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Competition and interest rates in the Dutch mortgage market

an econometric analysis over 2004-2010

Machiel Mulder and Mark Lengton

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Abstract

Triggered by evidence that the mortgage interest margins have risen since 2009, an econometric analysis is conducted to explain the interest rates in the Dutch mortgage market at the bank level over 2004 – 2010.

Controlling for the influence of costs, risks and also for some regulatory measures, we find statistically significant evidence that the degree of competition in the Dutch mortgage market (measured by C3 or HHI) affected the level of the mortgage interest rates. An increase in market concentration equal to the size of its standard deviation over the period of analysis raised the mortgage interest rate by approximately 0.10 to 0.20 percentage points. The impact of costs as well as risks appears to be about twice as large as the impact of market concentration.

In addition, we find a statistically significant negative relationship between the degree to which the state-supported banks act as price leaders, either through imposed regulation or at their own discretion, and the mortgage interest rate. The conclusions continue to hold if we use actual mortgage interest rates instead of window mortgage interest rates.

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Contents

Summary

1. Because of a perceived high level of the mortgage interest rates, a number of parties have complained about the functioning of the mortgage market in the Netherlands. In order to get a better insight into the factors driving mortgage interest rates, the NMa started an in-depth analysis of the mortgage market. This analysis, published in NMa (2011), included an econometric analysis, which is more fully reported here.

2. This econometric study aims to explain which factors drive the mortgage loan interest rates in the Dutch market and their relative weights. In particular we want to assess to which extent the mortgage interest rate is determined by costs and risks as well as by the degree of competition.

3. The economic literature shows a number of econometric papers explaining interest rates in the banking market. Several authors find a statistically significant effect of market power, besides an impact of a number of other factors such as operational costs. On the basis of this literature we have specified an econometric model, both at industry and bank level. The dependent variable in these models is the interest rate on mortgages. The independent variables are divided into four subgroups: cost variables, risk variables, market concentration variables and other variables (both industry and bank specific).

4. In a time-series analysis at the industry level, we use monthly data to assess the effect of a number of variables on the average mortgage interest rate in the Dutch market. Testing our data on non-stationarity, we cannot reject the null hypothesis of non-stationarity (unit root). Consequently, we estimate the model in first differences. Moreover, by adding the lagged dependent variable in this first-difference model as explanatory variable we remove the remaining serial correlation.

5. In the time-series model we find a positive effect of the mortgage costs and risks on the interest rate, but these estimates are not (highly) significant. It appears that the lagged dependent variable is the most important explanatory variable. We conclude that in the short term the mortgage interest rates are mainly determined by factors that have a prolonged influence, while the immediate effects appear to be relatively small.

6. In a panel analysis at the bank level, we use bank-specific data on an annual basis to explain the mortgage interest rates. This approach acknowledges the heterogeneity between firms and may therefore offer better insights compared to the time series analysis on the aggregate level. We estimate the models using panel regressions with cross-sectional fixed effects and controlling for autocorrelation (AR-1). In assessing the models we test for multicollinearity and autocorrelation.

7. We find statistically significant evidence that the degree of competition in the Dutch mortgage market, measured by C3 or HHI, affected the level of the mortgage interest rates during the period 2004 - 2009. In this period, the degree of competition fluctuated in response to entrance and disappearance of a number of banks. An increase in market concentration equal to the size of its standard deviation over the period of analysis raised the mortgage interest rate by about 0.10 to 0.20 percentage points.

8. Besides the degree of competition, the mortgage interest rates were also influenced by the costs of lending, the risks banks faced and regulatory restrictions on banking behaviour. The impact of costs as well as risks appears to be about twice as large as the impact of market concentration. Using actual mortgage interest rates instead of window mortgage interest rates, we find similar results.

9. The size of a bank does not appear to have an upward effect on interest rates. This follows from the result that market share, as a proxy for the influence of bank size on consumer behaviour, shows a negative sign, but is also found to be insignificant. Of course, this result does not exclude any other influence of bank characteristics, like reputation, on the ability of banks to charge higher interest rates.

10. We find a statistically significant relationship between the degree to which the state-supported banks act as price leaders and the mortgage interest rate. This means that when these three banks price less aggressively, either through imposed regulation or at their own discretion, mortgage interest rates tend to go up. The restrictions imposed by the European Commission in response to the state support for a number of banks, therefore, are likely to lead to higher mortgage interest rates.

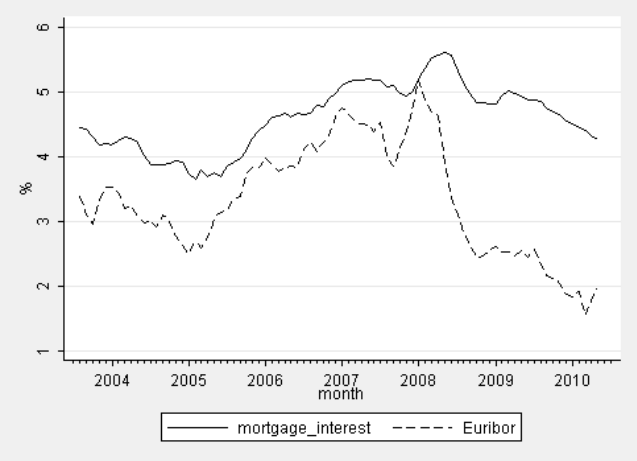
1 Introduction

1.1 Background

Because of a perceived high level of the mortgage interest rates, a number of parties have complained about the functioning of the mortgage market in the Netherlands. In their view, the market for mortgages is not functioning competitively. It is said that financing costs for banks have drastically fallen over the last two years, but that they have reneged on passing these lower costs on to the consumer level (see Figure 1.1). In addition, it is suggested that mortgage rates in the Netherlands are, in an international context, relatively high. The Home Owners' Association (VEH) has also suggested that mortgage suppliers are possibly fixing prices. Consequently, the VEH, the Consumer's association and several members of the Dutch parliament have requested the NMa to further investigate this matter.

In its report **Quick Scan Hypotheekrente**, the NMa (2010) observed that mortgage rates in the Netherlands were indeed relatively high compared to other EU-countries over the past years. Furthermore, where other EU-countries showcased a steady decline in mortgage rates, those in the Netherlands rose. Using three different methods of calculating mortgage loan interest margins, the authors also found that the interest margins appear to follow a similar trend.

Figure 1.1 Mortgage interest rate and Euribor



Euribor is the 6-month rate.

In response to these findings, representatives of a number of banks said to be fully confident that the rise in interest margins could be explained by the increase in costs and in risks. More specifically, they pointed at the rise in risk premiums banks had to pay on top of the swap rate. In addition, it was said that the interest margins had been too low in the period before the credit crisis as a result of intensive competition for market shares. The interest rates in that period were, in their view, not sustainable in the long term.

In order to get a better insight into the factors driving mortgage interest rates, the NMa conducted an in-depth analysis of the mortgage market (NMa, 2011). This analysis included an econometric analysis. This Working Paper describes the method of the econometric analysis as well as its results.

1.2 Research question and scope

This study aims to explain which factors drive the mortgage loan interest rates and the relative weights of those factors. The key research question is therefore posed as follows:

Which factors contributed to the movements in the mortgage loan interest rates in the Netherlands since January 2004?

This study focuses on the factors contributing to the interest rates in the Dutch mortgage market. In particular we want to assess to which extent the mortgage interest rate is determined by costs, risks and the degree of competition. Although the latter factor is one of the key components in our research, we will not attempt to investigate possible abuse of market power or to identify possible collusion among players on this market. Such questions are beyond the scope of this econometric analysis.

In addition, we will not go into the international dimension of the mortgage interest rates. Answering the question how the Dutch mortgage loan interest rates are related to mortgage interest rates in neighbouring countries would require an extended study on international level, which is, due to time limitations, also out of scope for this study.

1.3 Method of research and structure of the paper

We conduct an econometric analysis that includes both a time series analysis and a panel analysis. The former is conducted on monthly industry-level data over the period January 2004 – October 2010. Although this approach lacks bank-specific information, the advantage of this method is the use of high-frequency data. However, from the time-series

analysis it appears that in the short term the mortgage interest rates are mainly determined by factors that have a prolonged influence, while the short-term effects are relatively small. In other words, in the short term, there is hardly an assignable effect of specific factors such as financing costs or the degree of competition. In Chapter 3 we describe the method and the results of the time-series analysis.

In order to take account of differences among banks, we also conducted a panel analysis on bank-specific data. As these are only available on annual basis, we are also more likely to be able to find effects of specific factors. In Chapter 4 we describe the method and the results of the panel analysis.

Before we go into the econometric analysis, we briefly discuss other economic literature on this issue in Chapter 2. Our conclusions are presented in Chapter 5.

2 Literature review

2.1 Introduction

There are numerous studies on competition issues in banking markets, including papers that focus on the factors that drive mortgage loan interest rates and on how mortgage loan interest margins can be explained. The empirical literature on the banking market can roughly be divided into two categories: a) exploring competition by analysing market behaviour and market structure and b) explaining interest margins.

2.2 Exploring competition

Considering the first group, Neven et al. (1999) specifically addresses market behaviour on the mortgage loan markets in a number of European countries, including The Netherlands, during 1981-1989 by approximating market behaviour using a Conduct Parameter Method. The authors conclude that they cannot reject the hypothesis that banks are operating like cartels. In addition, they find evidence that the market power in the industry is associated with coordination of behaviour. However, they also conclude that the behaviour of banks has become less collusive over time which is possibly the result of deregulation.

According to Toolsema (2002), the Dutch market for consumer credit is not hampered by a lack of competition. As this finding deviates from for instance Neven et al. (1999), the author assumes that in small submarkets, like the consumer market for credit, there might be more competitive pressure on banks compared to other submarkets. As a result, a lack of competition in the general banking market might coincide with competitive submarkets.

In a cross-country analysis of competition in European banking during 1995-2001, Carbó et al. (2009) find that the choice of the indicator for competition strongly affects the ultimate conclusion. This finding is illustrated by the fact that the correlation coefficients among five different indicators (such as the Lerner-index, the net interest margin and the return on assets) were no more than about 35%. These differences appeared to be mainly affected by country-specific factors such as real economic growth and inflation. If the indicators are corrected for these factors, the differences are significantly reduced. Therefore, the authors conclude that country-specific factors have to be taken into account when comparing the degree of competition among a group of countries.

De Haan and Sterken (2010) present an empirical analysis of the interest rate setting behaviour of the four largest banks in the Dutch mortgage market during 1997-2003. They use an Error Correction Model to determine the degree of adjustment of the mortgage interest rates to a change in funding costs. Using daily bank-specific data, they find that in the short run, most banks adjust their mortgage interest rates less strongly to increases than to decreases in funding costs, which would be advantageous to consumers. In the long run, they argue that mortgage interest rates appear to be set competitively as they are set on the basis of funding costs. However, they also find for two banks that the pass-through rates are lower than for the other two banks. In contrast, Toolsema and Jacobs (2007), using monthly macro data, find a downward rigidity in mortgage interest rates.

From these papers we learn that the banking market might be characterised by imperfect competition and therefore it makes sense to explore to which extent the degree of competition actually affects the interest margins.

2.3 Explaining interest margins

The second group of the related literature tries to explain the interest margins in the banking market. This group can also be divided into two subgroups, being a group of literature that attempts to explain the interest margins at the bank level and a group that attempts to explain the interest rate margins on (mortgage) loan level. While in the first subgroup numerous papers have been published, very few have been so in the latter.

The pioneering study in the field of bank interest margins is Ho and Saunders (1981). In their paper, they find that the factors behind the interest margin consist of two components: the degree of competition on the market and the interest rate risk the bank is exposed to. Several studies have expanded this model to add explanatory power to the model.

Maudos et al. (2004) expand the model with operational costs and a variable for market power and also take into account factors such as management quality, implicit interest payments and opportunity costs of bank reserves. Using data on the banking markets in the European Union (available through Bankscope), they find significant and positive effects of market power, credit risk, market risk, risk aversion of a bank, operating costs, implicit interest payments and opportunity costs of bank reserves; significant and negative effects of volume of loans and efficiency (as a proxy for management quality). The authors

in particular find a relatively large effect of market power and operating efficiency on margins. A 10% increase in the Lerner-index raises the interest margin by almost 30%, while a 10% reduction in average operating costs reduces the margin by more than 40%.

In a similar study, Hawtrey et al. (2008) use panel data to study the net interest margin in OECD countries. The outcome of their study is consistent with Maudos et al. (2004), presenting highly significant results[1] and similarly expected signs of the coefficients. Furthermore, the authors note that the effect of higher quality management is inconclusive in the theoretical literature, but find that banks with lower quality levels of management work with narrower margins, which supports the theory posed by Maudos et al. (2004).

The second subgroup consists of the literature that studies the factors that drive specifically mortgage loan interest margins. Titman et al. (2005) conclude, on the basis of 26.000 individual mortgages from 1992 till 2002, that higher default risk contributes to higher margins. They also find that margins on mortgage loans increased after periods of bad performance on the real estate markets or after periods of greater default on real estate loans. In addition, they find that loan terms also become stricter after such periods.

Dietrich et al. (2010) studied the mortgage rates for a single Swiss bank, using data on 8,120 fixed mortgage loans granted between January 1, 2000 and December 31, 2009. They divide the factors that may have an effect on the mortgage rate margin in three groups: loan-specific characteristics, macroeconomic and industry specific characteristics and bank-specific characteristics. They find significant and positive effects for inflation and operational efficiency, but significant and negative effects for market concentration (measured by HHI), GDP growth, volume, credit period and lending growth.

2.4 Conclusion

Summarizing, the first group of literature, which explores competition in the banking sector, mostly suggests that the banking market may be characterised by imperfect competition. The second group of literature, on explaining interest margins in the banking market, suggests that both costs as well as market structure have a significant and positive effect on the banks' interest rates. Furthermore, risk variables are generally also found to have a significant and positive effect on mortgage interest rates.

[1] All model variables are significant at the 5% level except for opportunity costs of reserves, which is also insignificant in Maudos et al. (2004).

3 Time series analysis at industry level with monthly data

3.1 Introduction

In the time-series analysis at the industry level, we use monthly data to assess the effect of a number of variables on the average mortgage interest rate in the Dutch market. Section 3.2 presents the model and describes the hypothesis on each of the explanatory variables. In Section 3.3 we describe the data, while the results are presented in Section 3.4.

3.2 Model

The dependent variable in the time-series model is the average monthly mortgage interest rate, while the explanatory variables consist of three groups of variables:

$$\text{Mortgage interest rate}_t = f(\text{Costs}_t, \text{Risks}_t, \text{Market structure}_t) \quad (1)$$

Table 3.1 Hypothesis about effect of explanatory variables (time-series model)

Explanatory variables	Mechanism
Cost variable	
Average mortgage costs (AMC)	The average mortgage costs indicate the price banks have to pay for financial capital. We expect that these costs, which are based on the Euribor rates, swap rates, interest rates on deposits and interest rates on 'residential mortgage backed securities', are positively related to the mortgage interest rates. (see NMa, 2011).
Risk variables	
Standard deviation (per month) of 6-months Euribor (SD_Euribor_m)	The standard deviation of the money market rate reflects volatility on the money market, which in turn reflects money market risk which is not already reflected in the above actual mortgage costs. If risks go up, we expect mortgage interest rates to go up. This monthly standard deviation is based on daily data per month. (see eg. Maudos et al., 2004; Hawtrey, et al. 2008)
Market Structure variables	
Joint market share of the three or four largest bank holdings (C3 or C4)	High levels of C3 or C4 suggest that a small number of banks may have market power that they can leverage to increase prices and earn higher profits. We therefore expect C3 and C4 to be positively related to the mortgage interest rates. (see e.g. Maudos, et al., 2004; Hawtrey, et al. 2008)
Herfindahl-Hirschman Index (HHI)	Higher level of HHI means that few banks have high market shares, suggesting that they are more able to exercise market power to increase prices and earn higher profits. We therefore expect HHI to be positively related to the mortgage interest rate. (see e.g. Maudos, et al., 2004; Hawtrey, et al. 2008)

Table 3.1 summarizes the mechanism behind each variable in the time-series model. Note that costs might also include premiums to reduce risks. Nevertheless these costs likely do not cover all risks which banks face. If the durations of funding contracts do not fully match the durations of the mortgage contracts, banks face a money market risk (see e.g. Maudos, et al., 2004; Hawtrey, et al. 2008).[2] In addition, banks are subject to default risk which might require higher interest rates as coverage (see e.g. Titman et al., 2005). In this time-series model at industry level, we are however not able to include the latter risk, but this risk will be included in the panel analysis at the bank level (see Chapter 4).

3.3 Data

The characteristics of the data used in the time-series analysis are described in Table 3.2, while Table A.1 in Appendix A presents the correlation matrix.

Table 3.2 Description of variables (1/2004 – 10/2010) (n=82)

Variable	Mean	Standard deviation	Minimum	Maximum
Mortgage interest rate	4.12	.86	3.10	6.00
AMC	1.61	.50	.92	2.78
SD_Euribor_m	.04	.06	.00	0.29
C3	.63	.04	.58	.74
C4	.72	.03	.68	.80
HHI (/100)	15.9	1.5	13.8	19.5

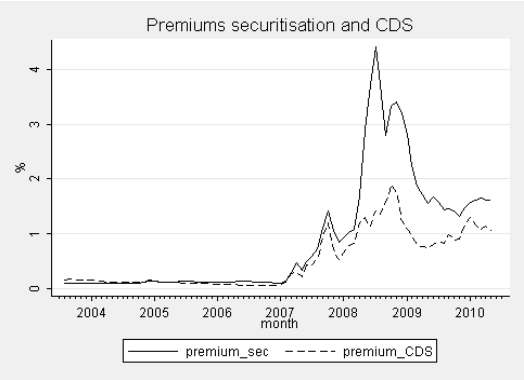
Souces: Mortgage interest rate: Moneyview; AMC and SD_Euribor_m: DNB; C3, C4 and HHI: Kadaster.

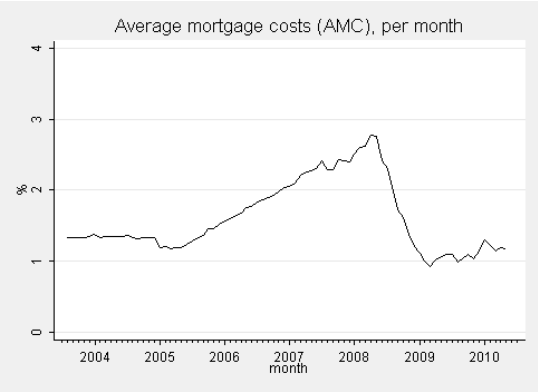
The mortgage interest rate and the Euribor rate were already depicted in Figure 1.1 (Chapter 1). From that figure we learn that the mortgage interest rate steadily rose from the end of 2005 until 2009. After that, the interest rate declined by approximately 1-percentage point. From the figure we also learn that the Euribor rate increased slightly from 2005 until mid 2008 before it decreased sharply in the second half of 2008.

Figure 3.1 (left hand side) shows that the premiums paid for securitisation and credit default swaps (CDS) grew rapidly during the last months of 2008 and the first months of 2009 and declined relatively sharply afterwards. In 2010, however, the premium levels were still significantly above the pre-financial crisis levels. The graph on the right hand side in Figure 3.1 shows the average mortgage costs (AMC) of banks. These costs are based on the Euribor (6 months), premiums for securitisation and CDS premiums (see also NMa, 2011).

[2] Imperfections in the matching of the funding might be due to pipeline risk or prepayment risk (see NMa, 2011).

Figure 3.1 Premiums for securitisation and CDS and average mortgage costs (AMC), on average per bank (1/2004 - 10/2010)

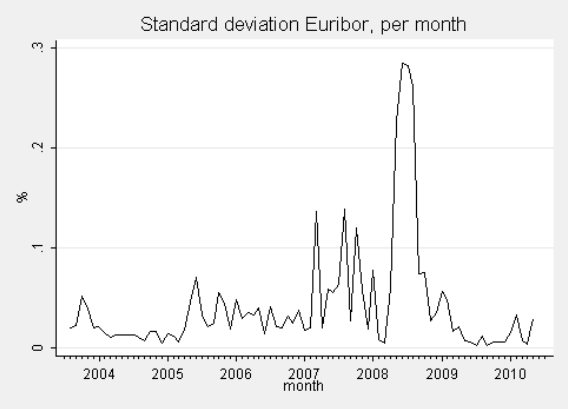




Source: see NMa(2010)

As a measure for risk in the money market we use the monthly standard deviation in the Euribor. This indicator measures the volatility in the rates for interbank deposits, which is the benchmark rate for mortgages interest rates. A higher volatility indicates higher uncertainty about the future cost of interbank lending. Figure 3.2 clearly shows that the risk strongly increased at the end of 2008, but reduced to normal levels afterwards.

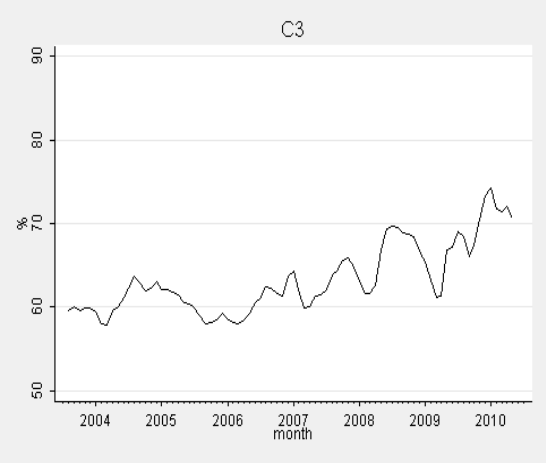
Figure 3.2 Monthly standard deviation in 6-month Euribor

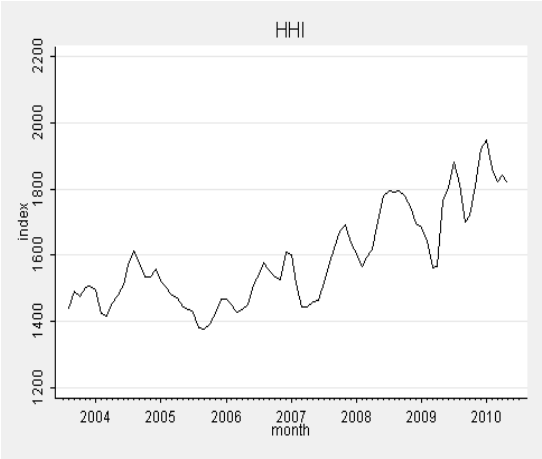


Source: DNB.

Figure 3.3, depicting the development in C3 and HHI, shows that the Dutch mortgage market became more concentrated during the years 2004 – 2010, in particular in the most recent years.

Figure 3.3 C3 and HHI in the Dutch mortgage market (monthly averages, 2004 - 2010)





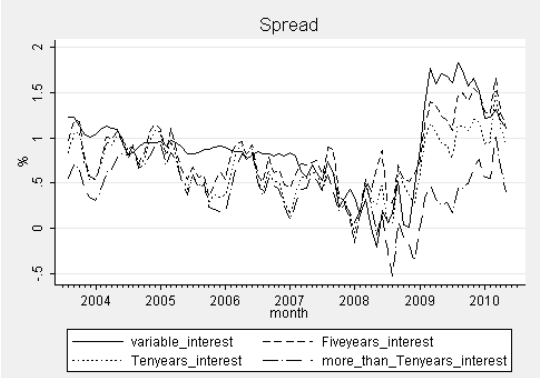
Source: Kadaster

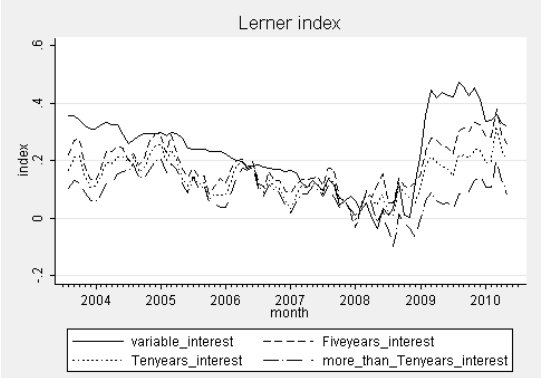
Marginal profit on industry level

On the basis of the mortgage interest rate and sourcing costs, we are able to calculate an estimate of the marginal profit, which can be viewed as coverage for non-financial costs as well as fixed costs. An indicator to measure the marginal profit is the spread, which is the difference between the mortgage interest rate (MIR) and the sourcing costs (SC): $Spread_t = MIR_t - SC_t$. The sourcing costs are determined by the weighted average of the costs of several types of funding (C), where the weighing factors (share) are based on the shares of the funding types in the average bank balance: $SC_t = \sum_i^n C_{i,t} \times share_i$. Another indicator is the Lerner-index (LI), which actually scales the marginal profit by the mortgage interest rate: $LI_t = Spread_t / MIR_t$.

It appears that the marginal profits at the industry level slightly decreased from 2004 until the end of 2008 (see figures below). Afterwards, the profits increased strongly. This holds true for the various types of mortgages, although in some cases (such as "variable interest") this pattern is more explicit than in others (such as "more-than_Tenyears interest"). This conclusion continues to hold if we scale the profit by using the Lerner index.

Spread and Lerner index on industry level (1/2004 - 10/2010)





3.4 Results

In a time-series analysis on high-frequency data, non-stationarity and autocorrelation might seriously distort the analysis. Although theoretically one can doubt why interest rates would be non-stationary, in practice non-stationarity is often the case (End, 2011).[3] Testing our data on non-stationarity with the augmented Dickey-Fuller test, we indeed cannot reject the null hypothesis of non-stationarity (unit root). As the residuals of an OLS-regression appear to be stationary, we can conclude that our data are cointegrated. In order to correct for non-stationarity, we estimate the model in first differences (see Tables 3.4 and 3.5 for the description).

Table 3.4 Description of first differences of variables in time-series analysis (n=81)

Variable	Mean	Standard deviation	Minimum	Maximum
d.Mortgage interest rate	.00	.15	-.58	.23
d.AMC	-.00	.09	-.35	.16
d.SD_Euribor_m	.00	.04	-.19	.17
d.C3	.14	1.41	-2.55	5.53
d.C4	.09	1.31	-3.66	5.89
d.HHI (/100)	.05	.50	-1.18	2.01

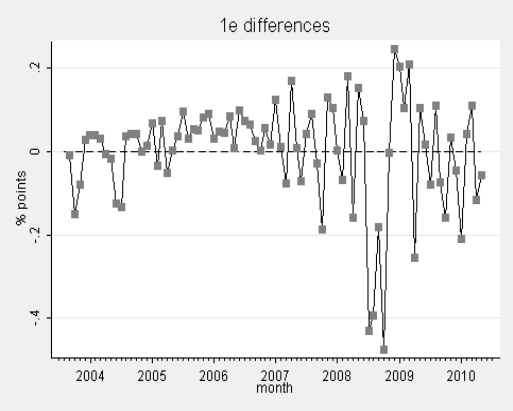
Table 3.5 Correlation matrix of first differences of variables in time-series analysis (n=81)

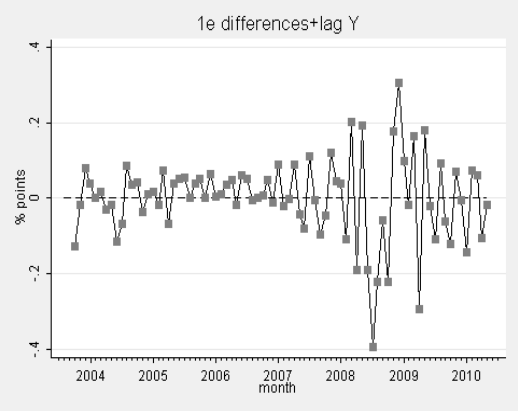
	d.Mortgage interest rate	d.AMC	d.SD_Euribor_m	d.C3	d.C4	d.HHI
d.Mortgage interest rate	1					
d.AMC	.49	1				
d.SD_Euribor_m	.29	.25	1			
d.C3	-.02	.11	.17	1		
d.C4	.09	.20	.13	.85	1	
d.HHI	-.02	.13	.09	.93	.89	1

The model in first differences shows autocorrelation. This follows from the plot of residuals (see Figure 3.4, left hand side) and also from the Breusch-Godfrey test (see Table 3.6).

[3] Interest rates do not follow a structural rising pattern, as for instance macroeconomic quantities do. In the long term, these data have a kind of an "anchor" which create stationarity.

Figure 3.4 Residuals in of regression without and with lagged dependent variable





In order to correct for autocorrelation, we add the lagged dependent variable in this first-differences model as an explanatory variable. The Breush-Godfrey test (see Table 3.6) and the graph on the right side in Figure 3.4 show that this specification solves the autocorrelation problem.

Table 3.6 Results of time-series analysis in first differences

d.Mortgage interest rate	**T.1**	**T.2**	**T.3**	**T.4**
d.AMC	.72	.30	.28	.30
	(4.45)	(1.90)	(1.74)	(1.90)
d.SD_Euribor_m	.66	.33	.30	.32
	(1.92)	(1.10)	(1.00)	(1.07)
d.C3	-.01	-.00		
	(-1.02)	(-.43)		
d.C4			.00	
			(.38)	
d.HHI				-.00
				(-.04)
d.Mortgage interest rate(-1)		.54	.55	.54
		(5.42)	(5.53)	(5.42)
Constant	.00	.00	.00	.00
	(.27)	(.10)	(.03)	(.10)
Goodness of fit				
adj. R^2	25%	45%	45%	45%
Bgodfrey (P>chi^2)	.03	.49	.80	.52

Note: t-statistics in parentheses.

Table 3.6 shows the results of the regression for 4 alternative model specifications. Model T.1 is the first-difference model without correction for autocorrelation, while in T.2 / T.4 we use the lagged dependent as an additional explanatory variable. Through the models T.2/T.4 we analyse the impact of using different measures for market structure.

In all models we find a positive effect of the mortgage costs and risks on the interest rate, but these estimates are not or hardly significant. It appears that the lagged dependent variable is the most important explanatory variable. Regarding the market structure variables, we see that none of them have an effect on the monthly interest rates. From this analysis we conclude that in the short term the mortgage interest rates are mainly determined by factors that have a prolonged influence, while the immediate effects appear to be relatively small.

4 Panel analysis at bank level with annual data

4.1 Introduction

In order to explain the mortgage interest rates at the bank level, we use bank-specific data in addition to general market data. This approach acknowledges the heterogeneity between firms and may therefore offer better insights compared to the time series analysis on the aggregate level. Section 4.2 presents our model and the hypothesis of the impact of the explanatory variables. Section 4.3 describes the data used to estimate the model. The results of this estimation are presented in Section 4.4.

4.2 Model

We use four categories of explanatory factors to explain the mortgage interest rates at the bank level: cost factors, risk factors, market-structure factors and other factors (both general and bank specific). The model that is estimated is therefore generally defined as:

$$\text{Mortgage interest rate}_{b,t} = f(\text{Costs}_{b,t}, \text{Risks}_{b,t}, \text{Market structure}_{t}, \text{OtherFactors}_{b,t}) \quad (2)$$

where b is an index for the individual bank and t for the year, and where f is a linear function of the explanatory variables.

As the explanatory factors can be measured through different indicators, we specify a number of alternative models (see Table 4.1). This table also describes our hypotheses about the mechanism through which the explanatory variables have influence on the mortgage interest rates.

We estimate the models using panel regressions with fixed effects and controlling for autocorrelation (AR-1). In assessing the models we test for multicollinearity[4] and autocorrelation[5].

[4] The Variance Inflation Factor, although not perfect with fixed effect panel regressions, is calculated for each specification to detect problems of multicollinearity. As a general rule of thumb, this factor should be lower than 10 in order to conclude that multicollinearity does not pose a serious problem, though with fixed effects they are likely to be biased upwards. Note, however, that problems with multicollinearity are also reflected by insignificance of coefficients.

[5] Autocorrelation is tested by the Modified Bhargava et.al. Durbin-Watson test and the Baltagi-WU locally best invariant test. The regression passes the autocorrelation test if the former is close to 2 and the latter exceeds 2.

Table 4.1 Hypotheses about the effect of explanatory variables (panel-data model)

Variables	Mechanism
Cost variables	
Marginal total costs. ($MTC_{b,t}$)	An increase in marginal total costs naturally leads to higher mortgage interest rates, as banks will price their products accordingly to their costs. We estimate the marginal costs by a translog cost function (see Appendix B). (see e.g. Van Leuvensteijn et al., 2007)
Average finance costs ($AFC_{b,t}$)	As an alternative to our estimated MTC, we use the average price of financial capital per bank per year. We expect a positive sign.
Average mortgage costs (AMC_t)	The third alternative measure for costs is called the average mortgage costs, which is based on data on the average costs for Dutch banks to finance mortgages (see NMa, 2011). These costs measure the average price banks have to pay for financial funds. The expected sign is positive.
Risk variables	
Standard deviation 6-month Euribor ($SD\_Euribor_t$)	The standard deviation of the money market rate reflects volatility on the money market, which in turn reflects money market risk. If the market risk goes up, we expect mortgage interest rates to rise as this risk is not fully covered by the cost variables (see eg. Maudos et al., 2004 and Hawtrey, et al. 2008).
Loan Loss Provisions ($LLP_{b,t}$)	Banks anticipate loan defaults and take provisions for that, which is measured by LLP. Higher credit risk could lead to higher mortgage interest rates in order to compensate for the higher risk level and extra losses on loans (see e.g. Titman et al., 2005 and Magri et al., 2009).
Market structure variables	
Joint market share of the 3 or 4 largest holdings ($C3_t$ or $C4_t$)	High levels of C3 suggest that a small number of banks may have market power that they can leverage to increase prices and earn higher profits. We therefore expect C3 to be positively related to the mortgage interest rates. (see e.g. Maudos, et al., 2004 and Hawtrey, et al. 2008)
Herfindahl-Hirschman Index (HHI_t)	Higher level of HHI means that few banks have high market shares, suggesting that they are more able to exercise market power to increase prices and earn higher profits. We therefore expect HHI to be positively related to the mortgage interest rate. (see e.g. Maudos, et al., 2004 and Hawtrey, et al. 2008)
Other variables	
Market share of firm ($ms_{b,t}$)	Consumers may be willing to pay higher mortgage interest rates for larger banks as these may appear to be less risky for consumers. Firm level market shares could therefore be a proxy for this. If this plays a role, we therefore expect firm level market share to be positively related to the mortgage interest rates.
Price Leadership of State Supported Banks ($PLSSB_t$)	In response to state aid given to specific banks, the European Commission imposed restrictive rules that do not allow these banks to be a price leader (ABN) or to set interest rates lower than their three lowest priced competitors (AEGON, ING) (see NMa, 2011). For every year, we calculated on a monthly basis the number of times that these banks were among the lowest three. We expect the variable to fall in 2010 and to have a negative effect on interest rates. (a lower number suggests less price competition, resulting in higher interest rates)

Note: The cost variables are meant as substitutes for each other, resulting in different model specifications.
The same holds for the market-structure variables.

4.3 Data

The characteristics of the data used in the panel analysis are summarized in Table 4.2, while Table A.2 in Appendix A presents the correlation matrix.

Regarding the annual mortgage interest rate, we use two sources: window tariffs[6] and actual tariffs[7]. Both are based on monthly data per type of mortgage per subsidiary or brand within bank holdings.[8] The graph at the left side of Figure 4.1 shows that the spread in (window) mortgage rates among banks is quite small compared to the general development over time. This graph clearly shows that the rates went up from 2005 to 2008 and then declined in 2009 and in particular in 2010.

Table 4.2 Description of variables in panel analysis

Variable	Mean	Standard deviation	Minimum	Maximum
Dependent variable				
Mortgage interest rate (% per year)				
- window tariffs	4.53	.55	3.45	5.67
- actual tariffs	4.62	.62	2.85	6.00
Cost Variables				
MTC (%)	6.83	3.50	3.69	29.70
AFC (%)	9.19	13.09	2.38	70.22
AMC (%, per year)	1.83	0.47	1.24	2.91
Risk variables				
SD_Euribor (% per year)	0.30	0.17	0.08	0.59
LLP (%)	0.30	0.38	0.00	1.28
Market-structure variables				
C3 (%)	62.81	3.42	58.90	70.59
HHI (index, in hundreds)	15.72	1.19	14.44	18.25
Other bank-specific variables				
ms (%/100)	0.02	0.04	0.00	0.25
PLSSB (n)	1.14	1.36	0	3

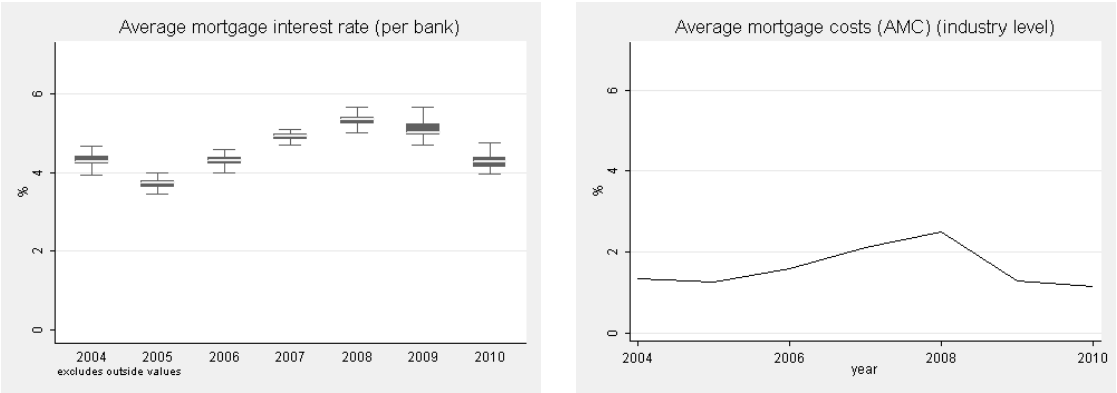
Note: these descriptives refer to the data set 2004 - 2010.

Regarding costs, we use three alternative measures: marginal total costs, average finance costs and average mortgage costs, where the last one is based on NMa (2011).

[6] Window tariffs are the tariffs used in advertisements. Source: Moneyview (public data).
[7] Actual tariffs are the tariffs actually paid by borrowers. Source: NHG (confidential data).
[8] Several bank holdings use a number of subsidiaries or brands to sell mortgage loans. In addition, per subsidiary or brand a number of different types of mortgage loans are sold, such as 'spaarhypotheek' or 'aflossingsvrije hypotheek', while within each type borrowers can choose the period they want to fix the interest rate. The interest rate used in the panel analysis is the average rate for five-years fixed periods per bank brand or subsidiary.

- The first one is the marginal total costs (MTC), which are estimated on the basis of a translog cost function, using accounting data on holding level from Bankscope. These costs refer to the total change in the costs of a bank in response to a change in the size of the loans. These marginal costs include all effects of an additional loan on total costs, such as the direct costs of funding, economies of scale and economies of scope. Appendix B describes how these marginal costs are estimated. Although using the marginal total costs is the theoretically preferred option, this approach has some limitations because of imperfections in the available data.[9] Therefore, we also estimate models with two other measures for costs.
- Another measure, which is also based on the annual accounts of banks from Bankscope, is the average (annual) price the banks paid for financial capital (such as deposits and short-term funding). We call this measure Average Financial Costs (AFC). The advantage of this measure above the MTC is its ease of calculation. The disadvantage, of course, is that it measures average costs in stead of marginal costs, while it excludes non-financial costs.
- The third measure gives the average costs for banks to finance their mortgages in the Netherlands. This measure, called Average Mortgage Costs (AMC), is also used in NMa (2011). The advantage of this measure above the former two is that it is directly related to the Dutch mortgage market and that we have data available to calculate these costs for 2010 as well. The disadvantage of this measure is the exclusion of non-financial costs as well as bank-specific information.

Figure 4.1 Mortgage interest rate (% per year per bank) and average mortgage costs (AMC; % of loans; industry level), 2004-2010

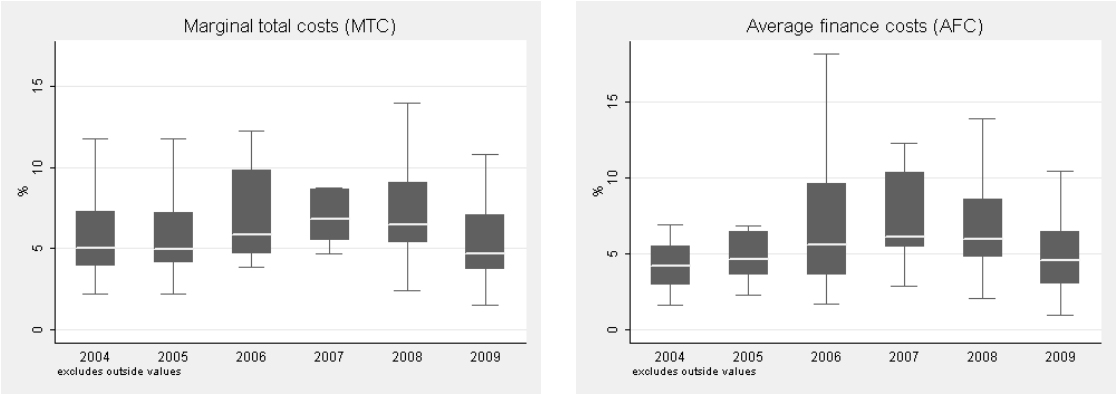


Sources: Mortgage interests rate: Moneyview; Average mortgage costs (AMC): DNB. Note: A box depicts the range between the 25th and 75th percentile while the horizontal line within a box shows the median.

[9] The available data are based on annual bank accounts of bank holdings without detailed information about the Dutch market or the share of mortgages in total loans (see Appendix B).

The average mortgage costs (AMC) are depicted in the graph on the right hand side in Figure 4.1. From 2005 – 2008 the AMC rose steadily, while they decreased sharply in 2009. The other two cost measures are shown in Figure 4.2. The graph at the left hand side shows the development of MTC over time. The spread between banks is considerable, which suggests significant heterogeneity among banks. Considering the average level of marginal costs, we observe rising marginal costs especially in 2006-2008, followed by a decline in 2009.

Figure 4.2 Marginal total costs and average finance costs per bank, 2004-2009 (% per loan)



Source: estimated on the basis of Bankscope data (see Appendix B). Note: A box depicts the range between the 25th and 75th percentile while the horizontal line within a box shows the median.

A comparable story is told by the graph on the right hand side of Figure 4.2 where the average finance costs (AFC) are depicted. Both cost measures tell us that the costs for banks rose in 2006 and 2007 and decreased sharply in 2009.

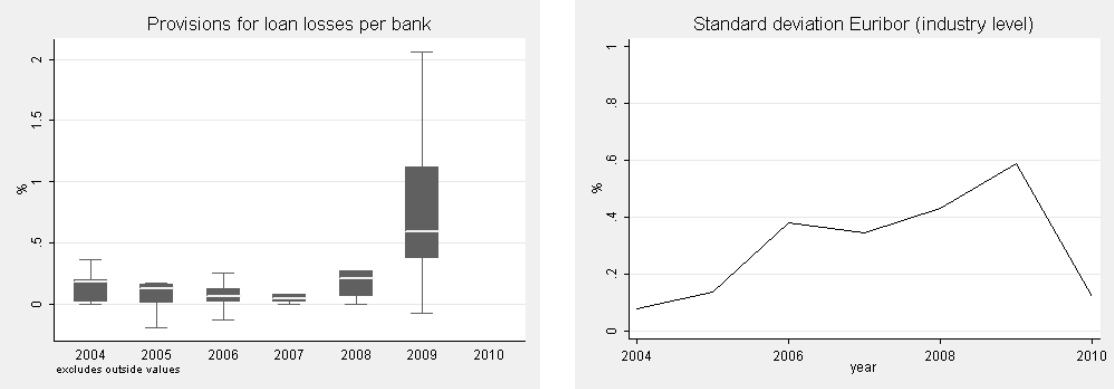
In order to include the risks in our model we use two variables. One is at the bank level, the other at general level. The bank-level indicator is LLP, which measures the provisions of banks for loan losses as percentage of total loans. Although LLP is related to macroeconomic variables, it also indicates bank-specific risks.[10] Figure 4.3 (left hand side) shows that these provisions rose strongly in 2009 and that the spread among banks appears to be large.

The general indicator for market risk is the volatility in the 6-month Euribor rate, depicted on the right hand side in Figure 4.3. This indicator measures the volatility in the rates for interbank deposits, which is the benchmark rate for mortgages interest rates (see e.g. ECB, 2009 and Titman et al. 2005). A higher volatility indicates higher uncertainty about the

[10] Pain (2003) finds, for UK banks, that the LLP are positively related to the magnitude of lending to risky sectors, such as commercial property companies, while Magri et al. (2009) finds, for Italy, that an increase in the probability of default has an upward effect on mortgage interest rates.

future costs of interbank lending. This indicator shows that the money-market volatility peaked in 2009. Although the bank-level indicator and the general indicator are related, they also give additional information. The former one measures the risk individual banks foresee in their loan portfolio, while the latter measures to which extent banks believe to be vulnerable to unexpected changes in future costs of borrowing. Because of the supplementary character of these risk indicators, we use them both as substitutes and as complementary variables.

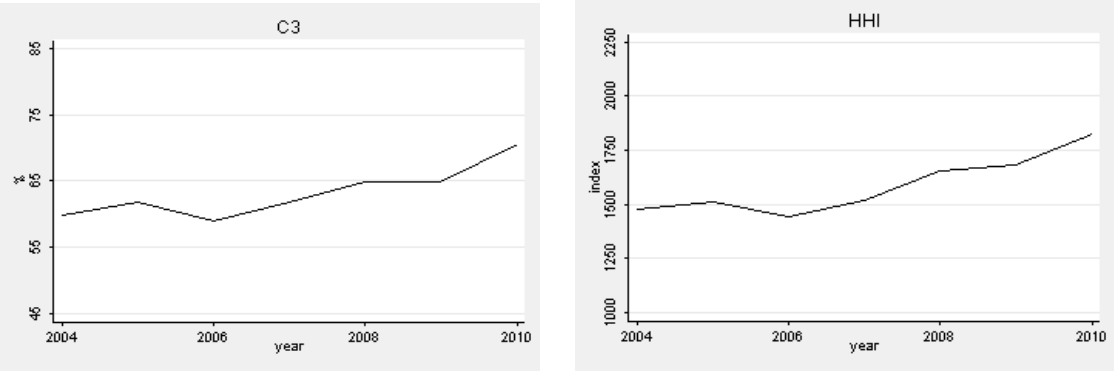
Figure 4.3 Loan loss provisions (per bank) and standard deviation Euribor, 2004-2009/2010



Source: Bankscope (Loan loss provisions; see Appendix B) and DNB (stdev. Euribor). Note: The standard deviation of the Euribor refers to the 6-months Euribor.

The impact of competition on the mortgage interest rate is measured through market-structure indicators. Figure 4.4 presents the average annual development in C3 (left hand side) and HHI (right hand side). According to both indicators, the mortgage market became more concentrated during 2004 – 2010.

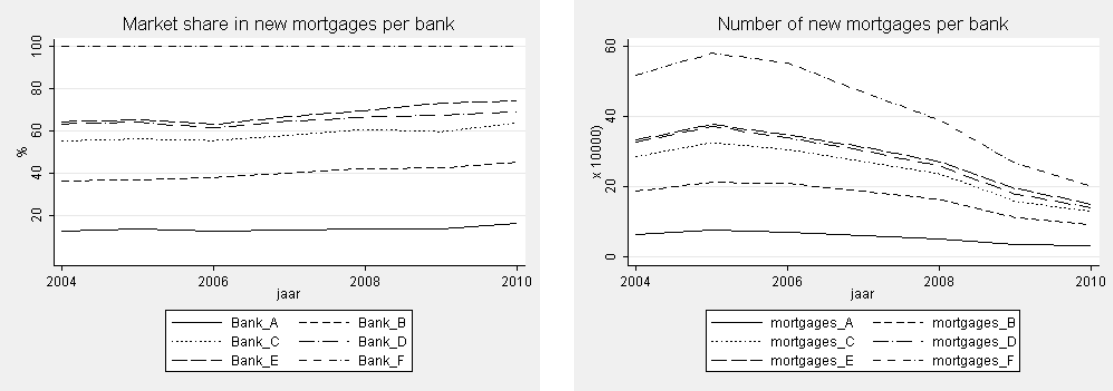
Figure 4.4 C3 and HHI in the Dutch mortgage market (yearly averages, 2004 - 2010)



Source: Kadaster. Note: C3 and HHI are defined at the level of bank holdings

We assess the influence of bank size on interest rates with brand-level market shares. Figure 4.5 (left side) shows the market shares of the largest banks (A/E) and all the other banks (F). We see that the market shares of the largest banks increased. From the graph on the right side we learn that the size (in numbers)[11] of the Dutch mortgage market strongly decreased in 2005 – 2010. In 2010, the total size is about 1/3 of the size in 2005. It appears that in this shrinking market particularly smaller banks faced a reduction in sales.

Figure 4.5 Cumulative market shares and cumulative number of mortgages per bank in the Dutch mortgage market, 2004 and 2010



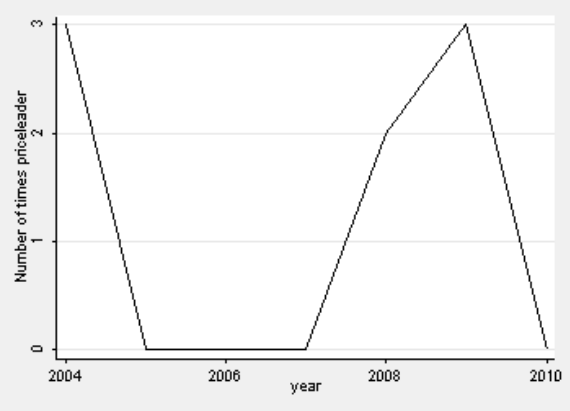
Source: Kadaster; note: both market shares and number of new mortgages are presented as cumulatives. The market share of Bank B, for instance, is equal to the difference between the (dotted) line of Bank B and the (solid) line of Bank A. Note also that "Bank F" refers to all other banks.

The effect of the restrictions imposed by the European Commission in 2010 are assessed through the variable PLSSB, which measures how often the banks which received state support were among the lowest priced suppliers. To calculate this variable, we first determined the monthly average mortgage interest rate of all the offered 5 years fixed NHG products for every subsidiary. We then defined for every holding the lowest average mortgage interest rate they[12] offered and subsequently ranked these in order to assess their position in the market.

Figure 4.6 shows the development of this variable over time. We see that the three respective banks are on average rarely price leaders on the market. We do, however, see a strong decline in 2005 and 2010. The latter might be the result of the restrictions set by the European Commission.

[11] Note that market shares in Euros of mortgages might differ from market shares in numbers.
[12] I.e. either the bank itself or one of their subsidiaries.

Figure 4.6 Number of times (months per year) that the three state-supported banks belong to the three lowest priced suppliers, 2004-2010.

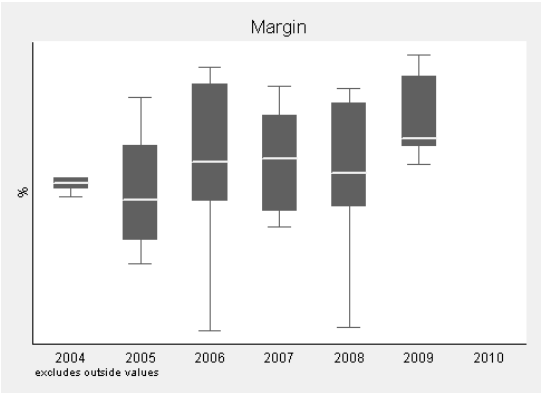


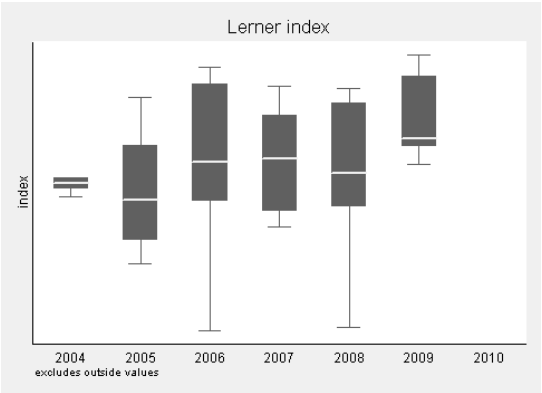
Source: Moneyview, authors' calculations

Marginal profit at the bank level

Using the translog cost approach (see Appendix B), we are able to assess the marginal profits at the bank level. The marginal profits at the bank level can be determined by comparing the mortgage interest rates and the marginal costs following from the translog-cost-approach. Note that the latter refer to the bank holdings, while the former refer to only one product of their output portfolio. Consequently, the resulting marginal profit is an approximation of the real marginal profit on mortgages. We find that in 2009 the average marginal profits are above the levels in previous years. We also learn that there is significant spread among banks in the level of marginal profits.[13] Apparently, banks differ significantly in portfolios and/or productive efficiency.

Marginal profit and Lerner index per bank per year (2004 - 2009)





Note that the marginal profits at the bank level include all marginal costs based on the translog cost estimations (see Section 4.3).

[13] The observed small spread in 2004 is caused by limitations in data availability.

4.4 Results

Combining the various variables in different combinations, we are able to define a large number of models. In Table 4.3 and Appendix C we present the results of 24 alternative model specifications.[14] The models P.1 – P.3 differ with regard to the cost variable. In model P.4 we explore the effect of including the market share. The models P.5 – P.7 differ from P.1 – P.3 with regard to the risk variable. In model P.8 we analyse the effect of combining two risk variables, one at the firm level and the other at the general level. In model P.9 we asses the effect of the bank-specific regulatory measures.[15] In order to correct for possible differences between the window and actual mortgage interest rates, we use confidential data on actual 5 years fixed NHG mortgage interest rates instead of window mortgage interest rates to estimate P.10 – P.12. In Appendix C we present the results of models P.13 – P.24, where we use HHI as indicator for market structure.

We find the following results:

- The marginal costs (MTC), resulting from the translog cost approach, show the expected sign and are significant in all model specifications (P.1, 4, 5 and 10). For the average financing costs at the industry level (AMC), we also find a significant and positive effect (P.3, 7, 8, 9, 11 and 12). However, using bank-specific information on total interest expenses (AFC), we find a positive, but insignificant effect (P.2 and 6). The relatively low values of the estimates for MTC and AFC are related to the relatively high levels of these explanatory data (see Table 4.2).
- We furthermore find that money market volatility has a significant and positive effect on mortgage interest rates in all model specifications. LLP, as a proxy for credit risk, shows the expected sign, but this variable is only significant in model specification P.7. Combining both risk variables (P.8) shows that the market risk is the dominant risk factor.
- Market structure (measured by C3) has a significant and positive effect on the interest rates in all model specifications. If we use C4 or HHI (see Appendix C) we obtain similar results. [16]

[14] The 24 models presented here still form a sample of all conceivable combinations of explanatory variables. However, model specifications without any variable on costs, risks or market structure are economically less valuable, although they might give information on the additional explanatory power of individual variables. As the relative importance is analysed in a different way, we omit these model specifications here.
[15] Models P.3, P.9 and P.12 only use sector-wide explanatory variables and are therefore not restricted by the availability of bank-specific variables. This means that we have data up till October 2010 for these models.
[16] Estimating the model without the variables on market level (i.e. SD_Euribor and C3/HHI) but with dummies for all years (except 2004), gives the general effect of separate years. This effect appears to be quite similar to the development within C3, suggesting that the latter is a major component of the annual effect.

Table 4.3 Results of panel-regression analysis (C3 as market-structure indicator)

Mortgage interest rate	Window rates									Actual rates		
	P.1	**P.2**	**P.3**	**P.4**	**P.5**	**P.6**	**P.7**	**P.8**	**P.9**	**P10**	**P11**	**P12**
Cost variables												
MTC	.14			.14	.085					.059		
	(5.18)			(5.27)	(2.84)					(2.26)		
AFC		.012				.006						
		(1.33)				(0.57)						
AMC			.67				.70	.67	.76		.27	.33
			(16.18)				(11.67)	(13.25)	(19.23)		(3.81)	(4.64)
Risk variables												
SD_Euribor	1.76	.88	1.39	1.8				1.40	3.40	1.56	1.63	2.96
	(4.98)	(2.49)	(9.48)	(5.07)				(5.36)	(9.64)	(4.14)	(7.32)	(6.31)
LLP					.19	-.58	.31	-.068				
					(1.20)	(-0.39)	(3.85)	(-0.71)				
Market-structure variable												
C3	.073	.10	.031	.073	.062	.08	.015	.021	.077	.054	.055	.077
	(5.02)	(7.22)	(4.86)	(5.01)	(3.16)	(4.72)	(1.27)	(2.25)	(8.23)	(4.02)	(6.51)	(7.21)
Other variables												
ms				-2.97								
				(-0.98)								
PLSSB									-.26			-.19
									(-6.13)			(-3.20)
Constant	-1.49	-2.11	.80	-1.43	.32	-.16	2.28	1.50	-2.81	.28	-.064	-1.95
	(-2.19)	(-2.89)	(2.63)	(-2.05)	(0.43)	(0.26)	(4.03)	(3.38)	(-5.40)	(0.49)	(-0.17)	(-3.53)
Goodness of fit												
R^2 overall	60%	57%	85%	60%	40%	50%	76%	87%	88%	35%	32%	33%
max(Vif)	3.0	8.2	2.5	24.9	3.0	8.4	3.0	4.1	2.5	2.6	2.1	2.3
Modified Bhargava et.al. DW	1.7	1.6	1.6	1.7	1.6	1.5	1.8	1.7	1.6	1.5	1.5	1.5
Baltagi_Wu LBI	2.2	2.2	2.2	2.2	2.1	2.1	2.5	2.3	2.1	2.0	1.9	1.8
nObs.	96	105	193	96	89	97	97	97	193	104	183	183
nGroups	29	33	48	29	26	29	29	29	48	27	37	37

Note: T-statistics in parentheses.

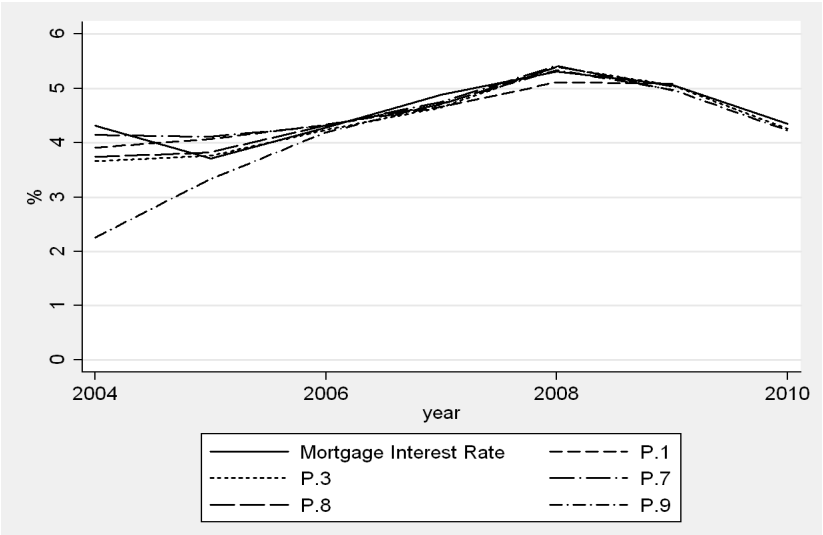
- Market share, as a proxy for the influence of bank size on consumer behaviour, shows a negative sign, but is also found to be insignificant.[17]

[17] Based on the large increase in the maximum Variance Inflation Factor in the model specifications with Market Share, we find it likely that this model suffers from a multicollinearity problem, rendering the results ambiguous. In addition, including the market share in the model may also cause an endogeneity problem, as a lower (higher) mortgage interest rate might result in higher (lower) market shares.

- Price Leadership of State Supported Banks (PLSSB) is found to be significant and negatively related to the mortgage interest rate. This means that when these three banks price less aggressively, either through imposed regulation or at its own discretion, mortgage interest rates tend to go up. The imposed restrictions therefore seem to lead to higher mortgage interest rates.
- The above results continue to hold if we use actual mortgage interest rates instead of window mortgage interest rates. The cost variables, however, show a smaller coefficient for the actual mortgage interest rates, but all explanatory variables have the expected sign and are significant.

Overall we see that most of the models presented here have a high level of explanatory power, that costs and money market risk have a significant and positive effect on the mortgage interest rates, and that controlling for costs and risks, market concentration appears to have a significant and positive effect on the mortgage interest rates.[18] Furthermore, less aggressive pricing of the banks that are subject to restrictions imposed for receiving State Aid overall leads to higher mortgage interest rates. Figure 4.7 depicts the 'predicted' mortgage interest rate (on average per bank per year) in relation to the actual interest rate for a number of model specifications. Except for the earliest year, the deviation (i.e. the residual) is small, which reflects the high explanatory power of the models.

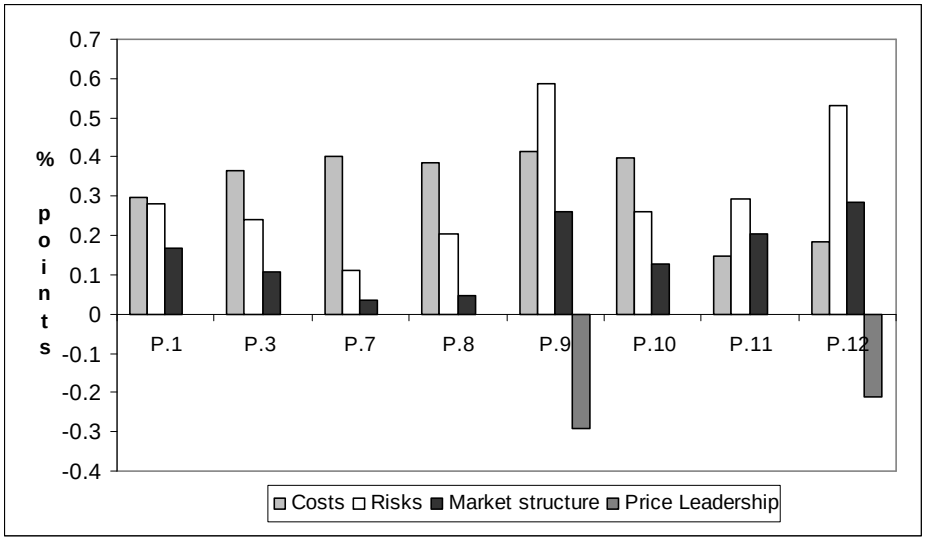
Figure 4.7 Actual and predicted mortgage interest rate, on average per bank, 2004-2010



[18] In technical terms: we have to reject the null hypothesis for each of these variables that they do not have an effect on the mortgage interest rate.

Using the results of Table 4.2 and Table 4.3, we are able to determine the relative contribution of each of the explanatory variables.

Figure 4.8 Effect of explanatory variables on mortgage interest rate using C3 as market structure variable, per model (%-points)



Note: the contribution per variable is calculated by multiplying the regression coefficient (see Table 4.3) with the standard deviation of the variable within the sample size of the regression.

We find that for most models, the effect of a standard deviation change in market concentration is smaller than the effect of such an increase in the cost or risk variables (see Figure 4.8).[19] An increase in market concentration equal to the size of its standard deviation raises the mortgage interest rate by about 0.10 to 0.20 percentage points. An increase in costs and risks equal to the size of their standard deviations raises the mortgage interest rate respectively by about 0.30 and 0.40 percentage points. We conclude that the mortgage interest rate is mostly affected by changes in costs and risks, but also significantly by changes in market concentration. In addition to these effects, the mortgage interest rate also appears to be related to the degree to which some of the larger banks act as a price leader.

[19] See Appendix D for a full overview of the effects of all variables in all models.

5 Conclusion

1. We find statistically significant evidence that the degree of competition in the Dutch mortgage market, measured by C3 or HHI, affected the level of the mortgage interest rates during the period 2004 - 2010. In this period, the degree of competition fluctuated in response to entrance and disappearance of a number of banks.

2. Besides the degree of competition, the mortgage interest rates were also influenced by the costs of lending, the risks banks faced and regulatory measures on banking behaviour. The impact of costs as well as risks appears to be about twice as large as the impact of market concentration. An increase in market concentration equal to the size of its standard deviation over the period of analysis raised the mortgage interest rate by about 0.10 to 0.20 percentage points.

3. The size of a bank does not appear to have an effect on the mortgage interest rates. This follows from the result that market share, as a proxy for the influence of market size on consumer behaviour, shows a negative sign, but is also found to be insignificant. This result does not exclude any other influence of reputational effects on the ability of banks to charge higher interest rates.

4. In addition, we find a statistically significant relationship between the degree to which the state-supported banks act as price leaders and the mortgage interest rate. This means that when these three banks price less aggressively, either through imposed regulation or at their own discretion, mortgage interest rates tend to go up. The restrictions imposed by the European Commission in response to the state support for a number of banks, therefore, seem to lead to higher mortgage interest rates.

5. The conclusions continue to hold if we use actual mortgage interest rates instead of window mortgage interest rates.

References

Berger, A.N. and L.J. Mester (1997), Inside the black box: What explains differences in the efficiencies of financial institutions, Journal of Banking and Finance, 21, pp. 895-947.

Bikker, J.A. and J.W.B. Bos (2005), Trends in Competition and Profitability in the Banking Industry: A Basic Framework, SUERF Studies, SUERF - The European Money and Finance Forum, 2005/2.

Bos, J.W.B. and J.W. Kolari (2005), Large Bank Efficiency in Europe and the United States: Are There Economic Motivations for Geographic Expansion in Financial Services?, Journal of Business, vol. 78(4), pp. 1555-1592.

Carbó, S., D. Humprey, J. Maudos and P. Molyneux (2009), Cross-country comparisons of competition and pricing power in European banking, Journal of International Money and Finance 28(2009) 115-134.

Dietrich, A. and C. Wunderlin (2010), What drives the margins of mortgage loans?, Institute of Financial Services IFZ, Lucerne University, Switzerland.

ECB (2009), Housing finance in the Euro area, Occasional Paper Series 101, European Central Bank, Frankfurt am Main.

End, J.W. van den (2011), Statistical evidence on the mean reversion of interest rates, DNB Working Paper 284, De Nederlandse Bank NV., Amsterdam.

Hawtreya, K. and H. Liang (2008), Bank interest margins in OECD countries, North American Journal of Economics and Finance 19 (2008) 249–260.

Leuvensteijn, M. van, J.A. Bikker, A.A.R.J.M. van Rixtel and C. Kok-Sörensen (2007), A new approach to measuring competition in the loan markets of the euro area, CPB Discussion Paper 84. July.

Magri, S. and R. Pico (2009), The rise of risk-based pricing of mortgage interest rates in Italy, Journal of Banking & Finance, 35, pp. 1277-1290.

Maudos, J. and J. F. Fernández de Guevara (2004), Factors explaining the interest margin in the banking sectors of the European Union, Journal of Banking & Finance, 28, pp. 2259–2281.

Mojon, B. (2001), Financial Structure and the interest rate channel of the ECB monetary policy, Economie et Prevision No. 147, 1, pp. 89-115.

Neven, D. and. L-H. Röller (1999), An aggregate structural model of competition in the European banking industry, International Journal of Industrial Organization 17(1999) 1059-1074.

NMa (2010), Quick Scan Hypotheekrente; een onderzoek naar de marges op hypotheken.

NMa (2011), Sectorstudie Hypotheekmarkt; een onderzoek naar de concurrentieomstandigheden op de Nederlandse Hypotheekmarkt, mei.

Pain, D. (2003), The provisioning experience of the major UK banks: a small panel investigation, Bank of England, Working Paper no. 177.

Swank, J. (1996), How stable is the multiproduct translog cost function? Evidence from the Dutch banking industry, Kredit und Kapital, 29, pp. 153-72.

Titman, S. and S. Tompaidis (2005), Determinants of credit spreads in commercial mortgages, Real Estate Economics, 33(4), pp. 711-738.

Toolsema, L.A. (2002), Competition in the Dutch consumer credit market, Journal of Banking & Finance, 26, 2215-2229.

Toolsema, L.A. and J.P.A.M. Jacobs (2007), Why do prices rise faster than they fall? With an application to mortgage rates, Managerial and Decision Economics, 28, pp. 701-712.

Valverde, S.C. and F.R. Fernández (2005), The determinants of bank margins in European banking, University of Granada, Spain.

Appendix A Correlation matrices of explanatory data

Table A.1 Correlation matrix of variables in time-series analysis (n=82)

	Mortgage interest rate	AMC	SD_Euribor_m	C3	C4	HHI
Mortgage interest rate	1					
AMC	.92	1				
SD_Euribor_m	.50	.51	1			
C3	.09	-.06	.22	1		
C4	-.02	-.17	.19	.94	1	
HHI	.10	-.07	.19	.97	.95	1

Table A.2 Correlation matrix of variables in panel analysis

	Mortgage Interest Rate	MTC	AFC	AMC	Std.dev Euribor	LLP	C3	C4	HHI	ms	PLSSB
Mortgage Interest Rate	1.00										
MTC	.31	1.00									
AFC	.39	.46	1.00								
AMC	.89	.28	.39	1.00							
SD_Euribor	.72	.014	.15	.65	1.00						
LLP	.39	-.08	-.27	.33	.58	1.00					
C3	.65	.11	.18	.71	.56	.55	1				
C4	.47	.030	.056	.71	.40	.56	.95	1			
HHI	.70	.074	.14	.71	.67	.64	.97	.94	1		
Ms	-.077	.021	-.14	.025	.0090	-.039	.040	.046	.043	1	
PLSSB	.49	-.0091	.080	-.34	.37	.55	.56	.66	.70	.047	1

APPENDIX B Estimating marginal costs at the bank level

Background

Estimating marginal costs is not a new phenomenon in the academic literature. There is an ample stream of literature that estimates marginal costs on the firm level by using translog cost functions. More specifically, there is also a vast stream of academic literature on estimating marginal costs at the bank level, also using a translog cost function (TCF) to derive these. A TCF is a second-order Taylor expansion of a dual cost function with all variables in logarithms.[20] The notion that it is a proven method for the banking sector in particular makes it an attractive approach to explore in this paper. We mention the following applications of the TCF approach in analysing the banking market:

- While a Fourier flexible form may in theory be more precise than the simpler translog functional form, Berger and Mester (1997) compare the two and find that despite the added flexibility of the Fourier flexible form, there seems to be little difference between the results. We therefore argue that we can use the simpler translog functional form.

- Maudos and Guevara (2004) analyse the interest margins in several European banking sectors[21] in the period 1993-2000, for which they calculate the marginal costs per bank. Using Bankscope data, they estimate a TCF with a single output, Total Assets, three inputs, price of respectively labor, physical capital and deposits, and a trend, to incorporate technological change. They do not, however, report the results of the TCF.

- Bos and Kolari (2005) use translog cost and profit functions with three inputs, three outputs and a trend to estimate scale and scope economies and X-efficiencies for large European and American banks in the period 1995-1999. They also include equity in the TCF as a control variable. The trend is included in the model together with its square and its interactions with the inputs and outputs. They do not present the results of their TCF, but justify its use by noting that previous bank efficiency studies, e.g. Berger and Mester (1997) and Swank (1996), have shown that "[..] **the translog cost and profit functions are locally stable in large bank applications [..]"**.

[20] Except for time variables and in some cases control variables, such as equity.
[21] Germany, France, UK, Italy and Spain.

- Van Leuvensteijn et al. (2007) measure the level of competition on the lending markets for five major EU countries, Japan, the UK and the US in the period 1992-2004. Using a TCF with two inputs, three outputs, equity as a control variable and time dummies to capture the trend, they estimate the marginal costs per country for every bank with bank-level data from Bankscope. In the Appendix, they report the regression results for a single country (Germany) and they also report the means of their calculated marginal costs per country. The regression results overall show highly significant coefficients and a high overall fit of the model.

Model specification and data

Following Van Leuvensteijn et al. (2007), but omitting their dummy for type of bank, the TCF can generally be specified as:

$$\ln C_{it} = \alpha_0 + \sum_{t=1}^{T-1} \partial_t d_t + \sum_{j=1}^{K} \beta_j \ln x_{ijt} + \sum_{j=1}^{K} \sum_{k=1}^{K} \gamma_{jk} \ln x_{ijt} \ln x_{ikt} + \nu_{it}$$

where

$\mathbf{C_{it}}$ = total production costs of the bank

$\mathbf{d_t}$ = time dummies (trend); equals 1 in year **t**, 0 otherwise.

x_{ikt} = represents three groups of explanatory variables ($\mathbf{k}$ = 1, ..., $\mathbf{K}$), with $\mathbf{K_1}$ a group of bank output components, such as loans and securities, $\mathbf{K_2}$ a group of input prices, such as the price of financial capital and wages, and a third group of ($\mathbf{K}$-$\mathbf{K_1}$-$\mathbf{K_2}$) control variables, such as the equity ratio.

The duality problem requires symmetry and homogeneity in input prices (see Bikker and Bos, 2005). Similar to Van Leuvensteijn et al. (2007), we set j = k (in order to apply the symmetry restrictions), such that $Y_{j,k}=Y_{k,j}$. Therefore, x_{ijt} also equals x_{ikt}. Bikker and Bos (2005) suggest that homogeneity in input prices can be imposed by normalising the dependent variable and all input price variables. Therefore, we scale the output (total costs) and the prices of financial capital and labour by the price of other inputs. All input prices (W1 and W2) and the total costs (TC) are scaled by the Price of Physical Capital (W3) to impose linear homogeneity in input prices.

The marginal costs of loans follow from taking the derivative of the TCF to loans.

$$mc_{ilt} = \partial c_{it} / \partial x_{ilt} = (c_{it} / x_{ilt}) \partial \ln c_{it} / \partial \ln x_{ilt}$$

Bos and Kolari (2005) specify a more precise formula of the TCF in their paper. Following them, we specify the TCF regression as follows[22]:

$$\begin{aligned}\ln TC = {} & \beta_0 + \beta_1 \ln Y1 + \beta_2 \ln Y2 + \beta_3 \ln Y3 + \beta_4 \ln W1 + \beta_5 \ln W2 + \beta_6 Z + \beta_7 \tfrac{1}{2}(\ln Y1)^2 \\ & + \beta_8 \ln Y1 \ln Y2 + \beta_9 \ln Y1 \ln Y3 + \beta_{10} \tfrac{1}{2} (\ln Y2)^2 + \beta_{11} \ln Y2 \ln Y3 + \beta_{12} \tfrac{1}{2}(\ln Y3)^2 \\ & + \beta_{13} \tfrac{1}{2}(\ln W1)^2 + \beta_{14} \ln W1 \ln W2 + \beta_{15} \tfrac{1}{2}(\ln W2)^2 + \beta_6 \ln Y1 \ln W1 + \beta_{17} \ln Y1 \ln W2 \\ & + \beta_{18} \ln Y2 \ln W1 + \beta_{19} \ln Y2 \ln W2 + \beta_{20} \ln Y3 \ln W1 + \beta_{21} \ln Y3 \ln W2 + \beta_{22} \ln Y1 Z \\ & + \beta_{21} (\ln Y2) Z \ln Y3 Z + \beta_{23} \tfrac{1}{2} Z^2 + \beta_{24} Z \ln W1 + \beta_{25} Z \ln W2 + \beta_{26} T + \beta_{27} \tfrac{1}{2} T^2 + \beta_{28} (\ln Y1) T \\ & + \beta_{29} (\ln Y2) T + \beta_{30} (\ln Y3) T + \beta_{31} (\ln W1) T + \beta_{32} (\ln W2) T + \beta_{33} ZT\end{aligned}$$

for which TC, W1 and W2 are scaled by W3[23] and where:

TC = Total Costs = Total Interest Expenses + Total non-Interest Expenses - non-Recurring Expenses

Y1 = Loans = Gross Loans (volume)

Y2 = Investments = Other Earning Assets (volume) / AEX index[24]

Y3 = Other Income = Net[25] Fees and Commissions

W1 = Price of Financial capital

= Total Interest Expenses / Total Deposits, Money Market and Short-Term Funding (volume)

W2 = Price of labour = Total Personnel Expenses / Total Assets (volume)

W3 = Price of Physical Capital = Other Operating Expenses / non-Earning Assets

Z = Equity ratio = Equity / Total Assets

T = Time[26]

---

[22] From the Taylor expansion it follows that the squared interaction terms are multiplied by 0.5, hence we multiply the respective squared variables by 0.5.

[23] Bikker and Bos (2005) suggest that homogeneity in input prices can be imposed by normalising the dependent variable and all input price variables. Therefore, we scale the output (total costs) and the prices of financial capital and labour by the price of other inputs. All input prices (W1 and W2) and the total costs (TC) are scaled by the Price of Physical Capital (W3) to impose linear homogeneity in input prices.

[24] Investments have been scaled by the trend on the stock markets, proxied by the AEX index, to correct the book value of investments for fluctuations in underlying market value. If the investment portfolio e.g. falls in value while the bank's investment activities stay the same, we would erroneously assume that this bank had less investment activities. However, the actual level of activity is reflected in the total costs, so if we do not correct for market value, this would greatly distort the effect of investment activities on total costs.

[25] Since we are interested in the effect of loans, i.e. Y1.

[26] Time, its square and its interactions are included in our regression to prevent multicollinearity problems with using time dummies instead. Bos and Kolari (2005) incorporate time in a similar manner in their translog cost and profit functions.

We estimate the equation with a robust panel regression with cross-sectional fixed effects, using data from annual reports of all banks in the Netherlands in the period 2004-2009, as provided by Bureau van Dijk's Bankscope.

Results

The regression results are presented in Table B.2. Individually, not all variables are significant in the TCF, but it is important that the variables with respect to lnY1 jointly are and therefore we test the joint effect (and significance thereof) of lnY1 and its interaction terms on lnTC. Table B.1 presents the results of the joint significance test. The joint coefficient of lnY1 and its interactions is found highly significant.

Table B.1 Lincom test for joint significance of Y1 and its interactions on lnTC

lnTC	Coefficient	Std. Err.	T	P>t	[95% Conf.Interval]	
Joint lnY1	0.794	0.194	4.08	0.000	0.392	1.195

Taking the derivative of lnTC with respect to lnY1 (loans), we find the marginal costs of lending.[27]

$$dlnTC/dlnY1 = \beta_{lnY1} + \beta_{½(lnY1)^2} * lnY1 + \beta_{lnY1lnY2} * lnY2 + \beta_{lnY1lnY3} * lnY3 + \beta_{lnY1lnW1} * lnW1 + \beta_{lnY1lnW2} * lnW2 + \beta_{(lnY1)Z} * Z + \beta_{(lnY1)T} * T$$

In order to get the marginal costs per unit of loans we have to rewrite the above marginal costs, which are in logarithmic terms:

$$(dlnTC/dlnY1)_{it} = dTC_{it}/dY1_{it} * (Y1_{it}/TC_{it})$$

Hence:

$$dTC_{it}/dY1_{it} = (dlnTC/dlnY1)_{it} * (TC_{it}/Y1_{it}) = \text{marginal costs (MTC)}$$

In other words, the marginal costs resulting from the regression estimation (i.e. dlnTC/dlnY1) have to be multiplied with (TC/Y1).

[27] Note that taking the derivative with respect to lnY1 of the terms $\beta_{lnY1} * lnY1 = \beta_{lnY1}$; and of $\beta_{½(lnY1)^2} * ½(lnY1)^2 = \beta_{½(lnY1)^2} * lnY1$; etc.

Table B.2 Results of estimation of TCF

lnTC	Coefficient	Standard Error	Significance
lnY1	.700	.132	***
lnY2	.405	.073	***
lnY3	.063	.102	
lnW1	.734	.153	***
lnW2	.158	.166	
Z	.006	.005	
½(lnY1)²	.051	.149	
lnY1lnY2	-.0159	.064	
lnY1lnY3	-.0163	.088	
½(lnY2)²	.0003	.049	
lnY2lnY3	.023	.041	
½(lnY3)²	.006	.048	
½(lnW1)²	.071	.046	
lnW1W2	-.107	.068	
½(lnW2)²	.319	.155	*
lnY1lnW1	.0603	.082	
lnY1lnW2	.00002	.098	
lnY2lnW1	-0.183	.066	**
lnY2lnW2	.127	.059	**
lnY3lnW1	.142	.050	***
lnY3lnW2	-.183	.082	**
(lnY1)Z	-.0016	.002	
(lnY2)Z	-.0012	.0016	
(lnY3)Z	.0044	.0018	**
½(Z)²	-.00003	.00018	
(lnW1)Z	.0011	.0020	
(lnW2)Z	-.0061	.0030	*
T	.1135	.078	
½(T)²	-.028	.078	*
(lnY1)T	.0156	.0282	
(lnY2)T	-.0441	.018	**
(lnY3)T	.0216	.0261	
(lnW1)T	-.0101	.036	
(lnW2)T	.0198	.045	
ZT	-.0008	.0011	
Constant	-5.835	1.16	***
Observations; 96; **Number of groups**: 25; **R-squared:** 0.973			

It is worthwhile to consider the effect of the different components of the TCF on the marginal costs. Figures B.2 and B.3 show the effect that some of the inputs and prices have on the marginal costs. The price of financial capital, loan volume and economies of scope are positively related to marginal costs, while the equity ratio is negatively related to marginal costs.

Figure B.2 Economies of scale and economies of scope

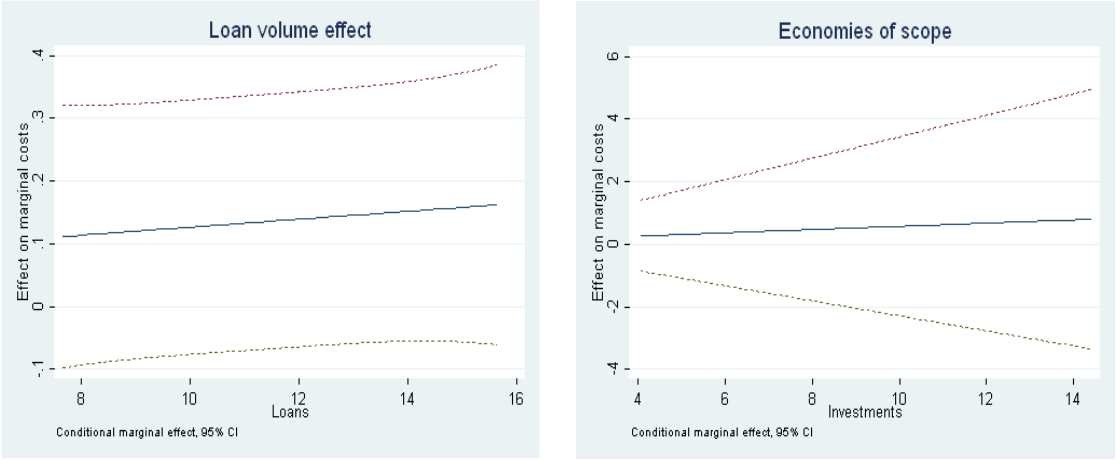
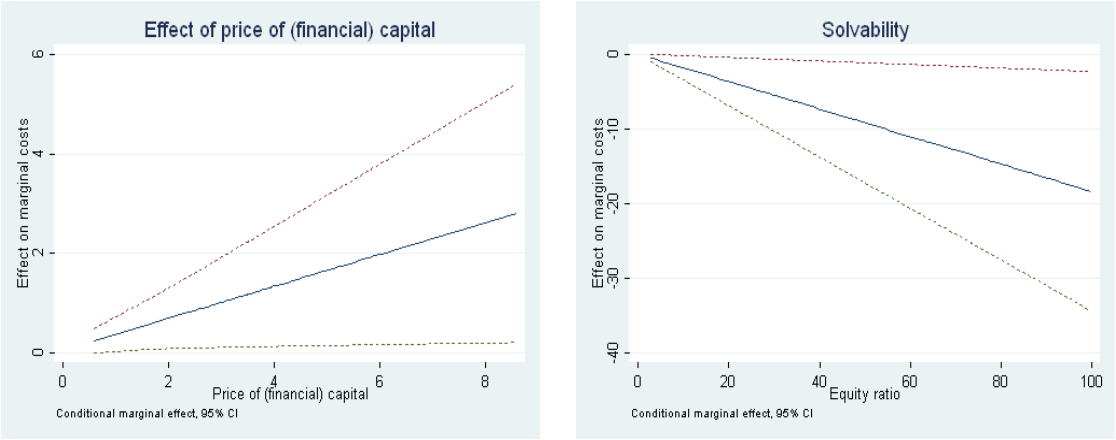


Figure B.3 Effect of price of financial capital as well as equity on marginal costs



Note: the dotted lines represent the 95% confidence interval.

Appendix C Results of panel analysis (HHI as market-structure indicator)

Table C.1 Results of panel-regression analysis (HHI as market-structure indicator)

Mortgage interest rate	Window rates								Actual rates			
	P.13	P.14	P.15	P.16	P.17	P.18	P.19	P.20	P.21	P.22	P.23	P.24
Cost variables												
MTC	.14			.15	.097					0.064		
	(5.26)			(5.34)	(3.47)					(2.42)		
AFC		.0057				.0099						
		(0.62)				(0.95)						
AMC			.68				.69	.69	.80		.30	.39
			(16.72)				(12.01)	(13.47)	(20.93)		(4.25)	(5.58)
Risk variables												
SD_Euribor	1.36	0.15	1.23	1.41				1.28	3.68	1.28	1.37	3.47
	(3.39)	(0.39)	(9.39)	(3.48)				(4.84)	(10.79)	(3.05)	(6.47)	(6.74)
LLP					.013	-.22	.25	-.044				
					(0.08)	(-1.44)	(2.76)	(-0.45)				
Market-structure variable												
HHI	.21	.30	.083	.21	.29	.33	.063	.046	.27	.16	.15	.28
	(4.79)	(6.65)	(4.78)	(4.77)	(4.98)	(6.10)	(1.59)	(1.43)	(9.39)	(3.52)	(5.83)	(7.40)
Other variables												
ms				-3.03								
				(-0.98)								
PLSSB									-.34			-.30
									(-7.58)			(-4.40)
Constant	-.086	-.070	1.52	-.018	-.40	-.43	2.27	2.10	-2.31	1.25	1.02	-1.81
	(-0.17)	(-0.13)	(6.92)	(-0.04)	(-0.60)	(-0.72)	(4.59)	(5.96)	(-5.50)	(2.61)	(3.37)	(-3.44)
Goodness of fit												
R^2 overall	57%	56%	85%	57%	50%	51%	78%	87%	86%	35%	31%	32%
max(Vif)	2.9	8.1	2.4	24.9	3.3	8.6	4.1	4.4	2.4	2.6	2.2	2.2
Modified Bhargava et.al. DW	1.6	1.6	1.7	1.6	1.7	1.5	1.9	1.7	1.6	1.5	1.5	1.5
Baltagi_Wu LBI	2.1	2.1	2.3	2.1	2.2	2.1	2.5	2.4	2.1	2.0	1.9	1.8
nObs.	96	105	193	96	89	97	97	97	193	104	183	183
nGroups	29	33	48	29	26	29	29	29	48	27	37	37

Note: T-statistics in parentheses.

Figure C.1 Effect of a std. dev. change in explanatory variables on mortgage interest rate using HHI as market structure variable, per model (%-points)

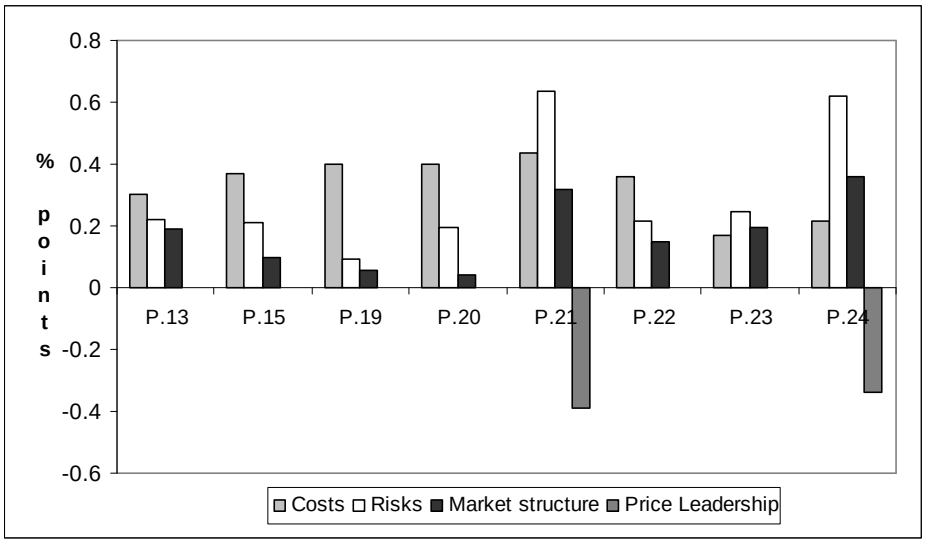
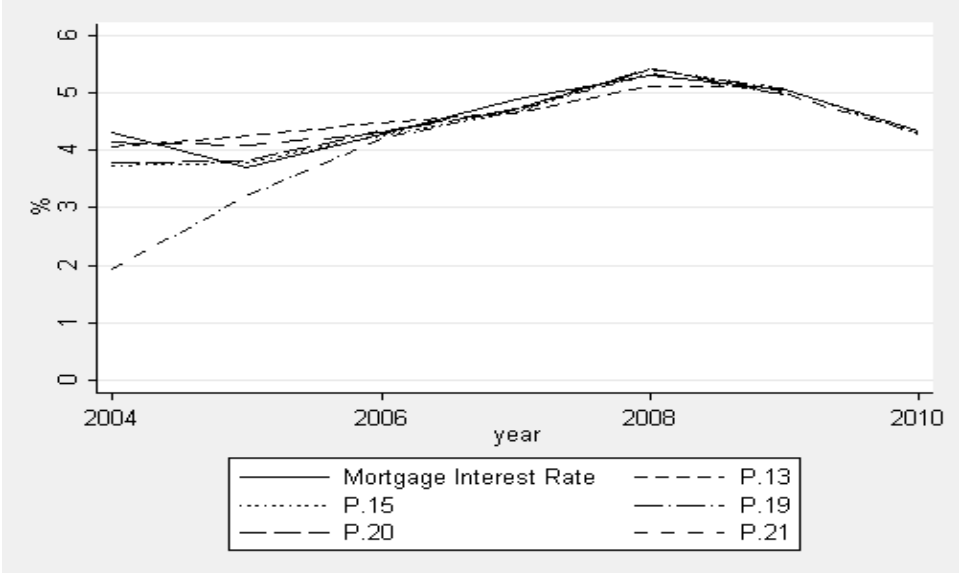


Figure C.2 Actual and predicted mortgage interest rate, on average per bank, 2004-2010

Figure 5.1



Appendix D Relative contribution of explanatory variables

Table D.1 Effect of a change in explanatory variables on mortgage interest rate (%-points)

C3 as market indicator												
	P.1	**P.2**	**P.3**	**P.4**	**P.5**	**P.6**	**P.7**	**P.8**	**P.9**	**P.10**	**P.11**	**P.12**
MTC	.30			.30	.18					.14		
AFC		.24				.09						
AMC			.37				.40	.39	.42		.15	.18
SD_Euribor	.28	.14	.24	.29				.23	.49	.26	.29	.53
LLP					.07	-.02	.11	-.02				
C3	.17	.31	.11	.21	.14	.19	.03	.05	.26	.13	.20	.28
ms				-.14								
PLSSB									-.29			-.21
HHI as market-structure indicator												
	P.13	**P.14**	**P.15**	**P.16**	**P.17**	**P.18**	**P.19**	**P.20**	**P.21**	**P.22**	**P.23**	**P.24**
MTC	.30			.31	.21					.15		
AFC		.08				.14						
AMC			.37				.40	.40	.44		.17	.22
SD_Euribor	.22	.02	.21	.23				.21	.63	.22	.25	.62
LLP					.005	-.08	.09	-.02				
HHI	.19	.27	.10	.19	.26	.30	.06	.04	.32	.15	.20	.36
ms				-.14								
PLSSB									-.39			-.34

Note: The change in explanatory variables is expressed in the respective standard deviations (see Table 4.2 for a general indication, though the actual standard deviations differ with the model specifications).