BASEL IV AND ITS IMPACT ON SWEDISH BANKS - FOCUS ON RESIDENTIAL MORTGAGE LOANS

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Jacintha De Vos

Dutch Summary

De globale financiële crisis van 2008 heeft internationale financiële regulering op het voorplan van de hervormingsagenda geplaatst. Het Bazelcomité stelde verstrengde internationale financiële regulering op. Eerst werd Bazel III gepubliceerd met als hoofddoel het internationaal financieel systeem beter te beschermen. Na Bazel III werd in november 2017 Bazel IV gepubliceerd. Bazel IV heeft als hoofddoel om de geloofwaardigheid van kapitaalratio's te vergroten en om deze ratio's ook meer vergelijkbaar te maken tussen banken van verschillende landen. Deze thesis focust op de Bazel IV-veranderingen in kredietrisico aangezien dit risico het meest risico gewogen activa met zich meebrengt. De grootste verandering van Bazel IV is de implementatie van een 72,5% kapitaalvloer. Met als gevolg dat Zweedse banken vanaf 2027 nog altijd hun eigen risico's mogen berekenen, maar de uitkomst daarvan mag nooit lager zijn dan 72,5 percent van de kapitaalsvereisten volgens de standaardbenadering. Aangezien Zweedse banken veel hypotheekleningen hebben op hun balans en de rating vaak intern gebeurd, wordt er verwacht dat Zweedse banken de impact van de Bazel IV-regulering zullen voelen.

Daarnaast is Zweden getekend door de vastgoedcrisis van de jaren '90. Deze heeft ervoor gezorgd dat regulering in Zweden strenger is in vergelijking met andere Europese landen. Met als gevolg dat er nu in Zweden extra kapitaalbuffers zijn voor de drie grootste banken. Deze werden ingevoerd omdat Zweden vond dat de banken te veel risico's namen met hypotheekleningen en omdat er de kans bestaat dat zich momenteel een huis bubbel aan het opbouwen is in Zweden. De Zweedse financiële autoriteit heeft publiek gemaakt dat ze de kapitaalbuffers zullen verlagen wanneer de Bazel IV-kapitaalvloer wordt geïmplementeerd. Wat niemand echter weet is met hoeveel de kapitaalbuffers verlaagd zullen worden. Met als gevolg dat het allemaal zeer voorbarig is om uitspraken te doen over hoe Bazel IV Zweedse banken zal beïnvloeden. Wat wel vaststaat is dat de risico gewogen assets zullen stijgen in Zweden maar wat er met het kapitaal van de banken gaat gebeuren zullen we moeten afwachten.

Preface

This master's dissertation is the summit of my studies in Finance and Risk at the University of Ghent. As I was thinking about different topics for a dissertation, I already knew that I wanted to explore the impact of regulation on the banking industry. More specifically, I wanted to research the impact of Basel regulation on banks. This is because during my internship at Unicredit in Balance Sheet and Capital Management, I noticed how big the impact is of Basel regulation on the daily operations of banks. This is a very accurate matter, and I hope that I can contribute new insights with my dissertation concerning this topic.

I am very grateful to my supervisor, Professor Van Cauter. Without his guidance and support, I would not have achieved the result that I have reached today. He always made time for me to review previous versions and gave me that extra push that I needed. I would also like to thank Dr. Michael Teig, credit analyst at Unicredit. He made time for me during my six months internship at Unicredit to discuss possible dissertation topics. He also provided me some papers concerning the impact of Basel IV on Nordic banks that I otherwise would not have been able to access. I would also like to thank Dr. Jonas Niemeyer from Riksbank for giving me insight information in the Swedish banking system and discussing the main findings of my dissertation.

Furthermore, I would like to thank Richard Volwahsen and Eline Minjauw for their comments on earlier versions of this work. Finally, I also want to thank my parents. Even though they were not directly involved in my dissertation, they were always there for me during my studies. They gave me the chance to go to university and taught me to persist in order to achieve the goals that I set for myself.

Jacintha De Vos

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List of used abbreviations

AT1	Additional Tier 1
BCBS	Basel Committee of Banking Supervision
CDO	Collateralized debt obligation
CET1	Common Equity Tier 1
CPI	Consumer Price Index
CRD	Capital Requirements Directives
CRR	Capital Requirement Regulation
CVA	Credit Valuation Adjustment
DSTI	Debt service-to-income
DTI	Debt-to-income
EAD	Exposure at default
EBA	European Banking Authority
ECB	European Central Bank
ESRB	European Systemic Risk Board
EU	European Union
FI	Finansinspektionen
FSA	Financial Supervisory Authority
GDP	Gross Domestic Product
G-SIB	Global systemically important bank
IMF	International Monetary Fund
IRB	Internal ratings-based
LGD	Loss given default
LTD ratio	Loan-to-deposit ratio
LTI	Loan-to-income
LTV	Loan-to-value
MBS	Mortgage-backed security
NSFR	Net Stable Funding Ratio
OECD	Organisation for Economic Co-operation and Development
PD	Probability of default
pp	percentage points
REA	Risk Exposure Amount
RRE	Residential Real Estate
RW	Risk-weight
RWAs	Risk-weighted assets
SA	Standardised Approach

SEB	Skandinaviska Enskilda Banken
SEK	Swedish Krona
SHB	Svenska Handelsbanken AB
SME	Small and medium-sized enterprise
T2	Tier 2
US	United States

List of figures and tables

1. Introduction

Boom-bust cycles in the real estate market have been a major contributor to systemic financial crises in the past (ECB, 2015). Therefore, it is essential that the real estate market receives a lot of attention from macroprudential policymakers. Macroprudential policymakers have two main objectives: to actively limit the build-up of systemic financial risks and to strengthen the financial system in general (Gadanez & Jayaram, 2015). One of these macroprudential policymakers is the Basel Committee on Banking Supervision (BCBS) (BIS, 2010). On December the 7th of 2017, the BCBS issued the final version of the Basel III capital accord (BIS, 2017b). In the banking world, these reforms are generally referred to as Basel IV (McKinsey, 2017). Basel IV seeks to strengthen credibility[1] of risk-weighted assets (RWAs)[2] calculation and to improve comparability of banks' capital ratios (BIS, 2017b). More specifically, it addresses the issue of banks using very low risk-weights (RWs) for residential mortgage loans because they are allowed to calculate these with the internal ratings-based (IRB)[3] approach (BIS, 2017b). For banks, it is better to use the IRB approach to calculate RWAs of their mortgage loans. This is because RWs are generally lower when they are calculated with the IRB method instead of using the RWs of the standardised approach (ESRB, 2018). Basel IV will be gradually implemented starting from January 2022 (EC, 2017b).

There are two main reasons why Sweden is such an interesting country to analyse. First of all, Sweden was in the 1990s hit by a severe real estate crisis (Englund, 1999). This crisis made Swedish banking regulation more stringent compared to the rest of Europe (Erlandsen & Lundsgaard, 2007). Secondly, even though Swedish banking regulation was so strict, Sweden still received a warning from the European Systemic Risk Board (ESRB) for medium-term residential real estate (RRE) vulnerabilities in 2016 (ESRB, 2016d). Moreover, the RRE vulnerabilities that caused the warning in 2016 are still the vulnerabilities of today in Sweden.

The applied methodology involves a broad literature review on the connection between the real estate and financial sector, mortgage loans, Basel IV and its impact on Swedish banks. The literature review shows that Swedish banks with high exposure to low-risk weights will be

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[1] BIS (2017a) found an unacceptably wide variation in RWAs across European banks, which is mainly caused by the excessive use of the IRB approach to calculate the RWAs. This variation makes it difficult to compare capital ratios across banks and undermine the confidence in banks' capital ratios (BIS, 2017a).

[2] Risk-weighted assets are calculated as followed: $RWA = \sum RW_j \times A_j$ where j is an asset (ESRB, 2018). There are two options to set RW: Standardised Approach (SA) or the Internal Rating Based (IRB) (ESRB, 2018).

[3] With the IRB approach banks calculate the required amount of RWAs with their estimations of the probability of default (PD), loss given default (LGD), exposure at default (EAD) and maturity of the exposure (BIS, 2017b).

significantly affected by Basel IV for two reasons (Mckinsey, 2017; Unicredit, 2018). First of all, their amount of RWAs for credit risk will increase noticeably (Unicredit, 2018). This is mainly due to the fact that many Swedish banks are heavy users of the internal model to calculate the required amount of RWAs (IMF, 2016). Secondly, Swedish financial institutions tend to hold a larger proportion of traditionally low-risk assets, such as mortgage loans on their balance sheet (ESRB, 2016e). As a result, Swedish banks will need to considerably increase their amount of RWAs for RRE mortgage loans. As a consequence, these banks will need a higher amount of equity for a given amount of debt in the future to comply with the Basel regulation (Riksbank, 2017). Subsequently, their profitability will decrease. This leads to the main research question of this dissertation: "How will Basel IV changes in credit risk RWAs calculation impact Swedish banks and their RRE mortgage lending?". The empirical case study only focusses on the impact on Swedish banks' profitability and RRE mortgage lending.

This dissertation is structured into four chapters. The first chapter contains the introduction. This is followed by an extensive literature review in the second chapter, which is divided into five subsections. The first subsection explains why residential real estate[4] is important for financial stability and the real economy. The next subsection discusses past financial crises that have been caused by RRE. In this part, there is extra attention to the Swedish crisis of the 1990s. The third subsection of the literature review discusses macroprudential measures. More specifically, it explains Basel IV and what is expected from banks. The fourth subsection goes deeper into how much Swedish banks are already prepared for the Basel IV regulation. This subsection is divided into two parts: the already taken macroprudential measures in Sweden and three case studies of the biggest Swedish banks. Currently, the three biggest Swedish banks are Skandinaviska Enskilda Banken (SEB), Svenska Handelsbanken AB (SHB) and Swedbank (FI, 2018c). The case studies describe how vulnerable these three banks are to the implementation of Basel IV. Finally, there are three possible solutions provided for how Swedish banks could react to the adjusted Basel framework. First of all, banks could focus on lower loan-to-value (LTV) segments. Secondly, they could increase their mortgage loan rates to offset lower future profitability. Finally, Swedish banks could also change their funding structure. The third chapter of this dissertation contains an empirical case study. This empirical case study focusses on the impact of increased RWAs on Swedish banks' profitability and how they could possibly offset this loss. As a result, this part continues with the one of the three solutions that were described in the second section. Namely, it looks whether there was a correlation between the average Swedish mortgage loan rate and

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[4] In literature, there is a distinction between commercial and residential real estate mortgage loans. This dissertation only considers residential real estate mortgage loans. Residential real estate mortgage loans are the real estate loans that are used to finance your own property (BIS, 2012).

the RWAs of Swedish banks in the past. The fourth and last chapter aims to summarise the main findings and gives a future outlook for the Swedish banks.

2. Literature review

2.1. Importance of RRE for financial stability and real economy

This part of the dissertation contains an overview of the connection between RRE, the financial system and the real economy. ESRB (2016d) found three main reasons why developments in RRE sector can have significant implications on both financial stability and real economy. First of all, RRE is a major part of households' wealth (ESRB, 2016c). More specifically, it is the largest and most common form of households' debt. The second reason is that RRE constitutes a major source of collateral for lenders (ESRB, 2016c). Consequently, collateral is often a large part of banks' balance sheets. The third reason is housing construction, which is a typical component of the real economy (ESRB, 2016c). It is a source of employment, investment, and growth.

Those three aforementioned reasons cause that RRE mortgage loans are a big source of systemic risks (NBB, 2018; ESRB, 2016e). A systemic risk in the financial system is a threat that can cause a seizing-up or breakdown of this system. Moreover, it can trigger large damages to the real economy (ECB, 2009). In the past, systemic risks related to RRE already caused domestic financial instability in some countries, such as Sweden during the 1990s real estate crisis (ESRB, 2016e). It also had negative consequences for the real economy (ESRB, 2016e). Additionally, systemic risks can lead to negative spillovers to other countries (ESRB, 2016e).

Vulnerabilities in RRE can have direct effects, for example through losses of capital or funding among lenders (ESRB, 2016e). It can also have indirect effects through a lower economic output, which may have second-round effects on the financial system (ESRB, 2016e). The underlying source of those RRE vulnerabilities can differ. Often, they emerge from domestic structural features, from cyclical developments, from social and economic policies or a combination of all the aforementioned factors (ESRB, 2016e).

To conclude, RRE is very important for financial and macroeconomic stability (ESRB, 2016e). That is why it is very important for macroprudential policymakers to analyse the RRE vulnerabilities. In Europe, this is the key responsibility of the ESRB (ESRB, 2016e). In November 2016, the ESRB issued public warnings to 8 countries[5] (including Sweden) with medium-term RRE vulnerabilities (ESRB,2016c). The RRE vulnerabilities and trends that were identified with those 8 countries had the potential to disrupt financial stability over a period of five years (ESRB, 2016d). That is why the RRE vulnerabilities were called medium-term RRE vulnerabilities. This

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[5] The eight warnings for medium-term vulnerabilities in the residential real estate sector were addressed to: Austria, Belgium, Denmark, Finland, Luxembourg, the Netherlands, Sweden and the United Kingdom (ESRB, 2018b).

does not mean that policy measures should not be taken immediately (ESRB, 2016d). This is because macroprudential measures tend to be more effective when they are introduced in a timely matter (ESRB, 2016d). That is why the ESRB issued warnings to eight countries with medium-term vulnerabilities in 2016 (ESRB, 2016e). How the ESRB identifies the RRE vulnerabilities will be discussed in 2.1.1. Afterwards, the current Swedish RRE vulnerabilities will be reviewed.

2.1.1. How does the ESRB identify RRE vulnerabilities?

The ESRB is an independent European body, which was established on the 16th of December 2010 in response to the most recent global financial crisis. The main objective of this institution is to keep macroprudential oversight of the European Union (EU) in order to prevent and mitigate systemic risks. The ESRB developed together with the European Central Bank (ECB) a framework to analyse RRE vulnerabilities (ESRB, 2016e). This framework takes into account the levels of and dynamics in RRE prices, as well as vulnerabilities related to lenders and borrowers (ESRB, 2016e). This analytical framework developed by the ECB and ESRB distinguishes between collateral, household and banking stretches (ESRB, 2016e). These three stretches comprise vulnerabilities that are identified with a number of indicators.

The "collateral stretch" consists of vulnerabilities relating to property markets, especially in relation to a sudden reversal in RRE price growth (ESRB, 2016e). Whilst, "income stretch" covers vulnerabilities related to borrowers' indebtedness and the ability to service and repay a debt (ESRB, 2016e). In addition, this stretch covers the borrowers' ability to maintain their consumption pattern (ESRB, 2016e). This is included because a reduced consumption pattern could have negative feedback effects on housing demand and prices, as well as on the economy in general (ESRB, 2016e). Eventually, this could lead to potential negative effects on financial stability (ESRB, 2016e). The final stretch, "banking stretch", comprises vulnerabilities related to direct losses by banks or bank losses of funding due to their RRE exposures (ESRB, 2016e). The overlap between different stretches are amplifiers of RRE vulnerabilities (ESRB, 2016e).

For all three stretches, a number of indicators are identified as shown in Figure 1. The indicators of the "income stretch" have to assess the soundness of household balance sheets (ESRB, 2018). These indicators are loan-to-income (LTI), debt service-to-income (DSTI)[6] and debt-to-income (DTI)[7] limits as well as amortisation requirements (ESRB, 2015). The "collateral stretch" indicators are: LTV limits and amortisation requirements (ESRB, 2015). LTV ratio is the ratio of housing loan

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[6] DSTI ratio gives a broader indication of affordability, by relating debt service payments (i.e. capital repayments and interest) to disposable income (Belgian Financial Forum, 2018).

[7] DTI is a ratio that compares an individual's monthly debt payment to their monthly gross income (Investopedia, 2019a).

to the value of the real estate that was pledged as collateral (ESRB, 2016a). Amortisation is used as an indicator of both "income" and "collateral" stretch. This is because it affects the repayment burden (thus related to income) and also brings down the LTV over time (thus related to collateral). The "collateral stretch" indicators are there to detect unsustainable price developments and potential price misalignment (ESRB, 2018). Indicators of the "banking stretch" have to detect unsustainable developments in lending (ESRB, 2018). These comprise sector-specific capital-based requirements such as increasing risk weights or underlying parameters for real estate-related exposures (ESRB, 2015). Based on the indicators mentioned above, the ERSB (2016d) analyses RRE vulnerabilities across EU countries.

Figure 1: Instruments by stretches related to residential real estate lending
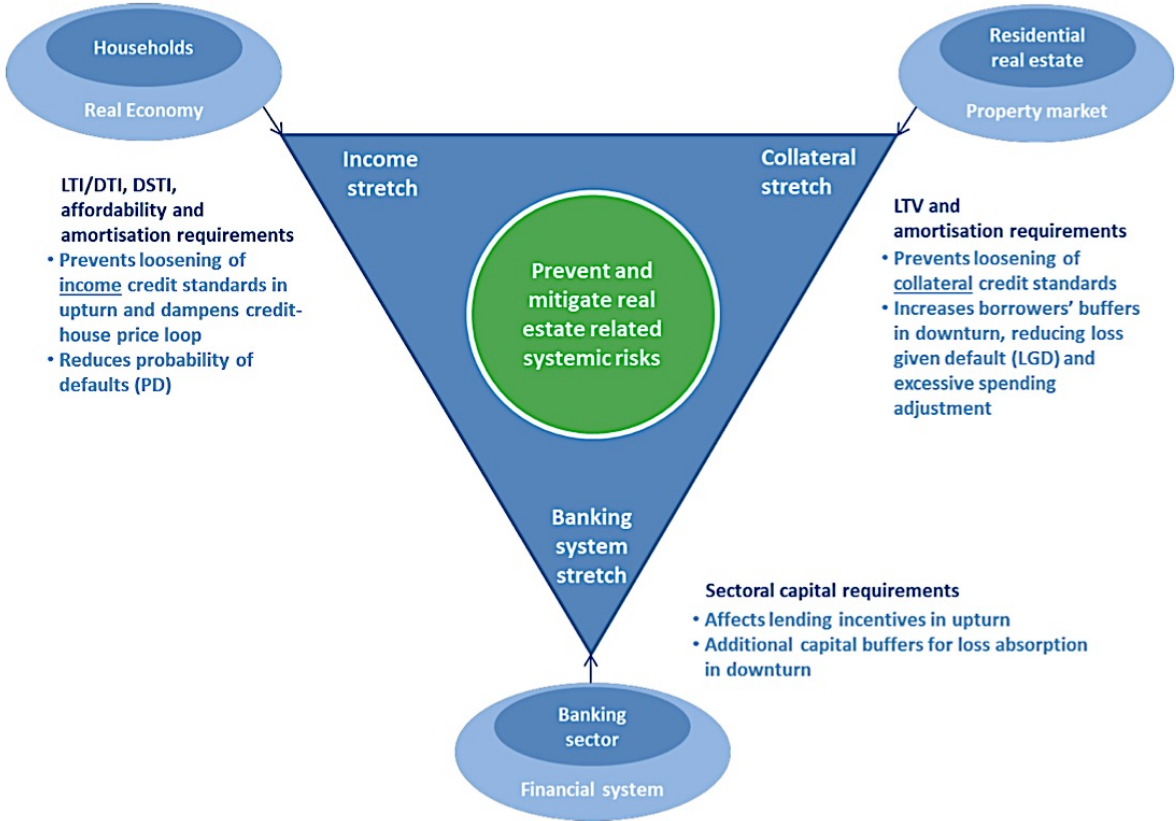
Source: ESRB (2015)

After this assessment, the ESRB can issue warnings or recommendations. Both warnings and recommendations can be addressed to the EU as a whole or to sole member states (ESRB, 2019c). A warning is issued when the ESRB identifies significant systemic risk and when it is necessary to mark the risks (ESRB, 2019c). When a warning is issued, the ESRB can also issue recommendations for remedial action (ESRB, 2019b). The ESRB decides, on a case-by-case basis, whether or not the warning and the eventual recommendation are made public (ESRB,

2019b; 2019c). Since the ESRB has no legal powers to impose its will on others, its warnings and recommendations are not binding (Ferran & Alexander, 2010).

On the 22nd September 2016, the ESRB decided to issue warnings to eight member states (including Sweden) and to make these warnings public (ESRB, 2016d; 2016b). The main RRE vulnerabilities that the ESRB found with these eight countries are of a medium-term nature. They mainly relate to increasing indebtedness and the ability of households to repay their mortgage debt or to the valuation or price dynamics of RRE (ESRB, 2016c). The current Swedish RRE vulnerabilities are discussed in the following part.

2.1.2. Swedish RRE vulnerabilities

This dissertation researches the influence of Basel IV on Swedish banks specifically. Therefore, it is important to know what the current Swedish RRE vulnerabilities are. As mentioned in 2.1.1 Sweden received in 2016 a warning for medium-term RRE vulnerabilities from the ESRB (ESRB, 2016d). There were six medium-term RRE vulnerabilities why Sweden received this warning (ESRB, 2016d). The six Swedish RRE vulnerabilities were: low-interest rate environment, increased RRE prices, rising household debt levels, structural factors controlled by government, risk of reverse economic situation and interconnectedness between Nordic banks. Of these six Swedish RRE vulnerabilities of 2016, five are still valid today. In the following part the RRE vulnerabilities of Sweden will be discussed.

The first RRE vulnerability of 2016 and today is the low-interest rate environment in Europe and Sweden (FI, 2018c). According to FI[8] (2018c) there are two significant risks related to the current low-interest rate environment in Sweden. Firstly, this low-interest rate environment in Sweden has created a breeding ground for debt and risk-taking. This is mainly due to the fact that it is difficult for savers and investors to get a return on traditionally secure investments, such as savings, when interest rates are low (FI, 2018c). Figure 2 represents how the policy rates of different geographical areas are expected to develop over the next years. On the X-axis years from 2010 until 2020 are shown. While the Y-axis shows the interest rates in percentage. As shown in Figure 2 the FI expects that monetary policy will return to normal. As a result, this could lead to a swing to risk aversion in Sweden. This would result in falling asset prices both in Sweden and the rest of the world (FI, 2018c). As a result, the current house bubble could burst in Sweden. Secondly, a lot of Swedish households have a mortgage loan with a variable interest rate (FI, 2018c). This together with the rising Swedish household debts, makes Swedes very sensitive to

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[8] Finansinspektionen (FI) is the Swedish financial supervisory authority. This institution aims to ensure that the Swedish financial system is sufficiently resilient to function even in the presence of shocks to the financial markets or the economy in general (FI, 2018c).

a possible increase of the interest rates. This could have second-round effects on Swedish household consumption, investments and saving.

Figure 2: Policy rates are expected to increase slowly (in %)
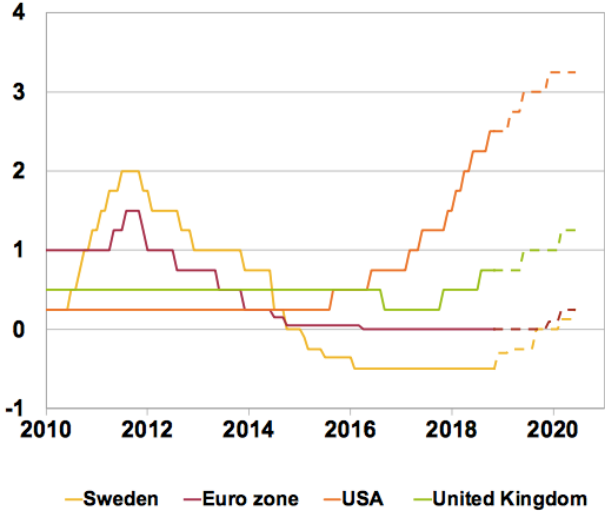
Source: FI (2018c)

Secondly, the increased Swedish RRE prices as current RRE vulnerability will be discussed. Even though house prices declined a bit since their peak of August 2017, the RRE price level is still too high in Sweden as shown in Figure 3. Figure 3 shows how the house price index developed since 2013 until 2019 in Sweden. RRE prices in Sweden have increased substantially in the last decade (ESRB, 2016d; ESRB, 2016c). It increased even so much, that Swedish RRE prices appear to be overvalued based on estimates by the ECB and the International Monetary Fund (IMF) (ESRB, 2016d).

Figure 3: Swedish house prices (Index, 2010=100)
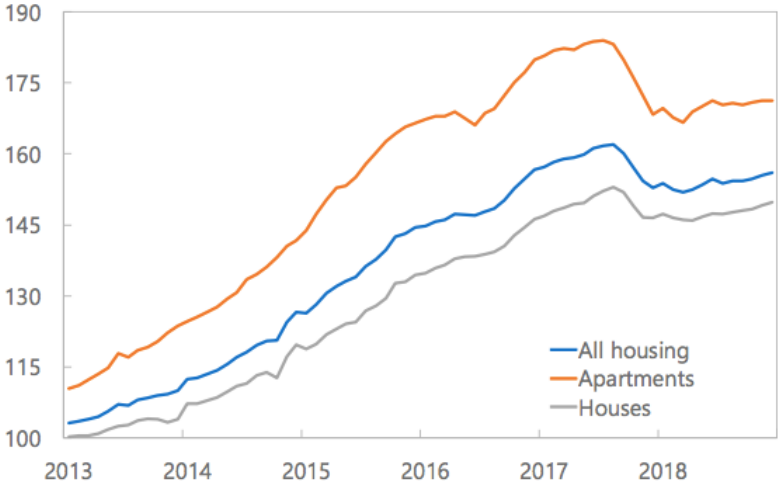
Source: IMF (2019)

As shown in Figure 3, the house price index in Sweden increased around 50 since 2013. Moreover, in recent years RRE prices have been increasing at a faster pace than the household income (ESRB, 2016d; ESRB, 2016c). These house price developments are due to several factors but are mainly caused by the imbalance between supply and demand for housing in Sweden (Riksbank, 2018). The housing demand is continuously increasing because of the low mortgage interest rates that are caused by the low-interest rate environment (FI, 2018c). Additionally, in the last two years, there has been a large growth in population in Sweden, which contributed to the rising housing demand (Moore, 2018). On top of everything, there also is the urbanisation trend in Sweden (Moore, 2018). Consequently, of the 290 Swedish municipalities, more than 255 said there is a lack of housing in 2018 (Moore, 2018). Particularly in Stockholm, there is a big shortage of accommodation as it is one of Europe's fastest growing cities (Moore, 2018). This, whilst the supply cannot keep up with this rising demand. Even though residential construction rapidly increased since 2013 after several years of weak figures, growth decreased again from 2016 (Svenska Bankföreningen, 2018b). More precisely, the increase in housing starts was 6 percent in 2017 (Svenska Bankföreningen, 2018b). While in 2016 it was at 26 percent (Svenska Bankföreningen, 2018b). The explanation for the construction growth decrease since 2016, is that the number of building permits has dropped (Svenska Bankföreningen, 2018b).

The third Swedish RRE vulnerability of 2016 and today is the rising household debt levels, which are caused by the previously mentioned higher Swedish RRE prices. (ESRB, 2016d; Riksbank, 2018). In 2018, new Swedish households mortgage loans had an average DTI ratio of 290% (FI, 2018c). This was among the highest in the EU (ECB, 2018). Figure 4 shows how the DTI ratio division evolved between 2014 and 2018.

Figure 4: DTI ratios division in Sweden between 2014 and 2018
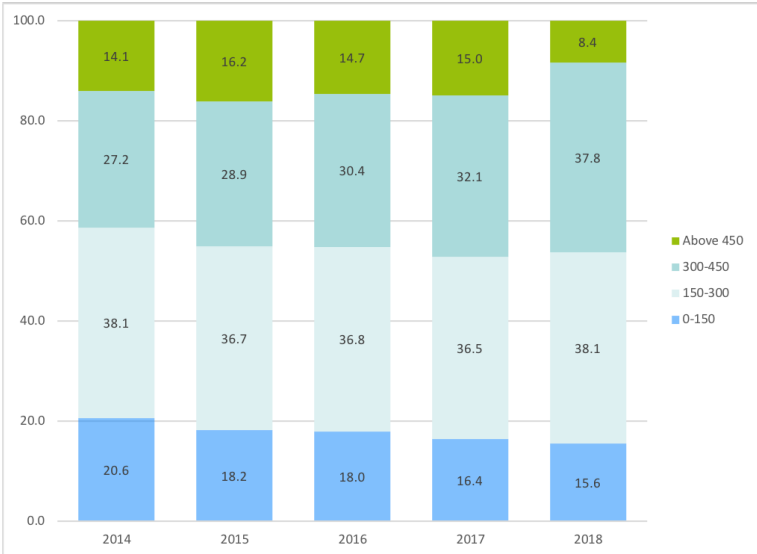
Source: FI (2018c)

Around 15 percent of the new loans in 2018 have a DTI ratio between 0 and 150 (Figure 4). As shown in Figure 4, 38.1% of the new Swedish loans had a DTI ratio between 150 and 300 at the end of 2018. The percentage of new loans with a DTI ratio between 300 and 450 increased with almost 6% since the end of 2017. Consequently, in 2018 37.8% of the new loans had a DTI ratio between 300 and 450 in Sweden. However, the new loans with a DTI ratio above 450 reduced a lot in the last year. The ratio came from 15% in 2017 and reduced to 8.4% in 2018. According to FI (2018c), high household debt could mean risks for individual households, banks, financial stability and macroeconomic development. That is why the FI has implemented a number of measures to increase the resilience of Swedish households (FI, 2018c). For example, as of March 2018 FI introduced stricter amortisation requirements (FI, 2018c). As shown in Figure 4, these macroprudential measures payed-off, because there are significantly less new loans with a DTI ratio above 450 at the end of 2018.

The fourth Swedish RRE vulnerability of 2016 and today are structural factors that are under control of the Swedish government that contribute to the build-up of RRE vulnerabilities (ESRB, 2016d). One of those structural factors is the tax benefit for homeowners in Sweden (ESRB, 2016d). Currently, the Swedish tax system allows inhabitants to recover 30% of their mortgage interest when it is below the amount of Swedish Krona (SEK) 100,000 (approximately 10,500 EUR) in their tax declaration (EC, 2017c). For amounts that are higher than this limit, Swedes can deduct 21% of their mortgage interest in their taxes (EC, 2017c). With this amount, mortgage interest deductibility in Sweden is one of the most generous ones in Europe (EC, 2017c). Moreover, Sweden is together with Denmark, one of the few EU countries that do not have a ceiling to the total amount of interest deduction (EC, 2017c). Additionally, there are no conditions for a mortgage loan to qualify for this tax deduction in Sweden (EC, 2017c). In case of structural factors that are under control of the Swedish government, macroprudential policy measures should be taken to enhance the resilience of the financial system and the households' balance sheet (ESRB, 2016d).

The fifth Swedish RRE vulnerability of 2016 is that when an adverse economic scenario would materialise, it would have negative effects on the households' incomes. It would further enhance the negative direct and indirect effects on the Swedish financial stability (ESRB, 2016d). However, this is not a vulnerability of today, the European Banking Authority (EBA) developed stress tests to assess the resilience of EU banks to a common set of adverse economic developments to be able to identify potential risks (EBA, 2018). In Sweden, the 2018 EBA stress test was done in SEB, Handelsbanken and Swedbank (EBA, 2018). Out of the 2018 EBA stress tests in Sweden followed that Swedish banks are resilient and that they do have the ability to withstand a sharp deterioration in the market (FI, 2018b). This result is in contrast with the conclusion of the ESRB

in 2016. The discrepancy between these two results can be due to the fact that the ESRB results were based on 2016 numbers, while the EBA stress tests were based on 2017 and 2018 numbers.

The last Swedish RRE vulnerability of 2016 and today is the significant interconnectedness between Nordic banks (ESRB, 2016d). This is driven by the close relationship between Nordic countries in the real economy and trade as well as cross-border operations (Unicredit, 2018). This interconnectedness means that there could be significant cross-border spill-overs between the Nordic banking systems as a result of vulnerabilities related to RRE (ESRB, 2016d). This interconnectedness became even bigger when Nordea moved his headquarters from Stockholm to Helsinki in 2018 (FI, 2018c). This is because even though Nordea moved his headquarter to Helsinki, it still plays a major role in the Swedish financial system (FI, 2018c).

To conclude, in 2016 the ESRB (2016d) found six medium-term RRE vulnerabilities as a source of systemic risks to the Swedish financial stability, of which five are still valid today. The six Swedish RRE vulnerabilities in 2016 were: low-interest rate environment, increased RRE prices, rising household debt levels, structural factors under control of the Swedish government, risk of reverse economic situation and interconnectedness between Nordic banks. The one Swedish RRE vulnerability that is not valid today is the risk of reverse economic situation (EBA, 2018). According to EBA (2018), Swedish banks are resilient and have the ability to withstand a sharp deterioration in the market. Additionally, since 2016 some of these RRE vulnerabilities improved such as the RRE prices and the household debt. However, the levels are still too high. That is why they are still RRE vulnerabilities of Sweden today. These remaining vulnerabilities may have the potential for serious negative consequences for the real economy (ESRB, 2016d).

2.1.3. Non-RRE vulnerabilities in Sweden

In the previous part, the current RRE vulnerabilities in Sweden were discussed. The following part of the dissertation goes deeper into some non-RRE vulnerabilities of Sweden today. Currently, the biggest non-RRE vulnerability in Sweden is that many banks are heavy users of the IRB approach to calculate the required amount of RWAs (IMF, 2016). This excessive usage of the IRB model together with the increase of RRE prices as mentioned before, caused a decrease of the RWAs of the major Swedish bank from 2011 as shown in Figure 5. For banks, it is very important to keep their risk-weighted assets as low as possible. This is because RWAs are used to determine the bank's capital requirements (Riksbank, 2017). Since low risk-weighted assets give a lower capital requirement and vice versa. It gives banks a considerable incentive to reduce their amount of RWAs (Riksbank, 2017). This is what happened in Sweden as shown in Figure 5.

Figure 5: Major Swedish banks' RWAs and total assets from 2011 (SEK billion)

Source: Riksbank (2017)
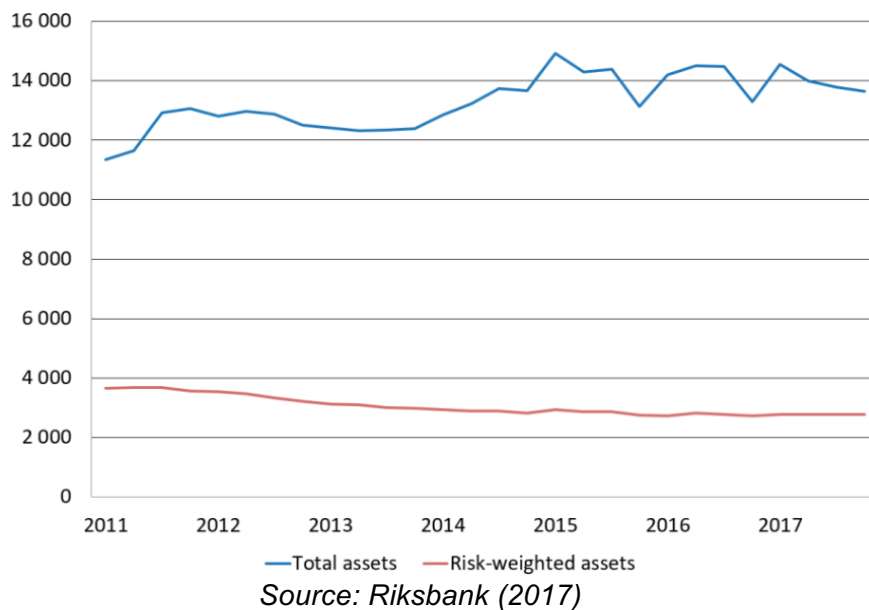
As a result, the low risk weights applied by Swedish banks are a non-RRE vulnerability today (Wyman, 2016). There are four features that cause these lower risk weights in Sweden (Wyman, 2016). Firstly, Swedish loans are known for their historically low default rates, in other words Swedish loans have a low probability of default (PD) (Wyman, 2016). Secondly, as mentioned before a higher proportion of assets is covered by the IRB approach in Sweden (Wyman, 2016). This is due to the early adoption of Basel II (Wyman, 2016). Thirdly, in Sweden it is easier than in other European countries to recover losses from loans in default (Wyman, 2016). As a result, Swedish loans have low loss given default (LGD) rates. This is because Sweden has a particular legal system, business environment and governance structure (Wyman, 2016). Finally, the Swedish banking system has relatively more exposure to corporates, SMEs and real estate (RRE loans), and less to specialised lending and securitisations (Wyman, 2016).

Another non-RRE related vulnerability that could form a threat to the financial stability in Sweden, is the lack of liquidity in Swedish banks (Riksbank, 2018). Riksbank (2018) finds it important that Swedish banks reduce their liquidity risk. This liquidity risk is in Sweden is caused by mismatches between the maturity of the banks' assets and maturities of banks' liabilities (Riksbank, 2016). This mismatch exists due to the composition of the banks' assets and liabilities (Riksbank, 2016). That is why the NSFR was introduced in January 2018. This ratio helps banks to maintain a stable funding profile in relation to the composition of their assets and off-balance sheet activities (BIS, 2014) The Swedish Net Stable Funding Ratio (NSFR) was 106 percent at the end of 2017 (Riksbank, 2018). This exceeds the 100 percent that is requested by the BCBS in the Basel III regulation.

The NSFR is calculated as followed (BIS, 2014):

$$\text{NSFR} = \frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}} > 100\%$$

The available amount of stable funding is the portion of capital and liabilities that is expected to be reliable over a time horizon of one year (BIS, 2014). The required amount of stable funding of a bank is a function of the liquidity characteristics and residual maturities of the different assets held by that bank as well as of its off-balance sheet exposures (BIS, 2014). Riksbank (2018) stated that the NSFR does not fully capture the large mismatch that exists in Sweden between banks' assets and liabilities. This is because the NFSR does not represent the difference in maturity for funding of more than one year (Riksbank, 2018). There are different reasons why the mismatch in maturity is so large for Swedish banks. On the assets side, Swedish banks have a larger share of loans than many other European banks (Riksbank, 2016). These loans often have long maturities for example RRE mortgage loans. As a result, it takes a long time before Swedish banks get their money back. On the liability side, Swedish banks have a comparatively small amount of deposits (Riksbank, 2016). Instead, they use wholesale funding, which has proved in earlier crises to be less stable than deposits (Riksbank, 2016). Wholesale funding is less stable because professional investors in bonds have proved to be less willing to continue lending money to banks in periods off stress (Riksbank, 2016). This where households keep their deposits on the bank because they are protected by a deposit guarantee. Because of this specific composition, major Swedish banks are exposed to greater structural risks than many other European banks, which is not fully reflected in the NSFR ratio (Riksbank, 2018). As a result, Riksbank (2018) asked Swedish banks to reinforce their liquidity reserves. This can be done by strengthening their liquidity buffers in currencies where they have low levels, and by limiting their maturity conversion to a greater extent (Riksbank, 2018). Additionally, the design of the Swedish banking system makes it extremely important to limit the banks' liquidity risks (Riksbank, 2016). This is because at the end of 2018, the size of Sweden's banking sector amounted to 300% of Sweden's gross domestic product (GDP) (Riksbank, 2018). As a result, it could lead to major costs for Swedish taxpayers when the banks suffer from a financial problem that requires support from the state (Riksbank, 2016).

The last non-RRE vulnerability in Sweden discussed in this dissertation is the concentration of the banking system (Riksbank, 2018). In 2018 the three major Swedish banks, Handelsbanken, SEB and Swedbank were responsible for 60% of the loans to the public in Sweden (FI, 2018c). Consequently, the competition is very high. This makes it very hard for one of those banks to increase mortgage loan rates. When one major bank would increase the Swedish mortgage loan

rate, they would lose all their borrowers to one of the other two Swedish banks. This is also one of the reasons why mortgage loan rates are so low in Sweden right now.

2.2. Financial crises relating to RRE

The first subsection of this dissertation explains the importance of RRE for financial stability and real economy. The following part covers financial crises that were caused by RRE vulnerabilities in the past. There only came so much attention to RRE vulnerabilities in the last years because it caused many financial crises in the past. These financial crises or banking crises were costly. Reinhart and Rogoff (2009) proved that a banking crisis costs on average in the three years after its occurrence 86% of the country's GDP. This is the reason why the ESRB was founded, to monitor the RRE vulnerabilities in Europe (ESRB, 2016e). This is how Europe tries to avoid a new financial disaster that could possibly affect the entire economy (ESRB, 2016e). This second subsection of the dissertation is divided into two parts. First of all, the Swedish crisis of the 1990s will be discussed. This crisis led to some regulatory changes in Sweden, which are mentioned in 2.1.1.1. After the Swedish crisis, this dissertation continuous with the most recent global financial crisis. Both crises that will be explained in this section are RRE related and caused regulatory changes in Sweden.

2.2.1. Swedish crisis 1990s

In the early 1990s, the Swedish economy was hit by a banking crisis that was mainly caused by a housing bubble (Englund, 1999; Kiander & Vartia, 2009). Ten years before this crisis started, in the early 1980s, it seemed like Sweden was immune to the economic issues where larger European countries were struggling with at that time (Kiander & Vartia, 2009). Sweden was known for low unemployment rates, advanced welfare and as a relatively rich country (Kiander & Vartia, 2009). Nevertheless, starting from 1985 the Swedish economy faced extensive institutional changes (Kiander & Vartia, 2009). The biggest change was the complete deregulation of the financial market (Andersson & Viotti, 1999). Free capital movements were introduced and it also meant the end of credit rationing and controlled interest rates (Kiander & Vartia, 2009). The newly deregulated credit markets stimulated a competitive process between Swedish financial institutions (Englund, 1999). During this competitive process, expansion was given priority (Englund, 1999). This in combination with an expansive macro-policy, led to a house price boom in Sweden (Englund, 1999). More specifically, between 1985 and 1990 the Swedish price index of residential and commercial real estate jumped from 100 to 248 (Jes-Iversen & Sjögren, 2014). The main reason for this housing bubble was the substantial increase in competition between banks and finance companies in a deregulated market (Jes-Iversen & Sjögren, 2014). In this highly-competitive environment, agents accepted collaterals with higher risks to gain more market

share (Jes-Iversen & Sjögren, 2014). This growth strategy of the financial intermediaries was rewarded in the short term with profits but proved detrimental in the long run (Jes-Iversen & Sjögren, 2014).

From the early 1990s, Swedish economy began to weaken, the industrial production declined and the housing bubble busted (Jes-Iversen & Sjögren, 2014). As a result, Sweden entered an unexpected deep economic recession at the beginning of the 1990s (Kiander & Vartia, 2009). The consequences of this crisis were severe. The credit losses increased from 0.25% of lending volume in 1989 to 8% of lending volume in 1992. Next to this, Första Sparbanken and Nordbanken, two of the five major Swedish banks back then, went quasi bankrupt. Första Sparbanken got in troubles because of the regulatory change of turning savings banks into commercial banks (Ögren, 2017). Apparently, the bank took on more risk than a normal commercial bank would do in order to gain market share (Ögren, 2017). More specifically, between 1988 and 1990 Första Sparbanken doubled its lending (Ögren, 2017). This to new market segments such as financial and real estate corporations (Ögren, 2017). The other troubled bank was Nordbanken, which was then for 70.6% owned by the Swedish state (Ögren, 2017). The main cause of the issues in this bank were business activities undertaken by the bank in the late 1980s to gain more corporate market share (Ögren, 2017). Just as Första Sparbanken, Nordbanken had the aspiration to become a modern commercial bank (Ögren, 2017). In the end both banks were rescued by the Swedish government.

2.2.1.1. Consequences of the 90's crisis in Sweden

After the Swedish crisis in the early 1990s, stringent regulatory changes were implemented in Sweden (Erlandsen & Lundsgaard, 2007). This crisis forced Sweden to take early action compared to other Organisation for Economic Co-operation and Development (OECD) countries. In 2017 these other OECD countries were struggling with how to make public finances more robust in an ageing context (Erlandsen & Lundsgaard, 2007). This whilst the 1990s reforms that were made in Sweden were paying off during the previous global financial crisis in terms of productivity and GDP growth (Erlandsen & Lundsgaard, 2007). This part of the dissertation will focus on the five regulatory changes that were implemented in Sweden after their 1990s real estate crisis. The five regulatory changes in Sweden discussed underneath are: tax reforms, collective wage bargaining, abolishment of the fixed exchange rate, entering the EU and state-owned monopolies that were opened for competition.

First of all, there was the 'tax reform of the century' in Sweden, mainly implemented in 1991 (Fölster & Kreicbergs, 2014). Before this major tax reform, the Swedish tax system created significant disadvantages for workers and investors (Fölster & Kreicbergs, 2014). For example, in

the old tax system, individuals with a similar income were taxed differently. That is why the tax reform was implemented to encourage employment and investment level in Sweden. This would lead to a boost for the entire Swedish economy. This was done in different steps. Firstly, income tax rates were reduced across income levels (Fölster & Kreicbergs, 2014). Secondly, for incomes above a certain level in Sweden, individuals would pay 20% national income tax (Fölster & Kreicbergs, 2014). Thirdly, there was the reform of corporate income taxes, which lowered from 50% to 30% (Fölster & Kreicbergs, 2014). These tax cuts were financed by tax increases elsewhere and also by cuts in the public expenditures (Fölster & Kreicbergs, 2014). Reducing the marginal tax rates made it more profitable to work and more expensive to borrow.

The second regulatory change that was implemented after the 1990s crisis, was that collective wage bargaining found an entirely new form (Erlandsen & Lundsgaard, 2007). Between the 1970s and 1980s, nominal wage increases were often higher than 10% per year (Fölster & Kreicbergs, 2014). This was a much higher rate than in most other European countries. Against this high wage increase, the Industrial Cooperation and Negotiation Agreement was launched in 1997 (Fölster & Kreicbergs, 2014). With this agreement, the major Swedish union and employer organisations agreed on new forms of collective wage bargaining (Fölster & Kreicbergs, 2014). In this new form of wage bargaining, representatives met continuously between bargaining periods (Fölster & Kreicbergs, 2014). Additionally, the employer organisations nominated members of an economic council (Fölster & Kreicbergs, 2014). Its main objective was to analyse the economy and to provide a joint point of reference for wage negotiation (Fölster & Kreicbergs, 2014). Finally, unions and employers also appointed together mediators who were given much more authority than before (Fölster & Kreicbergs, 2014).

Thirdly, the Swedish fixed exchange rate was abolished (Erlandsen & Lundsgaard, 2007). After the crisis of the 1990s, the Swedish central bank (Riksbank) had to submit to market pressure. During the last decades of the fixed exchange rates in Sweden, wages were rising accompanied by an accommodating exchange rate policy (Berg & Gröttheim, 1997). This together contributed to a high level of inflation in Sweden (Berg & Gröttheim, 1997). At the same time, in the late 1980s, the Swedish economy became overheated (Berg & Gröttheim, 1997). Because of the then fixed exchange rate regime, there could not be any monetary changes (Berg & Gröttheim, 1997). This is why, Sweden abandoned its fixed exchange rate regime in 1992 (Fölster & Kreicbergs, 2014). Since then, the new monetary policy objective became a 2% inflation target (Fölster & Kreicbergs, 2014).

Fourth, at the first of January 1995, Sweden entered the EU (Erlandsen & Lundsgaard, 2007). That means that Sweden had to adjust to the EU norms (Fölster & Kreicbergs, 2014). Instead of

launching a committee of enquiry with the official investigation into how to avoid a new financial crisis, the focus of Sweden went to how to harmonise Swedish financial regulation to European standards (Fölster & Kreicbergs, 2014).

Finally, state-owned monopolies became subject to competition (Erlandsen & Lundsgaard, 2007). This measure was necessary because economic growth had been lagging behind for many decades in Sweden (Fölster & Kreicbergs, 2014). As a result, after the 1990s crisis, Swedish economy's competitiveness became a priority (Fölster & Kreicbergs, 2014). That is why Sweden opened its aviation, telecom, postal services, electricity, taxi and railway markets (Fölster & Kreicbergs, 2014). Consequently, Sweden has currently more deregulated markets than the European average (Fölster & Kreicbergs, 2014).

The result of this reform wave after the 1990s Swedish financial crisis was remarkable (Fölster & Kreicbergs, 2014). Before this wave Sweden performed economically lower than other European countries. For example, twenty years before 1995, GDP and productivity growth were significantly lower than in other countries (Fölster & Kreicbergs, 2014). However, from 1995 on the Swedish economy entirely changed. Since then, GDP and productivity growth have been higher than in comparable countries (Fölster & Kreicbergs, 2014). Not only the Swedish economy is performing well, but Swedish major banks are also very profitable (Scope Ratings, 2018). Their returns and efficiency ratios are among the strongest in Europe (Scope Ratings, 2018). Currently, capital ratios of Swedish banks are higher than those from most of their European peers (Scope Ratings, 2018).

2.2.2. Global financial crisis

To see the importance of monitoring the RRE market for the financial system, this part explains how the global financial crisis started. After the 1990s' financial crisis in Sweden, followed the global financial crisis in 2008. This worldwide financial crisis was triggered by the subprime mortgage crisis in the United States (US) (Shirai,2009). From the 1990s a boom period in the US housing market started. This housing boom was encouraged by the excessively easy monetary policy during 2003 and 2004 (White, 2010). Moreover, during that decade lending to subprime borrowers[9] expanded dramatically, this was both a result of the boom and a force that strengthened the boom (White, 2010). Many of those subprime mortgages were securitized into mortgage-backed securities (MBS) and other mortgage-related securities (usually collateralized debt obligations (CDOs)) that have multiple tranches with varying seniority (White, 2010).

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[9] Subprime borrowers are people that are considered to have a relatively high credit risk for the lender (Investopedia, 2018). They have a higher chance to go into default, that is why they receive less favourable loan terms in comparison to good credit quality borrowers (Investopedia, 2018).

Essential for the profitability of the securities was the favourable ratings (White, 2010). These ratings were provided by the three biggest US credit rating agencies (Standard & Poor's, Moody's and Fitch Group) (White, 2010). However, this system of securities only works as long as the house prices keep increasing and when everyone believes that they will continue to increase in the future (White, 2010). As a result, when the house prices stopped rising mid-2006 and then started falling, the whole financial system broke down (White, 2010). With rising mortgage defaults, the value of the CDOs sharply decreased as well. Therefore, the once excessively optimistic ratings on thousand tranches of these CDOs were downgraded (White, 2010). In turn, all the financial institutions that had invested in these CDOs experienced declines in the values of their asset portfolios. The CDOs were not only sold to American banks but worldwide. Consequently, soon after the crisis broke out in America it dragged the rest of the world with them. This happened because all banks were interconnected through securities. This is another reason why, it is very important to monitor residential real estate cycles.

There have been many financial crises in the past and a big part of them are caused by the boom-bust cycles in asset prices, mainly real estate. Examples of crises caused by bubbles in asset prices are: the Dutch Tulipmania, the Japanese real estate crisis of the 1990s and the 1990s Nordic housing crisis (Allen & Gale, 2000). These bubbles in asset prices typically exist of three phases (Allen & Gale, 2000). The first phase usually starts with financial liberalisation, which increases lending, which leads to an increase in asset prices (Allen & Gale, 2000). During the second phase, the asset bubble bursts and the asset prices collapse (Allen & Gale, 2000). The third phase consists of many firms and other agents that invested in the assets to go into default (Allen & Gale, 2000). These three phases also happened in the 1990s Swedish crisis as described in 2.2.1. As a result, it is very important to monitor monetary policy and asset prices in the future especially real estate prices.

According to Klepczarek (2015) the recent global financial crisis could stand as empirical evidence of the ineffectiveness of the prudential mechanisms of the global financial system More specifically, it became clear that a lot of banks did not have enough capital to be able to manage the serious crisis that had arisen (Riksbank, 2011). Banks were not able to completely absorb the losses that arose and to ensure the market had confidence in them (Riksbank, 2011). Many authorities of European countries, had to undertake action to restore stability to the financial system (Riksbank, 2011). They also had to avoid detrimental consequences for the real economy (Riksbank, 2011). The global financial crisis forced governments and central banks of developed economies to become more active in reinforcing regulation and tightening their supervision in lending channels (Lou & Yin, 2014). To conclude, the global crisis in 2007-2009 made clear that the regulations regarding the banks' capital significantly underestimated the amount of capital the

banks need to be able to manage this type of problem (Riksbank, 2011). This is also the main reason why the ESRB was founded in response to the most recent global financial crisis in 2010. The main objective of this institution is to keep macroprudential oversight of the European Union (EU) in order to prevent and mitigate systemic risks.

2.2.2.1. Effects of the global crisis on Sweden

Swedish banks had almost no exposure to the American financial market at the time of the global financial crisis. Despite that, other European banks did own securities based on American subprime loans. As a consequence, bad assets were circulating in Europe. However, no one really knew which banks owned the bad assets and in what amounts. This triggered widespread suspicions among European banks. As a result, European banks could not safely lend money to each other anymore (Irwin, 2013). These interbank loans are very important for the short-term financing of these banks. Consequently, widespread suspicions led to liquidity problems for European banks (Irwin, 2013).

In Sweden, the government made together with the Riksbank clear commitments to ensure that the Swedish financial sector was not dragged into the global financial crisis (Larsson & Söderberg, 2017). That is why, on October 29 of 2008 the Swedish Parliament approved the Stability Plan (Larsson & Söderberg, 2017). This was a voluntary program that allowed Swedish financial institutions and mortgage banks to obtain state guarantees (Larsson & Söderberg, 2017). In exchange, banks had to pay a fee and implement restrictions on their salaries and bonuses (Larsson & Söderberg, 2017). The goal of this Stability Plan was to reduce the costs of funding by reducing the associated costs (Larsson & Söderberg, 2017). Of the four biggest Swedish banks in 2008 (SEB, Swedbank, Handelsbanken and Nordea), only Swedbank decided to participate. That is why, the Parliament decided to permit state support to a credit institute when it was to maintain the Swedish financial stability (Larsson & Söderberg, 2017). Starting with SEK 15bn government money, the Swedish stability fund was created (Larsson & Söderberg, 2017). This fund was used to finance government actions to ensure financial stability in Sweden. Additionally, money paid by institutes that were a part of the Stability Plan also went into the fund (Larsson & Söderberg, 2017). Finally, as a lender of last resort, the Riksbank stepped up to lend liquidity to banks that were solvent but experiencing temporary liquidity problems (Larsson & Söderberg, 2017). Next to short-term financing, banks also need long-term financing to survive. The mistrust in the European banking market also affected the long-term financing. That is why, the Riksbank started to issue loans with 12-month maturities to banks (Larsson & Söderberg, 2017). These funding measures from the Swedish government and Riksbank made the Swedish banking system more resilient than other European banks.

2.3. Macroprudential measures

As mentioned in 2.1, changes in RRE prices can have a huge impact on financial stability and the real economy of a country. In the worst case scenario, it can lead to a systemic crisis as described in 2.2. That is why it is important for macroprudential policymakers to monitor RRE vulnerabilities. In Europe, this is the task of the ESRB. However, this is not the only macroprudential policymaker. The BCBS is another institution that tries to maintain financial stability and to prevent a new financial crisis (BIS, 2010). The BCBS was founded in 1974 by the central bankers from the G10[10] countries (Investopedia, 2017). The Committee was formed to work towards a new international financial structure after the Bretton Woods system[11] of foreign exchange rates collapsed in 1973 (Niemeyer, 2016). Since 1988, the BCBS developed a series of highly influential policy recommendations known as the Basel Accords (Investopedia, 2017).

The Basel Accords have three main objectives. First of all, it wants to ensure the stability of the global banking system (FBF, 2018). The second objective is to establish effective supervision of banks worldwide (FBF, 2018). Finally, it wants to promote cooperation between banking supervisors (FBF, 2018). As the Basel framework is not a law, it has to be transposed into EU and national law (EBF, 2019). In Europe, this has been done with the Capital Requirements Regulation (CRR) and the Capital Requirements Directives (CRD). Consequently, Basel IV will be implemented in Europe by adjusting the CRR/CRD framework (Unicredit, 2017). These laws are applicable to all European banks. On December the 7th of 2017, the BCBS issued the final version of the Basel III capital accord (BIS, 2017b). In the banking world, these reforms are generally referred to as Basel IV (McKinsey, 2017). The following part describes the Basel IV regulatory changes. More specifically, it deepens the changes in credit risk RWAs calculation that will impact the RRE mortgage loans. The Basel IV framework still needs to be implemented in the EU before it enters into force (FI, 2018a). As a result, the final design is thus not completed yet (FI, 2018a). The Basel framework sets the minimum capital requirements, but countries can also decide to implement stricter capital rules (FI, 2018a).

2.3.1. Basel IV

Basel IV follows to the Basel III framework. Basel III was developed in 2010 in response to the global financial crisis (BIS, 2017a). This framework addresses a number of shortcomings in the pre-crisis regulatory framework. More specifically, Basel III provides a foundation for a resilient

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[10] G10 consists of eleven industrial countries (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands. Sweden, Switzerland, the United Kingdom and the United States) which consult and work together on economic, monetary and financial matters (OECD, 2013).

[11] The Bretton Woods system was a monetary system with to gold linked fixed foreign exchange rates (Niemeyer, 2016). This monetary system was the basis for exchange rates among the world's most important currencies from 1945 to 1973 (Niemeyer, 2016).

banking system that should help to avoid the build-up of systemic vulnerabilities (BIS, 2017a). While Basel III focused more on the capital side of the capital ratio calculation (the numerator), Basel IV concentrates on the calculation of the RWAs (the denominator) as shown in Figure 6. Figure 6 shows how the risk-based capital ratio is calculated. The numerator of the equation, regulatory capital consists of the Common Equity Tier 1 (CET1), Additional Tier 1 (AT2) and Tier 2 (T2) of a certain bank (BIS, 2017a). CET1 are the common shares, retained earnings and other reserves of a certain bank. While AT2 contains the capital instruments with no fixed maturity. Finally, T2 consists of the subordinated debt and general loan-loss reserves of a bank. The denominator of the equation underneath is the amount of risk-weighted assets of a certain bank. This is calculated by the exposure to a certain type of assets multiplied with the relevant risk weight of the asset. Banks need to have less capital to cover exposures to safer assets and vice versa (BIS, 2017a).

Figure 6: Risk-based capital ratio calculation
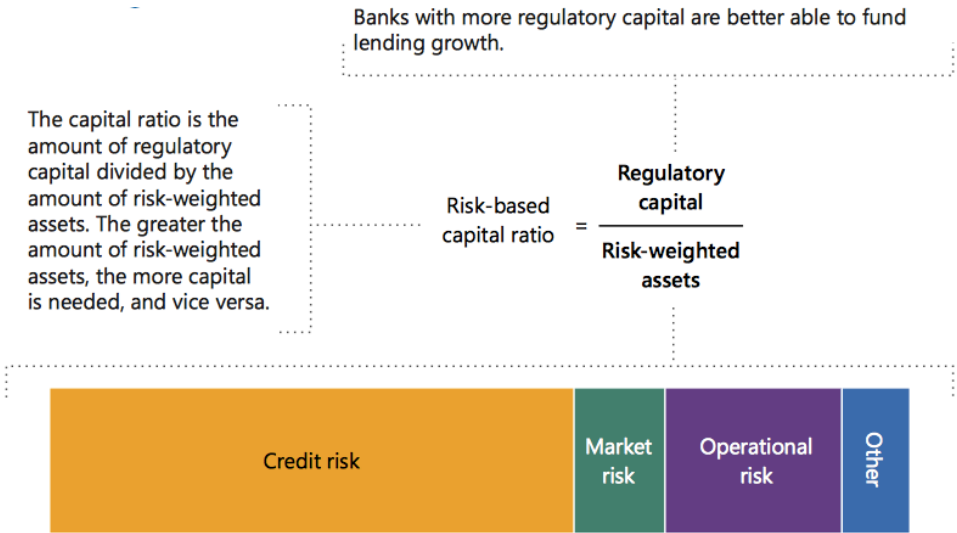
Source: BIS (2017a)

Basel IV is meant to make banks more resilient to financial crises (BIS, 2017a). It wants to restore credibility in the calculation of RWAs and improve the comparability of banks' capital ratios (BIS, 2017a). This is done by implementing four new components into the Basel framework. First of all, the robustness and the risk sensitivity of the standard approach for credit risk, credit valuation adjustment (CVA)[12] risk and operational risk will be enhanced (BIS, 2017b). Secondly, Basel IV wants to constrain the use of the internal model approach to calculate the required RWAs for a certain amount of debt. This is done by placing limits on certain inputs used to calculate the capital

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[12]CVA risk is an accounting valuation adjustment for derivatives to account for counterparty credit risk (KPMG, 2018b). Consequently, the capital requirements for CVA risk aims to cover the risk of changes in valuation adjustment (KPMG, 2018b).

requirements under the internal rating-based approach (BIS, 2017b). Next, Basel IV introduces a leverage ratio buffer to further limit the leverage of global systemically important banks (G-SIBs) (BIS, 2017b). Finally, Basel IV replaces the already existing Basel II output floor with a more robust risk-sensitive floor based on the Basel Committee's Basel IV standard approaches (BIS, 2017b). Most aspects of Basel IV will phase-in from January 2022 (EC, 2017b). The reformed Basel framework is expected to force banks to re-examine their portfolio management practices and to change their capital requirements, especially in Sweden (KPMG, 2018a).

As shown in Figure 6, credit risk accounts for the bulk of most banks' risk-taking activities (BIS, 2017a). This risk type covers the risk of loss due to a borrower being unable to pay back a debt in full or partially (BIS, 2017a). Since credit risk is the largest risk type of banks, there are more regulatory capital requirements for this risk type that banks have to fulfil (BIS, 2017a). That is why this dissertation focusses on the Basel IV adjustment for the RWAs calculations of credit risk. There are two Basel IV changes that concern credit risk. Namely, changes in the standardised approach and the internal rating- based approach to calculate the RWAs for credit risk.

First, the changes in the standardised approach to calculate the credit risk RWAs will be discussed (BIS, 2017a). The BCBS improved its granularity and risk sensitivity (BIS, 2017a). For example, the Basel II standardised approach assigns a flat risk weight of 35% to all residential mortgages (BIS, 2017a). While in Basel IV, the mortgage risk weights depend on the loan-to-value ratio of the mortgage loan (Figure 7). Investopedia (2019b) defines the loan-to-value ratio as:

$$\text{LTV ratio} = \frac{\text{Mortgage Amount}}{\text{Appraised Property Value}}$$

This ratio is an assessment of lending risk that a financial institution takes when it would approve the mortgage loan (Investopedia, 2019b). A high LTV ratio means that there is a high risk (because of the higher LGD). Therefore, when the mortgage loan gets approved, it will be with higher loan costs than when it would be a loan with a lower LTV ratio (Investopedia, 2019b). As a result, instead of the flat risk weight of 35% on RRE mortgage loans, there will be a RW amount that actually reflects the riskiness of the loan with the Basel IV implementation (Figure 7). Additionally, the revised standardised approach provides the foundation for a revised output floor to internally modelled capital requirements (to replace the already existing Basel II floor). It also enhances comparability across banks and restores a level playing field (BIS, 2017a). The revised standardised approach for credit risk will be implemented on the 1st of January 2022 (BIS, 2017b).

Figure 7: Overview of the revised standard approach of credit risk for RRE

Residential real estate exposures								
LTV bonds	Below 50%	50-60%	60-70%	70-80%	80-90%	90-100%	Above 100%	Criteria not met
General RRE								
Whole loan approach RW	20%	25%	30%		40%	50%	70%	RW CPT[13]
Loan-splitting approach RW	20%		RW CPT					RW CPT
Income-producing residential real estate (IPRRE)								
Whole loan approach RW	30%	35%	45%		60%	75%	105%	150%

Source: BIS (2017b)

Secondly, the changes in the internal ratings-based approach for the credit risk RWAs in Basel IV will be discussed. The key element here is the introduction of the aggregated output floor of 72.5%, which will be phased in over a five-year transition period from 2022 to 2027 as shown in Figure 8. The output floor will limit the use of internal risk models for banks to calculate credit risk RWAs. After this phase-in period, as of January 2027, RWAs calculated with internal models cannot be smaller than 72.5% of the RWAs calculated with the standardised approach. This measure has also the intention to diminish the discrepancies in RWA calculations across banks.

Figure 8: Implementation dates of the Basel IV output floor

Revision	Implementation date
Output floor	1 January 2022: 50%
	1 January 2023: 55%
	1 January 2024: 60%
	1 January 2025: 65%
	1 January 2026: 70%
	1 January 2027: 72.5%

Source: BIS (2017b)

Expected is that once Basel IV is completely implemented in 2027, financial institutions with a low-risk density, large low-risk real estate and high utilization of the IRB approach will face the highest RWAs increase (Unicredit, 2017). As a result, the relative RWA-inflation will be higher, for instance, for Nordic banks (including Sweden) and banks in the Netherlands (Unicredit, 2017). The pressure on the IRB approach RWAs is partly offset by the revision of the SA risk-weight framework (Unicredit, 2017). This is because the flat risk weight of 35% on residential mortgage

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[13] Risk weight of counterparty

loans is reviewed (BIS, 2017b). With Basel IV residential mortgage loans with a low LTV will have a lower SA risk-weight than in the Basel III framework (BIS, 2017b).

As mentioned before, Swedish banks are heavy users of the IRB method and have a big amount of residential mortgage loans on their balance sheet. That is why, Swedish banks will definitely feel an impact of the Basel IV implementation. Most Swedish banks will be able to cope with the RWAs inflation over the transition period by organically strengthening their capital positions and by adjusting their balance sheets (Unicredit, 2017). It might occur, that the Basel IV reforms cause uncertainty in the market during the transition period (Unicredit, 2017). Unicredit (2017) expects that the strongly capitalised banks will begin to publish Common Equity Tier 1 (CET1) ratios[14] with the full Basel IV impact before the end of the transition period. This, while other banks will be rather reluctant to publish those numbers (Unicredit, 2017). Additionally, investors will increasingly demand an adjustment of the capital ratios to the Basel IV fully phased-in levels before 2027 (Unicredit, 2017). This could lead to bond volatility (Unicredit, 2017).

As mentioned before, the Basel framework is not a law. This means that the consequences of the Basel IV implementation for Sweden highly depend on how the Basel framework will be implemented in the EU rulebook (Svenska Bankföreningen, 2018a). What is certain, is that when the IRB output floor is implemented as mentioned before, Swedish low-risk banks will be impacted (Svenska Bankföreningen, 2018a). More specifically, it will result in sharp increases in capital requirements for low-risk Swedish banks (Svenska Bankföreningen, 2018a). According to Svenska Bankföreningen (2018a), this will lead to a deterioration of banks' capacity to finance the real economy in Sweden. This will lead to higher capital requirements due to the IRB output floor, which will cause higher interest rates for the majority of customer (Svenska Bankföreningen, 2018a). This will result in customers having to look for a different source of mortgage funding in Sweden. This is actually against the main objective of the Basel IV regulation.

2.4. Did Swedish banks prepare enough for Basel IV?

After having discussed the 1990s Swedish real estate crisis, the current Swedish RRE vulnerabilities and the changes in credit risk RWAs calculation of Basel IV in 2.3.1, the next subsection focusses on the current situation in Sweden. This part is divided into two parts. First of all, the regulatory measures that already have been taken in Sweden to improve the mortgage market resilience are deepened. This is followed by case studies of the three largest Swedish banks. Currently, the three major Swedish banks are Swedbank, SEB and Handelsbanken.

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[14] CET 1 ratio is a measure of the relationship between core capital and the risk-weighted assets of banks (Klepczarek, 2015).

2.4.1. Macroprudential measures to improve the Swedish mortgage market resilience

In 2.1.2 and 2.1.3 of this dissertation, the current vulnerabilities in Sweden were described. The vulnerabilities of Sweden today are: low-interest rate environment, increased RRE prices, high DTI ratios, tax incentives, interconnectedness of Nordic banks, low RWs, high maturity mismatches and high concentration in the Swedish banking system. These vulnerabilities could lead to a systemic risk in Sweden. That is why the Swedish FSA, Finansinspektionen (FI) has already implemented a few macroprudential measures in Sweden since 2010 to improve the resilience of Swedish banks. First, the general Swedish macroprudential measures will be discussed. This is followed by a part describing the systemic buffers for the three major Swedish banks that were implemented by Finansinspektionen.

Figure 9: Macroprudential measures implemented in Sweden since 2010

Implementation year	Measure
2010	LTV cap at 85% for new loans
	Amortisation requirement for loans with LTV above 75%
2013	15% risk-weight floor for mortgages
2014	Amortisation on loans with LTV > 70%
	Risk-weight floor at 25%
2016	Amortisation requirement on loans
	with LTV > 70%: 2% p.a.
	with LTV > 50%: 1% p.a.
2018	Increased amortisation for borrowers with LTI > 450%

Source: Fitch (2018)

Figure 9 gives an overview of the macroprudential measures that have been taken in Sweden since 2010. This table excludes the extra capital buffers for the three major Swedish banks. As shown in Figure 9, there have been two lending restrictions implemented to improve the Swedish mortgage market resilience since the global crisis. First of all, in October 2010, a LTV limit of 85% was implemented (Fitch, 2018). This implies that since 2010 only mortgages at 85% of the house value are allowed in Sweden (CE, 2017). With this macroprudential measure Swedish banks are forced to take on less risky mortgage loans. Secondly, in June 2016, an amortisation requirement was implemented in Sweden (Fitch, 2018). This means that households must amortise 2% of the size of their mortgage loan when the LTV is higher than 70%. In case the LTV is between 70% and 50%, households need to amortise 1% of the mortgage loan. This means that new mortgage holders with an LTV above 70% will repay at least 2% of their original loan each year (EC, 2017).

Afterwards, households will repay at least 1% per year until the LTV is reduced to 50% (EC, 2017). Currently, the Swedish Financial Supervisory Authority (FSA) is working on a third lending restriction. Namely, they want to implement a DTI limit of 600% (CE, 2017). This would mean that new mortgages would not be able to result in debt for households, that is more than six times higher than the disposable income (CE, 2017). An alternative measure for the third lending restriction is a bit milder. It suggests that 15% of new mortgages for each institute can have a DTI that is higher than 600% (CE, 2017). The idea behind those lending restrictions is to avoid a housing bubble to build up, which could lead to systemic risk and later on to a financial crisis in Sweden.

As shown in Figure 9, there were not only lending restrictions implemented in Sweden after the global crisis. First of all, in 2010 there was an amortisation requirement for loans with LTV above 75% put into practice (Fitch, 2018). After this macroprudential measure in Sweden, the next measure was put into place in 2013. Then a 15% risk-weight floor for mortgages phased-in (Fitch, 2018). This was followed by two new measures in 2014. First of all, there was the amortisation on loans with LTV higher than 70% (Fitch, 2018). Secondly, a risk-weight floor of 25% was implemented (Fitch, 2018). The 25% risk-weight floor is the revised and recalibrated version of the 15% risk-weight floor that was implemented in 2013 (ESRB, 2016b). This measure was implemented to maintain the stability of individual credit institutions as well as the Swedish financial sector (ESRB, 2016b). Since 2014, Swedish credit institutions have to hold own funds that fully cover the risks in the Swedish mortgage portfolios with a more forward-looking perspective than was used with the IRB estimations (ESRB, 2016b). The 25% risk-weight floor is defined as the average risk weight at the portfolio level (ESRB, 2016b). Finally, since March 2018 there is increased amortisation requirements for borrowers with LTI > 450% (Fitch, 2018). This means that households need to amortise an additional 1 percent of their mortgage if their LTI exceeds 450% (ESRB, 2019a).

Next, to the macroprudential measures mentioned in Figure 9, the Swedish FSA increased the capital of the three major Swedish banks by implementing two systemic risk buffers in 2014. According to Scope Ratings (2015), Swedish banks are amongst the best-capitalised banks in Europe, based on a comparison of the capital ratios. This is partly due to the frontloading of CCR and CRD IV, but also because of the cautious approach of the Swedish FSA (Scope Ratings, 2015). These extra measures of the Swedish FSA are there for a reason (Scope Ratings, 2015). The Swedish financial system is exposed to structural systemic vulnerabilities as mentioned in 2.1.2 and 2.1.3. This is why the 5 percent (of which 3% under Pillar 1 and 2% under Pillar 2) extra capital buffer in Sweden for systemic risk is well justified (Scope Ratings, 2015). These two systemic risk buffers were implemented in 2015 to strengthen the resilience of the Swedish

banking sector (Reuters 2019). This leads to the following capital requirements for the three biggest Swedish banks in the first quarter of 2019 as shown in Figure 10. Data used in Figure 10 were submitted to FI (Swedish FSA) on the 13th of May 2019.

Figure 10: Total capital requirement, major Swedish banks Q1 2019 (as % of total REA[15])
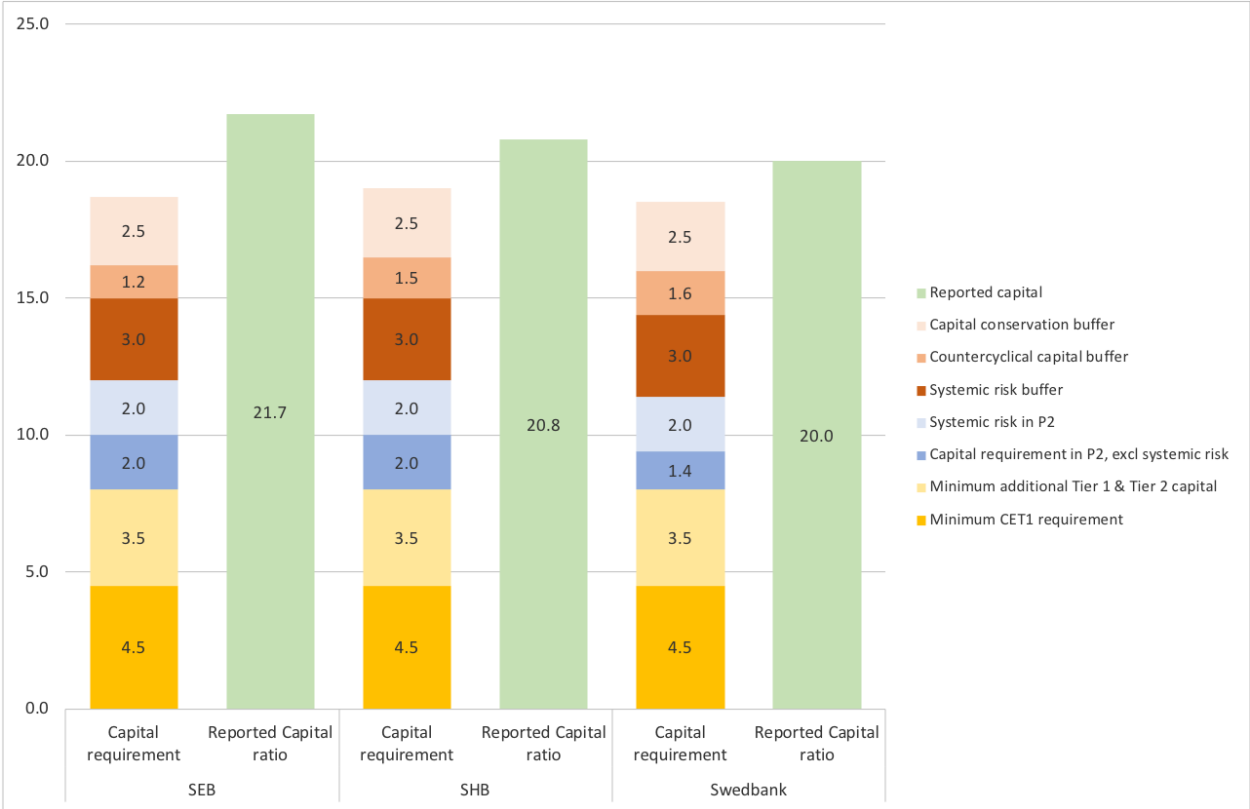
Source: FI (2019)

The total capital requirement of the three major Swedish banks in the first quarter of 2019 consisted out of seven elements. Two of these seven elements are specifically applied to the three major Swedish banks as a macroprudential measure. These elements are the systemic risk buffer in Pillar two and the systemic risk buffer (FI, 2019). The systemic risk in pillar two buffer is 2 percent of the total risk-weighted amount for the three major banks (FI, 2019). This is covered entirely by CET1 capital (FI, 2019). The second buffer is the systemic risk buffer, which is 3 percent of the total risk-weighted amount for the three major Swedish banks (FI, 2019). This buffer is just like the systemic risk buffer in Pillar 2 covered entirely by CET1 capital (FI, 2019). To conclude, the reason why Swedish banks have such good capital ratios compared to other European peers is that the Swedish FSA implies stricter capital requirements on the three major Swedish banks. These stricter capital requirements are implemented with two systemic risk

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[15] Risk Exposure Amount (FI, 2019)

buffers. These macroprudential measures were implemented to increase the resilience of the Swedish banking system.

2.4.2. Case studies major Swedish banks

On the first of October 2018, Nordea moved his headquarter from Stockholm to Helsinki (Nordea, 2018). Since then the three biggest Swedish banks are Handelsbanken (SHB), SEB and Swedbank (FI, 2018c). Figure 11 shows that both Swedbank and SHB were responsible for 22% of lending to the public in Sweden in the second quarter of 2018. This makes from Swedbank and SHB the two largest banks of the Swedish credit market. SEB provided 16% of the Swedish loans to the public during that quarter (FI, 2018c). As a result, these three major banks represented in the second quarter of 2018 approximately 60 percent of the total lending to the public in Sweden (Figure 11).

This means that the major Swedish banks play a central role in how well the Swedish banking system functions (FI, 2018c). In turn, this leads to higher capital and liquidity coverage requirements from the FI. This is necessary with the high banking concentration in Sweden (FI, 2018c). This makes the banking system more vulnerable when something would go wrong in one of these three banks. Even though Nordea moved his headquarter to Helsinki, it still plays a major role in the financial system in Sweden (FI, 2018c). In figure 11, Nordea is in the group "Foreign". This group includes lending in Sweden from foreign banks. Danske Bank together with Nordea are the two biggest banks in this category. Finally, the category "others" in Figure 11 represents all the Swedish credit institutions except SEB, SHB and Swedbank.

Figure 11: Distribution of bank lending to the public in Sweden from Q2 2018 (in %)

Swedbank 22%
SHB 22%
SEB 16%
Foreign 21%
Other 19%
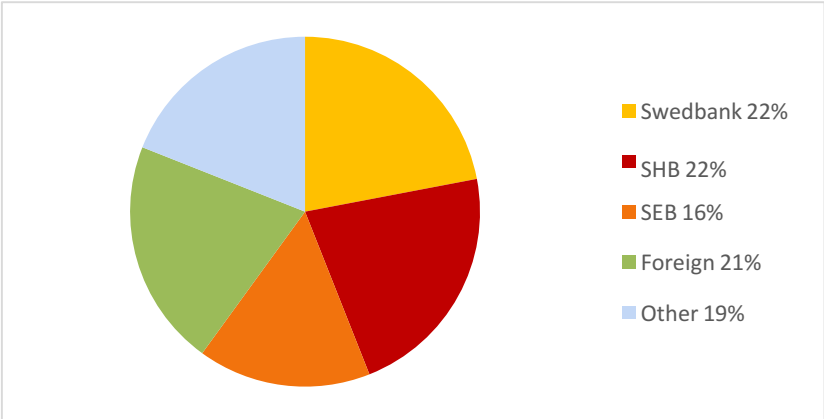
Source: FI (2018c)

When it comes to mortgage loans, the market share is quite similar to the distribution in the Swedish credit market (loans to the public). In the second quarter of 2018, the biggest market

share of residential mortgage loans was for Swedbank. This bank was responsible for 24% of the market share (Svenska Bankföreningen, 2018b). Followed by Handelsbanken with 23% (Svenska Bankföreningen, 2018b). Finally, SEB had 14% of the residential mortgage market share in Sweden in June 2018 (Svenska Bankföreningen, 2018b). Together, the three largest Swedish banks were in the second quarter of 2018 responsible for 61% of the residential mortgage market share in Sweden. Therefore, the developments in the real estate market can have a major impact on the Swedish banks' financial position (FI, 2018c). Since the global economy is showing signs of a slow-down, the FI considers that there is an elevated probability of a major fall in house prices (FI, 2018c). As a result, the risks to the financial system continues to be elevated (FI, 2018c). In the following part, the three biggest Swedish banks will be discussed with extra attention to the future Basel IV regulation.

2.4.2.1. Swedbank

Swedbank was founded in 1997 following the merger of Sparbanken Sverige and Föreningsbanken (Swedbank, 2019a). The merged bank, FöreningsSparbanken, was renamed Swedbank in 2006 (Swedbank, 2019a). Swedbank AB is a Swedish retail and commercial bank (Swedbank, 2019a). Its products and services include deposit-taking, savings facilities, loans and mortgages, as well as investment, cash management, trade finance, payment processing, investment banking, asset management services and insurance (Swedbank, 2019a). As mentioned before, in the second quarter of 2018 Swedbank was responsible for 24% of the Swedish residential mortgage loans (Svenska Bankföreningen, 2018b). With its 24% market share, Swedbank was Sweden's largest mortgage lender in the second quarter of 2018 (Svenska Bankföreningen, 2018b). This makes from Swedbank the most vulnerable bank to changes in RRE prices

As of March 2019, Swedbank Group reported consolidated assets of SEK 2,462bn (Swedbank, 2019c). Figure 12 shows roughly how the balance sheet structure of Swedbank Group was build-up in the first quarter of 2019. SEK 1,677bn loans to the public was the biggest group of assets in the first quarter of 2019 (Swedbank, 2019c). In Figure 12, the loans to the public were divided into two groups: mortgage loans (SEK 886bn) and other loans to the public (SEK 796bn). As a result, with SEK 886bn in mortgage loans Swedbank was highly exposed to fluctuations on the Swedish house market. However, this risk will only realise when some of the counterparties go into default and cannot pay back their mortgage loans to Swedbank. Since the asset quality of Swedbank is very strong, it has a credit impairment ratio of only 0.05%, the chance of realisation of credit risk is very small (Swedbank, 2019b). On the liability side, the biggest risk for Swedbank in the first quarter of 2019 was the amount of covered bonds and other debt securities (Figure 12). With SEK 920bn they were a big part of the liabilities. The group's other debt securities in

Figure 12 (SEK 404bn) contains commercial papers, senior unsecured bonds and structured retail bonds. As a result, a big part of Swedbank's funding comes from market funding, which could be a risk in a reverse economic situation. However, with its CET1 ratio of 15.9 percent Swedbank is well above the CET 1 Capital requirement of 14.7 percent set by FI in the first quarter of 2019 (FI, 2019c).

Figure 12: Balance sheet structure Swedbank Group Q1 2019 (in SEK bn)
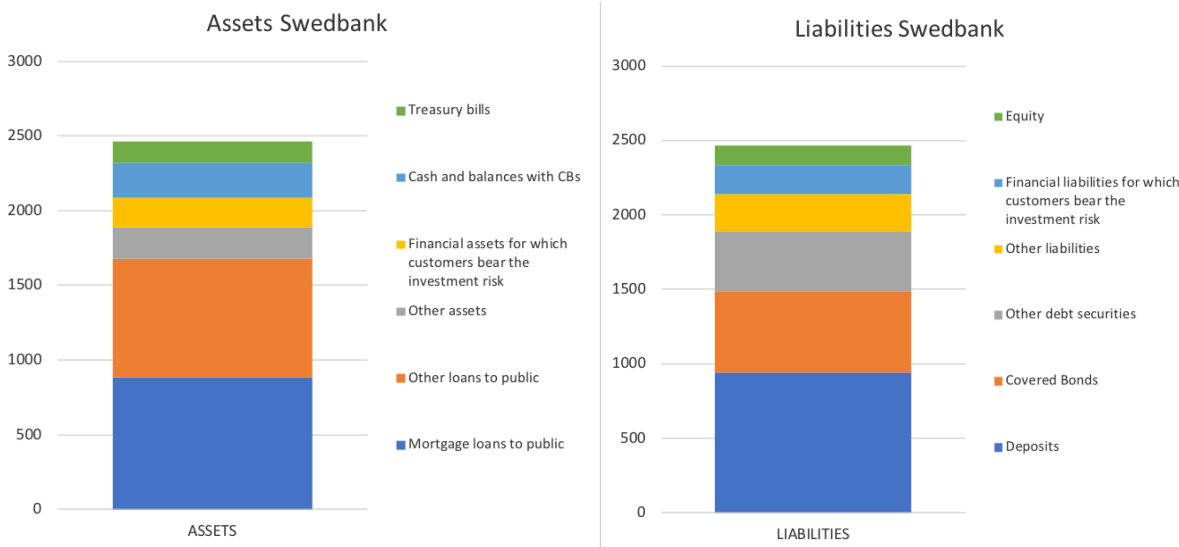
Source: Swedbank (2019c)

2.4.2.2. Skandinaviska Enskilda Banken (SEB)

Skandinaviska Enskilda Banken (SEB) was founded in 1856 as Stockholm's first private bank and one of the first commercial banks in Sweden (SEB, 2012). The bank operates in five main segments: merchant banking, retail banking, wealth management, life and Baltic, which comprises the bank's operations in the Baltic region (SEB, 2012). As mentioned before SEB was in the second quarter of 2018 responsible for 14% of the Swedish residential mortgage loans (Svenska Bankföreningen, 2018b). With its 14% market share, SEB was Sweden's third biggest mortgage lender to Swedish households in the second quarter of 2018 (Svenska Bankföreningen, 2018b).

In the first quarter of 2019, SEB Group reported consolidated assets of SEK 2,886bn (SEB, 2019). Figure 13 shows roughly how the balance sheet structure of SEB Group was build-up in the first quarter of 2019. With SEK 1,729bn was loans to the public the biggest group of assets in the first quarter of 2019 (SEB, 2019). In Figure 13, the loans to the public were divided into two groups: mortgage loans (SEK 563bn) and other loans to the public (SEK 1166bn). As a result, with SEK

563bn in mortgage loans SEB is less exposed than Swedbank to fluctuations on the Swedish house market. Nevertheless, percentage wise 19.5% of SEB's total assets were RRE mortgage loans in the first quarter of 2019. The biggest group, other loans to the public mainly consisted of loans to non-financial corporations (SEK 827bn) in the first quarter of 2019 (SEB, 2019). As shown in Figure 13, on the liability side the biggest part is for deposits and borrowings from the public with SEK 1,196bn. Followed by the debt securities that are issued by SEB, which amounted SEK 791bn in the first quarter of 2019 (SEB, 2019). In Figure 13, the debt securities is the sum of the covered bonds and the other debt securities. This means that SEB mainly financed his activities with deposits and issued securities in the first quarter of 2019. With its CET 1 ratio of 17.1 percent SEB is well above the CET1 Capital requirement of 14.7 percent set by FI in the first quarter of 2019 (FI, 2019c).

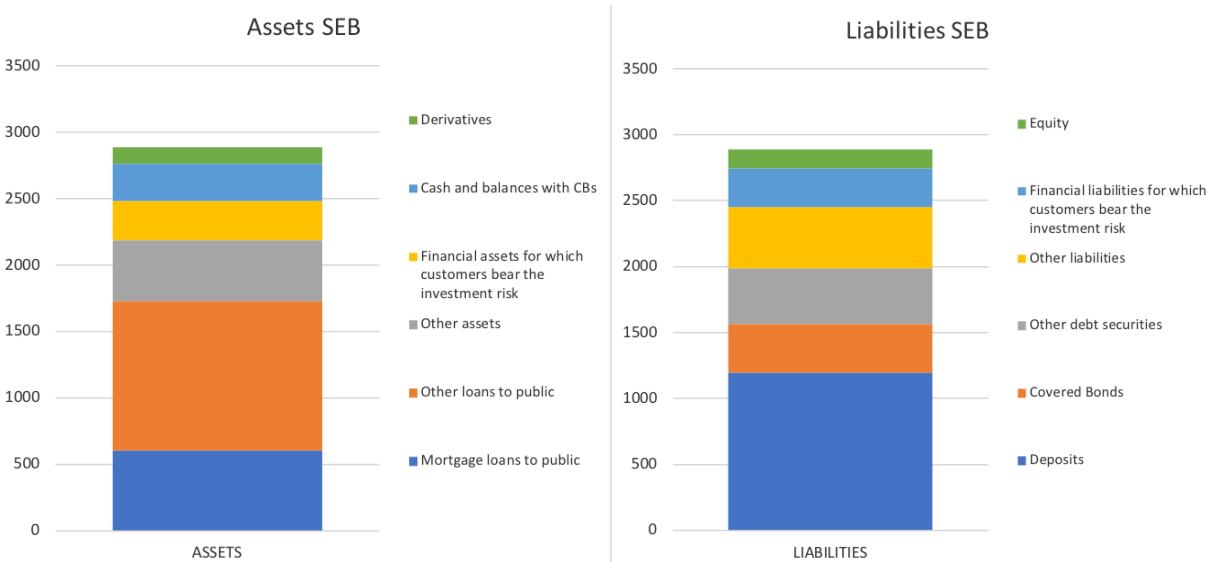Figure 13: Balance sheet structure SEB Group Q1 2019 (in SEK bn)

Source: SEB (2019)

2.4.2.3. Svenska Handelsbanken AB (SHB)

Svenska Handelsbanken AB was founded in 1871 under the name of Stockholm's Handelsbank (Handelsbanken, 2019a). Handelsbanken does everything from corporate transactions, investment banking, trading, consumer banking to life insurance (Handelsbanken, 2019a). As mentioned before Handelsbanken was in the second quarter of 2018 responsible for 23% of the Swedish residential mortgage loans (Svenska Bankföreningen, 2018b). With its 23% market share, Handelsbanken was Sweden's second largest mortgage lender to Swedish households (Svenska Bankföreningen, 2018b).

Figure 14: Balance sheet structure Handelsbanken Group Q1 2019 (in SEK bn)
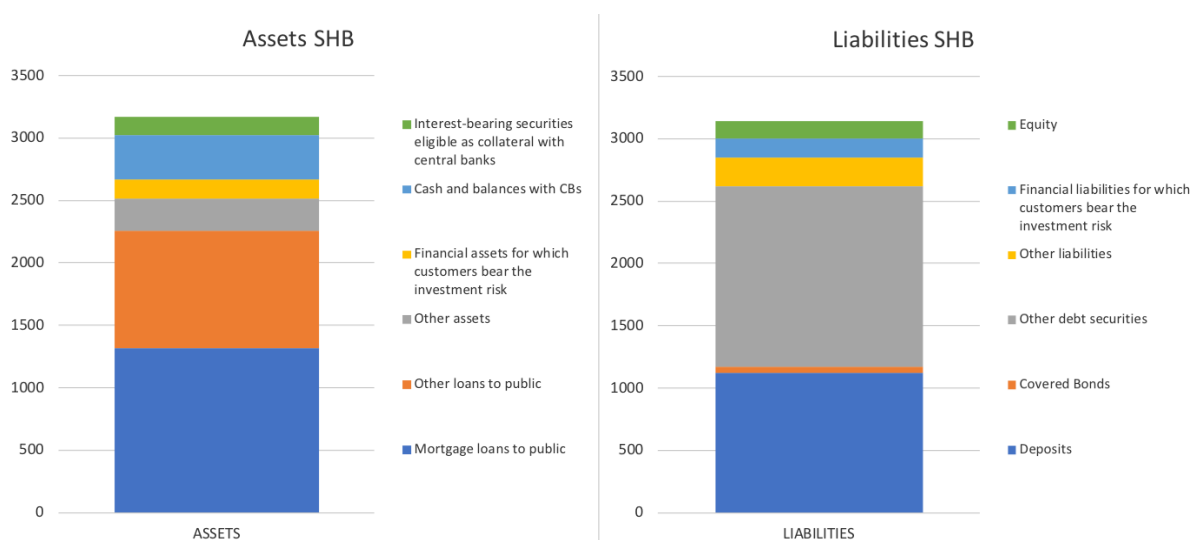
Source: Handelsbanken (2019b)

As of March 2019, SHB Group reported consolidated assets of SEK 3,170bn (Handelsbanken, 2019b). Figure 14 shows roughly how the balance sheet structure of SHB Group was build-up in the first quarter of 2019. With SEK 2,258bn loans to the public was the biggest group of assets in the first quarter of 2019 (Handelsbanken, 2019b). In Figure 14, the loans to the public are divided into two groups: mortgage loans (SEK 1,319bn) and other loans to the public (SEK 939bn). As a result, with SEK 1,319bn in mortgage loans is SHB most exposed of the three major banks to fluctuations on the Swedish house market. However, this risk will only realise when some of the counterparties go into default and cannot pay back their mortgage loans to SHB. Since the asset quality of SHB is very strong, it has just as Swedbank a credit impairment ratio of only 0.05%. Consequently, the chance of realisation of credit risk is very small (Handelsbanken, 2019b). On the liability side, Figure 14 shows that SHBs' funding comes mostly from deposits (SEK 1,120bn) and market funding (SEK 1,449bn) (Handelsbanken, 2019b). As a result, SHB took risks funding wise in the first quarter of 2019 because they had a relatively high percentage of market funding. This market funding could form a threat to SHB in a reverse economic situation. However, the SHB groups' CET1 ratio was 16.4 percent in the first quarter of 2019, which was well above the CET1 Capital requirement of 15.1 percent set by FI (FI, 2019c).

To summarise, there are a number of strengths and weaknesses in the three major banks. As strengths, there is good profitability and excessive capital ratios of the three major Swedish banks. The CET1 capital ratios of Swedbank, SHB and SEB were all higher than the CET1 capital requirement set by the Swedish FSA in the first quarter of 2019 (FI, 2019c). As vulnerabilities, there is a high percentage of RRE mortgage loans on the balance sheets, the use of market funding and as mentioned before the usage of low RWs to calculate the RWAs.

2.5. Solutions

Out of the previous parts of this dissertation, we can conclude that the consequences of the Basel IV implementation for Sweden highly depend on how it will be implemented in the EU rulebook (Svenska Bankföreningen, 2018a). What is certain, is that when the IRB output floor is implemented as described in the Basel framework, Swedish low-risk banks will be impacted (Svenska Bankföreningen, 2018a). More specifically, their RWAs will significantly increase. This will result in sharp increases in capital requirements for low-risk Swedish banks (Svenska Bankföreningen, 2018a). In turn, these higher capital requirements could lead to lower profitability. That is why the following part of this dissertation goes deeper into three possible solutions to maintain the profitability after the Basel IV implementation. Assuming that Swedish banks would have to increase their equity in order to comply with the Basel IV framework after the implementation of the output floor. Firstly, Swedish banks could focus on lower loan to value segments in the future. In this case, the costs of higher equity requirements will be transferred to the mortgage borrowers that have a high loan to value percentage. Secondly, Swedish banks could increase their mortgage loan rate. As a result, the borrower would pay for the higher regulatory capital that banks would have to hold after the Basel IV implementation. Finally, Swedish banks could also change their funding structure. In this way, they can spare their borrowers the extra costs of their higher capital requirements. However, cheaper funding also means riskier funding.

2.5.1. Focus on lower LTV segment

One of the possible solutions for Swedish banks could be to avoid the whole issue of having a higher amount of RWAs. This could be done by focusing on a lower LTV segments when Basel IV is implemented. For example, when a bank has now an average risk weight of 25% on residential mortgage loans in all LTV segments but calculated with the current regulation and the IRB model. For them, it could be a solution in the future to mainly focus on the LTV segments until 60% because that has an RW of 25% with the Basel IV regulation (Figure 7). Then depending on the number of mortgage loans in the LTV segment below 50% which only has a risk weight of 20% it can also accept some mortgage loans with LTV higher than 60%. In this way, their amount of risk-weighted assets stays the same. Consequently, their equity does not increase so their profitability also stays equal. However, this solution would also have disadvantages. For the higher LTV segments, it will become more expensive to receive a residential mortgage loan. This is because after the Basel IV implementation banks will prefer to focus on the lower LTV segments. Some Swedish banks could also go for more drastically measures (Svenska Bankföreningen, 2018a). For example, they could no longer issue loans in higher LTV segments.

As a result, customers that want a mortgage loan with a high LTV would have to use alternative sources of funding when this would happen (Svenska Bankföreningen, 2018a).

2.5.2. Mortgage loan rate

Anderson et al. (2012) found that the effects of increasing banks' risk weights on residential mortgage loans mainly depends on the required equity return on these loans by banks. For example, when the required equity return on mortgage loans of a bank is 10%, banks would have to increase their residential mortgage rates with 0.15 percentage points (Anderson et al., 2012). However, an increase in RWs not automatically means that there will be an increase in mortgage rates. It all depends on how much the banks want to pass on the costs to the residential borrowers (Anderson et al., 2012). In turn, this is dependent on the concentration in the banking sector. As mentioned before, the Swedish banking world is very dense. As a result, there is a lot of competition between the largest Swedish banks. Consequently, Swedish banks will wait as long as possible to pass the extra costs of higher risk weights to the residential mortgage borrower. Nevertheless, in the long run, it is expected that banks will adjust their lending rates (Anderson et al., 2012). The empirical case study in the next part of this thesis will research this question with Swedish numbers. Namely, it will research whether or not there is a correlation between the average Swedish mortgage loan rate and amount of RWAs that Swedish banks had to hold in the past.

2.5.3. Change funding structure

The third method to offset the reduced bank profit due to a higher amount of RWAs is changing the Swedish banks' funding structure. This structure tells how the banks' business, primarily lending (in Sweden mostly residential mortgage lending) is financed (EC, 2017a). Normally, banks collect deposits to finance the loans they grant (EC, 2017a). An indicator of how stable a banks' funding is, is to use the loan-to-deposit ratio (LTD ratio). This ratio shows the share of the loan book that is covered by deposits, which are presumed to be a stable funding source (EC, 2017a). In 2016, the LTD ratio was higher than 100% in only five European countries (EC, 2017a). One of these five was Sweden (EC, 2017a). The reason why this ratio was in 2016 higher than 100% in Sweden, was because Swedish banks also used covered bonds to fund their loans (Unicredit, 2018).

In 2004 the covered bonds legislation was implemented on the Swedish mortgage market (Elliot & Lindblom, 2015). By Swedish law, covered bonds must fulfil certain criteria (Macro voices, 2017). First of all, the face value of the mortgages must exceed 102% of the face value of the covered bond (Macro voices, 2017). Secondly, the LTV cannot be higher than 75% for any of the

individual mortgages (Macro voices, 2017). After the implementation of the covered bonds legislation in Sweden, between 2006 and 2008 Swedish banks gradually replaced their residential mortgage-backed bonds with covered bonds (Elliot & Lindblom, 2015). In many respects, mortgage-backed bonds are quite similar to covered bonds (Elliot & Lindblom, 2015). More specifically, they both have fixed maturities, their face value is repaid at maturity and they are collateralised by a pool of underlying assets (Elliot & Lindblom, 2015). The only difference is that covered bonds are kept on the banks' balance sheets while the mortgage-backed bonds are kept off-balance sheet (Elliot & Lindblom, 2015). In 2017, almost a quarter of the Swedish banks' average total lending was financed by covered bonds (Elliot & Lindblom, 2015). This is not only a trend in Sweden. Covered bonds became a key funding tool for residential mortgage loans in many other European countries in the last years (Norges Bank, 2017). Covered bonds have confirmed their position as a resilient source of funding, even under stressed market conditions (Norges, 2017). Particularly in Nordic countries this funding method is very popular (as seen in the case studies). This sophisticated way of mortgage loans financing makes it possible for Swedish banks to provide households with a large volume of mortgage loans at a low loan cost (EC, 2017c).

What Swedish banks could do, is use even more covered bonds funding than they are currently using. In this way, they could offset the diminished banks' profit caused by the higher RWAs with cheaper funding. However, this funding method has also disadvantages. First of all, banks are often both issuers and holders of covered bonds (Norges, 2017). Consequently, this can increase systemic risks in Sweden (Norges, 2017). Secondly, there is the danger of the role of banks as market-makers (EP, 2015). More specifically, when many investors decide at the same time to sell their covered bonds, banks must be able to buy them on their own account (EP, 2015). This would raise the risks on their balance sheet, probably above the levels accepted internally or by regulators, forcing them to sell as fast as possible (EP, 2015). Thirdly, the covered bonds are being used as liquidity buffers (EP, 2015). However, the covered bonds market is less liquid than others. Consequently, a big part of the banks' liquidity is unusable because of the usage of covered bonds (EP, 2015). Finally, there is the risk that the underlying value of the asset reduces during economic downturns (EP, 2015). In this case, banks would require more assets to be pledged to raise a certain given level of funding (EP, 2015). In a crisis situation, this may significantly limit a bank's activities (EP, 2015).

3. Empirical Case Study

The following part of this dissertation contains the empirical case study. The literature review showed that there are currently three trends going on when it comes to Swedish banks and residential mortgage loans. First of all, Swedish banks hold a large proportion of traditionally low-risk assets, such as mortgage loans on their balance sheet (ESRB, 2016e). According to the ECB (2018) residential mortgage loans made up on average 50% of the total lending of the four major Swedish banks in 2018. The second trend is the high usage of the IRB model to calculate the required amount of RWAs for residential mortgage loans in Sweden. For Swedish banks, it is better to use the IRB model to calculate the RWAs of their mortgage loans. This is because the RWs are generally lower when calculated with the IRB method (due to the low PD) instead of with the standardised approach (ESRB, 2018). Finally, the third trend is the low-interest rate environment. This makes it harder for banks to make a profit.

These three trends make Swedish banks very sensitive to the Basel IV framework. This is mainly due to the Basel IV changes in credit risk RWA calculation. The main changes are the revision of the SA approach and the implementation of the IRB output floor. This brings us to the first assumption of the empirical case study. The first assumption of this empirical case study is that the credit risk RWAs of Swedish banks will increase. Since credit risk accounts for the bulk of most Swedish banks' risk-taking activities, this increase in RWAs will be very large for Swedish banks (BIS, 2017a). The assumption of increased credit risk RWAs is based on the following facts. With Basel IV there will be an output floor for the IRB implemented. Since Swedish banks are high users of the IRB model, this will affect Swedish banks' RWAs amount. This higher RWAs as a part of the total assets will lead to higher equity requirements to fulfil the Basel regulation. As a result, the profitability of Swedish banks will diminish. Additionally, as mentioned above, the low-interest rates make it also hard for Swedish banks to make profit. As a consequence, with the Basel IV implementation, there will be two factors putting pressure on the profitability of Swedish banks.

Since Swedish banks cannot influence the low-interest rate environment, this empirical case study focusses on the analysis of how Swedish banks could possibly offset this loss in profitability caused by higher equity requirements. In 2.5 of this dissertation, three possible solutions were discussed. Swedish banks could focus on lower LTV segments, change mortgage loan rate or change their funding structure. This empirical case study will focus on changing the average Swedish mortgage loan rates. As mentioned before, by increasing the Swedish mortgage loan rates, Swedish banks would be able to maintain their profitability level after the Basel IV

implementation. In this way, Swedish banks could pass the costs of higher equity requirements on to their customers as described in 2.5.2. This is the second assumption of this empirical case study. However, Basel IV is not implemented yet. It all depends on how Basel IV will be implemented in the EU. Additionally, this also means that there is no statistical data on Basel IV available. As a result, this empirical case study will research whether changes in the RWAs as part of the total assets of the four largest Swedish banks (Swedbank, SEB, Handelsbanken and Nordea) of 2018 had an impact on the average mortgage loan rate in Sweden in the past. In the empirical case study is Nordea still implemented. This is because the data used was from 2011 until 2018. Then Nordea's headquarter was still in Stockholm. With this empirical case study, I test the hypothesis that the Swedish average mortgage loan rate will increase when the RWAs as a part of the total assets will increase with the Basel IV regulation.

3.1. Data and descriptives

This part contains information regarding the sample selection, used variables in the empirical research analysis and the data sources. The data used for this empirical research are secondary time series data on a quarterly basis starting from the fourth quarter of 2011 until the fourth quarter of 2018. As dependent variable, to measure the mortgage loan rate in Sweden, the average Swedish RRE mortgage loan rate is used. More precisely, the lending rates to households for housing loans from the new and renegotiated agreements in Sweden were used. This variable is extracted from Swedish Statistics. As independent variable for the empirical model, RWAs as a percentage of the total assets are used. There are two possible ways to get this data. The ECB provides the variable "Risk-weighted assets (% of total assets)", this variable has as sample all Swedish banks. The variable provided by the ECB contains data from the fourth quarter of 2007 until the third quarter of 2018. However, this time span cannot be fully used in the empirical model because there are some missing values until the third quarter of 2014. This leaves only 16 data points, which is a small sample to execute the empirical research. The second source for the independent variable is Swedish Statistics. The positive thing about this source, is that the sample is bigger. On Swedish Statistics, there is data available from the fourth quarter of 2011 until the fourth quarter of 2018. Consequently, this source offers 29 data points to perform the empirical model. This makes the data from Swedish Statistics a better source to use for the empirical model than the ECB data. However, there are two pitfalls with the Swedish statistics data that need to be considered in this model. Firstly, Swedish Statistics data has as sample the four biggest Swedish banks (SEB, Swedbank, Handelsbanken and Nordea) of 2018. While the ECB offers as sample all Swedish banks. This means that when the empirical model is performed with the Swedish Statistics data, the results are only valid for the four biggest Swedish banks. Secondly, Swedish Statistics does not directly provide the variable RWAs as a percentage of the total assets.

However, they do provide the following two variables:

$$\frac{\text{Regulatory Tier 1 capital}}{\text{RWAs}} \quad \text{and} \quad \frac{\text{Regulatory Tier 1 capital}}{\text{Assets}}$$

By dividing these two variables the following variable is created:

$$\frac{\text{Regulatory Tier 1 capital}}{\text{Assets}} * \frac{\text{RWAs}}{\text{Regulatory Tier 1 capital}} = \frac{RWAs}{Assets}$$

This new variable could be used as the independent variable for the empirical model. However, before using this variable it is important to check the data quality. To check the quality of the newly created variable, the variable from the ECB should be compared with the variable from Swedish Statistics. In Attachment A, data of the two sources are compared with each other. Table 6 shows that the deviation between the ECB and Swedish Statistics data is minimal. Additionally, Table 7 of Attachment A shows that the average deviation between the two aforementioned sources is on average 0.61 percentage points (pp). Therefore, the Swedish statistics data of the four largest Swedish banks of 2018 can be considered to be representative for all Swedish banks in the following calculations.

To control the regression analysis for different market conditions, seven financial and economic variables are added to the empirical model. Namely: inflation, Gross Domestic Product, amount of money, RRE prices, Euro interest rate, Swedish Krona interest rate and the 10-year treasury bonds rate in Sweden. The data of these control variables are extracted from Federal Reserve Bank of St. Louis database and Swedish Statistics.

For GDP, the percentage change compared to the previous quarter data was extracted from Swedish Statistics. Inflation rate data according to Consumer Price Index (CPI) and the growth rate of M1 from Sweden data originate both from the Federal Reserve Bank of St. Louis database. As indicator of the Swedish RRE prices, the real estate price index for one- and two-dwelling buildings for permanent living (1981=100) for Sweden downloaded from Swedish Statistics was used. Data for the 10-year Swedish government bond yield comes from the Federal Reserve Bank of St. Louis database. Just like the government bond yield, the interbank rate data for the Euro Area and Sweden are extracted from the Federal Reserve Bank of St. Louis database. Table 8 of Attachment B contains the summary of statistics of all the variables mentioned above.

At the end of this empirical case study the main findings will also be discussed with Jonas Niemeyer from Riksbank. This part is added to attain some insight in how Swedish supervisors

see the impact of Basel IV on Swedish banks. The transcript of the interview can be found in Attachment C.

3.2. Empirical model

This empirical case study aims to test whether the amount of risk-weighted assets as a percentage of their total assets of Swedish banks had an impact on the average Swedish mortgage loan rate in the past. To investigate the relationship between the average Swedish mortgage loan rate (MLR$_t$) and the risk-weighted assets as percentage of the total assets (RATA$_t$) the following regression model is tested[16]:

$$MLR_t = \alpha_0 + \alpha_1 * RATA_t + \alpha_2 * INF_t + \alpha_3 * GDP_t + \alpha_4 * M1_t + \alpha_5 * RP_t + \alpha_6 * IR_t + \alpha_7 * SR_t + \alpha_8 * TR_t + \epsilon_t$$

This is a multiple regression model. The following part contains a brief literature overview that motivates why these seven control variables: inflation (INF$_t$), Gross Domestic Product (GDP$_t$), money amount (M1$_t$), residential real estate price index (RP$_t$), Euro immediate interbank rate (IR$_t$), Swedish 3-month interbank rate (SR$_t$) and the 10-year Swedish government bond yield (TR$_t$), were used in the empirical model.

First of all, there is the control variable inflation (Investopedia, 2019c). Inflation is defined as an increase of price levels for goods and services in the economy (Ebrahim & Mathur, 2007). Its caused by the complex and dynamic interactions of four groups of factors: monetary (demand-side) shocks, real (supply-side) shocks, price adjustment factors and institutional factors (Ebrahim & Mathur, 2007). Additionally, inflation is an essential factor in the overall economy as well as a critical factor for mortgage lenders (Investopedia, 2019c). Mortgage lenders generally try to maintain interest rates at a level that is at least enough to overcome the erosion of purchasing power through inflation (Investopedia, 2019c). In this way, mortgage lenders ensure that their interest returns represent a real net profit (Investopedia, 2019c). As a result, when the inflation increases the mortgage loan rates will increase and vice versa.

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[16] MLR$_t$: average Swedish residential mortgage loan rate for loans with a maturity longer than 5 years in percentage.
RATA$_t$: the RWAs as a percentage of the total assets of the 4 biggest Swedish banks.
INF$_t$: Inflation rate in Sweden according to CPI.
GDP$_t$: quarterly Swedish GDP growth rate.
M1$_t$: growth rate of M1 compared to the previous quarter in Sweden.
RP$_t$: RRE price index in Sweden with as base year 1981=100.
IR$_t$: less than 24 hours interbank rate for the Euro Area
SR$_t$: 3-month interbank rates for Sweden
TR$_t$: 10-year Swedish government bond yield.
α_0: constant variable
ϵ_t: error term

Secondly, GDP was implemented in the empirical model as an indicator for economic growth. It is necessary to implement an economic growth factor because a higher level of economic growth means higher incomes and consequently higher levels of consumer spending (Investopedia, 2019c). As a result, more consumers seek for mortgage loans for home purchases. Generally, the upswing in mortgage demand tends to cause higher mortgage rates (Investopedia, 2019c). This is because lenders only have a certain amount of money available to lend out. As a consequence, when the demand of mortgage loans exceeds the supply, it will lead to higher mortgage rates. This is also valid the other way around. Lower economic growth leads to lower mortgage interest rates. That is why in this empirical model GDP is implemented as control variable for economic growth.

The third control variable used in the empirical model is M1, it is used as an indicator of monetary policy. Monetary policy influences both the economy in general and interest rates, including mortgage interest rates (Investopedia, 2019c). Monetary policy determines the money supply and this has an impact on the interest rates available to the public borrowings (Investopedia, 2019c). Generally, when money supply increases, it puts a downward pressure on the interest rates, including mortgage rates (Investopedia, 2019c). On the contrary, when there is a lower money supply, the mortgage rates move upwards (Investopedia, 2019c).

The fourth control variable of the empirical model is the Swedish residential real estate price index. This variable is used as an indicator of the property value. Economic theory suggests that house prices rise when the mortgage rates decline (McGibany & Nourzad, 2004). This is because most home sales are financed by credit (McGibany & Nourzad, 2004). As a result, lower borrowing costs causes an increase in house demand (McGibany & Nourzad, 2004). When the supply doesn't follow, this leads to rising house prices (McGibany & Nourzad, 2004). Several studies, at national, international and regional levels, have shown that mortgage rates have a significant negative effect on property prices (Page, 1964; Reichart, 1990; Englund and Ioannides, 1997).

The fifth and sixth control variables are interest rate related. According to Vose (2008) interest rate and mortgage rate are highly correlated. The mortgage loan rate is in essence dependent on the interest rate (Vose, 2008). Important here is to make the distinction between the Euro interest rate and the Swedish Krona interest rate. Because Sweden has its own currency, it also has its own central bank (Riksbank), with its own monetary policy. However, this does not mean that the Riksbank can act without taking the Euro interest rate into account. For example, in 2018 Sweden had the lowest benchmark interest rates in the world, namely -0.5% (FT, 2018). Even though the Swedish economy was growing, Riksbank did not increase this interest rate because they feared that the Krona would strengthen too quickly (FT, 2018). Sweden is waiting for the ECB to increase

the Euro interest rate first, to avoid a possible deflation in Sweden (FT, 2018). Both Euro and Swedish Krona interest rates are implemented in the empirical model as control variables.

The last control variable that is implemented in this empirical model is the 10-years Swedish treasury rate. According to Sirmans et al. (2013) there is a strong relationship between mortgage loan rates and capital market rates, most prominently the 10-years treasury rate. This positive relationship has strengthened over time as the mortgage and capital markets have become more integrated (Sirmans et al., 2013). Consequently, when the 10-years Swedish treasury rate increases, the mortgage rate will also increase and vice versa.

3.3. Estimations and results

The goal of this empirical study is to build an optimal empirical model that represents the changes in average Swedish mortgage loan rate on a quarterly basis. To do so, first a simple regression is made with just the dependent and independent variable. This is followed by a multiple regression where all the control variables are added to the previous regression model, showing which variables are significant. Finally, the optimal empirical model exists of the dependent and independent variable with all the significant control variables of the previous regression. First, a simple regression is made to start the empirical analysis, where the following model is used:

$$MLR_t = \propto_0 + \propto_1 * RATA_t + \epsilon_t$$

Table 1: Impact of the RWAs as a percentage of total assets of the four biggest Swedish banks' mortgage loan rates

	Average Swedish Mortgage loan rate
Constant	0.305364
	(0.6572)
RWAs as % of total assets	0.102044***
	(5.936)
Observations	29

Notes: OLS-model without outliers. The t statistics are written in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$: statistically significant on the 10%, 5% or 1% level.

Table 1 shows that there is a significant positive correlation between the RWAs as a percentage of the total assets of the four Swedish banks and their average mortgage loan rate. This confirms the previously made assumption that Swedish banks could pass on the costs of higher equity requirements to their customers. More specifically, Table 1 shows that when RWAs as percentage

of the total assets increases by 1 percentage point, the average Swedish mortgage loan rate is expected to increase by 0.10 percentage points. The R-squared of this simple regression is 56.61 percent. As a result, 56.61 percent of the variation in the average mortgage loan rate is explained by the RWAs as a percentage of the total assets of the four biggest Swedish banks. However, this OLS-model shown in Table 1 does not test whether the data is stationary and if there is a unit root in the residuals. Additionally, this model is also not tested for the pitfalls that can occur when time series variables are used, namely: omitted variable bias[17], multicollinearity[18], heteroscedasticity[19] and residual autocorrelation[20].

In the following part, the simple regression is performed again with all the additional test as mentioned above. First of all, the Augmented Dickey-Fuller test was executed. Both MLR_t and $RATA_t$ have a unit root and are thus non-stationary. Secondly the Engle-Granger test was performed. Here the result was that there is a unit root in the residuals. Consequently, there is no cointegration. Because the previous model is a spurious regression, there needs to be a new model with the differences of the two variables. The new single regression model is:

$$\Delta MLR_t = \propto_0 + w_1 * \Delta RATA_t + \epsilon_t$$

Table 2: Impact of RWAs as a percentage of total assets on the average Swedish mortgage loan rates

	ΔAverage Swedish Mortgage loan rate
Constant	-0.0998908*
	(-1.927)
ΔRWAs as % of total assets	-0.00405380
	(-0.2273)
Observations	28

Notes: OLS-model without outliers. The t statistics are written in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$: statistically significant on the 10%, 5% or 1% level.

Table 2 shows that there is not a significant relationship between RWAs as percentage of the total assets of the four biggest Swedish banks and their average mortgage loan rates. This result

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[17] Omitted variable bias is a statistical term for the issue where you exclude explanatory variables that actually should be present in the regression. When these omitted variables are correlated with the included explanatory variables, then the OLS estimates of the coefficients on the included explanatory variables will be biased.

[18] Multicollinearity is a high correlation between the variable itself and the interaction term, which makes it difficult to distinguish the separate effects from each other and interpret the estimated result.

[19] Heteroscedasticity means that the standard errors of OLS estimates could be inappropriate.

[20] Residual autocorrelation implies that there are some patters in the errors.

is in contrast to the assumption made before. The R-squared (0.002 percent) in this model is much smaller but this one is correct compared to the one of the previous model. However, this model still needs to be tested for heteroscedasticity and autocorrelation in the residuals. To test for heteroscedasticity, the White test was performed. The results from this test is that there is no heteroscedasticity. Next, the model needs to be tested for autocorrelation in the residuals. To test this the Durbin-Watson test is performed. Here the result is between d_L and d_u. Consequently, the results are inconclusive. That is why the GLS model is made.

Table 3: Impact of RWAs as percentage of total assets of the four biggest Swedish banks

	ΔAverage Swedish Mortgage loan rate
Constant	-0.101631*
	(-1.809)
ΔRWAs as % of total assets	-0.00420515
	(-0.2321)
Observations	27

Notes: GLS-model without outliers checked for heteroscedasticity. The t statistics are written in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$: statistically significant on the 10%, 5% or 1% level.

Table 3 confirms the results of Table 2 that there is no relationship between RWAs as percentage of the total assets of the four biggest Swedish banks and their average mortgage loan rates. This result is in contrast to the assumption made before. The R-squared of the GLS-model is 0.004 percent.

To make this model better, we add all seven aforementioned control variables to the empirical model. This model is tested for all the possible time series pitfalls. The following multi-regression model is tested:

$$\Delta MLR_t = \propto_0 + \propto_1 * \Delta RATA_t + \propto_2 * \Delta INF_t + \propto_3 * GDP_t + \propto_4 * M1_t + \propto_5 * \Delta RP_t + \propto_6 * \Delta IR_t + \propto_7 * \Delta SR_t + \propto_8 * \Delta TR_t + \epsilon_t$$

Table 4: Results of the empirical analysis with all control variables

	ΔAverage Swedish Mortgage loan rate
Constant	-0.134537
	(-1.517)
ΔRWAs as % of total assets	0.000616693

	(0.04520)
ΔInflation	−0.0529530
	(−0.4585)
GDP	−0.0716881
	(−0.8375)
M1	0.0391119
	(1.214)
ΔRRE price index	0.00361600
	(0.6945)
ΔEuro Rate	0.324688
	(0.5315)
ΔSwedish Krona Rate	−0.107909
	(−0.2854)
ΔTreasury rate	0.886868***
	(5.112)
Observations	28

Notes: OLS-model without outliers checked for heteroscedasticity, non-stationary data and residual outliers. The t statistics are written in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$: statistically significant on the 10%, 5% or 1% level.

Table 4 shows the results of the multi-regression analysis where all control variables are implemented. Here some of the data had to be modified for the difference between data points as to negate the influence of growth trends. The R-squared of this OLS-model (0.61 percent) is much higher than the R-squared from the previous model with only the dependent and independent variable. Table 4 shows that there is only one significant variable, namely the Swedish 10-year government bond yield. More precisely, when the 10-years Swedish treasury rate increases by with 1 percentage point, the average Swedish mortgage loans rate is expected to increase by 0.89 percentage points. Consequently, there is a significant positive correlation between the Swedish treasury rate and average Swedish mortgage loan rate. All the other variables are not significant.

Now the optimal regression analysis is made. As mentioned above there is only one significant variable in this empirical model, the 10-years treasury rate. This variable is together with the Swedish interbank rate and M1 the optimal regression. The following model is tested:

$$\Delta MLR_t = \propto_0 + \propto_1 * \Delta RATA_t + \propto_2 * M1_t + \propto_3 * \Delta SR_t + \propto_4 * \Delta TR_t + \epsilon_t$$

	ΔAverage Swedish Mortgage loan rate
Constant	−0.147218*
	(−1.976)
ΔRWAs as % of total assets	−0.00169611
	(−0.1388)
M1	0.0318195
	(1.149)
ΔSwedish Krona Rate	−0.179371
	(−0.5424)
ΔTreasury rate	0.871161***
	(5.435)

Notes: OLS-model without outliers checked for heteroscedasticity, non-stationary data and residual outliers. The t statistics are written in parentheses. * p<0.10, ** p<0.05, *** p<0.01: statistically significant on the 10%, 5% or 1% level.

Even in the optimal model, results are not in line with the second assumption that was made at the beginning of this empirical case study. As shown in Table 5 there is only 1 significant factors in the optimal model, namely the Swedish 10-year government bond yield. More precisely, when the 10-years Swedish treasury rate increases by with 1 percentage point, the average Swedish mortgage loans rate is expected to increase by 0.87 percentage points. Consequently, there is a significant positive correlation between the Swedish treasury rate and average Swedish mortgage loan rate. As shown in Table 5, all the other variables in the optimal model are not significant.

3.4. Summary of the empirical results

From the regressions, can be concluded that there is only one significant variable. Growth in the 10-year Swedish treasury rate has a significant positive correlation with the growth of the average Swedish mortgage loan rate. This result is in line with the findings of Sirmans et al. (2013). They found that there is a strong positive relationship between mortgage loan rates and capital market rates, most prominently the 10-year treasury rate. The other variables of the optimal model: growth rate of the RWA as percentage of the total assets of Swedish banks, money amount in Sweden (M1) and growth rate of the 3-months Swedish interbank rate were not significant (Table 5). As a result, the assumption that the average Swedish mortgage loan rate will increase when the RWAs as a part of the total assets will increase with the Basel IV regulation is not confirmed with this empirical research. More specifically, between the fourth quarter of 2011 and 2018 there has been no correlation between the Swedish mortgage loan rates and Swedish banks' RWAs

as a percentage of the total banks' assets. The literature review showed that when money supply increases, it puts downward pressure on the interest rates, including mortgage rates (Investopedia, 2019c). This is not in line with the results of the optimal regression.

There are different explanations for these remarkable results. First of all, the concentration of the Swedish banking sector was not taken into account. As mentioned in 2.1.4 the Swedish banking industry is a dense sector. In 2018 the four major Swedish banks, Handelsbanken, Nordea, SEB and Swedbank were responsible for 80% of the Swedish banking market (Riksbank, 2018). Consequently, the competition is very high. This makes it very hard for one of these banks to increase mortgage loan rates. When one bank would do that, they would lose all their borrowers to one of the other big three Swedish banks. This is also one of the reasons why mortgage loan rates are so low in Sweden right now. This could be the first reason why the results in Table 5 of the RWAs as percentage of the total Swedish assets was not significant. Secondly, instead of charging the extra cost of the higher Basel IV equity requirements, banks could also change their funding structure. As seen in Table 5, the average Swedish mortgage loan rates have almost a one on one relationship with the 10-years government bond yield. This is because banks use government bonds as a long-term funds (Sirmans et al., 2013). As a result, when the bond yield increases it will influence the mortgage loan rates of banks. The third reason for the discrepancy between the literature review of the control variables and the empirical result is the samples. In the empirical research Sweden was taken as a sample while the literature was often Europe or another country.

Finally, I discussed the results of this empirical case study with Jonas Niemeyer from Riksbank[21]. Niemeyer (2019) had several remarks. Firstly, he confirmed that if the Basel IV output floor will be implemented in Europe the way it is described in the Basel framework, the RWAs of the major Swedish banks are expected to increase. As a result, Niemeyer (2019) confirmed the first assumption that was made in this empirical research. This assumption was that the credit risk RWAs of Swedish banks will increase with the implementation of Basel IV. Secondly, he stated that this does not necessarily mean that the capital requirements in terms of amounts of Swedish banks will increase. This is because Swedish banks are subject to high buffers set by the FSA as described in 2.4.1 of this dissertation. The Swedish FSA has publically declared that they would review the systemic risk buffers when the Basel IV output floor is implemented in Sweden (Niemeyer, 2019). This means that it all depends on the Swedish FSA whether or not Swedish banks' capital requirements will increase or not with the implementation of Basel IV. Finally, Niemeyer (2019) stated that mortgage loans are a very profitable business for Swedish banks.

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[21] Riksbank is the Swedish Central Bank

As a result, if a bank in Sweden would face problems, it is possible that they would increase their mortgage loan rates.

4. Conclusion

This dissertation researches the impact of Basel IV changes in credit risk RWAs calculation on Swedish banks and their RRE mortgage lending. The focus is on the impact of Basel IV on Swedish banks because it is expected that the RWAs of Swedish banks will significantly increase due to the implementation of the output floor. In addition, this thesis explored the connection between the residential real estate and financial sector, mortgage loans and financial crises in Sweden.

In the literature, I learned that many financial crises in the past were caused by boom-bust cycles in the RRE sector. Both the Swedish real estate crisis of the 1990s and the most recent global financial crisis were caused by RRE bubbles. This is because RRE is a major part of households' wealth and RRE also constitutes a major source of collateral for lenders. Additionally, RRE is also connected to the real economy. It is a source of employment, investment and growth. In 2010 the ESRB was founded to keep macroprudential oversight of the European Union and in order to prevent and mitigate systemic risks. The ESRB developed together with the ECB a framework to analyse RRE vulnerabilities. The ESRB gave in 2016 a medium-term warning for RRE vulnerabilities to Sweden and 7 other member states. In 2016 the ESRB found six medium-term RRE vulnerabilities as a source of systemic risk to the Swedish financial stability, of which five are still valid today. The six Swedish RRE vulnerabilities in 2016 were: low-interest rate environment, increased RRE prices, rising household debt levels, structural factors under control of the Swedish government, risk of reverse economic situation and interconnectedness between Nordic banks. The one Swedish RRE vulnerability that is not valid today is the risk of reverse economic situation. Currently there are also non-RRE related vulnerabilities in Sweden, such as low RWs, high maturity mismatches and the high concentration in the Swedish banking system.

Next to the ESRB, there is also the BCBS as a macroprudential policymaker. After the most recent global financial crisis they developed the Basel III accords. The aim of Basel III was to strengthen regulation, supervision and risk management. It provides a foundation for a resilient banking system that should help to avoid the build-up of systemic vulnerabilities. While Basel III focused more on the capital side of the capital ratio calculation, Basel IV concentrates on the calculation of the RWAs. More specifically, with Basel IV the BCBS wants to strengthen credibility of risk-weighted assets calculation and to improve comparability of banks' capital ratios. This is done by making the RWs more risk sensitive. For example, instead of a flat risk weight of 35% for a RRE mortgage loan calculated with the SA approach, with Basel IV the risk weights of mortgage loans will depend on the LTV ratio. Additionally, with Basel IV risk weight used in the SA approach will

form the basis for the RWs of the IRB approach. This is because of the output floor. With Basel IV the RW of the IRB has to be at least 72.5% of the SA approach. In this way, the riskiness of the RRE mortgage loans will be better represented into the capital that banks have to hold with the implementation of Basel IV. This Basel IV framework together with the fact that Swedish banks are heavy users of the IRB model and they also have a high percentage of RRE mortgage loans on their balance sheets, makes Swedish banks vulnerable to the new Basel framework.

By adding the empirical case study to the dissertation, I attempted to investigate whether Basel IV would increase the Swedish mortgage loan rates. More specifically, I tested the hypothesis that the Swedish average mortgage loan rate will increase when the RWAs as a part of the total assets will increase with the Basel IV regulation. This hypothesis was based on two assumptions. This is because Basel IV is not implemented yet. As a result, there is no data available yet on the impact of Basel IV regulation on banks. However, it is possible to look at the balance sheets how they are today and see what happens when Basel IV would be implemented now. The first assumption is that the RWAs of Swedish banks will increase due to the output floor of Basel IV. As a result, Swedish banks would have to increase their capital in order the be compliant with the Basel capital requirements. The second assumption that was made was that Swedish banks could possibly pass on the extra funding costs to their customers. This is done by increasing the mortgage loan rates. However, the empirical case study showed that between the fourth quarter of 2011 and 2018 there was no correlation between the Swedish mortgage loan rates and Swedish banks' RWAs as a percentage of the total banks' assets. Additionally, there was only one significant variable in the analysis namely, growth in the 10-year Swedish treasury rate. As a result, the hypothesis that the average Swedish mortgage loan rate will increase when the RWAs as a part of the total assets will increase due to Basel IV is not confirmed with this empirical research.

In the last paragraph, I would like to critically evaluate the methods and results presented in this dissertation. I do this in the hope to help to formulate proposals for further research. In the empirical case study, I looked at how RWAs as percentage of total assets of the major Swedish banks affected the mortgage loan rates in the past. There were seven control variables added to the model in order to control the financial and economic circumstances. However, I could have added more variables to the empirical model, for instance a variable that covers the concentration in the Swedish banking world or a dummy variable for changing the systemic risk buffers in Sweden. The main pitfall of this dissertation is that Basel IV is not implemented in the EU rulebook yet. Moreover, Basel III is not even fully implemented. As a result, the balance sheets of Swedish and other European banks are continuously adapting to new regulatory frameworks. Additionally, there is the fact that the Swedish FSA will reduce the systemic risk buffers when the Basel IV

output floor will be implemented. As a result, it is too early to make estimations of how Basel IV will impact Swedish banks exactly. What we can conclude today is when the output floor would be implemented now as the situation is, the RWAs of Swedish banks would increase. In the following years further research should be done with taken the Swedish FSA into considerations and all necessary variables to have a better view of how big the Basel IV impact will actually be on Swedish banks.

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Attachment A: Independent variable data quality analysis

Table 6: Comparison data RWAs/Total assets between two sources (ECB and Swedish Statistics) from Q4 2014 until Q3 2018 [22]

Date	ECB Data (%)	Swedish Statistics Data (%)	Deviation (pp)
2014 - Q4	22.71	22.05	0.66
2015 - Q1	21.58	21.21	0.37
2015 - Q2	22.11	21.65	0.46
2015 - Q3	21.77	21.18	0.58
2015 - Q4	23.13	22.75	0.38
2016 - Q1	21.38	20.85	0.53
2016 - Q2	21.77	21.13	0.64
2016 - Q3	21.62	21.27	0.36
2016 - Q4	23.29	23.04	0.25
2017 - Q1	21.86	20.78	1.08
2017 - Q2	22.17	21.12	1.05
2017 - Q3	22.30	21.30	0.99
2017 - Q4	23.91	23.18	0.73
2018 - Q1	22.60	22.08	0.52
2018 - Q2	22.29	21.74	0.55
2018 - Q3	22.48	21.79	0.69

Table 7: Statistics of the Deviation between the sources from above

	Deviation (pp)
Mean	0.61
Median	0.57
Minimum	0.25
Maximum	1.08

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[22] ECB data (%): RWAs/Total assets of all Swedish banks
Swedish Statistics (%): RWAs/Total assets of the four biggest Swedish banks in 2018 (Nordea, SEB, Swedbank and Handelsbanken)

Attachment B: Summery Statistics

Table 8: Summary of Statistics empirical model variables

Variable	Mean	Median	Std. Dev.	Minimum	Maximum
MLR_t	2.9858	2.6187	0.87802	1.8585	4.6330
$RATA_t$	26.267	22.460	6.4740	20.779	39.000
INF_t	0.85517	0.80000	0.96273	-0.50000	2.9000
GDP_t	0.52512	0.65258	0.65410	-1.6918	1.5700
$M1_t$	2.1438	2.2102	1.3791	-0.23192	5.0107
RP_t	649.28	644.00	95.776	525.00	782.00
IR_t	-0.087724	-0.11850	0.27026	-0.36390	0.62700
SR_t	0.087011	-0.28333	0.81811	-0.77667	1.5467
TR_t	1.1610	0.79667	0.65158	0.16333	2.3767

Attachment C: Interview Jonas Niemeyer (Riksbank)

This appendix contains the transcript of the phone interview with Jonas Niemeyer from Riksbank on the 29th of May 2019. This transcript was reviewed by Jonas Niemeyer and agreed to use as an official source for this dissertation.

1. How do you explain the decrease of RWAs of Swedish banks between 2011 and 2017 even though the total assets of the Swedish banks increased?

   There are two explanations for the decrease in RWAs during this period.
   - *IRB approach has been successfully introduced in Swedish banks. Now Swedish banks use the IRB approach for more portfolios than they did a few years back.*
   - *The second explanation of this lower RWAs even though the total assets of the Swedish banks increased is the housing boom. This had as result that there is a bigger proportion of mortgage loans compared to loans to corporates on the Swedish banks' balance sheets. Since these mortgage loans typically have lower RWs, the average RWs have fallen between 2011 and 2017.*
   - ⇨ *Shift in the composition on the asset side and the increased IRB model effect.*

2. How do you explain the high profitability of Swedish banks while they also have a high amount of equity compared to their European peers?

   Swedish banks have fairly high capital ratios (RW ratios). However, Swedish banks' leverage ratios are not so high compared to their European peers.
   It depends on how you look at the risks:
   > *Risk based measures are very high in Sweden.*
   > *However, on the balance sheet the capital ratios are less impressive.*

   High profitability is partly due to the crisis of the '90 which caused a focus on decreasing the costs. There are comparatively few branches in Sweden. The branches that remain are mainly advisory branches. As a result, Sweden has much lower staff costs than most European banks. Scope for improving efficiency in European banks is very high. While in Swedish banks this is lower, because they already made the transition.

   Additionally, Swedish banks also have low funding costs.
   This is because Swedish banks are highly dependent on market funding. Half of Swedish banks their funding is market funding (which is also a risk). More specifically, of this market funding around 50% is in foreign markets (Mainly US).

3. How far does Sweden stand with the implementation of Basel III and IV. Is there an overview of how far all the banks are?

   Sweden follows the European implementation of the Basel rules. This means that the first Basel III measures are largely implemented. A part of Basel III comes into bank package 2, which was agreed last year. This bank package 2 has to be implemented by the end of 2020 in Sweden (including leverage ratio requirements and NFSR.)

Swedish banks are preparing for the Basel III finalised output floor. The FSA has implemented a systemic risk buffer of 3% + pillar two requirement of 2 percent (for the biggest Swedish banks). These banks would be most affected by the implementation of the output floor. When the Basel III finalised output floor is implemented the FSA has publically declared that they would review and adjust the buffer requirements.

The output floor will reduce the reported capital. This does not mean that banks really have to adjust their capital because FSA will adjust the buffer requirements.

Output floor increases the denominator (RWAs). The FSA already increased the nominator. As a result, when the denominator increases and the nominator would be adjusted by the FSA, capital requirements could remain constant or increase only marginally in terms of Krona. Therefore, it is not clear whether Swedish banks really have to increase their equity. To which extent the FSA will adjust the nominator is not known yet. Additionally, the way how the output floor will be implemented in Europe is not clear yet.

4. During the development of Basel III and IV, Stefan Ingves (Governor of the Sveriges Riksbank) took on the responsibility of being the BCBS chairman. Did this influence the Basel III and IV regulation positively towards Sweden?

   Stefan Ingves did not impact Basel III positively towards Sweden. His task as the chairman was to reach an agreement not to promote particular Swedish positions. Stefan Ingves was very successful in this effort.

5. How will Basel IV affect the RWAs of the Swedish banks?

   If the Basel IV output floor will be implemented in Europe the way it is described in the Basel framework the Swedish RWAs are expected to increase. This doesn't necessarily mean that the capital requirements in terms of amounts of Swedish banks will increase because Swedish banks are today subject to high buffers. The FSA will most likely reduce these buffers when the output floor is implemented.

   The Swedish bankers Association also made a simulation indicating that when the output floor would be implemented in Sweden today that these banks their capital requirements would increase substantially. However, this is not a reasonable outcome. The FSA will adjust the buffers and this was not taken into account in these simulations. The question is: "to what extent will the buffers will be adjusted by the FSA?".

6. In case when the RWAs increase with the Basel IV implementation what is expected to happen in Sweden to fulfil the Basel regulation.

   It is too early to tell if capital requirements in Euros will increase or decrease. However, mortgage loans are a very profitable business for banks. If banks would face problems it is possible that they would shift it on the mortgages but this is speculation of course.

7. Which factors determine the Swedish mortgage loan rates.

   Here is already assumed that capital is more expensive than debt funding (according to the Miller Modigliani theory it should not be more expensive, but this does not take taxes

into account). As a result, it is not 100% clear that equity funding is so much more expensive than debt funding.

The FSA has imposed a number amortisation requirements. The aim of these amortisation requirements is to limit the number of mortgages granted in Sweden because this reduces the LTVs and DTIs. These amortisation requirements have dampened the mortgage market, this could have in turn an influence on the Swedish mortgage loan rates.
However, there are more important factors that influence the Swedish mortgage loan rates, such as the funding costs and interest rate environment.