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In this paper I revisit the debate on the impact of bank and market characteristics on the rigidity of retail bank interest rates. Whereas existing research in this area has been exclusively concerned with static measures of bank and market structure, I adopt a dynamic approach which explores the rigidity effects of the changes of bank and market structure generated by bank mergers. I find that bank mergers significantly affect the frequency of changes to deposit rates. In particular, the probability of adjusting deposit rates in response to shocks in money market rates significantly drops after mergers that involve large target banks and after mergers that generate a substantial geographical expansion of bank operations. These effects, however, materialize only after a "transition" period characterized by very frequent changes of the deposit rates.

Key words: bank mergers, bank market structure, interest rate dynamics, hazard rate.

JEL codes: G21, L11.

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1. Introduction

It is a well established fact in the empirical banking literature that bank retail interest rates change only infrequently and react with a substantial delay to monetary policy rate changes. This infrequency of retail interest rate changes has been recognized as an important determinant of the pace of the monetary policy transmission process (Hannan and Berger, 1991). As a result a growing theoretical and in particular empirical literature has focused on the exploration of the determinants of the frequency of bank retail loan and deposit products' repricing.

The theoretical foundation of the analysis of bank retail interest rate rigidity's determinants follows the tradition of adjustment costs theories of price dynamics (Sheshinski and Weiss, 1977, Rotemberg and Saloner, 1987). These theories argue that the decision of a firm to change its price (or a bank to change its retail rates) is driven by the trade-off between the costs of adjusting the price and the costs of deviating from a typically unobservable optimal price. In this framework bank and market structure characteristics, such as bank size, geographical scope, distribution of market shares, can significantly affect the probability of retail interest rate changes since they affect both the adjustment costs and the optimal price. Empirical research supports these theoretical insights by finding a statistically and economically significant impact of variables such as market concentration, bank size, etc. on the probability of changing bank retail interest rates (Hannan and Berger 1991, Mester and Sounders 1995, Craig and Dinger 2010). Existent empirical research, however, has only been focused on a static view of bank and market structure and ignores the information contained in their dynamics.

The static view of bank and market structure involves two substantial risks for the validity of the empirical results. Identification is threatened, on the one hand, by omitted variable biases since a number of bank and market characteristics which possibly affect the frequency of adjusting retail interest rates eventually remain unobservable. On the other hand, the fact that

bank and market structure variables are potentially endogenous with respect to the price dynamics of the banks endangers the consistency of the empirical results.

In this paper I address these shortcomings of existing research and adopt a dynamic perspective of bank and market structure. In particular, I explore the effects of bank mergers as a major source of bank and market structure dynamics on the frequency of changing retail deposit rates. The information contained in bank mergers is especially valuable since it allows the empirical examination of the impact of substantial changes in key bank and market structure characteristics, such as the size of the banks, the number of markets it serves and the change of market concentration in each of the markets. A major advantage of studying mergers in this context is the fact that the exact timing of reasonably exogenous bank and market characteristics' changes[1] is known, so that the identification of the empirical effects of these bank and market characteristics' on bank pricing behavior is feasible after controlling for a transition period around the merger date.

The effect of bank mergers on the frequency of changing retail deposit rates is examined by duration model estimations. In the framework of the duration model approach I estimate the ceteris paribus effects of the time distance from a bank merger as well as of the merger characteristics -such as the change in bank size, the change of the number of markets and the change of market share- on the conditional probability of a bank changing its deposit rates.

I start the analysis by comparing the hazard functions of changing retail deposit rates between banks which have recently undergone a merger and the rest of the sample banks using standard Kaplan-Meier non-parametric hazard function estimates. Next, I proceed to estimating the semi-parametric Cox hazard functions including time dummies measuring the time distance to the latest merger as well as proxies for the bank and market structure changes generated by the merger as covariates along with control measures such as the magnitude and the changes of monetary policy and market interest rates.

[1] Although bank mergers can be endogeneous with respect to market structure, I focus and explore here their exogeneity with respect to the frequency of changing retail bank interest rates.

The estimations employ a comprehensive dataset combining weekly information about retail deposit rates offered by roughly 600 US banks for a period of almost a decade (1997-2006) with data about the corresponding bank and local market characteristics. A complete list of bank mergers in and around this time period is matched to the interest rate data. The resulting sample covers banks with a wide range of variation in size, geographical scope and local market shares and reflects their interest rate setting policy in more than 160 local markets defined as metropolitan statistical areas (MSAs). The focus on deposit rather than loan interest rates is driven not only by the better availability of deposit rate data but also by the fact that deposits are the more homogenous products of the banks less affected by credit risk considerations which cannot convincingly be controlled for.

The results of the estimations show that bank mergers significantly affect the duration of bank retail deposit rates. In the first post-merger year merging banks tend to change their retail deposit rates at a higher frequency than non-merging banks, suggesting that the merger induces a process of transition toward a new retail rate dynamics. During the second post-merger year the frequency of changing retail deposit rates of merging banks does not significantly differ from that of non-merging banks. A systematically higher duration of deposit rates of merged banks becomes statistically significant only after two years following the merger. Among the characteristics of the merger, the frequency of changing deposit rates is particularly affected by the size of the target bank as well as by the change in the number of local markets where the bank operates. The increase in market share is shown to have ambiguous effects depending on the degree of local market concentration.

These results contribute to the literature in several dimensions. First, they confirm in a dynamic context with strengthened identification the impact of bank and market features on deposit rate rigidity found in studies where market structure is viewed in a static way.

Next, the results uncover the importance of mergers for bank deposit rate dynamics. They are related to the literature on the effects of bank mergers on bank interest rate setting behavior

which has so far been exclusively focused the level of retail interest rates (Hannan and Prager, 1998; Focarelli and Panetta, 2003; Craig and Dinger, 2009). The evidence presented here shows that mergers not only affect the long-term interest rate level but are also important for understanding the dynamics of the adjustment towards this level. Observed difference in deposit rates between merging and non-merging banks can, therefore, be explained by both differences in the optimal deposit rate but also in the timing of adjustments towards this long-term optimum. The peculiarities of deposit rate dynamics around bank mergers also underline the risks associated with using only static measures of bank and market structure when analyzing their effect on bank interest rate setting behavior. If such an empirical analysis is applied to periods with substantial empirical importance of bank mergers, the results can be driven by the transition itself rather than be the long-term optimum interest rate setting policy of the banks.

In sum, the evidence presented in this paper suggests, on the one hand, that a substantial change in retail rate dynamics can be expected a few years after bank mergers. On the other hand, this evidence illustrates that the retail rate dynamics directly after the mergers can show a seeming flexibility in the interest rate setting unrelated to the long-term effect of bank and market characteristics. This result concerning the short-term "transition" effects of mergers on the frequency of "price" changes represents a novel contribution to the broader price dynamics literature which has to my knowledge so far ignored the eclectic dynamics of the frequency of price changes around firm mergers.

The rest of the paper is structured as follows. Section 2 presents the data and defines the measures of retail interest rate durations employed in the duration models. Section 3 shows some stylized facts about the effect of mergers on the probability of changing deposit rates and compares the hazard functions of changing retail deposit rates between merging and non-merging banks. Section 4 presents the results of the hazard function estimation, and Section 5 concludes.

2. Data Sources and measurement issues

Data Sources

The empirical estimation presented in the following sections is based upon a unique dataset that combines weekly information on the retail deposit rates offered by 624 U.S. banks in 164 local markets (defined as MSAs) with the full list of bank mergers in the US in the time period 1992-2006. The retail deposit rate data are drawn from *Bankrate Monitor's* reports. They encompass a total of 1738 bank-market groups for the period starting on September 19, 1997, and ending on July 21, 2006. The merger data is drawn from the *Supervisory Master File of Bank Mergers and Acquisitions* and indicates that 121 of the banks for which interest rate information is available have in the examined period been involved in mergers as acquirers. The deposit rates reported show a substantial variation not only across time but also across banks and across local markets. In particular, deposit rates offered by multimarket banks in different local market vary substantially. This variation which has been described in detail in earlier studies (Craig and Dinger, 2009 and Craig and Dinger, 2010) is a signal of banks' reaction to local market competitive conditions. Because of the interest rate variation across markets I use the interest rate observations reported on the bank-market level. By doing so, I employ both the cross-market and cross-bank variation in deposit rate dynamics for the identification of bank and local market characteristics' impact.

As already mentioned in the introduction I focus on deposit rates only. This focus on deposit rates admittedly limits the scope of the analysis by leaving aside loan rate dynamics which plays a key role in the monetary transmission process. It does, however, enables a focus on the price setting behavior of the banks without concerns of customers' credit risk.

Among the broad range of retail deposit rates reported by *Bankrate Monitor* (checking accounts, money market deposit accounts and certificates of deposits with a maturity of three months to up to five years) I concentrate on checking account and money market deposit

account (MMDA) rates, since these are the retail deposit rates with a substantial degree of rigidity for which the duration of the rates is a key determinant of the retail rate dynamics[2].

In addition to the retail deposit rate and merger data, the dataset includes 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. I 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.

Defining spells and durations

The duration analysis presented in the following two sections requires a measure of deposit rate durations. For this purpose I first track for each bank and market the duration of retail interest rates by setting the definitions of the individual quote lines and deposit rate spells. I define the quote-line$_{i,j,p}$ as the set of deposit rates offered by bank *i* in local market *j* for deposit product *p*. The deposit rate spell is defined as a subsection of the quote line for which the deposit rate goes unchanged. The definition of the deposit rate spells assumes that if the same interest rate is reported in two consecutive weeks, it has not changed between observations. I define the number of weeks for which the interest rate goes unchanged as the duration of the interest rate spell.

To avoid left censoring I include only spells for which the exact starting date (the week for which this particular rate was offered for the first time) can be identified. That is, for each bank-market I exclude all observations before the rate changes for the first time. A spell ends with either a change of the interest rate or with an exit of the bank-market unit from the observed sample. In the latter case the issue of right censoring arises. To deal with this issue I only include spells for which the end date is identifiable. *Bank Rate Monitor* reports rates offered by smaller banks only if the quoted rate deviates from the rate quoted in the preceding week. To control for this I assume that an interest rate spell "survives" through the weeks

[2] See Table 1 and Table 2 for illustrations of checking and MMDA rate (relative) rigidities.

until the next observation is reported (if the next reported rate is in week *t*, I assume the rate has "survived" until week *t*-1). However, a few instances are present in our sample in which the bank-market unit exits the sample for a longer period (up two a few years) and re-enters the sample again. In this case, the assumption that observations are missing only because no change in the interest rate is observed is too strong. I control for this by treating an unreported rate as an unchanged rate only if the period of missing observations is less than 52 weeks[3,4].

Table 1: Number of spells and number of time changes reversed within four weeks

Product	total number of spells	total number of uncensored spells	number of "sales" with one week duration	number of "sales" with 2 weeks duration	number of "sales" with 3 weeks duration	number of "sales" with 4 weeks duration
deposits						
cheching account	8084	5714	628	149	107	70
MMDA	14433	11814	1600	240	257	103

Source: Own calculations based on BankRate Monitor data

An important measurement issue is the treatment of temporary deposit rate changes (the equivalent of sales in the price rigidity literature). Since temporary changes are an important component of a bank's deposit rate setting policy I consider a temporary deposit rate change as a "failure" of the spell. As illustrated in Table 1, which presents summary information on the number of spells defined with the procedure described above as well as information on the number of temporary changes with different durations, temporary deposit rate changes are common. However, the number of temporary deposit rate changes reversed within only one week is substantially larger than the number of temporary changes with a longer duration suggesting that a substantial portion of the one week "temporary changes" are might not reflect changes of the deposit rate but rather misreporting. Since I cannot disentangle potential reporting errors from temporary deposit rate changes, the estimations presented in the next

[3]I did a few robustness checks here. For example, for the checking account rates our approach identifies 204 spells for which the rate was not observed for a few weeks but reappeared with a changed value within 52 weeks. If I account only for rates that reappear within 26 weeks, I identify 191 spells. If I impose no cut-off point with regard to the number of weeks a price was not observed, the result is a total of 311 spells.

[4]The spell definition procedure here is similar to the one presented in Craig and Dinger (2010).

two sections are based on a definition of a spell failure that ignores temporary changes with one week duration. I have rerun all estimations alternatively using the full sample of spell failures as well as samples ignoring temporary changes with durations of two or four weeks. Results stay qualitatively unchanged.

Table 2 illustrates the summary statistics regarding the duration of the deposit interest rates in the sample when I consider a spell end only if the change is sustained for more than a week. It shows how the duration of the rates that I focus on (checking account and MMDA rates) is with average durations of almost 18, respectively almost 13 weeks, substantially longer than the rates on alternative deposit products – such as the CDs - which have been previously been shown to follow more competitive pricing outcomes (Hannan and Berger, 1998).

Table 2: Average duration of interest rate spells and average change of the rate

Product	average duration (in weeks)	average change (in %)	average rate	average change relative to average rate
deposits				
cheching account	17.71	0.16	0.53	0.30
MMDA	12.76	0.26	1.07	0.24
CD 3 months	7.87	0.33	2.33	0.14
CD 12 months	6.08	0.35	2.96	0.12

Source: Own computations based on BankRate Monitor data. Average change (in %) presents the average absolute value of the deposit change in weeks where the change is non-zero. Average rate is the average deposit rate throughout the sample and average change relative to average rate is the ratio of the absolute value of the average change to the average rate.

The lumpiness of deposit rate adjustments is illustrated in Table 2 not only by the low frequency of deposit rate changes but also by the large magnitude of the observed retail deposit rate changes. The second column of this table illustrates that the absolute value of the change in the checking account rate in the occasions when a nonzero change is observed is 0.16%, which is quite substantial given the average magnitude of checking account rates of

only 0.53%. This observation implies that once a bank decides to adjust a retail deposit rate the adjustment is substantial. Given the degree of lumpiness in the retail interest rate adjustment process the examination of the interest rate duration and its determinants is of key importance for understanding interest rate dynamics.

3. Bank mergers and the probability of changing bank retail interest rates

I start the empirical examination of the effect of bank mergers on deposit rate rigidity by exploring the difference in the duration of deposit rate spells between banks which have recently accomplished a merger and banks which have not. For this purpose I compare the Kaplan-Meier estimations of the hazard function of changing the deposit rate for the subsamples of banks which have undergone a recent merger to those of banks which have not recently been merging.

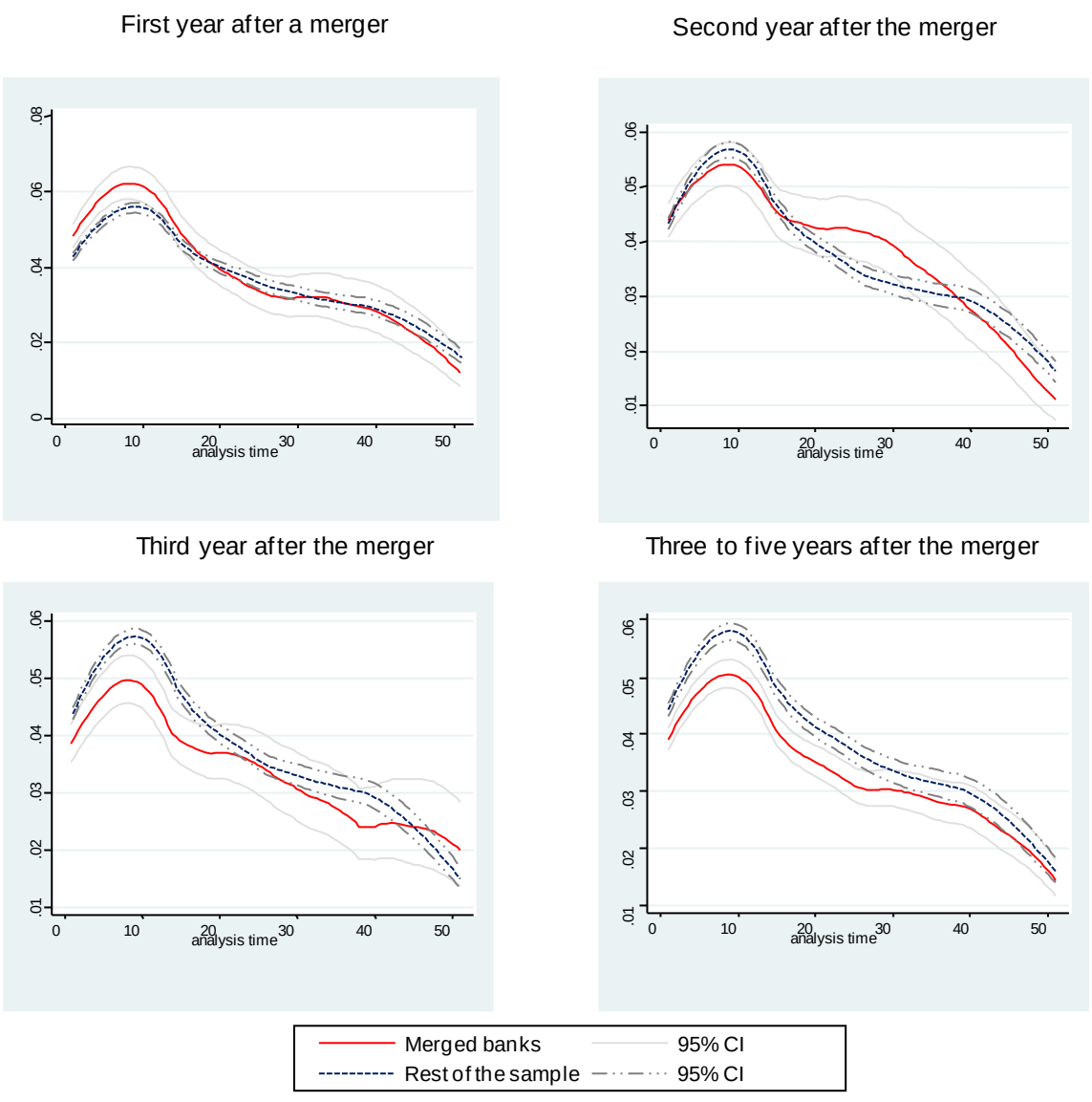
In particular, I compare the hazard of changing the retail deposit rates (checking account and MMDA rates) between merging and non-merging banks in the first, second and the third year following a merger as well as at the longer time horizon of three to five years after the merger. This is done by the introduction of time dummies reflecting the time to the latest merger of the bank[5]. These time dummies are constructed as follows. First, merger date is defined as the date on which the charter of the target bank was withdrawn[6]. Next, the time distance to the merger date is computed for each of the observations. Then the dummy variable *merger 1 year* is generated that takes the value of one if the bank has undergone a merger in the last 12 months and zero otherwise. Similarly, the dummy variables *merger 2 years* and *merger 3 years* are generated taking the value of one if the bank has undergone a merger in the last 13

[5] The focus on the latest merger substantially reduces the number of mergers that are explored. The limitation is imposed in order to avoid the noise of overlapping time periods affecting the tightness of the estimated coefficients. As a robustness check I have rerun the estimations using up to three earlier mergers in the analysis. Results stay qualitatively the same.

[6] This definition of the merger data is standard in the literature (see Hannan and Prager 1998; Focarelli and Panetta 2003). In the next section I control for potential effects occurring prior to the official merger date by including a pre-merger proxy.

to 24 months and in the last 25 to 36 months, respectively. And finally, a dummy *merger 3 to 5 years* which takes the value of 1 if the bank has undergone a merger 36 to 60 month prior to the observation time and 0, otherwise is introduced to summarize the longer term effects of the merger. The results of the estimated hazard functions are presented in Figure 1 and Figure 2 for the checking account and the MMDA rates, respectively.

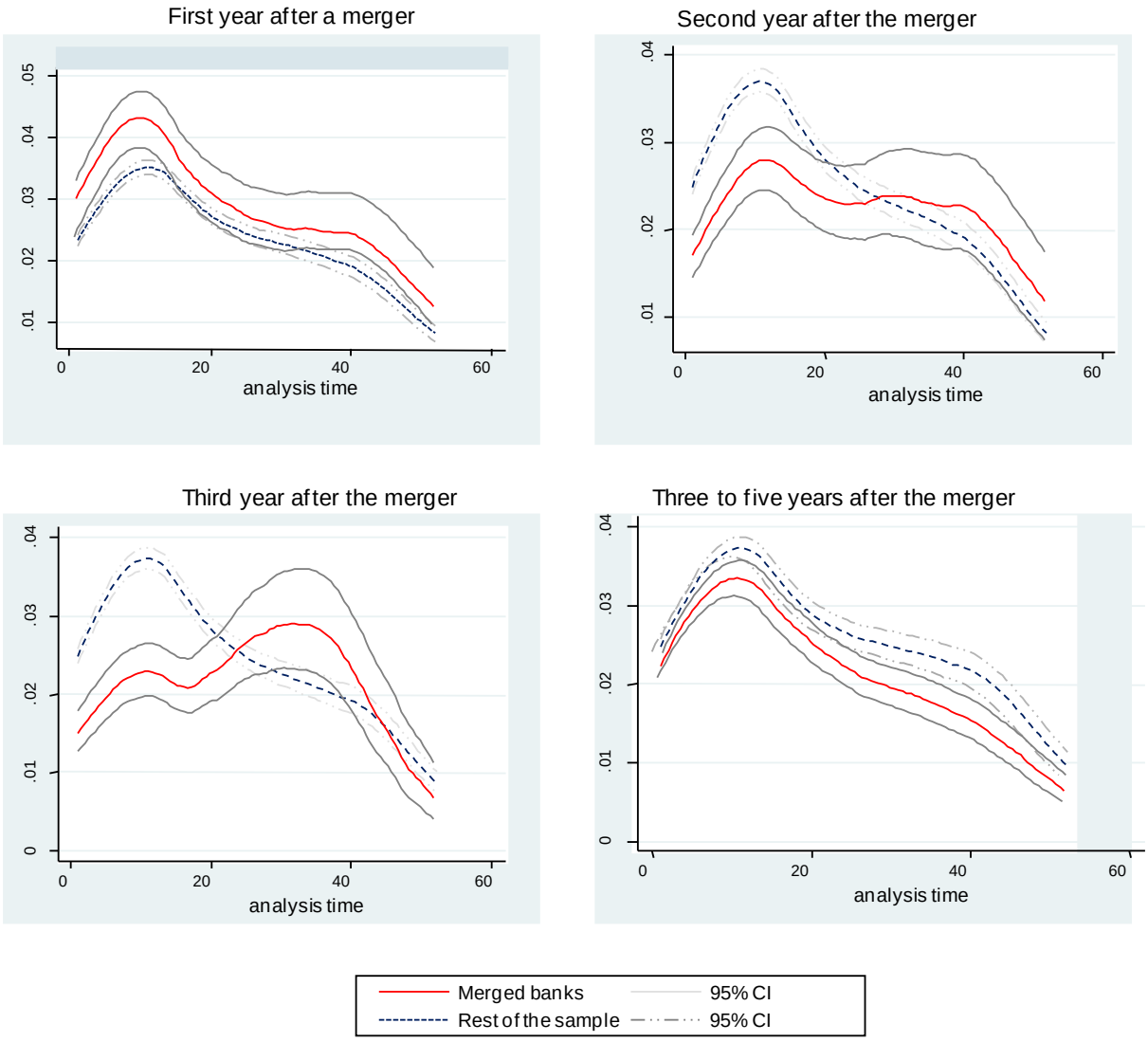
Figure 1: Smoothed hazard Kaplan-Meier estimates of checking account rate duration, analysis time in weeks



The comparison of the estimated hazard function presented in these two figures points to two effects present for both the checking account and the MMDA rates. On the one hand, the probability of changing the retail deposit rates is higher for the banks which have undergone a

merger in the last 12 months than for banks which have not merged or have merged a longer time period ago. This evidence is consistent with the existence of a transition period when the two merging institutions explore new deposit rate setting policies taking into account the potential changes in the pool of depositors. On the other hand, starting from the third year after the merger, the hazard of changing both the checking account and the MMDA rates significantly drops below the deposit rate changing hazards for banks which have not recently merged.

Figure 2: Smoothed hazard Kaplan-Meier estimates of MMDA rate duration, analysis time in weeks



This second observation is consistent with the argument presented in static studies that bank market consolidation – as measured by increased size and market power of a few banks - enhances deposit rate rigidity (Hannan and Berger, 1991; Craig and Dinger, 2010). The hazard functions estimates presented in this section, however, underline that this effect is not materialized immediately but rather only after a substantial period of frequent deposit rate changes in the first year and a period – approximately coinciding with the second post-merger year when deposit rate duration of merging banks does not differ significantly from that of non-merging banks (see the second panels of both charts).

The observed relation between the time from the latest merger and the modified probability to change deposit rates could spuriously emerge if most of the mergers take place in (or shortly before) years with very volatile market interest rates. In the regressions presented in the next section I explicitly address the effect of market interest rate changes on the frequency of retail deposit rate changes. The existence of this spurious effect could non-technically be challenged at this point by the observation that most of the mergers in our sample happened in 2003 and 2004- both years with very infrequent fed funds target rate changes and relatively tranquil T-Bill rate dynamics.

Note that the fact that merging banks re-set their deposit interest rates more often during the first years after the merger does not necessary imply that deposit rates in this transition period are set more competitively. More frequent retail rate changes could actually emerge from the behavior of a merging bank that is testing the "limit" of its new pricing horizon. Indeed, existing studies (Hannan and Prager, 1998 and Craig and Dinger, 2009[7]) show that deposit rates of merging banks drop almost immediately after the merger.

To shed more light on this issue I examine the direction of deposit rate changes in the first year after a merger. In the case of checking account rates I observe a total of 609 checking

[7] This study is based on the same dataset as the one explored here.

account rate changes in bank-market observations of banks which have been involved in a merger within less than a year. 182 of these changes are positive while 427 are negative. Out of the 427 negative changes only 23 correspond to situations where the trend in the general interest rate level (as measured by T-Bill rate changes) has been negative. In the case of MMDA rates a total of 1269 changes are observed in bank-market observations of banks which have been involved in a merger within less than a year. 540 of these are positive and 729 are negative changes. Out of the 729 negative changes only 106 correspond to situations of a negative general interest rate level trend[8]. These observations underline the complexity of deposit rate dynamics and shed light on the limits of exploring the effect of bank and market structure characteristics in a static framework.

4. Bank mergers, bank and market structure changes and the hazard of changing the retail interest rates

The Kaplan-Meier non-parametric estimates of the hazard function presented in Section 3 indicate a significant effect of mergers on the frequency of changing bank retail interest rates. The simple univariate Kaplan-Meier framework although suitable for illustrating the basic relations between bank mergers and deposit rate rigidity is unapt for the identification of the channels and determinants of a merger's impact on retail interest rate rigidity. In this section I extend the analysis and focus on the impact of various dimensions of bank mergers on the frequency of adjusting bank retail interest rates. For this purpose I estimate a proportional Cox hazard model of the general form:

$$h(t|x_{ijt}) = h_0(t)\exp(x_{ijt}\beta_x),$$

where $h_0(t)$ denotes the baseline hazard, x_j is the vector of covariates and β_x are the regression coefficients to be estimated from the data. A major advantage of the Cox model is

[8] A thorough empirical evidence on the impact of mergers on the levels of retail deposit rates is presented in Hannan and Berger (1998), Focarrelli and Panetta (2003) and Craig and Dinger (2009).

that it requires no parameterization of the baseline hazard function. The model solely assumes that the value of the covariates ceteris paribus proportionally shifts the baseline hazard. Since the units of observation are retail rates at the bank-market level and some degree of coordination of deposit rate setting decisions on the bank level is possible, the standard Cox model may produce biased results due to the omission of the unobserved common component across the observations in different market of the same bank. To this end, I estimate the model with a shared frailty option which controls for the existence of a random firm specific effect[9].

The Cox proportional hazard framework allows me to reexamine the effect of bank mergers in different time periods around the merger date documented in Section 3 while controlling for potentially relevant determinants of retail rate dynamics such as general market interest rate dynamics and bank and local market characteristics. Also, this framework enables the identification of the merger characteristics which most substantially affect the re-pricing frequency of retail deposits.

The choice of variables included in the vector of covariates x_{ijt} builds upon the empirical model presented by Craig and Dinger (2010) which examines the role of wholesale rate dynamics and static measures of bank and market characteristics. As in Craig and Dinger (2010) I examine the frequency of changing retail deposit rates in the framework of adjustment costs theories of price/interest rate dynamics (Sheshinsky and Weiss 1977; Hannan and Berger 1991). These theories relate the decision to change a price (or a retail interest rate) to the trade-off between the costs of deviation from an unobservable optimal price level and the costs of adjusting the price to this optimal level (see Klenow and Malin 2010 for a comprehensive review of this literature). I approximate the deviation from the optimal retail deposit rate by the cumulated change in the market interest rate between the observation time *t* and the time of the latest change of the retail deposit rate. This

[9] The incidental parameter problem makes the use of fixed effects implausible in this framework.

approximation is based on the intuition that the unobservable optimal retail rate is a function of the market interest rate. I measure the market interest rate by the 3-month T-bill rate. To account for the potential asymmetry of interest rate adjustments (which have been documented by Hannan and Berger, 1991; Neumann and Sharpe, Craig and Dinger, 2010), I also a include a dummy for a positive T-Bill rate change and the interaction of this dummy with the absolute value of the cumulated T-Bill rate change as a covariate. Since from a monetary policy perspective there are might be interest in the effect of the adjustment speed to changes in the monetary policy rather than in the market rate I have rerun the estimations using the average effective fed funds rate as a marginal costs proxy instead of the T-Bill rate[10]. The results of these estimations are qualitatively the same as the one using T-Bill rates and have not been reported in the text for the sake of parsimonious exposition.

In the absence of perfect competition the reaction of the optimal deposit rate to changes in the market interest rates is modified by bank and market characteristics which indicate the market power of the bank. In particular, I include the *bank size* as measured by the natural logarithm of the bank's total assets; the *market share* of the bank in the respective market computed as the ratio of the bank's deposits in the total sum of deposits in the MSA; the *number of markets* given by an integer reflecting the number of local MSAs represented in our sample where the bank has a branch; and the *Herfindahl-Hirshman Index* of the MSA which controls for the general market concentration level of the local market.

The descriptive statistics of the bank, local market and merger characteristics in the sample, presented in Table 3, illustrate large variation in the characteristics of the sample banks. So for example the sample includes banks with a total asset value of less than a billion to more than a trillion USD. The average market share of the sample banks in the sample MSAs is

[10] Following Craig and Dinger (2010) I also run robustness checks including proxies for the market interest rate expectations as well as for the volatility of the market/monetary policy rates. Results are available from the author upon request and are qualitatively the same.

14% and the average herfindahl index value is 0.16, although again large variation across banks and markets is observed.

Table 3: Descriptive statistics of bank and market characteristics

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
bank size (bill USD)	140242	148	237	0	1100
market share	140242	0.143	0.104	0.000	0.872
herfindahl	140242	0.161	0.071	0.051	0.773
number of markets	140242	25.365	26.200	1.000	110.000

Source: Own calculations

I extend this static market structure view by controlling for the effect of mergers on the banks' probability to change retail deposit rates. In particular, I focus on the key dimensions of the mergers which reflect the changes in bank and market characteristics caused by the merger and therefore, potentially affect the frequency of changing retail deposit rates by modifying either the optimal deposit rate or the costs of adjusting to this optimal rate.

To start with, a bank merger changes the size of the bank. To this end, I include the change of bank size as measured by the natural logarithm of the target bank's total assets (*target_size*) as a covariate. The change in bank size generated by the merger can affect the frequency of changing bank retail interest rates by affecting both the adjustment costs and the costs of deviating from the optimal rate. If interest rate adjustment costs have a fixed component independent of the volume of deposits (such as costs of reviewing competitors price, management costs of taking the re-pricing decision) then an increase in the size of the bank may reduce the relative weight of adjustment costs in the decision to re-price a retail deposit product and result in more frequent adjustments. On the other hand, the growing size of the bank may inhibit frequent re-pricing because of the challenges of coordinating the re-pricing decisions both across branches and across deposit products. Also, as pointed out by Park and Pennacchi (2008), larger banks have access to more diversified sources of financing. For these banks retail deposits may represent only a minor share of a bank's liabilities. If this is

the case, large banks could avoid the costs of adjusting retail liabilities simply because these are of minor importance for their funding costs. Therefore, the incentives to adjust deposit rates to competitors' benchmarks can depreciate, when a merger generates a substantial growth in the bank's balance sheet.

Next, bank mergers change the market share of the bank in those local markets where both the merging and the target bank operated prior to the merger. Market shares affect the opportunity of banks to extract market power and therefore determine the magnitude of the competitive pressure to adjust to shocks in the money market rates (Hannan and Berger, 1991). To this end I include the change in market share generated by the merger as a covariate. I do not have data on the change of market share directly related to the merger for each of the affected local markets, but I can approximate this change with the change of market share realized in the year of the merger. That is, I 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[11] normalized by the pre-merger year's market share (CMS).

Also, most modern bank mergers change the number of markets in which the bank operates. As suggested by the linked-oligopoly hypothesis (Bernheim and Whinston, 1990), the number of markets in which a bank is active might also significantly affect its pricing behavior, since banks which create competitive pressure in one of the markets by quickly adjusting interest rates might fear competitor's response in numerous other markets where adjustment is not desirable. Also the raise in number of markets increases the coordination efforts across different geographical divisions of the bank. In order to estimate the effect of the market-extension dimension of the mergers I 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, I

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

approximate the CNM with the ratio of the number of markets in which a bank operates in the years before and after the merger.

The target size as well as the change in market share and the change in the number of markets summarize the three main dimensions of bank and market structure dynamics. Table 4 which presents the summary statistics of the key merger features illustrates how modern bank mergers substantially vary in their nature[12,13]. This variation strengthens the identification of the dynamic empirical approach presented here and allows me to empirically disentangle the effect of the various dimensions of bank and market structure changes on deposit rate rigidity.

Table 4: Descriptive statistics of merger characteristics

Merger chracteristics	Number of mergers	Mean	Standard deviation	Minimum	Maximum
target size (bill USD)	121	111	148	0	655
change market share	121	0.001	0.032	0.000	0.177
change number of market	121	0.343	0.635	-0.250	5.000

Source: Own calculations

I control for the peculiarities of retail deposit rate directly around the merger illustrated in the previous section by adding to the covariates a vector of time dummies related to the time elapsed to/from the most recent merger[14]. This vector contains the dummy variables for the first and the second year after the merger as well as a dummy for the period of three to five years after the merger as introduced in Section 3[15]. It also includes a pre-merger dummy

[12] Earlier research typically examines merger effect separately for in-market and out-of-market mergers. Since mergers observed in the last two decades often combine the characteristics of both in- and out-of market mergers I restrain from the separate analysis of these two merger groups but rather examine their effect in a joint framework where the effect of the different merger dimensions is separately controlled for.

[13] The average change in the post-merger market share is relatively low, suggesting that for a large portion of the mergers the out-of-market dimension dominates. This suggestion is confirmed by the relatively large average post-merger change in the number of markets operated by the merging bank.

[14] I have explored the effect of the third and second to the latest merger as well. The results which are available from the author upon request point to a mostly insignificant effects of these mergers.

[15] As a robustness checks I have rerun the estimations using linear splines for the time distance to the latest mergers. Results are qualitatively the same.

taking the value of 1 if the bank is merging with another bank in the following year and 0 otherwise[16].

Empirical results

The results of Cox proportional hazard estimations are presented in Table 5 and Table 6 for the checking account and the MMDA rates, respectively. The estimations are based on the full sample of observations and thus explore the full range of variation of bank and market characteristics.

The estimated coefficients of the time dummies confirm the pattern of retail rate rigidity dynamics around the merger date documented in Section 3. After controlling for market interest rate dynamics and various merger, bank and market characteristics I still find that the frequency of changing both the checking account rate and the MMDA is significantly affected by bank mergers. In sum, the time pattern suggested by the coefficients of the merger dummies in the checking account rate regressions implies that, following a period of less flexibility directly before the merger date, shortly – up to one year- after a merger the acquiring bank is revising its retail deposit rates more frequently than banks which have not recently experienced a merger. The frequency of changing retail rates in the second year after a merger is not systematically different from that of non-merging banks. Starting from the third post-merger year banks tend to change their retail rates less frequently. In the case of checking account rate the only statistically significant result with respect to the time to merger dummies points to a long-term rigidity increasing effect of bank mergers.

Turning to the estimated impact of the various features of the merger I find that both target size and the number of new local markets added through the merger significantly reduce the

[16] This is to reflect the fact that the merger date reported in the data, which is the date when the charter of the target bank is revoked is usually preceded by a period of merger preparations that might be reflected in the interest rate setting policy of the bank.

ceteris paribus frequency of changing the retail deposit rates. The economic impact shown by the estimated coefficients is quite substantial.

Table 5: Checking account rate duration: Cox proportional hazard estimates

	without merger controls		with merger controls	
	Hazard ratio	standard error	**Hazard ratio**	standard error
premerger	**0.885**	0.069	**0.803** ***	0.064
merger 1 year	**1.132** ***	0.053	**0.999**	0.051
merger 2 years	**0.987**	0.055	**0.852** ***	0.051
merger 3 and more years	**0.954**	0.035	**0.756** ***	0.043
target_size			**0.876** ***	0.029
change in market share			**0.921**	0.404
change in number of markets			**0.861** ***	0.027
absolute change wholesale rate	**0.814** *	0.094	**0.986**	0.131
dummy for negative change	**1.580** ***	0.059	**1.573** ***	0.065
negative change*absolute change	**1.702** ***	0.096	**1.708** ***	0.106
bank size	**1.075** ***	0.013	**1.211** ***	0.044
market share	**0.723** **	0.111	**0.758** *	0.124
herfindahl	**1.214**	0.260	**1.286**	0.295
number of markets	**0.988** ***	0.001	**0.989** ***	0.001
# spells	**6483**		**5388**	
# Failures	**4581**		**3818**	
LR Chi(2)	**897.49**		**888.86**	

Note: Semi-parametric Cox proportional hazard estimates. Hazard ratios higher than unity suggest an increased hazard of changing the retail rate. Hazard ratios lower than unity indicate a lower probability of changing the retail rate and thus more rigid retail rates.

One standard deviation of target size (equal in natural log terms to 1.9 and in levels to USD 82 bill) reduces the probability of changing the checking account rates by roughly 24.13% and of changing the MMDA rate by 15.2% per week. One standard deviation of the change in number of markets (equal to 0.51) corresponds to about 6% lower probability of changing the checking account rate rates. The corresponding probability of changing the MMDA rate in each of the weeks is reduced by slightly more than 3%.

The effect of the change in market share is, however, statistically insignificant. The interpretation of this result at face value would imply that market shares do not substantially affect the rigidity of retail deposit rates. However, the lack of statistical significance could as

well be explained by the heterogeneity in our sample. In particular the relative change in the market share might have different effect on interest rate duration depending on the concentration of the markets where the merging banks operate – which on aggregate cancel out. I will address this issue in the next subsection.

Table 6: MMDA rate duration: Cox proportional hazard estimates

	without merger controls		with merger controls	
	Hazard ratio	standard error	**Hazard ratio**	standard error
premerger	**0.935**	0.047	**0.941**	0.048
merger 1 year	**1.027**	0.032	**1.010**	0.034
merger 2 years	**1.056**	0.036	**1.027**	0.037
merger 3 and more years	**1.005**	0.026	**0.912** **	0.035
target_size			**0.916** ***	0.020
change in market share			**0.642**	0.198
change in number of markets			**0.911** ***	0.019
absolute change wholesale rate	**1.887** ***	0.186	**1.729** ***	0.185
dummy for negative change	**1.489** ***	0.039	**1.491** ***	0.043
negative change*absolute change	**1.223** ***	0.057	**1.268** ***	0.064
bank size	**1.061** ***	0.009	**1.156** ***	0.028
market share	**0.786** ***	0.080	**0.659** ***	0.073
herfindahl	**1.017**	0.147	**1.001**	0.159
number of markets	**0.992** ***	0.001	**0.993** ***	0.001
# spells	**12690**		**10375**	
# Failures	**10579**		**8648**	
LR Chi(2)	**1050.82**		**928.76**	

Note: Semi-parametric Cox proportional hazard estimates. Hazard ratios higher than unity suggest an increased hazard of changing the retail rate. Hazard ratios lower than unity indicate a lower probability of changing the retail rate and thus more rigid retail rates.

Another potential explanation for the statistical insignificance of the CMS coefficient is the fact that as illustrated in Table 4 the variation of the CMS variable is much smaller than the variation in the other two variables describing the merger.

Nevertheless, the fact that the change in bank size and the change in number of markets significantly reduce the frequency of changing deposit rates while the effect of the change in market share is statistically insignificant points to the complexity of the repricing decision and

the magnitude of adjustment costs rather than to the increased market power as the main drivers of deposit rate rigidity changes in response to the merger.

Turning to the control variables, the estimated effect of the market interest rate changes is consistent with the results of earlier studies which find an asymmetric adjustment pattern (Hannan and Berger, 1991; Craig and Dinger, 2010). Also, I find that bank size affects the probability of changing deposit rates positively, but this is a ceteris paribus result that should be interpreted jointly with the negative effect of bank market share and the number of markets. Quite surprisingly market concentration - as measured by the HHI – which have been found by earlier research (Hannan and Berger, 1991) to substantially affect the probability of changing deposit - rates enters alls Cox regressions with statistically insignificant coefficients.

Subsamples of highly and less concentrated markets

As illustrated in Table 3 local banking markets observed in the sample exhibit substantial heterogeneity with regard to their concentration. It is likely that the effect of bank mergers on rigidity can differ substantially in markets with different concentration levels and more importantly that the effect of market concentration is not non-linear. In particular the effect of increased bank size or market share could differ substantially depending on the general level of local market contestability To address these issues I present a next set of regressions, where the sample of bank-market observations is divided in two subsamples (highly concentrated and less concentrated local markets) depending on the Herfindahl-Hirschman index of the local market. As a cut-off point of the Herfindahl-Hirschman index I use the critical value of market concentration used by the U.S. Department of Justice in the evaluation of bank mergers equal to 0.18. The results of these estimations are reported in Table 7 and Table 8 for the checking account and the MMDA rates, respectively.

The results of the re-estimated model indeed point to some substantial differences in the effect of mergers in highly and less concentrated deposit markets. In particular, in less concentrated markets the rigidity enhancing effect of bank mergers materializes immediately after the merger. The transition period with higher deposit rate flexibility during the first year of the merger seems to characterize mostly the interest rate setting behavior of banks in highly concentrated markets. Also the effect of target size on rigidity substantially differs across the two subsamples. While target size does not have any significant impact on deposit rate rigidity in highly concentrated markets, it substantially enhances the rigidity of deposit rates in less concentrated markets. This difference in the effect of target size could arise from the fact that in highly concentrated markets bank size is more likely to be substantial.

Table 7: Checking account rate duration: Cox proportional hazard estimates for subsamples of high and less concentrated local banking markets

	highly concentrated markets			**less concentrated markets**		
	Hazard ratio		standard error	**Hazard ratio**		standard error
premerger	**1.071**		0.148	**0.707**	***	0.069
merger 1 year	**1.355**	***	0.122	**0.881**	**	0.055
merger 2 years	**1.107**		0.120	**0.768**	***	0.056
merger 3 and more years	**0.956**		0.100	**0.687**	***	0.048
target_size	**0.950**		0.066	**0.855**	***	0.032
change in market share	**0.283**	*	0.181	**2.194**	*	1.280
change in number of markets	**0.852**	***	0.052	**0.853**	***	0.032
absolute change wholesale rate	**1.234**		0.306	**0.938**		0.150
dummy for negative change	**1.575**	***	0.120	**1.569**	***	0.077
negative change*absolute change	**1.559**	***	0.174	**1.749**	***	0.132
bank size	**1.152**	*	0.088	**1.226**	***	0.051
market share	**0.725**		0.157	**0.725**		0.182
number of markets	**0.989**	***	0.003	**0.990**	***	0.002
# spells	**1648**			**3939**		
# Failures	**1120**			**2698**		
LR Chi(2)	**243.93**			**670.27**		

Note: Semi-parametric Cox proportional hazard estimates. Hazard ratios higher than unity suggest an increased hazard of changing the retail rate. Hazard ratios lower than unity indicate a lower probability of changing the retail rate and thus more rigid retail rates. Markets with high concentration are those with a Herfindahl-Hirshman index higher than 0.18, all other markets are considered less concentrated.

Another substantial difference is observed in the estimated effect of the change in market share[17]. In the case of checking account rate duration, the estimated effect of the change in market share is of opposite directions in high and less concentrated markets. While the change in market share increases the frequency of resetting checking account rates in less concentrated market, it decreases this frequency substantially in highly concentrated markets. These empirical observations could be explained by the fact that delayed changes to market interest rate development could only be sustained in a highly concentrated market where customers cannot easily switch to competitors.

Table 8: MMDA rate duration: Cox proportional hazard estimates for subsamples of high and less concentrated local banking markets

	highly concentrated markets		**less concentrated markets**	
	Hazard ratio	standard error	**Hazard ratio**	standard error
premerger	**1.046**	0.096	**0.895** *	0.055
merger 1 year	**1.115** *	0.069	**0.972**	0.039
merger 2 years	**1.153** **	0.080	**0.991**	0.042
merger 3 and more years	**0.979**	0.069	**0.875** ***	0.040
target_size	**0.951**	0.041	**0.902** ***	0.023
change in market share	**0.480**	0.224	**0.748**	0.308
change in number of markets	**0.860** ***	0.037	**0.926** ***	0.022
absolute change wholesale rate	**1.727** ***	0.360	**1.981** ***	0.259
dummy for negative change	**1.528** ***	0.084	**1.477** ***	0.050
negative change*absolute change	**1.179** *	0.114	**1.275** ***	0.077
bank size	**1.095** *	0.053	**1.179** ***	0.033
market share	**0.596** ***	0.093	**0.763** *	0.123
number of markets	**0.994** ***	0.002	**0.992** ***	0.001
# spells	**2981**		**7623**	
# Failures	**2402**		**6246**	
LR Chi(2)	**250.04**		**714.27**	

Note: Semi-parametric Cox proportional hazard estimates. Hazard ratios higher than unity suggest an increased hazard of changing the retail rate. Hazard ratios lower than unity indicate a lower probability of changing the retail rate and thus more rigid retail rates. Markets with high concentration are those with a Herfindahl-Hirshman index higher than 0.18, all other markets are considered less concentrated.

In the case of MMDA rate durations the change in market share does not significantly affect the hazard of changing the rate in neither of the two subsamples. This result corresponds to

[17] A Wald test formally proves that the difference in the estimated coefficients of "target size" and „change of market share" variable in the two subsamples is statistically significant.

the findings of earlier studies (Hannan and Prager 2006; Craig and Dinger 2009) which show that the level of MMDA rates hardly reacts to local market power conditions. This phenomenon is typically explained by the fact that local customer proximity is less important in the case of MMDA products than in the case of checking accounts.

In sum, these results illustrate how the effects of bank mergers on interest rate rigidity differ across markets with different concentration levels. They also suggest that the rigidity impact of market characteristics is potentially non-linear and interrelated to premerger market features.

5. Conclusion

It has long been known that bank market structure affects the rigidity of bank interest rates (Hannan and Berger, 1991). In this paper I examine the dynamics of this effect and show that changes in bank and market structure characteristics generated by bank mergers substantially affect the retail rate dynamics of merging banks. In particular, the empirical examination is concentrated on the effect of changes in key bank characteristics (such as banks size, market share and number of geographical markets) generated by the merger on the probability to adjust retail deposit rates. The analysis is based on a unique dataset reflecting deposit rate dynamics with a weekly frequency. The high frequency of the data allows me to explore the retail rate dynamics and its determinants using duration analysis.

The results of the duration analysis imply a significant impact of bank mergers on the probability of a bank to change the retail deposit rates it offers. In detail, I find that for a period of roughly one year after the merger merging banks change deposit rates relatively often. Only after about two years after the merger, the duration of retail rates offered by merging banks becomes significantly longer than the duration of deposit rates offered by non-merging banks. This effect is particularly strong for banks which have through the merger

substantially expanded their size and the geographical scope of their operations. The change in market share inhibits retail rate flexibility mostly in highly concentrated local markets.

This evidence strengthens the validity of previous results of the literature on retail interest rate dynamics by presenting evidence based a dynamically identified estimation. It also sheds some new light on the discussion of the effects of the recent (post financial-crisis) wave of bank market consolidation on interest rate dynamics by suggesting that the speed of adjustment to monetary policy changes might be affected substantially by the mergers especially in those markets where market concentration was already high prior to the merger.

Literature:

Arbatskaya, M. and M. Baye (2004): Are prices 'sticky' online? Market structure effects and asymmetric responses to cost shocks in online mortgage markets, *International Journal of Industrial Organization*, Vol. 22 (10): 1443-1462

Caballero, R, Engel, E. and J. Haltiwanger (1995): Plant Level Adjustment and Aggregate Investment Dynamics, *Brookings Papers on Economic Activity* 2 , Macroeconomics, 1-54

Craig, B. And V. Dinger (2009): Bank Mergers and the Dynamics of Deposit Interest Rates, *Journal of Financial Services Research* 2009, Vol. 36 (2-3): 111-133

Craig, B. And V. Dinger (2010): A Microeconometric Investigation into Bank Interest Rate Rigidity, *Federal Reserve Bank of Cleveland Working Paper* 2010-01

De Graeve, F. O. De Jongh, and R.V. Vennet (2007): Competition, transmission and bank pricing policies: Evidence from Belgian loan and deposit markets, *Journal of Banking & Finance*, Vol. 31(1): 259-278

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, T. and A. Berger (1991): The Rigidity of Prices: Evidence from the Banking Industry, *American Economic Review*, Vol. 81(4): 938-945

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

Hofmann, B. and P. Mizen (2004): Interest Rate Pass Through in the Monetary Transmission Mechanism: UK Banks' and Building Societies' Retail Rates', *Economica*, 71, 99-125,

Mester, L. (1994): Why are Credit Card Rates Sticky?, *Economic Theory*, Vol.4: 505-530

Mester, L. and A. Saunders (1995): When Does the Prime Rate Change? *Journal of Banking and Finance*, Vol. 19: 743-764

Nakamura, E. and J. Steinsson (2009): Five Facts about Prices: A Reevaluation of Menu Costs Models, forthcoming, *Quarterly Journal of Economics*

Neumark, D. and S. Sharpe (1992): Market Structure and the Nature of Price Rigidity: Evidence from the Market for Consumer Deposits, *Quarterly Journal of Economics*, Vol. 107(2): 657-680

Rotemberg, J. (2009): Altruistic Dynamic Pricing with Customer Regret, *NBER Working Papers* 14933

Rotemberg, J. and G. Saloner (1987): The Relative Rigidity of Monopoly Pricing, *American Economic Review*, vol. 77(5), pages 917-26

Sheshinski, E. and Y. Weiss (1977): Inflation and Costs of Price Adjustment," *Review of Economic Studies*, vol. 44(2), pages 287-303