it is unclear whether overlay strategies are used to obtain, offset or substitute for certain portfolio exposures beyond those provided by the underlying physical investment portfolio.

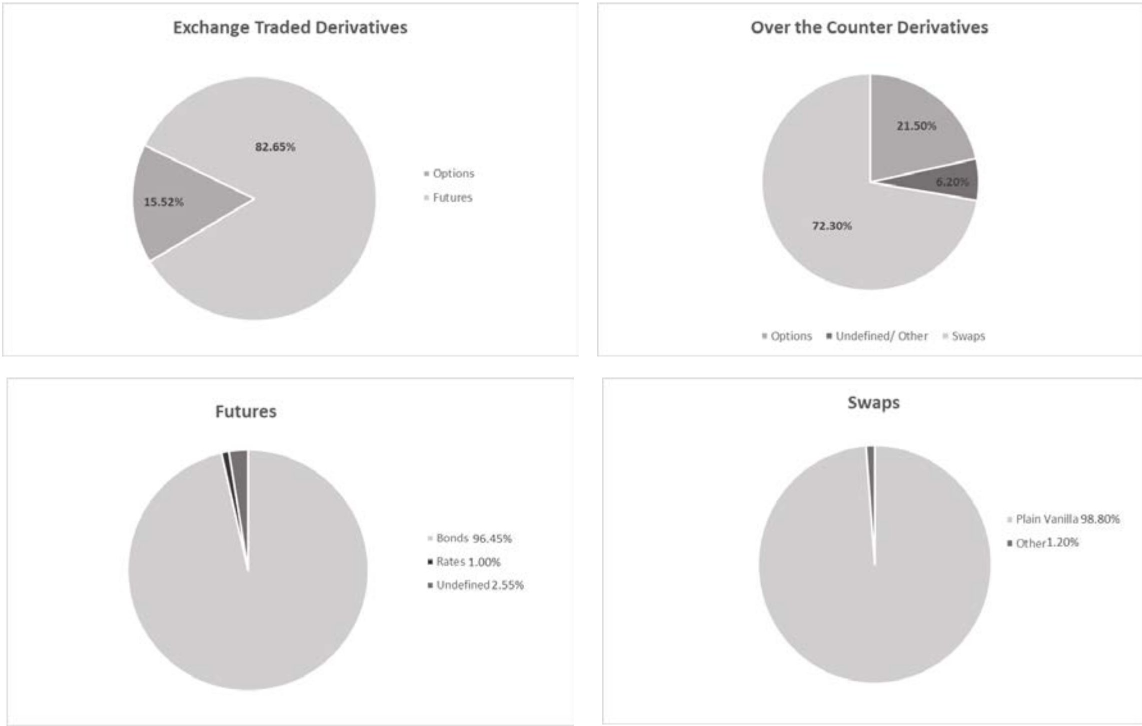
The current conventional regulatory toolkit, which is largely designed to contain intermediary leverage, may not be well suited to dealing with the growing non-bank sector. Given this limitation of regulation, and because monetary policy has a direct influence on the behaviour of asset managers, the financial stability risks that these managers create should be factored into the design and conduct of monetary policy (Stein 2013; Brunnermeir and Sannikov 2016).

FIGURE 1: EVOLUTION OF OUTSTANDING CORPORATE AND SOVEREIGN BONDS



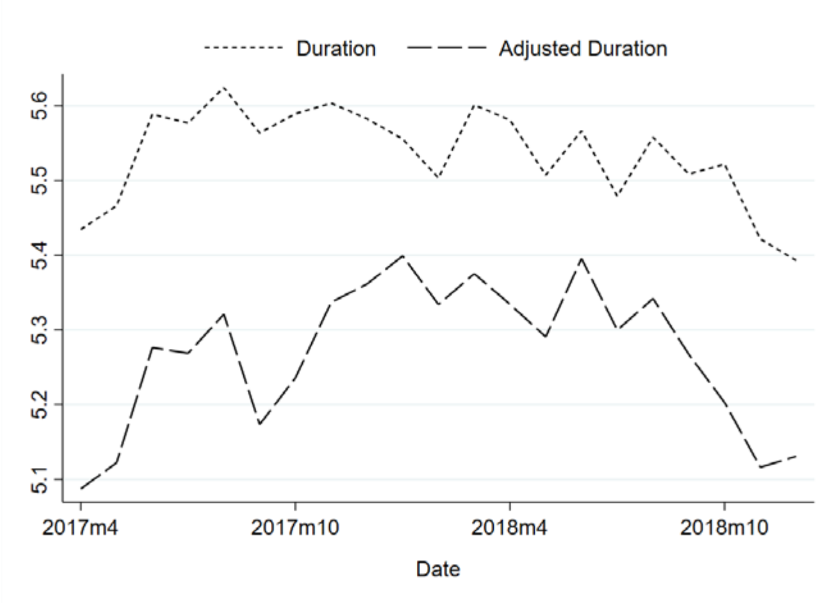
Note: This figure presents the sum of EUR-denominated corporate and sovereign bond nominal amount outstanding (normalised to 2004:M12) for the period 2004-2018. The solid black line refers to the total nominal amount outstanding, while the dashed black line refers to the notional amount of bonds outstanding with maturity above eight years. Source: Bloomberg and own calculations.

FIGURE 2: DECOMPOSITION OF INTEREST RATE DERIVATIVES DATA



Note: These pie charts show the decomposition of the data in our sample. The left and right top panel show the relative chare of derivatives with exchange-traded and over-the-counter traded derivatives, respectively. In the left and right bottom panel, we further show the different types of futures and swaps in our data, respectively.

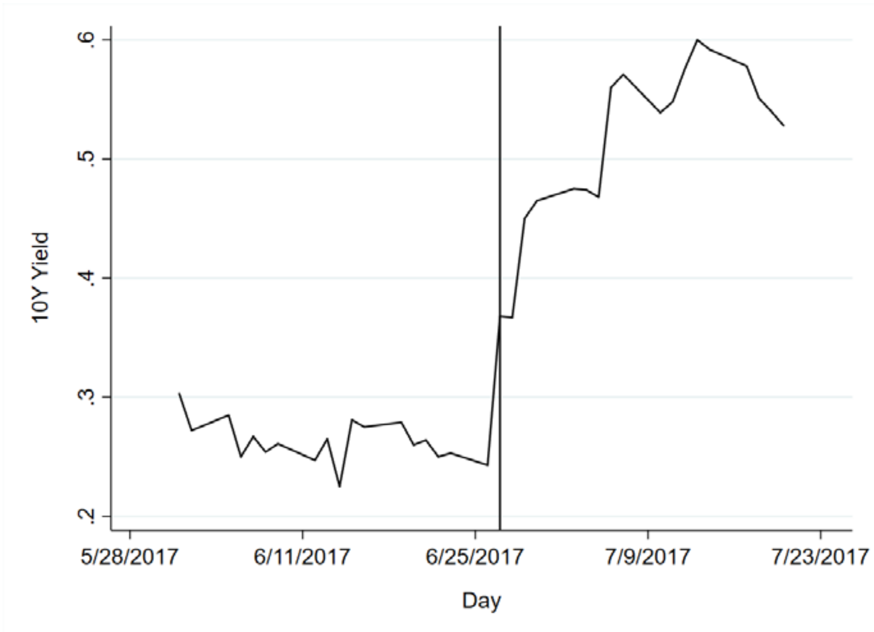
FIGURE 3: AVERAGE DURATION WITH AND WITHOUT FUTURES



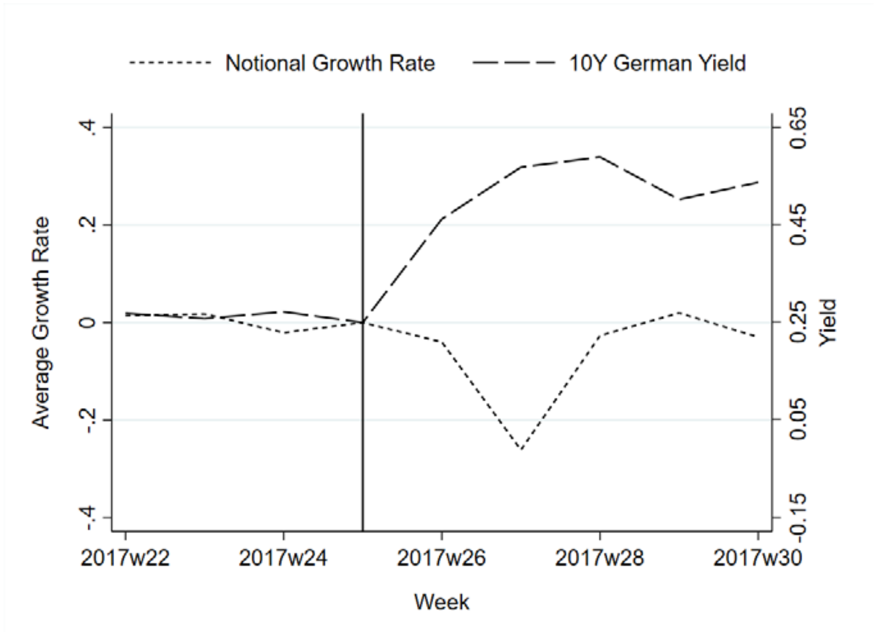
Note: This figure shows the cross-sectional average of funds' portfolio duration over the period 2017:M4 and 2018:M12. The dotted black line represents the portfolio duration of all Euro-denominated bond holdings without controlling for derivatives positions held ('Duration'). The dashed black line refers to the portfolio duration after including derivatives held ('Adjusted Duration').

FIGURE 4: SINTRA SPEECH AS EVENT STUDY

Subfigure A:10-year German Bund Yield



Subfigure B:Bond Future Position



Note: In subfigure A, we plot the day-end level of the 10-year German Bund yield before and after Mario Draghi's speech in Sintra on June 27, 2017. In subfigure B, we plot the weekly average yield (righ scale, dashed black line) of the 10-year German Bund and the average growth rate in the total notional amount held (left scale, dotted black line) in bond futures by funds before and after Mario Draghi's speech in Sintra on June 27, 2017. In each subfigures, the vertical line refers to the day and week, respectively, on which the speech was given.

TABLE 1: SUMMARY STATISTICS ON INVESTMENT FUNDS

	Obs.	Mean	Std.	P 10	P 25	P 50	P 75	P 90
Total Assets	1267	455.48	855.38	21.59	43.97	124.94	400.67	1295.23
Bond Securities/ Total Securities	1267	70.77	25.90	33.83	52.61	73.09	99.42	100.00
Bonds	1267	182.89	336.58	8.93	19.87	55.94	160.53	486.32
Cash/ Bonds	1267	23.50	49.60	1.47	2.86	7.11	19.06	56.45
Longterm Bonds/ Bonds	1267	23.12	20.26	2.26	9.04	18.71	31.19	49.81
Risky Bonds/ Bonds	1267	32.51	21.41	0.00	16.02	33.55	46.90	58.79
Inflows/ Bonds	1267	2.86	7.26	0.00	0.00	0.42	2.02	6.77
Outflows/ Bonds	1267	1.97	5.95	0.00	0.00	0.00	0.92	4.43
Insurance Sector	1267	0.30	0.46	0.00	0.00	0.00	1.00	1.00

This table reports the summary statistics of the respective variables used in the paper by fund i during month t between January 2017 and December 2018. For each variable, we take the time average per fund. 'Total Assets' is the market value of total assets under management (in EUR millions). 'Bond Securities/ Total Securities ' is the market value of bond securities (in EUR million) as a fraction of the market value of total security holdings (in EUR million) in percent. 'Bonds' is the nominal amount of bonds (in EUR million). 'Cash/ Bonds' are the cash holdings (in EUR million) as a fraction of bonds in percent. 'Longterm Bonds/ Bonds' is the nominal amount of bonds with maturity higher than eight years as a fraction of total bond holdings in percent. 'Risky Bonds/ Bonds' is the nominal amount of bonds with credit rating lower than Moody's Baa as a fraction of total bond holdings in percent. 'Inflows/ Bonds' is the total amount of net inflows divided by bonds in percent. 'Outflows/ Bonds' is the total amount of net outflows divided by bonds in percent. 'Insurance Sector' is a binary variable that takes the value of one for any fund that has the insurance sector as investor base, and zero otherwise.

TABLE 2: SUMMARY STATISTICS ON FUTURES

	Obs.	Mean	Std.	P 10	P 25	P 50	P 75	P 90
Short	17389	-12.51	67.69	-26.00	-9.00	-2.00	1.40	8.80
Medium	33640	-9.06	41.89	-27.30	-10.20	-2.50	0.70	9.80
Long	35843	-4.64	46.63	-25.80	-8.30	-1.90	0.60	9.50
Ultra-Long	14599	-0.70	7.89	-4.50	-1.60	-0.40	0.50	3.50
Total	101471	-6.89	46.46	-23.20	-7.80	-1.60	0.70	8.40

This table reports summary statistics on the notional amount (in million Euros) held in ETD futures by fund i in the maturity bucket b during week t between 2017:W1 and December:W52. It takes negative (positive) values whenever the fund is net short (net long) in the futures bucket during the given week. 'Short' is the bucket containing contracts where the underlying bond's maturity is 1.75 to 3.25 years. 'Medium' is the bucket containing contracts where the underlying bond's maturity is 4.5 to 6 years. 'Long' is the bucket containing contracts where underlying bond's maturity is 8.5 to 11 years. 'Ultra-Long' is the bucket containing contracts where the underlying bond's maturity is 24 to 35 years.

TABLE 3: YIELD CHANGES AND DERIVATIVES TRADING (EXTENSIVE MARGIN)

	Dependent Variable			
	Yes/No Derivatives		Yes/No Trade	
	(1)	(2)	(3)	(4)
|Δ Yield|	0.059***	-0.002	0.079***	-0.002
	(0.015)	(0.005)	(0.016)	(0.006)
|Δ Yield|*ETD		0.123***		0.162***
		(0.030)		(0.032)
Observations	216,066	216,066	216,066	216,066
R-squared	0.715	0.715	0.412	0.412
Fund*Contract FE	YES	YES	YES	YES
Contract*Month FE	YES	YES	YES	YES
Fund*Month Controls	YES	YES	YES	YES

This table reports estimates on end-of-week positions in ETD and OTC interest rate derivatives of German open-end investment funds between 2017:W1 and 2018:W52. The outcome variables are dichotomous with '1' and '0'. In columns 1 and 2, the outcome variable is '1' if the fund holds an ETD or OTC contract and '0' otherwise. In columns 3 and 4, the outcome variable is '1' if the fund makes a trade (changes its position) in the ETD or OTC contract and '0' otherwise. '|Δ Yield|' is the absolute weekly change in the 10-year German government Bund yield (in %) during week t-1.'ETD' is a binary variable that takes the value of one for the total amount of exchange-traded futures contracts by fund i during week t, and zero otherwise (i.e., over-the-counter swaps). Fund month controls include the monthly lag of logarithm of 'Total Assets', 'Bond Securities/ Total Securities', 'Cash/ Bonds', 'Inflows/ Bonds', and 'Outflows/ Bonds' as defined in table 1 respectively. Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 4: YIELD CHANGES AND DERIVATIVES TRADING (INTENSIVE MARGIN)

	Dependent variable: Net Long			
	(1)	(2)	(3)	(4)
|Δ| Yield	-2.875***	-2.495***	-0.935*	-0.828***
	(0.655)	(0.498)	(0.560)	(0.198)
Observations	101,471	101,471	101,471	101,471
R-squared	0.000	0.449	0.451	0.951
Fund FE	NO	YES	YES	-
Bucket FE	NO	YES	YES	-
Fund*Month Controls	NO	YES	YES	-
Month FE	NO	NO	YES	-
Bucket*Fund*Month FE	NO	NO	NO	YES

This table reports estimates on end-of-week positions in ETD (exchange-traded derivatives) of German open-end investment funds between 2017:W1 and 2018:W52. The outcome variable 'Net Long' is the logarithm of the notional amount held in ETD futures (in EUR million) by fund i in the maturity bucket b during week t. It takes a negative (positive) value whenever the fund is net short (net long) in futures during the given week. For a description of the maturity buckets see table 2. '|Δ| Yield' is the weekly change in the 10-year German government Bund yield (in %) during week t-1. The control variables are as described in table 5 . Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 5: OVERLAY STRATEGY USING INTEREST RATE FUTURES

	Dependent variable: Net Long							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
|Δ| Yield	-0.826***							
	(0.197)							
|Δ| Yield*(Longterm Bonds/ Bonds)	-0.047***	-0.046***	-0.036***	-0.039***	-0.045***	-0.046***	-0.044***	-0.028**
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.012)	(0.013)
Derivatives Exposure			1.866***					1.869***
			(0.213)					(0.213)
|Δ| Yield*Derivatives Exposure			-1.992***					-1.848***
			(0.534)					(0.542)
|Δ| Yield*Bonds				-0.326**				-0.333**
				(0.130)				(0.136)
|Δ| Yield*(Risky Bonds/ Bonds)					-0.008			-0.005
					(0.009)			(0.009)
|Δ| Yield*Insurance Sector						-0.114		0.274
						(0.445)		(0.462)
|Δ| Yield*Outflow Exposure							-2.532***	-2.646***
							(0.691)	(0.697)
Observations	101,471	101,471	101,471	101,471	101,471	101,471	101,471	101,471
R-squared	0.951	0.951	0.952	0.951	0.951	0.951	0.951	0.952
Bucket*Fund*Month FE	YES	YES	YES	YES	YES	YES	YES	YES
Bucket*Week FE	NO	YES	YES	YES	YES	YES	YES	YES

This table reports estimates on end-of-week positions in ETD (exchange-traded derivatives) of German open-end investment funds between 2017:W1 and 2018:W52. The outcome variable 'Net Long' is the logarithm of the notional amount held in ETD futures (in EUR million) by fund i in the maturity bucket b during week t. It takes a negative (positive) value whenever the fund is net short (net long) in futures during the given week. For a description of the maturity buckets see table 2. '|Δ| Yield' is the weekly change in the 10-year German government Bund yield (in %) in week t-1. 'Bonds' is the logarithm of the nominal amount of bonds (in EUR million) in month t-1. 'Longterm Bonds/ Bonds' is the nominal amount of bonds with maturity higher than eight years as a fraction of total bond holdings in % in month t-1. 'Risky Bonds/ Bonds' is the lagged nominal amount of bonds with credit rating lower than Moody's Baa as a fraction of total bond holdings in % in month t-1. 'Outflow Exposure' is a binary variable that takes one if fund i experienced net ouflows in month t-1. 'Insurance Sector' is a binary variable that takes the value of one for any fund that has the insurance sector as investor base, and zero otherwise. 'Derivatives Exposure' is a binary variable that takes the value of one for any fund i with a net long position in ETD futures during week t-1, and zero otherwise (i.e., with net short positions in ETD futures during week t-1). Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 6: OVERLAY STRATEGY USING INTEREST RATE FUTURES

HETEROGENEITY ACROSS FUNDS

	Dependent variable: Net Long				
	(1)	(2)	(3)	(4)	(5)
|Δ| Yield*(Longterm Bonds/ Bonds)	-0.036***	-0.056***	-0.099***	-0.031***	-0.088***
	(0.011)	(0.013)	(0.020)	(0.012)	(0.021)
|Δ| Yield*Bonds	-0.300**				-0.423***
	(0.132)				(0.141)
|Δ| Yield*(Longterm Bonds/ Bonds)*Bonds	-0.006				-0.015***
	(0.004)				(0.006)
|Δ| Yield*(Risky Bonds/ Bonds)		-0.010			-0.002
		(0.009)			(0.010)
|Δ| Yield*(Longterm Bonds/ Bonds)*(Risky Bonds/ Bonds)		-0.002***			-0.002**
		(0.001)			(0.001)
|Δ| Yield*Insurance Sector			-0.206		-0.094
			(0.442)		(0.459)
|Δ| Yield*(Longterm Bonds/ Bonds)*Insurance Sector			0.105***		0.122***
			(0.026)		(0.031)
|Δ| Yield*Outflow Exposure				-2.331***	-2.206***
				(0.668)	(0.671)
|Δ| Yield*(Longterm Bonds/ Bonds)*Outflow Exposure				-0.087**	-0.065
				(0.042)	(0.042)
Observations	101,471	101,471	101,471	101,471	101,471
R-squared	0.951	0.951	0.951	0.951	0.951
Bucket*Fund*Month FE	YES	YES	YES	YES	YES
Bucket*Week FE	YES	YES	YES	YES	YES

This table reports estimates on end-of-week positions in ETD (exchange-traded derivatives) of German open-end investment funds between 2017:W1 and 2018:W52. The outcome variable 'Net Long' is the logarithm of the notional amount held in ETD futures (in EUR million) by fund i in the maturity bucket b during week t. It takes a negative (positive) value whenever the fund is net short (net long) in futures during the given week. For a description of the maturity buckets see table 2. '|Δ| Yield' is the weekly change in the 10-year German government Bund yield (in %) in week t-1. 'Bonds' is the logarithm of the nominal amount of bonds (in EUR million) in month t-1. 'Longterm Bonds/ Bonds' is the nominal amount of bonds with maturity higher than eight years as a fraction of total bond holdings in % in month t-1. 'Risky Bonds/ Bonds' is the lagged nominal amount of bonds with credit rating lower than Moody's Baa as a fraction of total bond holdings in % in month t-1. 'Outflow Exposure' is a binary variable that takes one if fund i experienced net ouflows in month t-1. 'Insurance Sector' is a binary variable that takes the value of one for any fund that has the insurance sector as investor base, and zero otherwise. 'Derivatives Exposure' is a binary variable that takes the value of one for any fund i with a net long position in ETD futures during week t-1, and zero otherwise (i.e., with net short positions in ETD futures during week t-1). Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 7: OVERLAY STRATEGY USING INTEREST RATE FUTURES

HETEROGENEITY ACROSS FUTURES CONTRACTS

	Dependent variable: Net Long		
	(1)	(2)	(3)
|Δ| Yield	-0.280	-0.299	
	(0.257)	(0.260)	
|Δ| Yield*Longterm Futures	-1.100***	-0.986**	
	(0.395)	(0.393)	
|Δ| Yield*(Longterm Bonds/ Bonds)		-0.015	
		(0.015)	
|Δ| Yield*(Longterm Bonds/ Bonds)*Longterm Futures		-0.056**	-0.042*
		(0.023)	(0.025)
Observations	101,471	101,471	101,471
R-squared	0.951	0.951	0.970
Bucket*Fund*Month FE	YES	YES	YES
Fund*Week	NO	NO	YES
Bucket*Week	NO	NO	YES

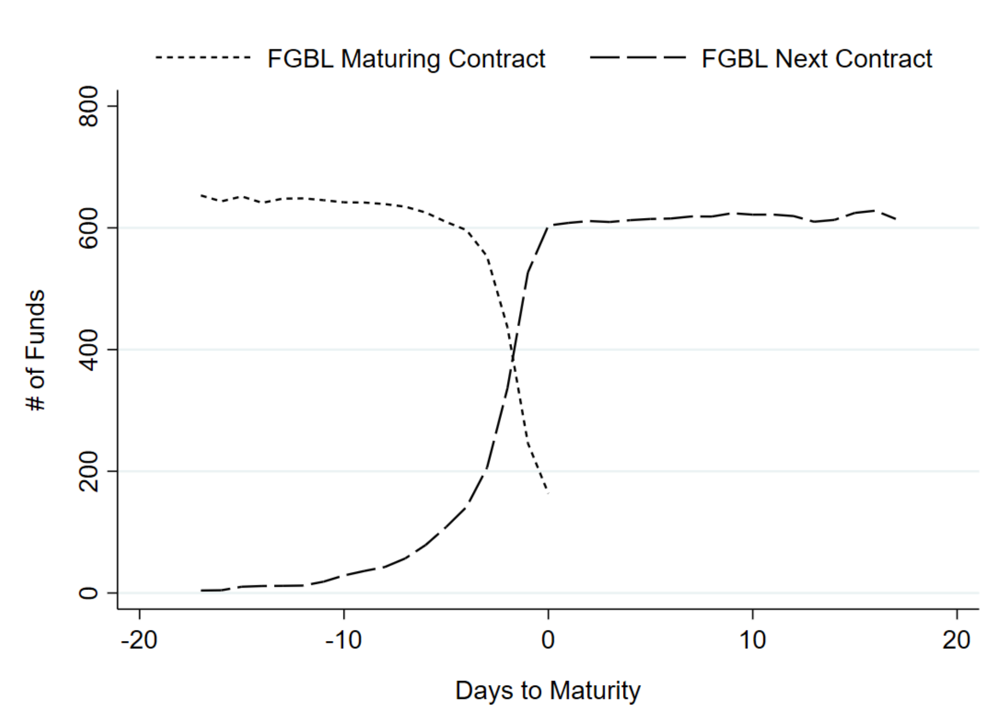
This table reports estimates on end-of-week positions in ETD (exchange-traded derivatives) of German open-end investment funds between 2017:W1 and 2018:W52. The outcome variable 'Net Long' is the logarithm of the notional amount held in ETD futures (in EUR million) by fund i in the maturity bucket b during week t. It takes a negative (positive) value whenever the fund is net short (net long) in futures during the given week. For a description of the maturity buckets see table 2. '|Δ| Yield' is the weekly change in the 10-year German government Bund yield (in %) in week t-1. 'Longterm Bonds/ Bonds' is the nominal amount of bonds with maturity higher than eight years as a fraction of total bond holdings in % in month t-1. 'Longterm Futures' is an indicator variable that takes the value of one for ETD futures positions held by fund i during week t, where underlying maturity is more than eight years, and zero otherwise. Robust standard errors using Huber-White estimators are reported in parentheses *** p<0.01, ** p<0.05, * p<0.1.

TABLE 8: OVERLAY STRATEGY AROUND DRAGHI'S SINTRA SPEECH

	Dependent variable: Net Long					
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.529***	-0.529***				
	(0.137)	(0.137)				
Post*(Longterm Bonds/ Bonds)		-0.015*	-0.018**	-0.014*	-0.003	
		(0.008)	(0.008)	(0.008)	(0.009)	
Post*Derivatives Exposure				-1.066***		
				(0.386)		
Post*(Longterm Bonds/ Bonds)t*Longterm Futures					-0.031*	-0.035**
					(0.016)	(0.017)
Observations	4,804	4,804	4,804	4,804	4,804	4,804
R-squared	0.911	0.911	0.912	0.912	0.912	0.939
Bucket*Fund FE	YES	YES	YES	YES	YES	YES
Bucket*Week FE	NO	NO	YES	YES	YES	YES
Fund*Week FE	NO	NO	NO	NO	NO	YES

This table reports estimates on end-of-week positions in ETD (exchange-traded derivatives) of German open-end investment funds around Mario Draghi's speech held in Sintra, Portugal, on June 27, 2017. The outcome variable 'Net Long' is the logarithm of the notional amount held in ETD futures (in EUR million) by fund i in the maturity bucket b during week t. It takes a negative (positive) value whenever the fund is net short (net long) in futures during the given week. For a description of the maturity buckets see table 2. We only include 4 time points into the regression, two weeks before the speech in Sintra and two weeks afterwards. 'Post' is a binary variable that equals one in the weeks after speech and zero otherwise. 'Longterm Bonds/ Bonds' is the nominal amount of bonds with maturity higher than eight years as a fraction of total bond holdings in % in end of May. 'Longterm Futures' is an indicator variable that takes the value of one for ETD futures positions held by fund i during week t, where underlying maturity is more than eight years, and zero otherwise. 'Derivatives Exposure' is a binary variable that takes the value of one for any fund i with a net long position in ETD futures five weeks before the speech, that is, one week before our sample starts, and zero otherwise (i.e., with net short positions in ETD futures). Robust standard errors using Huber-White estimators are reported in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

APPENDIX FIGURE A1: TRADING BEHAVIOUR IN FGBL



Notes: On the day of maturity of the future (not underlying bond), the counterparty side with a short position in the future has to deliver any underlying that satisfies the above mentioned criteria to the counterparty side with a long position. However, rather than delivering the underlying, investors usually close out the old position and roll over into the next contract. For example, the FGBL has four different contracts, which mature on four different dates in a given year: RXH – March, RXM – June, RXU – September, RXZ – December. All contracts have an initial maturity of nine months. The so-called "active" contract is the one with the closest maturity date – as of May 2019, the June contract. The contract started trading on Friday 7 September 2018 and will expire on Thursday 6 June 2019. Market participants usually only trade in the contract with the closest maturity and roll over to the next contract before maturity. In Figure A1, we show the trading pattern of investment funds in the FGBL future. As of February 20, 2017, roughly 750 funds had an open position (either net short or net long) in the FGBL that matures on March 8, 2017. Close to maturity, funds net out this position and start building exposure in the subsequent contract. On day of maturity around 80% of funds having had open interest in the March contract, closed out their position.

APPENDIX A

This is a list of all ETD in our sample:

- FGBL (**Eurex Symbol**): Future on fictive German government bond with residual maturity of 8.5 to 10.5 years and a coupon rate of 6%.

- FGBM: Future on fictive German government bond with residual maturity of 4.5 to 5.5 years and a coupon rate of 6%.

- FGBS: Future on fictive German government bond with residual maturity of 1.75 to 2.25 years and a coupon rate of 6%.

- FGBX: Future on fictive German government bond with residual maturity of 24 to 35 years and a coupon rate of 4%.

- FOAT: Future on fictive French government bond with residual maturity of 8.5 to 10.5 years and a coupon rate of 6%.

- FBTB: Future on fictive Italian government bond with residual maturity of 8.5 to 11 years and a coupon rate of 6%.

- FBTS: Future on fictive Italian government bond with residual maturity of 2 to 3.25 years and a coupon rate of 6%.

- FBON: Future on fictive Spanish government bond with residual maturity of 8.5 to 10.5 years and a coupon rate of 6%.

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