Deposit Market Competition, Wholesale Funding, and Bank Risk

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Abstract: In this paper we revisit the long debate on the risk effects of bank competition and propose a new approach to the empirical estimation of the relation between deposit market competition and bank risk. This approach is based on the classical moral hazard problem of the bank: deposit market competition raises the optimal risk choice of the bank by raising the costs of bank liabilities. Since banks can substitute between retail and wholesale funding we relate deposit market competition to wholesale market conditions and examine their joint effect on the risk of bank assets. The analysis is based on a unique comprehensive dataset which combines retail deposit rates data with data on bank characteristics and with data on local deposit market features for a sample of 589 U.S. banks. Our results support the notion of a risk-enhancing effect of deposit market competition.

Key words: bank competition, wholesale funding, bank risk, deposit rates

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1. *Introduction*

Understanding how bank competition interacts with bank risk is essential for the formulation of appropriate regulatory policies. Given the applicability to policy, it is not surprising that a wide body of research has focused on examining, theoretically and empirically, the potential trade-off between competition and stability. However, theoretical and in particular empirical results are still controversial. The indefinite state of the debate motivates us to revisit the question.

In this paper we present a novel empirical approach for the estimation of the relation between deposit market competition and risk. This approach aims at empirically testing one of the traditional views in the theoretical analysis of the relation between bank competition and risk that is based on the classical moral hazard problem of the bank. The proponents of this view argue that the incentives of the bank to invest in risky projects are increasing with the costs of its funding (Allen and Gale, 2000 and 2004; Hellmann et al., 2000). The intuition of this argument is that investment in riskier projects allows bank owners high excess returns in beneficial states of the world, while the losses in adverse situations are mainly shifted to the creditors of the bank. Therefore, in the classical understanding of a bank as fully funded by retail deposits, intense bank competition will increase the incentives to invest in risky projects by increasing the costs of bank funding[1]. The implication of this strand of theory is therefore that banks operating in a competitive environment will hold riskier assets relative to banks facing less intense competition. Boyd and de Nicoló (2005), however, challenge the validity of this argument, within a theoretical model based on the same analytical framework. These authors underline the fact that the traditional moral hazard view on the relation between bank competition and risk ignores a similar moral hazard problem that arises at the bank borrowers'

[1] Shy and Stenbacka (2004), however, argue that this result only holds because deposit insurance makes depositors insensitive to bank risk. If in the absence of deposit insurance, banks compete in both the risk and the deposit rate dimensions, in the presence of deposit insurance they only compete in the deposit rate dimension.

level and affects bank risk in a reverse direction. If banks have monopoly power, they will charge higher lending rates which in turn will result in higher costs of debt of bank borrowers[2]. Facing high costs of debt bank borrowers are then likely to shift to risky projects, which in the case when the bank does not have the technology of perfectly monitoring and enforcing the project choice of its borrowers will result in higher risk of the bank assets.

The fact that a moral hazard problem at the borrowers' level can reverse the risk effects of the bank's moral hazard problem, does not imply, however, that an empirical test of the bank's moral hazard problem is useless. Boyd and de Nicoló's (2005) critique rather implies the importance of disentangling the effects of loan and deposit market competition in empirical work.[3] Given the fact that a bank can face different intensities of competition in the deposit and in the loan market and that regulation can affect competitiveness in these two markets differently (e.g. Regulation Q is an example of how regulators can limit deposit market competition without directly affecting the intensity of loan market competition), the more focused knowledge of the effects of competition on both sides of the banks' balance sheets, can then be used for constructing better directed regulations.

Given this theoretical background, a natural approach to empirically test the moral hazard problem of the bank is to estimate the effect of the costs of deposits – proxied by retail deposit rates[4] - on the risk of bank assets while controlling for the intensity of loan market competition. This is the intuition of the empirical exercise we present here. When applied to a sample of modern banks this empirical test should, however, not only reflect the costs of retail deposits (which will reflect a narrow interpretation of those theoretical models) but should

[2] The effects of loan market competition on bank risk has also been analysed by Broecker (1990), who shows that the average quality of banks' asset portfolios is negatively correlated with the number of loan market competitors, because a rise in the number of banks increases the probability of "lemon" borrowers to be granted a loan. In a related argument, Dell Ariccia and Marquez (2005) show that the share of "unknown" borrowers determines the incentives of the banks to invest in screening costs and thus increases the probability of lending booms and banking crises

[3] This distinction is especially important in the case when banks face different competitive position in the deposit than in the loan market, e.g. because of specialization in deposit raising versus loan production.

[4] Following Allan and Gale's (2000) model we ignore fixed costs of deposits and focus on their marginal costs.

also incorporate the possibility of banks to shift to wholesale funding if intense deposit market competition raises the costs of retail funds. This is especially relevant for many modern banks for which short-term wholesale liabilities (e.g. repo lending) became of crucial importance[5]. This is presumably because of the spread of the securitized banking business model (see Gorton and Metrick, 2009 for an extensive discussion of the change of banking industries business model towards securitized banking funded by wholesale liabilities).

The potential substitutability between retail and wholesale funds motivates us to integrate the conditions that banks face in the wholesale market in the analysis of the deposit market competition and risk relationship. By doing so we extend the scope of the analysis and avoid potential omitted variable bias concerns. These concerns arise by the implications of the market discipline literature which argues that the structure of bank liabilities and the risk of bank assets are chosen simultaneously. They are intensified by the recent debate on the risk effects of short-term wholesale liabilities (Huang and Ratnovsky, forthcoming; Huang and Ratnovsky, 2009, Brunnermeier and Pedersen, 2009). Also, by including wholesale funding in the analysis we can compare the risk effects of the costs of insured versus uninsured liabilities in a joint empirical framework.

In this framework, we consider the substantial degree of heterogeneity across banks with regard to the structure of their liabilities. While some banks are predominantly funded by wholesale liabilities, other banks still almost exclusively rely on retail deposits. We consider this heterogeneity and examine the risk effects of the retail and wholesale costs of funding not only for the full sample of banks but also for subsamples of banks with different liability structures.

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[5] Data from the "Flow of Funds Accounts" by the Federal Reserve Board suggest that retail deposits represent less than 58% of total bank liabilities in 2002; by 2007 the share of retail deposits has fallen below 52%.

Since the costs of retail and in particular the costs of wholesale liabilities can be affected by the risk of bank assets, our approach also accounts for the reverse causality by estimating a joint system of equations modelling the interrelation between these three variables. We identify the system by a zero restrictions strategy.

We estimate the equations using a rich dataset of deposit rates offered by 581 U.S. banks in 164 metropolitan statistical areas (MSAs), combined with balance sheet data of the banks as well as market structure characteristics of the MSAs. The time period encompasses 1997 to 2006. The richness of the data allows us to employ variation across local deposit markets, across banks, and across time in the analysis.

The results of our empirical analysis point to a robust, positive, and statistically and economically significant relation between the retail deposit rates offered by a bank and its asset portfolio and default risk. These results are consistent with the economic insights of the moral hazard argument on the relation between bank competition and risk. They show that banks with cheap retail sources of funding pursue more conservative risk strategies (Allen and Gale, 2000; Hellmann et al., 2000, etc). They should not, however, be interpreted as a direct support for limiting bank market competition. The reason being that we do not present any welfare analysis and are thus unable to address the trade-off between the lack of efficiency resulting from imperfect bank competition and the potential fragility of competitive banks. Also, we compare levels of bank assets' portfolio risk but do not empirically determine the threshold whereupon the risk of individual banks should be considered excessive, which would establish a direct link to financial system stability. Our results can, however, be used by regulators to focus regulatory and supervisory attention on banks with a limited access to retail deposits[6].

[6] As argued by Huang and Ratnovsky (2009) this policy implication could also be employed when comparing banking systems internationally: banks in countries with predominantly retail banking systems were more resilient to the financial distress during recent financial crises.

This paper contributes to the literature by directly addressing the main challenges of the existing empirical studies on the relation between bank competition and risk. Whereas most of the existing studies measure competition by broad concentration ratios, which cannot disentangle deposit and loan market competition (Keeley, 1990; Demsetz etl al, 1996, Brewer and Seidenberg, 1996, Salas and Saurina, 2003, Boyd et al., 2006, de Nicolo and Loukianova, 2007, Schaeck et al., 2008 and Schaeck and Cihak 2008) we explicitly target deposit market competition's effect on bank risk[7], while controlling for loan market competition. This approach allows us to address the challenge of mixing up the effects of deposit and loan market competition which, as suggested by Boyd and de Nicolo (2005), potentially work in opposite directions.

The choice of deposit rates as a measure for the intensity of deposit market competition faced by the bank is driven the theoretical motivation for this study: if bank competition affects risk because of a positive shift in the costs of bank deposits then an empirical test could directly exploit the information about the costs of retail deposits contained in the retail deposit rates rather than going the loop way of using the rough approximations of competition intensity (concentration ratios, Herfindahl indeces, Panzar-Rose and Boone competition statistics). An additional advantage of using retail deposit rates offered by the bank as a proxy for the intensity of the deposit market competition it faces, is that it allows banks operating in the same local market to face different intensities of competition, for example, because of comparative advantages in serving some depositor groups[8]. Doing so we can strengthen identification by exploiting deposit rate variation both across markets and across banks.

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[7] Jimenez et al (2010) present the only other empirical study that we are aware of that distinguishes between deposit and loan market competition. Their approach, however, fails to account for both the role of wholesale funding and the endogeneity of a bank's competitive position.

[8] We are aware of only three other empirical studies which employ bank-level competition measures. Schaeck and Cihak (2008) use the Boone indicator (Boone, 2008) as a competition measure. This indicator does not distinguish between deposit and loan market power of the bank. Jimenez et al. (2010) measure deposit and loan market competition separately by the deposit and the loan market Lerner index of the bank, respectively. They, however, have only aggregate retail rate data for each of the sample banks and no information about the rates in

Also, we recognize that a bank's competitive position in the deposit market is not exogenous with respect to bank risk,[9] and we employ the substitutability between retail and wholesale funding in our identification strategy.

The rest of the paper is organized as follows. Section 2 introduces the data. Section 3 presents the empirical methodology. Section 4 discusses the main results. Section 5 focuses on the analysis of the costs of funding and risk relation depending on the liability structure of the bank. In Section 6 we discuss the potential differences in the risk effects of the costs of longer-term versus short-term wholesale funding and reestimate the model using subordinated debt as an alternative form of wholesale funding. Section 7 concludes.

2. *Data*

This empirical study is based on a comprehensive dataset combining three main data sources. First, we employ the financial statements (balance sheets and income statements) reported by 589 U.S. banks in the *Quarterly Reports of Conditions and Income* (Call Reports). We then match the Call Report data with *BankRate Monitor* data on the retail deposit rates offered by each of these banks in each of 164 metropolitan statistical areas covered by *BankRate Monitor*[10](if the respective bank has a branch in the MSA). *BankRate Monitor* deposit rate data have weekly frequency. To match the quarterly frequency of the Call Reports, we use only the deposit rates reported on the last week of each quarter. Third, we match our bank-market observations with characteristics of the local bank market (the MSA) drawn from the

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the different local markets. Berger et al. (2008) employ a bank-level overall Lerner index reflecting output and input prices in both the deposit and loan market.

[9] See Shy and Stenbacka (2004) for a model of the endogeneity of deposit market competition and risk. Obviously, as these authors note, deposit insurance schemes reduce the impact of bank risk on the competitive position of the bank relative to deposit markets. Nevertheless, as numerous examples from the recent crisis showed, depositors care about the risk of the bank.

[10]The coverage of *BankRate Monitor* limits our sample to 589 banks.

Summary of Deposits[11]. The data encompass a period starting on September 19, 1997, and ending on July 21, 2006.

After merging our data, we have a multidimensional (unbalanced) panel dataset consisting of bank-level data (risk variables, bank size, capitalization), market-level data (HHI, market size, average income of the MSA's population, income growth, etc.), and bank-market-level data (retail deposit rates, share of the MSA's branches, branches per deposit volume in the market).

3. *Methodology*

In the tradition of the theory of bank risk and competition (Allen and Gale, 2000, Hellman et al, 2000) an examination of the effect of deposit market competition on bank risk can be based on an empirical test of the moral hazard problem of the bank. Such a test would focus on the effect of the costs of bank (retail and wholesale) funding on the risk of bank assets. Following this argument, the main hypothesis that we test states that the risk of bank assets increases with the interest rates the bank pays on its retail and wholesale liabilities.

For the empirical test of this hypothesis we start with a main equation describing the impact of deposit[12] and wholesale rates on the risk of bank assets:

$$r_{i,t} = f(d_{i,j,t}, w_{i,t}, controls) \quad , \qquad (1)$$

where r denotes the risk of the bank, d the retail deposit rates, and w the interest rate on wholesale liabilities. The subscripts i, j, and t refer to the bank, the local market (MSA), and the time period, respectively. In the formulation of this equation as a test of the moral hazard problem we assume that both retail and wholesale funding have a linear effect on the riskiness

[11] *Summary of Deposits* data have annual frequency (as of end of June). We attach the same values of the local market variables to all four corresponding quarters.

[12] Equation (1) explicitly accounts only for the variable costs of retail and wholesale funds. We include a number of control and instrument variables to account for the variation in the fixed costs of deposits and wholesale funds.

of bank assets independent of the structure of bank liabilities. In Section 5 we explicitly focus on the heterogeneity of bank liability structure and the potential non-linearities and re-estimate equation (1) using subsamples of banks with different liability structures.

Since both retail and wholesale interest rates can be affected by the riskiness of the bank, we explicitly model the reverse causality by the following equations (2) and (3). The system is then identified using a zero restriction identification strategy[13] that we will discuss in detail in Section 3.2.

$$d_{i,j,t} = f(r_{i,t}, w_{i,t}, controls) \tag{2}$$

$$w_{i,t} = f(r_{i,t}, d_{i,j,t}, controls) \tag{3}$$

Equation (2) models the dependence of retail deposit rates on bank risk and the costs of wholesale funding[14]. While in the formulation of equation (1) as an empirical test of the moral hazard problem of the bank deposit rates are considered as the outcome of deposit market structure, in equation (2) we account for the fact that deposit rates are also affected by a bank's risk and alternative sources of funding. In other words, in equation (2) we account for the component of deposit rates that is driven by factors other than deposit market competition.

The dependence of deposit rates on bank risk is based on the assumption of some risk sensitivity of insured deposits, or in other words, that bank risk is a determinant of its deposit market competitive position.

[13] One of the reasons we prefer a static to a dynamic identification scheme (e.g., one based on lags of the dependent variable) is the rigidity of bank retail deposit rates, which implies that we might observe the same retail rate in two consecutive quarters.

[14] Jimenez et al. (2010) is the only other study we are aware of that uses prices as a measure of the intensity of competition. The authors explore the relation between competition and risk in the Spanish banking sector. They fail to recognize, however, the simultaneity of prices and proceed with a reduced-form model.

The dependence of deposit rates on wholesale rates has already been shown in theoretical work (e.g. Kiser, 2004 and Park and Pennacchi, 2008). These papers generally assume that bank assets (e.g. loans) are the output in a production function that uses retail and wholesale funds as inputs. The assumption is then made that, whereas banks can have market power in the retail deposit market, they are price takers in the wholesale market. In this framework, an exogenous rise in the wholesale rate is related to an increase in the optimum retail deposit rate offered by the bank[15].

Equation (3) describes the risk sensitivity of the wholesale funding rate[16]. Wholesale rates are assumed to be risk-sensitive because wholesale creditors adjust the interest rate to the probability of the borrower's failure since wholesale liabilities are not covered by deposit insurance. Furfine (2001), for example, proves that riskier banks pay higher rates on federal funds. Moreover, Flannery and Sorescu (1996), DeYoung et al. (2001) find that riskier banks pay higher interest on subordinated debt[17]. Following Pennacchi (1988), we also allow wholesale rates to depend on retail rates, assuming that banks facing intense deposit market competition show a higher demand for wholesale funds. Note that the fact that observed wholesale rates might depend on retail deposit rates does not imply that the wholesale market is not competitive. By including deposit rates as determinants of wholesale rates we control for the possibility that banks which face high rates on retail deposits will be more likely to

[15] An alternative approach of modeling the relationship between retail and wholesale deposits is taken by Jimenez et al (2007). These authors concentrate solely on the difference between wholesale and retail rates (deposit market Lerner index) as a measure of deposit market power and do not explicitly model the interaction between wholesale and retail rates.

[16] Here we deviate from the simple Lerner indices approach presented by Jimenez et al (2007) which implicitly assumes that all banks, independent of their risk levels, face the same country-wide money market rates.

[17] To our knowledge the only study that relates wholesale funding, competition, and risk is Goyal (2005). In his empirical framework Goyal assumes that high bank competition is reflected in low bank charter value and high bank risk, and examines the effect of the charter value on the yield and the inclusion of covenants on bank subordinated debt. He finds that low charter values correspond to more covenants in the subordinated debt contract and higher subordinated debt yields.

borrow in the wholesale market even when wholesale market rates are relatively high[18]. Also by including equation (3) we explicitly allow for the interdependence between retail rates and bank risk to be driven by a "wholesale" channel: as shown by Billet et al. (1998), riskier banks might shift from uninsured wholesale funds to insured retail liabilities. Such a shift requires higher retail rates to attract sufficient retail deposits.

3.1.Measures of bank risk, deposit rates, and wholesale rates

We employ two alternative measures of bank risk in the estimations: the non-performing loans ratio (NPL) and the z-score [19]. The choice of the NPL as a risk proxy is driven by the fact that we are focused on the risk of bank assets, which have traditionally been measured by the share of impaired loans (e.g. Jimenez et al, 2010; Demsetz et al, 1996, etc. use this risk proxy in their analysis of the bank competition and risk relation). We compute the NPL ratio as the ratio of impaired loans to total outstanding loans and use the log of the ratio with a four-quarter lead[20]. The intuition of introducing the lead is that the risk of the current projects will only be reflected with a delay in the nonperforming loan ratios of the bank[21].

[18] The results of the empirical estimation are qualitatively the same if we estimate the wholesale equation without including retail deposit rates as a regressor. Including it, however, strengthens identification.

[19] Boyd et al. (2006) and Schaeck and Cihak (2008) measure bank risk by the z-score. They find that bank competition (measured by the Herfindahl index or the concentration of the banking industry in Boyd et al, 2006 and the Boone indicator in Schaeck and Cihak, 2008) has a negative impact on risk. On the other hand, Jimenez et al. (2010) concentrate on the risk of the loan portfolio measured by the ratio of nonperforming loans to total loans. They find that deposit market competition has no significant impact on asset risk, but loan market competition is positively related to the risk of a bank's asset portfolio.

[20] Regression specifications using the current (as in Jimenez et al., 2010) and the two-quarter-lead of the nonperforming loan ratios result in qualitatively the same results.

[21] As a robustness check we have rerun the model using the ratio of nonperforming loans to equity as a risk measure (again with a four-quarter lead). According to Ashcraft (2008), this is a better measure of bank risk since the capitalization of the bank affects the amount of nonperforming loans a bank can absorb before harming its creditors. The results of the estimation are very similar to those using nonperforming loans to total loans as a dependent variable.

Our alternative risk measure, the z-score, is computed (following Boyd et al, 2006) as the ratio of the sum of a bank's average return on assets (ROA) and capitalization (E/A = equity/total assets) to the standard deviation of the return on assets[22]:

$$z-score=\frac{\overline{ROA}+\overline{E/A}}{\sigma(ROA)}. \qquad (4)$$

The z-score, therefore, presents information on how many standard deviations of the return on assets are needed to drive the bank into default and is a broader measure of risk than the nonperforming loans ratio, which is exclusively focused on loan risk. The z-score a as a distance to default measure broadly used by practitioners and regulators. Banks with a low z-score are more likely to default. That is, the z-score is decreasing with bank risk. To facilitate the interpretation of the results and the comparison with the alternative risk measures, we use the negative z-score as a risk proxy in the regressions.

By analyzing the impact of bank deposit market competition on these two alternative proxies of bank risk we can examine whether the controversial results of earlier studies have been driven by the choice of different risk measures. Also even though we are aware of the various shortcomings of both risk measures and the existence of potentially dominating risk proxies[23], we focus on these two traditional risk measures to compare our results to the results of the existing literature on this topic, which to our knowledge exclusively use one these two risk proxies.

Turning to bank retail deposit rates as a proxy for deposit market competitive position, we choose the rates on money market deposit accounts (MMDA) as most suitable for our exercise. This choice is motivated, on the one hand, by the fact that alternative retail deposit products either contain a substantial service component (e.g. checking accounts) which we

[22] The means and the standard deviation are computed by using rolling windows of 8 quarters.

[23] The CDS spread has been argued to measure bank risk consistently (reference???). Its use, however, would have dramatically reduced our sample size since many of the banks we study here have not issued CDS.

cannot observe because of data limitations, or they are insensitive to local market conditions (e.g. certificates of deposits[24]). On the other hand, MMDAs are one of the most important retail deposit product of the banks in our sample: on average they represent about a third of bank deposits. As a robustness check we have rerun all regression specifications using the checking account rates as a retail deposit rate measure. The results are qualitatively the same as those reported here[25].

It is often assumed in the banking literature that multimarket banks charge uniform rates across local markets (e.g. Radecki, 1998; Park and Pennacchi, 2008). A closer look at our sample, however, uncovers a high degree of cross-market variation in multimarket banks' pricing.

Table 1: Cross-market and cross-bank variation in MMDA rates

	MMDA rates			
	variation within the market		variation within the bank	
Year*	standard deviation	mean absolute deviation from the mean	standard deviation	mean absolute deviation from the mean
1997	0.53	0.38	0.17	0.07
1998	0.42	0.31	0.25	0.13
1999	0.58	0.43	0.18	0.10
2000	0.67	0.50	0.32	0.18
2001	0.36	0.27	0.10	0.06
2002	0.23	0.17	0.05	0.03
2003	0.06	0.05	0.04	0.03
2004	0.22	0.16	0.05	0.03
2005	0.36	0.26	0.10	0.07
2006	0.41	0.29	0.12	0.07

*as of first quarter

Note: Variation within the market is computed by first computing by local market the variation (standard deviation or mean absolute deviation from the mean) of the checking account rates offered by all banks. Then the variation is averaged across local markets. Variation within the bank is computed by first computing by multimarket bank the variation (standard deviation or mean absolute deviation from the mean) of the checking account rates offered in the various local markets. Then the variation is averaged across all multimarket banks.

[24] See Hannan and Prager (1998) and Craig and Dinger (2009)
[25] Results are available from the authors upon request.

The data presented in Table 1 illustrate that the variation in the deposit rates set by a multimarket bank in the different MSAs is equal to about one-third of the variation of all deposit rates offered by all banks in a MSA.

We explore this cross-market variation in the pricing of multimarket banks as a proxy for local market competitive conditions. Since we observe bank retail rates in different local markets (MSAs) we control for the intensity of local deposit market competition and identify the deposit rate equation using the variation of local market characteristics across the MSAs.

And finally, in our baseline specification, we use the interest rate on "federal funds purchased and securities sold under agreement to repurchase" as a proxy for the costs of wholesale funding. We follow King (2008) and impute this interest rate by the ratio of "expense of federal funds purchased and securities sold under agreements to repurchase" (line riad4180 in the Call Report) to "federal funds purchased and securities sold under agreements to repurchase" (line rcfd3353 in the Call Report)[26]. The format of the Call Report does not allow us to disentangle federal funds borrowing from repo, so that we have a position including both uncollateralized (federal funds purchased) and collateralized (securities sold under agreement to repurchase) borrowing. Both types of borrowing bear in common the fact that they are of a very short maturity and the counterparty is an institutional investor, usually a bank, so we can use the imputed rate as representing the cost of overnight wholesale liabilities. The substantial variation, of the costs of overnight wholesale liabilities both cross-section and across time gives us additional identification.

Having in mind traditional banking systems overnight wholesale liabilities might not seem a close substitute to retail deposits. Considering the architecture of the modern US banking system with its shift towards securitized banking (see Gorton and Metrick, 2009 and Schleifer

[26] This rate on overnight bank liabilities is imputed by dividing average quarterly costs on average quarterly volumes. For few observation the ratio is implausibly large. We clean the data by excluding observations with a negative rate or rate>20% (29 bank*quarter observations are excluded).

and Vishny, 2009 for an extensive discussion), however, suggest that these short term wholesale liabilities indeed turn out to have replaced substantial amounts of retail deposits. Moreover, the rate a bank pays on federal funds and repo has been shown to be closely correlated with alternative bank wholesale liabilities (such as subordinated debt, advances from Federal Home Loan Banks, and others[27]), which are potentially better substitutes for retail deposits from a bank's point of view. The advantage of federal funds and repo over these alternative wholesale liabilities for our framework is that we have observations for most banks in our sample[28]. Moreover, comparison across banks is further facilitated by the fact that the fed funds market borrowing is a standardized "product"[29]. In Section 6 we alternatively estimate the model using the subordinated debt rate as a wholesale rate proxy mainly to control for the potential difference between the risk effects of short- versus longer term bank debt, whose importance has been underlined in the context of the recent financial crises (Huang and Ratnovsky, forthcoming; Brunnermeier and Petersen, 2009).

Table 2 illustrates descriptive statistics of the variables included in our estimations. It shows substantial variation of the MMDA rate, between 0 and 5.83%. Some of that variation is due to the time series dimension of our data, which span a period from 1997 to 2006 and cover a full interest rate cycle. Our risk measures also exhibit substantial variation: the z-score varies between 3 and 53, and the nonperforming loan ratios vary between zero and more than 12%.

[27] Ashcraft et al (2008)

[28] In order to account for the noise introduced in the fed funds rate data when the volume of fed funds liabilities is negligibly small, we introduce a screen based on the share of fed funds liabilities in total assets in the estimation of equation (3) and account for the potential selection bias by using a Heckman correction (Heckman, 1976).

[29] Alternative wholesale funding products bear a substantial nonprice component such as covenants (see Goyal, 2005), which should be accounted for, for a precise comparison. Data about these are, however, unavailable for the broad range of banks included in our study.

Table 2: Descriptive statistics

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
MMDA rate (in %)	18715	1.356	0.879	0.000	5.830
checking account rate (in %)	18715	0.538	0.539	0.000	3.800
T-Bill three month (in %)	18715	3.361	1.769	0.880	6.210
effective fed funds rate (in %)	18715	3.535	1.949	0.938	7.125
rate on subordinated debt (in %)	13279	0.025	0.181	0.000	7.793
rate on federal funds purchased (in %)	17439	2.405	2.061	0.036	19.682
Z-score	9679	16.188	5.422	3.312	53.155
NPL (in %)	12098	0.001	0.003	0.000	0.122
branch_deposit	16039	0.022	0.022	0.000	1.050
share of branches in the MSA	16039	0.116	0.066	0.001	0.390
BHCdummy	18715	0.947	0.225	0.000	1.000
average income in the MSAs in Th. USD	15581	32.257	16.367	5.672	375.689
average income growth in the MSAs	15581	0.050	0.024	-0.054	0.158

Note: The ”raw” rates on wholesale liabilities before applying the screen of federal funds purchase > 1% of total assets and outstanding subordinated debt >1% of total assets are reposted in the table.

3.2.Identification and Instruments

Our identification follows a “zero restriction” strategy. The intuition of this traditional identification approach is the inclusion of additional control variables which are allowed to enter only some of the equations with a non-zero coefficient. The coefficients of the rest of the equations are restricted to zero. This identification strategy is equivalent to instrumenting each of the endogenous variables by a suitable set of instrumental variables, which are uncorrelated with the error term but strongly correlated with the instrumented endogenous variable.

In the case of retail deposit rates, we base the identification on the assumption that banks control for local deposit market competition when setting their deposit rates[30]. Classical measures on deposit market conditions which have been found to determine retail deposit rates are the *Herfindahl* index (see Hannan and Berger, 1992; Park and Pennacchi, 2008) and the *market size* (see Prager and Hannan, 2004). The *Herfindahl* index controls for the concentration of market power. It is computed as the sum of squares of the deposit market shares of all banks operating in the MSA (this variable is drawn from the FDIC *Summary of*

[30] Note that we observe substantial cross-market variation in retail rates within the multimarket banks (which we will discuss in our data section) in our sample, which can be employed in the identification.

Deposits). The *market size* variable is the log of the population of the respective market. This variable is informative on the volume of potential customer and has been found to be positively correlated with competitiveness. Since the observed retail rate of a bank might also depend on the bank's branch network as a proxy of the service quality and proximity we add the ratio of *branches to deposits* computed at the bank-market level as the ratio of the number of bank *i*'s branches in local market *j* to bank *i*'s total deposits (in millions of USD) in this market. We argue that *Herfindahl* index, *market size* and *branches to deposits* are right-hand variables in the deposit equation only, their coefficients in the other two equations are restricted to zero. These restrictions are based – consistent with Allen and Gale (2000) and Hellmann et al (2000) - on the assumption that if deposit market structure has an effect on bank risk or on wholesale rates this effect is realized only through the costs of retail funding.

Similarly, the instrumentation of the wholesale rate focuses on variables which affect the rate a bank pays on wholesale liabilities but which do not have a direct impact on deposit rates and bank risk. Our major instrument for the rate on wholesale funds is the average effective level of the federal funds rate (as announced by the Federal Reserve Bank of New York, based on its survey of four major brokers). The inclusion of this instrument follows the argument that the rate banks pay on wholesale liabilities reflects changes in the average rate on fed funds. Note that by including this instrument in the regressions we also control for the general interest rate level, so that variation in the *MMDA rate* is then only related to cross-market and cross-bank variation and not to the general interest rate cycle. A change in the effective fed funds rate is probably also related to the amount of risk taken on by the bank (see Jimenez et al., 2007), as well as the deposit rate it can charge, but we assume that this impact goes through the costs of overnight wholesale funding faced by the bank. Moreover, additional identification comes from the fact that the overnight bank wholesale funding rate and the effective fed funds rate are stronger correlated than deposit rates and the effective fed funds rate. This is the case because while effective fed funds rate and bank overnight wholesale rates are at the shortest maturity end of the yield curve and co-move strongly, deposit rates implicitly have a longer maturity, might reflect dynamics of other yield curve maturity segments and typically adjust only very infrequently to market interest rate changes.

Using the effective fed funds rate as an instrument for the wholesale rate we assume that any effect of the fed funds rate on risk and deposit rates works through the wholesale rate that the bank pays. We also use a dummy variable, which takes the value of one if the bank belongs to a bank holding company and zero otherwise (*BHC dummy*), as an additional instrument for the wholesale rate. The intuition behind this instrument is that wholesale funding is cheaper for banks that are members of large bank holding companies (BHCs), but risk choice and the deposit rate do not necessarily depend on BHC membership. Both the average fed funds rate and the BHC dummy are weak instruments. The average fed funds rate shows no variation across banks, while the BHC dummy shows almost no variation across time. To strengthen identification, we also include a dummy variable taking the value of one if the bank is a member of the Federal Home Loan Bank, and zero otherwise (*FHLB dummy*), as an additional instrument for the wholesale rate. The inclusion of this instrument follows King (2008) and Ashcraft et al (2008). These authors argue that advances from the Federal Home Loan Bank system are empirically relevant substitutes for other forms of wholesale borrowing. By including FHLB borrowing as an identifying instrument we assume that its availability can shift a bank's demand for federal funds but not for retail deposits.

The identification of bank assets' risk is based on the argument that the riskiness of bank assets is affected by the general economic conditions in the geographical regions where the bank operates. Following this argument, we use the average household income in the markets where a bank operates (*income*) and the annual household income growth averaged across the markets where a bank operates (*income growth*)[31] as risk instruments. The importance of general economic conditions for bank risk has been empirically confirmed in cross-country comparisons that find that GDP and GDP growth are important determinants of non-performing loans and bank Z-scores (Dinger and von Hagen, 2009 and Boyd et al, 2006). Recent studies also confirm its validity when comparing the performance of loans across US regions. E.g. Mian and Sufi (2008) demonstrate for the case of mortgage lending a negative relation between default rates and ZIP code zone's average income. General economic conditions are effective instruments because, although they significantly affect the risk of the banks operating in the local market, they do not have a direct impact on wholesale and deposit rates. In other words, we assume that the effect of local economic conditions on local deposit interest rates and on wholesale rates is not a direct one but a consequence of local economic condition affecting bank risk.

In the case of all instruments, the Stock-and-Watson-rule-of-thumb measure[32] confirms the strength of the instrument, and, in the case of multiple instruments, a Hansen test does not reject exogeneity of the instruments.

3.3.Control variables

As suggested by earlier research, a few variables such as capitalization and bank size can affect all three dependent variables (Hannan and Hanwick, 1988, Furfine, 2001, Boyd et al., 2006). That is why, we include as control variables in all three equations the ratio of bank equity to total assets as a measure of *capitalization,* and the log of the bank's total assets as a proxy for *bank size,* as well as the squared *bank size* variable (to control for nonlinearities in

[31] Average FICO scores can alternatively be used as a risk instrument. We do not have the FICO score data for the full sample period at our disposal. Previous research (see Cohen-Cole, 2008), however, suggests a very strong correlation between average FICO scores and average household income.

[32] The so-called Stock and Watson rule of thumb (Stock and Watson, 2003) is often used as a proxy for the strength of an instrument. According to this rule, the first-stage F-statistic testing the hypothesis that the coefficients on the instruments are jointly zero should be at least 10. In the case of the deposit rate instruments, the F-statistic is 14.5, for the wholesale rate instruments the F-statistic is 13.2, and for the risk instruments the F-statistic is 12.4.

the relation between bank size and bank risk and retail and wholesale rates). Also, as suggested by King (2008), the rate of loan growth might be an important determinant of the wholesale rate. Since the loan growth rate can also significantly affect the retail deposit rates offered by the banks and the risk of their asset portfolio, we also include *loan growth* as a control variable in all three equations.

In the formulation of the empirical test we are primarily focused on the effect of deposit market competition and thus deposit rates. Nevertheless, Boyd and de Nicolo's (2005) concerns underline the importance of controlling for the intensity of loan market competition. Controlling for loan market competition is challenging. First of all, using reported loan rates as a proxy for competition is less feasible because of our limited ability to account for the riskiness of the borrowers and potential credit rationing. We therefore, choose to apply a less direct but also less controversial measure of the loan market power of the bank, namely the ratio of loans in the balance sheet plus the volume of securitized loans to the total assets of the bank (*loans to total assets*)[33]. The idea is that if a bank has substantial market power in the loan market, it will have a higher share of loans (which on average generate higher returns than alternative assets) in its portfolio. Since the bank can securitize and sell the loans after origination, we add the amount of securitized loans to on-balance sheet loans. This approach gives us a simple way of controlling for the intensity of loan market competition. Obviously, it ignores the potential interactions between deposit and loan market competition. We argue, however, that given the existence of a competitive wholesale market for funds these interactions are irrelevant to the subject of this study.

[33] The inclusion of more comprehensive loan market competition measures and the analysis of their interactions with deposit market competition is a planned extension of this research project.

3.4. Estimation technique

In the estimation of equations (1) and (3), bank-level dependent variables (the risk proxy and the rate on wholesale liabilities) are regressed on bank-market-level explanatory variables (e.g., deposit rates). In this case, the assumption of uncorrelated error terms across the observations may be violated (it is likely that observations of the same bank in different markets will show correlated error terms), resulting in potentially inconsistent estimates. We adopt three alternative approaches to deal with our multidimensional panel.

First, we use the full sample of bank-market observations and cluster the standard errors by bank. This estimation allows us to explore variation of deposit market competition and risk both across bank and across markets. Second, we alternatively estimate the model on the bank level by computing the average values of the bank-market-level variables (deposit rate, average income, branches-to-deposits ratio, etc.). For each bank and time period, we compute the average value of each of these variables across all the local markets in which the bank operates. Through the aggregation, we achieve consistency of the estimated coefficients but lose information on the intensity of the local deposit market and dramatically reduce the number of observations, which in turn reduces the efficiency of the estimation. Obviously, this estimation approach can only account for the variation across banks. It has, however, the advantage that it accounts for the possibility that banks reshuffle deposits across local markets. In this case, the average intensity of deposit market competition might be the one that matters for bank risk. And third, we estimate the model using the subsample of single-market banks (112 out of our sample of 589 banks operate in only one MSA). Single-market banks (SMBs) face deposit market competition in one market only, and their bank-level risk is related to the competitive conditions in only this deposit market. The drawback of this approach is that we again dramatically reduce our sample size.

In the estimation of the wholesale rate equation we control for the potential selection bias, which arises from the fact that if banks perceive that they have to pay a disadvantageous rate on their wholesale liabilities, they may refrain from borrowing wholesale funds[34]. Consequently, for such banks we will observe no (or only negligible volumes) of wholesale funding. For these reasons we use the censored regression specification suggested by Heckman (1976) when estimating the wholesale rate equation. Unless the share of wholesale liabilities is large enough, the purchased funds are likely to represent unusual purchases made under extreme time pressure and are thus unlikely to represent the price of wholesale funds as deposit substitutes. Because of this, we did not include an observation in the estimated wholesale funds equation unless the volume of federal funds purchased represented at least 1% of the bank's assets. [35] The Heckman specification creates an auxiliary variable in the first stage, the "inverse Mills' ratio," which represents the bias caused by the censoring process. As noted by Heckman, instrumental variable estimators are still consistent, once the predicted inverse Mills' ratio is included in the system[36].

4. Estimation results

In this section we present the results of the baseline model, with the rate on federal funds purchased and securities sold under agreement to repurchase as a wholesale funding rate proxy and the money market deposit account rate as a proxy of the intensity of deposit market competition.

The results illustrated in Table 3 which contains a column for each of the risk measures (negative z-score and the nonperforming loans ratio (NPL)), reflect the estimation based on the full sample of bank-market level observations with a quarterly frequency. These results

[34] These selection issues have been explicitly studied by King (2008).

[35] As robustness check we have re-estimated the model using both a fix volume of the federal funds purchased as a trigger point (1 million USD, as in King, 2008) and alternative trigger values of the fed funds purchased share in total assets (0.05% and 2%). Results do not change qualitatively.

[36] Note that the Mill's ratio is significant in the estimation of all specifications of the wholesale equation.

show a statistically significant positive link between deposit rates and bank risk, which is robust to the choice of the risk measure. The estimated coefficients suggest a relatively large economic significance of the results. So, a one-standard-deviation increase of the MMDA rate (0.879) corresponds to a drop in the z-score of 183 basis points and an increase in the nonperforming loans ratio of 0.003 (equal to roughly one standard deviation of the nonperforming loans ratio). The rate on federal funds purchased enters the regression using the z-score as a risk measure with a statistically insignificant coefficient. Its effect on the nonperforming loans ratio is, however, positive and statistically significant: banks paying higher rates on federal fund have on average riskier loan portfolios. The magnitude of the estimated coefficient, however, suggests that the economic significance of the wholesale rate's impact is lower than the one of retail deposit rates[37].

Turning to the control variables, the coefficients of the bank size variables suggest humped shape of the relation between bank size and bank risk. Moreover, well capitalized banks are supposed to pursue less risky strategies. Banks holding more loans on their portfolios are significantly riskier. This result suggests that, on the one hand, loans are riskier than alternative bank assets. On the other hand, it is consistent with Boyd and de Nicolo's (2005) argument that when banks have high loan market power – signalled by a large share of loans in total assets- their risk might be increased because of the borrowers' moral hazard. And last but not least, average household income and income growth corresponds to less risky bank portfolios. Their coefficients in the bank risk regression supports them as efficient instrument for bank risk in the deposit rate and wholesale rate equations[38].

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[37] The lower economic and statistical significance of the wholesale rate relative to the retail rate coefficients might be due to the fact that our measure of retail rates is less noisy than our wholesale rate measure (imputed from the Call Report) and that our retail rate instruments are stronger than the wholesale rate instruments.

[38] One potential concern is that relation between bank competition and risk might have changed during the sample period which almost a decade . As a robustness check we have reestimated the model using including time dummies as additional control variables. Results are qualitatively the same, however, since the effective average federal funds rate has no cross-sectional variation the efficiency of the estimation is dramatically reduced because of colinearity. Alternatively, we have reestimated the model for two sub-periods (1997-2000)

Table 3: All banks; bank-market level observations; the wholesale rate is measured by the rate on fed funds purchased

Risk measure	negative Z-score			NPL		
	Coefficient		Standard	Coefficient		Standard
Dependant variable: bank risk						
MMDA rate	2.088	**	1.052	0.004	**	0.002
rate on federal funds purchased	-0.593		0.423	0.001	**	0.001
bank size	2.389	*	1.300	0.008	***	0.002
bank size^2	-0.064		0.039	-0.001	***	0.000
capitalization	-38.735	***	5.642	-0.013		0.012
loan growth	-0.005		0.389	0.001	*	0.001
loans_ta	2.505	**	1.126	0.014	***	0.002
income	-0.410	***	0.145	-0.008	**	0.004
income growth	8.176		13.007	-0.022	***	0.006
constant	-42.339	***	13.992	-0.074	***	0.020
Observations	4910			7544		
R-squared	0.07			0.01		
Dependant variable: MMDA rate						
bank risk	0.322	***	0.049	72.491	***	20.827
rate on federal funds purchased	0.177	***	0.026	0.403	***	0.040
bank size	-0.557	***	0.206	-0.715	***	0.162
bank size^2	0.012	**	0.006	0.019	***	0.005
capitalization	17.691	***	2.915	1.138		0.906
loan growth	0.279	***	0.106	-0.053		0.088
loans_ta	-1.492	***	0.157	-1.063	***	0.176
market size	0.000	***	0.000	0.000	***	0.000
branch_deposit	4.150	***	1.627	-0.659		1.030
HHI	-2.169	***	0.425	-0.964	***	0.229
constant	11.277	***	2.313	6.985	***	1.426
Observations	4910			7544		
R-squared	0.22			0.22		
Dependant variable: rate on federal funds purchased						
MMDA rate	0.545	***	0.130	0.475	***	0.129
bank risk	0.048	**	0.019	11.914		14.950
bank size	0.771	***	0.118	0.820	***	0.137
bank size^2	-0.021	***	0.003	-0.022	***	0.004
capitalization	-2.071		1.327	-5.441	***	0.672
loan growth	-0.159	*	0.089	-0.236	***	0.083
loans_ta	0.237	*	0.129	0.287	*	0.161
effective fed funds rate	0.396	***	0.035	0.422	***	0.034
FHLB dummy	-0.165		0.162	-0.084		0.178
BHC dummy	-0.165		0.286	-0.010		0.281
constant	-5.929	***	1.387	-7.214	***	1.397
Observations	13842			13842		
Censored observations	634			634		
R-squared	-			-		

Note: Two-stage least squares IV estimations. Endogenous variables are: bank risk (measured by z-score, NPL), MMDA rate and the rate on fed funds purchased and securities sold under agreement to repurchase. The fed funds rate equation is estimated using a Heckman procedure to control for potential selection bias. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

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and (2001-2006). Results, which are available from the authors upon request) are robust. However, for latter subsample we observe both economically and statistically stronger effects.

Table 4: All banks; bank level observations; the wholesale rate is measured by the rate on federal funds purchased

Risk measure	negative Z-score			NPL		
	Coefficient		Standard error	Coefficient		Standard error
Dependant variable: bank risk						
checking account rate	1.360	***	0.345	0.005	**	0.002
rate on federal funds purchased	0.463	**	0.215	0.004	***	0.001
bank size	5.860	***	2.064	0.005		0.004
bank size^2	-0.169	***	0.064	0.000		0.000
capitalization	-61.987	***	5.525	0.012		0.019
loan growth	-0.306	**	0.152	0.001		0.001
loans_ta	1.290	**	0.462	0.015	***	0.004
income	-0.002		0.002	0.000		0.000
income growth	-5.539		4.014	0.027	*	0.014
constant	-61.483	***	16.590	-0.049		0.031
Observations	1260			2350		
R-squared	0.16			0.00		
Dependant variable: checking account rate						
bank risk	0.030		0.110	4.410		23.187
rate on federal funds purchased	0.479	***	0.076	0.505	***	0.049
bank size	-0.499		0.330	-0.386		0.250
bank size^2	0.013		0.010	0.010		0.008
capitalization	4.423		9.576	3.368	*	1.731
loan growth	-0.148		0.121	-0.139		0.103
loans_ta	-0.378		0.577	-0.946	***	0.277
market size	0.000	*	0.000	0.000		0.000
branch_deposit	0.878		2.387	-2.426		2.155
HHI	-0.921	*	1.621	-1.367	***	0.432
constant	5.070		4.124	4.137	**	2.057
Observations	1260			23550		
R-squared	0.27			0.27		
Dependant variable: rate on federal funds purchased						
checking account rate	0.081	***	0.033	0.006	***	0.021
bank risk	0.001		0.036	-19.520		14.372
bank size	0.478		0.373	0.654	*	0.394
bank size^2	-0.013		0.011	-0.018		0.011
capitalization	-3.888		3.591	-3.049	***	1.129
loan growth	-0.114		0.144	-0.137		0.130
loans_ta	0.403	*	0.221	0.637	***	0.242
effective fed funds rate	0.528	***	0.116	0.578	***	0.073
FHLB dummy	-0.010		0.217	-0.123		0.231
BHC dummy	-0.586		0.411	-0.365		0.436
constant	-3.290		3.529	-5.158		3.742
Observations	4141			4141		
Censored observations	345			345		
R-squared	-			-		

Note: Two-stage least squares IV estimations. Endogenous variables are: bank risk (measured by z-score, NPL), MMDA rate and the rate on fed funds purchased and securities sold under agreement to repurchase. Bank-market level variables are averaged at the bank level. The fed funds rate equation is estimated using a Heckman procedure to control for potential selection bias. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

Table 5: Single-market banks only; the wholesale rate is measured by the rate on fed funds purchased

Risk measure	negative Z-score		NPL	
	Coefficient	Standard error	Coefficient	Standard error
Dependant variable: bank risk				
MMDA rate	1.465 ***	0.500	0.002 **	0.001
rate on federal funds purchased	-0.397 **	0.173	-0.001	0.001
bank size	-9.529	8.930	-0.015	0.018
bank size^2	0.337	0.308	0.001	0.001
capitalization	-50.804 ***	15.494	0.096 **	0.046
loan growth	-3.394 **	1.510	0.036 ***	0.006
loans_ta	2.920 **	1.164	0.003	0.005
income	-0.002	0.002	0.000	0.000
income growth	-4.501	6.289	0.086 **	0.035
constant	51.303	64.860	0.088	0.133
Observations	188		341	
R-squared	0.02		0.19	
Dependant variable: MMDA rate				
bank risk	-0.358	0.369	75.162 *	44.437
rate on federal funds purchased	0.203	0.181	0.480 ***	0.091
bank size	-22.914	21.170	-4.841 **	2.259
bank size^2	0.804	0.751	0.176 **	0.081
capitalization	-16.841	23.322	18.258 **	7.921
loan growth	-0.356	1.998	2.406 *	1.404
loans_ta	-1.305	0.885	-1.005 **	0.431
market size	0.000	0.000	0.000 **	0.000
branch_deposit	-7.483	5.768	-2.569 **	1.225
HHI	1.488	4.003	5.085	3.967
constant	161.491	147.014	32.758 **	15.526
Observations	188		341	
R-squared	0.03		0.18	
Dependant variable: rate on federal funds purchased				
MMDA rate	0.160	0.235	0.583 **	0.225
bank risk	0.010 *	0.014	23.649 *	17.736
bank size	0.713	1.079	0.963	1.096
bank size^2	-0.020	0.036	-0.030	0.037
capitalization	-3.563	2.443	-8.091 **	4.008
loan growth	0.103	0.665	-0.620	0.822
loans_ta	0.487	0.333	0.292	0.360
effective fed funds rate	0.596 **	0.085	0.500 *	0.094
FHLB dummy	0.140	0.405	0.363	0.427
BHC dummy	-0.568	0.383	-0.661	0.389
constant	-5.407	8.180	-6.865	8.234
Observations	704		704	
Censored observations	99		99	
R-squared	-		-	

Note: Two-stage least squares IV estimations. Endogenous variables are: bank risk (measured by z-score, NPL), MMDA rate and the rate on fed funds purchased and securities sold under agreement to repurchase. Only observations of single-market banks The fed funds rate equation is estimated using a Heckman procedure to control for potential selection bias. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

The results of the estimation of the deposit rate equation in this baseline specification also confirm the positive link between bank risk and deposit rates. So, for example, banks with a high z-score are expected to pay lower deposit rates. Similarly, banks with high relative volumes of nonperforming loans offer higher deposit rates. We also find support for a positive relation between the MMDA rate and the rate on federal funds purchased. This result is consistent with the substitutability of retail and wholesale funding, and it confirms the arguments of Kiser (2004) and Park and Pennacchi (2008).

And finally, the results of the estimation of the wholesale rate equation support the hypothesis that banks which pay high retail deposit rates also pay on average higher wholesale rates relative to their peers. That is, within a comprehensive empirical framework, we are able to confirm a positive relation between the cost of retail and wholesale funding. Bank risk enters the wholesale rate regression with a positive statistically significant coefficient only when measured by the negative Z-score. The rates on overnight interbank liabilities are not significantly responding to the non-performing loans ratio. These mixed results with regard to the risk sensitivity of overnight interbank rates are consistent with the discussion on the shortcomings of market discipline mechanisms in the case of exposures with very short (overnight) maturity[39].

Next, we re-estimate the model using a sample of observations averaged at the bank level. That is, for each bank and quarter we now use only one observation and cannot account for the market-level variation. By doing so, we control for the possibility that banks reshuffle deposits across local markets. The results of these estimations are presented in Table 4.

Qualitatively, these results are very similar to the bank-market-level results presented in Table 3. The key result concerning the positive relationship between retail deposit rates and bank

[39] See Rochet and Tirole (1996) and Huang and Ratnovsky, forthcoming for a theoretical discussion on the issue and Huang and Ratnovsky (2009) for a related empirical result based on cross-country comparisons

risk is also confirmed in this specification. However, the reduced number of observations is reflected in the lower power of the estimations.

And finally, we estimate the model on the sample of banks operating in only one local market (see Table 5). In this case, we are again able to qualitatively replicate the results from the bank-market-level estimation. The small sample size again results in relatively low power of the estimations, but we still find a positive statistically significant relation between retail deposit rates and bank risk. The economic significance of retail rate's effect on bank risk in this case is again comparable to the one found in the full sample of bank-market observations.

In sum, we find a statistically and economically significant positive relation between deposit rates and bank risk. Our empirical results, therefore, support the implications of a series of theoretical papers (e.g., Allen and Gale, 2000, Hellmann et al., 2000) that deposit market competition drives bank risk up by increasing the costs of bank retail deposits. Moreover, we find that wholesale funding rates also positively affect bank risk. This result extends the scope of the competition and risk argument to a more general interdependence of bank costs of funding and risk.

5. *Deposit market competition and bank risk: the role of liabilities structure*

The results reported above point to a strong statistically significant positive effect of the costs of retail and wholesale funds on the riskiness of bank assets. These results are generated by a sample of almost 600 banks which exhibit a large degree of heterogeneity especially with regard to the structure of their liabilities. For example, in more than 10% of the bank-quarter observations the share of overnight wholesale liabilities to total assets is below 1%, while for 10% of the bank-quarter observations this share is larger than 17%[40]. Obviously, the relation between the costs of retail and wholesale liabilities and bank risk can depend on the structure

[40] The sample includes both small regional banks funded almost exclusively by retail deposits and the largest money-center banks with a substantial wholesale exposure. The 25%, 50% and 75% quantiles of the ratio of overnight wholesale liabilities to total assets are 0.028726, 0 .060116 and 0.103086, respectively.

of liabilities. So, for example, the risk of banks predominantly funded by wholesale liabilities might not react to observed deposit market rates but rather to wholesale market conditions[41]. However, if the costs of retail funding affect the structure of bank liabilities, deposit market competition will have an indirect effect on bank risk even though the effect of observed retail deposit rates on bank risk is insignificant[42].

In this section we examine this dimension of bank heterogeneity in two steps. First, we show that liability structure depends on the conditions a bank faces in the deposit market. Second, we re-estimate the risk equation (1) for subsamples of banks with different share of overnight wholesale liabilities.

In step one we address the robustness of the results for groups of banks with different scope of liabilities. We examine the effect of deposit market competition on the structure of bank liabilities by estimating the following model:

$$liability\_structure_{i,t} = f(r_{i,t}, d_{i,j,t}, controls) \qquad (5)$$

where $liability\_structure_{i,t}$, is measured by the ratio of wholesale liabilities (federal funds purchased and securities sold under the agreement to repurchase) to total assets and the risk, $r_{i,t}$, and the deposit market structure,, $d_{i,j,t}$, are defined as above.

Since bank risk and retail deposit rates are potentially endogenous with respect to the liability structure we estimate the equation using the same instruments for bank deposit rates and bank risk that we defined in Section 3. The results of the estimations are presented in Table 6, which again contains a column for each of the two alternative risk measures.

[41] A straight-forward way to control for the volume of wholesale funding will be to include the share of wholesale to total liabilities as a control variable in the system of equations. However, given the endogeneity of wholesale funding volume with respect to both bank risk and deposit market competition the inclusion of wholesale volume would have imposed additional identification challenges. Moreover, the issue of non-linearities would have remained unresolved.

[42] Moreover, if banks shift to wholesale funding when deposit market competition accelerates the costs of retail funding above a certain threshold, the heterogeneity across banks may reflect a nonlinearity of the effect of retail deposit rates on bank risk

Table 6: Wholesale funding and retail deposit rates

Dependant variable: share of purchased funds	**negative Z-score**			**NPL**		
MMDA rate	0.009	**	0.005	0.013	**	0.005
bank risk	0.004	***	0.001	-0.812		0.685
bank size	-0.024	**	0.011	0.031	**	0.014
bank size^2	0.001	***	0.000	-0.001	***	0.000
capitalization	0.085	*	0.070	-0.275	***	0.037
loan growth	-0.005	**	0.002	-0.011	***	0.002
loans_ta	0.003		0.005	-0.006		0.013
effective fed funds rate	-0.001		0.001	0.000		0.001
FHLB dummy	0.014		0.015	-0.017		0.009
BHC dummy	0.017		0.012	0.006		0.007
constant	0.271	***	0.099	-0.141		0.136
Observations	4905			7544		
R-squared	0.03			0.04		

Note: Two-stage least squares IV estimations *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

These results indicate that banks facing higher retail deposit rates are more likely to use larger volumes of wholesale funding. They are, therefore, consistent with our argument that deposit market competition and the structure of bank liabilities are related. Further, the relation between retail deposit market competition and wholesale volume connects our discussion on the risk effects of deposit market competition to the risk effects of the structure of bank liabilities as discussed by Huang and Ratnovsky, (2009).

Given the strong relevance of the costs of retail funding to the structure of bank liabilities that we establish in step one, we next focus on the effect of the heterogeneity of liability structure on the relation between costs of funding and bank risk. For this purpose in step two we draw the distribution of bank liabilities and divide the full sample in four subsamples using the quartiles of the distribution as cut-off points. We then rerun the risk equation (1) for each of the subsamples[43].

The results of the estimation of the risk equation for the subsamples are presented in Table 7 which contains a panel for each of the two alternative bank risk measures (NPL and Z-score) and graphically illustrated in Chart 1.

[43] To control for the potential sample selection bias in the two cases we estimate the model using the censored regression specification by Heckman (1976) that we explain in Section 3.4

Table 7: Retail and wholesale rates and bank risk: subsamples of banks with different liability structure

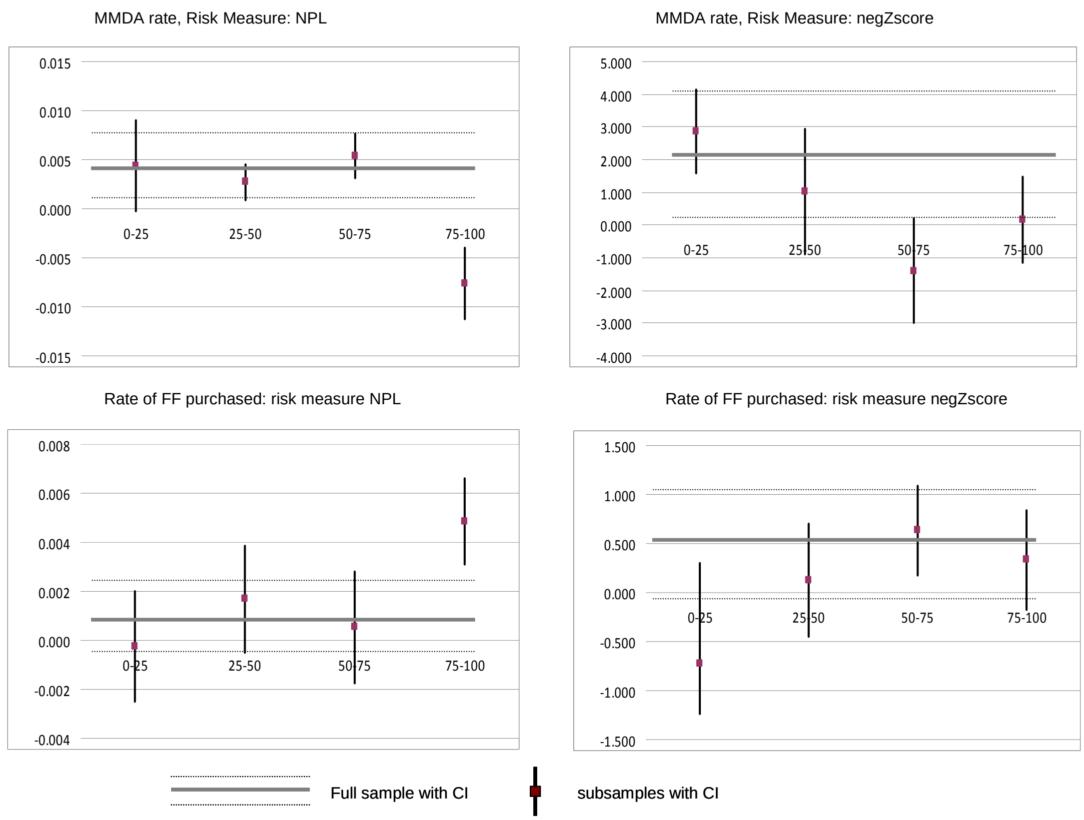
liability structure	0-25		25-50		50-75		75-100	
Panel A: dependant variable NPL								
	coefficient	standard error	coefficient	standard error	coefficient	standard error	coefficient	standard error
MMDA rate	0.004 *	0.003	0.003 *	0.001	0.005 ***	0.001	-0.008 ***	0.002
rate on federal funds purchased	0.000	0.001	0.002	0.001	0.001 **	0.001	0.005 ***	0.001
bank size	0.009 **	0.004	0.005 *	0.003	0.008 ***	0.002	0.006	0.004
bank size^2	0.000 **	0.000	0.000	0.000	0.000 ***	0.000	0.000	0.000
capitalization	0.002	0.016	-0.014	0.017	0.014	0.012	0.097 ***	0.034
loan growth	0.001	0.001	-0.005 ***	0.002	0.000	0.002	0.006 ***	0.002
loans_ta	0.006 **	0.003	0.013 ***	0.003	0.022 ***	0.002	-0.003	0.003
income	0.000 **	0.000	0.000	0.000	0.000	0.000	0.000	0.000
income growth	0.025	0.014	-0.053 ***	0.008	-0.014 *	0.008	-0.040 ***	0.008
constant	-0.074 **	0.035	-0.050 ***	0.027	-0.085 ***	0.022	-0.045	0.032
Observations	1936		2033		1973		1780	
R-squared	0.03		0.40		0.26		0.42	
Panel B: dependant variable negZscore								
MMDA rate	2.856 ***	0.757	-0.180	1.026	-1.397	0.946	0.155	0.769
rate on federal funds purchased	-0.727 ***	0.298	0.121	0.337	0.634	0.270	0.334	0.300
bank size	0.176	1.928	1.032	2.579	5.726 **	2.509	-8.729 ***	1.260
bank size^2	0.003	0.058	-0.035	0.073	-0.166 **	0.070	0.276 ***	0.033
capitalization	-37.369 ***	2.411	-34.514	8.297	-73.163 ***	7.431	-37.002 ***	13.827
loan growth	-0.471 **	0.230	-1.212	0.909	-3.011 ***	0.933	-0.951	0.706
loans_ta	1.048	0.626	-0.541	1.860	-0.687	0.548	-0.273	1.008
income	-0.004 **	0.002	0.002	0.002	-0.008	0.005	-0.003 ***	0.001
income growth	3.177	6.909	-13.522	8.043	-27.385	15.958	-21.555 ***	6.324
constant	-17.451	16.264	-19.785	23.602	-56.707 **	22.618	55.169 ***	12.290
Observations	1363		1207		1048		1292	
R-squared	0.21		0.05		0.28		0.51	

Note: Two-stage least squares IV estimations. Endogenous explanatory variables are: MMDA rate and the rate on fed funds purchased and securities sold under agreement to repurchase. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

These results indicate that depending on the structure of bank liabilities the relation between bank risk and the cost of retail and wholesale funding is indeed different. The positive effect of retail deposit rates on bank risk is strongest in the subsamples with a low share of wholesale liabilities. This effect is negligible (and could even turn negative) for the banks characterized by a high share of wholesale liabilities. The risk of such predominantly wholesale dominated banks is affected by the rates on wholesale funding rather than retail deposit rates.

These results are still consistent with the moral hazard argument: the observed costs of retail funding matters most for the risk of those banks argument that heavily rely of this funding form. However, they underline a non-linearity in the bank risk and deposit rate relation: once banks have chosen to focus on wholesale funding (a decision co-determined by the deposit market conditions they face), their risk is mostly driven by the condition in the wholesale funding markets and hardly reacts to retail deposit rates.

Chart 1: Estimated coefficients in subsamples with different liability structure



To further explore the effect of liability structure heterogeneity on the relation between bank costs of funding and risk, we have alternatively estimated the model using a quantile regression framework[44]. The results of this estimation are for reasons of space not reported here. This exercise requires introducing the liability structure as an additional endogenous regressor in the estimation of equation (1). As already mentioned identification is challenging in this case. One avenue for identification that we explore is to use the set of instrument for the MMDA rate and the wholesale rate identification to also identify liability structure. The weakness of the identification in this case is then reflected in very weak statistical significance of the estimation results in the lower (up to the 50th) quantiles. Similarly to the results reported in Table 7 for the higher liability structure quantiles the risk increasing effect

[44] These results are available form the authors upon request.

of MMDA rates is statistically insignificant but that of the costs of wholesale liabilities is high and statistically strongly significant.

These results do not imply that deposit market competition is not relevant for the risk of predominantly wholesale-funded banks but rather that the effect of retail deposit competition on bank risk is realized through the changed structure of bank liabilities.

6. Longer-term bank wholesale liabilities

A potential limitation of our approach is that we proxy the costs of wholesale funding by the rate on overnight wholesale liabilities. To check the robustness and also to compare the risk effects of the costs of short to longer term wholesale liabilities, we re-estimate the model using the rate banks pay on subordinated debt as an alternative measure of the cost of wholesale liabilities. Because of its longer maturity, subordinated debt can be considered as a better substitute for retail deposits than federal funds. Nevertheless, subordinated debt has other drawbacks for our research framework, especially if we consider that subordinated debt issues might not be related to a shortage of retail funds but rather to the eligibility of subordinated debt as tier-2 capital. We impute the subordinated debt rate in analogy to the rate on fed funds purchased by the ratio of “interest on subordinated notes and debentures” (line riad4200) and the amount of outstanding “subordinated notes and debentures” (line rcfd3200) of the Call Report. Again, when estimating the wholesale rate equation, we account for the potential selection issue by estimating a Heckman model with instrumental variables[45]. The results of the estimation of this model specification are illustrated in Table 8.

[45] The results presented in Table 10 are based on the following censoring rule: the subordinated debt is accounted for if the share of subordinated debt in total assets is at least 1%. Alternative trigger points (0.5% and 2%) yield qualitatively the same results.

Table 8: All banks; bank-market level observations; the wholesale rate is measured by the subordinated debt rate

Risk measure	negative Z-score			NPL		
	Coefficient		Standard	Coefficient		Standard
Dependant variable: bank risk						
MMDA rate	1.429		1.096	0.003	***	0.001
rate on subordinated debt	-0.176		0.307	0.002	***	0.001
bank size	-14.585	***	1.183	0.000		0.002
bank size^2	0.416	***	0.034	0.000		0.000
capitalization	-50.934	***	1.421	0.006		0.008
loan growth	-1.771	***	0.323	0.000		0.001
loans_ta	1.739		1.698	0.012	***	0.001
income	-0.002	*	0.001	0.000		0.000
income growth	-8.601		7.747	-0.020	***	0.004
constant	114.751	***	11.657	-0.008		0.019
Observations	3733			5715		
R-squared	0.330			0.380		
Dependant variable: MMDA rate						
bank risk	0.210	***	0.036	14.592		30.639
rate on subordinated debt	0.179	***	0.021	0.924	***	0.231
bank size	0.647	***	0.249	-2.259	**	0.949
bank size^2	-0.020	***	0.007	0.068	***	0.028
capitalization	10.982	***	1.924	12.206	***	3.250
loan growth	0.448	***	0.144	-0.308		0.285
loans_ta	-1.394	***	0.083	-1.268	***	0.435
market size	0.000	***	0.000	0.000		0.000
branch_deposit	3.740	*	1.991	-17.477	***	5.958
HHI	-0.530	*	0.291	-0.563		0.735
constant	-1.942		2.125	16.431	**	7.570
Observations	3733			5715		
R-squared	0.160			0.200		
Dependant variable: rate on subordinated debt						
MMDA rate	2.772	***	0.544	2.369	***	0.554
bank risk	0.267	***	0.070	236.269	***	62.761
bank size	6.089	***	1.340	6.062	***	1.437
bank size^2	-0.148	***	0.033	-0.145	***	0.035
capitalization	1.640		4.354	-22.183	***	2.888
loan growth	-0.984	***	0.330	-1.470	***	0.380
loans_ta	1.212	**	0.484	0.394		0.592
effective fed funds rate	-0.366	***	0.132	-0.367	***	0.142
FHLB dummy	-2.565	***	0.717	-1.278		0.834
constant	-55.390		13.529	-60.230	***	15.037
Observations	13842			13842		
Censored observations	5153			5153		
R-squared	-			-		

Note: Two-stage least squares IV estimations. Endogenous variables are: bank risk (measured by z-score, NPL), MMDA rate and the subordinated debt rate. The sub debt rate equation is estimated using a Heckman procedure to control for potential selection bias. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

These results show that the positive link between retail rates, wholesale rates, and bank risk is robust to the choice of the wholesale rate measure. The statistical and economic significance of the wholesale rate and risk relation is in the case of subordinated debt rate even stronger than in the federal funds purchased rate[46], showing that the maturity of wholesale exposures is an important determinant of the relation between bank risk and the costs of wholesale funding.

7. Conclusion

Despite the intense political and academic interest into the issue of the potential risk effects of bank competition, the literature has not yet reached a consensus on whether bank competition indeed has a positive effect on bank risk. In this paper we revisit the debate by estimating a system of equations which describe the relation between deposit market competition, the costs of wholesale funding, and bank risk. Although wholesale funding affects both the risk of a bank and its behavior in the deposit market, the wholesale market for funds has so far been ignored in the competition and risk literature. The main contribution of this study is, therefore, the integration of the market for wholesale bank funding into the analysis of the competition and risk nexus.

The results of our empirical estimation show a robust positive link between the intensity of deposit market competition faced by a bank and the risk of the bank. We interpret these results as evidence for the risk-increasing effects of deposit market competition and suggest that banks with less deposit market power are more likely to choose riskier strategies. However, our results reflect only potential costs of bank competition. The examination of the trade-off between the efficiency gains of a competitive versus oligopolistic banking sector and the higher risk of banks operating in competitive environment go beyond the scope of this study. This trade-off, which is essential for the formulation of regulatory policies, is still underexplored in the empirical banking literature and should be subject to further research.

[46] This positive link has already been shown by DeYoung et al. (1998), and Morgan and Stiroh (2001).

Literature

Allen, F. and D. Gale, (2000). “Comparing Financial Systems”. Cambridge, MA, MIT Press.

Allen, F. and D. Gale, 2004. “Competition and financial stability”, *Journal of Money, Credit and Banking* 36(2): 453-480

Ashcraft, A., 2008. “Does the Market Discipline Banks? New Evidence from the Regulatory Capital Mix“ *Journal of Financial Intermediation*

Beck, T., A. Demirgüç-Kunt and R. Levine, 2006. “Bank concentration, competition, and crises: first results”, *Journal of Banking and Finance*, 30, 1581-1603.

Berger, Allen N., Klapper, Leora F. and Rima Turk-Ariss. 2008. „Bank Competition and Financial Stability“, *Journal of Financial Services Research*, forthcoming

Berger, Allen N & Hannan, Timothy H, 1992. "The Price-Concentration Relationship in Banking: A Reply," The Review of Economics and Statistics, MIT Press, vol. 74(2), pages 376-79, May.

Billett, Matthew T., Jon A. Garfinkel, and Edward S. O’Neal. 1998. “The Cost of Market versus Regulatory Discipline in Banking”. *Journal of Financial Economics,*48: 333-358.

Board of Governors of the Federal Reserve System, 2008, Flow of Funds Accounts

Boone, J., 2008. “A New Way to Measure Competition”, *The Economic Journal*, 118: 1245-1261.

Boyd, J.H. and De Nicoló, G., 2005. “The theory of bank risk taking and competition revisited,” *Journal of Finance*, 60, 1329-1343.

Boyd, J.H., De Nicoló, G. and Al Jalal, A., 2006. “Bank risk taking and competition revisited: New theory and new evidence,” Manuscript, Carlson School of Management, University of Minnesota.

Brewer III, E. and M. R. Saidenberg, 1996. “Franchise value, ownership structure, and risk at savings institutions”, *Federal Reserve Bank of New York Research paper 9632*

Broecker, T., 1990. “Credit-Worthiness Tests and Interbank Competition”, *Econometrica*, 58: 429-452

Brunnermeier, M. and L. Pedersen, 2009, “Market Liquidity and Funding Liquidity”, *Review of Financial Studies*, 22 (6), 2201-2199

Carletti, E. and P. Hartmann, 2003, “Competition and Financial Stability. What’s Special about Banking?” In *Monetary History, Exchange Rates and Financial Markets: Essays in Honor of Charles Goodhart*, Vol. 2, edited by P. Mizen. Cheltenham, UK, Edward Elgar.

Cohen-Cole, E. , 2008. “Credit Card Redlining”, *Federal Reserve Bank of Boston Working Paper* WPS QUA 08-1

Claessens, S. and L. Laeven, 2004. “What drives bank competition? Some international Evidence”, *Journal of Money, Credit and Banking* 36(3): 563-583.

Craig, B. and V. Dinger , 2008. “Bank Mergers and the Dynamics of Deposit Interest Rates”, *Proceeding of the 44th Chicago Bank Structure Conference*

Dell Ariccia, G. and R. Marquez, 2005. “Lending Booms and Lending Standards”, *Journal of Finance*

Demsetz, R.S., M. R. Saidenberg and P. E. Strahan, 1996. “Banks with something to lose: The disciplinary role of franchise value”, *FRBNY Economic Policy Review* October, 1-14.

De Nicoló, G. and E. Loukoianova, 2007. “Bank Ownership, Market Structure and Risk”, *Unpublished manuscript*.

Dermine, J., 1986. “Deposit rates, credit rates and bank capital”, *Journal of Banking and Finance* 10: 99-114

DeYoung, R., M. J. Flannery, W.W. Lang, and S. Sorescu, 2001. “The information content of bank exam ratings and subordinated debt prices.” *Journal of Money, Credit, and Banking* 33, p. 900-925.

Dinger, V. and J. von Hagen, 2008. „Does Interbank borrowing Reduce Bank Risk?”, *Journal of Money, Credit and Banking,* forthcoming

Flannery, M. J. and S. M. Sorescu, 1996. “Evidence of Bank Discipline in Subordinated Debenture Yields: 1983 – 1991”, *The Journal of Finance*, 51: 1347-1377

Freixas, X. and J. C. Rochet, 1997. Microeconomics of Banking. The MIT Press.

Furfine, C, 2001. “Banks Monitoring Banks: Evidence from the Overnight Federal Funds Market,” *The Journal of Business*, 2001, vol. 74, 1, 33-58.

Gorton, G. and A. Metrick, 2009. “Securitized Banking and the Run on Repo”, Yale ICF Working Paper 09-14

Goyal, V. K. 2005. “Market discipline of bank risk: Evidence from subordinated debt contracts”, *Journal of Financial Intermediation*, 14: 318-350

Hannan, T. and G. Hanweck, 1988."Bank Insolvency Risk and the Market for Large Certificates of Deposit" (with Gerald Hanweck), *Journal of Money, Credit, and Banking*, vol. 20.

Hannan, T. and R. Prager, 2004.” The Competitive Implications of Multimarket Bank Branching", 28(8), 1889-1914

Heckman, J. J. (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 5, 475–492.

Hellmann, T., K. Murdock, and J. Stiglitz (2000): Liberalization, moral hazard in banking, and prudential regulation: are capial requirements enough?, *American Economic Review*, 90: 147-165

Huang, R. and T. Ratnovsky, “The Risks of Bank Wholesale Funding”, forthcoming, Journal of Financial Intermediation

Huang, R. and T. Ratnovsky, 2009. “Why Are Canadian Banks More Resilient During the Crisis?“ *IMF Working Paper 09/152*

Goyal, V. K. 2005. “Market discipline of bank risk: Evidence from subordinated debt contracts”, *Journal of Financial Intermediation*, 14: 318-350

Jimenez, G., Lopez, J. and J. S. Salas, 2010.”How Competition Impact Bank Risk Taking”, Banco de Espana Working Paper 1005

Jiminez, G. , S Ongena, and J Saurina, 2007. "Hazardous Times for Monetary Policy: What do Twenty-three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk?," Discussion Paper 2007-75

Keeley, M.C., 1990. “Deposit insurance, risk and market power in banking,” *American Economic Review*, 80: 1183-1200.

King, T., 2008. “Discipline and Liquidity in the Interbank Market”, *Journal of Money, Credit and Banking*, 40: 295-317

Kiser, E., 2002. "Predicting Household Switching Behavior and Switching Costs at Depository Institutions," *Review of Industrial Organization*, 20: 349-65.

Kiser, E, 2004. “Modeling the Whole Firm: The Effect of Multiple Inputs and Financial Intermediation on Bank Deposit Rates, *Finance and Economics Discussion Series 2004-07*. Washington: Board of Governors of the Federal Reserve System

Mian, A. R. and Sufi, A., 2008. “The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis”. *Working Paper Series*

Park, Kwangwoo and G. Pennacchi (2008): “Harming Depositors and Helping Borrowers: The Disparate Impact of Bank Consolidation,” , *Review of Financial Studies*

Pennacchi, G., 1988: “Loan Sales and the Cost of Bank Capital,” *Journal of Finance* 43(2)

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

Salas, V. and J. Saurina, 2003. “Deregulation, market power and risk behavior in Spanish banks”, *European Economic Review*, 47: 1061-1075.

Schaeck, K., M. Cihak, and S. Wolfe (2008) Are competitive banking systems more stable? *Journal of Money, Credit, and Banking*, forthcoming

Schaeck, K. and M. Cihak (2008): “Competition, efficiency, and soundness in banking: An industrial organization perspective“, *mimeo*

Schleifer and Vishny, 2009. “Unstable Banking” NBER Working Paper

Shy, O. and R. Stenbacka (2004): Market Structure and Risk Taking in the Banking Industry, Journal of Economics, Vol 82(3):249-280

Stock, James H., and Mark W. Watson, 2003. *Introduction to Econometrics*. Boston, MA: Addison-Wesley.