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Financial Framework and Crisis Effect on the Mortgage Investments of Insurance Companies

Developments, Risks, and Financial Conglomerates

Jasper Uhe

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Jasper Uhe / 11316284
Uhe.jasper@gmail.com
Amsterdam University College
Social Sciences
Tutor: Dr. Diederik van Werven
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Supervisor: Dr. Mauro Mastrogiacomo
m.mastrogiacomo@vu.nl
(Vrije Universiteit Amsterdam)

Second Reader: Dr. Chris Elbers
c.t.m.elbers@vu.nl
(Vrije Universiteit Amsterdam & Amsterdam University College)

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Abstract

Insurance companies are subject to restrictions on negligent risk-taking behaviour. This study aims to identify the causal effect of the macroprudential regulation, Solvency II, on investment decisions of Dutch insurance companies and specifically how this is reflected in the quantity/quality of mortgage lending. In response to the financial crisis in 2008, supervisors passed strict requirements, in order to induce a change in risk management as well as to prevent further risk-exposure and underfunding. We use a differences-in-differences regression analysis estimating the causal effect of the regulatory framework, by exploiting the fact that underfunded institutions, those with a solvency ratio below the sample median, are more likely to be constrained by the regulation and thus incentivized to use risk-shifting towards low-risk investments, such as government bonds and residential mortgages. Our results suggest that the financial crisis induced underfunded insurance companies to increase their mortgage investment by 182%. We find that around the introduction of Solvency II there was no significant increase in mortgage underwriting by affected insurers. The largest increase, however, took place before, due to a possible mix of transparent announcements by policymakers, forward-looking insurance companies reallocating their portfolio, and banks anticipating the risk of higher capital requirements. These anticipations of low-capitalized insurers led to an increase of around 31 million Euros per year in their residential mortgage portfolio. At the same time, insurance companies that are part of financial conglomerates also increased their mortgage undertakings by more than 20 million Euros, while awaiting Basel III.5. Thus, higher capital requirements in both macroprudential regulations incentivized risk-shifting towards residential mortgages that, in fact, served as a tool to immunize their portfolio.

Keywords: *Solvency II, Direct Residential Mortgage Investment, Solvency Capital Requirement, Portfolio Immunization, Differences-in-differences regression analysis, Financial Conglomerates*
JEL classification: *G11, G21, G22, G28*

** I had the unique opportunity of writing this Bachelor's thesis under the supervision of Dr. Mauro Mastrogiacomo, together with doing an internship at De Nederlandsche Bank. Views expressed in this thesis are those of the individual author and do not necessarily reflect official positions of De Nederlandsche Bank.*

I. Introduction

This study investigates to what extent the macroprudential regulation Solvency II induces mortgage lending of insurance companies in the Netherlands and to what extent these investments are used as a tool for immunization with regards to the quality of the loans at hand. We link balance sheet data of insurance companies to loan-level data on their mortgage underwriting in order to identify a treatment group which is potentially affected by the regulation and a control group with an evidently more solid financial position. This strategy will allow for eliciting the causal effect of the introduction of Solvency II on mortgage underwriting. We find a significant positive effect, but the largest increase in mortgage underwriting of insurers affected by Solvency II started years before the regulation was implemented. We observe that this corresponds to a reduction in mortgage underwritings by banks. Besides the fact that insurers might have taken advantage of this reduced competition, we also suggest that anticipation effects within financial conglomerates (FICOs) could be responsible for this, where the banking part of the conglomerate transferred part of the portfolio to the insurance company. We speculate that this could be due to strategic choices of banks that want to avoid higher capital requirements. Our results estimate that while Solvency II lead to an increase of only 2.23% in mortgage lending, 51.39% were due to the financial crisis and overall increases of 14.88% and 31.52% were caused by anticipating on and preparing for Solvency II and Basel III.5, respectively.

When ABN AMRO, one of the largest Dutch banks, was nationalised during the repercussions of the financial crisis in 2009, the institution was temporarily forbidden to compete on mortgage rates (Jansen, Bijlsma, Kruidhof & Pattipeilohy, 2013). While our data indicates that investment in residential mortgages by underfunded institutions has increased in the last decade, confounding variables, such as decreasing house prices and thus reduced influence of international investors (Davis, 2002; Treur & Boonstra, 2014), need to be singled out, to accurately estimate the causal effect of the regulation. Following, we address the question what led to more favourable conditions for insurance companies in the mortgage market. The US subprime crisis – as the name predicts – left securitized mortgages with a rather unsavoury reputation and led to an effective close of the market for new securitizations in 2008/09 (Jansen et al., 2013; IMF, 2017). At the same time, banks underwent a period of balance sheet recovery with strategies, such as profit retention, and rationing to create capital buffers, regain consumer- and investor- confidence and reposition themselves in a market scarred by investors' reluctance (Uluc & Wieladek, 2018). Adding to this, most evidently, historically low interest rates discouraged banks to provide mortgages even more (Ponds & van Riel, 2009). All of the above led to the fact that banks withdrew from the mortgage market, while other less conventional institutions, namely insurance companies and pension funds, increased their market share (Dijkstra, Randag & Schinkel, 2014). These latest developments are underlined by the fact that beginning 2016, the three largest Dutch banks issued less than 50% in newly produced mortgages for the first time.

Concurrently, on 10 July 2007 the European Commission proposed a new solvency regime, called Solvency II, which is entirely oriented around the risk profile of insurance investments (Eling, Schmeiser & Schmit, 2007; Vandenabeele, 2014). Solvency II introduces prudential requirements tailored to the specific risks within an insurance company's portfolio. The new framework requires some underfunded insurance companies – those failing to conform with the required solvency ratio – to change their portfolio allocation. Thus, this requirement is the basis of our strategy to identify affected insurers.

As indicated above, data shows that insurance companies have significantly increased their share in the Netherlands' €660 billion worth mortgage market, bypassing traditional lenders (Hoj, 2011; Berglund & Stensletten, 2016). To summarize, there seem to be two forces that may have caused this: a.) the conveniences of banks withdrawing from the mortgage market after the financial crisis and b.) a solvency capital requirement imposed on insurance companies dependent on the nature of the balance sheet. Our results suggest that these two effects are not mutually exclusive. Insurance companies that are part of a financial conglomerate, in other words that are affiliated with a bank, have increased their mortgage investment substantially in anticipation of higher capital requirements according to Basel III.5.

The study is organized as follows: Section 1 illustrates institutional details, specifies particular components of Solvency II, and elaborates further on relevant literature. In Section 2, we will describe the datasets used for the following analysis and lay the foundations to our hypotheses. Section 3 presents the research methodology and estimates the direct effect of Solvency II. From our analysis it will follow that we also test whether this behaviour is different for insurers that belong to a FICO and whether FICO-banks achieve economies of purpose by outsourcing certain financial assets to sister companies to circumvent stricter requirements. Furthermore, we research to what extent insurance companies acquire loans as a tool of immunization (to reduce risk in the overall portfolio), by looking at borrower- and loan- characteristics of mortgages issued after the crisis. Lastly, Section 4 concludes.

1.1 Institutions and Related Literature

There are three main fields of literature that provide the foundation to this research. The first field of literature analyses past, present, and future legislations from the banking-, pension fund-, and insurance company- sector (i.e., Basel I-IV, FTK, and Solvency I & II) and investigates their shortcomings and effects of implementation in the economy. Furthermore, we provide the fundamentals of the regulatory framework Solvency II, as this is the source of identification of the effect discussed above. The second body of literature examines the effects of solvency or capital requirements on the optimal portfolio allocation of an investor and is precisely what this study attempts to explain. This is also directly connected to the investment behaviour of insurance companies. The last field researches the functioning of the Dutch mortgage market, which will provide the groundwork for analysing the loan-level Mercurius data.

1.1.1 Solvency Regulations

As of 2016, insurance companies are required to hold enough capital to have 99.5% confidence that they could cope with the worst expected losses over a year – that is, exceeding the so-called solvency capital requirement, which is the heart of the prudential regulation (EIOPA, 2012; Spaan, 2012; Vandenabeele, 2014). In short, the goal of Solvency II is to enable insurers to absorb financial losses without detriment for the policyholders.

The amount of capital an insurance company is required to hold consists of the minimum capital requirement (MCR), the solvency capital requirement (SCR), and excess own funds (see Figure 1), listed by descending order of risk-exposure. The MCR, or the solvency threshold, corresponds to the level of capital, below which the insurance company is exposed to an unacceptable level of

risk (EIOPA, 2014). It is the ultimate lowest amount before losing autonomy over the company's investments, and supervisory intervention (e.g., by De Nederlandsche Bank (DNB)) will then follow inevitably (European Commission, 2016). Next, the SCR under the new framework determines the capital that is required when considering all "material and quantifiable risks" in the balance sheet of an insurer (European Commission, 2009, p. 58). This is the fundamental difference to its predecessor, Solvency I, which did not incorporate any risk-weights, and thus did not provide any incentive for insurers to improve the risk management of an investment (Vermaat, 1998; Antao & Lacerda, 2011; Dotterweich & Koestner, 2011). As long as a Dutch insurer is below the required level of the SCR, DNB requires the institution to submit a recovery plan or revokes its authorization. Those drastic consequences predict several to be observed measures for immunization, which we will analyse in this paper. This motivates our first hypothesis concerning why the updated SCR would incentivize changing investment behaviour as well as risk-shifting and portfolio reallocation (de Haan & Kakes, 2011; Uluc & Wieladek, 2018).

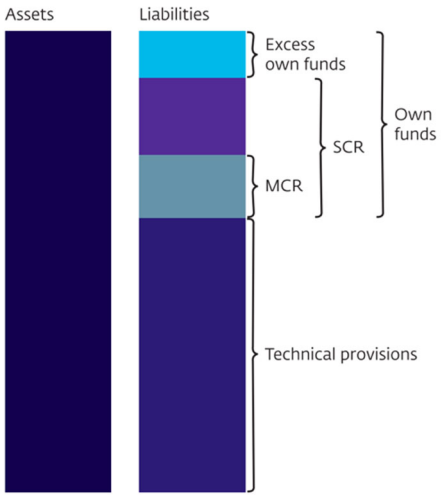

Figure 1. Balance Sheet under Solvency II (DNB, 2007)

The SCR value also allows this paper to make the fundamental assumption as to what extent insurance companies are affected or constrained by Solvency II. DNB oversees insurers' balance sheets and assesses whether the institutions comply with the standards[1]. A good estimation for a firm's financial health is the Solvency II ratio, defined as "the ratio of the actual solvency margin to the required solvency margin" (see equation 1) (de Haan & Kakes, 2010, p. 1619). As the ratio is approaching one, authorizing bodies should raise red flags. This paper considers an insurer to be low-capitalized (treatment group), if its Solvency II ratio is comparably low, making it more likely that the insurer is constrained by the higher capital requirements. Thereby, we overcome the crucial identification problem of affected insurers, as DNB is not allowed to share its internal threshold signalling active supervision.

[1] The SCR value is calculated by a standard formula, provided within Solvency II, or by a partial or full internal model that adapts specific internal structures present at the individual firm level. Please find the Appendix for a more elaborate explanation on how the SCR value is computed incorporating insurers' balance sheets.

$$Solvency\ II\ Ratio_{i,t} = \frac{Own\ Funds_{i,t}}{Solvency\ Capital\ Requirement\ (SCR)_{i,t}} \qquad (1)$$

Regarding financial conglomerates, however, not only legislations imposed on the insurance company sector are important. While Basel I & II were in many regards very similar to Solvency I, as they also did not account for risk weights (but merely assigned the risk weight of 50% to financial assets regardless of risk exposure), Basel III responded to their shortcomings by including risk weights and higher capital requirements dependent of borrower- and loan- characteristics (Juelsrud & Wold, 2018, Junge & Kugler, 2018; Uluc & Wieladek, 2018). Beginning 2015, DNB urged banks to factor in higher requirements as the upcoming Basel III.5 legislation aims to address the exploitation of banks using internal models computing SCR values, but rather introduces an output floor implementing significantly higher risk weights on residential mortgages (DNBulletin, 2015). To summarize, Solvency II and Basel III.5 are very similar as they both turned towards a system with higher capital requirements calculated by adjustable risk-weights.

1.1.2 Optimal Portfolio Allocation

One of the questions remaining is what has caused this sudden increased interest in residential mortgages of insurance companies in the first place. Something must have changed that led to this revulsion in investment behaviour since the issued mortgage investment by Dutch insurers before 2000 only accounts for 3.74% of their overall mortgage investment (Hoj, 2011). Juelsrud & Wold (2018) provide evidence from the Norwegian banking system that under current legislations around 90% of the increase in capital ratios is achieved by portfolio reallocation, in which investors substitute high-risk assets with low-risk ones. They investigate that while the average risk weight of mortgage investment is 0.35 (Campbell & Cocco, 2015), corporate lending is assigned an average risk weight of 1.0 under Solvency II (Azcue & Muler, 2009). To conclude, shifting credit supply from firms (high-risk) to residential mortgages (low-risk) is an efficient way of complying with Solvency II requirements (Juelsrud & Wold, 2018), which is central to this paper's main hypothesis.

While minimizing the capital required, according to the SCR, insurers must, however, still optimally allocate it into a profit-maximizing and well-diversified portfolio of financial assets. In recent years, other alternative low-risk financial assets, such as AAA government securities, have been trading on a negative yield. Thus, insurance companies saw an opportunity in earning higher returns in the mortgage market, as bond yields were held down by post-crisis policies of the central bank (IMF, 2017).

1.1.3 The Dutch Mortgage Market

Developments in the Dutch mortgage structure contribute to the understanding of shock-transmission mechanisms (Duijm & Bisschop, 2018), the inherent risk in the system (Basten & Koch, 2015), and thus implications on economic growth and welfare in the Netherlands (IMF, 2017). As the Dutch income system allows for a generous deduction of mortgage interest payments that are not constrained in size, mortgage investment is relatively high in the Netherlands compared to other European standards (de Haan & Kakes, 2011). From a macroeconomic and policymaking perspective, the Dutch mortgage market presents a paradox. While it is shaped by a high share of

non-amortizing loans[2] (Li, 2014), a relatively high vulnerability to interest rate shocks (Franzen, 2010), and the second highest loan-to-value (LTV) ratio in Europe (Verbruggen et al., 2015), it has the second lowest default rate[3] (Nederlandse Vereniging van Banken, 2014).

In order to accurately discuss the underlying risk in the Dutch mortgage market, Mastrogiacomo & van der Molen (2015) divided loans into four different groups by combining information on LTV and loan-to-income (LTI) ratios. "While in case of default, high LTV ratios generate more substantial losses, borrowers with high LTI ratios are more likely to actually default. This motivated the grouping of borrowers into the following four risk categories in ascending order of risk-exposure: low LTI / low LTV (i.e., low default risk, manageable losses); low LTI / high LTV (i.e., low default risk, significant losses); high LTI / low LTV (i.e., high default risk, manageable losses); high LTI / high LTV (i.e., high default risk, significant losses)" (Polansky, 2017, p. 19). The tables in Section 2 of the Appendix show the distribution of those four risk groups in our Mercurius data, related to other risk categories elaborated on in the next section.

II. Data and Summary Statistics

In the following section, we aim to investigate the quality and riskiness of the mortgage investments of insurers. We combine several datasets such as the loan-level data, and two waves of the Mercurius data, which are collected by DNB[4] and which contain unique, detailed information on all mortgages issued in the Netherlands. We will discuss the most important loan characteristics, more precisely NHG[5] coverage, the interest rate, loan types, LTV, and lastly LTI ratio, which will form the core of explanatory variables used in the analysis in Section 3.

2.1 NHG Coverage

Our data estimates that loans covered by NHG amount to 3.1 billion Euros. This represents about 39.4% of the Dutch Mortgage investment. Whereas 38.7% of loans have been insured against default in 2017 alone, overall averages (44.8%) seem to be inflated by post-crisis anxiety and uncertainty that led to increased precautionary measures. Figure 2 shows an exponential increase of insured loans after 2008. In recent years, this figure has fallen back to our sample period average. One reason for this are rising house prices[6] that disqualify many mortgages from NHG coverage in recent years, due to its limitation based on the balance of a loan (Galati, Teppa & Alessie, 2012; Basten & Koch, 2014).

[2] Non-amortizing loans do not require, unlike their counterpart, monthly payments, but the principle is fully repaid as a lump-sum at the end of the loan. Such mortgages include interest-only-, savings-, life-, and investment- mortgages.
[3] Many studies point to the Calvinistic tradition prevalent in the Dutch culture, such that borrowers feel an obligation to repay their debt (DNB, 2014).
[4] The combined datasets contain around 400,000 borrowers who on average took out 1.65 loans from Dutch insurance companies. For our analysis, we have focused on 15 insurance companies over a time period of 32 years from 1985 to 2017 in monthly intervals, for which data was mostly complete.
[5] The National Mortgage Guarantee (NHG) works as an insurance for the lender against unpredictable circumstances beyond a lender's control such as unemployment, or divorce, therefore implying a lower likelihood of default.
[6] This is later included as a control variable, because housing prices turn out to dominantly dictate the Dutch mortgage landscape.

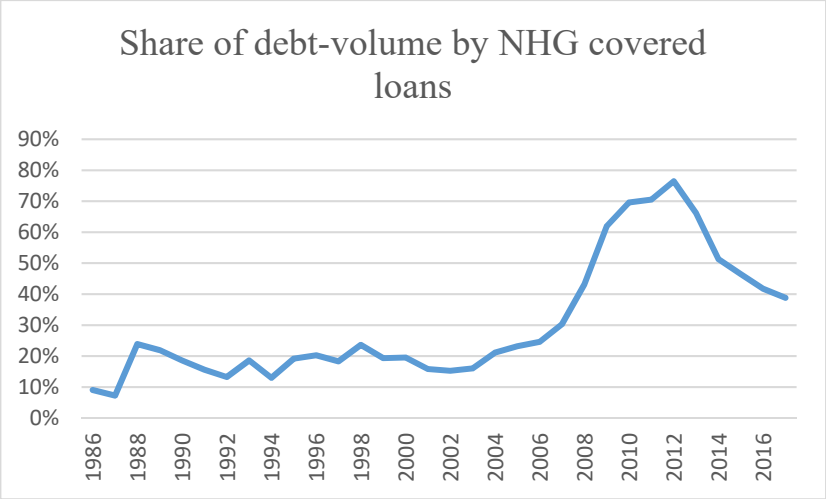

Figure 2. Share of debt-volume of NHG covered Loans of insurance companies (Mercurius data)

Our data shows that there is a strong positive relationship between the LTV ratio of a mortgage and its NHG coverage. Whereas loans with an LTV ratio of less than 50% are only NHG covered in around 12% of the cases, more than 50% are insured for loans with negative equity. Hence, we can conclude that NHG coverage is an essential risk-mitigating factor for insurance companies that increases insurance for lenders against default.

2.2 Interest Rates

Interest rates are subject to the overall well-being of the economy as well as reflect credit risk. In this regard, our data shows higher interest rates during the financial crisis and lower interest rates during periods of expansion. As a company's return on its mortgage portfolio is mainly determined by the terms of a loan's underlying interest rate (e.g., loan origination date and the interest rate reset interval) (Treur & Boonstra, 2014), insurance companies benefit comparably more from older loans subject to higher interest rates (Juelsrud & Wold, 2018). Whereas 75% of loans are characterized by an interest rate below 2.75% for all recently issued debt (loans issued within the past three months), 40% of debt issued in the period between 1985 and the financial crisis is set at an interest rate above 4.75%.

Our data also provides evidence that at origination, the mortgage interest rate is typically fixed for a period between 5 and 10 years (49.03%), but almost never for the entire loan period (Mastrogiacomo & van der Molen, 2015). Evidence suggests that the initial interest rate reset interval is getting longer because borrowers lock in the low interest rates prominent in recent years. As a result, while the reset interval used to be around 10 years, the mean interest rate reset interval increased up to 15 years for recently issued debt. This, combined with an adjustable rate mortgage, is a common catalyst for possible future defaults (Campbell & Cocco, 2003; Dietsch & Welter-Nicol, 2014).

Solvency II incorporates a trade-off scheme between taking additional risk (i.e., targeting higher interest rate loans), thus increasing returns, and needing to hold more capital as a result. Figure 3 shows the average interest rate of low-capitalized (treatment group) and high-capitalized (control

group) insurers. It seems that during the financial crisis, underfunded institutions have been targeting higher-risk borrowers.

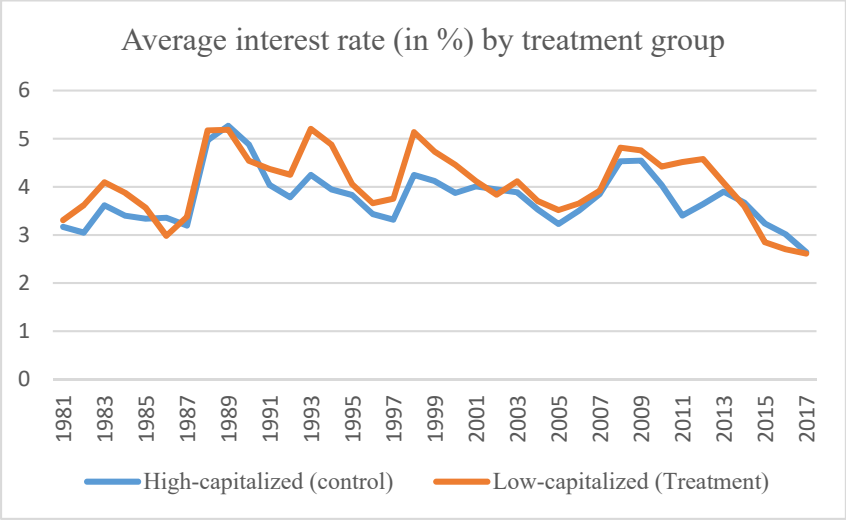

Figure 3. Average interest rate by low- and high- capitalized insurers (Mercurius data)

2.3 Loan Types

The Mercurius data shows that more than 68% of the Dutch mortgage portfolio consists of non-amortizing loans. While interest-only (IO) loans allow for a more flexible repayment scheme in line with the permanent income hypothesis (e.g., repaying a higher share when income is higher), this loan type, similar to an interest rate shock, may also attribute to increased default risk due to mall estimation of future cash flows (Li, 2014; IMF, 2015).

Several trends stand out when looking at how the debt volume share by loan types issued since 1996 evolved (see Figure 4). After 2012, savings-, life-insurance-, and investment portfolio-mortgages disappeared from the market, and interest-only loans went down by around 40%. This gap was closed by a subsequent sharp increase of annuities (Campbell & Cocco, 2012). The primary reason for this significant change in the loan type landscape can be found in the Dutch income tax system, which allows for a generous deduction of mortgage interest payments directed at particular loan types. While until 2012, not even 5% of all newly issued debt was amortizing, the share of amortizing loans settled at around 60 to 70% in recent years.

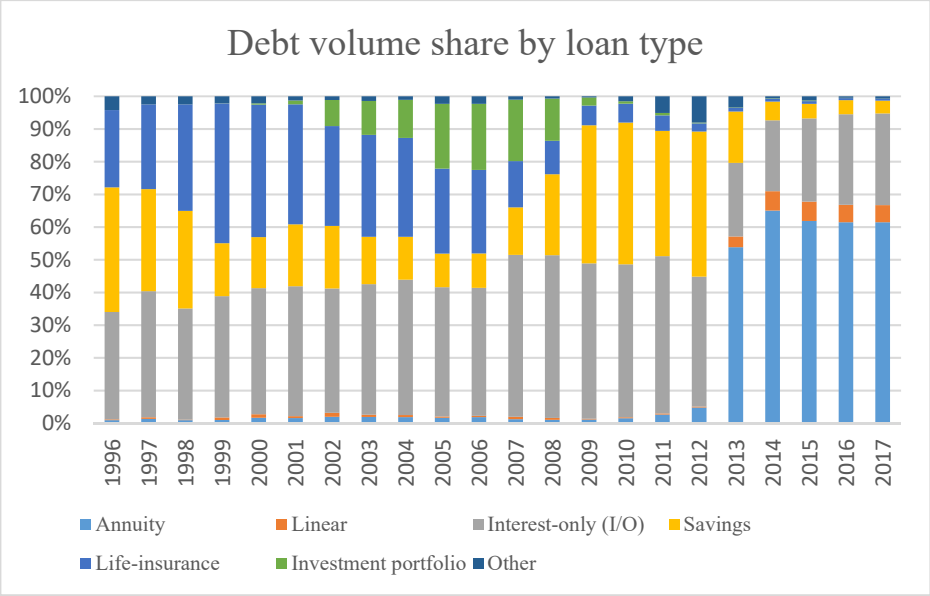

Figure 4. Debt-volume share by loan type of insurance companies (Mercurius data)

Furthermore, the following graph shows the distribution of the IO share across different LTV intervals. Figure 5 indicates that there is a negative correlation between the share of interest-only mortgages and the LTV ratio (-0.45). As these two risk factors seem to be heterogeneously distributed, the underlying risk is divided among different borrower groups in our sample. The figure is consistent with "anecdotal evidence that IO loans were very popular among elderly as a mean to cash out home equity" (Mastrogiacomo & van der Molen, 2015, p. 24).

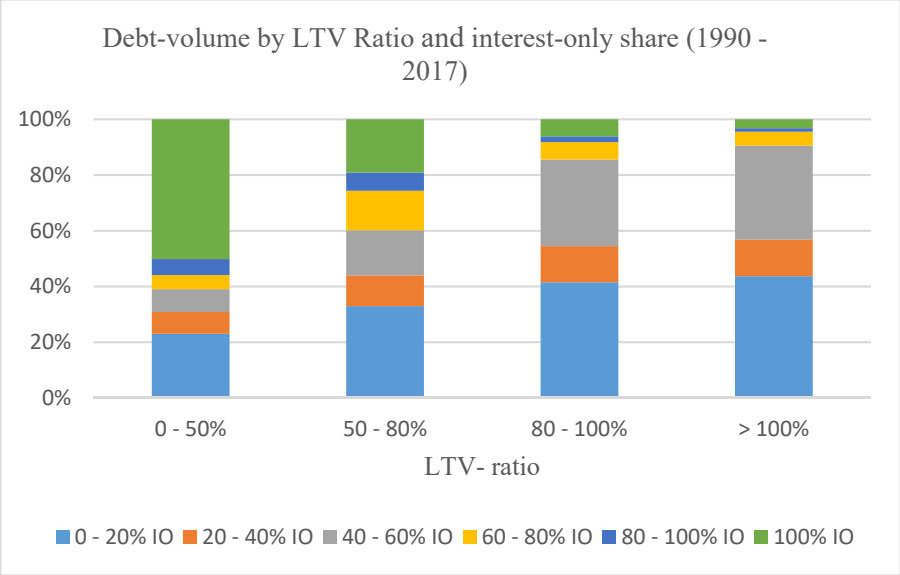

Figure 5. IO share (measured by debt-volume) by LTV ratios of insurance companies (Mercurius data)

2.4 Loan-to-value Ratio

Till today, the Dutch LTV limit remains very high from an international perspective with a mean LTV ratio of 90.85% between 2000 and 2017. Most alarmingly, 50% of the current mortgage investment has an LTV ratio above 100%, and 43% of loans had negative equity.

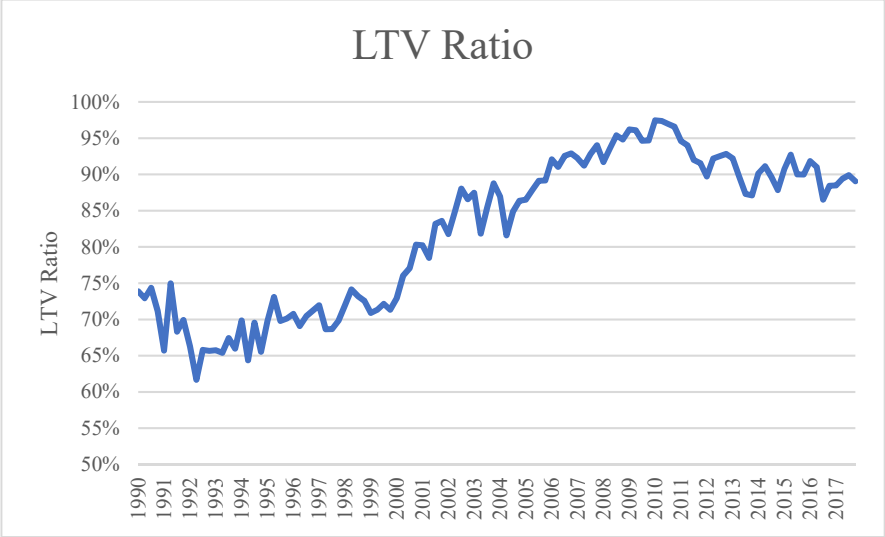

Figure 6. LTV-ratio of insurance companies (Mercurius data)

In 2013, regulatory changes introduced a gradual decrease of the maximum LTV-cap to 100% in 2018, meant to correct the market failures leading to such unsustainable high LTV ratios. Due to this constraint, first-time buyers will have to accumulate savings, before being able to issue a loan. Evidence shows that the average age of first-time buyers[7] consequentially increased by around five years. Whereas the mean LTV ratio for young residential mortgage borrowers (dummy young computed to be lower than median age) is around 96%, old lenders (above median age) have a mean value of 82%. These differences clearly show that age is an important factor in characterizing borrower risk.

Under Solvency II, the LTV ratio is the primary driver of capital for mortgages. For example, a 65% LTV residential mortgage would have a 0% default risk within the standard formula of Solvency II, whereas a 90% LTV residential mortgage would have a default risk of 4.5% (Manning & Comerford, 2018). Our data suggest that before 2016, the LTV ratio played a negligent role in reducing the risk in the portfolio. Low- and high- capitalized firms increased their risk during the financial crisis to up to an average of 96%. However, there is a clear sign of risk-shifting around 2015, when the introduction of Solvency II became imminent (Figure 11).

2.5 Loan-to-income Ratio

The mean LTI ratio of insurance companies is 3.78, meaning that on average, a borrower could pay off her mortgage within four years (excluding interest), if she saved her entire income for

[7] This should be interpreted with caution, as our data does not allow for an accurate identification of first-time buyers. This study assumed borrowers who issued their first loan in recent years to be a first-time buyer.

repayment. The development of LTI ratios shows a fairly similar pattern as the LTV ratio, suggesting a high correlation coefficient (0.52). Data supports the literature as the LTI ratio and age are negatively correlated since older borrowers generally have more income available to their disposal. Whereas young borrowers have an average LTI ratio just below 4, older borrowers settle at a ratio around 3.

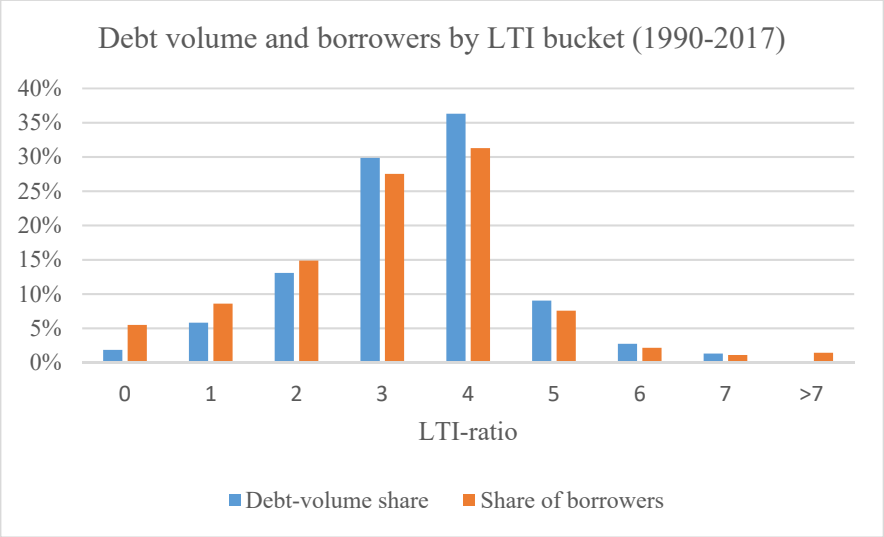

Figure 7. Share of debt-volume and borrowers by LTI bucket of insurers (Mercurius data)

Figure 7 shows the distribution of debt by original LTI. The distribution peaks between 3 and 4 – about 65% of debt fall into this category. As the distribution is slightly skewed to the right, it suggests that borrowers with larger LTIs also issue larger mortgages, which is rather intuitive.

2.6 Developments in the Dutch Mortgage Market

Figure 8 motivates this study's hypothesis dividing the mortgage investment among high-capitalized and low-capitalized insurance companies. From the figure below, it becomes clear that investment decisions differed substantially between our control- and treatment- group. Interestingly, before the early 2000s, mortgages were pretty much non-existent on the balance sheet of insurance companies. Around the build-up of the financial crisis, low-capitalized insurers seem to have increased their mortgage investment disproportionately to high-capitalized institutions. This gave motivation to the primary research question of this study.

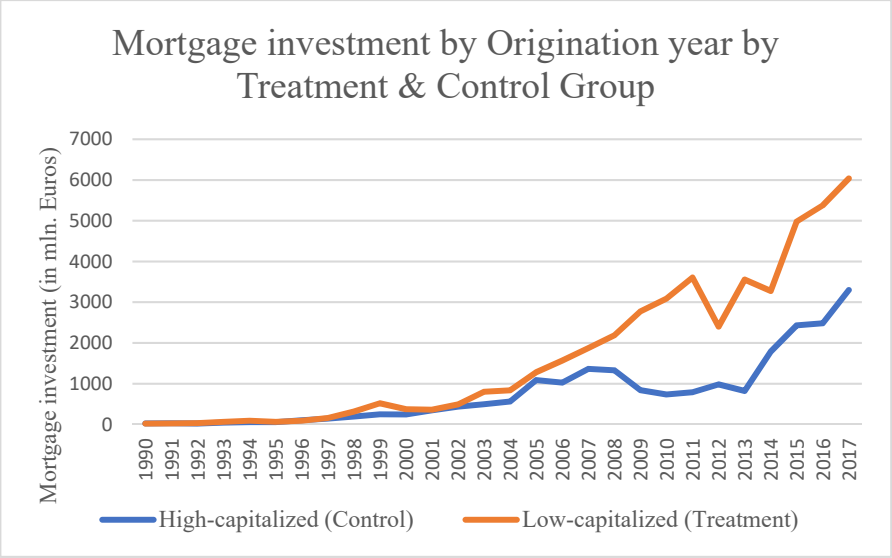

Figure 8. Mortgage investment by low- and high- capitalized insurers (Mercurius data)

Our analysis will show positive and significant portfolio reallocation due to Solvency II, though the largest increase in mortgage investment happened in the years prior to 2016. Due to the complex nature of the Dutch economy, this paper can therefore single out the direct effect of Solvency II, but cannot disentangle precisely what motivates the increase in mortgage underwriting observed before, so we also explore other explanations.

Figure 9 and 10 show the mortgage investment by low- and high- capitalized insurance companies split up according to whether they belong to a financial conglomerate. The two figures below suggest that exogenous changes to the banking sector, such as the announcement and implementation of Basel III and Basel III.5 might have incentivized portfolio reallocation of mortgage investment from the balance sheets of banks to those of insurers. While the observed effect in Figure 8 disappears among non-FICO banks (Figure 9), the divergence seems to grow even more significant for FICO banks after 2013 (Figure 10).

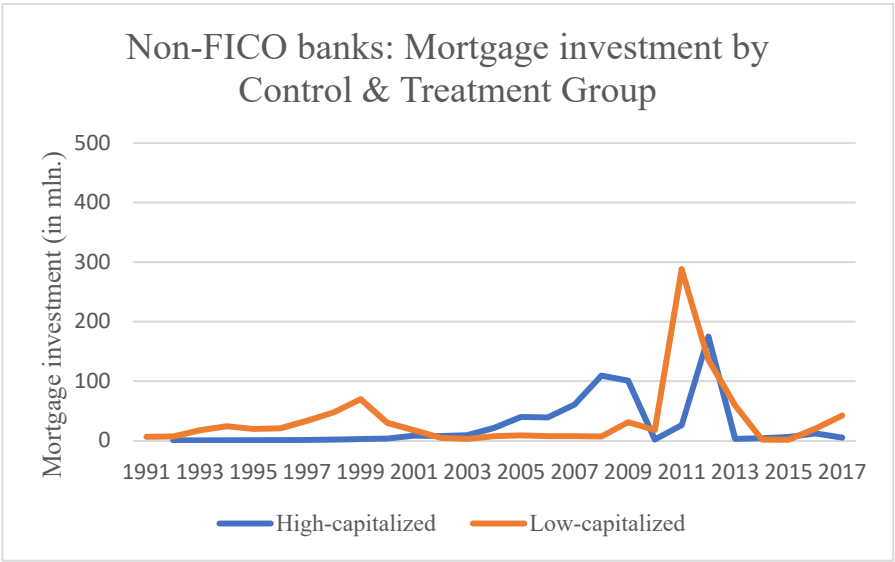

Figure 9. Mortgage investment by low- and high- capitalized insurers (by non-FICO banks) (Mercurius data)

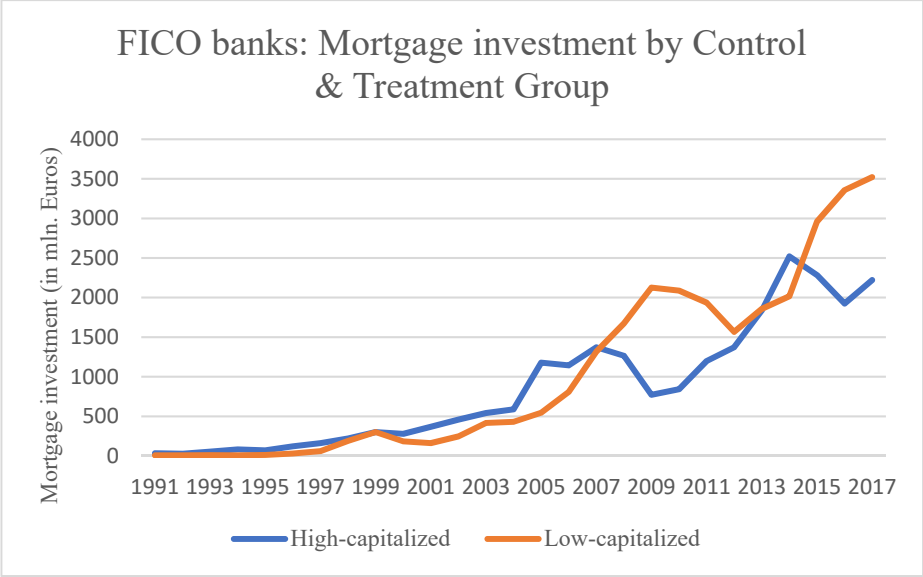

Figure 10. Mortgage investment by low- and high- capitalized insurers (by FICO banks) (Mercurius data)

Apart from investigating which regulatory framework or market circumstance explains the increase in mortgage underwriting of Dutch insurance companies, we also aspire to evaluate the effectiveness of the legislations. Figure 11 highlights that underfunded institutions committed to risk-shifting in recent years and lowered their number of participants with negative equity considerably. The graph below suggests that the introduction of Solvency II led to an entirely new risk-targeting scheme, away from high LTV ratios. This hints at the fact that institutions that are constrained by Solvency II actively target safer participants.

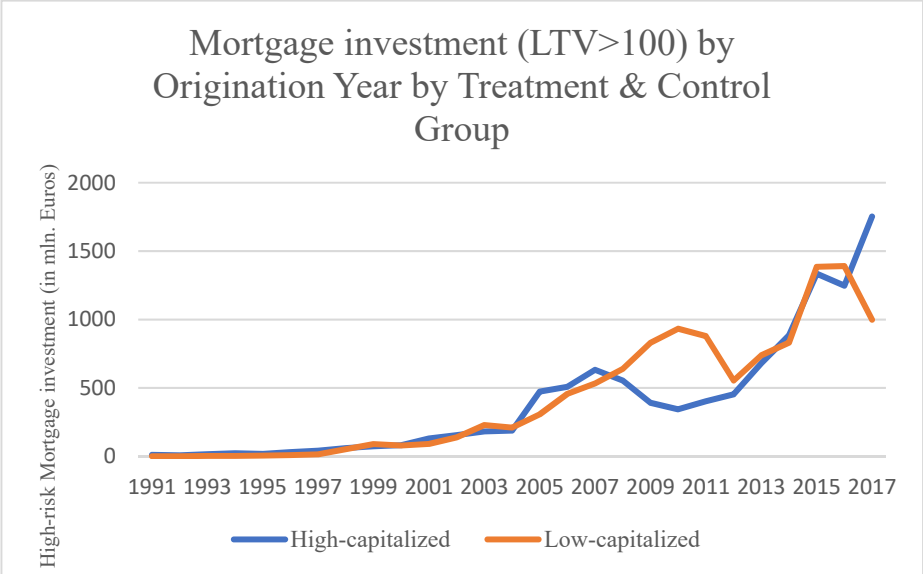

Figure 11. High-risk Mortgage investment by low- and high- capitalized insurers (Mercurius data)

Figure 12 supports our hypothesis that Solvency II incentivized risk-shifting. It shows that low-capitalized insurers increased their mortgage investment in loans with an LTV ratio below 100% by more than their high-capitalized counterparts. The general increase in both groups in low LTV mortgage investment seems to be mainly carried by the general effect of Solvency II (or Basel)

observed in Figures 8 and 10, as well as the conveniences connected to banks withdrawing from the market.

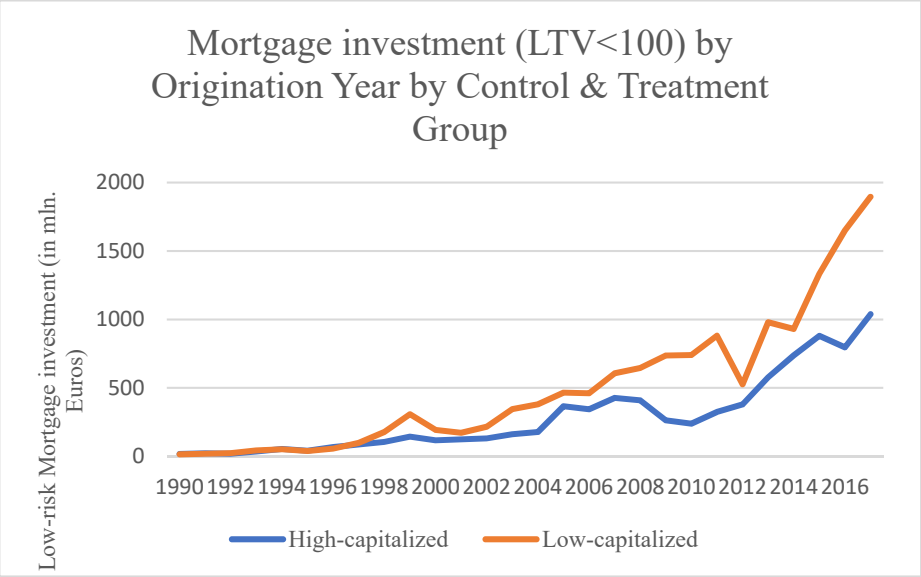

Figure 12. Low-risk Mortgage investment by low- and high- capitalized insurers (Mercurius data)

III. Methodological Framework & Results

Using the regulatory threshold level of trading activity to determine whether an insurance company is likely to be constrained (low-capitalized) or not constrained (high-capitalized) to the SCR, we implement a differences-in-differences (DID) approach, thus focusing on the difference in the effect of the trading activity on insurance company risk between low- and high-capitalized insurance companies before and after the introduction of Solvency II. This paper employs the classification of de Haan & Kakes by taking the median Solvency II ratio of 181.31%[8] (see equation 1) as a cut-off point and excluding firms too close to the threshold (2010, p. 1624). Although the SCR implemented in 2016 was levied on all insurance companies, they affected insurers differently due to their pre-reform performances (Juelsrud & Wold, 2018). Informally, we base our identification strategy on additional balance sheet data, which lets us exclude those institutions that report heavy fluctuations in their funding ratio from the analysis. We exploit this in a flexible differences-in-differences framework (Juelsrud & Wold, 2018; Junge & Kugler, 2018).

On top of the two time periods outlined in Section 1, namely the financial crisis and the introduction of Solvency II, it can also be argued that anticipation effects must have played a role. In the remainder of this study, we investigate whether we can propose an interpretation for such differences in portfolio reallocation strategies. The first candidate answer would be that insurance companies anticipated the implementation of Solvency II far in advance, thanks to the extremely transparent policymaking of the European Commission issuing several announcements. According

[8] As a robustness check, we have included additional regressions to test for different cutoff points in the Appendix (Table 13, Coloumn 5 & 6). Similar results hold.

to Malani & Reif (2011), "anticipation is a reasonable diagnosis if individuals are forward-looking, have access to information on future treatment, and there is a benefit to acting before treatment is adopted" (p. 2). There has been an overwhelming amount of literature published on the effects and implications of Solvency II before it was even implemented. Additionally, Solvency II was, at the time the first directive was published, meant to be implemented in 2014, which in turn also led to timely preparation and transitional changes (Ronkainen et al., 2007; de Haan & Kakes, 2010; Bridges et al., 2014). We consequentially test whether insurance companies prepared for Solvency II and already repaired their balance sheet (i.e., increased investments in mortgage lending) before the regulatory framework[9].

To summarize, the analysis follows a quasi differences-in-differences fixed effects panel regression analysis estimating the effect of the regulatory framework on investment decisions in mortgage loans (as was done in de Haan & Kakes, 2010/11; Holod, Kitsul & Torna, 2017; Abraham & Sun, 2018; Uluc & Wieladek, 2018). Our regression models will test for three main time periods that could have incentivised insurance companies to turn their attention towards mortgage lending. The first, that we have just discussed, is the effective introduction of Solvency II in 2016. The second period looks at the span from announcements to imminent introduction that were made by several policy bodies after 2012, which then also includes FICOs. The third investigates banks withdrawing from the mortgage market after the financial crisis in 2008. This paper acknowledges that the identification assumption based on the insurer's performance in 2016 may not as easily be traced back to the financial crisis, as the capitalization of an insurer is likely to fluctuate.

3.1 Effect of Solvency II

The first set of regression models assumes that these events are mutually exclusive (Equation 2 to 4) or jointly taken into account (Equation 5):

$$Y_{i,t} = \beta_0 + \gamma LC_i + \delta FRE_t^{crisis} + \theta CE_{i,t}^{crisis} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (2)$$

$$Y_{i,t} = \beta_0 + \gamma LC_i + \delta FRE_t^{anticipation} + \theta CE_{i,t}^{anticipation} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (3)$$

$$Y_{i,t} = \beta_0 + \gamma LC_i + \delta FRE_t^{solvency\,II} + \theta CE_{i,t}^{solvency\,II} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (4)$$

$$Y_{i,t} = \beta_0 + \gamma LC_i + \sum_{k=1}^{3} \delta FRE_t + \sum_{k=1}^{3} \theta CE_{i,t} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (5)$$

where $Y_{i,t}$ = outstanding debt in mortgage portfolio of institution i at time t (where we look separately at total debt and underwater debt (see Section 3.3)). LC_i characterizes an institution i to be low-capitalized and identifies the treatment group[10]. FRE_t are the three financial regulation

[9] Since the SCR was only reported since 2016, DNB does not have accurate information about the solvency ratio of insurance companies before, because the mandatory reporting of the balance sheet was not binding then, at least not with the risk weights incorporated. Collecting data from the insurance company division at DNB made clear that under Solvency I the documentation looked fundamentally different, and thus requirements cannot be easily compared. Therefore, the anticipation effect leads to an overestimation of the financial standing of an insurance company, as insurers repaired their balance sheet already in advance.

[10] Over time several institutions have changed in structure. Some FICOs have legally split the bank and insurance branch. As we observed these institutions in 2017 being already split, and have no previous micro data before the

effects mentioned above. $CE_{i,t} = LC_i * FRE_t$, and is the main parameter of interest. $X_{i,t}$ is a vector of all borrower-, loan-, insurance company-, and macroeconomy- characteristics on either institution-, time-, or institution and time- level (fully listed in Table 13 in the Appendix). $\varepsilon_{i,t}$ is assumed to be the normally distributed error term.

Our results show that during the financial crisis, the conveniences of banks withdrawing from the market allowed low-capitalized institutions to compete and led them to issue around 15 million Euros per year more in mortgage lending than high-capitalized institutions (Table 1, Model 2). In other words, the crisis caused underfunded insurance companies to increase their mortgage lending by 182% more than healthy insurers (see Figure 8).

	Dependent variable: Mortgage investment				
	(2)	(3)	(4)	(3.1)	(3.2)
Low-capitalized (LC)	11.38*** (2.37)	23.15*** (2.62)	22.64*** (2.48)	18.23*** (2.57)	22.04*** (2.62)
Crisis, Regulatory Framework Effect (FRE)	10.85*** (3.78)	31.82*** (5.28)	15.94*** (8.35)	n.a	40.03*** (13.08)
Interaction effect (LC*FRE) (CE)	13.45*** (4.29)	n.a	n.a	31.27*** (9.30)	6.23** (2.78)

Table 1. Regression Coefficients[11] Results of equations 2-4[12] (Mercurius data)

Next, the effect of Solvency II on mortgage lending is hard to disentangle. Alone in 2013, the announcements and publications of the European Commission and DNB caused a significant increase in mortgage lending by underfunded insurance companies of 27.75% or 32 million Euros (Model 3.1). We estimate that whereas those years prior to the planned implementation of Solvency II[13] (2013 & 2015) significantly increased mortgage investment, the interim periods had an offsetting effect leading to an overall insignificant effect of the whole anticipation phase (Models 3, 3.1 and 3.2). Moreover, after the implementation of Solvency II there seems to be no significant effect of the macroprudential regulation on mortgage investment, as control- and treatment- group increase their investment by roughly the same. In section 3.3, we will show that the direct increase in underwriting due to the regulation[14] is estimated to be 2.23% of mortgage investment, keeping in mind that overall levels have already increased a substantial amount before 2016.

Combining all of the above, we show that Dutch insurance companies used residential mortgage investments to prepare for Solvency II. Also we note that without imminent closeness of implementation, mortgage investment does not seem to be within the profit-maximizing strategy. This would explain the results from Models 3-3.2. Also, Figure 8 and Model 4 justify

split, we assume that the present allocation of the mortgage portfolio in the separated firms resembles the allocation across the within FICO balance sheets of the bank and the insurance before the split.

[11] Legend: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; n.a. not significant

[12] Model 5 is included with all regression coefficients in Table 13 in the Appendix.

[13] In 2014, the scheduled implementation of Solvency II was postponed due to several implications. Announcements and publications from policy advisors and academics grew prevalent around that time. Please note that for those years, models 3.1 and 3.2 have been extended. These are spelled out in the Appendix (Section 6.3).

[14] Here, however, we assume the effect of Solvency II to appear after its implementation, so to be purely observable.

DNB's latest announcements that while Solvency II is a European wide framework, Dutch insurers are relatively well-prepared and thus the transitional process was predicted to be relatively smooth (DNB, 2007). Thus, the significant increases in mortgage underwritings of low-capitalized insurers before the regulation sufficed to move out of effective supervision. This explains the insignificant interaction effect in Model 4.

To summarize, it can be argued that due to adjustment- and transitional- costs (e.g., hiring experts in new mortgage business; offering competitive rates next to established mortgage lenders; reaching economies of scale), as well as uncertainty as to how the new macroprudential regulation would work, it is likely that insurance companies prepared for the changes in capital requirements far in advance. This is manifested in the resulting 32 million Euros average increase in mortgage investment after 2013. Thus, we can conclude that Solvency II most certainly had a positive effect on insurance companies' investment in residential mortgages.

3.2 Portfolio Rebalancing through Financial Conglomerates

As discussed above, we find large anticipation effects. We speculated that these might be due to the introduction announcements of Solvency II, but we could not exclude that the real motivation depends on the higher capital requirements for banks; next we test this additional hypothesis. The test rests on an additional identification assumption, namely that anticipation effects on restrictions to banks regulation should not have any effect on insurance companies that do not belong to a FICO. For these insurers only market considerations (banks withdrawing from mortgage underwriting) link them to banks' policies. Insurers within FICOs instead are affected at the same time by market considerations, but also by anticipation effects on the risk of higher capital requirements for banks that hold large mortgage portfolios. Thus, in this second group, the strategic behaviour of affiliated banks shifting their portfolio to the 'own' insurance adds up to the standard market considerations. Eyeball analysis of Figure 9 already suggests that insurers outside of a FICO increased their mortgage underwriting in the aftermath of the financial crisis, when banks withdrew from the market. That increase was larger for low-capitalized insurers. Figure 10 suggests that this was also the case for FICO banks, but the additional and continued increase is only visible in this second case. This suggests that banking regulations could be responsible for the differences between these two graphs. So, we have estimated triple-differences models to test our speculation. Formally:

$$Y_{i,t} = \beta_0 + \gamma LC_i + \phi FB_i + \delta FRE_t^{crisis} + \psi TD_{i,t}^{crisis} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (6)$$

$$Y_{i,t} = \beta_0 + \gamma LC_i + \phi FB_i + \delta FRE_t^{anticipation} + \psi TD_{i,t}^{anticipation} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (7)$$

$$Y_{i,t} = \beta_0 + \gamma LC_i + \phi FB_i + \delta FRE_t^{solvency\ II} + \psi TD_{i,t}^{solvency\ II} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (8)$$

$$Y_{i,t} = \beta_0 + \gamma LC_i + \phi FB_i + \sum_{k=1}^{3} \delta FRE_t + \sum_{k=1}^{3} \psi TD_{i,t} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \quad (9)$$

where FB_i indicates whether an insurance company is part of a FICO. $TD_{i,t} = LC_i * FB_i * FRE_t$, and is the main parameter of interest in these models. If it appeared that ψ is significant and

positive, this would suggest that instead of awaiting and preparing for Solvency II, FICOs were awaiting Basel III.5 and banks outsourced their mortgages to insurers' balance sheets.

The financial crisis had the largest effect of the three to be investigated time periods with an average increase of 50 million Euros (Table 2, Model 6). FICO insurers increased their mortgage investment by over *150%* more than incumbent institutions during that time period (Table 11, Appendix). Even though this effect goes down to 130% when controlled for balance sheet characteristics such as the funding ratio, it can be assumed that especially banks needed to repair their balance sheets in order to regain investor- and consumer- confidence and comply to the Basel regulations. This is then estimated to be the joint effect of market conveniences during the crisis as well as higher capital requirements from Basel III. The effect becomes less as we move out of immediate need of portfolio reallocation in recent years.

	Dependent variable: Mortgage investment		
	(6)	(7)	(8)
Low-capitalized (LC)	11.00** (4.63)	10.06** (4.00)	8.29** (3.64)
Crisis, Regulatory Framework Effect (FRE)	n.a	n.a	-18.35** (7.33)
Interaction effect (LC*FRE) (CE)	n.a	n.a	n.a
FICO-bank (FB)	28.97*** (4.68)	25.45*** (3.96)	26.71*** (3.56)
Interaction effect (LC*FB)	-19.21*** (6.10)	n.a	n.a
Interaction effect (FRE*FB)	n.a	18.75*** (6.69)	n.a
Interaction effect (LC*FRE*FB) (Triple-difference)	48.16*** (8.02)	15.66* (9.03)	20.73* (11.76)

Table 2. Regression coefficients of main effects by FICOs of Models 6-8[15] (Mercurius data)

In 2015, DNB publicly urged banks to factor in higher capital requirements under Basel III.5, as the regulation will desist from the practise that banks use internal models to set their SCR, and instead introduce an output floor. The introduction of an output floor is meant to limit discretionary powers as the use of internal models remains controversial. One regulatory loophole is then shifting mortgage investment to a sister company, namely the FICO insurer, which then is subject to relatively less constraining requirements. DNB estimates that the prudential regulation will increase the required capital for a typical standardised bank by approximately 3%, which will mainly driven by residential mortgages (DNBulletin, 2015). In 2015 alone, affected insurers increased their mortgage investment by more than 100%.

From a policy perspective, this interconnectedness may lead to a contagion pathway between banks and insurers because separate regulatory frameworks might allow institutions to

[15] Again, please find Table 13 in the Appendix for Model 9.

play the system (Hauton & Hèam, 2015). Therefore, cross-sector consolidation is in need of closer regulatory coordination between the banking- and the insurance company- sector (Lelyveld & Schilder, 2007).

3.3 Overall Effect

This study aimed at investigating to what extent Solvency II influenced mortgage lending of insurance companies. By assuming that the effects were sequential, our hypothesis implies first an effect of the financial framework, then of the financial crisis and if anything else is left, it is due to anticipation. As already touched upon in the previous two sections, we find that Solvency II had a minimal direct effect with only making up 2.3% of the observed increase. Next, the financial crisis had the largest effect, increasing mortgage lending by 51.3%. One of the main findings of this paper was, however, that rather than awaiting the legislation, insurers anticipated on the implementation and prepared in due time by reallocating their portfolio towards financial assets benefiting from the risk-return mix the to be implemented capital requirement dictates. Furthermore, our findings revealed that despite the fact that we focused our analysis on insurance companies, prudential regulations from different sectors have an influence as well. Therefore, we divide here anticipation effects among awaiting and preparing for Solvency II and for Basel III.5. FICO insurers thus increased their mortgage lending by 31.5%, whereas non-FICO insurers increased theirs by 14.9% due to anticipation effects.

	Effect on Mortgage Lending
Solvency II	2.23%
Financial Crisis	51.39%
Anticipation of Basel III.5	31.52%
Anticipation of Solvency II	14.86%
Total	100.00%

Table 3. Quantitative effects on mortgage lending

Comparing these results, we find that Solvency II almost played a negligent role, as even Basel III.5 had a larger influence on investment decisions (Table 3). Also, the financial crisis and the associated withdrawal of banks from the mortgage market during that time period had the largest effect. This highlights that the mortgage market is still predominantly shaped by trends and the risk involved in the banking sector, which is due to a high interconnectedness between banks and other less conventional lenders.

One of the main questions that remains, however, to what extent was it really necessary to repress mortgage lending after the crisis? After all, we showed that defaulting on mortgage loans is extremely rare in the Netherlands and therefore it seems unlikely that the high share held by banks

results in systemic effects on the Dutch economy or even financial sector. It remains unclear whether depressing mortgage lending has helped the seizing up of the housing market following the 2008 financial crisis.

Section 1 had the aim to highlight that since the financial crisis, banks have experienced reduced funding due to several reasons, which is prompting them to curtail their mortgage lending, usually by charging higher interest rates (Hoj, 2011). The resulting lower competitive pressures give the remaining mortgage lenders scope for temporarily achieving higher profit margins. The strategy of banks focusing on profit retention and rationing in order to strengthen their balance sheets fits in with this (Jansen, Bijlsma, Kruidhof & Pattipeilohy, 2015). The higher interest rates attract entrants, which supports the impression that the reduced competition in the mortgage market is a temporary phenomenon. Tellingly, Dutch insurers have lately expanded their activities in the mortgage market, explaining that substantial increase since the financial crisis.

Furthermore, it may be argued that the observed withdrawal of banks from the mortgage market can be traced back to the overexposure of those dominant players. Even though on a micro-level it seems reasonable to invest in mortgage lending, from a financial regulatory viewpoint, however, legislations need to limit the dominance of the key players in the Dutch mortgage market, especially because of the high levels of inherent risk. Hence, whereas under Basel III the required capital for mortgages was relatively low (only around 1%), more stringent capital requirements (calculated by an output floor instead of internal models) for the banking sector under Basel III.5 may lead to more selective lending, higher interest rates on loans, and shifting assets to FICO insurers. This reduces the amount of tied-up capital and increases the gross margin on lending (Uluc & Wieladek, 2018). Retention of profits is an important strategy for improving the capital base.

3.4 Mortgage investment as a Tool of Portfolio Immunization

Next, we must emphasize that Solvency II had the aim of making insurance companies more resilient to shocks and protect policyholders, rather than increasing their mortgage lending investment (though these are not mutually exclusive). And while this research focuses specifically on residential mortgage lending, it still aims to evaluate the effectiveness of the regulation.

In order to account for the underlying risk exposure, the dependent variable has been chosen to assess the impact of the performance of mortgage investment in insurance company portfolios. The models below will draw attention to the risk-exposure of insurance companies as a result of the increase in mortgage investment. Several variations to Model 5 within the dependent variables have been made to isolate loan preferences of managers of insurance companies.

As Figure 11 highlighted, underfunded institutions invested significantly more in high-risk loans during the financial crisis. In those years, low-capitalized insurers invested around 50%[16] more in loans with negative equity than their high-capitalized counterparts. With Solvency II, however, the results estimate the exact opposite. While insurers were still increasing their mortgage investment with an LTV ratio above 100% by 7 million Euros during the crisis, once negotiations around Solvency II started, this value fell by twice this size and decreased even further with the introduction of the regulation (Table 4). With the implementation of Solvency II, low-capitalized firms reduced their investment in loans with an LTV ratio above 110% by 122% (Table 12,

[16] The coefficient tables of log models are included in the Appendix (Table 12).

Appendix). Moreover, Solvency II led to a significant decrease of around 12 million in mortgages issued for young borrowers (Table 4).

	Dependent variable: Mortgage investment by risk categories				
	Debt LTV >100	Debt LTV >110	Debt Young	Debt Old	Debt Interest-Only
Interaction effect low-capitalized / Crisis	7.09*** (1.68)	n.a	9.87** (1.84)	3.63*** (1.18)	14.55*** (2.30)
Interaction effect low-capitalized / Anticipation	-6.11** (2.94)	-9.12*** (1.92)	n.a	-30.89*** (5.62)	-15.93*** (2.68)
Interaction effect low-capitalized / Solvency II	-13.93*** (4.58)	-8.24*** (3.23)	-11.92*** (4.71)	n.a	n.a

Table 4. Coefficient Table main effects of different risk-models (riskiness of dependent variable)

Section 1 underlined many shortcomings of past solvency regulations such as Solvency I and Basel I & II. We have shown that under past legislations higher capital requirements incentivized institutions to shift lending towards riskier borrowers to boost short-term profitability and grow capital through higher retained earnings (i.e., being able to charge extra fees and/or higher interest rates), instead of cutting back on investments as a whole (Uluc & Wieladek, 2018). Insurers also did this under Solvency I, when capital requirements were increased without risk-weights compensating for specific borrower- and loan- characteristics. However, our results suggest that finally, increases in capital requirements under Solvency II did, in fact, make insurers more resilient, as it led to lower riskiness of an insurer's balance sheet by inducing risk-shifting behaviour. Constrained insurers invested significantly less in mortgages shaped by young borrowers, borrowers with high LTV ratios, and non-amortizing loans (Table 4). Therefore, Solvency II's calculation of the SCR value is successfully discouraging companies of their destructive and insensible behaviour observed in the past. Also, by controlling for insurance company characteristics we see that Solvency II incentivized portfolio reallocation, as the share of mortgage investment on the balance sheet increased significantly after 2012 from 7% to almost 20% (Figure 16, Appendix). To summarize, it appeared that those insurers constrained by Solvency II targeted borrowers that default less and voluntarily repay more, so insurers use these investments as immunization.

3.5 Robustness Checks & Limitations

The present study applied several tests, such as the Breusch-Pagan/Cook-Weisberg- or the Variance Inflation Factor- (VIF) test to check whether the Gauss-Markov assumptions are satisfied. We find that our results might have bias in the variance of the error term. The Appendix provides extended models running fixed effects regressions (Table 10 & 13). On a positive note, we can exclude selection bias as a possible problem, since DNB requires all insurers to report their balance sheet.

Furthermore, the findings motivate many aspects future studies should focus on and also imply difficulties in interpreting the results. Unfortunately, the Mercurius dataset does not provide information on loan applications (e.g., rejection for a loan; number of applications; worsening

terms after negotiations; multiple loans from different institutions) or tracks borrowers beyond their own institution, which means that we cannot formally differentiate between the respective adjustment channels caused by Solvency II. Also, it is difficult to make assertions about FICOs as in the loan level data, loans are merely listed with the origination date the moment they appear on the balance sheet of the institution. Adding to this, future studies could apply a similar analysis to the present research, but focus on the effect of Basel III and Basel III.5 on banks' investment behaviour. Combining the findings will provide us with a more complete picture of the Dutch mortgage market.

Additionally, more advanced econometric models could be implemented in future research to more accurately correct for the exogeneity assumption. Also, our data was, due to its recency, very limited in the observation period of Solvency II. Thus, future studies using updated datasets could lead to statistically stronger results. By combining the thesis with a field study collecting interviews of managers of insurance companies, the assumption of the anticipation phase could be improved. Furthermore, future research could apply stress tests or shocks to investigate how well Solvency II worked in making insurance companies in the Netherlands more resilient and better capable in protecting its policyholders. Despite the aforementioned limitations, the present study nonetheless was successful in revealing dynamics in the Dutch mortgage market, encouraged policy changes, and positively confirmed the relative effectiveness of Solvency II.

IV. Conclusion

This paper aimed to estimate the effect of the prudential regulation Solvency II on mortgage lending by insurers. The results suggest rather than waiting till the implementation of Solvency II, insurers adjusted their mortgage lending investment time in advance. We find that after 2012, public announcements (and academic literature) increased, and so did mortgage lending. This increase, however, could also have been caused by other prevailing regulations or factors in the Dutch economy. Next, negotiations around Basel III and Basel III.5 focused on implementing an output floor increasing the risk weight specifically for mortgages. This trend made us look into insurers that are part of financial conglomerates, meaning that they are affiliated with a bank. We estimate that on top of preparing for Solvency II, banks also reacted to the Basel negotiations and shifted part of their mortgages from their portfolio to the portfolios of insurers. Overall, this has drastically reduced the share of mortgages held by banks in the Dutch economy in the past few years. Our results estimate that the direct causal effect of Solvency II explains merely 2.23% of the increase in mortgage lending, while over 50% of it can be explained by repercussions of the financial crisis that connect to Basel frameworks, and market responses after banks' withdrawal from the mortgage market. Furthermore, 14.9% and 31.5% of the increase in mortgage lending originates from insurers anticipating and preparing for different, more complex capital requirements connected to Solvency II and Basel III.5, respectively. We find that there are within differences between insurers, as those, affiliated with a bank and therefore affected by an additional framework, commit to a higher degree of portfolio reallocation towards residential mortgages. Lastly, Section 1 has provided us with the fundamental source of the failure of past solvency regulations, namely the lack of adjustable risk weights. With Solvency II and Basel III, risk weights were introduced that require more capital for financial assets with a higher risk exposure. Our results show that these higher risk weights have incentivised insurers to commit to risk-shifting towards safer loans, characterized by lower LTV- and LTI- ratios, lower default rates, and older

borrowers. Thus, we can confirm our hypothesis that insurers used mortgage investment as a tool to immunize their portfolio.

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VI. Appendix

The Appendix is divided into three sections: Section 6.1 will give a more elaborate description of how the SCR value is computed. This was well beyond the scope of this paper, however, we hope to provide an intuition as to where our hypotheses originate from as well as to underline the complexities connected with finding the optimal portfolio allocation. Section 6.2 provides a more detailed picture of the composition of the Mercurius dataset that we are using. Also, we apply Mastrogiacomo & van der Molen's (2015) scheme of classifying risk groups among four different groups characterized by combinations of high and low LTV- and LTI- ratios. Furthermore, we aim to investigate the relation to other risk categories. The following tables serve as a foundation for our regression models used in Section 3.3 above. Lastly, Section 6.3 provides additional graphs showing the main effect on mortgage lending by treatment group, where mortgage lending is further split up by risk factors. Also, we will provide the coefficient tables for transparent insights into our regression results.

6.1 Solvency II

The standard formula calculates the capital needed to cover various adverse circumstances that can arise, and is subject to supervisory approval, conducted by DNB in the Netherlands (Bowles, 2011). Unlike Solvency I, the capital requirements at hand take into account diversification effects. Those diversification effects are considered when capital requirements are aggregated by using correlation matrices (EIOPA, 2014).

As touched upon in Section 1, the standard formula consists of six modules: market risk, health underwriting risk, default risk, life underwriting risk, non-life underwriting risk, and intangibility risk (see Figure 3). Each of those modules has a certain number of submodules. Just for illustration purposes, the market module, for instance, has seven submodules: interest rate risk, equity risk, property risk, credit spread risk, currency risk, concentration risk, and illiquidity risk.

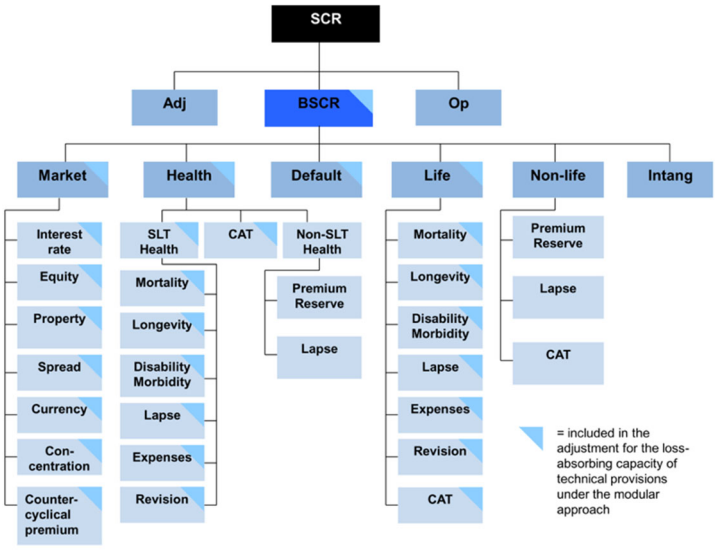

Figure 13. Modules and Submodules in the standard formula of Solvency II (EIOPA, 2012, p. 115)

The Solvency Capital Requirement can be determined by the means of the following formula (Spaan, 2012):

$$SCR_{i,t} = BSCR_{i,t} + Adj_{i,t} + SCR_{i,t}^{Op} \tag{16}$$

, where

$$BSCR_{i,t} = Basic\ Solvency\ Capital\ Requirement \tag{17}$$

$$Adj_{i,t} = Adjustment\ for\ risk\ absorbing\ effects \tag{18}$$

$$SCR_{i,t}^{Op} = Solvency\ Capital\ Requirement\ for\ operational\ risk \tag{19}$$

The BSCR can be determined by the following formula:

$$BSCR_{i,t} = \sqrt{\sum_{m,n} Corr_{m,n} * SCR_{m,t} * SCR_{n,t}} + SCR^{intang} \tag{20}$$

, where

$$Corr_{m,n} = The\ Correlation\ between\ m\ and\ n\ according\ to\ the\ correlation\ matrix \tag{21}$$

$$SCR_m, SCR_n = Capital\ requirements\ for\ the\ individual\ SCR\ risks\ according\ to\ the\ rows\ and\ columns\ of\ the\ correlation\ matrix\ Corr \tag{22}$$

$$SCR^{intang} = Solvency\ Capital\ Requirement\ for\ intangible\ risk \tag{23}$$

$$m, n = market\ risk,\ health\ underwriting\ risk,\ default\ risk,\ life\ underwriting\ risk,\ non-life\ underwriting\ risk \tag{24}$$

All in all, this section was meant to show that the way the SCR is computed is highly complicated. We have outlined that each insurance company faces a trade-off between investing in profit-maximizing financial assets and having to hold more capital. Something within the standard formula, we hypothesize, favors residential mortgages to other investments and this trade-off is relatively low. Thus, insurers increased their mortgage investment.

6.2 Descriptives

Type	Loan Size (in 1000 Euros)			Number of observations
	Mean	St. dev.	Median	
Whole Sample	107.36	78.80	95.00	607,343
Low-capitalzed Institution	102.40	70.77	92.00	387,431
High-capitalized Institution	109.46	90.16	90.90	263,506
High Income	130.84	98.93	113.45	253,930
Low Income	88.89	57.94	81.00	397,007
NHG-covered	102.05	54.85	96.00	292,026
not NHG-covered	108.21	94.43	87.50	352,978
High Interest rate	99.96	71.70	89.60	447,521
Low Interest rate	116.91	92.74	100.00	203,416
Metropole	126.22	100.11	104.50	33,529
Outside Metropoles	110.99	85.27	97.50	361,263
Young Borrower	125.50	83.18	112.70	218,307
Old Borrower	96.88	86.40	78.05	173,365
Interest-only mortgage	87.11	70.25	75.21	274,484

Table 5. Loan size by lender and borrower characteristics (Mercurius data)

Type	LTV ratio (%)			Number of observations
	Mean	St. dev.	Median	
Whole Sample	90.24	27.75	99.05	607,343
Low-capitalzed Institution	85.89	28.04	95.00	387,431
High-capitalized Institution	97.75	27.55	103.45	263,506
High Income	91.85	25.63	100.00	253,930
Low Income	87.92	29.96	96.67	397,007
NHG-covered	96.26	20.68	101.70	292,026
not NHG-covered	84.32	32.08	90.47	352,978
High Interest rate	91.61	26.66	99.79	447,521
Low Interest rate	84.70	31.43	94.29	203,416
Metropole	90.57	31.72	99.99	33,529
Outside Metropoles	86.00	31.15	95.60	361,263
Young Borrower	95.75	24.65	101.83	218,307
Old Borrower	75.37	34.18	78.15	173,365
Interest-only mortgage	83.73	32.29	91.67	274,484

Table 6. LTV ratio by lender and borrower characteristics (Mercurius data)

Type	LTI ratio (%)			Number of observations
	Mean	St. dev.	Median	
Whole Sample	3.73	1.52	3.87	607,343
Low-capitalzed Institution	3.65	1.50	3.84	387,431
High-capitalized Institution	3.91	1.54	3.93	263,506
High Income	3.46	1.40	3.61	253,930
Low Income	3.91	1.57	4.05	397,007
NHG-covered	3.70	1.21	3.87	292,026
not NHG-covered	3.77	1.73	3.88	352,978
High Interest rate	3.80	1.50	3.93	447,521
Low Interest rate	3.57	1.54	3.74	203,416
Metropole	3.70	1.56	3.80	33,529
Outside Metropoles	3.65	1.54	3.80	361,263
Young Borrower	3.94	1.31	4.05	218,307
Old Borrower	3.31	1.73	3.29	173,365
Interest-only mortgage	3.66	1.67	3.79	274,484

Table 7. LTI ratio by lender and borrower characteristics (Mercurius data)

	Per Capita Mortgage Debt (Whole Sample - HC - LC)			Mortgage Debt by Volume (Whole Sample - HC - LC)		
Low - Low	49.57%	39.91%	53.98%	28.68%	24.95%	30.63%
Low - High	4.32%	5.16%	3.94%	25.55%	26.36%	25.44%
High - Low	38.11%	44.73%	35.09%	24.59%	24.02%	26.16%
High - High	7.98%	10.23%	6.96%	21.18%	24.66%	17.78%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table 8. Risk Matrix (see Section 2.3) of whole sample, high-capitalized-, and low-capitalized insurers (left to right) (Mastrogiacomo & van der Molen, 2015) (Mercurius data)

	Share of Arrears / Default (Whole Sample - HC - LC)			Interest Rate (Whole Sample - HC - LC)			NHG Coverage (Whole Sample - HC - LC)		
Low - Low	0.72%	0.66%	0.46%	3.48%	3.47%	3.50%	38.14%	23.52%	30.98%
Low - High	1.03%	1.07%	1.53%	3.56%	3.60%	3.54%	11.79%	4.28%	4.28%
High - Low	3.17%	2.98%	3.13%	3.75%	3.57%	3.95%	46.13%	30.01%	43.63%
High - High	3.79%	4.16%	3.76%	3.86%	3.73%	4.02%	23.05%	7.63%	7.63%
Average	**2.06%**	**2.09%**	**1.61%**	**3.65%**	**3.59%**	**3.73%**	**29.34%**	**16.14%**	**21.26%**

Table 9. Risk Matrix (see Section 2.3) of whole sample, high-capitalized-, and low-capitalized insurers (left to right) (Mastrogiacomo & van der Molen, 2015) (Mercurius data)

6.3 Analysis

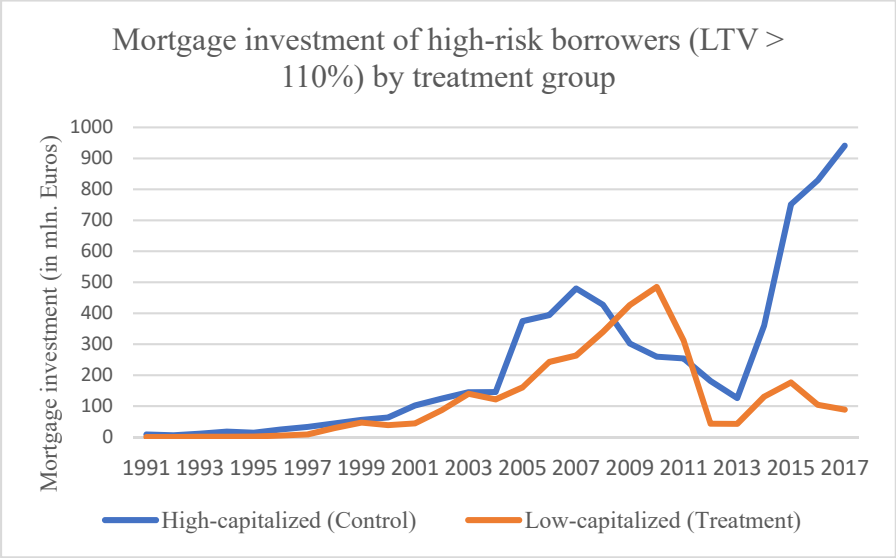

Figure 14. Mortgage investment of high-risk borrowers (LTV >110%) by treatment & control group of insurers (Mercurius data)

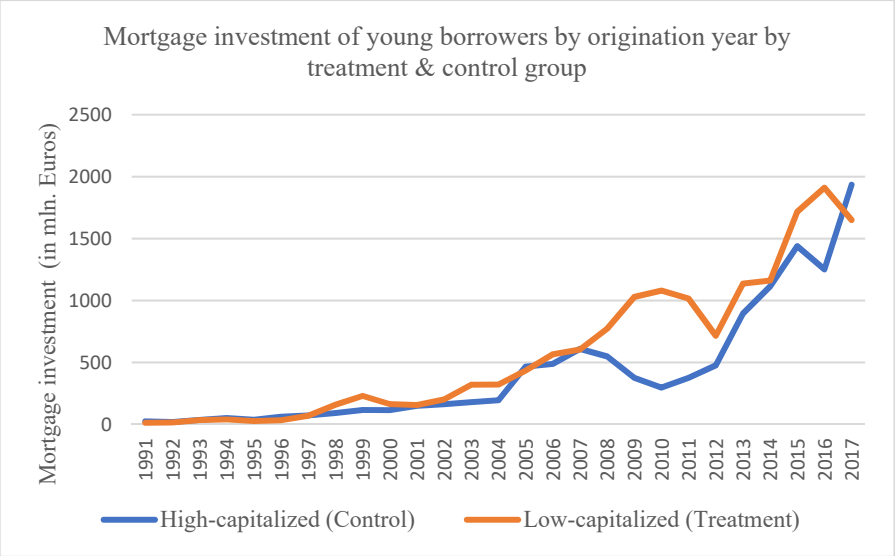

Figure 15. Mortgage investment of young borrowers by treatment & control group between 1990 and 2017

Later on, results suggested that we should check for the individual years prior to the announced years of implementation. Thus, we have added the following two models:

$$Debt_{i,t} = \beta_0 + \gamma LC_i + \delta FRE_t^{2013} + \theta CE_{i,t}^{2013} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \qquad (3.1)$$

$$Debt_{i,t} = \beta_0 + \gamma LC_i + \delta FRE_t^{2015} + \theta CE_{i,t}^{2015} + \beta_1 X_{i,t} + \beta_2 \varepsilon_{i,t} \qquad (3.2)$$

	Dependent variable: Mortgage investment				
	(2), FE	(3), FE	(4), FE	(3.1), FE	(3.2), FE
Low-capitalized (LC)	omitted	omitted	omitted	omitted	omited
Crisis, Regulatory Framework Effect (FRE)	11.63*** (3.52)	26.28*** (4.40)	n.a	n.a	25.79*** (6.54)
Interaction effect (LC*FRE) (CE)	23.90*** (3.84)	n.a	n.a	25.45*** (7.37)	12.39** (4.67)

Table 10. Coefficient Table main effects (fixed effects panel data analysis)

	Dependent variable: Mortgage investment (log)		
	(6)	(7)	(8)
Low-capitalized (LC)	1.80*** (0.20)	1.58*** (0.17)	1.42*** (0.16)
Crisis, Regulatory Framework Effect (FRE)	n.a	n.a	

			-0.71** (0.32)
Interaction effect (LC*FRE) (CE)	-0.70** (0.27)	n.a	n.a
FICO-bank (FB)	3.23*** (0.21)	2.86*** (0.17)	3.19***. (0.15)
Interaction effect (LC*FB)	-1.86*** (0.26)	-1.26*** (0.21)	-1.13*** (0.19)
Interaction effect (FRE*FB)	n.a	1.78*** (0.28)	0.94** (0.38)
Interaction effect (LC*FRE*FB) (Triple-difference)	1.29*** (0.35)	1.48** (0.62)	n.a

Table 11. Coefficient Table main effect of FICO insurers (natural log of dependent variable)

	Dependent variable: Mortgage investment by risk categories				
	Debt LTV >100	Debt LTV >110	Debt Young	Debt Old	Debt Interest-Only
Interaction effect low-capitalized / crisis	0.47* (0.24)	n.a	n.a	n.a	0.41* (0.22)
Interaction effect low-capitalized / anticipation	-0.59** (0.28)	-1.62*** (0.41)	-0.64** (0.28)	-0.43* (0.26)	-1.07*** (0.27)
Interaction effect low-capitalized / Solvency II	n.a	-1.22** (.56)	n.a	0.66* (0.34)	n.a

Table 12. Coefficient Table main effects of different risk-models (log) (riskiness of dependent variable)

	Dependent variables: Mortgage investment (variations made to risk category, identification assumption, and model)						
	(5)	OLS Debt LTV >100	Fixed Effects (FE) Debt	FE Debt LTV >100	FE Debt (LC<1.65)	FE Debt LTV>100 (LC<1.65)	(9)
CE / TD - crisis	27.62***	7.09***	31.80***	6.71***	40.47***	9.76***	54.29***
CE / TD - anticipation	-20.68***	-6.11**	-14.27**	-7.91***	-30.89***	-14.39***	13.88**
CE / TD - Solvency II	n.a	-13.93***	n.a	-13.77***	n.a	-8.15***	-25.38**
Age of borrower at origination	-.37*	n.a	-1.22***	-0.40***	-1.23***	-0.41***	n.a
Income of borrower	0.10***	0.04***	0.06**	0.03***	0.08***	0.03**	n.a
Top 0.6% income dummy (>210k)	-107.53**	-30.75***	-71.66**	-24.67**	-75.56**	n.a	-130.21***
Original LTV	0.35***	0.18***	-0.14*	-0.09***	-0.15*	-0.09***	0.62***
Value of mortgage	n.a	n.a	n.a	n.a	n.a	n.a	0.01***
Dummy underwater mortgage	33.51***	/	n.a	/	n.a	/	93.61***
Dummy for LTI >5	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Interest rate	n.a	n.a	n.a	1.36***	n.a	1.27**	n.a
Dummy for NHG	11.79**	4.94***	10.22**	4.61***	9.20**	4.61***	27.06***

Share of Arrears, default, and foreclosures	-977.32***	-333.10***	n.a	n.a	n.a	n.a	-1297.8***
Dummy for property in metropole	n.a	n.a	n.a	-8.07**	n.a	-8.16**	n.a
Dummy Affiliation with a bank	27.06***	12.34***	omitted	omitted	omitted	omitted	/
Dummy for annuity	-37.84***	-10.43***	n.a	n.a	10.54*	n.a	-80.29***
Dummy for interest-only	-22.84***	-10.60***	n.a	n.a	n.a	-5.06**	-42.60***
Share of mortgage investment in portfolio	312.33***	76.45***	n.a	12.83*	n.a	n.a	339.26***
Total Assets	0.56***	0.21***	0.42***	0.19***	0.38***	0.19***	0.54***
GDP growth	4.89**	1.47**	4.82***	1.38**	4.82***	1.38**	5.84***
Inflation	-2.77***	-1.42***	-5.08***	-2.09***	-4.95***	-2.14***	11.01***
House price index	0.33***	0.10***	0.94***	0.36***	0.96***	-2.13***	n.a
R^2	57.20%	65.41%	39.16%	55.10%	56.10%	53.42%	57.00%

Table 13. The causal effect of the crisis, anticipation of Solvency II, and Solvency II on mortgage investment and high-risk mortgage investment[17]

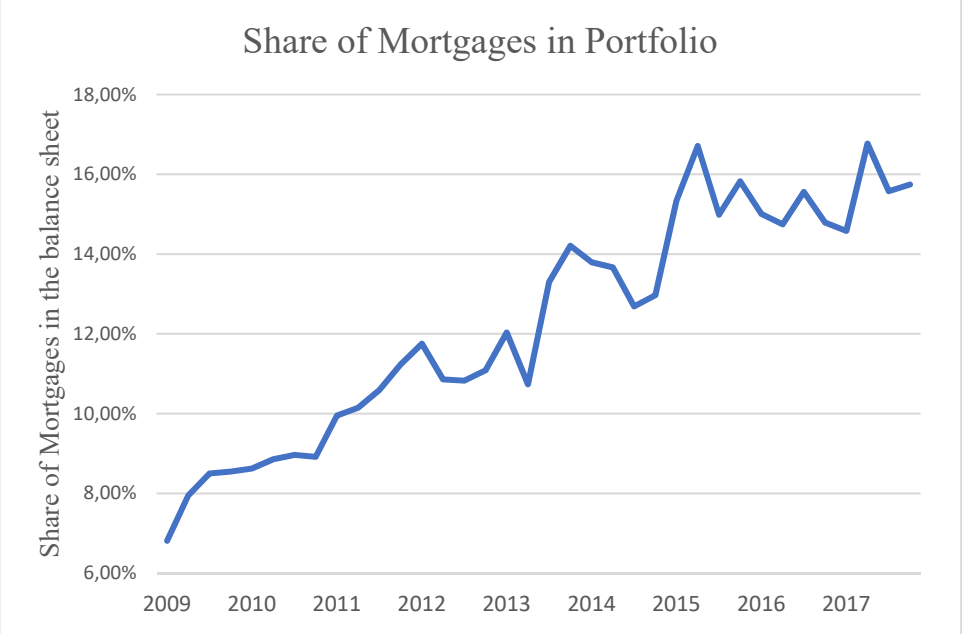

Figure 16. Share of mortgages on the insurers' balance sheet, proof of portfolio reallocation

[17] Coloumn 5 & 6 test our identification assumption by assuming different cutoff points of the SCR value (LC = low-capitalized).