working paper

08 06R

Bank Mergers and the Dynamics of Deposit Interest Rates

by Ben R. Craig and Valeriya Dinger

FEDERAL RESERVE BANK OF CLEVELAND

Working Paper 08-06R February 2009*

Bank Mergers and the Dynamics of Deposit Interest Rates

by Ben R. Craig and Valeriya Dinger

Despite extensive research interest in the last decade, the banking literature has not reached a consensus on the impact of bank mergers on deposit rates. In particular, results on the dynamics of deposit rates surrounding bank mergers vary substantially across studies. In this paper, we aim for a comprehensive empirical analysis of a bank merger's impact on deposit rate dynamics. We base the analysis on a unique dataset comprising deposit rates of 624 US banks with a monthly frequency for the time period 1997-2006. These data are matched with individual bank and local market characteristics and the complete list of bank mergers in the US. The data allow us to track the dynamics of bank mergers while controlling for the rigidity of the deposit rates and for a range of merger, bank, and local market features. An innovation of our work is the introduction of an econometric approach for estimating the change of the deposit rates given their rigidity.

Key words: deposit rate dynamics, bank mergers, deposit rate rigidity.

JEL code: G21, L11

*Original version posted September 2008.

The authors thank participants of the Federal Reserve Bank of Cleveland Research Seminar, the University of Bonn Macro-Workshop, the Pro-Banker Symposium 2007 in Maastricht, and the FDIC-Chicago Fed Conference on Mergers and Acquisitions of Financial Institutions for useful comments on earlier versions of the paper. Dinger gratefully acknowledges financial support by the Deutsche Forschungsgemeinschaft (Research Grant DI 1426/1 and DI 1426/2-1).

Ben R. Craig is senior economic advisor at the Federal Reserve Bank of Cleveland and can be reached at ben.r.craig@clev.frb.org. Valeriya Dinger is assistant professor at Institute for International Economics, University of Bonn and can be reached at valeriya.dinger@uni-bonn.de.

1. Introduction

Bank mergers affect bank competition by altering the market structure in affected markets and the size and geographical scope of the merging banks. Widespread bank consolidation in the US has motivated a growing literature on the impact of bank mergers on bank competition. A substantial portion of this literature focuses on the impact of bank mergers on bank loan and deposit rates.

Berger and Hannan (1989) were the first to show in a static framework that high market concentration results in lower deposit rates. In a later work, Hannan and Prager (1998) explicitly concentrate on bank mergers as a determinant of local bank market concentration and study the dynamics of deposit rates during the first year after a bank merger. They document a negative impact of mergers on deposit rates. On the other hand, Focarelli and Panetta (2003) find the opposite when they extend the time of analysis. They argue that whereas the market power effect of a merger materializes soon after the merger, potential efficiency gains can materialize only after a delay. These authors extend the time horizon of the analysis to six years after the merger, and their results imply that in the long run, merging banks offer higher deposit rates than their rivals.

The seemingly contradicting results of these studies motivate us to revisit the topic. In this paper we present a comprehensive analysis of the impact of bank mergers on deposit rate dynamics. Our focus is on the effect of the merger on the bank price-setting mechanism, rather than on its effect on efficiency and other performance measures.

We base our analysis on a new, unique dataset, which comprises monthly deposit rate data for 624 banks in the period 1997-2006. The deposit rate data are matched with bank and market characteristics and a complete list of bank mergers from 1988 to 2005.

Our dataset allows us to address two important lacunae of the existing literature. First, the empirical literature on deposit rate dynamics around bank mergers has so far ignored the rigidity of deposit rates. As documented in earlier studies (Hannan and Berger, 1991; and Neumark and Sharpe, 1992) deposit rates adjust sluggishly to changes in market interest rates. Deposit rate rigidity is relevant for the analysis of the changes of deposit rates around bank mergers because no immediate change in deposit rates is observed for a significant number of observations. In addition to a possibly slow adjustment to the change in market structure, which must be modelled with a dynamic model, the data present the additional problem of censoring: that is, for the vast majority of observations, the price is the same as for the period before. In econometric terms this censoring presents large potential problems. It has long been known that in the presence of censoring, OLS regression results can be inconsistent and biased (see a standard text such as Wooldridge, 2002).

We incorporate the rigidity of deposit rates in the empirical analysis by explicitly integrating the censoring process into the empirical estimation. For this purpose, we estimate a model of deposit rate changes which considers both the probability of a deposit rate change and the magnitude of the change. The construction of the model heavily borrows from the (S,s) literature, which assumes a lumpy cost of price adjustment in the analysis of firm price-setting behaviour[1]. The application of this approach to model the price-setting mechanism in the banking industry is a major innovation of this study.

Second, previous research on the impact of bank mergers has mostly concentrated on in-market mergers. We argue that the distinction between in- and out-of-market mergers is not clear-cut since modern bank mergers might be classified as both in- and out-of-market depending on the perspective of the local market. We include all bank mergers (without ex ante imposing restrictions on the type of merger) together with a range of controls for the

[1] See Sheshinski and Weiss (1977), Caplin and Spulberg (1987), Cabalero and Engels (2007)

characteristics of the mergers. Thus, we are able to assess the impact of a wide range of bank mergers and how this impact may be modified by various features of the merger (bank size growth, market share growth, or rise in the number of markets). In other words, we estimate whether bank mergers exert negative impacts on depositors and if that is the case, which features of the merger reinforce the negative impact.

The results of our study uncover a significant negative impact of bank mergers on checking account rates, both in the short and in the long run. These results are consistent with Hannan and Prager's (1998) finding of a drop in deposit rates after bank mergers. Contrary to Focarelli and Panetta (2003), we show that this negative effect is not exhausted in the first year after the merger. The negative effect of bank mergers on deposit rates is mainly driven by the change in the local market share of the merging banks. In other words, the post-merger dynamics of deposit rates seems to be mainly driven by the in-market dimension of the merger. The out-of-market dimension's impact on deposit rates turns out to be much smaller than the effect of the in-market dimension. Having said this, we should mention that we were able to document a negative impact of bank mergers only on checking account rates. Our analysis of the dynamics of money market account rates, which, being an investment product, are associated with lower switching costs, show no persistent change around bank mergers.

The rest of the paper is organized as follows. Section 2 presents a review of the existing literature. Section 3 describes the data. Section 4 presents replications of earlier research approaches using our new dataset. Section 5 presents our empirical approach and its results. Section 6 makes some concluding remarks.

2. Literature

Our study aims to contribute to a broad empirical literature on the pricing effects of mergers. Many studies exist on the impact of company mergers in various industries[2], but because of better data availability, most of the research deals with the banking industry. Most of the literature on the impact of bank mergers focuses on testing the validity of two hypotheses, the "efficiency hypothesis" and its opposite, the "structure-conduct-performance hypothesis". The "efficiency hypothesis" states that the merged bank might realize economies of scale and other efficiency gains and transfer these to the customers in the form of more beneficial interest rates. The most important assumption made by the proponents of the efficiency hypothesis is that efficiency gains are passed on to consumers rather than to other stakeholders. The "structure-conduct-performance hypothesis", on the other hand, states that the merged bank may exploit its increased market power and impose interest rates that are disadvantageous to consumers.

The seminal paper by Berger and Hannan (1989), which emphasizes the structure-conduct-performance hypothesis, is a static study of the relationship between local banking market concentration and deposit rates. Here, the authors find that more concentrated deposit markets are characterized by lower deposit rates[3]. The later work by Hannan and Prager (1998) examines bank mergers as a determinant of bank market concentration. The authors explore the dynamics of the deposit rate changes[4] and find that after a substantial in-market merger, the merging banks significantly decrease their deposit rates, which they explain by an increase in market power.

[2] In a study that inspired the early research on the effect of mergers, Kim and Singal (1993) find that airline mergers have resulted in higher airfares. However, Connor et al. (1997) find that hospital mergers have resulted in lower consumer prices.

[3] Corvoisier and Gropp (2002) replicate Berger and Hannan's (1989) analysis on a sample of EU banks.

[4] Kahn et al. (2005) study the dynamics of loan rates in a similar framework.

Focarelli and Panetta (2003) argue for the efficiency view, maintaining that the post-merger period examined in previous studies is too short[5]. They argue that the effect of market power materializes instantaneously, while efficiency gains need more time to materialize[6]. They present a more comprehensive study, which incorporates long-run post-merger dynamics and controls for bank size and asset risk with total assets and bad loans, and for the market. In their study, efficiency gains prevail. Whereas merging banks tend to decrease deposit rates in the transition period (up to three years after the merger), in the long-run, deposit rates of merged banks go up and beyond those of rival banks.

The studies mentioned above focus mostly on in-market mergers, occasionally using out-of-market mergers as a control for mergers that do not increase market power. A newer strand of the literature suggests that although out-of-market mergers do not directly affect the distribution of market shares, they can significantly impact bank pricing behavior. The theoretical foundation, as given by the models of Barros (1999) and Park and Pennacchi (forthcoming), is based on the assumption that multimarket banks (which are a result of out-of-market mergers) have access to more diverse sources of financing, whereas single-market banks depend largely on retail deposits[7]. As a result, they argue, out-of-market mergers lead to lower deposit rates. Park and Pennacchi (forthcoming)[8] and Hannan and Prager (2006) present empirical tests of this hypothesis, and both find that multimarket banks offer lower deposit rates than their single-market rivals. Using a separate dataset and estimation approach, Rosen (2003), however, finds different results. He argues that growing banks tend to offer

[5] Sapienza (2002) studies loan rate dynamics in a similar framework.

[6] Berger, Sounders, Scalise and Udell (1998), and Calomiris and Karceski (2000) argue that the gestation period needed to restructure a merged bank is three years.

[7] The structure of bank liabilities has been the subject also of a growing literature on market discipline. It has argued that banks may not refinance in the wholesale market because wholesale exposures are not insured and create incentives for the lenders to monitor. Therefore, banks which are perceived as riskier may prefer to refinance mostly with insured retail deposits (Billett, et al., 1998).

[8] Park and Pennacchi use bank size as a proxy for geographical scope.

higher interest rates on deposits, and moreover, a market with more and larger multimarket banks generally sees higher deposit rates at all banks.

The literature of multimarket banking is closely related to that strand of research that investigates the interaction between bank size and the way banks compete. In a seminal paper, Stein (2002) argues that large and small banks process information differently and that is why they compete differently in the loan market. Park and Pennacchi (forthcoming) extend this argument and argue that bank size is also important for deposit market competition.

The literature on multimarket banks is also related to literature on industrial organisation that investigates multiple contacts between firms as a factor facilitating collusion. Edwards (1955) points to the fact that when firms meet in numerous markets they may have higher incentives to collude because retaliation by rivals may follow in so many markets. This relation is known as the "linked oligopoly" hypothesis. Mester (1987) provides an empirical test of this hypothesis and finds that, contrary to expectations, multiple market contacts lead to more competitive pricing, especially in concentrated markets.

In this paper we focus on the seemingly contradictory results with regard to deposit rate dynamics. One potential reason for the deviating results is that researchers have used different datasets. Results might also be biased because of the inadequate treatment of deposit rate dynamics (in particular, the time series structure of deposit rates has been ignored). Moreover, all existing studies include only a fraction of past mergers in the analysis. We add to the literature by performing a comprehensive analysis, which addresses both the dynamics of deposit rates and a broad range of features of bank mergers with a single dataset, allowing us to control for pre- and post-merger characteristics of the local markets.

3. Data

We base the empirical estimation on a unique dataset that is drawn from the full list of bank mergers in the US for the time period 1988-2005, from the *Supervisory Master File of Bank Mergers and Acquisitions*. For each bank we construct a list of its six most recent mergers. We match this data with *Bankrate Monitor's* deposit rates of 624 US banks operating in 164 local markets (a total of 1,738 bank-market groups) for the period starting September 19, 1997, and ending July 21, 2006[9]. Radecki (1998) presents evidence that multimarket banks tend to offer uniform rates across local markets. However, in our sample we observe banks that offer different rates in different local markets. Therefore, we prefer to keep the bank-market as the observation unit. By doing this, we can control for both bank and local market characteristics in the analysis.

Bankrate Monitor's deposit rate data have weekly frequency. But using weekly deposit rate changes as a proxy for deposit rate setting after a merger introduces a lot of noise. Therefore, as in Kahn et al. (2005), we base our tests on rate changes computed over four-week intervals. Our sample encompasses a total of 461 weeks, which allows us to construct a time series of 115 four-week intervals, which we refer to as "months" although they do not correspond to calendar months. This approach also allows the comparison of our results with those of Hannan and Prager (1998), which are also based on data with a monthly frequency.

Bankrate Monitor reports cover a comprehensive set of deposit products (checking accounts, money market deposit accounts, and certificates of deposits with a maturity of three months to up to five years). In this paper we concentrate on checking account and money market deposit account (MMDA) rates only. We exclude the rates on certificates of deposit because they are investment products with a relatively high minimum denomination, and we expect them to

[9] Our merger data start roughly 10 years before the start of our deposit rate dataset. This is motivated by the fact that we need data about past mergers in order to examine both the short-term and the long-term effects of bank mergers on deposit rates.

react less to changes in local market conditions.[10] As noted by Örs and Rice (2007), *Bankrate Monitor* reports give deposit rates for "the lowest minimum deposit amount," which might be the "effectively lowest rates offered by banks and not the most-commonly cited rates". Although a downward bias in the *Bankrate Monitor* deposit rate data is possible, if this bias is persistent, it is unlikely to affect our results, since we concentrate on deposit rate changes around the merger rather than on deposit rate levels.

In addition, we enrich the dataset with a broad range of control variables for individual banks from the *Quarterly Reports of Conditions and Income* (*call reports*). These are at a quarterly frequency. We also include control variables for the local markets. The source of the local market controls is the *Summary of Deposits,* and these data are available only at an annual frequency.

4. Mergers and deposit rate dynamics: a simple empirical framework

As pointed out in Section 2, previous studies have reached contradictory results on the impact of bank mergers on deposit rates. Results may differ because of different estimation approaches but also because researchers have employed different data sources. Hannan and Prager (1998), for example, employ data from US bank mergers, whereas Focarelli and Panetta (2003) base their analysis on Italian data. In order to illustrate how sensitive the empirical results are to the changes of the model specification, we start the empirical analysis by replicating Hannan and Prager's and Focarelli and Panetta's estimation approaches with our dataset.

Our first exercise is to apply Hannan and Prager's (1998) estimation approach to our dataset. For the sake of comparability, we concentrate in this section on substantial in-market mergers

[10] Hannan and Prager (1998) find no significant impact of bank mergers on certificate of deposit rates.

only[11]. As in Hannan and Prager (1998), we estimate the following empirical model by a panel OLS with robust standard errors methodology[12]:

$$\ln deprate_{ijt} - \ln deprate_{ijt-1} = \alpha_0 + \alpha_1 merger\_dummies_{i,t} + \xi_{i,j,t}\,. \qquad (1)$$

The dependant variable, $\ln deprate_{ijt} - \ln deprate_{ijt-1}$, is the change in the log of the deposit rate (for checking accounts and money market deposit accounts) between *t*-1 and *t*. The variable $merger\_dummies_{i,t}$ denotes vectors of dummy variables, which measure the amount of time relative to the latest merger of bank i. We adopt five time dummies here: 26 to 1 weeks pre-merger, 0 to 12 weeks post-merger, 13 to 26 weeks post-merger, 27 to 39 weeks post-merger and 40 to 52 weeks post-merger. The dummies take the value of 1 if a bank has experienced a merger within the respective time window and 0 otherwise.[13]

As illustrated in Table 1 for both checking account and MMDA rates, we are able to qualitatively replicate the results of Hannan and Prager (1998). The time dummy for *13 to 26 weeks post-merger* enters the checking account rate regression with a negative, statistically significant coefficient. All other "time-to-merger" dummies are statistically insignificant. In the case of money market deposit account rates, the pre-merger effect and the merger effect *13 to 26 weeks* after the merger are negative and statistically significant, whereas the *27 to 39 weeks* after the merger effect is positive. The cumulative effect is, however, negative. These results confirm the negative short-term effect of in-market mergers[14] on deposit rates and can be interpreted as evidence in support of the structure-conduct-performance hypothesis.

---

[11] As in Hannan and Prager (1998), we concentrate on substantial in-market mergers defined as mergers which led to a rise in the local market's HHI of at least 100 basis points.

[12] As argued by Hannan and Prager (1998), because the dependent variable is first differenced, fixed effects are not needed in the estimation.

[13] Our approach is slightly different from Hannan and Prager's here. They adopt a dummy variable for each of the -12/+12 months around the merger.

[14] In these regression specifications we follow Hannan and Prager (1998) and do not control for any features of the bank or the local market.

Table 1: Short-term effects of in-market bank mergers

	checking account rate	money market deposit account rate
26 to 1 week pre-merger	**0,005**	**-0,008** **
	0,003	0,004
0 to 12 weeks post-merger	**-0,001**	**0,000**
	0,004	0,004
13 to 26 weeks post-merger	**-0,006** **	**-0,010** **
	0,003	0,004
27 to 39 weeks post-merger	**0,001**	**0,014** ***
	0,003	0,004
40 to 52 weeks post-merger	**0,001**	**-0,002**
	0,003	0,004
constant	**-0,006**	**-0,005** ***
	0,000	0,001
Observations	57218	55123
R-squared	0.01	0.01

Note: The dependant variable is the monthly change in the log of the deposit rate. The model is estimated by panel OLS with heteroskedasticity-robust standard errors. Coefficients in bold, standard errors below coefficients. *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

In Hannan and Prager's (1998) framework the change of deposit rates around a merger is studied without controlling for changes in the reference interest rates (T-bills or fed funds), which are important determinants of deposit rates. One potential approach to control for the reference rate is suggested by Focarelli and Panetta (2003). These authors examine the level of deposit rates relative to the reference rate rather than just the change of deposit rates[15]. They also expand the time period analyzed after the merger and include a few controls on the bank and local market levels. The estimated model in this case is:

$$relative\_rate_{i,j,t} = \gamma_0 + \gamma_1 merger\_dummies_{i,t} + \gamma_2 Controls + \nu_{i,j,t}. \qquad (2)$$

As in Focarelli and Panetta (2003) the model is estimated using panel OLS with heteroskedasticity-robust standard errors. The dependant variable, $relative\_rate_{i,j,t}$, is the difference between the deposit rate (checking account rate or MMDA rate) and the fed funds rate. The time distance to the merger is measured by a set of five dummies (for the first,

[15] Note that by using the relative rate as a dependent variable, a coefficient of -1 on the reference rate, which corresponds to a perfect adjustment of deposit rates to reference rates, is assumed. This is a strong assumption given the rigidity of deposit rates.

second, third, fourth, and fifth year after the merger). Controls for bank characteristics are bank size (log of total assets) and bank size squared. On the local market level we control for market concentration using the Herfindahl index (HHI) and average per capita income in the local market (in log form)[16].

Table 2: Long-term effect of bank mergers

	checking account rate	money market deposit account rate
1st year after the merger	**0,095 ****	**0,082 ****
	0,041	0,035
2nd year after the merger	**0,099 ****	**0,134 *****
	0,045	0,039
3rd year after the merger	**0,718 *****	**0,705 *****
	0,049	0,042
4th year after the merger	**0,881 *****	**0,768 *****
	0,051	0,044
5th year after the merger	**0,968 *****	**0,743 *****
	0,055	0,048
size	**-4,395 *****	**-3,083 *****
	0,123	0,104
size squared	**0,154 *****	**0,107 *****
	0,004	0,003
market share	**-1,808 *****	**-1,002 *****
	0,191	0,163
HHI	**-0,391 ***	**-0,819 *****
	0,201	0,174
income	**0,000 *****	**0,000 *****
	0,000	0,000
constant	**26,171 *****	**18,494 *****
	1,024	0,866
Observations	47674	47674
R-squared	0.03	0.03

Note: The dependant variable is the difference between the deposit rate (money market rate or checking account rate) and the fed funds rate. panel OLS with heteroskedasticity-robust standard errors. Coefficients in bold, standard errors below coefficients. *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

As shown by the results of the estimations of model (2) presented in Table 2, we are able to qualitatively replicate Focarelli and Pannetta's (2003) results. Using Focarelli and Panetta's approach, we also document that bank mergers have a positive effect on deposit rates. Our

[16] Our set of control variables slightly differs from Focarelli and Panetta's in that we include the squared bank size term (significant in all regression specifications) in addition to bank size to control for nonlinearity in the size's impact on deposit rates. The Herfindahl index (HHI) is included as a market structure proxy instead of the concentration ratio used by Focarelli and Panetta (2003).

results, however, differ from Focarrelli and Panetta's results, in that we do not document a negative short-term impact on deposit rates (that is, in the first two years after the merger). The control variables enter the regression with coefficients of the expected sign, given a Focarelli and Panetta world. So, larger banks offer lower deposit rates, but the negative effect of bank size is exhausted at a certain threshold. The Herfindahl index has a negative and statistically significant coefficient, suggesting that banks offer lower deposit rates in more concentrated local markets.

The results of this exercise differ substantially from those of Hannan and Prager (1998). Obviously, Focarelli and Panetta's approach deviates from Hannan and Prager's in more ways than the choice of the time horizon after the merger. Both the inclusion of control variables and the choice of the dependent variable might also affect the results. In order to better understand what drives the empirical results, we have estimated numerous alternative models, which combine different specifications of Hannan and Prager's (1998) and Focarelli and Panetta's (2003) approaches. The results of these estimations are available from the authors' website.[17] So, for example, including a standard set of control variables turns the negative effect of mergers documented in Hannan and Prager (1998) into a positive one even in the short run. When, in addition to adding control variables, we also change the dependent variable from the deposit rate change (as in Hannan and Prager) to the relative rate (as in Focarelli and Panetta) we find a negative merger effect if we examine only one year after the merger and a positive one if we examine a period of up to five years after. A comparison of the results illustrates that even when the same dataset is employed, empirical results change substantially depending on the choice of dependent variable, the time span, and the set of control variables. This conclusion leads us to track the dynamics of deposit rate changes in a more comprehensive framework.

[17] http://www.iiw.uni-bonn.de/dinger/

5. Bank mergers and the dynamics of deposit interest rates: an extended empirical analysis

The empirical tests presented in Section 4 do not consider the censoring issue arising from the rigidity of deposit rates. When we replicate Hannan and Prager's (1998) approach, we estimate a regression in which the dependent variable is the monthly change of deposit rates. As illustrated in Table 3, we observe no change in the deposit rate for a huge share of observations in our sample. On average, checking account rates stay unchanged in 90% of the months, whereas money market account rates do not change in more than 84% of the months.

Table 3: Frequency of positive and negative monthly deposit rate changes

	fed funds rate	checking account rate	money market deposit account rate
positive change	45%	2%	5%
negative change	38%	8%	11%
no change	16%	90%	84%

The dependent variable, $\ln deprate_{ijt} - \ln deprate_{ijt-1}$, is equal to 0 for these "no change" observations. In econometric terms, this implies that observed values of the dependent variable are severely censored. As a result of the censoring, OLS estimates can be biased and inconsistent[18].

In this section we present an estimation methodology that accounts for the censoring and thus incorporates deposit rate rigidity. We employ the following baseline empirical model:

$$\ln deprate_{ijt} - \ln deprate_{ijt-1} = \beta_0 + \beta_1 merger\_splines_{it} + \beta_2 Controls_{it} + \beta_3 Controls_{jt} + \beta_4 \Delta fedfund_t + \varepsilon_{ijt}, \quad (3)$$

[18] Although less obvious, the censoring problem is also present in Focarelli and Pannetta's (2003) framework, where the difference between the deposit and the interbank rates is used as a dependent variable. Again, since deposit rates change very infrequently, the changes of the dependent variable are driven only by changes in the interbank rate.

where $deprate_{ijt}$ is the deposit rate (checking account rate or money market deposit account rate) offered by bank i in market j in “month” t, $merger\_splines_{it}$ is a vector of linear splines[19] for different time distances from the merger. $Controls_{it}$ and $Controls_{jt}$ are vectors of control variables on the individual bank level and the local market, respectively[20]. $\Delta fedfund$ is a vector of the change in the fed funds rate during the periods: (t–1,t), (t–2, t–1) and (t–3, t–2).

Our model therefore estimates how the process of adjustment—of bank deposit rates to changes in the reference rate during the current and previous periods—is modified by bank mergers and the characteristics of the bank and the local bank market. Thus, when we discuss a negative or positive impact of a merger on deposit rates, we mean the impact of the merger on this process.

Estimation technique

As a benchmark, we first estimate the model by standard OLS. We then proceed to model the rigidity of deposit rates and to estimate the impact of bank mergers on deposit rates with a “trigger model,” with fixed costs of the price (deposit rate) adjustment constructed in the tradition of the (S,s) literature[21]. In this literature, the optimizing agent must pay a fixed cost for adjusting its price. Faced with this decision, and a set of simplifying assumptions, the agent will act according to a simple decision rule involving a change that would be desired by the bank in the absence of fixed costs and a threshold level. The bank does not change its price until the difference between the current price and the desired price exceeds the threshold, whereupon the bank changes the price to the desired level.

[19] The derivation of the spline values will be discussed in detail in the next section.

[20] Our dependent variable data are monthly, whereas some of the bank and local market-level controls are quarterly or annual. To deal with this issue we estimate the model using clustered standard errors.

[21] (S,s) models were first introduced to model retail inventories, where inventory levels had to fall below a threshold value, “s”, before the firm would order new production. In the last two decades they have been extensively used to model lumpy price adjustments (Sheshinski and Weiss, 1977; Cabalero and Engels, 2007).

In other words, we assume that an underlying latent variable, itself a function of measured time series characteristics, must reach a positive or a negative trigger point before the deposit rate can change in either direction.

The desired deposit rate adjustment, in the absence of a fixed cost, is $\Delta \ln deprate^{*}_{ijt}$. We rewrite equation (3) as a desired level of adjustment,

$$\Delta \ln deprate^{*}_{ijt} = X_{ijt}\beta + \varepsilon_{ijt} \,, \qquad (4)$$

where $X_{ijt}\beta$ denotes vectors of the explanatory variables of equation (3), $X_{ijt}\beta \equiv \beta_0 + \beta_1 merger\_splines_{it} + \beta_2 Controls_{it} + \beta_3 Controls_{jt} + \beta_4 \Delta fedfund_t$, and u_{ijt} is the error term, as before.

The idea behind what we observe in the deposit rate (as opposed to what is actually desired by the bank) is that the bank has a fixed cost of adjusting the nominal deposit rate; this fixed cost may vary depending on the measured and unmeasured characteristics of the bank, and until the difference between the desired and the current rate is large enough, the bank does not change its nominal rate. As in the classic (S,s) model, we model the deposit rate process such that $\Delta \ln deprate_{ijt}$ (without the star) denotes the observed deposit rate change. It is a function of the desired deposit rate change, $\Delta \ln deprate^{*}_{ijt}$, which must exceed a threshold (the trigger point) for an actual change to occur. Note that in our framework the absolute values of the upper and lower threshold can be different. This is to allow for the possibility that banks are less likely to adjust their deposit rates upward than downward[22]. For example, we do not observe a positive change unless the desired change plus a random error term exceeds an upper threshold, c_u:

[22] Neumark and Sharpe (1992) and Berger and Hannan (1991) show that deposit rates are especially inflexible when the pressure is to adjust upward.

$$\Delta \ln deprate_{ijt} = \Delta \ln deprate^*_{ijt}, \text{ if } \Delta \ln deprate^*_{ijt} + u_{ijt} > c_u$$

$$\Delta \ln deprate_{ijt} = \Delta \ln deprate^*_{ijt}, \text{ if } \Delta \ln deprate^*_{ijt} + u_{ijt} < c_l \tag{5}$$

$$\Delta \ln deprate_{ijt} = 0, \text{ otherwise.}$$

The first part of equation (5) represents the change if the "desired change" exceeds the upper threshold, the second part gives the change if the desired change is less than the lower threshold, and the third part simply says that no change is observed otherwise, because the fixed costs of changing do not make it worth the possible benefits of adjustment. Here the functions c_l and c_u represent the trigger points of the (S,s) rule (where $c_l < 0 < c_u$) and are estimated from the data. They are functions of the same control variables as those used in equation (3). The term u_{ijt} represents an error term associated with the trigger points.

While this structure is fairly straightforward econometrically, it is worth noting that the simple ordinary least squares estimation of equation (5), which uses only those observations where the bank changed its price, is inconsistent. This can be seen by calculating the bias term, which we use later in forming a consistent estimate. If the errors are assumed to be normally distributed, that is, $\varepsilon_{ijt} \sim N(0,\sigma_1)$ and $u_{ijt} \sim N(0,\sigma_2)$, then calculating the expectation of the observed deposit rate change is straightforward. The expectation, given the control variables, X_{ijt}, and the fact that the observed change is not zero is

$$\begin{aligned} &E(\Delta \ln deprate_{ijt} \big| X_{ijt}, \Delta \ln deprate_{ijt} \neq 0) = A_l E(\Delta \ln deprate_{ijt} \big| X_{ijt}, \Delta \ln deprate_{ijt} < 0) \\ &+ A_l E(\Delta \ln deprate_{ijt} \big| X_{ijt}, \Delta \ln deprate_{ijt} > 0) \end{aligned}, \tag{6}$$

which can be expressed

$$E(\Delta \ln deprate_{ijt} \big| X_{ijt}, \Delta \ln deprate_{ijt} \neq 0) = X_{ijt}\beta + A_l \sigma \frac{\phi(v_l)}{\Phi(v_l)} + A_u \sigma \frac{\phi(v_u)}{\Phi(v_u)}, \tag{7}$$

where φ and Φ are the standard normal density and cumulative normal density functions, respectively, and function values are expressed

$$v_l = \frac{c_l - X_{ijt}\beta}{\sigma}, v_u = \frac{-c_u + X_{ijt}\beta}{\sigma}, \sigma = \sqrt{\sigma_1^2 + \sigma_2^2}, \tag{8}$$

and weights are

$$A_l = \frac{\Phi(v_l)}{\Phi(v_l) + \Phi(v_u)}, A_u = 1 - A_l. \tag{9}$$

Although the likelihood functions for the system described above are well defined, maximum likelihood estimation procedures rarely converged because of the large numbers of parameters, combined with the huge number of observations. However, the form of the equation suggests a different approach based on the work of Heckman (1976, 1979).

This approach has to do with approaching equation (7) as if it were a simple linear least squares problem with a bias term, $A_l\sigma\frac{\phi(v_l)}{\Phi(v_l)} + A_u\sigma\frac{\phi(v_u)}{\Phi(v_u)}$, tacked onto the end of it. The idea is that we first estimate what this term is, up to the linear parameter, σ, and then include it in a linear least squares estimation as one of the variables. This term requires one to calculate the argument of the standard normal cumulative and density functions, v_u and v_l, which we estimate in a first stage. Then we form a variable $A_l\frac{\phi(v_l)}{\Phi(v_l)} + A_u\frac{\phi(v_u)}{\Phi(v_u)}$, which we include as a linear argument in a second stage. By including this estimated bias term, our estimated variable β will be consistent. The estimated coefficient of this variable in the second-stage estimation has the interpretation of the parameter σ.

So, in the first step, we estimate $v_l = \frac{c_l - X_{i,t}\beta}{\sigma}$ and $v_u = \frac{-c_u + X_{i,t}\beta}{\sigma}$ using two separate probits on whether or not we observe price increases or decreases and compute

$$\hat{\lambda}(v_l, v_u) = A_l(\hat{v}_l, \hat{v}_u)\frac{\phi(\hat{v}_l)}{\Phi(\hat{v}_l)} + A_u(\hat{v}_l, \hat{v}_u)\frac{\phi(\hat{v}_u)}{\Phi(\hat{v}_u)}. \tag{10}$$

The intuition of λ is that it represents the expectation of the error term due to the censoring process. The parameters β are estimated in the second step using simple GLS on the observations of the changes in the deposit rate that are nonzero:

$$E(\Delta \ln deprate_{ijt} \mid X_{ijt}, \Delta \ln deprate_{ijt} \neq 0) = X_{ijt}\beta + \sigma\hat{\lambda}(v_l, v_u). \tag{11}$$

By including an estimated value of λ as a right-hand variable in a second stage, we ensure that the unobserved error term has an expectation that approaches zero in large samples, giving us consistent estimates of our parameters of interest, β. That is, λ is included as a regressor in the estimation of $\Delta \ln deprate_{ijt}$ to correct for the censoring bias.

Of course, the standard errors for the estimated parameters must be estimated in a way that accounts for the fact that an included regressor, $\lambda(v_l, v_u)$, is estimated in the first stage. The methods we use are standard in the literature. Because each stage of the procedure represents an M-estimate, in the sense of Huber (1967), standard errors can be estimated from the stacked system in fairly standard ways, described in Wooldridge (2002). Finally, the trigger functions, c_l and c_u, can, in principle, be easily recovered from the probit estimates of the first stage, along with the estimated parameters of the second stage.

The empirical approach described above gives us a consistent estimate of the impact of mergers on deposit rates while accounting for interest rate rigidity. The estimates illustrate how mergers affect bank price setting and, in particular, how a bank's reaction to a change in the reference rate is modified by a merger.

Explanatory variables

We include three sets of explanatory variables: those that measure a merger's impact across time, those that control for the type of merger, and general bank and market level control variables.

Variables measuring merger's impact across time and

When defining the impact of a bank merger on deposit rates, we concentrate on two major issues, the evolution of the effect of a bank merger over time; and the question of how many of a given bank's previous mergers should be considered (numerous banks acquire multiple targets within a very short period). By concentrating exclusively on the latest merger, we might omit important information about the evolution of bank merger effects.

To consider the evolution of a merger effect, we account for a period from one year before the merger date[23] to up to ten years after the merger. We approximate the development of deposit rates around the merger by linear spline interpolation, the simplest form of spline interpolation[24]. It is equivalent to piecewise linear interpolation, where the function to be modelled is divided into a fixed number of subintervals, and within each of the subintervals the function is linearly approximated. Nonlinearity can, therefore, be modeled by different slopes of the linear functions across the subintervals. The end points of the linearly approximated subintervals are known as "knots".

Algebraically, each spline is a linear function constructed as:

$$f(x) = \frac{x_{i+1} - x}{x_{i+1} - x_i}\alpha_i + \frac{x - x_i}{x_{i+1} - x_i}\alpha_{i+1}, \qquad \text{when } x \in (x_i, x_{i+1}],$$

$$= \qquad 0, \text{ otherwise}, \qquad (12)$$

[23] The merger date is the date on which the target bank loses its charter.

[24] See Craig and Santos, 1997.

and where x is the value of the explanatory variable (the time distance to the merger, in our case). The values x_i denote the "knots" of the spline, and the coefficients, α_i, are estimated from the data. In our case, we approximate the impact of a merger on the change in deposit rates by dividing the time period around the merger into several subperiods. We fix the knots, x_i, at six months before the merger date, at the merger date, six months, one year, one and one-half years, two years, three years, and four years after the merger. Through the splines we model the potential nonlinearity of the dependence between deposit rate changes and time after the merger.

To our knowledge, previous research on the impact of mergers on bank rates has used only dummies for different time windows around the merger. A disadvantage of the dummies is that they are a stepwise and discontinuous approximation of the merger effect across time. Linear splines give a more precise approximation by modeling the effect of mergers as a set of continuous linear functions.

As a robustness check, we reran both the trigger model and the OLS regressions with dummies instead of splines; results did not change qualitatively. The results of these estimations are presented on the authors' web site.[25]

With regard to the history of banks that have experienced numerous mergers, we proceed as follows: To keep the model parsimonious, we define the splines for the time distance from the latest merger only. For previous mergers, we define a set of dummy variables, $merger_i$, which takes the value of 1 if the bank has had at least i mergers and 0, otherwise. Our dataset contains up to six mergers for an individual bank. The variables $merger_4$, $merger_5$, and $merger_6$ entered all regression specifications with statistically insignificant coefficients, so we dropped them from the analysis. We interpret the insignificance of the dummies for earlier

[25] http://www.iiw.uni-bonn.de/dinger/

mergers as a result of the fact that banks that have merged three times during our sample horizon tend to have merged numerous times and so are all similar in this regard.

Variables controlling for the type of merger

In our study, we include the full sample of bank mergers in the period 1988-2005. We do not divide mergers into in-market and out-of-market groups, because we think that this distinction is not clear cut. Most of the mergers in the US during the last few years have been between banks that were already operating in multiple markets. From one local market's point of view, a merger might appear as an in-market merger (if the local market is part of the overlapping geographical range of the two merging banks). In contrast, from the point of view of a local market in which only one of the merging banks has been operating, the merger appears as a market extension (out-of-market) merger. Based on these considerations, we include all mergers in the analysis, together with a range of merger characteristics as controls.

The existing literature has so far emphasized three important features of bank mergers, which might influence the pricing behavior of the merged bank, and we include these in our model. The first is the change in market share. When two banks operating in the same market merge, their joint market share allows them to exercise market power and offer lower deposit rates. We control for this effect by including in the regressions the change of market share (CMS) caused by the merger. Because we do not have precise data on the change of market share directly related to the merger for each of the affected local markets, we have to approximate it with the change of market share realized in the year of the merger. That is, we approximate the change of market share caused by the merger as the difference between the bank's market share in the years before and after the merger[26].

[26] *Summary of Deposits* publishes market shares as of June 30; therefore, we define the year in this case as the period July 1 to June 30.

In order to estimate how the effect of the change of market share evolves in the time after the merger, we also introduce a cross-product of CMS and the time after the merger (CMS**time after merger*=CMS*ln(1+ weeks after the merger)).

The second key aspect of mergers that has been emphasized in the literature is the change of bank size. Because banks grow in size when they merge, they might achieve efficiencies of scale. On the other hand, as Park and Pennacchi (forthcoming) point out, larger banks have access to more diversified sources of financing and might, therefore, keep deposit rates low. To estimate the impact of the merged banks' size (*target's size*), we include the volume of total assets of the target bank[27] (normalized to the acquirer's total assets) in the regression. The cross-product of the *target's size* and the time after the merger (*TS*time after merger*= target's size* ln(1+ weeks after the merger)) is also included in the regression.

Finally, as suggested by the linked-oligopoly hypothesis, the number of markets in which a bank is active might also significantly affect its pricing behavior. In order to estimate the effect of the market-extension dimension of the mergers we include the *change of number of local markets* (CNM) divided by the number of markets prior to the merger as a regressor. As with the CMS, we have to approximate the CNM, which we do with the ratio of the number of markets in which a bank operates in the years before and after the merger. Again, we include the cross-product of the CNM variable and the time after the merger (CNM* ln(1+ weeks after the merger)) as a regressor.

Control variables

In addition to the merger-related variables and the variables measuring the change of the fed funds rate, we include a number of control variables for the merged bank and for the local market. For individual banks, these are bank size (measured by the log of total assets), bank

[27] The *Supervisory Master File of Bank Mergers and Acquisitions* provides data for the target banks' ID. Given these, we match the acquiring banks' data with the target banks' data from the *Call Report*.

size squared, and the share of deposits to total assets (lagged one year in order to avoid simultaneity). This variable is included as a measure of a bank's dependence on retail deposits, following the argument by Park and Pennacchi (forthcoming) that banks with easier access to wholesale funds might compete less aggressively in the retail deposit market. For the local market, we control for market concentration (as measured by the Herfindahl index) and per capita income (in log form) for the counties in the market.

Empirical results

The results of the baseline OLS estimations of changes in checking account rates and money market deposit account rates are presented in Tables 3 and 4, respectively. Estimations of the trigger model are presented in Table 5 and 6[28].

A comparison of the results of the OLS and the trigger models indicates that both the economic and the statistical significance of the merger's effect on deposit rate dynamics is stronger when we control for the rigidity of deposit rates. The higher statistical significance of the trigger estimates can be explained by the fact that the trigger model ignores the noise introduced by the "no change" observations. The lower economic significance of the OLS estimates is a direct effect of the censoring bias, which is present in the OLS estimation. The economic intuition of the difference between the trigger model and the OLS results is that within the trigger model we explicitly treat the dynamics of the deposit rates, especially their rigidity. That is, in the presence of positive price adjustment costs, the observed path of deposit rate dynamics differs from the desired one. In the following discussion we will concentrate on the unbiased trigger model results.

The empirical results on changes in checking account rates point to a negative impact of mergers. Whereas the pre-merger effect is insignificant in all checking account rate regression

[28] The results of the first-stage of the estimation (the probit regressions on positive or negative deposit rate changes) are available from the authors upon request and on the authors' website (www.iiw.uni-bonn.de/dinger/).

specifications, the immediate effect of the merger is negative and statistically significant. Moreover, the merger continues to exert a negative impact on deposit rates up until the beginning of the third year after the merger. Only during the third year can we identify a positive impact of the merger on deposit rate changes, but this impact is offset by the negative effect during the following years. The spline coefficients presented in Tables 3 to 6 do not represent the marginal effects but the estimated knots of the splines, which in turn model the dynamics of the log change of the deposit rates. These coefficients suggest a very high magnitude of the estimated changes. The spline coefficients in the checking account rate regression presented in the first column of Table 5 suggest a marginal change at six months after the merger of -8.6%. The marginal effect at 12 months after the merger is estimated to be -2%, and at three and four years at 9.6% and -5.5[29]. At one year the cumulative effect on the checking account rates is estimated to drop by almost 75%. The cumulative effect on the checking account rates four years after the merger is estimated to be a 87% drop[30].

All in all, mergers negatively and statistically significantly affect deposit rate adjustments. One potential explanation for the positive effect around the third year is the fact that during most of our sample period stakeholders have assumed that the "gestation" period needed to restructure a merged bank is three years (Berger et al., 1998, and Calomiris and Karceski, 2000). Following this assumption, some window dressing around the third year might have taken place.

[29] The marginal effects are estimated by computing the exponential of the estimated coefficient of the spline knot. In other words, the marginal change at the knot is equal to $exp(\beta) - 1$, where β is the estimated knot coefficient.

[30] We derive the cummulative effects by integrating the marginal effects estimated from the spline knots. Because this also integrates the estimation error, we believe that the confidence intervals for these estimates are very large, and thus emphasize that the large magnitude of the cumulative effects should be treated with caution.

Table 3: Mergers and checking account rate dynamics: OLS estimates

	(1)	(2)	(3)	(4)	(5)
spline-0.5	**-0.001**	**0.000**	**-0.001**	**-0.001**	**0.000**
	0.006	0.006	0.006	0.006	0.006
spline0	**0.023 *****	**0.023**	**0.023**	**0.023 *****	**0.023 *****
	0.004	0.004	0.004	0.004	0.004
spline+0.5	**0.003**	**0.001**	**0.003**	**0.003**	**0.002**
	0.004	0.004	0.004	0.004	0.004
spline+1	**0.006**	**0.004**	**0.006**	**0.006**	**0.004**
	0.004	0.004	0.004	0.004	0.004
spline+1. 5	**-0.011 *****	**-0.014 *****	**-0.011 *****	**-0.011 ****	**-0.013 *****
	0.004	0.005	0.004	0.005	0.005
spline+2	**-0.007 ***	**-0.011 *****	**-0.007 ***	**-0.007 ***	**-0.010 ****
	0.004	0.004	0.004	0.004	0.004
spline+3	**0.002**	**-0.002**	**0.002**	**0.002**	**-0.001**
	0.004	0.004	0.004	0.004	0.004
spline+4	**-0.012 *****	**-0.018 *****	**-0.013 *****	**-0.012 *****	**-0.017 *****
	0.003	0.003	0.003	0.003	0.004
target's size		**-0.006**			**-0.005**
		0.005			0.005
TS*time after merger		**0.005**			**0.006**
		0.002			0.002
change market share (CMS)			**-0.023**		**-0.013**
			0.031		0.031
CMS*time after merger			**0.005**		**-0.001**
			0.009		0.009
change number of markets (CNM)				**-0.002**	**-0.001**
				0.002	0.002
CNM*time after merger				**0.000**	**-0.001**
				0.001	0.001
merger2	**0.000**	**0.000**	**0.000**	**0.001**	**0.000**
	0.003	0.003	0.003	0.003	0.003
merger3	**-0.003**	**-0.002**	**-0.003**	**-0.004**	**-0.002**
	0.003	0.003	0.003	0.003	0.003
change fed fundsrate (t;t-1)	**0.022 *****	**0.022 *****	**0.022 *****	**0.022 *****	**0.022 *****
	0.002	0.002	0.002	0.002	0.002
change fed fundsrate (t-1;t-2)	**0.052 *****	**0.052 *****	**0.052 *****	**0.052 *****	**0.052 *****
	0.002	0.002	0.002	0.002	0.002
change fed fundsrate (t-2;t-3)	**0.031 *****	**0.032 *****	**0.031 *****	**0.031 *****	**0.032 *****
	0.002	0.002	0.002	0.002	0.002
bank size	**-0.016 *****	**-0.013 ****	**-0.017 *****	**-0.018 *****	**-0.014 ****
	0.005	0.005	0.005	0.005	0.005
bank size squared	**0.001 *****	**0.000 *****	**0.001 *****	**0.001 *****	**0.000 *****
	0.000	0.000	0.000	0.000	0.000
deposits to assets	**0.001**	**-0.001**	**0.000**	**0.000**	**-0.001**
	0.014	0.014	0.014	0.014	0.014
market share	**-0.006**	**-0.008**	**-0.006**	**-0.006**	**-0.008**
	0.007	0.007	0.008	0.007	0.008
HHI	**-0.005**	**-0.005**	**-0.006**	**-0.006**	**-0.005**
	0.011	0.011	0.011	0.011	0.011
income	**0.004 ****	**0.004 ****	**0.004 ****	**0.004 ****	**0.004 ****
	0.002	0.002	0.002	0.002	0.002
constant	**0.096 ****	**0.074 ***	**0.099 ****	**0.106 ****	**0.075 ***
	0.044	0.046	0.044	0.045	0.047
number of observations	41440	41440	41440	41440	41440
R-squared	0.0194	0.0195	0.0194	0.0197	0.0198

Note: *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 4: Mergers and money market deposit account rate dynamics: OLS estimates

	(1)	(2)	(3)	(4)	(5)
spline-0.5	**-0.005**	**-0.005**	**-0.005**	**-0.005**	**-0.005**
	0.007	0.007	0.007	0.007	0.007
spline0	**-0.003**	**-0.002**	**-0.003**	**-0.003**	**-0.002**
	0.005	0.005	0.005	0.005	0.005
spline+0.5	**-0.007**	**-0.008**	**-0.007**	**-0.007**	**-0.007**
	0.005	0.005	0.005	0.005	0.005
spline+1	**0.027 *****	**0.026 *****	**0.027 *****	**0.027 *****	**0.027 *****
	0.005	0.005	0.005	0.005	0.005
spline+1. 5	**-0.002**	**-0.003**	**-0.002**	**-0.002**	**-0.003**
	0.005	0.005	0.005	0.005	0.005
spline+2	**-0.017 *****	**-0.018 *****	**-0.017 *****	**-0.017 *****	**-0.018 *****
	0.004	0.005	0.004	0.005	0.005
spline+3	**0.007**	**0.006**	**0.007**	**0.007**	**0.006**
	0.004	0.004	0.004	0.004	0.004
spline+4	**-0.023 *****	**-0.025 *****	**-0.023 *****	**-0.023 *****	**-0.025 *****
	0.003	0.004	0.003	0.004	0.004
target's size		**0.006**			**0.007**
		0.005			0.006
TS*time after merger		**0.001**			**0.002**
		0.002			0.002
change market share (CMS)			**-0.001**		**-0.006**
			0.034		0.035
CMS*time after merger			**-0.002**		**-0.003**
			0.010		0.010
change number of markets (CNM)				**0.000**	**-0.001**
				0.002	0.002
CNM*time after merger				**0.000**	**0.000**
				0.001	0.001
merger2	**0.000**	**-0.002**	**0.000**	**0.000**	**-0.001**
	0.003	0.003	0.003	0.003	0.003
merger3	**-0.001**	**0.001**	**-0.001**	**-0.001**	**0.000**
	0.003	0.003	0.003	0.003	0.003
change fed fundsrate (t;t-1)	**0.021 *****	**0.021 *****	**0.021 *****	**0.021 *****	**0.021 *****
	0.003	0.003	0.003	0.003	0.003
change fed fundsrate (t-1;t-2)	**0.073 *****	**0.073 *****	**0.073 *****	**0.073 *****	**0.073 *****
	0.003	0.003	0.003	0.003	0.003
change fed fundsrate (t-2;t-3)	**0.035 *****	**0.035 *****	**0.035 *****	**0.035 *****	**0.035 *****
	0.003	0.003	0.003	0.003	0.003
bank size	**-0.001**	**0.002**	**-0.001**	**-0.001**	**0.003**
	0.006	0.006	0.006	0.006	0.006
bank size squared	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
	0.000	0.000	0.000	0.000	0.000
deposits to assets	**0.070 *****	**0.070 *****	**0.070 *****	**0.070 *****	**0.071 *****
	0.016	0.016	0.016	0.016	0.016
market share	**0.014 ***	**0.012**	**0.014 ***	**0.014 ***	**0.012**
	0.008	0.008	0.008	0.008	0.008
HHI	**0.000**	**0.001**	**0.000**	**0.000**	**0.001**
	0.012	0.012	0.012	0.012	0.012
income	**0.004 ****	**0.004 ****	**0.004 ****	**0.004 ****	**0.004 ****
	0.002	0.002	0.002	0.002	0.002
constant	**-0.026**	**-0.054**	**-0.027**	**-0.024**	**-0.056**
	0.050	0.052	0.050	0.050	0.053
number of observations	39861	39861	39861	39861	39861
R-squared	0.0261	0.0262	0.0261	0.0261	0.0262

Note: *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 5: Mergers and checking account rate dynamics: results of the "trigger" model

	(1)	(2)	(3)	(4)	(5)
spline-0.5	**-0.058**	**-0.054**	**-0.059**	**-0.056**	**-0.056**
	0.057	0.056	0.057	0.057	0.057
spline0	**-0.102 ****	**-0.110 ****	**-0.095 ****	**-0.104 ****	**-0.102 ****
	0.046	0.046	0.047	0.046	0.046
spline+0.5	**-0.090 ****	**-0.109 ****	**-0.090 ****	**-0.096 ****	**-0.107 ****
	0.044	0.045	0.044	0.045	0.045
spline+1	**-0.021**	**-0.030**	**-0.022**	**-0.027**	**-0.033**
	0.039	0.039	0.039	0.039	0.039
spline+1. 5	**-0.102 ****	**-0.128 *****	**-0.106 ****	**-0.098 ****	**-0.121 *****
	0.044	0.044	0.044	0.045	0.045
spline+2	**-0.092 ****	**-0.115 *****	**-0.098 ****	**-0.093 ****	**-0.115 *****
	0.041	0.042	0.041	0.042	0.043
spline+3	**0.096 *****	**0.072 ****	**0.088 ****	**0.095 *****	**0.068 ***
	0.035	0.035	0.035	0.035	0.035
spline+4	**-0.056 ****	**-0.096 *****	**-0.064 ****	**-0.057 ***	**-0.096 *****
	0.028	0.031	0.029	0.030	0.032
target's size		**-0.034**			**-0.016**
		0.030			0.032
TS*time after merger		**0.043 *****			**0.040 *****
		0.013			0.014
change market share (CMS)			**-0.408 ****		**-0.378 ***
			0.195		0.193
CMS*time after merger			**0.143 ****		**0.103 ***
			0.061		0.060
change number of markets (CNM)				**-0.021 ***	**-0.017**
				0.012	0.013
CNM*time after merger				**0.002**	**0.000**
				0.005	0.005
merger2	**-0.028**	**-0.026**	**-0.023**	**-0.022**	**-0.019**
	0.021	0.022	0.021	0.021	0.022
merger3	**-0.017**	**-0.014**	**-0.019**	**-0.021**	**-0.018**
	0.019	0.020	0.019	0.020	0.020
change fed fundsrate (t;t-1)	**-0.015**	**-0.013**	**-0.014**	**-0.017**	**-0.014**
	0.016	0.015	0.016	0.016	0.015
change fed fundsrate (t-1;t-2)	**0.103 *****	**0.104 *****	**0.103 *****	**0.101 *****	**0.103 *****
	0.013	0.013	0.013	0.013	0.013
change fed fundsrate (t-2;t-3)	**0.059 *****	**0.061 *****	**0.059 *****	**0.056 *****	**0.058 *****
	0.015	0.015	0.015	0.015	0.015
bank size	**-0.096 ****	**-0.087 ****	**-0.105 ****	**-0.114 *****	**-0.103 ****
	0.043	0.043	0.044	0.045	0.044
bank size squared	**0.003 ****	**0.003 ****	**0.003 ****	**0.003 *****	**0.003 ****
	0.001	0.001	0.001	0.001	0.001
deposits to assets	**0.354 *****	**0.350 *****	**0.341 *****	**0.351 *****	**0.338 *****
	0.112	0.112	0.112	0.112	0.113
market share	**0.057**	**0.053**	**0.039**	**0.064**	**0.043**
	0.061	0.061	0.062	0.061	0.062
HHI	**-0.226 ****	**-0.229 ****	**-0.222 ****	**-0.241 *****	**-0.235 *****
	0.091	0.091	0.091	0.091	0.091
income	**0.020**	**0.020**	**0.021**	**0.019**	**0.019**
	0.014	0.014	0.014	0.014	0.014
lambda	**-0.374 *****	**-0.379 *****	**-0.367 *****	**-0.380 *****	**-0.377 *****
	0.034	0.034	0.034	0.034	0.034
constant	**0.949 ****	**0.886 ****	**1.013 *****	**1.111 *****	**1.015 *****
	0.384	0.384	0.390	0.396	0.392
number of observations	41440	41440	41440	41440	41440
censored regression observations	4360	4360	4360	4360	4360
R-squared	0.09	0.09	0.09	0.09	0.09

Note: *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 6: Mergers and money market deposit account rate dynamics: results of the "trigger" model

	(1)	(2)	(3)	(4)	(5)
spline-0.5	**-0.017**	**-0.017**	**-0.017**	**-0.015**	**-0.016**
	0.023	0.023	0.023	0.023	0.023
spline0	**0.032**	**0.031**	**0.032**	**0.031**	**0.033**
	0.021	0.021	0.021	0.021	0.021
spline+0.5	**-0.113 *****	**-0.113 *****	**-0.113 *****	**-0.117 *****	**-0.116 *****
	0.034	0.034	0.034	0.034	0.034
spline+1	**0.108 *****	**0.101 *****	**0.108 *****	**0.105 *****	**0.099 *****
	0.037	0.037	0.037	0.037	0.038
spline+1. 5	**0.022**	**0.023**	**0.022**	**0.018**	**0.021**
	0.029	0.030	0.029	0.029	0.030
spline+2	**-0.102 *****	**-0.102 *****	**-0.101 *****	**-0.105 *****	**-0.105 *****
	0.025	0.028	0.025	0.026	0.029
spline+3	**0.092 *****	**0.087 *****	**0.093 *****	**0.089 ****	**0.086 ****
	0.035	0.033	0.035	0.035	0.033
spline+4	**-0.076 *****	**-0.082 *****	**-0.075 *****	**-0.081 *****	**-0.084 *****
	0.020	0.023	0.020	0.021	0.024
target's size		**0.007**			**0.018**
		0.021			0.024
TS*time after merger		**0.006**			**0.004**
		0.010			0.010
change market share (CMS)			**0.100**		**0.085**
			0.157		0.157
CMS*time after merger			**-0.029**		**-0.029**
			0.047		0.047
change number of markets (CNM)				**-0.011 ***	**-0.015 ***
				0.007	0.008
CNM*time after merger				**0.002**	**0.003**
				0.003	0.003
merger2	**-0.017**	**-0.019**	**-0.018**	**-0.014**	**-0.018**
	0.015	0.015	0.014	0.015	0.015
merger3	**-0.022 ***	**-0.020**	**-0.022 ***	**-0.023 ***	**-0.020**
	0.013	0.013	0.013	0.013	0.013
change fed fundsrate (t;t-1)	**-0.027 ****	**-0.026 ****	**-0.027 ****	**-0.027 ****	**-0.027 ****
	0.012	0.012	0.012	0.012	0.012
change fed fundsrate (t-1;t-2)	**0.080 *****	**0.081 *****	**0.080 *****	**0.080 *****	**0.080 *****
	0.010	0.010	0.010	0.010	0.010
change fed fundsrate (t-2;t-3)	**0.016**	**0.017**	**0.016**	**0.015**	**0.016**
	0.010	0.010	0.010	0.010	0.010
bank size	**0.082 *****	**0.088 *****	**0.084 *****	**0.074 ****	**0.082 *****
	0.028	0.029	0.028	0.029	0.030
bank size squared	**-0.002 *****	**-0.003 *****	**-0.002 *****	**-0.002 ****	**-0.002 *****
	0.001	0.001	0.001	0.001	0.001
deposits to assets	**0.375 *****	**0.375 *****	**0.378 *****	**0.365 *****	**0.370 *****
	0.069	0.069	0.069	0.069	0.070
market share	**0.045**	**0.045**	**0.048**	**0.047**	**0.047**
	0.043	0.043	0.044	0.043	0.044
HHI	**-0.061**	**-0.059**	**-0.060**	**-0.065**	**-0.062**
	0.070	0.070	0.071	0.070	0.071
income	**0.013**	**0.013**	**0.013**	**0.012**	**0.013**
	0.010	0.010	0.010	0.010	0.010
lambda	**-0.221 *****	**-0.218 *****	**-0.221 *****	**-0.223 *****	**-0.220 *****
	0.019	0.019	0.019	0.018	0.019
constant	**-0.717 *****	**-0.774 *****	**-0.738 *****	**-0.653 *****	**-0.727 *****
	0.238	0.246	0.239	0.247	0.249
number of observations	39861	39861	39861	39861	39861
censored regression observations	6893	6893	6893	6893	6893
R-squared	0.07	0.07	0.07	0.07	0.07

Note: *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

Among the merger features we study, only the change in market share (CMS) has both a statistically and an economically significant impact. Substantial in-market mergers have a stronger negative effect on checking account rates in the affected market. This negative effect does, as expected, decrease with time after the merger. This result is consistent with Hannan and Prager's (1998) results, who also document a negative impact of substantial in-market mergers on deposit rates. The effect of target size is statistically insignificant. The effect of the change of the number of markets (CNM) is negative but only marginally significant statistically. These results are interesting in light of the discussion of the importance of out-of-market mergers. Whereas most extant studies have ignored these types of mergers, others (e.g. Park and Pennacchi, forthcoming; Hannan and Prager, 2006) have argued that out-of-market mergers have a substantial negative effect on deposit rates. In this study, when we include all mergers and compare them within a uniform framework, we find that out-of-market mergers have only a negligible negative effect on deposit rates. That is, the main driving force of the negative effect of bank mergers on deposit rates is the in-market rather than the out-of-market dimension of the merger.

The statistically insignificant coefficients of the *merger2* and *merger3* variables indicate that earlier mergers do not have a significant impact on checking account rates. The change of the fed funds rate during the current month also has no significant impact on the change in checking account rates. The change in checking account rates is determined instead by changes in the fed funds rate in the previous two months. These results show that checking account rates adjust to fed fund rate changes with a substantial delay. The coefficients of the change in fed funds rate variables also suggest that the pass-through is incomplete[31].

Bank size enters the checking account rate regressions with negative significant coefficients, indicating that larger banks tend to offer lower deposit rates. This result is consistent with

[31] Gropp et al. (2007) find evidence on incomplete and delayed adjustment of deposit rates offered by European banks.

results of previous studies (Hannan and Prager, 2004; Park and Pennacchi, forthcoming). The ratio of deposits to total assets has a significant positive impact on checking account rates: A bank whose primary source of financing is retail deposits will be more likely to increase its deposit rates. Market share and the average income of the local market's population are not significant, but the local market concentration (measured by the Herfindahl index) enters the regression with the expected negative, significant coefficient.

When we turn from checking account rates to money market deposit account rates, we cannot document a persistent positive or negative impact of mergers. MMDA rates significantly decrease about six months after the merger but recover again about a year after the merger. They drop again about two years after the merger and significantly increase during the third year. In the following years, the effect is negative. Six months after the merger its marginal effect is estimated to drop by 10.7%. The marginal effect of the merger one, three and four years after its completion date are estimated to increase 11.3% and 9.6% and then to decrease 7.3%, respectively. The cumulative effect one year after the merger shows a decrease of 19% with a drop of 2.2% four years after the merger[32]. We interpret this dynamic path of MMDA rate changes as a result of the post-merger integration of the pricing policies of the merging banks. It is unlikely that this pattern is caused by a systematic abuse of market power.

Among the merger features we examine, only the change in the number of markets enters the regression with a statistically significant coefficient. The sign of this coefficient is negative and points to a negative impact of geographical expansion on MMDA rates. *Target's size* and the change in market share have no significant impact on MMDA rates.

A comparison between the checking account and MMDA rate results shows that mergers mainly affect checking account rates. Our interpretation of this result is that because of high switching costs, monopoly rents can more easily be extracted from checking account

[32] Again, we conjecture that the confidence interval for the cumulative effect to be large.

customers. In contrast, MMDAs are an investment product with low switching costs, and MMDA customers can easily switch to a competitor if their current bank offers relatively low MMDA rates.

Moreover, the coefficients of our control variables suggest that local market characteristics are irrelevant for MMDA rates. These results suggest that competition in the MMDA market is not geographically limited to the metropolitan statistical area (MSA). Previous research has already argued that the traditional definition of a local bank market as limited to the MSA may not be valid nowadays, because telecommunication allows customers to access more distantly located banks (Edelstein and Morgan, 2006). Our results show that MMDA rates are indeed generally decoupled from local market conditions. Checking account rates, on the contrary, still strongly depend on local market concentration and on the changes in the distribution of market shares.

Another interesting difference between MMDA and checking account rates is their dependence on bank size. Whereas larger banks tend to keep checking account rates low,[33] they are more likely to increase their money market account rates. It may be that larger banks are associated with more sophisticated customers, who can take advantage of the increased competition offered in larger geographical markets.

6. Conclusion

This research paper is motivated by the contradictory results of previous studies that have examined the impact of mergers on deposit rates. By replicating previous studies with our new, comprehensive deposit rate dataset, we are able to show that empirical results are very sensitive to the treatment of the time span around a merger and the choice of control variables. This observation encourages us to revisit the topic of deposit rate dynamics around bank mergers. For this purpose, we employ deposit rate data with monthly frequency. The high-

[33] This result is consistent with the results of Park and Pennacchi's (forthcoming) study.

frequency data allow a better treatment of the deposit rate dynamics. However, they make an estimation methodology which can account for the rigidity of deposit rates necessary.

When accounting for deposit rate rigidity, we are able to document a significant negative impact of mergers on checking account rates. In particular, in-market mergers, which substantially increase the market share of the merging bank, tend to cause a substantial drop in checking account rates. On the other hand, MMDA rates are not consistently affected after bank mergers. Moreover, once we control for bank size, we cannot document a negative impact of out-of-market mergers on deposit rates. Our results are consistent with results of earlier studies, which find support for the structure-conduct-performance hypothesis (Berger and Hannan, 1989, and Hannan and Prager, 1998). Our findings do, however, contradict Focarelli and Panetta's (2003) results, since we are not able to find any positive long-term effects of the mergers on both types of deposit rates.

A major contribution of our analysis is that we demonstrate the importance of deposit rate dynamics. A more comprehensive analysis of the time series structure of deposit rates and their reaction to reference rate changes is a scheduled extension of this research paper.

References:

Barros, Pita P. (1999): Multimarket competition in Banking, with an example from the Portuguese market, *International Journal of Industrial Organization* Vol. **17:** 335–352

Berger, Allan N. and Timothy H. Hannan (1989): The Price-Concentration Relationship in Banking. *The Review of Economics and Statistics*, Vol. 71: 291-299.

Berger, Allan N. and Timothy H. Hannan (1991): The Rigidity of Prices: Evidence from the Banking Industry. *The American Economic Review*, Vol. 81: 938-945

Berger, Allan N., Saunders, Anthony, Scalise, Joseph M. and Gregory F. Udell (1998): 'The Effects of Bank Mergers and Acquisitions on Small Business Lending. *Journal of Financial Economics,* Vol. 50: 187-229.

Billet, M. T., Jon A. Garfinkel and Edward S. O’Neal (1998): The cost of market versus regulatory discipline in banking. Journal of Financial Economics, Vol. 48: 333 - 358

Caballero, Ricardo J. and Eduardo Engel (2007): Price Stickiness in Ss Models: New Interpretations of Old Results, *mimeo*

Calomiris, Charles W. and Jason Karceski (2000): Is the Bank Merger Wave of the 1990's Efficient? *Mergers and Productivity, ed. by S. N. Kaplan. Chicago: The University of Chicago Press*: 93-161.

Connor, Robert, Feldman, Roger, Dowd, Bryan and Tiffany Radcliff (1997): Which Types of Hopsital Mergers Save Consumers Money? *Health Affairs*, Vol. 16: 62-72

Corvoisier, Sandrine and Reint Gropp (2002): Bank Concentration and Retail Interest Rates. *Journal of Banking and Finance,* Vol. 26: 2155–2189

Craig, Ben and Santos, Joao (1997): Banking Consolidation Effects on Small Business Lending, Federal Reserve Bank of Cleveland, Working Paper.

Edelstein, Paul and Donald P. Morgan (2006): Local or State? Evidence on Bank Market Size Using Branch Prices, *Economic Policy Review*, Vol. 12: 15-25

Edwards, Corwin (1955): Conglomerate Bigness as a Source of Power, *NBER Conference report* “Business Concentration and Price Policy”, Princeton University Press, Princeton

Focarelli, Dario and Fabio Panetta (2003): Are Mergers Beneficial to Consumers? Evidence from the Italian Market for Bank Deposits. *American Economic Review*, Vol. 93 : 1152-1172

Hannan, Timothy H. and Robin A. Prager (1998): Do substantial horizontal mergers generate significant price effects? Evidence from the banking industry. *Journal of Industrial Economics*, Vol. 46: 433-452

Hannan, Timothy H. and Robin A. Prager (2004): The competitive implications of multimarket bank branching, *Journal of Banking and Finance*, Vol. 28: 1889-1914

Hannan, Timothy H. and Robin A. Prager (2006): Multimarket bank pricing: An empirical investigation of deposit interest rates, *Journal of Economics and Business*, Vol. 58(3): 256-272

Heckman, James (1976): The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models, *Annals of Economic and Social Measurement*, Vol. 5: 475-492

Heckman, James (1979): Sample Selection Bias as a Specification Error, *Econometrica*, Vol. 47: 153-161

Huber, Peter (1967): The behavior of Maximum Likelihood Estimates under Nonstandard Conditions, *Proceedings o fthe Fifth Berkeley Symposium on Mathematical Statistics and Probability*, Vol. 1: 221-233

Gropp, Reint Kok Sørensen, Christoffer and Jung-Duk Lichtenberger (2007): The dynamics of bank spreads and financial structure," *ECB Working Paper Series* 714

Kahn, Charles, Pennacchi, George and Ben Sopranzetti. (2005): Bank Consolidation and Consumer Loan Rates, *Journal of Business*, Vol. 78: 99-133

Kim, E. Han and Vijay Singal (1993): Mergers and Market Power: Evidence from the Airline Industry, *American Economic Review*, Vol. 83(3)

Mester, Loretta (1987): Multiple Market Contact between Savings and Loans. *Journal of Money, Credit, and Banking,* Vol. 19: 538-549.

Mester, Loretta and Anthony Saunders (1995): When does the prime rate change. *Journal of Banking and Finance,* Vol. 19: 743–64.

Neumark, David and Steven A. Sharpe (1992): Market Structure and the Nature of Price Rigidities: Evidence from the Market for Consumer Deposits. *Quarterly Journal of Economics*, Vol. 107: 657-680.

Örs, Evren and Tara Rice (2007): Definitional and Statistical Difference in Imputed and Offered Deposit Rates, *mimeo*

Park, Kwangwoo and George Pennacchi (forthcoming): Harming Depositors and Helping Borrowers: The Disparate Impact of Bank Consolidation, *Review of Financial Studies*

Radecki, Lawrence (1998): The Expanding Geographic Reach of Retail Banking Markets, *Economic Policy Review* (Federal Reserve Bank of New York), Vol. 4

Rosen, Richard (2003): Banking Market Conditions and Deposit Interest Rates, *FRB of Chicago Working Paper* 2003-19

Sapienza, Paola (2002): The Effects of Banking Mergers on Loan Contracts. *Journal of Finance*, Vol. 57: 329-368

Sheshinski, Eytan and Yoram, Weiss (1977): Inflation and Costs of Price Adjustment. *Review of Economic Studies*, Vol. 44: 287-303

Stein, Jeremy C. (2002): Information production and capital allocation: Decentralized vs. hierarchical firms, *Journal of Finance*

Wooldridge, Jeffrey (2002): Econometric Analysis of Cross-Section and Panel Data, *MIT Press, Cambridge*