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Determinants of Interest Rates on Time Deposits and Savings Accounts: Macro Factors, Bank Risk, and Account Features*

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ABSTRACT

Using a novel dataset from the Netherlands' banking sector, we examine how macroeconomic, bank-specific, and account-specific characteristics affect the interest rates of banking products. Our results show that interest rates have become more sensitive to bank risk since the onset of the global financial crisis. More generally, we show that time deposits reflect more closely the economic environment than bank interest rates on savings accounts do. Interest rates on deposit products vary not only across, but also within banks (i.e., across account of individual banks). We find that maturity-increasing conditions (i.e., withdrawal fees for savings accounts and product maturity for time deposits) positively influence a product's interest rate.

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I. INTRODUCTION

We study the determinants of interest rates on both savings accounts and time deposits in the Netherlands during the period 2003–2014.[1] Time deposits have a fixed maturity, usually preventing early withdrawal of the deposited funds. The interest rate conditions on these deposits are communicated to depositors in advance. By contrast, savings accounts can be accessed at all times, and

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1 According to the DNB Household Survey 2014, 78% of Dutch individuals have one or more savings or deposit accounts. The overwhelming majority of current accounts in the Netherlands are non-interest bearing accounts.

generally come with a floating interest rate. Both types of accounts can be used by bank customers to deposit funds and earn interest. In order to study deposit rate determinants, we employ a unique dataset, which consists of rates and conditions on a daily basis offered by all commercial banks active in the Netherlands. Figure 1 depicts the highest, lowest, and median interest rates offered on Dutch savings accounts during these years. In most years, the highest interest rate was approximately 1.5% points above the median rate. During the height of the financial crisis, the gap widened to no less than 2.5% points. Our study aims to gain a better understanding of the developments of deposit rates in general, and of the impact of a financial crisis on these developments in particular. Our analysis focuses on a wide range of factors representing macroeconomic, bank-specific, and account-specific variables.

The extent to which deposit rates reflect macroeconomic variables is studied by, among others, Kok Sørensen and Werner (2006), De Graeve et al. (2007), Gambacorta (2008), and Antao (2009). In general, it is found that the market rate, inflation rate, and volatility of both the market rate and the stock market all exert a positive impact on bank rates. By contrast, economic growth and the level of bank concentration are negatively related to interest rates. Both De Graeve et al. (2007) and Kok Sørensen and Werner (2006) make a distinction between short-term and long-term deposit products. We follow them by separately studying savings accounts and time deposits.

The impact of bank-specific variables on the price of deposits is generally studied in the market discipline literature. Market discipline refers to the process in which debtholders, such as depositors, require higher returns when the probability increases that they incur losses in case of, for example, a bank default. In general, bank risk and the deposit rate are positively related (e.g., Park and Peristiani 1998; Mondschean and Opiela 1999; Martinez Peria and Schmukler 2001; Demirgüç-Kunt and Huizinga 2004; Imai 2006; Murata and Hori 2006;

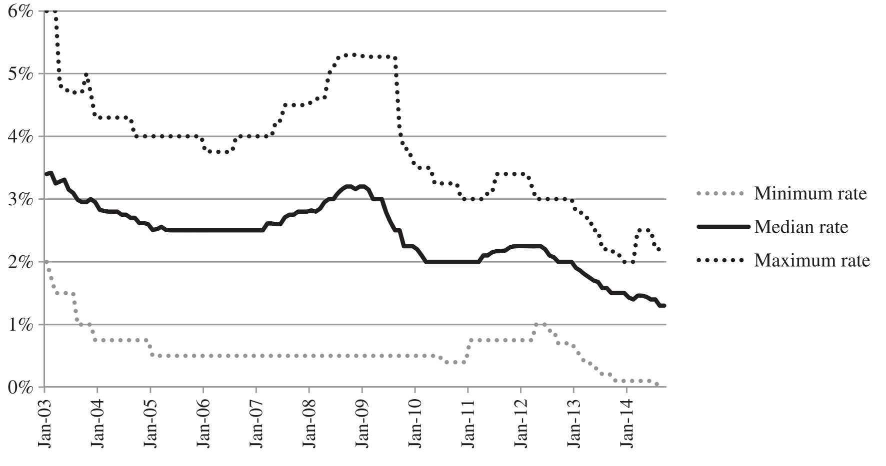

Figure 1 The interest rate on savings accounts in the Netherlands, 2003–2014.

Hori et al. 2009; Beyhaghi et al. 2014), despite the fact that deposit insurance weakens this relation (e.g., Mondschean and Opiela 1999; Demirgüç-Kunt and Huizinga 2004).[2]

Lastly, Johnson et al. (2008) acknowledge the effect of account-specific variables on interest rates. They show that rates generally increase with the maturity of the deposit. By contrast, bank savings accounts are usually treated by the literature as one single entity, while in reality banks offer different savings accounts with different characteristics. For example, an account can come with a minimum balance, a withdrawal fee, or a bonus rate for rewarding loyal customers.

In addition to examining the pricing of macroeconomic, bank-specific and account-specific variables in savings account and time deposit interest rates, we specifically study whether the impact of these variables changed during the financial crisis. To the best of our knowledge, the impact of bank risk on deposit rates during the recent financial crisis is only studied by Beyhaghi et al. (2014).[3] They study Canadian banks and find for this period that bank-specific risk factors lose their importance in explaining deposit rates, which they attribute to a greater market awareness of government guarantees for potentially failing banks. These results cannot be generalized to other countries per se, because Canada "has no history of government bailouts" (Beyhaghi et al. 2014: 396) and did not experience a bank failure during the 2007–2009 period. Stolz and Wedow (2010) document government support measures in the USA and the EU countries and show that the financial sector in most countries is less robust than in Canada, possibly leading to greater concerns among depositors. In 2008, depositors in the Netherlands were confronted with the nationalization of both the Belgian–Dutch Fortis bank (which had acquired one of the largest banks of the Netherlands ABN Amro only one year earlier) and the Iceland-based Landsbanki, which operated in the Dutch market under the Icesave brand. In addition, ING received a capital injection by the Dutch government in 2008. Fortis-ABN Amro and ING were two of the three largest banks in the Netherlands in 2008, the other one being the Rabobank. Icesave was a smaller online savings bank targeting retail clients. Another relatively small bank, DSB Bank, failed in 2009, and the fourth largest bank SNS Reaal was nationalized in 2013. The Dutch market can therefore be regarded as a different setting than that in the work of Beyhaghi et al. (2014) as depositors have been confronted

2 Demirgüç-Kunt and Huizinga (2004) find that this type of insurance leads to a perception among depositors that deposits are safer, resulting in a lower required deposit rate. Mondschean and Opiela (1999) conclude for the Polish market that the relation between deposit rates and bank characteristics diminished after the introduction of deposit insurance. In contrast, Park and Peristiani (1998) illustrated for US thrifts that riskier institutions had to pay a higher interest rate, despite the fact that the deposits were insured.

3 We acknowledge the paper by Berger and Turk-Ariss (2015); however, they focused on deposit amounts rather than the deposit rate.

with failing banks. Hence, our paper provides an alternative channel how a crisis can affect depositor behavior.

Our paper contributes to the literature in two ways. First, it is the first paper to study the effects of account-specific variables – in conjunction with macro-specific and bank-specific variables – on the costs of deposits for banks. Second, the paper explains how the recent crisis has changed the sensitivity of deposit holders to bank risk taking in a setting where several banks were bailed out [contrary to the Canadian setting in the work of Beyhaghi et al. (2014)]. To address these issues, we make use of a unique dataset, which comprises daily interest rates on all savings and time deposit products offered by 58 different banks to retail customers in the Netherlands. This overcomes limitations of data used in the overwhelming majority of existing studies, as they mostly rely on implicit interest rates (e.g., a ratio between interest payments and attracted deposits, both presented in financial statements). The reported that frequency of variables in these datasets is limited, and in addition, analyses relying on these measures are most likely less precise, given that deposits with different characteristics are often grouped together under one heading in the financial statements. Our dataset therefore not only benefits the precision of the analysis but also enables us to consider the impact of account-specific feature on interest rates, including minimum balance requirements, withdrawal fees, and bonus rates for rewarding loyal customers. In addition, the data enable us to address the impact of the global financial crisis on the determinants.

We find that while the rate on time deposit products tends to follow the market rate quite closely, the interest rate on savings accounts is only loosely related to the market rate. This outcome is in line with findings by De Graeve et al. (2007) and Gambacorta (2008). The empirical results for the macroeconomic variables show that the market rate, its volatility, and the inflation rate are positively related to interest rates on both time deposits and savings accounts, while the concentration index and economic growth exhibit a negative relation. Our analysis reveals that bank-specific variables influence interest rate levels for both product types as well: the lower a bank's risk, the higher the interest rate it offers. This holds for all three proxies, namely, credit spread [measured as credit default swap (CDS) spreads], capital ratio, and credit rating. The latter variable is significant only when excluding bank size from the analysis, which is a result of the strong relation between credit ratings and bank size (e.g., Estrella et al. 2000). Other bank-specific variables exhibit mixed results. With regard to account-specific factors, the term of the deposit product and a withdrawal fee condition for savings accounts both positively influences the interest rate. A required minimum balance positively affects the rate on savings accounts, while its effect on time deposit rates is ambiguous. The bonus rate generally has a positive effect on savings and deposit rates. Evidence on the other account-specific features is mixed.

The data period for savings accounts allows us to analyze separately the pre-crisis period and the crisis period. We find that indicators for bank risk such as credit spread and capital ratio are not significantly related to interest rates prior to the crisis, in line with findings that deposit insurance dampens the impact of bank risk on interest rates (for example, Mondschean and Opiela 1999; Demirgüç-Kunt and Huizinga 2004). However, during the 2008–2014 subperiod, savings account rates started to depend positively on credit spreads and negatively on a bank's capital ratio, which is both evidence of the fact that the level of bank risk has become more relevant for the pricing of savings products since the onset of the financial crisis. The crisis seems to have functioned as a wake-up call for depositors, despite the existence of the deposit insurance scheme. One explanation may be that private persons' savings above €100,000 are not covered. Another reason for a relation could be restitution costs (Murata and Hori 2006), which consist for the Dutch market most likely only of indirect costs such as the waiting time for deposit redemption (as suggested by Park and Peristiani 1998). In addition, it is possible that a significant part of the depositors is insufficiently aware of deposit insurance.

Our findings are relevant for academics as this study is, to the best of our knowledge, the first study that focuses simultaneously on macro, bank-specific, and account-specific determinants of the interest rates on savings accounts and time deposits. In addition, our study provides a setting of the impact of a crisis on bank rates different to that of Beyhaghi et al. (2014) as a number of larger and smaller banks in the Netherlands either failed or were bailed out by the government. The findings are also relevant to practitioners as the study shows why some banks may offer higher rates than others. Anecdotal evidence points to depositors taking deposit products solely enticed by high interest rates offered. This study shows that high-rate accounts are typically offered by banks with higher bank risk, especially during crisis periods. Our findings can thus be used by practitioners in their deposit allocation process.

This paper is laid out as follows. Section II presents a literature review and develops our hypotheses. Section III introduces our data and methodology, and Section IV contains our empirical results and robustness checks. Section V provides our conclusion and discussion

II. DETERMINANTS OF THE DEPOSIT RATE

This study seeks to explain the interest rate on various types of savings accounts and time deposits offered by banks active in the Netherlands. We distinguish between three different categories of variables that might influence deposit rates: macro variables, bank-specific variables, and account-specific variables. Each category can be divided into a number of specific determinants. This section discusses these factors and subsequently formulates our expectations regarding each potential determinant. Given that most factors hold for both savings accounts and time deposits, we usually refer to the generic term "interest rates" in this section. Where appropriate, we make a distinction between demand and supply effects for each variable.

A. Macro variables

Banks operate in a wider economic environment, which may also influence the interest rates offered by banks. Most research acknowledges that the *market rate* influences the deposit rate. Gambacorta (2008) states that an increase in the money market rate makes investing in alternative risk-free securities more attractive. The subsequent reduction in the supply of deposits leads to an upward pressure on deposit interest rates. In line with this argument, Martin-Oliver et al. (2008) show that deposit interest rates follow the trend of interbank interest rates. Accordingly, Jarrow and Van Deventer (1998) theoretically argue that the deposit rate is a function of the market rate. They add that the deposit rate is determined by the change in the market rate compared with the previous period. Finally, a positive relation between market rates and deposit rates is also established by Beyhaghi et al. (2014). The pass-through literature makes a distinction between the impact on time deposits and savings accounts. Kok Sørensen and Werner (2006) conclude that a long-run relationship could not be detected for savings accounts, while time deposit interest rates are efficiently adjusted. De Graeve et al. (2007) confirm this as they find that time deposits have higher estimates of long-run interest rate pass-through. The market rate typically includes inflation expectations. When the market rate, and hence the inflation component, is not completely followed, savings and deposit rates might additionally be driven by inflation itself.

Banks are exposed to reinvestment and refinancing risk, because they have to deal with deposit supply by and loan demand from bank customers, which may be at different points in time. An increase in the *volatility of the market rate* will thus lead to higher reinvestment and refinancing risks. Consequently, banks have to operate with higher interest margins to compensate for the increased risks. Maudos and De Guevara (2004) empirically observe that such volatility positively influences the net interest margin. The Ho and Saunders (1981) model predicts that this interest margin increase does not prevent a rise in the deposit rate, given that it is associated with an even larger increase in loan rates. Finally, Gambacorta (2008) empirically shows that market rate volatility is positively associated with the deposit rate. The expected sign of the impact of volatility on the deposit rate is therefore positive.

Changes in supply of and demand for deposits can also be triggered by *economic growth*. Gambacorta (2008) states that a higher real income increases the supply of deposits, which might, in turn, trigger an interest rate decrease. Economic growth may also positively affect bank clients' demand for loans. This might lead to an increase in the loan rate and/or to an increase in the bank's demand for deposits. However, also Park and Peristiani (1998) found a negative relation between GDP growth and deposit rates. We therefore decided to follow the literature by expecting a negative relation between economic growth and interest rates.

Market concentration is another possible determinant of interest rates. There are two contrasting hypotheses on how market concentration may influence deposit rates. First, the market power hypothesis states that a concentrated market structure will lead to less competitive conduct and performance, resulting in higher prices and profits at the expense of lower consumer welfare (Shaffer 1994). According to Tokle R.J and Tokle J.G. (2000), this hypothesis means that a concentrated market structure leads to lower deposit rates offered to depositors. This negative relation is empirically confirmed by Hutchinson (1995) and De Graeve et al. (2007). Second, the efficiency hypothesis states that concentration increases the overall efficiency of the banking sector (Gropp et al. 2007). In a more concentrated market, banks may therefore price their deposits more competitively and hence offer higher rates on deposits. Although Martin-Oliver et al. (2008) found evidence for this hypothesis for the Spanish market, the market power hypothesis constitutes the dominant view. Accordingly, we expect a negative relation between market power and interest rates.

The last macro factor is the level of *market stress*. Markets under pressure may be a proxy for difficult access to wholesale funding by banks and may therefore cause banks to offer higher interest rates to attract deposit funding. This measure is of specific interest, because the financial crisis is covered by our research period. Panel A of Table 1 summarizes the expected signs of the macro explanatory variables' coefficients.

B. Bank-specific variables

The interest margin literature has identified several bank-specific variables, which may determine the difference between the lending and the borrowing rate. We build on that knowledge to formulate expectations for the relation between bank-specific variables and the deposit rate. We start with *bank risk*. Kiser

Table 1 The hypothesized determinants of interest rates on savings accounts and time deposits

Panel A. Macro determinants		Panel B. Bank-specific determinants	
Market rate	Positive	Bank risk	Negative
Inflation	Positive	Bank size	Negative
Market rate volatility	Positive	Foreign bank	Positive
Economic growth	Negative	Liquidity surplus	Negative
Concentration	Negative	Liquidity mismatch	Negative
Stock market stress	Positive	Inefficiency	Negative
		Deposit funding	Negative
Panel C. Account-specific determinants *Time deposits*		*Savings account*	
Maturity	Positive	Withdrawal fee	Positive
Minimum balance	Positive	Minimum balance	Positive
Ascending rate	Undetermined	Bonus rate	Positive
Payment frequency	Undetermined	Payment frequency	Undetermined

(2004) argues that well-capitalized banks with less risky asset portfolios may pay a lower risk premium for wholesale funds than their riskier competitors. If wholesale funds are used as substitutes for retail deposits, the bank's ability to obtain wholesale funds at low cost reduces its demand for retail deposits. Gambacorta (2008) confirms this finding by stating that poorly capitalized banks are less likely to be able to issue bonds and therefore try to increase the amount of deposits by offering higher deposit rates. Park and Peristiani (1998) showed similar findings. Cooperman et al. (1992) evaluate interest rates on certificates of deposit in crisis times and find that especially lowly capitalized banks raise their rates. For depositors, an increase in bank risk increases the probability that they will not be able to collect deposits in excess of the deposit guarantee scheme cover (e.g., €100.000 in the European Union). When a bank fails, it may take up to 20 working days before deposits are repaid.[4] Because the likelihood of a loss of deposits (or the opportunity costs faced during these 20 days) increases as the level of bank risk increases, depositors would require compensation in terms of higher interest rates. Hence, we expect a positive impact of bank risk on the deposit rate. For bank risk, we consider three different proxies.

- The first measure is the credit spread as measured by the spread on CDSs for the respective bank. A CDS contract is a type of insurance contract in which the buyer receives credit protection from the seller, in exchange for periodic payments (also referred to as spreads). Given the potential losses to the insurance seller, CDS spreads positively depend on the probability of default. Ericsson et al. (2009) find evidence that CDS spreads are related to idiosyncratic risk, as they empirically show that these spreads are positively related to both financial leverage and firm-specific volatility.
- As a second proxy we examine credit ratings issued by Standard & Poor's (S&P) or, where not available, by Moody's Investors Service. S&P state that a credit rating is the "current opinion of the creditworthiness of an obligor" (Standard and Poor's 2006). In determining a credit rating, financial variables as well as qualitative measures are taken into consideration. An illustration of the importance of financial variables is given by Moody's: it justified a bank's downgrade by stating that the "ratings incorporate the severe solvency and liquidity risks that the bank face."[5] An example of the qualitative measure is the reputation of a financial

4 Until 2009, this period could be as long as 3 months, which could be extended to 9 months; see Directive 2009/14/EC of the European Parliament and of the Council.

5 On 12 June 2012, Moody's issued a press release in which they announced the downgrade of two Cypriot banks. This statement concerned the Cyprus Popular Bank. See the following website for the full press release: http://www.moodys.com/research/Moodys-downgrades-two-Cypriot-banks--PR_248015

institution, as a good reputation may influence the future financial performance and the capacity to meet financial obligations.

- The third indicator of bank risk is a bank's capital ratio as measured by the BIS ratio. This ratio is defined as the sum of Tier 1 and Tier 2 capital divided by total risk-weighted assets, as defined by the Basel Committee on Banking Supervision. Claeys and Vander Vennet (2008) suggest that holding capital above the regulatory minimum is a credible signal of the creditworthiness of the bank. A larger capital base increases a bank's capacity to absorb losses on its loan portfolio. That means that the probability of default is expected to be lower for banks with higher ratios. Estrella et al. (2000) find evidence of this notion as they show that the capital ratio can be used as a predictor of bank failures.

The impact of a bank's *size* on interest rates may be related to both the supply and the demand channel. The supply channel impact concerns the "too big to fail, TBTF" argument. As large, troubled banks may be rescued – with depositors anticipating such rescue action – by the government, these banks are regarded as safer, implying that depositors are less reluctant to deposit funds in excess of the level guaranteed by deposit insurance scheme. Large banks can hence offer lower interest rates to their depositors. Imai (2006) considers a deposit insurance reform in Japan where insurance became limited. They found evidence for the TBTF effect on deposit rates. Size is also relevant for deposit demand. Large banks have greater access to alternative funding sources such as wholesale funds. As a result, the deposit demand for large banks is likely to be lower. In addition, smaller banks increase their deposit rates in order to be more competitive with larger banks (Ruthenberg and Elias 1996). Hannan and Prager (2006), Jacewitz and Pogach (2014), and Beyhaghi et al. (2014) all find that large banks offer lower deposit interest rates than their smaller counterparts. Given demand and supply rationales outlined previously, we expect a negative relation between size and the interest rate offered.

A bank's nationality may be important to depositors, more specifically, whether the bank has domestic roots or whether it is a *foreign bank*. Mondschean and Opiela (1999) found for the Polish market that foreign banks offered lower interest rates, a finding they attributed to a higher trust level of depositors in foreign banks. Given that the Dutch banking landscape is characterized by large global banks, trust in domestic banks is not a concern for most depositors. In fact, the potential regulation by a different banking supervisor may limit the willingness to supply deposits. In addition, deposit supply may be limited as depositors may be prone to a home bias. Turning to the demand side for deposits, a bank setting up branches in foreign markets may do so because it cannot find sufficient funding in its home market. The deposit demand of these banks is likely to be relatively high. As a result, we expect that foreign banks have to offer a higher interest rate to attract deposit funding.

Liquidity is defined as "the ability of a bank to fund increases in assets and meet obligations as they come due, without incurring unacceptable losses" (BIS 2008).

De Graeve et al. (2007) find liquidity to act as a buffer against market fluctuations. Less liquid banks have less capacity to issue bonds, and they therefore need to encourage deposit supply by offering relatively high interest rates (Gambacorta 2008). If a bank has available liquidity in excess of the level required by the banking supervisor, the bank's demand for deposits is likely to be lower, that is, we expect a negative effect of liquidity on the level of interest rates offered.

De Graeve et al. (2007) hypothesize that more *efficient* banks have lower costs and therefore can afford to offer above-average deposit rates. Their empirical results confirm that the deposit spread (that is, deposit rate minus market rate) is positively related to the efficiency factor. Focarelli and Panetta (2003) and Gambacorta (2008) both show a positive relation between bank efficiency and deposit interest rates.

A bank's *deposit funding* structure is the next determinant. The country level comparison of Pattipeilohy (2013) shows that in countries where banks face a deposit funding gap banks offer relatively high deposit rates. As banks prefer the cheapest source of funding over more expensive sources, they will be more aggressive in acquiring relatively cheap deposits over more expensive market funding. We expect the same bank behavior within domestic markets: banks with a relatively low deposit base will be more aggressive in attracting deposit funding, that is, by offering higher interest rates. In addition, Demirgüç-Kunt and Huizinga (2004) document that the reliance on non-deposit funding is positively associated with the level of perceived bank risk, which might in turn positively influence the required return by depositors. In summary, Panel B of Table 1 depicts the expected impact of bank characteristics on the deposit rate.

C. Account-specific variables

Most of the existing studies regarding deposit rate differences across banks use standardized accounts across banks (for example, De Graeve et al. 2007). This paper extends the knowledge of deposit pricing to account-specific features. Time deposits differ in terms of *maturity*. Depositors generally have a preference for liquidity, which is why the supply of deposits is likely to decrease with the maturity of the account. The demand for longer maturity deposits is likely to be higher, given that banks prefer stable funding sources. We therefore expect the interest rate to increase with the maturity of the time deposit. Johnson et al. (2008) study the interest rate on certificates of deposit with differing maturities and find support for this rationale.

Although savings accounts do not come with specified maturities, some of these accounts have additional features aimed at either increasing the term for which money is deposited or increasing the stability of the deposit base level. First, accounts may include a *withdrawal fee*, meaning that a fee has to be paid when money is withdrawn from the account. Such withdrawal fees are an incentive to increase the term for which the funds are deposited, and we expect depositors to be compensated for these fees by higher interest rates. Second, savings accounts may award additional interest, a so-called *bonus rate*, subject to the deposited amount not having decreased during a specified period. We expect the bonus rate to be used to reward loyal clients, and we therefore expect these accounts to offer higher interest rates – including the bonus rate. A third account feature may be a *minimum savings balance*. Given both the positive effects of this requirement for banks and the resulting reduction in flexibility for clients, we expect such a measure to have a positive impact on interest rates. In addition to savings accounts, some time deposits also have this feature.

Some bank accounts in our sample have two additional features for which it is interesting to document how banks price them. Time deposit accounts may offer *ascending interest rates*. Generally speaking, these products are characterized by low interest rates in the first year, followed by increases in the course of the remaining life of the deposit. This feature could be associated with relatively high average effective interest rates if banks expect some clients to withdraw their money early anyway. Alternatively, banks might be able to attract funding at a low cost if clients are impressed by the prospect of a high interest rate during the final contract year.

A final feature, both for time deposits and savings accounts, is the possibility to receive *interest payments monthly, quarterly, or bi-annually* instead of on an annual basis. If this service is highly appreciated by depositors, banks might be able to decrease interest rates for these accounts. If banks, on the other hand, offer them as an additional service, the impact on the effective interest rate might eventually be positive. Panel C in Table 1 summarizes our expectations for the coefficients of the account-specific variables.

III. DATA AND METHODOLOGY

A. Data

We use two unique datasets comprising daily interest rates offered on all retail deposit accounts by 58 different banks on the Dutch market. The majority of deposits in the dataset are offered to domestic retail clients, hence concern so-called core deposits. The banking market in the Netherlands can be considered as a single market. Although physical presence may differ between banks, bank clients are able to open accounts at all banks, and interest rates apply to all clients. The first set consists of savings accounts in the January 2003–September 2014 period, and the second set comprises interest rates on time deposits in the June 2008–September 2014 period. These interest rate quotes are collected by *Spaarinformatie*.[6] The dataset is not affected by survivorship bias, as all discontinued banks are included in the sample. The dataset contains information on the account-specific conditions that are applicable to savings accounts and

6 This company can be regarded as an independent objective party, because they are in no way connected to or restricted by a financial institution. The daily list of deposit rates is available at http://www.spaarinformatie.nl.

time deposits. The data are complemented by market data and bank-specific data from the ECB, Standard & Poor's, Moody's Investors Service and Datastream, and with supervisory information from the Dutch central bank (*De Nederlandsche Bank* – DNB). Our final dataset combines market data, bank-specific data, and account-specific data. In the following discussion, we describe each of these three categories of independent variables, preceded by an explanation of the dependent variables. The Appendix contains details on data sources. In general, we relied on (i) Spaarinformatie for interest rates and account-specific features for both time deposits and savings accounts, (ii) the Dutch Central Bank (DNB) for bank-specific supervisory information, (iii) Thomson Reuters Datastream for macroeconomic variables, and (iv) Standard & Poor's and Moody's Investors Service for credit rating information.

i. Dependent variables

The dataset consists of daily interest rates for all different accounts. Given that data on the explanatory variables are available at a monthly frequency, we use monthly interest rate data in our analyses. For this purpose, we choose the interest rate on each account on the last day of every month. To describe the data on time deposit interest rates, we divide the time deposits in four maturity categories, and we averaged the interest rates on all time deposits for the following maturity categories: (i) 1 year or less, (ii) 5 years or less but more than 1 year, (iii) 10 years or less but more than 5 years, and (iv) more than 10 years.[7] The first four lines of Table 2 present summary statistics for these accounts. For both time deposits and savings accounts, the rates banks offered ranges from 0.05% to 6%.

A closer inspection of the rate differences across time deposits reveals that the rates increase with the maturity of the deposit. Figure 2 depicts the average interest rate developments for each maturity category of time deposits over the 2008–2014 period and for the savings accounts during the 2003–2014 period. This figure also depicts the short-term market rate, which is explained in the next subsection. Although interest rates on time deposits and savings accounts are related to the market rate, Figure 2 clearly shows that, relative to deposit rates, the response of interest rates on savings accounts to changes in the market rate is less pronounced. This pattern is consistent with findings in the pass-through literature (Kok Sørensen and Werner 2006; De Graeve et al. 2007).

ii. Macro independent variables

We use six variables to capture the macro factors: market rate, inflation, interest rate volatility, market concentration, economic growth, and stock market stress. To adhere to the measurement of the dependent variable, we use month-end values unless mentioned otherwise. As market rate, we use different Euribor rates. Given the maturity differences between savings accounts and time deposits, we follow different approaches to ensure a proper fit between the market rate and

7 Our empirical analyses include the actual maturity for each account in months.

Table 2 Descriptives of the time deposits and savings accounts datasets

Variable type	Variable	Sub-division and operationalization	Time deposits, 2008–2014 period					Savings accounts, 2003–2014 period				
			Mean	St. dev.	Min	Max	# of obs.	Mean	St. dev.	Min	Max	# of obs.
Independent	Time deposit rate (in %)	≤1 year (%)	2.33	1.09	0.05	5.80	4993					
		1 year ≤ 5 year (%)	2.80	1.00	0.10	6.00	9141					
		5 year ≤ 10 year (%)	3.47	0.80	0.70	6.00	4302					
		>10 year (%)	3.91	0.53	2.20	5.25	1168					
	Savings account rate (in %)							2.38	0.85	0.05	6.00	17,866
Macro	Market rate for time deposits	≤1 year (%)	0.59	0.87	−0.09	4.50	4993					
		1 year ≤ 5 year	1.21	1.02	−0.11	4.64	9141					
		5 year ≤ 10 year	2.29	0.98	0.40	4.72	4302					
		>10 year	2.57	0.59	1.13	4.52	1168					
	Market rate for savings accounts (in %)							2.02	1.39	0.24	5.08	140
	Inflation (in %)		1.93	0.80	0.19	3.22	75	1.78	0.67	0.19	3.22	140
	Market rate volatility for time deposits	≤1 year	0.03	0.03	0.00	0.29	4993					
		1 year ≤ 5 year	0.05	0.03	0.00	0.16	9141					
		5 year ≤ 10 year	0.05	0.02	0.02	0.12	4302					
		>10 year	0.05	0.02	0.02	0.11	1168					
	Market rate volatility for savings accounts (in %)							1.31	1.43	0.09	9.30	140
	Concentration	HHI index on deposits	0.24	0.01	0.22	0.25	76	0.23	0.01	0.22	0.25	140
	Economic growth (in %)	GDP growth	−0.38	1.90	−4.70	2.90	75	0.92	2.17	−4.70	4.70	140
	Stock market stress	VIX index	0.23	0.10	0.11	0.60	75	0.20	0.09	0.10	0.60	140
Bank-specific	Bank size (in billion €, ln applied in models)		150.06	254.32	0.10	1027.03	1844	153.93	274.33	0.01	1111.49	4980

Table 2 (*continued*)

Variable type	Variable	Sub-division and operationalization	Time deposits, 2008–2014 period					Savings accounts, 2003–2014 period				
			Mean	St. dev.	Min	Max	# of obs.	Mean	St. dev.	Min	Max	# of obs.
	Credit spread (in %)[a]	CDS spread	2.14	1.57	0.44	13.28	854	1.24	1.46	0.03	13.28	2015
	Credit rating (aaa = 22, d = 1)	Stand-alone credit profile	14.40	2.69	8.00	21.00	1783	15.22	2.81	7.00	21.00	4481
	Capital ratio (in %)	BIS ratio	15.48	3.81	6.01	37.18	1794	14.84	5.38	6.01	49.98	4775
	Liquidity surplus		11.73	8.52	−6.54	60.43	1840	13.93	14.81	−6.54	144.67	4793
	Liquidity mismatch for time deposits	Long mismatch	1.91	1.41	0.66	24.18	1857					
	Liquidity mismatch for savings accounts	Short mismatch						1.82	2.93	0.27	29.64	4864
	Inefficiency (in %)	Cost-to-asset ratio	0.46	0.35	0.01	3.01	1840	0.43	0.37	0.00	9.06	4976
	Deposit funding (%)		67.45	23.09	2.20	100.00	1844	64.23	24.46	0.21	100.00	5025
	Foreign bank		30.30	46.67	0.00	100.00	33	25.00	43.72	0.00	100.00	52
Account-specific	Maturity (in months)		56.49	50.18	1.00	240.00	462					
	Minimum balance (€, thousands)		13.21	72.59	0.00	500.00	462	0.68	6.66	0.00	100.00	269
	Payment frequency	0 annual, ½ semiannual, etc.	0.02	0.15	0.00	1.00	462	0.03	0.15	0.00	1.00	269
	Ascending rate		0.04	0.20	0.00	1.00	462					
	Bonus rate (in %)							0.05	0.35	0.00	5.00	269
	Withdrawal fees (in %)							0.05	0.25	0.00	2.00	269

Note: For expository reasons, this table presents the data in percentages. For the same expository reasons, we use the original data (in perunages) in the regression analyses; see Tables 5–11.[a]Basis points × 100.

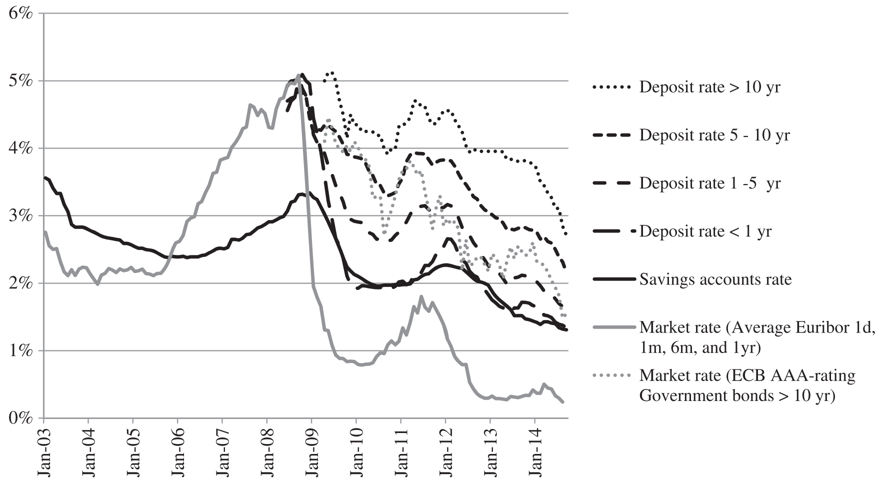

Figure 2 The interest rates on time deposits and savings accounts, together with the market rate.

the characteristics of the respective account. Bank clients may use savings accounts for the short-to-medium term. As a relevant market rate, we therefore compute the average of the one-day, three-month, six-month, and one-year Euribor interest rates. Time deposits are generally used by depositors with a longer savings horizon. To arrive at the market rate, we match the maturity of the time deposit with a corresponding maturity of the ECB AAA Government Paper yield curve. With regard to our descriptive statistics in Table 2, we computed the average for the available values of the yield curve for the four different maturity groups. In total, we used 37 points of the yield curve. Monthly rates were available for maturities of 3 to 24 months, half-yearly rates were available for 2- to 5-year maturities, and annual rates for 5- to 30-year maturities. Similar to the time deposit rates, the market rate increases with maturity.

Inflation is measured as the year-on-year percentage change in the Dutch consumer price index. Inflation ranges from 0.19% to 3.16%. Next, Table 2 displays the volatility of the market rate. For time deposits, we choose the volatility of the points on the ECB AAA-yield curve, which correspond with the maturity of the account. For savings accounts, we compute the average value of the 10-day standard deviation of the three-month, six-month, and one-year Euribor rates. In Table 2, five different volatilities are presented, which correspond to the five different types of accounts, which we compose for the purpose of this data description (i.e., four deposit account categories and the savings account). Market concentration is proxied by the HHI on the deposits of Dutch households. The mean HHI is around 0.23 for both datasets. We also use economic growth, measured as the year-on-year growth rate of Dutch GDP. As this variable is available on a quarterly basis only, we obtain monthly observations through linear extrapolation of the quarterly data. The last macro variable used is the CBOE SPX implied stock market volatility index (also known as VIX) as a measure for market stress. The maximum end-of-month value amounted to 0.60.

iii. Bank-specific independent variables

We use nine bank-specific variables. As a first determinant, we discuss bank size as measured by a bank's total assets. Table 2 presents the size in billions of euros. Our regressions include the natural logarithm of this size proxy. Banks' total assets varied from just €6 million to over €1,000 billion.

We use three different proxy variables for bank risk. The first proxy is the credit spread of banks, measured as the five-year senior CDS spread (source: CMA/Reuters). The average CDS spread was 214 basis points in the time deposit dataset versus 124 basis points in the savings account dataset. This difference reflects the fact that the global financial crisis played a relatively large role in the time deposit dataset as the data period only started in 2008. The second proxy for bank risk is the stand-alone credit profile as published by S&P. Where S&P ratings were not available, we took the baseline credit assessment from Moody's.[8] Similar to Cantor and Packer (1997), we transform the rating into a numerical value ranging from 1 (=d) to 22 (=aaa).[9] Relative to CDS spreads, ratings do not often change. That is why the explanatory variation in this variable is mainly limited to differences in ratings across banks. The average stand-alone credit profile for both datasets is around the bbb/bbb + level. The BIS capital ratio (i.e., the sum of Tier 1 and Tier 2 capital divided by total risk-weighted assets) as reported by banks to DNB is included as the third proxy for bank risk. This variable is not consistently measured over the entire sample period, as the BIS capital ratio definition changed with the introduction of Basel II. The new definition was designed to improve the extent to which risk components faced by banks were taken into account. On average, in our sample, the BIS capital ratio stands at around 15%.

For liquidity, we use two different measures. The first proxy is the liquidity surplus divided by total assets, as reported to DNB on a monthly basis. This surplus amounted to 11.73 and 13.93 on average for the time deposit dataset and the savings account dataset, respectively. The second proxy is different for the two datasets. The time deposit dataset includes a long (>1 year) liquidity

8 Most studies incorporating credit ratings use long-term credit ratings. However, these ratings are influenced by the possibility that a bank receives support from external parties such as the government to prevent a default. Given the importance of large banks to the functioning of the financial system, these banks are typically called systemically important banks and can, hence, count on support from external parties. This notion has received empirical support by Estrella et al. (2000), who observe that ratings are positively correlated to the size of a bank. In addition, Bongini et al. (2002) show that after controlling for bank size, credit ratings do not have substantial forecasting power regarding bank distress. To account for this effect, we use stand-alone credit profiles as published by rating agencies. These ratings exclude the possibility of external support and can hence be perceived as an assessment of the bank's stand-alone creditworthiness. Using long-term issuer ratings does not qualitatively change our results.

9 Standard & Poor's uses lower-case ratings to distinguish the SACP from regular credit ratings.

mismatch variable, measured as the ratio of the available long liquidity over required long liquidity. The savings account dataset includes a short (<1 year) liquidity mismatch variable, defined as the ratio of available short liquidity over required short liquidity. The long and short liquidity mismatch variables come out at 1.91 and 1.82 on average, respectively. These data also stem from the liquidity report that DNB receives from banks.

We use the cost-to-asset ratio as a proxy for inefficiency.[10] The average cost-to-asset ratio is 0.004 for both datasets. Deposit funding quantifies the extent to which a bank is funded by deposits. This is measured as the ratio of a bank's deposits made by non-credit institutions to the sum total of deposits and bonds (liquidity debt certificates) issued by that bank. The average ratio ranges from 0.64 to 0.67 in both datasets. The last bank-specific variable represents a dummy measuring a bank's roots, that is, domestic or foreign. A bank is considered a foreign bank (dummy is 1) when its head office is located outside the Netherlands. The mean values for this dummy are 0.30 and 0.25 for the time deposit dataset and savings account dataset, respectively.

iv. Account-specific independent variables

The account-specific variables were gathered from the dataset provided by *Spaarinformatie*, which includes supplementary information on the conditions of the various accounts. The time deposit dataset contains the maturity of the account in months. The maximum recorded maturity is 240 months (i.e., 20 years). Both the time deposit dataset and the savings account dataset include accounts that require a minimum balance of deposits. Both the mean and the maximum values are higher for time deposits than for savings accounts. Furthermore, a payment frequency variable is constructed and coded "11/12" if the account pays interest rates on a monthly basis instead of on an annual basis, "9/12" if the account offers the option of quarterly payment, and "6/12" if the account offers the option to receive interest rates on a 6-month basis. Only the time deposit dataset contains accounts with an ascending interest rate feature. An ascending interest rate dummy is coded "1" if the account has an ascending interest rate condition. The savings account dataset includes two additional account features. First, some accounts came with a bonus rate payable by the bank when, for example, the account balance does not decrease in a given calendar quarter. Second, the savings dataset contains accounts with withdrawal fees payable by the accountholder if funds are withdrawn.

B. Stationarity versus non-stationarity of the model variables

In order to specify the relationship between the explanatory variables and the deposit and savings interest rates, we need to know whether these variables are

10 Costs are understood to be the sum total of administration costs and other operating expenses.

Table 3 Augmented Dickey–Fuller unit root tests of model variables

	Time deposit rate model (2008–2014)				Savings rate model (2003–2014)			
	One lag		Two lags		One lag		Two lags	
	Z(t)	*p*-value	Z(t)	*p*-value	Z(t)	*p*-value	Z(t)	*p*-value
Market rate					−1.111	0.7106	−1.388	0.5882
Inflation	−2.027	0.2748	−2.004	0.2847	−2.781	0.0610	−2.737	0.0679
Market rate volatility					−4.160	0.0008*	−4.332	0.0004*
Concentration	−2.178	0.2141	−2.165	0.2190	−2.555	0.1026	−2.549	0.1040
Economic growth	−3.301	0.0148*	−3.148	0.0232*	−2.973	0.0375*	−2.723	0.0702
Stock market stress	−2.644	0.0842	−2.053	0.2637	−3.429	0.0100*	−2.800	0.0583

Note: *indicates that the unit root hypothesis is rejected at the 5% level of significance.

stationary or not. Stationary variables enable us to specify the level of a relationship. If variables are non-stationary but co-integrated, they should preferably be analyzed using an error correction model (ECM), making it possible to disentangle the long-run co-movement of the variables from the short-run adjustment toward the equilibrium. As a first step, we investigate the unit root properties of the variables. We start with the variables that are identical for all banks and accounts and where the Augmented Dickey Fuller (ADF) test is appropriate: inflation, concentration, economic growth, and stock market stress (for both time deposits and savings accounts), as well as the market rate and its volatility, for the savings rate model.[11] Table 3 presents the results of the ADF test for one and two lags. We assume non-stationarity in the market rate, inflation and concentration, because the unit root hypothesis cannot be rejected. We reject the hypothesis for volatility (indicating stationarity), while the evidence for the other variables is mixed.

For the variables with a panel structure (i.e., the variables exhibiting different values across banks or accounts as well as over time), we apply two types of tests based on two different null hypotheses. First, we apply Hadri's (2000) test, which is a panel version of the KPSS test (Kwiatkowski et al. 1992), testing the null hypothesis of stationarity:

$$Y_{i,t} = \alpha_i + \sum_{\tau=1}^{t} u_{i,\tau} + \varepsilon_{i,t} \tag{1}$$

The time series $Y_{i,t}$ are broken down into a random walk component $\Sigma_\tau\, u_{i,\tau}$ and a stationary component $\varepsilon_{i,t}$. The test statistic Z_τ is based on the ratio of the variances $\sigma_u^2/\sigma_\varepsilon^2$. The null hypothesis of the test assumes that this ratio is zero, implying that the interest rate does not contain a random walk component. By

11 Note that market rate and volatility in the time deposit rate depend on the term of the account.

contrast, rejection of the null hypothesis indicates the presence of unit root behavior in the variable under investigation. Both panel series test statistics are asymptotically normal. Second, as a cross-check, and because the power of the Hadri test is relatively low (Hlouskova and Wagner 2006), we use the IPS test (Im et al. 2003), which is a panel version of the ADF test on unit roots.

$$\Delta Y_{i,t} = \alpha_i + \rho_i Y_{i,t-1} + \sum_{j=1}^{p_j} \tau_{i,j} \Delta Y_{i,t-j} + \varepsilon_{i,t} \tag{2}$$

The autoregressive parameter is estimated for each bank separately, which allows for a large degree of heterogeneity. The null hypothesis asserts a unit root for all banks or accounts (i.e., H_0: $\rho_i = 0$), while the alternative hypothesis H_1 allows $\rho_i < 0$ for some banks or accounts. Rejection of the null hypothesis indicates stationarity. The test statistic Z_{t_bar} of the IPS test is constructed by cross-section averaging the individual *t*-statistics for ρ_i.

Table 4 presents the results for all potential panel variables in our models: the dependent variables, the bank-specific variables, and the market rate and its volatility in the time deposit model. The Hadri test accepts the hypothesis of a unit root for all variables, but as said, the power of this test is low. Particularly for the time deposit rate model, the IPS test's power may be low as well, as the time dimension is relatively limited (Hlouskova and Wagner 2006). With regard to the explanatory variables, we find mixed evidence as the hypothesis of a unit

Table 4 Panel unit root tests of model variables

	Time deposit rate model (2008–2014)				Savings rate model (2003–2014)			
	Hadri test (stationarity)		IPS test (non-stationarity)		Hadri test (stationarity)		IPS test (non-stationarity)	
	Z_t	*p*-value	Z_{t_bar}	*p*-value	Z_t	*p*-value	Z_{t_bar}	*p*-value
Dependent variables								
Time deposit rate	74.53	0.0000*	−4.06	0.0000				
Savings account rate					48.25	0.0000*	−0.60	0.2755*
Macro variables								
Market rate	178.74	0.0000*	−30.11	0.0000				
Market rate volatility	88.70	0.0000*	−20.11	0.0000				
Bank-specific variables								
Bank size	36.42	0.0000*	3.66	0.9999*	91.94	0.0000*	−2.50	0.0062
Credit spread	11.78	0.0000*	−5.66	0.0000	48.97	0.0000*	−1.13	0.1294*
Credit rating	45.43	0.0000*	−1.09	0.1387*	97.61	0.0000*	4.86	1.0000*
Capital ratio	28.98	0.0000*	−1.05	0.1473*	66.37	0.0000*	1.93	0.9734*
Liquidity mismatch	38.19	0.0000*	−5.61	0.0000	46.41	0.0000*	−6.45	0.0000
Liquidity surplus[a]	17.50	0.0000*	−1.50	0.0672*	63.39	0.0000*	−5.39	0.0000
Inefficiency	18.52	0.0000*	−11.85	0.0000	62.33	0.0000*	−6.40	0.0000
Deposit funding	39.95	0.0000*	4.24	1.0000*	34.03	0.0000*	5.34	1.0000*

Note: *indicates that the unit root hypothesis is not rejected. [a]Long liquidity surplus for the time deposit rate model and short liquidity surplus for the savings rate model.

root is sometimes accepted and sometimes rejected. In addition, the results are not consistent across different sample periods. The account-specific conditions are constant by definition and are, hence, stationary.

Given the mixed results with respect to stationarity or non-stationarity of our model variables, we specify our models both in levels and in error correction form.

C. Methodology

We use a panel dataset that allows us to study the average effects across individual observations of time deposits and savings accounts, as well as dynamic effects across the entire samples. Starting with models in levels, the basic time deposit (*td*) model following from the theory in Section II and data availability in Section *A* reads as

$$\begin{aligned} td_{ijt} = \alpha &+ \beta_1\, mr_{t-1} + \beta_2\, infl_{t-1} + \beta_3\, vol_{t-1} + \beta_4\, HHI_{t-1} + \beta_5 \Delta GDP_{t-1} + \beta_6\, VIX_{t-1} \\ &+ \gamma_1\, ta_{it-1} + \gamma_2\, cr_{it-1} + \gamma_3\, ls_{it-1} + \gamma_4\, llm_{it-1} + \gamma_5\, car_{it-1} + \gamma_6\, df_{it-1} + \gamma_7\, fb_i \\ &+ \delta_1\, mb_j + \delta_2\, fp_j + \delta_3\, ar_j + \delta_4\, ma_j + u_{ijt} \end{aligned} \tag{3}$$

In this equation, *i* refers to banks, *j* to time deposit accounts, and *t* to months. The first group of explanatory variables are the macroeconomic variables, with ß coefficients for the market rate (*mr*), inflation (*infl*), market rate volatility (*vol*), concentration (*HHI*), economic growth (ΔGDP), and stock market stress (*VIX*), all defined in Section *A*. These variables only vary over time. The second groups of explanatory variables are the bank-specific variables, with γ coefficients for total assets (*ta*), creditworthiness (*cr*), liquidity surplus (*ls*), long liquidity mismatch (*llm*), cost-to-asset ratio (*car*), deposit funding (*df*), and foreign bank (*fb*). Except for the latter variable, all bank-specific variables vary over time. Creditworthiness is represented by either the credit spread, credit rating, or capital ratio. The last groups of explanatory variables are the account-specific variables, with δ coefficients for minimum balance (*mb*), frequency of payments (*fp*), ascending rates (*ar*), and maturity (*ma*). These variables do not vary over time, because a change in account characteristics resulted in the recognition of a new account. The error term is denoted by *u*. Note that all the macroeconomic and bank-specific explanatory variables have been lagged by one month, as these determinants usually become available only with a certain delay.

The basic savings accounts (*sa*) model is similar to equation (3), with some exceptions, as the variables withdrawal fees (*wf*) and bonus rate (*br*) are now included, while the variables ascending rate and maturity are not applicable to these accounts. In addition, we replace the long liquidity mismatch (*llm*) with the short liquidity mismatch (*slm*):

$$sa_{ijt} = \alpha + ß_1\ mr_{t-1} + ß_2\ infl_{t-1} + ß_3\ vol_{t-1} + ß_4\ HHI_{t-1} + ß_5 \Delta GDP_{t-1} + ß_6\ VIX_{t-1} + \gamma_1\ ta_{i,t1} + \gamma_2\ cr_{i,t-1} + \gamma_3\ ls_{i,t-1} + \gamma_4\ slm_{i,t-1} + \gamma_5\ car_{i,t-1} + \gamma_6\ ds_{i,t-1} + \gamma_7\ fb_i + \delta_1\ mb_j + \delta_2\ fp_j + \delta_3\ wf_j + \delta_4\ br_j + u_{ijt} \quad (4)$$

Our first estimation approach is based on a fixed effects (FEs) model.[12] This approach adds dummy variables for each bank to pick up time-invariant omitted variables that may bias the observed relationships. We opt for dummy variables for each bank rather than for each account, as in the latter case all account-specific variables in equations (3) and (4) would disappear, because they are constant over time by definition. A disadvantage of FE is that level differences in bank-specific variables across banks are disregarded. Our second estimation approach is feasible GLS (FGLS; Wooldridge 2003, p. 404), which aims to overcome the problems of cross-sectional heteroskedasticity (e.g., bank-specific observations with different variances) and within-unit serial correlation (e.g., covariation between observations of the same account over time). FGLS is a two-step GLS approach where the unknown variance–covariance matrix in the second round is estimated using first-round OLS residuals.[13] We specify a heteroskedastic error structure without cross-sectional correlation, and within panels, we assume both AR(1) autocorrelation and a common AR(1) coefficient to all bank panels. A comparison of the FE and FGLS results may reveal how robust our estimates are.

Following De Graeve et al. (2007) and Gambacorta (2008), we also consider an ECM. As a first step, we use a co-integration test to verify whether long-term relationships as in equations (3) and (4) are established or not. For our panel data set, we apply the panel co-integration tests of Pedroni (1999, 2004). Account-specific variables and the foreign bank indicator are constant over time and are thus excluded here. The long-run coefficients for markets, $ß$, and banks, γ, in equations (3) and (4) may be different across banks, so we have $ß_{ki}$ and γ_{ki} (k = 1, 2, …, 6), with subindices i. We use the group mean panel version of the Pedroni test. The null hypothesis of this test assumes a unit root in the residuals of the co-integration regression, which implies absence of co-integration. The alternative hypothesis assumes a root less than one, but allows for different roots across banks.[14] We use three different types of test statistics: an ADF type that is similar to the ADF statistic used in

12 An alternative method is the random effects (RE) estimation, which assumes bank-specific characteristics arising from random causes resulting in bank-specific variances. The Hausman (1978) test rejects RE, so that FE should be used.

13 Note that GLS might also help to address estimation problems stemming from possible non-linearity in the interest rate model, due to option-like features of savings account such as withdrawing in relation to bonus rates and ascending rates.

14 In the panel versions of the tests the alternative hypothesis assumes a root, which is less than one, but is identical across the banks. Hence, the group mean versions allow for stronger heterogeneity. We focus on the test's group mean version.

univariate unit root tests, a nonparametric Phillips–Perron (Phillips and Perron 1988, PP) version, and a version based directly on the autoregressive coefficient (ρ-test).

Application of these three Pedroni tests to equations (3) and (4) reveals that most test statistics do not reject the null hypothesis of absence of co-integration or, in short, co-integration has not been accepted.[15] However, the test may suffer from power limitations given the relatively short data period. Furthermore, we do not expect that interest rates actually follow a true random walk, but are rather bounded between 0 and, say, 10%, the latter depending on the inflation rate. The expectation for a non-random walk also applies to explanatory variables such as GDP growth, inflation, market rate volatility, stress index, credit spread, capital ratio, and rating. Based on these considerations, they are expected to be co-integrated.

Despite the weak empirical underpinning, we follow De Graeve et al. (2007) and Gambacorta (2008) and estimate an ECM model, which is relevant for robustness purposes as well. We specify the ECM model both for equations (3) and (4). For brevity's sake, the ECM model for equation (3) only is displayed as follows:

$$\begin{aligned}\Delta\, td_{ijt} = {} & \alpha + \beta_1{}^{*}\, \Delta\, mr_{t-1} + \beta_2{}^{*}\, \Delta\, infl_{t-1} + \beta_3{}^{*}\, \Delta\, vol_{t-1} + \beta_4{}^{*}\, \Delta\, HHI_{t-1} + \beta_5{}^{*}\, \Delta\Delta GDP_{t-1} \\ & + \beta_6{}^{*}\, \Delta\, VIX_{t-1} + \gamma_1{}^{*}\, \Delta\, ta_{it-1} + \gamma_2{}^{*}\, \Delta\, cr_{it-1} + \gamma_3{}^{*}\, \Delta\, ls_{it-1} + \gamma_4{}^{*}\, \Delta\, llm_{it-1} \\ & + \gamma_5{}^{*}\, \Delta\, car_{it-1} + \gamma_6{}^{*}\, \Delta\, df_{it-1} - \varepsilon(\beta_1\, mr_{t-1} + \beta_2\, infl_{t-1} + \beta_3\, vol_{t-1} + \beta_4\, HHI_{t-1} \\ & + \beta_5 \Delta GDP_{t-1} + \beta_6\, VIX_{t-1} + \gamma_1\, ta_{it-1} + \gamma_2\, cr_{it-1} + \gamma_3\, ls_{it-1} + \gamma_4\, llm_{it-1} \\ & + \gamma_5\, car_{it-1} + \gamma_6\, df_{it-1} + \gamma_7\, fb_i + \delta_1\, mb_j + \delta_2\, fp_j + \delta_3\, ar_j \\ & + \delta_4\, ma_j - td_{ijt})_{-1} + u_{ijt} \end{aligned} \tag{5}$$

IV. EMPIRICAL RESULTS

This section starts with a discussion of the time deposits model using three different estimation techniques: FEs, feasible GLS, and – as a robustness test – an ECM. Subsequently, we discuss the outcomes for savings accounts. As regards both models, we consider three different measures for creditworthiness (i.e., credit spread, credit rating, and the capital ratio) in separate regressions. For the 2008–2014 time deposits model, the number of observations for the three proxies for creditworthiness ranges from close to 9000 to almost 18,000, while for the 2003–2014 savings accounts estimates, the number of observations varies from close to 10,000 to almost 17,000. The savings sample period is longer, but the number of savings accounts is lower, while a number of accounts did not exist during the entire period.

15 The results of these tests are available on request from the authors.

A number of bank-specific variables are proxies for unknown phenomena, such as liquidity and efficiency, which means that we are likely to encounter measurement problems. That is why we start with all the macroeconomic and account-specific variables and test the three bank risk variables one by one before considering the fully fledged model with all bank-specific variables. Further, we investigate in turns the effect of excluding one or two of the highly correlated variables as a sensitivity analysis.

We refer to Bikker et al. (2016) for detailed correlation tables of all our (sub) samples. Tables B.1 and B.2 in Bikker et al. (2016) provide correlations between the model variables in our time deposit models and our savings account models, respectively. These tables show a number of high correlation coefficients, particularly among bank-specific variables in the time deposit sample. The highest correlations exists between *bank size* and (i) *credit rating* (0.76), (ii) *liquidity surplus* (0.62), (iii) *liquidity mismatch* (0.56), and (iv) the *cost-to-asset ratio* (0.62). Such high correlation coefficients may impair the estimation results, while exclusion of one or more relevant explanatory variables may result in omission bias. All reported models pass the variance inflation factor (VIF) test for multicollinearity (i.e., all individual VIF values are below 3.9), indicating that multicollinearity does not distort our estimations. As a result, we include the correlated variables in our models.

A. Results for the time deposit model

i. Fixed-effects estimates for time deposits

Using the time deposit dataset, we start with the FE estimates of equation (3). Many banks may have specific characteristics not captured by our model. As far as these features are constant over time, they may be picked up by the bank-specific FEs. Hence, the advantage of this FE panel model is that the estimation results are less impaired by (bank-specific) omitted variables and therefore provide more consistent estimates than, for instance, OLS. Jointly, the FE parameters are highly significant according to the F-test (see lower panel of Table 5). As the signs of the coefficients are identical across the four specifications for almost all variables in Table 5, we discuss all outcomes collectively. The macro variables perform as expected in all four model specifications. The market rate, inflation, market rate volatility, and stress each consistently have a positive and highly significant impact on the interest rate of time deposits. The market rate coefficient ranges from 0.56 to 0.63, so although the time deposit rate follows the risk-free market rate, it does not do so to the full extent. Banks may deviate from the market rate, as they need to attract funding and offer an add-on to cover the credit risk to providers of bank finance. This variable has by far the largest economic impact.[16] The inflation coefficient ranges from

16 Economic impact is defined as a variable's standard deviation (as in Table 2) times its coefficient (as in Table 5).

Table 5 FE estimates for the effective time deposit interest rate model (2008–2014)

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.6145	99.77***	0.5713	114.80***	0.5654	119.73***	0.6314	95.69***
Inflation (+)	0.1322	20.91***	0.1725	34.78***	0.1629	33.27***	0.1132	16.89***
Market rate volatility (+)	0.0488	24.28***	0.0597	39.17***	0.0591	40.05***	0.0460	22.95***
Concentration (–)	–0.0660	–7.45***	–0.0838	–11.80***	–0.0692	–9.83***	–0.0514	–5.68***
Economic growth (–)	–0.0282	–12.17***	–0.0506	–27.26***	–0.0481	–26.21***	–0.0322	–13.55***
Stock market stress (+)	0.0056	9.96***	0.0159	36.99***	0.0152	36.65***	0.0059	10.42***
Bank-specific variables								
Bank size (–)	0.0077	20.92***	0.0049	21.95***	0.0041	19.76***	0.0078	17.92***
Credit spread (+)	0.0769	23.00***					0.0758	21.98***
Credit rating (–)			–0.0001	–1.57				
Capital ratio (–)					–0.0229	–15.99***		
Liquidity surplus (–)							–13.3208	–7.87***
Long liquidity mismatch (–)							–0.0017	–9.59***
Inefficiency (–)							–0.3291	–4.36***
Deposit funding (–)							0.0036	4.29***
Account-specific variables								
Maturity (+)	0.0000	37.92***	0.0000	43.70***	0.0000	45.67***	0.0000	35.15***
Minimum balance/10,000 (+)	–0.0013	–7.97***	–0.0015	–9.35***	–0.0012	–7.51***	–0.0014	–8.78***
Payment frequency (?)	–0.0019	–4.49***	0.0016	6.05***	0.0015	5.94***	–0.0017	–4.18***
Ascending rate (?)	0.0009	4.48***	0.0013	6.76***	0.0012	6.45***	0.0008	4.27***
No. of observations	8,970		16,785		17,729		8.970	
No. of banks	19		34		35		19	
F-test of FE (*p*-value)[b]	319.9		257.9		388.4		239.1	
F-test on *macroeconomic*[b]	4,522.6		7,612.0		8,616.5		3,450.7	
F-test on *bank-specific*[a]	486.3		249.2		378.2		197.7	
F-test on *account-specific*[b]	380.8		505.8		539.2		327.4	
R-sq within	87.8		84.6		84.3		88.0	
R-sq between	9.2		0.7		1.5		10.3	
R-sq overall	34.5		12.0		16.5		34.5	

Notes: Expectations with respect to the sign of the coefficients are presented in brackets after the variable name. The super-indices *, **, and *** denote significantly different from zero at the 95%, 99%, and 99.9% confidence levels, respectively. [a]The expected signs are presented in brackets. [b]All F-tests are significant at the 99.9% confidence level.

0.11 to 0.17. This compensation for inflation – or rather inflation expectations – comes on top of the compensation already included in the market rate.

Market rate volatility is another important determinant: volatility leads to statistically significant higher interest rates on time deposits. Market concentration shows the expected result with a negative and highly significant coefficient. A higher level of concentration in the market lowers the interest rate on time deposits, possibly reflecting less competition.[17] The significant negative coefficient for GDP growth indicates that a higher level of GDP growth leads to more supply of deposits, in turn leading to a lower interest rate. The estimates for the stock market stress variable VIX show a significantly positive impact in all model specifications. The higher the stress level, the higher the interest rate on time deposits. In times of stress, banks appear to search for retail funding through the provision of higher deposit rates on time deposits. Note that all macroeconomic variables have highly significant coefficients, with the same sign across all four specifications, even where the composition of the respective sample varies considerably, for example, in number of observations.

Moving to the bank-specific variables, we include "total assets (log)" throughout, as it proves to be an important determinant. Contrary to expectations, its coefficient is positive and significant in all four model specifications. This outcome can be attributed to the FE estimation procedure, which ignores size differences across banks in estimating the model parameters and only considers bank-specific size *changes*. The latter are relatively small over the short 2008–2014 period where a number of banks declined in size. In the next paragraph, where we present FGLS estimates, the bank size coefficients become negative, in line with our presumption. Our key interest is in the bank risk indicators, applied in turns; see the first three columns of Table 5. The credit spread coefficient is significantly positive, as expected: a higher CDS spread signals higher bank risk, which means that a bank needs to offer a higher interest rate on its savings accounts to attract funding. In terms of economic impact, this variable comes in second: a one standard deviation increase in CDS adds 0.12% to the deposit rate, while the difference between maximum and minimum CDS adds 0.97%. The next bank risk variable, credit rating, is negative, as expected, but does not have a significant coefficient. Rating changes over time are small in comparison with rating differences across banks. As FE estimates ignore cross-bank differences in estimating the model parameters, only these changes over time can provide information about this coefficient; these changes are apparently too little for the coefficient to become significant. The third bank risk variable is the BIS capital ratio. In line with expectations, the coefficient of the capital ratio is significantly negative: a better capitalized, and hence less risky, bank can afford to offer lower time deposit rates. Of course, it is difficult to individually compare the four specifications, as the samples are different. When combining all three

17 We are aware that, in general, the concentration index is a poor indicator of competition (e.g., Claessens and Laeven 2004; Bikker et al. 2007), but a better alternative is not available.

proxies for bank risk in one regression, the coefficient of the credit spread remains the most significant one, with a z-value of more than 23 versus the other two measures with z-values of around 7, all with the signs presented in Table 5.[18]

For the fourth model specification with bank-specific variables, we include the dominant credit spread as indicator of bank risk. We use two liquidity proxies: liquidity surplus, defined as the monthly reported liquidity surplus as a percentage of total assets (as reported to DNB), and long liquidity mismatch, defined as the ratio of available to required long liquidity. As expected, both variables show significant negative coefficients; see the last column of Table 5. The coefficient of our measure for inefficiency, the cost-to-asset ratio, is highly significant: cost-inefficient banks appear to offer lower time deposit interest rates, in line with theory. The coefficient of deposit funding is significantly positive: banks that rely to a relatively large extent on deposit funding tend to offer higher interest rates on time deposits. This is contrary to our expectations, which assumed that the necessity for banks with extended deposit funding to aggressively price deposits would be relatively low. The variable foreign bank is excluded from these regression results, as it is absorbed by the bank-specific FEs, because, in our sample, a bank's nationality did not change over time.

Finally, we consider the account-specific variables, with maturity being the most important factor. Its coefficient is significantly positive throughout. The coefficients of minimum balance have negative values while we expected that higher interest rates were needed to compensate for these requirements. Minimum balance hurdles appear not to be a serious problem for the more rational and wealthier time deposit accountholders. For the coefficients of payment frequency and ascending interest rates, we do not have *a priori* expectations. The payment frequency coefficients change signs across the model specifications. These dummy variables have non-zero values for a few accounts only (Table 2), which may cause a lack of robustness of their coefficients. The coefficient of the ascending interest rates is positive and significant for all models, indicating relatively high interest rates on these accounts. Comparing the explanatory power of the three groups of variables, we find that market variables dominate (see the F-test on macroeconomic variables reported in the lower section of Table 5), while the bank-specific and account-specific variables had intermediate or minor explanatory positions in turns, dependent on the model specification. The test on FEs shows that the joint effect of FE is highly significant.

ii. FGLS estimates for time deposits

A disadvantage of the within estimation of FE is that this approach ignores information across banks on the average levels of the variables over time. Feasible GLS estimation is in that sense more efficient and takes information across banks into

18 Not reported, but available on request from the authors.

account, at the same time correcting for possible heteroskedasticity and autocorrelation. FGLS is for that reason a good alternative, providing additional insight. Table 6 depicts our results. The macroeconomic effects only change to a limited extent now that our estimates are based on FGLS instead of bank-specific FEs. This observation is in line with our expectation that macro variables are hardly correlated with bank-specific FEs. We observe several minor changes. The FGLS market rate coefficients are lower, in a range of 0.44–0.46 versus the 0.52–0.60 range in the FE estimation. In addition, the impact of inflation, market rate volatility, GDP growth, and stress is somewhat lower, with concentration now having a higher coefficient.

As regards bank-specific variables, the FGLS coefficients of total assets are negative and highly significant now that average size differences across banks are taken into account: larger banks provide lower interest rates, as expected. Two bank risk measures, credit spread and capital ratio, remain highly significant with the "right" sign, but the coefficient of credit rating now becomes significantly positive, where a negative relation was expected. Despite the fact that we use the stand-alone credit profile instead of the long-term issuer rating, our rating variable is still highly correlated to the natural logarithm of total assets (i.e., a correlation coefficient of 0.76). In line with Imai (2006), we re-estimate the model without the bank size variable. The coefficient of the credit rating now becomes significantly negative as expected.[19] That result includes the effect of the omitted variable "bank size" on the deposit rate and cannot be attributed to the credit rating alone. From an empirical point of view, the credit spread and the capital ratio are preferable as bank risk indicator over the credit rating. The liquidity surplus measure remains significantly negative in line with theoretical expectations, while the long liquidity mismatch variable becomes significantly positive. Our measure for inefficiency, the cost-to-asset ratio, shows an insignificant coefficient. Deposit funding is significantly negative, in line with theory. Foreign ownership plausibly raises interest rates: being less known or new on the market requires provision of statistically significantly higher interest rates. The credit spread sample includes only one foreign bank, which is why we leave out this variable in columns 1 and 4. Not all bank-specific variables have coefficients with the expected sign. This may be due either to high correlations, as observed previously, or to possible measurement errors.

Finally, we consider the account-specific variables. The coefficient of maturity remains highly significantly positive. The minimum balance coefficient is negative, as before. The coefficients of payment frequency are barely significant or not significant at all. The ascending rate coefficient now becomes negative and significant in 3 out of the 4 models. FGLS includes an AR(1) term for the time series of each bank, with a coefficient fluctuating around 0.8 indicating the presence of bank-specific factors, which are picked up by the FE variables in the previous estimation approach.

19 Estimation results are available from the authors upon request.

Table 6 FGLS estimates for the effective time deposit interest rate model (2008–2014)

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.4623	70.19***	0.4443	86.93***	0.4410	86.64***	0.4447	68.88***
Inflation (+)	0.0766	13.75***	0.0832	18.87***	0.0778	17.85***	0.0759	13.64***
Market rate volatility (+)	0.0099	10.51***	0.0118	16.29***	0.0119	16.74***	0.0112	11.73***
Concentration (−)	−0.0931	−13.53***	−0.0842	−15.48***	−0.0863	−16.12***	−0.0894	−13.03***
Economic growth (−)	−0.0145	−4.22***	−0.0233	−8.71***	−0.0199	−7.59***	−0.0096	−2.96**
Stock market stress (+)	0.0076	20.59***	0.0100	36.18***	0.0096	35.63***	0.0070	19.01***
Bank-specific variables								
Bank size (−)	−0.0010	−10.63***	−0.0011	−18.90***	−0.0008	−15.54***	−0.0009	−9.78***
Credit spread (+)	0.0358	9.69***					0.0338	9.64***
Credit rating (−)			0.0002	4.99***				
Capital ratio (−)					−0.0229	−13.47***		
Liquidity surplus (−)							−5.5787	−3.39***
Long liquidity mismatch (−)							0.0008	5.42***
Inefficiency (−)							0.1038	1.68
Deposit funding (−)							−0.0184	−23.87***
Foreign bank (+)			0.0003	1.36	0.0014	5.71***		
Account-specific variables								
Maturity (+)	0.0001	37.09***	0.0001	37.85***	0.0001	38.73***	0.0001	40.84***
Minimum balance/10,000 (+)	−0.0008	−3.26**	0.0000	0.65	0.0000	2.94**	−0.0015	−6.59***
Payment frequency (?)	−0.0024	−1.95	0.0004	0.82	0.0010	1.94	−0.0021	−2.15*
Ascending rate (?)	−0.0013	−3.05**	−0.0008	−2.40*	−0.0010	−2.84**	0.0002	0.43
No. of observations	8448		15,985		16,971		8448	
No. of accounts	203		354		383		203	
AR(1) coefficient[b]	0.830		0.827		0.827		0.788	
F-test on macroeconomic[c]	6712.4		10,881.7		10,733.2		6741.9	
F-test on bank-specific[c]	320.8		717.7		797.6		1220.9	
F-test on account-specific[c]	1422.9		1469.5		1569.8		1694.9	

Notes: See notes on Table 5. We specify a heteroskedastic error structure without cross-sectional correlation. [a]The expected signs are in brackets. [b]Our FGLS approach specifies that, within each bank's time series, there is AR(1) autocorrelation and that the coefficient of the AR(1) process is common to all the bank panels.[c]All F-tests are significant at the 99.9% confidence level.

iii. Error correction model estimates for time deposits

As a robustness test, we also apply the ECM of equation (5). The ECM distinguishes between short-run and long-run effects and is tailored for non-stationary processes. The coefficient of the deposit rate reflects the impact of the error correction term: each month, the actual deposit rate moves toward the long-term "rating" model value with a statistically highly significant adjustment rate of 6.2%; see the first panel of Table 7.[20] The adjustment rates are slightly higher for the capital ratio (7.3%) and the bank-specific model based on the credit spread (8.3%).

For each model, we use short-run as well as long-run coefficients. The first are estimated directly, while the latter are the product of the equilibrium coefficient (presented in the "EC-term" column) and the adjustment rate (0.0621); this product is presented in the "Long-term" column. For the bank-specific model with CDS spread, all macro variables, most bank-specific variables and the account-specific variable maturity have a coefficient sign in line with our expectations (third panel in Table 7). The size measure "total assets (log)" has a positive effect, where a negative coefficient was expected, similarly to Table 5. Generally, the long-term estimates are similar to the coefficients in the previous Tables 5 and 6 with FE and FGLS estimates. For example, the market rate coefficient is 0.40 versus 0.63 and 0.44, respectively. Most macro variables in the other two models (rating model and capital model) have similar coefficients, with inflation being an exception. The bank risk proxies credit spread and capital ratio are significant with a sign as expected, while for rating this holds true only for the short-run. The sign of maturity switches, while the other three account-specific variables do not have a significant coefficient. All in all, the long-term effects are fairly comparable with those from earlier estimations.

Turning to the short-run effect, we observe that many macro variables also have the expected sign. For instance, the short-run market rate effect ranges from 0.15 to 0.21. This is also true for rating, but the short-run CDS and capital ratio are not significant.

iv. Conclusions regarding the time deposit models

Comparing the FE and FGLS estimates, we find market-specific and the account-specific "maturity" coefficients to be relatively insensitive to the estimation procedure used, but this does not hold for bank-specific coefficients. Bank-specific FEs absorb bank features, which remain relatively constant over time such as bank size and ratings. Depending on the method, we observe less robust sign outcomes for bank size, credit rating, liquidity mismatch, cost-to-asset ratio, and deposit funding. As a consequence, we need to be extra cautious when using these results. Where FE ignores "level" information across banks, the FGLS bank size coefficients may be more informative, but then we need to be careful because

20 Because of the absence of clear empirical support for the ECM (see Section IIIC), the *t*-statistics may be unreliable.

Table 7 ECM estimates for of the effective time deposit interest rate model (2008–2014)

	Credit spread					Capital ratio					Bank-specific				
	Short-term		EC-term		Long-term	Short-term		EC-term		Long-term	Short-term		EC-term		Long-term
	Coeff.	*t*-value	Coeff.	*t*-value	Calc.	Coeff.	*t*-value	Coeff.	*t*-value	Calc..	Coeff.	*t*-value	Coeff.	*t*-value.	Calc.
Deposit rate			0.0621	17.85***				0.0725	20.73***				0.0829	16.30***	
Macroeconomic variables[a]															
Market rate (+)	0.1545	20.32***	−0.0106	−3.49***	0.1707	0.1599	20.73***	−0.0149	−5.01***	0.2055	0.2126	21.81***	−0.033	−7.15***	0.3981
Inflation (+)	−0.0065	−1.38	0.0037	1.44	−0.0596	−0.0067	−1.4	0.002	0.76	−0.0276	0.0075	1.18	−0.0107	−2.96**	0.1291
Mkt rate volatility (+)	0.0115	15.49***	−0.0088	−10.29***	0.1417	0.0118	16.10***	−0.0096	−11.16***	0.1324	0.0101	9.77***	−0.0087	−7.22***	0.1049
Concentration (−)	−0.0603	−10.79***	0.0297	8.91***	−0.4783	−0.0566	−9.95***	0.0288	8.49***	−0.3972	−0.0838	−11.03***	0.0461	10.12***	−0.5561
Economic growth (−)	0.0218	5.10***	0.0206	23.90***	−0.3317	0.0231	5.29***	0.0202	22.87***	−0.2786	−0.0141	−2.29*	0.0112	9.34***	−0.1351
Stock market stress (+)	0.0027	9.21***	−0.0012	−5.36***	0.0193	0.0025	8.24***	−0.0013	−5.55***	0.0179	0.0032	7.95***	−0.0003	−0.86	0.0036
Bank-specific variables															
Bank size (−)	0.0009	2.24*	−0.0009	−8.92***	0.0145	0.0002	0.37	−0.0007	−7.00***	0.0097	0.0036	3.44***	−0.0015	−6.58***	0.0181
Credit spread (+)	−0.0004	−6.60***	0.0000	1.11	0.0000										
Credit rating (−)						0.0011	0.47	0.0037	5.75***	−0.0510					
Capital ratio (−)											0.002	0.56	−0.0167	−9.21***	0.2014
Liquidity surplus (−)											−2.6196	−1.32	1.2337	1.51	−14.8818
Long liquidity mismatch (−)											−0.0021	−6.29***	0.0001	0.72	−0.0012
Inefficiency (−)											0.1425	2.16*	−0.1443	−2.90**	1.7407
Deposit funding (−)											−0.0068	−3.81***	−0.0009	−2.18*	0.0109
Account-specific variables															
Maturity (+)		—	0.0000	−10.38***	0.0000		—	0	−11.76***	0.0000		—	0	−7.64***	0.0000
Minimum balance/10,000 (+)		—	0.0001	0.82	−0.0016		—	0	0.37	0.0000		—	0	0.54	0.0000
Payment frequency (?)		—	−0.0001	−1.30	0.0016		—	−0.0002	−1.39	0.0028		—	0.0003	1.47	−0.0036
Ascending rate (?)		—	−0.0001	−1.00	0.0016		—	−0.0001	−0.97	0.0014		—	−0.0001	−0.68	0.0012
Constant	−0.0067	−7.94***				−0.0074	−8.98***				−0.0049	−3.45***			
No. of observations	16,271					17,174					8630				

Notes: See notes on Table 5. [a]The expected signs are in brackets.

of possible omitted variable bias. Fortunately, most results are similar across both estimation approaches. We conclude that macro variables behave exactly in line with theory, while most bank-specific variables also behave as expected, particularly the bank risk measures credit spread and the capital ratio, and foreign ownership; other factors show varying signs.

The ECM estimates are in line with those of the long-run models, even though the empirical underpinning of this specification is limited. This model adds to the earlier results that (i) significant direct (i.e., short-run) effects exist and (ii) the continued adjustment to the long-run equilibrium is rather slow.

B. Results for the savings account models

As regards savings accounts, the estimates of equation (4) using FE and FGLS are presented in Tables 8 and 9, respectively. The overall outcome is that the behavior of savings interest rates appears to be less consistent with economic theory than that of time deposit rates. This is evident from the estimated coefficients, but also from the goodness-of-fit measures (R^2). This finding is consistent with evidence found in the pass-through literature (e.g., Kok Sørensen and Werner 2006; De Graeve et al. 2007). Savings accountholders prefer the continuous option to withdraw, for which no non-bank market alternatives are available, while time deposit accountholders are expected to have a more professional and rational attitude and to invest higher amounts, which implies that they are most likely to compare account conditions to market alternatives to a larger extent.

i. Fixed-effect estimates for savings accounts

The macro variables perform as expected in all model specifications. The market rate, inflation, and volatility each have a consistently positive and highly significant impact on the savings interest rates. The market rate coefficient ranges from 0.23 to 0.26, which is relatively low compared with the values of around 0.6 in the time deposit model. This might be attributed to the stickiness of savings rates. Still, the market rate is the variable with the largest economic impact. Competition between bank savings accounts and financial markets is limited, as the latter do not offer comparable charge-free, small-scale, and risk-free investment products with a withdrawal option as bank savings accounts have. The inflation coefficient ranges from 0.03 to 0.09, again much lower than in the time deposit model. The volatility in the market rate has a statistically significant positive impact on savings rates. The coefficient of market concentration is significantly negative, as expected, and roughly double the size of the coefficient for time deposit estimations. The significant negative coefficient for GDP is somewhat higher than for the time deposit model, while the impact of market stress is less pronounced than in the deposit model.

Moving to the bank-specific variables, we find that the FE estimates of the "total assets (log)" coefficient has alternating signs. These FE estimates ignore level information of size differences across banks in estimating model parameters,

Table 8 FE estimates for the effective savings interest rate model (2003–2014)

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.2289	21.11***	0.2556	30.70***	0.2480	32.22***	0.2353	19.68***
Inflation (+)	0.0276	2.15*	0.0868	9.38***	0.0788	9.03***	0.0666	4.97***
Market rate volatility (+)	0.0298	5.52***	0.0405	9.05***	0.0381	8.98***	0.0275	5.02***
Concentration (–)	–0.1580	–9.60***	–0.2094	–18.21***	–0.2283	–21.14***	–0.1486	–8.82***
Economic growth (–)	–0.0498	–9.33***	–0.0602	–14.16***	–0.0582	–14.31***	–0.0703	–11.43***
Stock market stress (+)	0.0040	3.95***	0.0066	8.49***	0.0083	10.88***	0.0028	2.73**
Bank-specific variables								
Bank size (–)	0.0009	3.29**	–0.0009	–4.70***	–0.0007	–4.24***	0.0008	2.51*
Credit spread (+)	0.0329	3.80***					0.0617	6.70***
Credit rating (–)			0.0005	5.95***				
Capital ratio (–)					–0.0238	–11.59***		
Liquidity surplus (–)							–7.2967	–3.15**
Short liquidity mismatch (–)							0.0028	5.77***
Inefficiency (–)							1.2707	13.04***
Deposit funding (–)							–0.0114	–8.85***
Account-specific variables								
Withdrawal fee (+)	0.4043	16.89***	0.3350	16.97***	0.3371	17.37***	0.3978	16.71***
Minimum balance/10,000 (+)	0.0000	1.35	0.0001	4.07***	0.0001	3.81***	0.0000	0.14
Bonus rate (+)	0.0666	5.05***	0.0659	5.00***	0.0698	5.34***	0.0756	5.76***
Payment frequency (?)	–0.0005	–0.31	0.0024	3.56***	0.0025	3.87***	–0.0002	–0.13
No. of observations	10,034		15,773		16,822		9,869	
No. of banks	25		49		52		24	
F-test of FE (p-values)[b]	39.4		33.5		45.7		46.1	
F-test on macroeconomic[b]	469.1		873.3		1,251.2		281.4	
F-test on bank-specific[b]	15.7		24.6		70.6		43.1	
F-test on account-specific[b]	76.5		85.0		89.4		76.4	
R-sq within	27.3		34.8		36.1		28.4	
R-sq between	4.8		33.8		15.7		5.3	
R-sq overall	20.8		32.5		34.4		22.3	

Note: See notes on Table 5. [a]The expected signs are in brackets. [b]All F-tests are significant at the 99.9% confidence level.

Table 9 FGLS estimates for the effective savings interest rate model (2003–2014)

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.0669	16.17***	0.0991	24.91***	0.1030	26.53***	0.0605	14.17***
Inflation (+)	0.0163	6.20***	0.0211	8.58***	0.0218	8.92***	0.0158	5.94***
Market rate volatility (+)	0.0034	5.85***	0.0033	6.03***	0.0034	6.34***	0.0035	5.78***
Concentration (−)	0.0005	0.13	−0.0089	−2.58**	−0.0134	−3.94***	−0.0004	−0.12
Economic growth (−)	−0.0253	−11.97***	−0.0278	−13.58***	−0.0283	−14.29***	−0.0217	−9.79***
Stock market stress (+)	0.0001	0.69	0.0006	4.27***	0.0007	4.40***	0.0001	0.64
Bank-specific variables								
Bank size (−)	−0.0002	−2.34*	−0.0004	−7.48***	−0.0004	−7.00***	−0.0003	−2.66**
Credit spread (+)	0.0054	2.49*					0.0052	2.38*
Credit rating (−)			0.0002	5.82***				
Capital ratio (−)					−0.0073	−7.45***		
Liquidity surplus (−)							−2.1714	−2.13***
Short liquidity mismatch (−)							−0.0010	−5.50***
Inefficiency (−)							0.0447	1.87
Deposit funding (−)							−0.0027	−4.10***
Foreign bank (+)	−0.0004	−0.26	0.0006	0.84***	0.0018	2.62**	−0.0036	−2.10*
Account-specific variables								
Withdrawal fee (+)	0.4411	6.32***	0.4501	8.40***	0.4447	8.57***	0.4534	6.93***
Minimum balance/10,000 (+)	0.0004	4.48***	0.0002	4.18***	0.0002	4.17***	0.0004	4.93***
Bonus rate (+)	0.0325	0.84	−0.0023	−0.07	0.0003	0.01	0.0334	0.91
Payment frequency (?)	−0.0040	−1.15	0.0021	1.33	0.0024	1.58	−0.0025	−0.75
No. of observations	9,992		15,635		16,696		9,827	
No. of accounts	165		238		254		164	
AR(1) coefficient	0.969		0.960		0.956		0.966	
F-test on macroeconomic	418.9		872.6		995.7		324.5	
F-test on bank-specific	12.5	(0.0057)	88.2		114.1		99.1	
F-test on account-specific	61.0		89.2		92.7		72.3	

Note: See notes on Table 6. [a]The expected signs are in brackets.

reducing the theoretical too-big-to-fail effects, even for such an extended sample period. The coefficients of two bank risk indicators, credit spread and capital ratio, have the expected sign and are significant, but with lower values than in the time deposit model.[21] The third bank risk variable – credit rating – shows a significant positive effect where a negative sign is expected, a finding that we again attribute to FE estimates ignoring level information of ratings across banks.[22] We conclude that the credit spread and the capital ratio can again be used to predict the interest rate, whereas ratings cannot. The liquidity surplus and deposit funding have significant coefficients with the expected sign, while the short liquidity mismatch and the cost-to-asset ratio have counterintuitive signs.

Finally, looking at the account-specific variables, we observe that they all have positive coefficients, where significant. The positive and highly significant coefficients of withdrawal fee, a new variable not occurring in the time deposit model, is fully in line with expectations. Apparently, compensation is needed for a withdrawal fee in the form of a higher interest rate. Minimum balances exhibit the expected positive coefficient: depositors need to be compensated for meeting the minimum balance requirements. Higher interest rates are also paid on accounts with bonus rates and, in two specifications, for more frequent interest payments. These account features, which are aimed at increasing bank funding stability at the expense of depositors' flexibility, come at a cost for banks offering these accounts.

In this savings sample, the F-tests on macroeconomic, bank-specific and account-specific variables have much lower values than in the time deposit sample, even though the number of observations is much higher. Macro effects dominate the model, with account-specific effects next in line in terms of importance. Also, the goodness of fit (R^2) is lower. This confirms that saving rates appear to behave much less according to "theory."

ii. FGLS effects estimates for savings accounts

Table 9 presents the FGLS estimation results of the savings model of equation (4). All statistically significant FGLS coefficients of the macro variables have identical signs to those in Table 6 for the time deposit model (hence, all theoretically correct), but their values are all substantially lower in absolute terms. Market stress appears redundant where the model includes the credit spread. Because level information has now been included, the size variable "total assets (log)" has again its expected sign across all four specifications. As regards the coefficients of the

21 After leaving out stock market stress from our models, the coefficient of the credit spread and its significance remain the same as before, which means that the correlation between VIX and CDS does not distort the estimates.

22 After leaving out the size variable (not shown here), the rating indeed obtains a highly significant coefficient with the expected negative sign (*z*-value: 4.5). Of course, apart from the assumed added value of the rating, rating then also picks up the impact of the (then) omitted bank's size.

bank risk indicators CDS and capital ratio, we observe that all signs are as expected, but the variables exhibit lower values and significance levels (but still at 1%). First, the cost-to-asset ratio coefficient has a significant negative value, in line with our presumption, indicating that more cost-efficient banks can offer higher interest rates on savings. Earlier estimates had not shown this expected negative sign. In addition, banks in need of liquidity offer higher savings rates. The negative sign of the funding coefficient is plausible. The coefficients, signs, and significance levels of the account-specific variables largely resemble those of the FE estimates. An exception is bonus rate where the coefficient sign varies and the significance level is low.

The high value of the AR coefficient estimate (0.95–0.96) points again to the stickiness of the omitted variables. This confirms that FE estimation, which picks up those omitted variables, is in this case preferable over the FGLS approach, even though the estimation results are generally identical in terms of signs. Contrary to the earlier time deposit estimates of Tables 5–7, the explanatory power of the macro variables of the savings model is limited; the account variables dominate here.

iii. Error correction model estimates for savings accounts

The estimated ECM of savings accounts does not function properly, as the coefficient of the error term is hardly significant (for the capital ratio model) or not significant at all. Also, the long-run coefficients (in case of the capital ratio model) and short-run coefficients are not in line with expectations, for example, a negative coefficient for the market rate. Furthermore, they show erratic variations across the (four) model specifications, different from all earlier estimations. It appears that banks' saving rates are very sticky and hardly or not adjusted to the expected, theoretical model. As a result, we have chosen not to present the outcomes of this inappropriate model specification.

C. Savings accounts model and the credit crisis

An interesting question is whether the setting of interest rates on savings accounts changed after the outburst of the credit crisis. We use the beginning of 2008 as the starting point for the financial crisis.[23] To investigate whether, for instance, bank risk or size ("too big to fail") has become more important, or whether macro influences became stronger, we split the savings account dataset into a pre-crisis (2003–2007) and a post-crisis (2008–2014) period. As our time deposit sample only covers the (post) crisis period, we cannot use such an approach for these data. Possible differences between the pre-crisis and post-crisis savings

23 There is no official starting date of the financial crisis. One event that could mark the start of it was the support of Bear Stearns for two failing hedge funds in June 2007. Another event is the bankruptcy of Lehman Brothers in September 2008. We use a rough mid-point of these events.

model may help to interpret the (post-crisis) time deposit results. For brevity, we present the FE estimates only, but note that the undisclosed FGLS results lead to quite similar conclusions. Tables 10 and 11 present FE savings model estimates for the pre-crisis and post-crisis periods, respectively.

The coefficients of the market rate are much larger and statistically much more significant after the crises (at around 0.40) than before 2008 (ranging from 0.15 to 0.20). Apparently, banks had to operate more in line with macro conditions to maintain and attract deposits after 2008, which resulted in post-crisis savings interest rates far above the market rate (2.4% versus 1.4%), while they were below the market rate during the pre-crisis period (2.6% versus 2.8%).[24] The post-crisis impact of market rates on savings rates at 0.40 is also closer to the impact of market rates on time deposit rates (around 0.60, as presented in Table 5). Furthermore, we find stronger post-crisis relationships for market rate volatility, GDP and market stress, but less a pronounced impact of inflation and concentration with different signs in the two subperiods. Finally, the goodness-of-fit (R^2 within) of the crisis models are around 0.40, whereas these values were around 0.10–0.15 pre-crisis. This is another indication that savings interest rates started to respond more to the economic reality as of the onset of the crisis.

An important question is whether the impact of bank risk changed between the pre-crisis and post-crisis periods. For the credit spread and the total capital ratio, this is indeed the case: these variables were insignificant before the crises, indicating that in those days (an excess of) bank risk did not have any systematic effect on the interest rate, while these measures were highly significant after the crisis (see the first and the two last columns in Tables 10 and 11).[25] Credit rating itself does not function well in FE models, as discussed in *Sections IVA* and *B*. Remarkably, coefficients of the account-specific variables are much smaller and statistically less significant after the crisis, indicating a shift in attention from account characteristics to bank risk. The F-tests underline all these observations: macroeconomic and bank-specific variables play a more important role after the crisis than before, while the opposite is true for account-specific variables.

We apply three robustness checks to our findings presented in the last columns of Tables 10 and 11: (1) first differences applied to all model variables, (2) exclusion of the largest banks, and (3) using quarterly observations instead of monthly ones (Tables 12 and 13). The findings from robustness checks (2) and (3) (i.e., regression results excluding the largest banks, and the use of quarterly observations) do not differ substantially from our base models results. Robustness check (1) (i.e., taking first differences) represents a significant departure from our base models and acts therefore as a substantial robustness check, as all level information in our model variables is ignored in this case. Despite this

24 Tables containing descriptions of the sub samples (as in Table 2) are available upon request from the authors.

25 On a related note, Gerritsen et al. (2017) showed that, relative to non-crisis years, bank risk played a larger role during the financial crisis in the decision to transfer funds between bank accounts in the Netherlands.

Table 10 FE estimates for the effective savings interest rate model, pre-crisis (2003–2007)

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.1944	6.28***	0.1508	7.62***	0.1512	8.37***	0.1949	5.26***
Inflation (+)	0.0606	1.50	0.0022	0.08	0.0098	0.38	0.0517	1.20
Market rate volatility (+)	−0.0099	−0.71	−0.0068	−0.70	−0.0063	−0.72	−0.009	−0.61
Concentration (−)	−0.2438	−2.96**	−0.3661	−7.66***	−0.3935	−9.05***	−0.2782	−3.12**
Economic growth (−)	−0.0690	−2.32*	−0.0711	−3.88***	−0.0690	−4.12***	−0.0581	−1.87
Stock market stress (+)	0.0028	0.43	0.0034	0.84	0.0042	1.12	0.0021	0.30
Bank-specific variables								
Bank size (−)	−0.0043	−2.86**	0.0013	2.42*	0.0017	3.36***	−0.0050	−2.34*
Credit spread (+)	−0.3698	−1.82					−0.3960	−1.47
Credit rating (−)			0.0000	0.08				
Capital ratio (−)					−0.0041	−0.71		
Liquidity surplus (−)							14.8546	1.49
Short liquidity mismatch (−)							−0.0002	−0.11
Inefficiency (−)							0.2566	0.60
Deposit funding (−)							−0.0102	−2.47*
Account-specific variables								
Withdrawal fee (+)	0.6126	14.80***	0.5802	17.34***	0.5819	18.12***	0.6045	14.52***
Minimum balance/10,000 (+)	0.0013	6.39***	0.0010	6.80***	0.0010	7.10***	0.0013	6.30***
Bonus rate (+)	0.3547	7.70***	0.3211	7.74***	0.3193	8.02***	0.3503	7.56***
Payment frequency (?)	0.0098	5.64***	0.0049	4.23***	0.0048	4.33***	0.0096	5.51***
Ascending rate (?)	0.0047	1.73	0.0043	1.72	0.0042	1.71	0.0046	1.67
Constant	0.0986	5.94***	0.1004	8.92***	0.1065	10.80***	0.1135	5.49***
No. of observations	3416		5669		6278		3378	
No. of banks	17		37		42		17	
F-test of FE[b]	32.99		70.80		88.46		24.07	
F-test on macroeconomic[b]	14.56		89.89		119.08		9.81	
F-test on bank-specific[b]	5.10		3.33	(0.036)	7.14		3.36	(0.0091)
F-test on account-specific[b]	64.71		79.02		86.03		62.00	

Table 10 (*continued*)

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
R-sq within	11.2		14.1		15.6		10.9	
R-sq between	06.5		13.0		1.2		7.1	
R-sq overall	1.3		1.4		0.8		0.9	

Note: See notes on Table 5. [a]The expected signs are in brackets. [b]All F-tests are significant at the 99% confidence level, except where the *p*-value is presented in brackets.

Table 11 FE estimates for the effective savings interest rate model, post crisis (2008–2014)

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.3698	24.53***	0.4264	32.50***	0.4349	35.34***	0.3466	21.62***
Inflation (+)	−0.0946	−5.81***	−0.0589	−4.31***	−0.0724	−5.54***	−0.0531	−3.08***
Market rate volatility (+)	0.0013	0.23	0.0134	2.63**	0.0123	2.52*	0.0072	1.22
Concentration (−)	0.1257	5.71***	0.1103	5.79***	0.1172	6.27***	0.0997	4.37***
Economic growth (−)	−0.1021	−17.57***	−0.1183	−23.45***	−0.1209	−24.7***	−0.0979	−14.88***
Stock market stress (+)	0.0078	7.36***	0.0111	12.34***	0.0112	12.9***	0.0057	5.08***
Bank-specific variables								
Bank size (−)	0.0032	7.44***	0.0001	0.45	0.0001	0.47	0.0035	6.69***
Credit spread (+)	0.0602	6.54***					0.0704	7.29***
Credit rating (−)			0.0001	1.11				
Capital ratio (−)					−0.0112	−4.67***		
Liquidity surplus (−)							3.3310	1.03
Short liquidity mismatch(−)							0.0006	1.22
Inefficiency (−)							0.5852	4.65***
Deposit funding (−)							−0.0070	−4.39***
Account-specific variables								
Withdrawal fee (+)	0.2573	9.30***	0.2159	9.33***	0.2166	9.44***	0.2539	9.16***
Minimum balance/10,000 (+)	0.0000	2.24*	0.0001	5.23***	0.0001	5.34***	0.0000	1.42
Bonus rate (+)	0.0529	4.21***	0.0560	4.21***	0.0572	4.29***	0.0523	4.16***
Payment frequency (?)	−0.0028	−3.69***	0.0011	2.19*	0.0011	2.22*	−0.0027	−3.54***
Ascending rate (?)	0.0001	0.07	−0.0014	−1.16	−0.0015	−1.23	−0.0001	−0.07
Constant	−0.0312	−5.77***	−0.0142	−3.06**	−0.0125	−2.81**	−0.0260	−4.40***
No. of observations	6623		10,139		10,629		6496	
No. of banks	22		44		47		21	
F-test of FE[b]	318.68		597.10		651.97		237.18	
F-test on macroeconomic[b]	484.49		802.49		1210.24		254.18	
F-test on bank-specific[b]	48.53		0.78	(0.45)	11.37		24.84	
F-test on account-specific[b]	24.36		27.72		28.57		22.93	

Table 11 *(continued)*

	Indicators of bank risk						Bank-specific characteristics + CDS	
	Credit spread		Credit rating		Capital ratio			
	Coeff.	z-value	Coeff.	z-value	Coeff.	z-value	Coeff.	z-value
R-sq within	38.6		43.5		44.5		38.4	
R-sq between	1.8		19.0		16.1		24.6	
R-sq overall	11.8		39.0		40.9		14.8	

Note: See notes on Table 5. [a]The expected sign are in brackets. [b]All F-tests are significant at the 99% confidence level, except where the *p*-value has been shown between brackets.

Table 12 FE estimates for alternative savings interest rate model, pre-crisis (2003–2007)

	Table 10, last column		First differences		Excluding large banks		Quarterly observations	
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.1949	5.26***	0.0721	5.01***	0.1927	3.91***	0.2527	2.74**
Inflation (+)	0.0517	1.20	−0.0106	−1.98*	0.0254	0.45	0.0376	0.42
Market rate volatility (+)	−0.009	−0.61	−0.0027	−2.14*	−0.0286	−1.51	0.0224	0.62
Concentration (−)	−0.2782	−3.12**	−0.0313	−2.55*	−0.2686	−2.31*	−0.3392	−1.04
Economic growth (−)	−0.0581	−1.87	0.0036	0.52	−0.0590	−1.47	−0.0793	−1.36
Stock market stress (+)	0.0021	0.30	−0.0005	−0.80	0.0009	0.10	−0.0009	−0.03
Bank-specific variables								
Bank size (−)	−0.0050	−2.34*	0.0019	2.25*	−0.0011	−0.38	−0.0068	−1.57
Credit spread (+)	−0.3960	−1.47	0.1118	3.14**	1.1839	2.32*	−1.0002	−1.12
Liquidity surplus (−)	14.8546	1.49	3.1117	1.37	2.1162	0.17	13.5566	0.70
Short liquidity mismatch(−)	−0.0002	−0.11	−0.0008	−1.59	−0.0007	−0.39	−0.0020	−0.58
Inefficiency (−)	0.2566	0.60	0.0735	0.88	0.0539	0.07	−0.2167	−0.22
Deposit funding (−)	−0.0102	−2.47**	0.0063	3.74***	−0.0105	−1.83	−0.0154	−1.77
Account-specific variables								
Withdrawal fee (+)	0.6045	14.52***			0.9118	17.75***	0.6009	8.26***
Minimum balance/10,000 (+)	0.0013	6.30***					0.0012	3.40***
Bonus rate (+)	0.3503	7.56***			0.8084	9.17***	0.3071	4.00***
Payment frequency (?)	0.0096	5.51***					0.0099	3.20**
Ascending rate (?)	0.0046	1.67			0.0040	1.42	0.0040	0.83
Constant	0.1135	5.49***	−0.0001	−6.53***	0.0895	3.20**	0.1427	2.00*
No. of observations	3378		3268		2198		1079	
No. of banks	17		17		14		17	
F-test of FE[b]	24.07		3.32		42.2		11.06	
F-test on macroeconomic[b]	9.81		6.6		5.83		3.72	(0.0011)
F-test on bank-specific[b]	3.36	(0.0091)	4.35		2.12	(0.0485)	1.03	(0.4072)
F-test on account-specific[b]	62.00				126.35		19.52	
R-sq within	10.9		2.6		17.7		11.0	
R-sq between	7.1		73.3		11.6		6.1	
R-sq overall	0.9		2.7		12.8		0.6	

Note: See notes on Table 5. [a]The expected signs are in brackets. [b]All F-tests are significant at the 99.9% confidence level, except where the p-value is presented in brackets.

Table 13 FE estimates for alternative savings interest rate model, post-crisis (2008–2014)

	Table 11, last column		First differences		Excluding large banks		Quarterly observations	
	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value	Coeff.	*z*-value
Macroeconomic variables[a]								
Market rate (+)	0.3466	21.62***	0.0470	8.03***	0.3897	15.97***	0.3246	11.98***
Inflation (+)	−0.0531	−3.08**	0.0179	4.61***	−0.0766	−2.86**	−0.0361	−1.12
Market rate volatility (+)	0.0072	1.22	0.0060	7.57***	0.0037	0.43	0.0002	0.02
Concentration (−)	0.0997	4.37***	−0.0018	−0.38	0.0942	2.83**	0.1034	2.66**
Economic growth (−)	−0.0979	−14.88***	−0.0221	−7.80***	−0.1102	−10.96***	−0.0501	−4.48***
Stock market stress (+)	0.0057	5.08***	−0.0003	−1.35	0.0034	2.16*	0.0118	5.83***
Bank-specific variables								
Bank size (−)	0.0035	6.69***	0.0014	3.10**	0.0044*	3.58***	0.0028	3.26**
Credit spread (+)	0.0704	7.29***	0.0136	5.55***	0.0726	5.65***	0.0630	4.12***
Liquidity surplus (−)	3.3310	1.03	−4.5337	−3.39***	1.2943	0.26	6.4975	1.20
Short liquidity mismatch(−)	0.0006	1.22	0.0001	0.49	0.0010	1.57	0.0003	0.35
Inefficiency (−)	0.5852	4.65***	0.0671	1.52	0.2099	0.86	0.4334	2.26*
Deposit funding (−)	−0.0070	−4.39***	0.0095	8.56***	−0.0027	−1.25	−0.0068	−2.62**
Account-specific variables								
Withdrawal fee (+)	0.2539	9.16***			0.3582	10.35***	0.2486	5.38***
Minimum balance/10,000 (+)	0.0000	1.42			−0.0000	−1.34	0.0000	0.65
Bonus rate (+)	0.0523	4.16***			0.5023	11.78***	0.0500	2.42*
Payment frequency (?)	−0.0027	−3.54***			−0.0143	−9.36***	−0.0028	−2.26*
Ascending rate (?)	−0.0001	−0.07			−0.0002	−0.15	−0.0003	−0.15
Constant	−0.0260	−4.40***	−0.0002	−19.51***	−0.0265	−2.83**	−0.0246	−2.46*
No. of observations	6496		6379		3584		2236	
No. of banks	21		21		18		21	
F-test of FE[b]	237.18		1.94	(0.0073)	22.56		10.56	
F-test on macroeconomic[b]	254.18		32.2		121.71		100.99	
F-test on bank-specific[b]	24.84		19.3		11.76		7.21	
F-test on account-specific[b]	22.93				62.97		8.0	
R-sq within	38.4		4.5		38.2		42.5	
R-sq between	24.6		3.2		32.2		31.2	
R-sq overall	14.8		4.5		22.1		23.5	

Note: See notes on Table 5. [a]The expected signs are in brackets. [b]All F-tests are significant at the 99.9% confidence level, except where the p-value is presented in brackets.

difference in modeling, all conclusions regarding the increased importance of bank risk for pricing bank deposits remain valid across these three alternative specifications. First, the coefficient for CDS is significant at a 99% confidence level after the crisis, while it is hardly or not significant before the crisis. The impact of the market variables is also stronger after the crisis compared with before, as witnessed by the coefficients for market rate, economic growth, and market stress, and also by the F-test values on "macroeconomics." In addition, bank-specific variables have gained importance after the crisis, while the impact of account-specific features declines (F-tests). Finally, the *R*-squares are higher after the crisis, indicating an increased explanatory power of our models on savings rates after the crisis.

All in all, the results indicate that the 2008 crisis had a serious impact on the setting of interest rates on savings accounts. Banks needed to retain their deposit funding and offered interest rates, which were more in line with macro conditions than prior to the crisis. After the crisis, banks with higher risks had to offer higher interest rates to retain and attract a stable deposit base.

V. CONCLUSION AND DISCUSSION

This paper investigates the determinants of interest rates on savings accounts and time deposits. Where previous research mostly considered interest rate changes, our study aims to explain the varying interest rate levels across banks and across different accounts within banks. These differences may be significant, given, for example, a difference of 2.5 percentage points between the savings account with the highest rate and the median savings account rate in 2008.

Our analyses are based on three different estimation techniques: FEs, feasible GLS, and error corrections. For both time deposits and savings accounts, we distinguish between three different groups of determinants: macro, bank-specific, and account-specific factors. We find that interest rates are strongly dependent on macro factors. The market rate, market rate volatility, inflation rate, and level of market stress all significantly positively influence interest rates, while both economic growth and concentration index negatively affect rates. As these effects are generally consistent across estimation approaches and varying specifications, we consider them to be robust. The coefficients for savings account interest rates are generally lower, indicating that savings accounts rates are stickier, that is, less responsive to these determinants.

While the general trend in interest rates may be explained by macro factors, interest rate differences across banks depend on bank-specific factors. Feasible GLS estimates, which take size differences across banks into account, reveal that larger banks offer lower interest rates. Although we did not study the reasons for this finding, we consider their access to substitute funding, or possible too-big-to-fail benefits as potential drivers for this effect. In addition, we find bank risk to be an important determinant for interest rates. We use three different proxies for risk, of which the credit spread measured on CDS contracts and the BIS capital ratio consistently indicate a trade-off between risk and return. The expected effect of credit ratings (i.e., higher ratings enable banks to offer lower interest rates) is observed only when bank size is excluded from our analyses. We conclude that credit ratings do not add explanatory power when bank size is taken into account, despite our use of stand-alone credit profiles rather than long-term issuer ratings. The majority of our models show that deposit rates are lower for banks, which are financed for a larger extent by deposits. A plausible explanation for this finding is that deposit demand for this type of banks is likely to be lower. In line with this finding, we observe that a larger liquidity surplus is related to lower interest rates on savings accounts and time deposits. The results for liquidity mismatch and bank efficiency are ambiguous.

Banks offer different types of accounts to their clients. In general, we find maturity-increasing features to have an upward effect on interest rates. This holds for different maturities for time deposits, but also for "softer" features such as withdrawal fees and bonus rates for savings accounts. Remarkably, imposing a minimum account balance is negatively associated with rates for time deposits, but positively with savings account rates. The features of an ascending rate over the term of the deposit, and a higher frequency of interest payments (relative to the norm of once a year) exhibit mixed evidence, which is plausible given that we use effective interest rates.

The savings account dataset allows us to separately analyze the pre-crisis period and the (post-) crisis years. Interestingly, bank risk played a much larger role during the period from 2008 than in the 2003–2007 period. In fact, prior to the crisis, bank risk and interest rates seemed to be completely unrelated. This is a clear manifestation of a decrease in, or absence of, awareness of credit risks prior to the crisis. Our findings show that, as of 2008, bank risk significantly negatively influences savings account rates. Note that this effect emerges even while savings by private persons of up to €100,000 are fully covered by the Dutch Deposit Guarantee Scheme (DGS). Possible reasons for this finding could be that (i) not all depositors are fully aware of the DGS, (ii) some depositors deposit amounts exceeding the DGS threshold, (iii) a number of depositors are not covered in the DGS (e.g., professional depositors, clubs, and foundations), and (iv) depositors might simply behave irrationally. In addition, we observe that the savings account rates followed the market rate more closely after the crisis (i.e., more similar to the time deposit rate behavior), and that the impact of various other macro factors became stronger. Both findings illustrate either a greater awareness of macro conditions among depositors or a greater need for banks to attract savings (and therefore a need to offer higher rates), or both. The importance of account-specific features decreased during the crisis.

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APPENDIX: DESCRIPTION AND SOURCE OF MODEL VARIABLES

Variable	Explanation	Source
Time deposit rate	Annual interest rate on time deposit, per ultimo month	Spaarinformatie
Savings account rate	Annual interest rate on savings accounts, per ultimo month	Spaarinformatie
Market rate	For time deposits ECB AAA-rated Euro area central Government bonds, corresponding with deposit maturity For savings accounts Average of Euro overnight (Eonia), Euribor 3 months, Euribor 6 months, and Euribor 1 year	Datastream
Inflation	Change in Dutch CPI (%yoy), non-seasonally adjusted	Datastream
Market rate volatility	For time deposits ECB yield AAA Government paper volatility, corresponding with deposit maturity For savings accounts Average of interest rate 3 months/6 months/ 1 year volatility – (Average 10d–StDev in months)	Datastream, own calculation
Concentration	Market concentration, as measured by Hirschman–Herfindahl Index (HHI) on household deposits	DNB – Monetary statistics, own calculation
Economic growth	Change in GDP volume (%yoy), seasonally adjusted (monthly data are intrapolated from quarterly observations)	Datastream
Stock market stress	CBOE SPX Volatility Index	Datastream
Bank size	Natural logarithm of total assets (monthly data are intrapolated from quarterly observations; in 1000 euro)	DNB – Supervisory information
Credit spread	Credit default swap spread 5 years (Senior)	Datastream
Credit rating	S&P Stand-Alone Credit Profile (aaa = 22 to d = 1), supplemented with Moody's Baseline Credit Assessment	Standard & Poor's and Moody's Investors Serivce
Capital ratio	BIS ratio, defined as the sum of Tier 1 and Tier 2 capital divided by total risk-weighted assets (monthly data are intrapolated from quarterly observations)	DNB – Supervisory information

Appendix *(continued)*

Variable	Explanation	Source
Liquidity surplus	Liquidity surplus (monthly period) divided by Total assets	DNB – Supervisory information
Liquidity mismatch	For time deposits Long mismatch, computed as Share long assets (>12 months) in total required liquidity divided by Share long liabilities (>12 months) in total available liquidity For savings accounts Short mismatch, Ditto <12 months	DNB – Supervisory information
Inefficiency	Operational inefficiency, measured with the cost-to-asset ratio	DNB – Supervisory information
Deposit funding	Deposits of non-credit institutions divided by the sum of Total deposits + Liquidity debt certificates issued	DNB – Supervisory information
Foreign bank	Bank has a headquarter outside the Netherlands, dummy variable	DNB – Supervisory information
Maturity	Maturity of time deposit in months	Spaarinformatie
Minimum balance	Minimum required savings balance (divided by 10000)	Spaarinformatie
Payment frequency	Payment frequency is 1 for annual payments, 1/4 for quarterly payments, and 1/12 for monthly payments	Spaarinformatie
Ascending rate	The rate that increases with passage of time	Spaarinformatie
Bonus rate	Extra interest is paid out when, for example, the savings balance has grown (in %)	Spaarinformatie
Withdrawal fee	Withdrawal from account can come with fee to be paid (in %)	Spaarinformatie