Determinants of RMBS default probability in the Netherlands and its performance in relation to prior-to-establishment ratings. Why have Basel III regulations mitigated the rating inflation effect and led to a better performance of the Dutch RMBS?

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June 23, 2016

Abstract

This paper studies the determinants of performance of Residential Mortgage Backed Securities (RMBS) in the Netherlands. Expected default rate of 33 RMBS transactions is estimated for 12 quarters after origination through logistic regression. Also, an abnormal default rate of each transaction is tested to determine what causes under- or over-performance of RMBS in the Netherlands. This paper finds that motives of origination, together with the macroeconomics performance, play a significant role in a post-origination performance of RMBS. The implementation of Basel III regulations has led to less rating inflation. Also, banks that have originated RMBS, in order to comply with the new Basel III regulations have seen their RMBS perform relatively better than less capital-constrained banks.

JEL classification: G11, G21, G24, G28.

Keywords: Residential Mortgage Backed Securities, Basel III, Rating Inflation.

1. Introduction

Originating Residential Mortgage Backed Securities (RMBS) involves selling part of a loan portfolio to a Special Purpose Vehicle (SPV) that is subsequently acquired by investors to obtain future cash flows from loan repayments (Iacobucci and Winter, 2005; Gorton and Souleles, 2007). During the years 2010-2015, RMBS have remained the most widely issued security which constituted on average 56 percent of the European securitization market worth 1.45 trillion euro (SIFMA, 2016). Furthermore, The Netherlands issued 23 percent (of which 92 percent was RMBS) of all the securities in Europe during the same period of time, meaning the Dutch market remains one of the major securitization markets.

Before a RMBS is sold to investors, it is assessed by credit rating agencies (CRAs) which determine its quality in terms of, among others, default risk. CRAs, with their rating methodologies, consider different aspects that relate to the characteristics of a borrower and a loan that he or she borrows. However, other potential factors have been identified that are not considered by CRAs, but which affect default probability of RMBS. This paper attempts to research and test them.

Opp, Opp, and Harris (2013) argue that Basel regulations, which require maintaining an adequate level of capital, increase demand for the highest rated assets, as they are considered to be the safest and require the least reserve capital (i.e. risk weighted assets) to cover eventual losses. This leads to a so called rating inflation, as CRAs provide RMBS with ratings that are inadequate to its performance. They also find that banks are likely to be aware of the higher than expected risk of the highest rated assets but are still likely to accept the lower than expected quality of securities with the highest rating, in order to maintain adequate capital ratios (e.g. Tier-1 Capital ratio). They expect that this might have changed after the introduction of the Basel III regulations which reduce the reliance of risk-weighted assets calculation methodologies for ratings assigned to a RMBS. As a result, banks are less likely to demand highest rated RMBS which might reduce the rating inflation among the highest rated RMBS and therefore their under-performance.

Also, He, Qian, and Strahan (2016) argue that there are originators that are likely to shop for a favourable rating by selecting a single CRA that provides the highest rating, rather than obtaining multiple ratings from different CRAs. Hence, it is likely that part of the RMBS have only one rating because additional ratings are unfavourable and the originator might decide not to publicize them. In such a situation, an average factual rating is lower than the single rating that is disclosed. He, Qian, and Strahan (2011) also find a positive relationship between the size of a bank in terms of asset value and ratings that they obtain. Larger banks are more likely to obtain higher ratings for RMBS of a similar credit quality compared with smaller banks. They explain that larger banks are able to pay larger fees to CRAs which leads to more competition for the higher fees by offering more attractive (i.e. more inflated) ratings. In addition to that, Ashcraft, Goldsmith-Pinkham, and Vickery (2010) find that the positive effect of subordination on improving RMBS credit quality tends to be overestimated which also results in rating inflation.

Furthermore, Acharya, Schnabl, and Suarez (2013) and Michelangeli and Sette (2016) find that banks that securitize are more likely to do it when they have a high need for capital, such as Tier-1 capital. It might lead to securitizing high quality loans that banks would not normally securitize. This is because banks might find it insufficient to restrict the amount of newly granted loans, in order to satisfy capital adequacy regulations (i.e. Basel regulations) in the short time horizon.

In this paper, I test whether actual default rates of Dutch securities diverge from what has been predicted by ratings provided by CRAs at the date when the security is originated. I determine the factors that cause the divergence in the actual default rate from the one predicted by rating agencies. Motivated by the research of Opp et al. (2013), I test whether new Basel III regulations have led to less rating inflation and hence, to a better performance of RMBS assets after 2014 when the new rules were introduced. Furthermore, I analyze whether capital-constrained banks are more likely to use securitization, a more drastic method of reducing the amount of risk-weighted assets compared to restricting te issuance of new loans,

as argued by Acharya et al. (2013) and Michelangeli and Sette (2016). Also, I determine whether the rating shopping phenomenon exists in the Netherlands, by analyzing whether large originators that disclose a rating from a single CRA for securitized assets under-perform thereafter, and whether the level of subordination affects the post-origination performance of RMBS.

I test the performance in terms of default rates on a carefully assembled sample of 33 RMBS transactions over 12 quarters after their origination. I gather a sample from the loan level data warehoused by the European Central Bank (ECB loan level data), which covers the period of November 2012 until January 2016. Loan level data samples for each quarter vary between 35,000 and 200,000 loans. These comprehensive samples allow me to estimate expected default for each transaction precisely, which is necessary to test the hypotheses.

To determine how RMBS perform in relation to its expectations at the time of origination, I follow the methodologies of Begley and Purnanandam (2014) and Demyanyk and Van Hemert (2011). I test the performance of RMBS in two steps. The first step of my methodology estimates expected default rates of RMBS transactions for each of the first twelve quarters after an origination. Expected default rates are obtained from fitted values, which can be conveniently calculated when conducting logistic regression. The relationship between loan characteristics and default rates of mortgages are in line with the assumptions of CRAs when they provide credit quality rankings.

In the second step of my empirical model I test whether ratings provided by CRAs predict default rates and what explains the eventual divergence of the actual default rate from its expected probability. I calculate the abnormal default rate, defined as the actual default rate divided by the expected default rate. The results of the second step suggest that Basel III regulations mitigated rating inflation, as a RMBS transaction originated during or after 2014 when the new rules had been put in force, is likely to perform better than the identical transaction originated before 2014. I also find that banks with a higher need for Tier-1 capital originate RMBS with a lower abnormal default rate than RMBS originated by less capital-

constrained banks. My study develops the theoretical model of Opp et al. (2013), which predicts that when the regulatory advantage (i.e. decreased amount of risk weighted assets) of possessing the highest rated notes is high, CRAs are more likely to provide the highest ratings, in order to "satisfy the increased demand from banks". However, if the regulatory advantage decreases, they expect that ratings will become more trustworthy because the demand for the highest rated RMBS decreases which discourages CRAs to inflate ratings. This was what is expected to occur after the introduction of Basel III and I test this theory empirically. Moreover, I find that capital-constrained banks are not only likely to reduce loan issuance, as argued by Michelangeli and Sette (2016), but they are also likely to securitize their existing loans to reduce the value of risk-weighted assets.

Furthermore, I find an unexpected significant negative effect between the size of an originator and the abnormal default rate, meaning that securitized mortgage loans from large banks over-perform compared with similar RMBS originated by smaller banks. However, I do not find any significant relationships between the level of subordination and the number of ratings provided to RMBS tranches.

The results are robust with respect to a different method of calculating the default rate, where it is equally-weighted, rather than value-weighted. Similar results are obtained in the case where non-rated RMBS tranches are quantified as if they were provided with the lowest available rating in the sample (CCC+/CAA1), rather than the lowest possible rating (CCC/CA). Also, the results remain unchanged when unemployment is substituted for GDP which is a factor that depicts a current macroeconomic situation.

The rest of the paper is structured as follows. Section two discusses the securitization process. Section three studies the methodologies of rating agencies and the rating process, as well as factors that cause rating inflation and develops the hypotheses tested in this paper. Furthermore, sections four and five analyze the data sample and develop the empirical model. Finally, section six tests the model and discusses the results. Section seven concludes the findings of this paper.

2. Securitization process

Originating RMBS is part of the structured finance discipline that deals with credit risk transfer instruments (Benmelech and Dlugosz, 2010). Securitization involves pooling debt instruments and individual loans and selling them as one package to third-party investors. Such products involve structured Mortgage Backed Securities (MBS) and Asset Backed Securities (ABS) among others. These are further categorized depending on the time horizon (long- or short-term) or the type of the underlying asset (residential, commercial, car loans, credit card loans, government bonds, covered bonds and so on).

Gorton and Souleles (2007) and Fender and Mitchell (2009) argue that there exist several incentives for securitization:

- Transfers risk to third parties, as the financial risk of default on mortgages is transferred to investors, which decreases the riskiness of an originator.

- Provides efficient access to new capital markets, which helps to diversify funding sources and offers a lower cost of capital.

- Increases the ability to raise capital for companies that are unable to borrow because of too much leverage or not sufficient liquidity. Securitization lowers leverage of an originator, so that current costs of capital are lowered, which increases their lending ability.

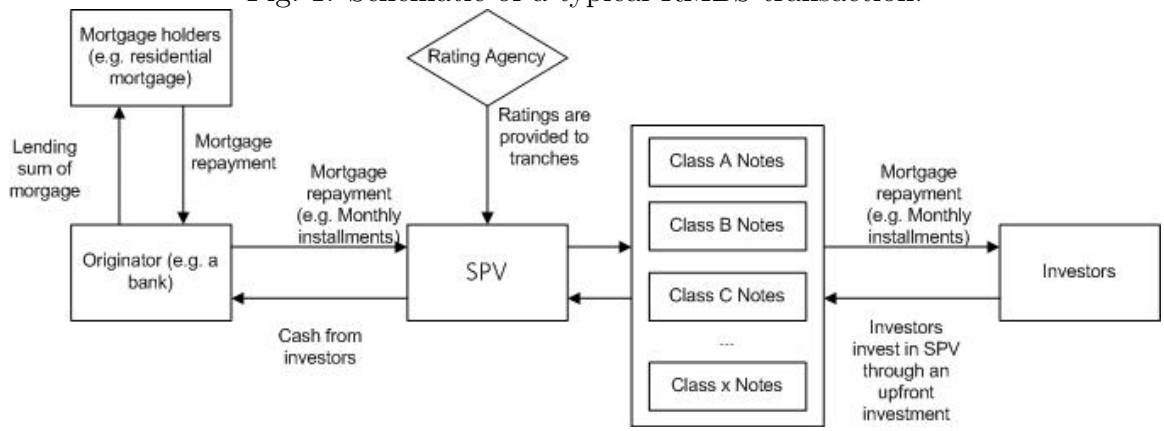
- Offers flexibility in case more valuable investment opportunities are available. Securitization allows the reallocation of funds to more profitable investments.

- Matches assets and liabilities to minimize risk, locking spread between interest earned on assets and interest paid on debt, so that liquidity and matching risks are reduced.

A typical RMBS securitization example is presented in Figure 1. During the issuance of a RMBS, a selected pool of assets (i.e. mortgage loans) is sold to a Special Purpose Vehicle (SPV), which is typically an independent limited liability company (*Dutch besloten vennootschap*), whose assets are not located on the originator's balance sheet and therefore, is bankruptcy-remote (Gorton and Souleles, 2007). The SPV issues debt that is backed by the assets transferred by the originator (e.g. mortgage loans) and receivables therein (i.e.

loan repayments). Asset tranches that differ in riskiness are purchased by different investors and proceeds from the sale are transferred to the originator (Iacobucci and Winter, 2005). The debt issued by an SPV is repaid to investors through the proceeds from mortgage loan borrowers.

Fig. 1. Schematic of a typical RMBS transaction.



Such tranches are subsequently rated by rating agencies to minimize the consequences of an investors'asymmetric information problem (He et al., 2011). Iacobucci and Winter (2005) argue that the securitization market is characterized by asymmetric information with respect to the true value and riskiness of securities originated by banks. Investors possess less knowledge than originators about the debt and its credit quality and this fact is likely to be discounted, thereby leading to lower prices of securities.

The rating process aims to increase the credibility of investment in securities through an estimation of credit ratings, which provides information about the default probability of an analyzed company or a borrower (DBRS, 2015; Fitch Ratings, 2015; Standard & Poor's, 2015; Raschl, 2009). Moody's Investors Service (2009) defines default as the state when a borrower has filed for bankruptcy or when there is a failure to pay or satisfy an obligation, subject to applicable grace periods or waiver of such failure (i.e. it is allowed to be in arrears for a specified number of days).

The rating process usually involves analyzing the following six factors: the macroeconomic situation, business analysis, corporate governance, cash flow analysis and the legal

environment.[1] Additionally, CRAs assess credit enhancement methods, such as subordination, reserve accounts, excess spreads and over-collateralization to improve the rating (Gorton and Souleles, 2007; Adams, 2005). The excess spread is the difference between the interest paid by debtors and coupons received by security owners. This difference serves as a buffer to cover eventual losses. A reserve account is a cash account in a SPV to cover unexpected losses. Over-collateralization means that debt is backed by collateral, which has a higher value than the debt. Lastly, subordination leads to creating a pool of assets through tranching where the lowest rated asset possessors will be the first to bear eventual losses (Ashcraft et al., 2010). The highest rated (usually AAA-rated) asset possessors will be the last to bear losses and thus, subordination provides a protection to AAA-rated asset possessors. According to Gorton and Souleles (2007), subordination remains the most widely employed instrument of the credit enhancement. A summary of all factors and their effect on the default probability that are considered by four largest CRAs (Standard & Poors, Moodys, Fitch and DBRS) in the Dutch market is enclosed in Appendix 1.

3. Literature Review and hypothesis development

Adelino (2009) argues that initial ratings and yields predict future performance in terms of rating downgrades. The lower the initial rating or the higher the initial yield, the more likely it is that the rating of a RMBS will be downgraded. He finds, however, that the yield might have more predictive power than a rating, which suggests that the yield contains additional information that a rating does not contain. Similarly, He et al. (2016) find that initial ratings can partially predict future performance of a security but also additional factors that are not included in the rating methodology might be relevant. Piskorski, Seru, and Witkin (2015)

[1]For example, there exists the National Mortgage Guarantee in the Netherlands (Dutch NHG: *Nationale Hypotheek Garantie*), which offers insurance for loans with a value up to 250,000 euro and guarantees that the NHG will cover the unrecoverable part of the loan in the case of default. This reduces the interest rates of the NHG-protected loans (Dirkx-Westerhof, 2009). Another feature of the Dutch jurisdiction is that mortgage loan interest payments are tax deductible, which affects leverage and the risk of bankruptcy, which is the fact that should be considered during the rating process (DBRS, 2015).

argue that a rating of a RMBS might not reflect its true quality because originators are incentivized to hide part of the relevant and negative information, which leads to overpriced securities and subsequent unexpected losses for investors. Richardson and White (2009) name this phenomenon as rating inflation, which is a consequence of originators that shop for desired ratings. Rating shopping occurs when an originator selects the rating agency that will assign the highest rating or that has the most lax criteria for achieving a desired rating (Benmelech and Dlugosz, 2010).

He et al. (2011, 2016) argue that MBS tranches that are provided with a rating from one rating agency are more likely to have a higher default rate than the tranches rated by multiple rating agencies. Moreover, they find that the larger (in terms of book value of assets) an originator is, the more likely it is that a MBS will under-perform in relation to the rating it has obtained. This is explained by the conflict of interest that occurs when a large originator offers on average larger fees to gain favorable ratings from rating agencies, whose goal is to maximize profits. This is because an originator that buys services of a single CRA, is more likely to have (negative) information to hide. Bongaerts, Cremers, and Goetzmann (2012) find that multiple ratings are primarily assigned to reduce uncertainty about the credit quality and lower the credit spreads. Hence, if a single rating is assigned to a note, it means that an originator has probably selected a CRA that provided the highest (not necessarily adequate) rating. Moreover, they find that notes with single ratings are originated by significantly larger banks compared to multiply rated tranches, which explains their previous findings. In addition, Xia and Strobl (2012) argue that originator paid CRAs are more likely to provide a favorable rating when the conflict of interest raised by the originator-pays compensation is more severe. They find a significant relationship between the rating assigned and the originator's short term liquidity needs, the CRAs revenue share and originators management turnover, which serves as a proxy for the severity of the conflict of interest. Thus, the first hypothesis tested in this paper is:

Hypothesis 1. *RMBS that are provided single ratings or are originated by larger banks are*

more likely to under-perform after origination.

Furthermore, capital regulations might stimulate the demand for the highest rated assets (e.g. triple A rated RMBS), as argued by Opp et al. (2013), who developed a theoretical model that describes the relationship between quality of securities originated, regulatory advantage and the costs of conducting research by a CRA. Financial regulations (e.g. Basel III) usually favor highest rated assets, as higher rated securities imply lower regulatory compliance costs (i.e. less capital is required to back risk-weighted assets). They divide assets into A-rated and B-rated, which indicate higher and lower rated securities respectively (e.g. BB and B, AAA and AA or junk and investment grade bond). They develop a model to test the regulatory advantage of having A-rated assets, rather than B-rated assets. They argue that there exists a unique threshold level of the regulatory advantage (e.g. higher demand for AAA-rated assets due to lower weighted risk), when CRAs provide the A-type rating to all rated assets and stop conducting research to determine the true credit quality of assets. It is because the higher demand for securities rated with the A-type rating (because of the regulatory advantage) outweigh the costs that relate to damaged reputation due to uninformative ratings of securities. They suggest that the effect can be most likely observed between AAA- and AA-rated securities, as well as between investment and junk grade thresholds. These thresholds are in line with Benmelech and Dlugosz (2010) who find that the adoption of Basel II, which ties bank capital requirements to credit ratings, provides additional demand for highly rated securities, in particular AAA, AA+ and AA.

As a result, RMBS that are assigned an A-type rating might in fact not follow the predicted default rate paths, which in turn leads to under-performance of RMBS with an A-type rating relative to its predicted performance by prior-to-establishment rating. However, Opp et al. (2013) argue that banks are likely to be aware of the higher than officially predicted riskiness of securities with the A-type rating. Banks are willing to accept the costs that relate to under-performance as long as they are outweighed by the regulatory advantage (e.g. saved costs due to low risk weight of AAA-rated assets).

However, Opp et al. (2013) mention that new Basel III regulations should decrease the regulatory advantage and thereby the rating inflation effect, as the benefits from the regulatory advantage might no longer outweigh costs that relate to under-performance of the A-rated RMBS. This is because Basel III regulations, whose implementation has begun in the Netherlands in 2014 and which is expected to be accomplished by gradual increases in required capital ratios by 2019 (Bonner and Jongen, 2013), aim to decrease the relevance of rating based approach in calculating risk weighted assets (Basel Committee on Banking Supervision, 2010). Risk-weighted assets can be calculated in a twofold and threefold manner for Basel II and Basel III respectively. Both methods in Basel II use risk weights that rely on a rating provided to assets (the higher the rating, the lower the risk weight), while there is a single approach (out of three) that only partially depends on the credit rating assigned to an asset in Basel III regulations. Furthermore, Basel III regulations introduce higher risk weights and increase the levels of capital ratios (i.e. proportion of safe assets that cover the eventual losses of risk weighted assets). Therefore, the new Basel regulatory changes discourage Dutch banks to hold assets with the highest ratings and requires them to increase capital ratios, which can be achieved through decreasing the amount of risk weighted assets or increasing the amount of safe assets (e.g. Tier-1 capital). Thus, it is more likely that a RMBS originated after the implementation of Basel III rules outperforms similar RMBS originated before the new rules were implemented, as argued by Opp et al. (2013). This effect might be explained by banks being less incentivized to profit from rating inflation due to less reliance on ratings based approach. A more thorough discussion of new Basel III regulations and risk weight calculation methodologies is included in Appendix 2, while a summary of risk weights of RMBS used under different approaches in Basel II and Basel III can be found in Table 7 in Appendix 3. The second hypothesis tested in this paper is:

Hypothesis 2. *Performance of a RMBS in relation to its initial ratings is highly affected by bank capital regulations. New Basel III regulations which aim to decrease the reliance on a ratings-based approach in RWA calculations and increase capital ratios lead to a bet-*

ter performance of RMBS because of the reduced benefits from regulatory advantage which minimizes the rating inflation.

Furthermore, Acharya et al. (2013) find that more capital-constrained banks (in terms of Tier-1 ratio and leverage ratio) are more likely to securitize part of their assets to fulfill the capital requirements. Also, Michelangeli and Sette (2016) find that the lower are the capital ratios (and the higher need for capital), the less loans are granted. This is because banks that need to increase their capital ratios, have to either increase amount of capital, or decrease the value of risk-weighted assets (e.g. through reducing the value of granted loans). Securitization is a less time consuming method of complying with capital regulations because it reduces the risk capital immediately, while reducing the scale of the issuance of new loans is a gradual process of risk capital reduction. Such a situation might also lead to a better performance of assets after the implementation of Basel III regulations, as banks that need to meet the new (stricter) regulatory requirements in a relatively short period of time might securitize high quality loans which they would not normally securitize. This is in line with Hill (1997) who finds that usually the loans that do not comply with banks quality standards are securitized, so that they no longer remain on the banks' balance sheets. If a bank is forced to quickly securitize its loans, it might also remove assets that are of a high quality. Therefore, the following hypothesis that relates to this phenomenon is tested:

Hypothesis 3. *The performance of RMBS originated by capital-constrained banks with a higher capital need, are more likely to securitize assets that are of higher quality and perform better than similar assets securitized by non-capital constrained banks.*

Additional factors that cause rating inflation might also be due to the subordination. DBRS (2015) considers subordinated debt tranches to be more risky, as they are the first to bear losses if a debtor encounters financial problems. Moreover, subordination causes the highest rated debt tranche holders to be safer, due to the cushion that low rating debt provides. Therefore, the highest rated debt tends to obtain a higher rating, due to the

credit enhancement that results from subordination. Subordination below a specific rating is defined as the percentage of securities issued in a deal that have lower ratings than assets with the highest rating (Ashcraft et al., 2010; Demiroglu and James, 2012). Ashcraft et al. (2010) find a positive relationship between the percentage of debt subordinated below AAA and the default probability and suggests that the effect of decreased riskiness due to the subordination effect is overestimated, which leads to ratings that are too high given the factual credit quality of RMBS. They also find that larger subordination below AAA-rated debt leads to a higher probability of credit rating downgrades. This phenomenon is included in the following hypothesis:

Hypothesis 4. *The larger the scale of subordination of a RMBS defined as the percentage of notes with a rating lower than AAA, the more likely it is to under-perform.*

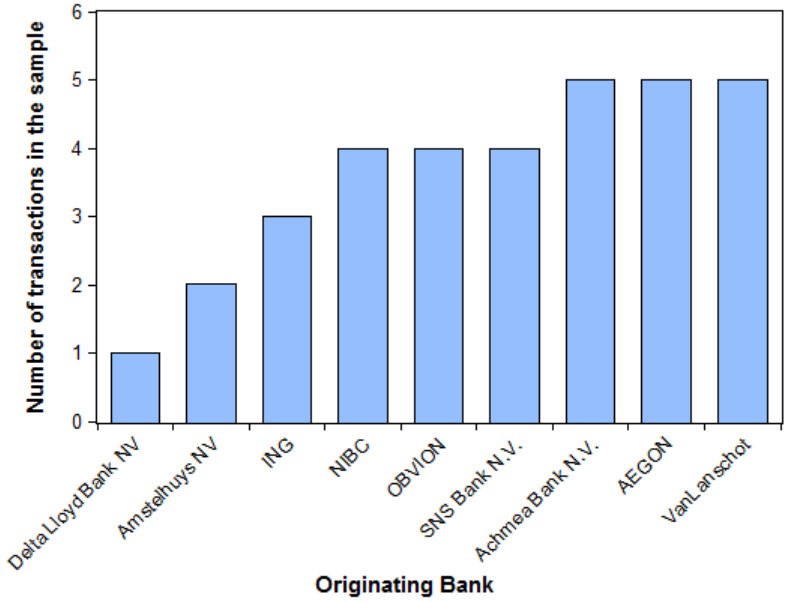
4. Data

The data have been obtained from the European Data Warehouse that maintains a database of loan level data for European RMBS transactions and contains quarterly data for 114 RMBS transactions at the time of conducting this research. I select 33 RMBS transactions for the period of November 2012 until January 2016 and the corresponding loan level data available for the first twelve quarters after the origination [2]. First, a significant part of the data is removed from the sample because standardized and complete database has been maintained by the European Data Warehouse only since November 2012. There are loan level data that are available for the earlier periods; however, it is non-standard and incomplete because it used to be a bank's own decision to maintain a loan level data base. I remove 83 transactions for which no data is available after November 2012 because these transactions have already closed or data is restricted, which could result in biased results. Part of the transactions do not contain complete loan level data for defaulted loans. Including such

[2]The data for each quarter are published at the end of a calendar month every three months. The origination dates can be found in Appendix 5 in the column vintage.

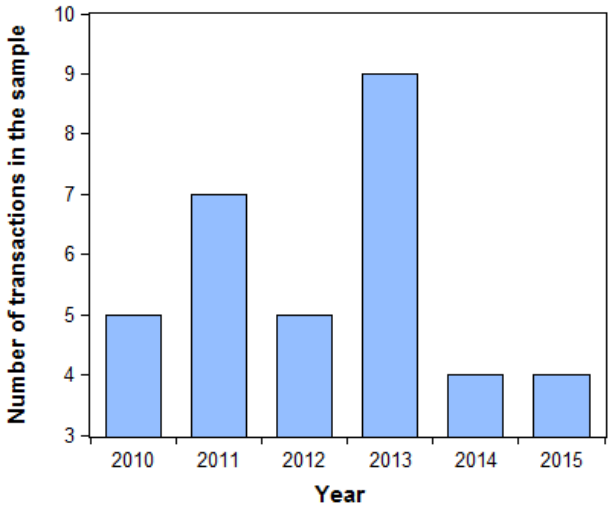
transactions would lead to low default rates for such transactions because the majority of the defaulted loans would be excluded from the sample, while the majority of active loans would still be included in the sample. Therefore, I hand-checked each transaction and excluded those that did not contain complete or nearly complete loan level data. I allow a maximum of 5 percent of all loans in a transaction to be missing, while the percentage of missing loans among defaulted loans to be similar to that of non-defaulted loans. Furthermore, I remove 20 transactions of ABN Amro, 5 transactions of Royal Bank of Scotland, 4 transactions of Nationale-Nederlanden and 2 transactions of Westland Utrecht Bank because they do not maintain any loan level information after defaults, which excludes the possibility of testing the determinants of the default probability. Figures 2 and 3 present distributions of selected RMBS transactions, grouped per originating bank and year of origination A list of more detailed vintage years for each transaction is enclosed in Appendix 5.

Fig. 2. Number of transactions per originating bank based on the sample of the 33 selected RMBS transactions. Nine banks out of thirteen active in the Dutch market during the tested period are included in the sample.



As presented in Figure 4, the default rate of selected transactions is on average 0.13 percent after the first quarter and increases to about 1.5-2 percent (depending on whether

Fig. 3. Number of transactions per origination year in the sample of 33 selected RMBS transactions.



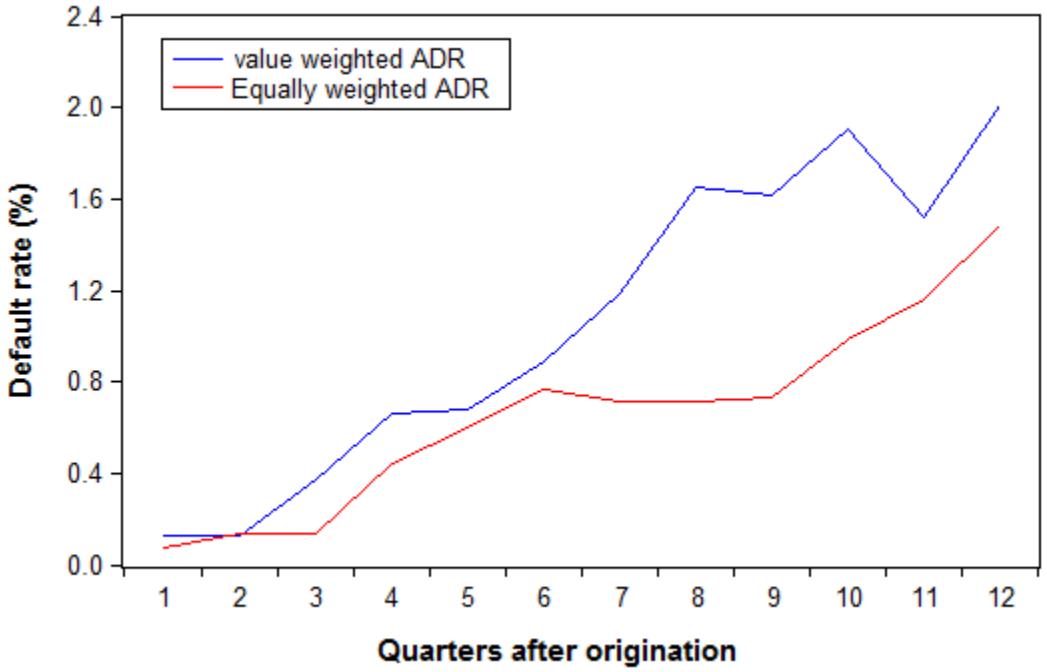
it is value- or equally-weighted) after 12 quarters.

Ratings data and the value for each tranche of RMBS transactions are collected from RMBS prospectuses accessed from the Loan by Loan database[3]. Additionally, I hand-collect supplementary information used in the empirical section of this paper; macroeconomic data (GDP and unemployment rate) from Eurostat and capital ratios (Tier-1 Ratio) together with asset value from the annual reports of the banks. I gather data from the annual reports that concern bank branches at the country level; for example, a Dutch branch of ING, so that the foreign branches of banks selected in the sample are excluded.

Table 1 presents the characteristics of RMBS transactions selected in the sample. Moreover, average value-weighted ratings vary between 2.55 and 2.85, depending on the method of quantifying non-rated loans, which suggests that the average rating of all transactions is between AA+ and AA. Furthermore, banks have increased their Tier-1 capital on average by 2.8 percent (median is 3 percent), which is explained by the stricter capital regulations introduced with Basel III. Figure 5 presents an overview of how the Tier-1 capital ratio has

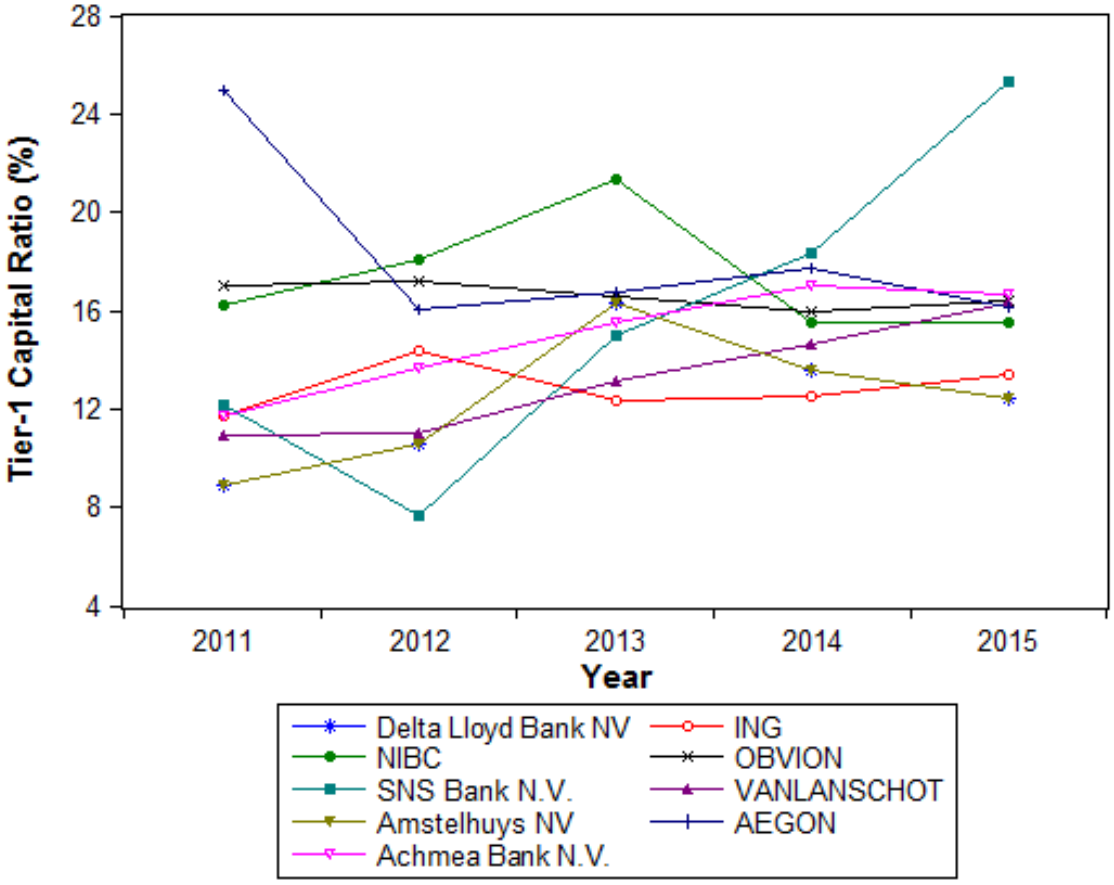
[3]Separate ratings are provided for different tranches that are part of a RMBS transaction. Therefore, I use the tranche value-weighted average rating that is quantified as follows: AAA is quantified as 1, AA+ as 2, AA as 3, A+ as 4 and so on. A complete list of rating quantifications is enclosed in Appendix 7

Fig. 4. Value- and equally-weighted ADR (Actual Default rate) for the selected 33 transactions for each quarter after origination. Value-weighted ADR takes defaulted values into account in default calculations. If a large loan is in default, it is thus likely to increase the default rate of the RMBS transaction significantly. Equally weighted ADR assumes that each defaulted loan has the same weight, irrespective of whether the loan is of a significant or insignificant size. The default rate decreases in the 11^{th} quarter for value-weighted ADR, which is explained by the fact that data is unavailable for each transaction for all the twelve quarters after origination. For example, the sample value might decrease slightly in the eleventh quarter, due to the fact that a RMBS transaction with a high default rate is included in the data for the 10^{th} quarter but excluded in the 11^{th} quarterm which decreases the default rate of the sample in the 11^{th} quarter.



been changing for the Dutch financial institutions included in the sample during the period 2011-2015. Also, on average 13.3 percent of the value of a transaction is rated by rating lower than AAA and each tranche is rated by an average of 1.189 (median 1.143) CRAs. The transactions were originated by banks with an average asset value of 43 billion euro (median 10.9 billion euro). During the period of 2013-2015, the GDP of the Netherlands has increased on average by 0.3 percent per quarter, while unemployment was equal to 7.2 percent on average.

Fig. 5. Tier-1 capital ratio change for Dutch financial institutions originating RMBS during the period of 2011 and 2015. Tier-1 ratio is defined as a proportion of Tier-1 capital to risk weighted assets.



Furthermore, I estimate the expected default rate based on the loan level characteristics for each of the 33 selected RMBS transactions. Descriptive statistics for the variables used in the logistic regression for each quarter is presented in Table 2.

The variables *PDTI* and *OLTV* were winsorized and 0.5 percent of the lowest and 0.5 percent of the highest values were excluded from the sample, in order to minimize the negative effect of outliers. The data are generally consistent with recent studies about the Dutch mortgage market.Fitch Ratings (2013) and Mastrogiacomo, Van der Molen, et al. (2015) report an average OLTV that ranges between 78-86 percent, which is comparable with an average *OLTV* ranging between 78 and 88 percent in the tested sample. Moreover,

Table 1: Descriptive statistics of transactions tested in this paper. The value-weighted rating (*ValWeighRat*) is calculated in a twofold manner. The first method treats non-rated tranches as the lowest available rating in the sample (17), while the second methods assumes that non-rated tranches are provided with the lowest rating that a transaction can obtain(24). Naturally, the first method leads to the lower value-weighted rating. Tier-1 gap (*Tier1Gap*) indicates a change in Tier-1 capital of banks between 2012 and 2014, which is the period that covers the pre- and post-implementation period of Basel III regulations. Subordination below AAA (*SubordAAA*) is defined as the proportion of a RMBS transaction that is rated with a rating lower than AAA. *AvgNoRat* indicates the average number of ratings provided per tranche in a RMBS transaction, *SizeOriginator* is the total book value of assets at the end of the year during which a RMBS transaction was securitized.

	Mean	Median	Maximum	Minimum	Std. Dev.
ValWeighRat	2.550	1.782	7.448	1.151	1.535
Tier1Gap	0.028	0.030	0.176	-0.026	0.045
SubordAAA	0.133	0.087	0.858	0.055	0.111
Size of a RMBS transaction (€m)	1,471	896	13,641	477	2,012
SizeOriginator (€m)	43,206,141	10,952,600	498,000,000	549,810	117,000,000
AvgNoRat	1.189	1.143	2.333	0.667	0.398
GDP	0.003	0.005	0.009	-0.004	0.004
Unemployment	0.072	0.072	0.078	0.065	0.004

the average equally-weighted default rate in the tested sample is about 0.13 percent for the 1st quarter and increases to 1.5 percent in the 12th quarter following the Figure 4. However, the value-weighted default rate varies between 0.13 percent and 2 percent. The expected lifetime Dutch mortgage default rate is 3.8 percent (Fitch Ratings, 2013) and ranges between 1.5 percent and 5 percent in the samples tested by Mastrogiacomo et al. (2015), who use all outstanding mortgage loans in the Dutch market. The default rate of 5 percent applies to a bucket of loans with a high *OLTV* that exceeds 100. They also report a median seasoning of the Dutch mortgages of 80 months, while it ranges between 74 and 110 in the tested sample. They also add that around 60 percent of all the Dutch mortgages are of interest-only type, while the share of interest-only loans ranges between 62 and 73 percent in the tested sample. Thus, the sample that I test is comparable in terms of characteristics with that of Mastrogiacomo et al. (2015), who analyze outstanding loans in the Dutch market. I therefore assume that the sample tested in this paper is representative.

Table 2: Descriptive statistics of the data used in the logistics regressions conducted on the loan level data for 12 quarters after origination. The variables include characteristics of loan and its borrower and capture factors that are considered by CRAs when estimating the credit quality of RMBS. The explanation of the variables is enclosed in Appendix 4.

	Quarter	*ADR*	*OLTV*	*PDTI*	*2Borr*	*Season*	*FixInt*	*IntOn*	*LifeIns Mortg*	*Mat More25*	*Re Mortg*	*RenCon*	*Sav Mortg*	*Self Emp*
Average	Q1	0.001	83.00	2.56	0.29	79.82	0.84	0.63	0.05	0.85	0.10	0.18	0.17	0.08
	Q2	0.001	82.92	2.42	0.42	93.66	0.86	0.62	0.05	0.85	0.12	0.15	0.22	0.08
	Q3	0.002	78.62	2.57	0.59	107.19	0.81	0.72	0.06	0.88	0.11	0.07	0.09	0.08
	Q4	0.002	78.73	2.57	0.51	110.28	0.81	0.72	0.06	0.87	0.11	0.06	0.09	0.08
	Q5	0.003	80.45	2.64	0.64	105.67	0.82	0.72	0.05	0.87	0.11	0.12	0.10	0.08
	Q6	0.004	80.66	2.62	0.62	105.62	0.83	0.73	0.05	0.86	0.10	0.11	0.09	0.08
	Q7	0.006	83.45	2.37	0.30	116.81	0.85	0.65	0.09	0.81	0.16	0.19	0.10	0.07
	Q8	0.008	85.02	2.47	0.38	106.36	0.85	0.62	0.09	0.82	0.12	0.16	0.10	0.07
	Q9	0.007	85.12	2.51	0.57	92.71	0.77	0.64	0.05	0.85	0.07	0.07	0.13	0.06
	Q10	0.005	83.29	2.47	0.56	97.42	0.76	0.64	0.05	0.85	0.08	0.07	0.13	0.06
	Q11	0.011	88.23	2.25	0.17	119.16	0.83	0.66	0.08	0.89	0.11	0.19	0.13	0.10
	Q12	0.007	80.19	2.37	0.46	109.57	0.72	0.72	0.05	0.86	0.07	0.06	0.14	0.07
Median	Q1	0	87.96	2.24	0	72	1	1	0	1	0	0	0	0
	Q2	0	86.73	2.12	0	86	1	1	0	1	0	0	0	0
	Q3	0	79.60	2.22	1	100	1	1	0	1	0	0	0	0
	Q4	0	79.71	2.23	1	103	1	1	0	1	0	0	0	0
	Q5	0	83.00	2.32	1	96	1	1	0	1	0	0	0	0
	Q6	0	82.77	2.31	1	96	1	1	0	1	0	0	0	0
	Q7	0	87.43	2.10	0	110	1	1	0	1	0	0	0	0
	Q8	0	89.91	2.20	0	100	1	1	0	1	0	0	0	0
	Q9	0	90.15	2.28	1	82	1	1	0	1	0	0	0	0
	Q10	0	87.86	2.20	1	88	1	1	0	1	0	0	0	0
	Q11	0	97.17	1.97	0	107	1	1	0	1	0	0	0	0
	Q12	0	81.00	2.11	0	99	1	1	0	1	0	0	0	0
Min	all	0	9.03	0.06	0	0	0	0	0	0	0	0	0	0
Max	all	1	164	12.61	1	513	1	1	1	1	1	1	1	1

5. Methodology

5.1. Step one: Expected Default Rate Estimation

Empirical testing consists of two steps. First the logistic regression model is estimated which allows me to calculate expected default rates in a convenient manner which is assumed to be equal to fitted values of the regression. Subsequently, expected default rates are used to calculate abnormal default rates, following the methodologies of Begley and Purnanandam (2014) and Demyanyk and Van Hemert (2011). Their methodologies allow me to estimate default rates of transactions through logistic regression after a specific period of time since an origination (e.g. 4 quarters). Therefore, the risk of a negative effect of asset correlation is minimized through the differencing of macroeconomic effects. If I tracked default rates of RMBS transactions over the same period of time, it is likely that results would be biased, as performance in terms of default rates tends to be highly correlated during economic recessions and rather uncorrelated during economic booms resulting in different distributions of default rates during macroeconomic recessions and booms. During economic recessions, when the correlation tends to be high, the distribution of losses resulting from defaults tends to be more tailed which means that expected tail loss is significantly higher during crises. The model attempts to replicate the methodologies of CRAs which are employed to predict cumulative default probabilities and to use factors that affect the likelihood of a loan default. Similar factors are also used by Begley and Purnanandam (2014). A summary of methodologies by four CRAs active in the Dutch market (Standard and Poors, Moodys, Fitch Ratings and DBRS) can be found in Appendix 1. The logistic regression equation of the tested model is:

$$\Pr(ADR_i = 1) = \frac{1}{1 + e^{-\boldsymbol{\beta X_i}}} \tag{1}$$

ADR_i equals one if a loan has defaulted and 0 otherwise and is reported for the i^{th} quarter after the RMBS origination date. $\boldsymbol{X_i}$ is a set of loan and borrower characteristics. These loan characteristics include factors that characterize the riskiness of a loan, namely

OLTV ($OLTV$), primary DTI ($PDTI$), seasoning ($Season$), fixed interest rate loans ($FixInt$), interest only loans ($IntOn$), life insurance mortgages ($LifeInsMortg$), savings mortgages ($SavMortg$) and loans with maturity longer than 25 years ($MatMore25$). However, factors that describe the riskiness of a borrower and his or her intentions include the following variables: remortgage ($Remortg$), borrowing for renovation or construction ($RenCon$), existence of a second borrower ($2Borr$) and self-employed borrowers ($SelfEmp$). A table with thorough explanations of variables, their expected relationship with ADR and source of data is enclosed in Appendix 4.

Variables $PDTI$ and $2Borr$ serve as a proxy for the DTI (debt-to-income) ratio which is missing for a significant portion of the loans, due to the restricted availability of information for the income of the second borrower. It is because banks are not required to report the income of the second borrower. As data for income of primary borrowers, as well as for principal value are available, I create a $PDTI$ which is backed by a dummy variable that equals 1 if there is a second borrower. The $OLTV$ variable also requires assumptions as it might change after origination of the loan due to the addition of the 2nd lien loans which might increase $OLTV$ after the origination of the first loan. I include the most recent $OLTV$ in the sample and expect that it should not have a negative effect on the results because I find less than 0.5 percent cases where $OLTV$ changes after the origination.[4]

Additionally, time and region fixed effects are added, in order to control for the differences in time and regions in the Netherlands. Two periods 1998-2007 and 2008-2014, are identified, where the Dutch housing index was characterized with an increasing and a decreasing trend respectively and which might have affected the demand for loans and their performance. In the case of a decrease in property prices, values of the part of the mortgages might decrease below the value of the mortgages, which may trigger more defaults where the recovered amount of loan is smaller than during the period of increasing property prices

[4]It should be stressed that most recent $OLTV$ does not correspond to current LTV, which is the LTV based on most recent data for a value of a property and outstanding amount of loan. Most recent OLTV is still based on original values of properties and original outstanding values of loans. $OLTV$ differ, however, because if a new loan is granted to the same borrower, its total $OLTV$ increases.

(van Dalen, Badir, and Giesbergen, 2015). Furthermore, a region fixed effect is included, in order to control for the effect of increased susceptibility to property price decrease of the Randstad region[5] which have the highest property prices in the Netherlands and therefore is considered to be more susceptible to significant value declines during crises (DBRS, 2015; Fitch Ratings, 2015; Standard & Poor's, 2015; Raschl, 2009). A borrower is assumed to belong to the Randstad if his or her postal code is equal to a number between 1000 and 3999 which approximately covers the area of the Randstad. A map of postcodes is available in Appendix 6.

Furthermore, borrowers who self-certified their income, are unemployed or possess loans of investment type, loans with a frequency of payments less than monthly or 2nd lien loans are excluded from the model because little or no such loans exist in the Dutch market and therefore it is impossible to test the riskiness of borrowers with these characteristics. Furthermore, a dummy variable indicating if a loan is of a floating rate type was excluded, due to the perfect correlation problem with a dummy variable indicating if a loan is of a fixed interest rate type. It is because there are only fixed or floating rate loans in the market which means that if the loan is not of fixed interest then it is certainly of floating interest, which results in a dummy trap. It is assumed, however, that loans with a reset date of 12 months or longer are also considered as fixed interest rate loans. This is because I regard 12 months period as a sufficient period of time during which interest rate might change significantly which might result in an interest rate shock at a reset date. Furthermore, a dummy variable indicating if loans are supported by the National Guarantee Fund (Dutch *Nationale Hypotheek Garantie*), which insures loans of a principal value up to €250,000, are excluded from the model because data regarding that information was unavailable for about 40 percent of all the loans which could lead to a significant reduction in the sample size.

[5]The Randstad region consists of North Holland, South Holland and Utrecht which are the most populated provinces in the Netherlands

5.2. Step two: Determinants of Abnormal Default Rate

After the determinants of default rate of RMBS for the first 12 quarters are tested, I calculate the abnormal default rate, which is regressed in the second step of the empirical model in this paper and which is equal to:

$$AbnormalDefault_{pi} = \frac{\sum_{i=1}^{Np} w_i(foreclosure_{ip})}{\sum_{i=1}^{Np} w_i(\widehat{foreclosure}_{i,p})} = \frac{ADR_p}{EDR_p} \tag{2}$$

Where ADR_{pi} is the actual default rate for pool (transaction) p and EDR_p is the expected default rate based on the fitted values for the estimated logistic regressions. Abnormal default indicates under-performance if it is above 1 and over-performance if it is below 1. For example, if it is equal to 1.4, it means that 40 percent more loans have defaulted than was expected. I test both value- and equally-weighted abnormal default rates. The value-weighted abnormal default rate is more precise, as values of defaulted loans exhibit significant variations. Also, it is likely that in the case of a default, part of the loan's balance can be recovered. However, in the selected data sample, the recovered value is not always available. If no data about defaulted value is available, I assume first that a borrower defaulted on the last current outstanding balance but in case it is not available I assume that he or she has defaulted on the original value of a loan. It should also be mentioned that part of the borrowers defaulting on the original value might lead to an overestimation of the value weighted default. However, there are around 14 percent of the cases where I assume that a borrower defaulted on the original value because no other information is available and therefore default rates should not be significantly overestimated.

Abnormal default is determined at the time of origination and is based on the information available at the origination moment. The determinants of abnormal default are subsequently tested in the second step and the following OLS regression is conducted:

$$
\begin{aligned}
AbnormalDefault_{pi} &= \alpha + \beta_1 ValWeighRat_{p0} * \beta_2 \geq 2014 + \beta_3 SizeOriginator \\
&= +\beta_4 Origin2012or2013 * \beta_5 Tier1Gap + \beta_6 AvgNoRat \\
&= +\beta_7 GDP_i + \beta_8 SubordAAA + \epsilon_i
\end{aligned} \tag{3}
$$

Where p stands for the pool (transaction) and i for the number of quarters after the origination. I test the unbalanced panel data in the second step through OLS regressions.[6] in order to determine the factors that influence the difference between actual and predicted performance of RMBS in relation to its prior-to-establishment rating.

To test the first hypothesis, I use the *AvgNoRat* and *SizeOriginator* variables. The first variable indicates the average number of ratings per tranche provided to a RMBS transaction. All RMBS transactions in the Dutch market consist of tranches[7], which vary in quality and ratings that are assigned. However, there is only one transaction that has been rated by a single CRA and therefore I create a proxy variable, the average number of ratings, which aims to capture whether a transaction contains relatively large amount of ratings. If the number is relatively low, it indicates that an originator is not confident about the quality of originated RMBS and selects relatively less CRAs to rate the security, which is a similar reasoning as He et al. (2016). Similarly, to test whether larger banks that possess larger financial resources are more likely to obtain a favorable rating, I include the *SizeOriginator* variable which I expect to have a negative coefficient.

The second hypothesis is tested in a natural experiment setting which is possible due to an opportunity that arose with the implementation of the new Basel III regulations in the Netherlands that took place in 2014 (Bonner and Jongen, 2013). Compliance with the new capital ratios has been accomplished through yearly increases in the required capital ratios

[6]Loan level data of sufficient quality has been reported since November 2012. For example, if a transaction was originated in 2011, it is impossible to get loan level data for RMBS transaction for the first four quarters after origination, which results in unbalanced panel data.

[7]The transactions tested in this paper contain between 3 and 7 tranches per transaction.

that is expected to be completed by 2019. As it is possible to estimate the abnormal default rate for whole transactions only, I follow the methodology of Adelino (2009) to quantify ratings and calculate value-weighted ratings for each RMBS transaction. Adelino (2009) determines the scale for ratings which is 26 for AAA, 25 is AA+ and so on. He also suggests that ratings can be quantified in a reverse manner and this is the methodology I follow in this paper. The rating equivalents between the four CRAs present in the Dutch market and their assumed numerical values are enclosed in Appendix 7. It is relevant to mention that the non-rated notes are assumed to have the lowest provided rating in the Dutch market (17) but I also test the case where non-rated is assumed to be equivalent of the lowest available rating (21). Value-weighted rating in combination with a dummy indicating if a RMBS was originated during or after 2014 is expected to be negative and suggests that rating inflation has deteriorated since the introduction of the new Basel III rules (Opp et al., 2013).

Furthermore, the third hypothesis is tested by determining whether the Tier-1 capital ratio gap (*Tier1Gap*), defined as the change in Tier-1 capital ratio between the years 2014 and 2012, had an influence on the performance of RMBS originated by banks with higher need for capital. I expect that RMBS originated in 2012 or 2013 (before the Basel III implementation) by banks with high capital need might perform better due to forced supply of high-quality RMBS which would have not been originated, had the Basel regulations not been changed (Hill, 1997; Michelangeli and Sette, 2016).

The last hypothesis is tested with the *SubordAAA* variable that indicates the percentage of the total value of a RMBS transaction that is rated with a rating lower than AAA. It is expected to be positive, as the higher the subordination level, the more likely it is that the rating provided by CRAs is too optimistic, as argued by Ashcraft et al. (2010). In addition to that, I include a GDP growth as a control variable which aims to control for macroeconomic effects. GDP growth is thought to be the main driver of post-issuance performance of RMBS (DBRS, 2015; Fitch Ratings, 2015; Standard & Poor's, 2015; Raschl, 2009).

6. Results and Discussion

6.1. Step one results: Expected Default Rate Estimation

The results of the 12 logistic regressions are provided in Table 3. The results are generally consistent with the expectations of CRAs. However, the relationships between risk factors and probability of default might be inconsistent at different time horizons since the origination date which should not be neglected by investors. The *OLTV* coefficient is positive and significant for all quarters, which suggests that the higher the indebtedness of a new investment (i.e. purchase of a new property), the higher is the risk that a borrower will be unable to repay the loan in the future. Similarly, *PDTI* is positive and highly significant after quarter 5 with the exception of quarter 7 where it is insignificant. It is likely that the *PDTI* is insignificant in the first quarters because if a borrower that succeeds to get a loan, it means that although, he or she is in a risky borrower, he or she must be able to repay the loan initially. However, through time the financial situation of a borrower might change and even a minor change in income with relatively high *PDTI* might lead to an inability of debt repayment which may result in a default. The relationship between *OLTV*, *PDTI* and default rates is consistent with the research of Ali and Daly (2010), who find a positive relationship between leverage of property investment and default rates. The results also confirm the research of Campbell and Dietrich (1983) and Morton (1975) who find a positive relationship between *initial* LTV and default rates.

Furthermore, I find that the relationship between *2Borr* and *ADR* is significant for all quarters with the exception of the 1st, 7th and 10th quarters. Moreover, it is negative for quarters 1-6 and positive for quarters 7-11.[8] It might be caused by the fact that on the one hand, if there are two borrowers, they are allowed to borrow more and therefore, might be more prone to bear risk. But on the other hand, they are more likely to provide a more stable repayment of debt, due to the existence of two sources of income and less risk that

[8]It is impossible to test this relationship for the 12th quarter because no defaulted loan has also been granted to a second borrower which leads to a perfect prediction problem.

the loan will not be repaid due to unemployment of the borrowers. Thus, during the first 6 quarters, the first effect might outweigh the second, so that loans granted to two borrowers are more likely to default.

The type of interest rate and debt repayment are also relevant. Loans with a fixed interest rate (*FixInt*) do not exhibit a constant pattern as they are both negative and positive during the 12 quarters after origination which is unexpected. This might be explained by the fact that interest rates have not been increasing during the period of 2012-2016 when the default rates were measured. Thus, there were no interest rate shocks that could trigger defaults and therefore, the relationship observed is inconsistent. The relationship between interest-only (*IntOn*) and *ADR* is significant and negative for the majority of the quarters, which is unexpected. Thus, interest-only loans are characterized with lower default rates. The reason for that might be twofold. First, interest-only loans might be safer, as lenders require more protection and collateral for the debt. Second, interest-only loan borrowers repay only interest on the principal and their obligations are temporarily lower which allows to avoid default in the short term. With the passage of time, however, borrowers are obliged to also repay the principal amount what may trigger defaults.

Furthermore, I analyze the relationship between the type and purpose of a loan and *ADR*. Loans with a maturity longer than 25 years (*MatMore25*) are more likely to default, and this relationship is significant and positive for the majority of the quarters. Loans with longer maturities require predicting the future financial situation of borrowers which is more difficult the longer is the maturity. Thus, it is more likely that the financial situation will change and the borrower will be financially insolvent, the longer the maturity is. Furthermore, life insurance mortgages are less likely to default and they exhibit a negative relationship for all quarters, except for the 6^{th} quarter, where the relationship is positive but insignificant.

Table 3: Regression statistics of the estimated default determinants of RMBS for each of the 12 estimated quarters after origination. The dependent binary variable is foreclosure status for each of the twelve quarters after origination. The relationship between factors such as *OLTV* and *PDTI* are tested. Other factors are dummy variables which include additional characteristics such as loan seasoning, the existence of a second borrower, interest only or fixed interest rate, loans backed by life insurance mortgage or savings mortgage, loans provided to self-employed borrowers or with the purpose of renovation or remortgage. I control for region fixed effects by including a the Randstad dummy variable (South Holland, North Holland, Utrecht) where property prices are significantly higher than in other regions of the Netherlands. Additionally, I include time fixed effect through dummy variables for the periods of 1998-2007 (housing price index increase) and 2008-2014 (housing price index decline). ***, **, * indicate significance at alpha equal to 1%, 5% and 10% respectively.

Quarter	1	2	3	4	5	6	7	8	9	10	11	12
C	**-11.98*** **	**-11.69*** **	**-11.85*** **	**-9.54*** **	**-7.62*** **	**-7.33*** **	**-6.8*** **	**-6.94*** **	**-10.3*** **	**-7.09*** **	**-8.22*** **	**-6.7*** **
s.e.	0.95	0.94	1.06	0.85	0.74	0.59	0.58	0.49	0.51	0.53	0.6	0.63
OLTV	**0.04*** **	**0.04*** **	**0.04*** **	**0.03*** **	**0.05*** **	**0.04*** **	**0.04*** **	**0.04*** **	**0.05*** **	**0.03*** **	**0.04*** **	**0.04*** **
s.e.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PDTI	**0.08***	**-0.01**	**0.01**	**0.03**	**0.11*** **	**0.07** **	**0.04**	**0.09*** **	**0.07*** **	**0.07*** **	**0.05***	**0.11*** **
s.e.	0.05	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03
2Borr	**0.14**	**0.74*** **	**0.5*** **	**1.68*** **	**0.67*** **	**0.35*** **	**-0.05**	**-0.37*** **	**-0.45*** **	**-0.12**	**-0.89*** **	
s.e.	0.19	0.21	0.19	0.18	0.15	0.13	0.12	0.1	0.08	0.1	0.3	
Season	**0.01**	**0.01**	**0.01*** **	**0.01** **	**-0.02*** **	**-0.01*** **	**-0.01*** **	**-0.01*** **	**-0.01**	**-0.01*** **	**-0.01**	**-0.01*** **
s.e.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
FixInt	**0.22**	**0.11**	**-0.14**	**-0.35***	**0.48** **	**0.24**	**0.08**	**-0.28*** **	**0.34*** **	**-0.21***	**-0.45*** **	**-0.3*** **
s.e.	0.25	0.24	0.19	0.19	0.21	0.16	0.15	0.1	0.11	0.12	0.13	0.11
IntOn	**-1.19*** **	**-0.86*** **	**-0.62*** **	**-0.52*** **	**-0.07**	**-0.02**	**-0.18**	**-0.29*** **	**-0.21*** **	**-0.23** **	**-0.37*** **	**-0.35*** **
s.e.	0.18	0.21	0.18	0.17	0.14	0.14	0.12	0.09	0.08	0.1	0.12	0.11
LifeInsMortg	**-2.36*** **	**-0.23**	**-0.36**	**-0.54***	**-0.33**	**0.23**	**-0.34***	**-0.54*** **	**-0.15**	**-0.39** **	**-0.38** **	**-0.3** **
s.e.	0.73	0.34	0.3	0.31	0.25	0.19	0.2	0.16	0.16	0.18	0.19	0.15
MatMore25	**0.34**	**1.00** **	**0.02**	**-0.12**	**0.13**	**0.63*** **	**0.8*** **	**0.47*** **	**0.47*** **	**0.41** **	**0.38***	**0.23**
s.e.	0.3	0.43	0.27	0.24	0.18	0.17	0.19	0.14	0.15	0.17	0.22	0.14
Remortg	**0.74*** **	**0.55** **	**0.75*** **	**0.35***	**0.66*** **	**0.38*** **	**0.46*** **	**0.62*** **	**0.98*** **	**0.45*** **	**0.45*** **	**0.53*** **
s.e.	0.24	0.25	0.2	0.18	0.16	0.14	0.14	0.11	0.12	0.13	0.16	0.12
RenCon	**-1.22*** **	**0.44**	**0.14**	**-0.51***	**-0.46*** **	**-0.19**	**-0.55*** **	**-0.61*** **	**-0.21**	**-0.78*** **	**-0.45** **	**-0.41** **
s.e.	0.38	0.28	0.26	0.27	0.16	0.14	0.16	0.14	0.16	0.2	0.19	0.19
SavMortg	**-2.5*** **	**-0.59***	**-1.19*** **	**-0.7** **	**0.14**	**0.11**	**-0.59** **	**-0.35***	**-0.81*** **	**-0.79*** **	**-0.89*** **	**-0.75*** **
s.e.	0.24	0.32	0.39	0.3	0.21	0.21	0.25	0.18	0.18	0.24	0.27	0.21
SelfEmp	**0.15**	**0.83*** **	**0.81*** **	**1.1*** **	**0.51** **	**1.06*** **	**1.33*** **	**1.04*** **	**0.74*** **	**0.9*** **	**0.26***	**-0.03**
s.e.	0.18	0.25	0.21	0.22	0.21	0.14	0.13	0.1	0.11	0.12	0.14	0.16
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	196255	97039	66042	45151	53313	54387	61776	79525	121559	63264	35958	40749
Mc-Fadden R-sq	0.092	0.093	0.076	0.089	0.098	0.081	0.117	0.091	0.128	0.074	0.122	0.094

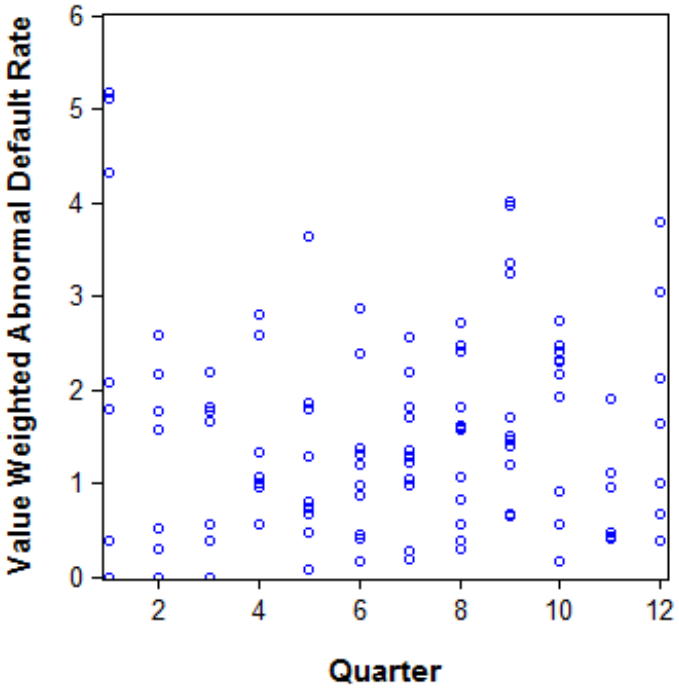
Other types of loans were loans with the purpose of remortgage (*Remortg*) for which the coefficient is significant and positive for all quarters. If a borrower uses a new loan to repay previous loans, it suggest a difficult financial situation and an increased probability of default. Loans with the purpose of renovation or construction (*RrenCon*) are less likely to default (the 2nd and 3rd quarters are an exception but the relationship is insignificant), which is unexpected. It is caused by the fact that such loans are usually of lower value and therefore it is less likely that a borrower will be unable to repay them. Moreover, having a savings mortgage generally decreases the probability of default and this relationship is significant for all the quarters, except for the 5th and 6th quarters where it is insignificant and positive. Savings mortgage allows for reduced mortgage interest rates by backing it with cash that is held by the same bank on a borrowers savings account. Therefore, the collateral of the loan is higher, which decreases the interest that must be paid on the outstanding value of the loan and thus, may lead to a lower probability of default. Also, borrowers that are self-employed are more likely to default, as the *SelfEmp* coefficient is significant and positive for 10 quarters. Self-employed workers are perceived to be less predictable, as their income is considered more volatile and unpredictable for rating agencies. These findings are in line with Vandell and Thibodeau (1985) who also find the positive and significant relationship between the default rate and either single or self-employed borrowers in their study of debtor characteristics.

6.2. Step two results: Determinants of Abnormal Default Rate

The regression coefficients presented in Table 3 are used to estimate fitted values and to calculate the expected default rates of loans (*EDR*), which are required to obtain the abnormal default rate. The average value-weighted abnormal default rate equals 1.456 (median 1.34), which indicates that, on average, Dutch transactions under-perform relative to expectations and there are 45.6% more defaults than expected. Also, the equally-weighted abnormal default rate equals 1.129 on average (median 1.062) which suggests an average

under-performance of 12.9%. The values of value-weighted abnormal defaults for each of the selected transaction is enclosed in Appendix 5 and presented in Figure 6. It can be observed that the range of abnormal default rates remains relatively stable during the 12 quarters.

Fig. 6. Value-weighted abnormal default rate for the 33 selected RMBS transactions for the 12 quarters after an origination. For example, an abnormal default rate of 2 suggests that a transaction exhibited the ADR that is 2 times larger than EDR, which means under-performance.



The results of the determinants of abnormal default are presented in the first column in Table 4. The results suggest that the motive of origination (e.g. fulfillment of Basel III regulations, increasing capital) play a significant role in post-origination performance of RMBS, next to macroeconomic factors. The first hypothesis is not confirmed by the results in Table 4. RMBS originated by larger banks exhibit significantly smaller abnormal default rates, which is unexpected and contrary to the findings of He et al. (2011, 2016). Larger banks might originate RMBS that perform better because they also grant loans with the purpose of raising capital. Banks with a lower asset value might, however, originate RMBS only if they are willing to exclude low-quality loans from their balance sheet, rather than

for the sole purpose of raising additional capital. Moreover, the relationship between the number of CRAs providing ratings and their abnormal default rate is positive but slightly insignificant and which does not confirm the findings of He et al. (2016) who argue that RMBS rated by a single CRA under-perform relative to other RMBS transactions. Furthermore, if the sample size could be increased, the *AvgNoRat* could become significant which would reject the predictions of He et al. (2016). It might be the case that the Dutch originators might not be willing to provide additional ratings if they originate high quality loans, as they do not need to do it because of a satisfactory demand for RMBS observed before origination. However, they might need to provide multiple ratings, in order to encourage skeptical investors that doubt the quality of RMBS by increasing the number of ratings. Such transactions are therefore more likely to under-perform and this could explain the positive and slightly insignificant relationship between *AvgNoRat* and the abnormal default rate.

Furthermore, RMBS transactions with the same rating but which have been originated in or after 2014 exhibit a relatively better performance than a similar RMBS originated before 2014. A transaction originated in or after 2014 rated with the same rating had an abnormal default rate that is lower by 0.356 on average compared with a similar transaction originated before 2014. This finding confirms the second hypothesis tested in this paper. It suggests that since Basel III rules have been implemented, RMBS transactions are less likely to suffer from rating inflation because similarly rated RMBS perform relatively better after 2013. This is in line with the predictions of Opp et al. (2013) who expect less benefits of rating inflation after the introduction of Basel III because the regulatory advantage of the highest rated RMBS is decreased. Basel III regulations aim to discourage reliance on a ratings based approach and reduce the benefits of holding the highest rated RMBS, which means investors are less likely to search for the highest rated RMBS "at all cost", in order to minimize the value of risk weighted assets. As a result, the demand for highly rated RMBS has decreased and CRAs are nowadays more incentivized to provide more reliable RMBS credit ratings, which means that highly-rated RMBS perform relatively better nowadays.

Table 4: Regression statistics of the second model testing abnormal default rate. Abnormal default rate is based either on value-weighted or equally-weighted default rate. Value-weighted rating is an average rating of a transaction which consists of tranches with different ratings. There are two types of value-weighted ratings. The first one quantifies non-rated tranches as 17, and the second one quantifies it as 21. Tier-1 Gap ratio measures change in a banks Tier-1 capital ratio from 2012 until the end of 2014. Other factors include unemployment, GDP growth, subordination below AAA-rated tranches, size of an originator (asset value) and average number of ratings per tranche in a transaction. ***, **, * indicate significance at alpha equal to 1%, 5% and 10% respectively.

Dependent variable	Value weighted abnormal default rate			Equally weighted abnormal default rate
C	5.079***	5.091***	2.662	2.993***
	(1.201)	(1.207)	(2.431)	(0.844)
ValWeighRat$*\geq$*2014*	-0.356***		-0.252*	-0.165*
	(0.132)		(0.131)	(0.085)
ValWeighRat21$*\geq$*2014*		-0.299**		
		(0.121)		
Unemployment			31.991	
			(30.838)	
GDP	-50.113*	-50.573*		-32.668
	(29.202)	(29.351)		(20.508)
*Origin2012or2013*Tier1Gap*	-4.798*	-4.696*	-5.342**	-2.665
	(2.475)	(2.487)	(2.527)	(1.737)
SubordAAA	-0.512	-0.518	-0.530	-0.948
	(1.070)	(1.076)	(1.084)	(0.752)
SizeOriginator	-0.237***	-0.237***	-0.235***	-0.084
	(0.081)	(0.082)	(0.082)	(0.057)
AvgNoRat	0.529	0.507	0.456	-0.144
	(0.326)	(0.328)	(0.326)	(0.229)
Obs.	111	111	112	111
Periods	12	12	12	12
Cross sections	33	33	33	333
R-squared	0.175	0.166	0.151	0.128

As expected by Opp et al. (2013), if CRAs provide triple-A rating to all assets, their rating opinions become unreliable which decrease the demand for CRAs' services because ratings do not provide any information and do not increase investors' confidence. When Basel III regulations were introduced, CRAs were no longer compensated for the rating inflation effect and they needed to begin with providing more informative ratings, in order to stimulate demand for their services and, as a result, less rating inflation is observed.

I also test the relationship between capital-constrained banks in terms of Tier-1 capital and the performance of RMBS. The banks that had a higher need for capital in terms of Tier-1 capital and that have originated RMBS transactions in 2012 or 2013 were more likely to originate transactions that do not suffer from rating inflation. Basel III, which came into force in January 2014, requires a gradual increase in capital ratios, in order to increase the solidity of the banking system. The new Basel III regulations were announced in September 2010 and thus, RMBS originated during the pre-implementation period of 2012-2013 were likely to have been originated with the goal of satisfying the new regulations. I find that the higher the capital need (in terms of Tier-1 capital ratio), in order to comply with Basel III regulations, the more likely it was that RMBS originated in 2012 or 2013 have lower abnormal default. A bank that increased its Tier-1 capital ratio by 5 percent during 2012-2014, originated RMBS that have abnormal default rate that is lower by approximately 24 percent. This is in line with findings of Acharya et al. (2013) and Michelangeli and Sette (2016), who find that more capital-constrained banks are more likely to reduce the amount of new loans granted in the markets and increase incentives for securitizing part of their loan portfolios. Such a situation is caused by the fact that more capital-constrained banks may securitize RMBS that contain loans that would not normally be securitized (Hill, 1997). However, due to a high need for capital that should be raised in a relatively short period of time, banks may also securitize high quality assets.

Furthermore, I find a negative but insignificant relationship between the level of subordination below AAA-rated assets and the abnormal default rate. It is unlikely that the

level of subordination leads to under- or over-performance of RMBS which does not confirm the fourth hypothesis. Dutch RMBS do not suffer from too optimistic credit enhancement resulting from subordination. The additional risk of including riskier loans through subordination is fully explained by the the model tested in the first step of the empirical model. For example, a transaction that contains 15 percent of loans that are subordinated is more risky than a transaction with 5 percent of subordinated loans. But the fact that there is more subordination, does not lead to under-performance relative to expectations that are modelled in the first step of the empirical model. Moreover, I find that the higher the GDP growth, the lower is the abnormal default of RMBS. If GDP growth increases to 0.5 percent per quarter, the abnormal default rate is lower by 25.6 percent, which is in line with the expectations of CRAs that argue that economic growth is the main driver of the post-origination performance of RMBS (DBRS, 2015; Fitch Ratings, 2015).

6.3. Robustness tests

I also test three additional models to check the robustness of my results. These are reported in the three rightmost columns of Table 4. In the first test I calculate the value-weighted rating (*ValWeighRat21*≥2014*), where the non-rated tranches are rated with the lowest available rating (21), rather than the lowest provided rating in the sample (17). Results and significance do not change significantly. The relationship between *ValWeighRat21*≥2014* and abnormal default rate becomes slightly less negative. Similarly rated RMBS originated after 2013 are likely to have an abnormal default rate that is 0.299 lower, compared with 0.356 in the original regression.

The second robustness test substitutes unemployment for GDP growth. Unemployment is highly correlated with GDP growth and contains not only information about the state of the economy, but also about the percentage of the population that are highly unlikely to repay their loans. As expected, there is a positive relationship between unemployment and abnormal default rate, however, it is insignificant. The coefficient of (*ValWeighRat21*≥2014*

becomes slightly less significant but remains negative. Other coefficients are qualitatively similar in terms of coefficient values and significance.

In the last robustness test, I calculate the abnormal default rate in a different manner by treating each default equally, irrespective of its default value. Coefficients remain qualitatively the same, however, *GDP*, *Origin2012or2013*Tier1Gap* and *SizeOriginator* become slightly insignificant with p-values of 0.114, 0.128 and 0.145 respectively. Only the coefficient for *ValWeighRat21*≥2014* remains significant. The loss in significance is caused by the fact that the equally-weighted abnormal default rate is less precise and more prone to bias than value-weighted abnormal default rate because it does not correct for the size of defaulted loans. Therefore, the relationships between variables become more "blurred" which results in an increase in p-values. I am therefore convinced that despite the loss in significance, the results confirm the predictions of the other three regressions, meaning that results are robust with respect to other specifications of variables.

7. Conclusion

This paper attempts to track the methodologies of CRAs, in order to estimate the expected default probabilities for the first twelve quarters after origination of RMBS in the Netherlands. The model developed in this paper allows me to estimate the expected default rate on the basis of loan level data available at origination date for 33 Dutch RMBS transactions. Furthermore, the factors that explain the performance after origination in terms of abnormal default rate of Dutch RMBS are studied.

I find similar relationships between default rate and its determinants as Begley and Purnanandam (2014) and Demyanyk and Van Hemert (2011). Loans with a high OLTV, loans granted with the purpose of remortgage or borrowed by self-employed individuals, loans with maturities longer than 25 years have a higher risk of default which is generally significant for all quarters after the loan origination. Furthermore, interest-only loans, loans

granted with the purpose of renovation or constructions or loans backed with a life insurance or savings mortgage exhibit a smaller probability of default.

I also find that loans with a higher PDTI are more likely to default, however this relationship is positive after the sixth quarter since origination. Similarly, the existence of a second borrower does not necessarily decrease the probability of default because it increases the riskiness of the loan for the first six quarters after the origination. Thus, one of the findings of this paper is that probability models should not only consider loan characteristics but also should study loan riskiness across time periods their origination. It is because the effect of risk factors is different during different periods after the origination of a loan.

The main findings of the paper relate to the performance of RMBS in relation to its expectations. I find that motives of origination are the main determinants of RMBS post-origination performance, next to macroeconomic factors. In line with findings of Opp et al. (2013), Basel III regulations have led to a decrease of banks reliance on the highest rated RMBS. RMBS originated after 2013, when the new regulations were introduced, have performed relatively better than RMBS with a similar rating originated before 2014. Therefore, Basel III regulations have decreased rating inflation in the RMBS market in the Netherlands.

Furthermore, I find that banks that have a higher need for Tier-1 capital tend to originate RMBS that perform relatively better than RMBS originated by less capital-constrained banks. It is caused by the fact that capital-constrained banks might originate high-quality loans that would not normally be securitized by banks without a need for capital. This is in line with findings of Acharya et al. (2013) and Michelangeli and Sette (2016) who argue that capital-constrained banks grant less loans and are more likely to securitize part of their existing loans.

Finally, I find that larger banks (in terms of asset value) originate RMBS which perform relatively better than RMBS originated by smaller banks, which is the opposite of the findings of He et al. (2016). Larger banks and smaller banks might have different motives for origination, as smaller banks might be willing to originate, in order to remove low-quality

loans from their balance sheet. Larger banks might, however, treat securitization as a source of capital, rather than a method of disposing low-quality loans.

Furthermore, I am not able to confirm the hypothesis that originators that are frugal in providing ratings to their RMBS transactions are less likely to securitize loans that underperform thereafter. Similarly I do not find a significant relationship between the level of subordination and the abnormal default rate.

The main message of this paper is that motives play a significant role in post-origination performance of RMBS assets. Future research should further examine each of the motive suggested in this paper and try to extend the sample of the Dutch RMBS. Also, a similar study could be conducted in other countries to determine whether similar conclusions can be reached with respect to other securitization markets.

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Appendices

Appendix 1. Credit Rating Methodologies and availability of data for particular factors

Table 5: Factors considered by CRAs in their RMBS rating methodologies. The second column indicates the European Central Bank (ECB) RMBS template and definition numbers. For example, a borrower is self-employed status if the row AR21 is equal to 5. Furthermore, the relationship between the default rate and the considered factors is marked with + or - indicating a positive and negative relationship respectively. If no + or - sign is reported, it means that CRAs do not consider this factor in their credit rating methodology.

Factor	Data available? (Reference to ECB RMBS reporting template)	Standard & Poor's	Moody's	Fitch	DBRS	Variable tested in this paper?
Factors that are particularly relevant at origination						
Other: original loan-to-value (OLTV)	AR135	+	+	+	+	YES
Other: debt-to-income	AR73 is an optional field but a proxy can be estimated from AR26 and AR66	+		+	+	YES
Other: Single income earner	AR20 is an optional field and incomplete				+	YES
Interest rate type: fixed rate with possibility to switch to floating rate	AR107/4 and AR107/5	+	+	+	+	YES
Repayment method: Interest-only	AR69	+	+	+	+	YES
Payment type: life insurance mortgages	AR72/8		+/-	+/-	+/-	YES
Other: loans with maturity longer or equal to 25 years	AR61				+	YES
Purpose: remortgage	AR59/2 AR59/6 AR59/8 AR59/9	+	+		+	YES
Purpose: renovation or construction	AR59/5 and AR59/3	+/-	+/-	+/-	+/-	YES
Employment Status: self- employed	AR21/5	+	+	+	+	YES
Repayment method: savings mortgage loans	AR69/8		-	-	-	YES
Employment Status: unemployed	AR21/4		+	+		NO
Interest rate type: floating interest rate	AR107/1 AR107/2	+	+	+		NO
Other: Self certification	AR27/1	+	+	+	+	NO

(Continued)

Factor	Data available? (Reference to ECB RMBS reporting template)	Standard & Poor's	Moody's	Fitch	DBRS	Variable tested in this paper?
Purpose: Investment mortgage	AR59/11		+	+	+	NO
Guarantee: NHG	AR74/7 but incomplete	-	-	-	-	NO
Other: second, third etc. loans	AR84 is an optional field and incomplete	+			+	NO
Occupancy type: Buy-to-let(BTL)	AR130/3 is an optional field and incomplete		+	+	+	NO
Occupancy type: second property	AR130/4 is an optional field and incomplete	+	+	+	+	NO
Other: Loan subsidy (e.g. from government) is present	AR64 is an optional field and incomplete		+		+	NO
Other: Loan-to-income	Not available				+	NO
Other: Loans with frequency of payments less than monthly	AR70/2-5, are optional fields and unavailable for the Dutch market		+	+		NO
Other: Negative previous history (e.g. previous credit impairments, arrears)	AR41 and AR47-49 are optional fields and incomplete	+	+	+	+	NO
Repayment method: part & part	AR69/7 is an optional field and unavailable for the Dutch market				+	NO
Factors that are particularly relevant after the origination						
Macroeconomic indicators: GDP	EUROSTAT			-	-	
Macroeconomic indicators: Unemployment rate	EUROSTAT			+		
Macroeconomic indicators: Interest rate	EUROSTAT			+	+	

Appendix 2. Calculating RWA using IRB and Standardized Approaches

Basel III is a set of new regulatory rules whose implementation has begun in the Netherlands in 2014 and is expected to be accomplished by 2019 by a gradual increase in required capital ratios (Bonner and Jongen, 2013). According to the Basel Committee on Banking Supervision (2010) the following set of rules are required and implemented by Basel III:

- Common Equity Tier 1 ratio must be at least 4.5 percent of risk-weighted assets, compared to 2 percent in Basel II.

- Tier 1 Capital must be at least 6 percent of risk-weighted assets in comparison with the 4 percent required under Basel II regulations.

- Total Capital (Tier 1 Capital and Tier 2 Capital) must be at least 8 percent of risk-weighted assets.

- Leverage ratio (new measure) defined as Tier 1 Capital divided by average total consolidated assets. The ratio must be at least 3 percent.

- Liquidity Coverage Ratio (new measure) to force banks to maintain short-term capital, in order to cover liquidity needs for the next 30-day stress period (Basel Committee on Banking Supervision, 2013).

- Net Stable Funding Ratio (new measure) which requires the available amount of stable funding to exceed the required amount stable funding for a year, so that a bank can avoid liquidity problems due do inefficient planning and a lack of funds to cover funding needs. Three methods of estimating risk-weighted assets (RWA) of securitization exposures (e.g. RMBS) are available and proposed in Basel III regulations (Basel Committee on Banking Supervision, 2014). These are: standardized approach (SA), internal ratings-based (IRB) and external ratings-based approach (ERB). The last two require employing internally developed models, in order to estimate factors that are needed to calculate RWA. The internally developed models have to be accepted by the national supervisor and have to meet several requirements stipulated by the Basel III regulator.

Basel Committee on Banking Supervision (2014) has implemented a new ERB approach

which employs external ratings with additional analysis of thickness of non-senior debt (share of a subordinated tranche in a total pool of RMBS) and maturity of the security (Basel Committee on Banking Supervision, 2014). The second approach allowed by the Basel III regulations is the IRB approach that is based on one year default probability estimation and involves estimating exposure at default, maturity, capital charge (K_{IRB}) and loss-given-default. Risk weights assigned to RMBS range from 15 to 1250 percent, similar to the ERB approach. The standardized approach requires calculating risk-weighted capital charge (K_{SA}) , the proportion of delinquent loans and capital requirement following the methodologies specified by Basel III regulations.

In the case of Basel II, only two approaches were applied, namely the IRB and standardized approaches (Basel Committee on Banking Supervision, 2009). The standardized approach relied solely on ratings, while the IRB approach required specifying the type of an RMBS (senior or non-senior and granular or non-granular) and relied on a ratings-based approach too (see Appendix 2 for the risk weights for both approaches). If a bank possessed an RMBS with rating of B+ or lower it was penalized by capital deduction, which aimed to discourage banks from holding risky securities. Basel Committee on Banking Supervision (2014) specifies a preferred hierarchy in which approaches should be used. First the IRB approach should be employed, which is followed by the ERB approach and the standardized approach respectively. In general, the standardized approach is considered to employ more conservative calculations of risk. However, all methods should lead to a calculation of RWA that is between 15 and 1250 percent. If none of the approaches can be employed, a risk weight of 1250 percent to all securities is applied. Furthermore, Basel Committee on Banking Supervision (2014) requires that the lowest rating to be used in an assessment if two ratings are assigned. If three or more ratings are assigned, then the lowest two are applied. However, if the two lowest are not equal, then the higher one is applied.

Appendix 2.1. Basel III: IRB approach

In the IRB approach, first the supervisory parameter p is calculated (Basel Committee on Banking Supervision, 2014):

$$P = max[0.3; (A + B * \frac{1}{N}) + C * K_{IRB} + D * LGD + E * M_T] \tag{4}$$

Where:

- 0.3 denotes the p-parameter floor

- N is the effective number of loans in the underlying pool

- K_{IRB} is the capital charge of the underlying pool

- LGD is the exposure-weighted average loss-given-default of the underlying pool

- M_T is the maturity of the tranche

- The parameters A, B, C, D and E are determined according to the following look-up table:

Table 6: A, B, C, D and E parameters values for different types of security exposures

Type of a security exposure		A	B	C	D	E
Wholesale	Senior, granular (N>=25)	0	3.56	-1.85	0.55	0.07
	Senior, non-granular (N<25)	0.11	2.61	-2.91	0.68	0.07
	Non-senior, granular (N>=25)	0.16	2.87	-1.03	0.21	0.07
	Non-senior, non-granular (N<25)	0.22	2.35	-2.46	0.48	0.07
Retail	Senior	0	0	-7.48	0.71	0.24
	Non-senior	0	0	-5.78	0.55	0.27

- The effective number of exposures is calculated as:

$$N = \frac{(\sum_{i=1} EAD_i^2)}{\sum_{i=1} EAD_i^2} \tag{5}$$

Where EAD_i represents the exposure-at-default associated with the ith instrument in the pool. Multiple exposures to the same obligor must be consolidated (i.e. treated as a single instrument).

- The exposure-weighted average LGD is calculated as follows:

$$LGD = \frac{\sum_{i=1} LGD_i * EAD_i}{\sum_{i=1} EAD_i} \tag{6}$$

The capital requirement per unit of securitization exposure under the IRB approach is a function of three variables, labelled a,u and l. The variables a,u and l are defunes as follows:

$$a = -\frac{1}{p * K_{IRB}} \tag{7}$$

$$u = D - K_{IRB} \tag{8}$$

$$l = max(A - K_{IRB}; 0) \tag{9}$$

Finally, the risk weight assigned to a securitisation exposure (e.g. a RMBS) when applying the IRB approach is calculated as follows:

- when D for a securitisation exposure is less than or equal to K_{IRB}, the exposure must be assigned a risk weight of 1250

- When A for a securitisation exposure is greater than or equal to K_{IRB}, the risk weight of the exposure, expressed as a percentage, would equal K_{SSFA} times 12.5.

- When A is less than K_{IRB} and D is greater than K_{IRB}, the applicable risk weight is a weighted average of 1,250 percent and 12.5 times K_{SSFA} according to the following formula:

$$RW = \left[\left(\frac{K_{IRB} - A}{D - A}\right) * 12.5\right] + \left[\left(\frac{D - K_{IRB}}{D - A}\right) * 12.5 * K_{SSFA}\right] \tag{10}$$

Appendix 2.2. Basel III: Standardized Approach

First the KA factor is calculated, as follows:

$$K_A = (1 - W) * K_{SA} + W * 0.5 \tag{11}$$

Where W is the ratio of delinquent underlying exposures to total underlying exposures in the securitisation pool.

In case a bank does not know the delinquency status, as defined above, for no more than 5 percent of underlying exposures in the pool, the bank may still use the standardized approach by adjusting its calculation of K_A as follows:

$$K_A = \left(\frac{EAD_{Subpool1 where W known}}{EAD \quad Total} * K_A^{Subpool1 where W known} \right) + \frac{EAD_{Subpool2 where W unknown}}{EAD \quad Total} \tag{12}$$

If the bank does not know the delinquency status for more than 5 percent, the securitization exposure must be risk weighted at 1,250 percent. Subsequently, the K_{SSFA} factor is calculated as follows:

$$K_A = \frac{e^{a*u} - e^{a*1}}{a(u-1)} \tag{13}$$

The variables a,u and l are defined as follows:

$$a = -\frac{1}{p * K_A} \tag{14}$$

$$u = D - K_A \tag{15}$$

$$l = max(A - K_A; 0) \tag{16}$$

Furthermore, the following applies to the calculation:

- The supervisory parameter p in the context of the standardized approach is set equal

to 1 for a securitization exposure that is not a resecuritization exposure

- When D for a securitization exposure is less than or equal to K_A, the exposure must be assigned a risk weight of 1,250 percent

- When A for a securitization exposure is greater than or equal to K_A, the risk weight of the exposure, expressed as a percentage, would equal K_{SSFA} times 12.5

- When A is less than K_A and D is greater than K_A, the applicable risk weight is a weighted average of 1,250 percent and 12.5 times K_{SSFA} according to the following formula:

$$RW = \left[\left(\frac{K_A - A}{D - A}\right) * 12.5\right] + \left[\left(\frac{D - K_A}{D - A}\right) * 12.5 * K_{SSFA}\right] \tag{17}$$

- The resulting risk weight is subject to a floor risk weight of 15

Appendix 3. Risk weights for security exposures under different Basel approaches

Table 7: This table presents risk weights for security exposures for both Basel III (ERB Approach) and Basel II (Standardized and IRB Approaches). No IRB or Standardized approaches are available for Basel III because they do not consider credit ratings of analyzed assets. The goal of Basel III was to reduce reliance on risk weighting approaches of credit ratings which can be observed in this table. Basel Committee on Banking Supervision (2010) argues that the internally developed models are likely to also exhibit less reliance on credit ratings.

	Basel III: ERB Approach				**Basel II: IRB Approach**			**Basel II: Standardized Approach**
	Senior tranche		Non-senior (thin) tranche					
Rating	Tranche maturity (Mt) 1 year	Tranche maturity (Mt) 5 years	Tranche maturity (Mt) 1 year	Tranche maturity (Mt) 5 years	Senior, Granular	Non-senior, Granular	Non-granular	
AAA	15%	20%	15%	70%	7%	12%	20%	20%
AA+	15%	30%	15%	90%	7%	12%	20%	20%
AA	25%	40%	30%	120%	8%	15%	25%	20%
AA	30%	45%	40%	140%	8%	15%	25%	20%
A+	40%	50%	60%	160%	10%	18%	35%	50%
A	50%	65%	80%	180%	12%	20%	35%	50%
A	60%	70%	120%	210%	20%	35%	35%	50%
BBB+	75%	90%	170%	260%	35%	50%	50%	100%
BBB	90%	105%	220%	310%	60%	75%	75%	100%
BBB	120%	140%	330%	420%	100%	100%	100%	100%
BB+	140%	160%	470%	580%	250%	250%	250%	350%
BB	160%	180%	620%	760%	425%	425%	425%	350%
BB	200%	225%	750%	860%	650%	650%	650%	350%
B+	250%	280%	900%	950%				
B	310%	340%	1050%	1050%				
B	380%	420%	1130%	1130%		Deduction		Deduction
CCC+/CCC/CCC	460%	505%	1250%	1250%				
Below CCC-	1250%	1250%	1250%	1250%				

Appendix 4. Variable explanations, the expected relationship with ADR based on the previously published literature and the source of data

Table 8: Description of variables used in the empirical section, their explanation, source of data and expected relationship with default rate.

Variable	Explanation	Source of data	Predicted relationship between a variable and ADR
ADR	The actual default rate of pool p in the ith quarter since origination date	European Data Warehouse	-
EDR	The estimated default rate of pool p in the ith quarter since origination date	Logistic regression estimations	-
OLTV	The original LTV ratio at the time of the issuance for RMBS.	European Data Warehouse	POSITIVE
PDTI	The initial debt to primary income ratio in at the time of the issuance for RMBS, excluding the income of an eventual second borrower.	European Data Warehouse	POSITIVE
2Borr	A dummy variable which is 1, if there exists a secondary borrower (e.g. wife or husband)	European Data Warehouse	NEGATIVE
Season	The maturity of a loan (since origination) in months.	European Data Warehouse	-
FixInt	A dummy variable which is 1 if a loan is of fixed interest rate type. Also, loans with a number of reset months larger than 12 are considered to be fixed interest loans.	European Data Warehouse	POSITIVE
IntOn	A dummy variable which is 1 if a loan is of an interest-only type.	European Data Warehouse	POSITIVE
LifeInsMortg	A dummy variable which is 1 if a loan is backed by a life insurance mortgage.	European Data Warehouse	?
MatMore25	The maturity of the loan equal to or more than 300 months (25 years).	European Data Warehouse	POSITIVE
Remortg	A dummy variable which is 1 if a purpose of loan is remortgaging.	European Data Warehouse	POSITIVE
RenCon	A dummy variable which is 1 if a purpose of loan is renovation or construction.	European Data Warehouse	?
SavMortg	A dummy variable which is 1 if loan is backed by savings mortgage.	European Data Warehouse	NEGATIVE

(Continued)

Variable	Explanation	Source of data	Predicted relationship between a variable and ADR
SelfEmp	A dummy variable that is 1 if a debtor is self-employed.	European Data Warehouse	POSITIVE
ValWeighRatValWeighRat21	The average rating per RMBS transaction, weighted with initial value of all the notes, where non-rated deals are quantified as 17 or 21. If non-rated deals are quantified as 21, then the ValueWeighRat21 variable is used.	European Data Warehouse	
GDP	The current GDP growth rate in the Netherlands in the ith quarter since origination.	Eurostat and CBS	NEGATIVE
Unemployment	The monthly Unemployment rate in the Netherlands in the ith quarter since origination.	Eurostat and CBS	POSITIVE
Tier1Gap	The change of banks Tier-1 capital ratio between December 2015 and December 2012.	Annual reports of RMBS originators.	POSITIVE
SubordAAA	The percentage of debt that is subordinated to the highest rated debt in an RMBS	Annual reports of RMBS originators.	POSITIVE
SizeOriginator	The natural logarithm of a banks value of assets at the time of RMBS origination measured in thousands of euro.	Annual reports of RMBS originators.	POSITIVE
AvgNoRat	The average number of ratings provided per tranche in a RMBS transaction.	Prospectuses of RMBS transactions	NEGATIVE
2014	A dummy variable equal to 1 if an RMBS transaction was issued in or after the year 2014	European Data Warehouse	
Origin2012or2013	A dummy variable equal to 1 if an RMBS transaction was issued in 2012 or 2013	European Data Warehouse	

Appendix 5. List of analyzed transactions, originators, assumed starting dates and abnormal defaults per quarter

Table 9: A list of transactions that are tested in this paper with their edcodes (used by the European Data Warehouse), transaction names, names of the originating bank, the vintage year and abnormal defaults for each quarter. Abnormal default, defined as actual default rate divided by expected default rate, is calculated for each quarter since the date of origination. If abnormal default is missing, it means that it is not included in the sample, due to insufficient data available for a given quarter and transaction.

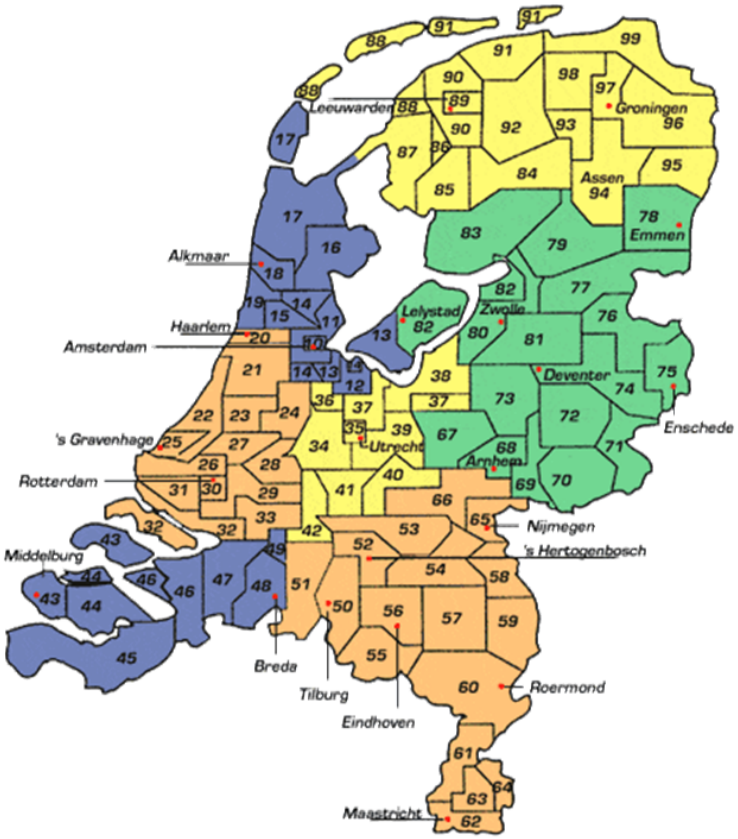
Unique edcode	**Deal Name**	**Originating Bank**	**Q0**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**
RMBSNL000087101120137	Orange Lion IX RMBS	ING	3-5-2013	0.00											
RMBSNL000087101320158	Orange Lion 2015-11 RMBS B.V.	ING	11-6-2015	0.35	0.43										
RMBSNL000143100920132	Dutch Mortgage Portfolio Loans XI B.V.	Achmea Bank N.V.	21-8-2013	2.85	5.93	2.73	3.24	2.53	3.03	2.06	1.52	1.28	0.90		
RMBSNL000143101020148	Dutch Mortgage Portfolio Loans XII B.V.	Achmea Bank N.V.	28-4-2014	0.00	0.75	0.92	0.81	0.68	1.00	0.56					
RMBSNL000143101120153	Dutch Residential Mortgage Portfolio I BV	Achmea Bank N.V.	28-5-2015	1.62	2.51										
RMBSNL000150100320130	ORANGE LION 2013-8 B.V.	ING	28-1-2013	0.00	0.00										
RMBSNL000164101920137	STORM 2013-I B.V.	OBVION	2-2-2013	0.00											
RMBSNL000164102420145	STORM 2014-II B.V.	OBVION	6-5-2014	0.00											
RMBSNL000164102720155	Storm 2015-I B.V.	OBVION	26-3-2015	0.00											
RMBSNL000164102820153	STORM 2015-II B.V.	OBVION	24-9-2015	0.00											
RMBSNL000179100120125	SAECURE 12 B.V.	AEGON	12-1-2012	5.82											
RMBSNL000180101720137	LOWLAND MORTGAGE BACKED SECURITIES 2 B.V.	SNS Bank N.V.	7-9-2013	0.00	0.41	0.29	0.52	0.88	1.01						
RMBSNL000180101820135	LOWLAND MORTGAGE BACKED SECURITIES 3 B.V.	SNS Bank N.V.	12-10-2013	0.00	0.00	0.00	0.12	0.21	0.37						
RMBSNL000184100420137	Courtine RMBS 2013-I B.V.	VanLanschot	8-3-2013	5.07		2.66	2.29	3.52	3.53	2.62	2.43	2.06	2.93	2.16	
RMBSNL000184100520134	Lunet RMBS 2013-I	VanLanschot	7-11-2013	3.79	2.07	2.81	2.44	1.34	2.15	2.49	3.07				
RMBSNL000527100120141	Cartesian Residential Mortgages 1 S.A.	BNP	20-3-2014	0.00	0.00	0.44	0.89	0.70	0.75						
RMBSNL000078101020146	Essence V B.V.	NIBC	27-11-2014	1.92	2.98	3.58	2.26								
RMBSNL000143100720128	Dutch Mortgage Portfolio Loans X B.V.	Achmea Bank N.V.	7-10-2012			2.16	2.61	2.79	3.28	3.28	2.67	3.09	2.91	2.97	1.05

(Continued)

Unique edcode	Deal Name	Originating Bank	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
RMBSNL000078100820132	Dutch MBS XVIII B.V.	NIBC	31-1-2013		1.67	1.60	1.52	5.84	6.32	6.22	6.35	9.07	6.34		4.35
RMBSNL000181100720110	Arena 2011-II B.V.	Amstelhuys NV	10-12-2011					0.16	0.37	0.28	0.71	0.00	0.00	0.00	0.00
RMBSNL000182100220119	E-Arena B.V.	Delta Lloyd Bank NV	8-9-2011					1.22	2.00	2.27	0.58				
RMBSNL000078100920122	Dutch MBS XVII B.V.	NIBC	30-9-2012			1.76	1.81		6.71	5.27	4.18	9.08	6.63	3.32	2.32
RMBSNL000143100620112	Dutch Mortgage Portfolio Loans IX B.V.	Achmea Bank N.V.	7-10-2011							2.81	3.85	2.81	2.85	1.57	1.65
RMBSNL000184100120117	Citadel 2011-I B.V.	VanLanschot	2-8-2011							1.98	1.46	1.59	1.09	0.99	0.82
RMBSNL000179100520118	SAECURE 10 B.V.	AEGON	4-12-2011									1.65	2.61		
RMBSNL000179100620108	SAECURE 8 NHG B.V.	AEGON	12-10-2010									3.73			
RMBSNL000180100220121	LOWLAND MORTGAGE BACKED SECURITIES 1 B.V.	SNS Bank N.V.	30-1-2012							0.00	0.00	1.15	1.40	1.90	2.11
RMBSNL000180101020124	HOLLAND MORTGAGE BACKED SERIES (HERMES) XVIII B.V.	SNS Bank N.V.	10-2-2012						0.00	0.00		1.04	1.40	2.15	1.97
RMBSNL000181100620112	Arena 2011-I B.V.	Amstelhuys NV	26-1-2011								0.98	0.65	0.26	0.38	
RMBSNL000179100420103	SAECURE 7 B.V.	AEGON	7-6-2010										3.52		
RMBSNL000179100720106	SAECURE 9 B.V.	AEGON	22-9-2010										3.53		
RMBSNL000078100120111	Essence IV B.V.	NIBC	1-3-2011							2.76	1.71	3.20	3.19	2.20	3.34
RMBSNL000184100220107	Citadel 2010-I B.V.	VanLanschot	2-7-2010												0.98
RMBSNL000184100320105	Citadel 2010-II B.V.	VanLanschot	30-7-2010												0.62

Appendix 6. A map with postal codes in the Netherlands

Fig. 7. An example map obtained from Landkaarten Nederland map publisher that presents the distribution of the first two numbers of the postal codes in the Netherlands. Note that postal code regions do not precisely match the borders of Dutch provinces.



Appendix 7. Ratings of CRAs and their assumed numerical equivalents

Table 10: Ratings provided by the four largest CRAs active in the Dutch market and their numerical scale used in the empirical section in this paper. The non-rated (NR) RMBS are tested in two cases. In the first case, the NR RMBS are assumed to have the lowest rating that exists in the sample (17), while in the second case it is assumed to have the lowest available rating (21).

Moodys	**Fitch**	**S&P**	**DBRS**	**Numerical scale**
AAA	AAA	AAA	AAA	1
AA1	AA+	AA+	AA+	2
AA2	AA	AA	AA	3
AA3	AA-	AA-	AA-	4
A1	A+	A+	A	5
A2	A	A	A	6
A3	A-	A-	A-	7
BAA1	BBB+	BBB+	BBB+	8
BAA2	BBB	BBB	BBB	9
BAA3	BBB-	BBB-	BBB-	10
BA1	BB+	BB+	BB+	11
BA2	BB	BB	BB	12
BA3	BB-	BB-	BB-	13
B1	B+	B+	B+	14
B2	B	B	B	15
B3	B-	B-	B-	16
CAA1	CCC+	CCC+	CCC+	17
CAA2	CCC	CCC	CCC	18
CAA3	CCC	CCC-	CCC-	19
CA	CCC	CC	CC	20
CA	CCC	C	C	21
NR	NR	NR	NR	17/21