DEUTSCHE BUNDESBANK
EUROSYSTEM

Discussion Paper

Deutsche Bundesbank
No 59/2020

Hampered interest rate pass-through – A supply side story?

Lotta Heckmann-Draisbach
(Deutsche Bundesbank)

Julia Moertel
(The University of Edinburgh)

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

Internet http://www.bundesbank.de

ISBN 978–3–95729–790–7 (Printversion)
ISBN 978–3–95729–791–4 (Internetversion)

Non-technical summary

Research Question

Previous research for the US and Europe finds that when banks have market power, realised loan and deposit rates' responses to changes in market rates is impeded. Several questions arise: Is banks' credit supply or borrowers'/savers' credit demand mainly responsible for this result? What should policy makers focus on to influence the interest rate pass-through?

Contribution

Changes in realised interest rates are always a product of shifts in both credit demand and supply, and assessing their relative importance is therefore challenging. We leverage a unique data set covering all small and medium sized banks in Germany: For an identical time frame, each bank had to report interest rates that it would set *i*) after a hypothetical shock where the yield curve unexpectedly shifts up and *ii*) when no shock was to occur. Defining the difference between reported rates in the two counterfactual scenarios per bank as the interest rate pass-through, we take out to a large extent potential credit demand shifts. As a result, we can show that the credit supply side is a major driver of hampered interest rate pass-through.

Results

We find that, after partialling out the influence of credit demand, the pass-through of an upward shift in the yield curve is smaller by up to 5 percentage points for loan rates and up to 10 percentage points for deposit rates in markets where banks have market power. Monopolistic banks seem to have the capacity to spare their borrowers increases in loan rates, but at the same time they withhold rising rates from their savers.

Nichttechnische Zusammenfassung

Fragestellung

Verschiedene Forschungsergebnisse für die USA und Europa deuten darauf hin, dass die Transmission von Zinsschocks in Märkten, in denen Banken Marktmacht haben, eingeschränkt ist. Daraus ergeben sich folgende Fragen: Ist die Angebotsseite des Kreditmarktes (d.h. die Banken) oder die Nachfrageseite (d.h. die Kreditnehmer bzw. Sparer) für dieses Phänomen ausschlaggebend? Wen sollte die Politik vorrangig im Auge haben, um die Transmission von Schocks auf den Marktzins zu beeinflussen?

Beitrag

Zinsänderungen, die sich am Kreditmarkt einstellen, sind stets ein Produkt aus Verschiebungen von Kreditnachfrage und -angebot. Daher ist es schwierig festzustellen, welche Seite des Marktes für die Höhe einer beobachteten Zinsanpassung verantwortlich ist. Wir arbeiten in diesem Forschungspapier mit einem Datensatz, welcher alle kleinen und mittelgroßen Banken in Deutschland abdeckt. Über den selben Zeithorizont betrachtet geben Banken an, welche Zinssätze sie *i*) nach einer hypothetischen plötzlichen Verschiebung der Zinsstrukturkurve nach oben und *ii*) bei einem Ausbleiben des Schocks setzen würden. Wir berechnen die Differenz aus den angegebenen Zinsen in den beiden kontrafaktischen Szenarien für jede Bank und definieren dies als Maß für die Weitergabe von Veränderungen des Marktzinses. Hierdurch kürzen sich ein Großteil potentieller Verschiebungen der Kreditnachfrage heraus und wir können somit zeigen, dass die Angebotsseite, d.h. die Banken, für eine unvollständige Transmission von Zinsschocks verantwortlich ist.

Ergebnisse

Unsere Ergebnisse deuten darauf hin, dass die Transmission von plötzlichen Erhöhungen des Marktzinses geringer ist je mehr Marktmacht Banken haben, und zwar um bis zu 5 Prozentpunkte bei Kreditzinsen und bis zu 10 Prozentpunkte bei Zinsen auf Einlagen. Diese Banken ersparen ihren Kreditnehmern somit einen Teil der Zinserhöhung und enthalten diese gleichzeitig ihren Sparern vor.

Deutsche Bundesbank Discussion Paper No 59/2020

Hampered Interest Rate Pass-Through – a Supply Side Story?*

Lotta Heckmann-Draisbach
Deutsche Bundesbank

Julia Moertel
The University of Edinburgh

Abstract

This paper shows that the supply side of credit is a major factor for the phenomenon of hampered interest rate pass-through in monopolistic banking markets. Our data, covering all 1,555 small and medium sized banks in Germany, provides a clear way to partial out demand shocks; we are thus able to show that while market-power banks charge higher loan rates, they spare their borrowers a part of exogenous upward shifts in the yield curve and furthermore withhold a substantial part of rising market rates from their depositors. Because high market-power banks in our sample are relatively more profitable, they seem to be able to insure their relationship-customers against adverse shocks.

Keywords: interest rate pass-through, bank competition, credit supply

JEL classification: E43, E51, E52, G21.

*Contact address: Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main. Phone: +49 (0)69 9566-6502. E-Mail: lotta.Heckmann-Draisbach@bundesbank.de, julia.moertel@ed.ac.uk. The authors thank Thomas Kick, Andy Snell, Jonathan Thomas, Alessia De Stefani, Ambrogio Cesa-Bianchi, Rafael Repullo and seminar participants at the Bundesbank, the University of Edinburgh and the 7th Workshop in Macro, Banking and Finance at the Collegio Carlo Alberto in Turin for helpful comments. The views expressed in this paper are those of the authors and do not necessarily coincide with the views of the Deutsche Bundesbank or the Eurosystem.

1 Introduction

During the Great Recession, central banks in the US and Europe have intervened heavily in order to boost banks' loan provision. However, this hinges on the assumption that, apart from its effect through real interest rates, monetary policy has a direct effect on the real economy via credit supply. Consequently, examining the interest rate pass-through and factors that hamper the transmission to financial and real variables has once again become an important topic for policy and research (Agarwal, Chomsisengphet, Mahoney, and Stroebel, 2017; Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, and Yao, 2017; Drechsler, Savov, and Schnabl, 2017).

Frictions on both the credit supply and the demand side drag on the interest rate pass-through not only to lending volumes (Agarwal et al., 2017; Drechsler et al., 2017) but also to prices. In particular, imperfect competition in banking markets seems to be associated with a hampered transmission to retail rates (Adams and Amel, 2011; Fungáčová, Solanko, and Weill, 2014; Leroy, 2014; Sääskilahti, 2016; Van Leuvensteijn, Sorensen, Bikker, and van Rixtel, 2013; Gropp, Kok, and Lichtenberger, 2014). Despite a large body of literature on the topic, the question about the underlying channel has remained largely unanswered. This is because research on the interest rate pass-through has so far only worked with realised retail rates over time which are however the result of a combination of shifts in credit demand and supply. Reasons for a hampered pass-through may lie *within* the banking sector making it optimal for institutions with more market power to transmit smaller fractions of positive interest rate shocks to retail rates. Alternatively, it may be the case that *across* banks with varying degrees of market power, credit demand shifts systematically differently over the business cycle. The former mechanism identifies frictions on the credit supply side; the latter instead tells a credit demand story.

We aim at filling this gap in the literature and leverage a unique supervisory data set, the *2017 low-interest-rate survey*, and determine whether imperfectly competitive banking markets impede the interest rate pass-through via the supply side of credit markets. In spring 2017, the German Federal Financial Authority and Deutsche Bundesbank conducted a supervisory measure which required all small and medium-sized banks in Germany to report interest rates for loans and deposits. In particular, end-of-2017 projected retail rates for two different predefined scenarios taking place over the same time horizon were to be disclosed: *i*) a hypothetical exogenous and permanent upward shift in the yield curve and *ii*) no change in the yield curve, as opposed to the end of 2016 respectively. This data set is exceptional for two reasons: because of its coverage (88 percent of all credit institutions in Germany[1]) and because it delivers two data points per bank, one for each scenario, which we can use as treatment and counterfactual outcome, respectively. By taking the difference between the retail rates in the shock and the constant scenario, we can partial out any other factors whose change banks expect to influence interest rates over the course of 2017. Consequently, expected shifts in credit demand unrelated to the hypothetical shock are controlled for. This allows us to assess the supply-sided effect of imperfect competition among banks on the interest rate pass-through to loan and deposit rates

We identify imperfect competition through two variables: an individual-level Lerner

[1]The only other data source available containing interest rates at the individual level (MFI interest rate statistic) is a substantially smaller subset of all German banks (Weth, 2002).

Index which measures the degree to which a bank can charge a markup on the reference rate; and a geographic measure of concentration, the Herfindahl index. Our results suggest that following an upward shift in the yield curve, a bank's pass-through to loan rates is on average smaller by 4–5 percentage points when the bank belongs to the 90th percentile of the pricing power distribution or when operating in a highly concentrated market. Banks also exert market power in the deposit market to a substantial degree: in a highly concentrated deposit market, banks have a lower average pass-through by almost 10 percentage points.

Results are confounded if – despite the instructions – banks assume credit demand to shift differently in the two scenarios. Because bankers understand the first scenario as an adverse scenario, they might assume credit demand to contract only in the shock scenario.[2] If they do so, they are likely to base their expectations on past events. Following monetary policy contractions, demand in the EU generally falls to a larger extent at riskier banks (Altavilla, Boucinha, Holton, and Ongena, 2018) and riskier banks tend to have less market power (Kick and Prieto, 2014). Therefore, predicted demand shifts should be larger at banks with lower levels of market power. An expected drop in demand would counteract the upward pressure on the price from an exogenous increase in funding costs and we should therefore observe a relatively *smaller* pass-through at banks with *less* market power. The fact that we find the opposite, suggests that we are identifying a pure credit supply shift. In any case, our results provide a lower bound on the differential pass-through between banks with high versus low market power. Because German banks operate locally and we find that banks in imperfectly competitive markets have higher profits and return on assets, our results furthermore indicate that these banks are likely to have the capacity to build relationships with their borrowers and subsequently insure them against adverse shocks.

Our findings speak to various strands of the literature debating about the effect of imperfect competition on loan and deposit pricing. Regarding interest rate *levels*, banks may extract monopolistic rents in concentrated markets and thus set relatively lower deposit rates and higher loan rates than in a competitive market (Berger, 1995).[3] However, a conflicting hypothesis postulates that efficiency and concentration can be positively correlated leading to an opposite relationship between market power and retail rates (Berger, 1995). On a similar note, market power can facilitate relationship lending which, through a reduction in information asymmetries, may lead to more favourable outcomes for some borrowers (Rajan, 1992; Petersen and Rajan, 1995).[4] Turning to *adjustments* in retail rates, we could expect banks with more market power to raise loan (deposit) rates to a relatively larger (smaller) extent in response to rises in market rates, provided that banks act as standard monopolists. In contrast, bank-borrower relationships could lead

[2] In stress testing exercises, the shock scenario is the one that challenges banks' balance sheets. Often, the adverse scenario also entails a macroeconomic scenario with a predefined decline in GDP. See e.g. `https://www.esrb.europa.eu/mppa/stress/shared/pdf/esrb.20180131_EBA_stress_test_scenario__macrofinancial.en.pdf?43a5f3c6c04f2daa03bd950b55d8897b`, viewed 20 February 2020.

[3] In the banking literature, this is also referred to as the *structure-conduct-performance paradigm* (Berger, 1995).

[4] While the majority of work finds results in favour of the former theory (Hannan and Berger, 1991; Sapienza, 2002), Fungáčová, Shamshur, and Weill (2017) concur that banks with market power charge less for loans to small and medium sized firms in Europe.

pricing power banks to smooth adjustments in retail rates, insuring in particular their borrowers against adverse events.

Macroeconomic models similarly formulate situations in which monopolistic competition leads to both amplified and mitigated responses in retail rates. Moreover, a hampering effect can feed through the demand or the supply side of credit.[5]

This paper confirms for the German context that banks in more concentrated markets charge higher loan rates and offer lower deposit rates. Furthermore, interest rate pass-through and market power are negatively related which is in line with most of the previous literature. In particular, Van Leuvensteijn et al. (2013) and Gropp et al. (2014) conclude an impaired pass-trough of monetary policy to realised loan and deposit rates with respect to within-banking sector competition in Europe. Schlueter, Busch, Sievers, and Hartmann-Wendels (2016) identify the same pattern for Germany. We contribute to the literature by showing that supply side effects dominate.

To our knowledge, only Drechsler et al. (2017) establish a direct, impeding effect of deposit market concentration on the transmission of monetary policy. Using geographical variation in the degree of concentration, they find that bank branches in more concentrated markets widen the spread between deposit rates and the Fed funds rate in response to a monetary policy contraction relative to a branch of the same bank but operating in a less concentrated market (Drechsler et al., 2017).[6] This result, however, is likely to be specific to the US case. Inherent structural differences across the two banking markets as well as effects that the recent financial crisis and different extraordinary monetary policy measures had on them raise doubts on whether findings for the US can be translated to Europe. In contrast to the US, our data for instance indicates that counties with high banking market concentration in Germany are on average smaller and populated by a lower share of people over the age of 65. Furthermore, the sovereign debt crisis in 2011/12 posed a particular challenge to Europe's unintegrated banking market and lead the European Central Bank (ECB) to target sovereign spreads of particular countries in Europe, a phenomenon which was absent in the US.

This paper proceeds as follows. Section 2 motivates the research question theoretically, section 3 introduces the data sets, section 4 outlines the measures of imperfect competition and section 5 specifies the empirical approach and presents results. Section 6 contains robustness tests and section 7 concludes.

2 Conceptual framework

In theoretical models, banking markets are commonly characterised by some sort of imperfect competition (Gerali et al., 2010; Martinez-Miera and Repullo, 2018). The market rate can be interpreted as a bank's marginal costs since banks consider it as the reference rate for their funding (Agarwal et al., 2017; Martinez-Miera and Repullo, 2018; Corbae and Levine, 2018).

[5] For amplification, see e.g. Gerali, Neri, Sessa, and Signoretti (2010) or Duffie and Krishnamurthy (2016). Models for a hampered pass-through via the supply side are provided by Martinez-Miera and Repullo (2018) and Corbae and Levine (2018). However the same outcome in monopolistic banking markets can occur due to constraints on the demand side (Güntner, 2011).

[6] This ultimately drives heterogeneities in bank lending, i.e. loan *quantities*. In contrast, we solely focus on prices.

The standard textbook model of monopolistic competition provides a useful and simple framework to formalise changes in prices for loans where p stands for the rate a bank charges for one unit of loan, q. Accordingly, a change in the equilibrium price can be the result of cost and/or demand shifts. A change in the equilibrium price, $\mathrm{d}p$, can then be expressed as a function of the two shocks:

$$\mathrm{d}p = \frac{\partial p}{\partial x}\mathrm{d}x + \frac{\partial p}{\partial i}\mathrm{d}i \tag{1}$$

where $\mathrm{d}x$ denotes an exogenous parallel cost shift (i.e. x denotes the intercept of the marginal cost curve) and $\mathrm{d}i$ a demand shift (i.e. i is the intercept of the inverse demand curve). The first term on the right-hand side of Equation (1) captures the equilibrium price change after a cost shock in the absence of demand shifts, and the second term the corresponding change after a demand shift when no funding costs shock is present. In the event that both shocks occur at the same time, Equation (1) formalises the full adjustment of the price from the old to the new equilibrium. For any functional form of demand and marginal cost curve, the analytical solution to $\mathrm{d}p$ is given in more detail by

$$\mathrm{d}p = \frac{\partial p}{\partial q}\frac{\partial q}{\partial x}\mathrm{d}x + \left(\frac{\partial p}{\partial i} + \frac{\partial p}{\partial q}\frac{\partial q}{\partial i}\right)\mathrm{d}i \tag{2}$$

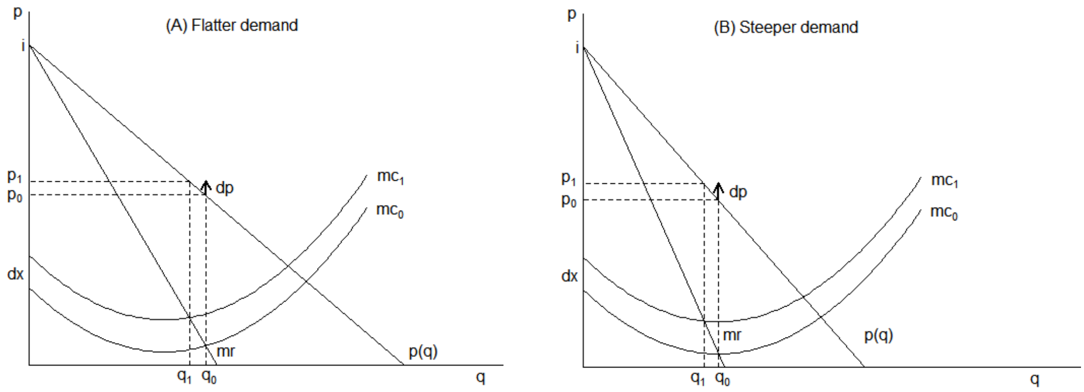
where $\frac{\partial q}{\partial x}$ is the change in the equilibrium quantity in response to a change in costs, $\frac{\partial p}{\partial i}$ is the partial derivative of demand with respect to its intercept and $\frac{\partial q}{\partial i}$ reflects the dependence of the equilibrium quantity on the intercept of the demand curve.[7] Equation (2) shows that the equilibrium price adjustment to any of the shocks depends on the slope of the demand curve, $\frac{\partial p}{\partial q}$. Thus, the steepness of demand (or the elasticity of demand) determines not only the extent to which a monopolist can exert market power[8], but also the adjustment of the equilibrium price in response to shocks. If for every loan quantity borrowers are suddenly willing to pay a different price, demand shifts. Here, a productivity shock or a shock to agent's expectations about the evolution of the business cycle may be one reason. Alternatively, a shock to the yield curve which causes a change in the cost of funds affects marginal costs: an upward shift in the yield curve (e.g. driven by a monetary policy contraction) increases costs and shifts the marginal cost curve up, leading to a higher equilibrium loan rate (see Figure 1). Equation (2) demonstrates that the size of the price adjustment always depends on the slope of demand and the according degree of the monopolist's pricing power.

Papers examining realised interest rates and their response to a change in the reference rate, observe rates over the monetary and business cycle where $\mathrm{d}p$ is the change in the price over time, $\mathrm{d}p = p_{t+1} - p_t$. According to derivations above, heterogeneities in $\mathrm{d}p$ can either stem from different supply side adjustments or from credit demand shifts unrelated to the shock (e.g. unrelated to monetary policy). In particular, it is plausible that demand

[7] See Appendix A.1 for proof.

[8] Solving $max_q\, \pi = p(q)q - c(q)$ gives $\frac{\mathrm{d}p(q)}{\mathrm{d}q}q + p(q) - \frac{\mathrm{d}c(q)}{\mathrm{d}q} = 0$. Rewriting leads to $p(q)[\frac{\mathrm{d}p}{\mathrm{d}q}\frac{q}{p} - 1] = mc$ with $\frac{\mathrm{d}c(q)}{\mathrm{d}q}$ denoting marginal costs, mc. The elasticity of demand, ϵ, is $\epsilon = \frac{\mathrm{d}q}{\mathrm{d}p}\frac{p}{q}$. Rewriting once more gives $\frac{1}{|\epsilon|} = \frac{p-mc}{mc}$ which is the definition of the Lerner Index. Therefore, the less elastic demand in the old equilibrium point, the more market power a bank can exert. Note, maximising over p instead of q leads to the same results.

Figure 1: Monopolistic competition



Note: The figure shows the pass-through of a cost shock to prices in two markets with monopolistic competition. Panel A considers a case with a relatively flat demand curve, i.e. a market in which a monopolist can exert relatively less market power; Panel B considers a case with a relatively steep demand curve, i.e. a market with relatively more market power. (Inverse) demand is denoted by $p(q)$, marginal revenues by mr and marginal costs by mc. A demand shock would shift $p(q)$, and accordingly mr.

behaves systematically differently across banks with varying levels of market power; in that event, resulting heterogeneities in the interest rate pass-through are not a result of frictions on the credit supply side.

In order to disentangle the role of the supply from the demand side in the interest rate pass-through, the ideal setting would be one where for every bank j, we have information on prices for two different counterfactual scenarios occurring at time t, one in which a change in market rates, $\mathrm{d}x$, is zero (i.e. where the yield curve does not shift) and one in which a change is equal to some (positive) value. The difference between the new loan rates in the two scenarios, both observed in $t+1$, could then be defined as the supply-sided interest rate pass-through. Specifically, this would lead to:

$$\mathrm{d}p_j = p_{j,t+1}|_{dx>0} - p_{j,t+1}|_{dx=0} \tag{3}$$

where $p_{i,t+1}|_{dx>0}$ represents the predicted loan rate in the shock scenario and $p_{i,t+1}|_{dx=0}$ the one in the scenario where no shock occurs. $\mathrm{d}p_j$ would then correspond to the pure supply-side adjustment in prices in response to an exogenous shock to the yield curve such as a monetary policy contraction because everything else that occurs between t and $t+1$ would automatically be cancelled out. This would allow us to determine the direction of

$$\frac{\mathrm{d}(\mathrm{d}p/\mathrm{d}x)}{\mathrm{d}\, market\, power} >< 0. \tag{4}$$

by simply regressing $\mathrm{d}p_j$ on a measure of market power.[9]

In this simple model, a shift in the yield curve does not shift the demand curve.

[9]Note that even in the simple model presented here, when market power is measured by the slope of demand, the direction is ambiguous; there exists a threshold in the slope of demand below which the above relationship is positive but turns negative above. The analytical solution to the threshold is derived

As shown in Figure 1, demand falls as a result of higher loan rates, represented by a movement *along* the demand curve. Yet, because a shift in the yield curve (e.g. through a monetary policy contraction) may affect borrowers' balance sheets, the change in credit demand could be amplified. A monetary contraction may result in declining asset prices which shrink collateral and ultimately the desire to invest (Bernanke and Gertler, 1989; Bernanke, Gertler, and Gilchrist, 1999). Thus, it is plausible that credit demand shifts inwards in the shock as opposed to the constant scenario. This would not be cancelled out when defining the interest rate pass-through according to Equation (3) and estimating Equation (4) would consequently mask the influence of credit demand on the interest rate pass-through.

However, evidence strongly indicates that borrowers do not assign randomly to lenders (Schwert, 2018). As a result, demand shifts are likely to vary systematically across banks. Indeed, Altavilla et al. (2018) find that in response to a monetary policy contraction, loan demand in the Euro area generally falls to a smaller extent at less riskier banks.[10] In addition, banks with more market power can be considered as less risky since they can realise profits from monopoly rents while in competitive markets, banks have to search for yield in riskier investments. Kick and Prieto (2014) confirm such a negative relationship between market power and bank risk taking for German banks.[11]

Therefore, if demand shifted inwards in the shock scenario, this shift would be relatively larger at banks with lower levels of market power, mitigating the upward pressure on the price from the shift in the yield curve. As a result, $\mathrm{d}p_j$ would ceteris paribus be smaller at less monopolistic banks. In other words, if an inward shift in demand in the constant scenario had a major contribution to the pass-through, $\mathrm{d}p_j$ would be *larger* among banks with *more* market power (giving Equation (4) a positive sign).

3 Data

We merge bank-level supervisory data of all banks in Germany with a unique dataset that contains interest rates for various product categories on banks' asset and liability sides: the *2017 low-interest-rate survey*.

3.1 The *2017 low-interest-rate survey*

Between April and June 2017, the German Federal Financial Authority (henceforth *BaFin*) and Deutsche Bundesbank (henceforth *Bundesbank*) conducted a supervisory measure on all 1,555 small and medium-sized German credit institutions on their prof-

in Appendix A.2.

[10]Results are obtained from the bank lending survey (BLS) for a time horizon that includes our time frame, i.e. 2002Q4 to 2017Q4 (Altavilla et al., 2018). The BLS collects information on credit supply and demand conditions for 150 institutions among which 30 are German. Bank risk is measured by their CDS spreads.

[11]Precisely, using the Lerner Index to measure individual pricing power, the authors find that market power in Germany (between 1994 and 2010) is significantly negatively related to several measures of bank risk, i.e. the probability of experiencing a distress event (e.g. receiving capital support), the ratio of non-performing loans to total loans, and the z-score (Kick and Prieto, 2014).

itability and resilience in the low-interest-rate environment.[12]

The data contains outcomes from various stress tests on interest rate risk, credit risk and market risk collected in a *bottom-up* exercise. Supervisory stress tests in the context of banking supervision are generally conducted in *top-down* and *bottom-up* exercises. Top-down refers to tests which the supervisory institutions run based on the bank-by-bank reporting data they have on the supervised banks; in bottom-up exercises, banks are obliged to run simulations or calculations themselves using their individual risk management assumptions and parameters while complying with constraints given by the authorities. Results need to be reported to the supervisors which in turn conduct quality assurance to ensure comparable results. While the exact modelling of banks is unknown, the bottom-up approach allows a more individual and thus more meaningful reflection of the banks' vulnerabilities under a certain scenario when taking into account data that the authorities do not have at hand.

For our purpose, we work with the stress test data on interest rate risk. In particular, banks had to report retail rates for loans and deposits which they would set in response to two hypothetical scenarios taking place as of 01.01.2017. The two scenarios were specifically phrased as follows:

1. "Constant yield curve (static balance sheet assumption[13]): the yield curve as of 31.12.2016 remains unchanged for the whole time horizon. The static balance sheet assumption holds."(BaFin/Bundesbank, 2017)

2. "+200 BP shock (static balance sheet assumption): the yield curve shifts ad hoc and parallelly by 200 BP as of 01.01.2017 compared to 31.12.2016 and remains unchanged for the whole time horizon. The static balance sheet assumption holds." (BaFin/Bundesbank, 2017)

Because the shift in the yield curve is defined to be permanent (BaFin/Bundesbank, 2017), the shock scenario could by definition also imply a contractionary monetary policy shock. It is verified that banks understand the shock to be permanent.[14]

To grant the highest possible adjustment in interest rates and to avoid that old contracts confound our results, we focus exclusively on banks' new business. For loans, this is further divided into fixed and floating rate contracts. For each scenario and bank, we then calculate the (new business) loan rate as a volume-weighted average over fixed and floating rate contracts. This aims at taking into account that banks with larger shares of fixed rate contracts might change loan rates to a smaller extent. Because deposit rates are floating rates only, volume-weighting is not necessary. Next, we calculate differences between banks' reported interest rates for the shock and the constant scenario (as outlined in Equation (3)) and normalise it by the size of the shock. For each bank and category

[12]The supervisory measure was conducted on all banks which are supervised by BaFin and Bundesbank according to § 6b KWG. Significant institutions (*SIs*) under direct European Central Bank (*ECB*) supervision are excluded.

[13]For comparability reasons and to prevent implausible portfolio enhancements, banks were required to replace maturing business with equivalent new business at prevailing standards e.g. regarding probabilities of default of borrowers, contracted volumes and type of contract. This is referred to as the *static balance sheet assumption*.

[14]Due to the permanent nature of the shock, all current and fixed assets have to be written down.

(i.e. loan and deposits), this gives a measure of the interest rate pass-through to retail rates.

Provided that banks correctly assume $\mathrm{d}i = 0$, we observe price changes conditional on an exogenous shift in the yield curve which fulfils the criteria of being able to disentangle supply from demand. Furthermore, due to the particular way in which we calculate the interest rate pass-through, the effect of any demand shocks which banks may potentially assume over the course of 2017 is differenced out – as long as these demand shocks are unrelated to the outlined shift in the yield curve. Similarly, any change in other factors, which matter for the pass-through (apart from the upward shift in the yield curve or demand shocks), that banks might expect cancels out.

Banks are legally required to provide authentic results.[15] In a quality assurance process, stress test submissions were continuously quality-checked to ensure that all reporting banks submit meaningful data. Cross-checks with reporting data (e.g. interest income and expenses or loan volumes) and peer group comparisons ensure that reported data are plausible and fulfil quality standards.[16] Furthermore, banks were advised to submit revised versions in case of poor or insufficient data. Data quality is of high importance because results provide the basis for individual (Pillar 2) capital guidance in the supervisory review and evaluation process (*SREP*) framework.[17] Remaining concerns regarding data quality and authenticity will be addressed in detail below. In particular, we provide evidence that survey responses are valid and unlikely to be biased by strategic incentives which may be correlated with market power.

3.2 Panel data

We select and estimate explanatory variables from balances and profit and loss accounts reported to the Bundesbank on a yearly basis. From this dataset, we take control variables and, most importantly, compute measures for market power. Because here we work on the entire population of financial institutions in Germany, we explicitly take the "big banks", i.e. SIs supervised by the ECB, in the pool of competitors into account. We keep a long time horizon (from 1994 to 2016) in order to make sure we achieve plausible results of estimated competition measures and their evolution over time. Due to mergers and acquisitions, we work with an unbalanced panel.

3.3 Data cleansing

Before merging the panel and the stress test data, we clean the two data sets separately. To exclude implausible bank-year observations in the panel data, we drop observations with negative or zero total assets, equity and total loans (i.e. sum of financial and non-financial loans) and impose the following conditions: loans-to-assets ratio and deposits-to-assets ratio must not exceed 1 and 0.98, respectively, and the equity-to-assets ratio must lie above 0.009 and below 0.5. The personnel expenses- and other administrative

[15] § 6b KWG and EU Regulation No. 1093/2010 (European Parliament and Council, 2010) apply.

[16] For instance, the maturing portion of a certain balance sheet position is compared across banks with a similar average maturity in that portfolio.

[17] For more information, see `https://www.bafin.de/SharedDocs/Veroeffentlichungen/EN/Fachartikel/2018/fa_bj_1807_Risikotragfaehigkeit_en.html`, viewed 25 February 2020.

expenses-to-assets ratio must be in a range of 0.0005 and 0.05 (Van Leuvensteijn et al., 2013). Before we impose the latter two conditions, we winsorize the expense variables at the upper and lower percentile (Kick, Pausch, and Ruprecht, 2015). This leaves us with more than 54,200 bank-year observations.

From the stress test data, building societies (*Bausparkassen*) are excluded as they are highly specialized. We furthermore exclude a handful of banks which, despite the elaborated quality assurance process, still appear to have provided data of insufficient quality. To deal with outliers, we winsorise interest rate levels and pass-through variables (the difference between the rates in the shock and the constant scenario, normalized by the size of the shock) at the winsorised at the bottom 1st and the top 99th percentile of the respective distribution. Finally, we only keep banks that pass the quality requirements imposed on both datasets.

4 Measures of competition and concentration

To examine the effect of imperfect competition on interest rate levels as well as the interest rate pass-through, we use an individual pricing power and a market concentration index.[18] The Lerner Index is widely applied in the banking literature (Valverde and Fernandez, 2007; Berger, Klapper, and Turk-Ariss, 2009; Kick and Prieto, 2014; Sääskilahti, 2016). In addition, it is to our best knowledge the only well-known measure one can compute *at the bank-level*. Because the banks in our sample operate locally, we also apply an aggregate concentration measure, the Herfindahl-Hirschman Index.[19]

4.1 Individual pricing power: Lerner Index

The Lerner Index (LI) measures a firm's monopolistic power by measuring its ability to charge a markup over marginal costs. The LI for bank j at time t is defined as:

$$LI_{jt} = \frac{\frac{TOR_{jt}}{Y_{jt}} - MC_{jt}}{\frac{TOR_{jt}}{Y_{jt}}} \tag{5}$$

with average revenues calculated as a fraction of total revenues TOR_{jt}, to total output Y_{jt}, and marginal costs denoted by MC_{jt}.[20] We define TOR as revenues that can be attributed to loan provision in a wider sense, excluding revenues from financial transactions such as trading derivatives.[21] In particular, total revenues consist of interest income from credit

[18] It has been established in the literature that various competition measures may be only weakly interrelated (see e.g. Claessens and Laeven, 2004; Bikker, Shaffer, and Spierdijk, 2012 and citations therein for empirical evidence, and Lapteacru (2014) for theoretical work) which calls for the use of alternative measures.

[19] Alternative measures would be the Boone Indicator (Kick and Prieto, 2014), or the Panzaar-Rosse H-Statistic. The latter has drawn much criticism in determining competition (Bikker et al., 2012 and Shaffer and Spierdijk, 2015).

[20] Under imperfect competition the price $P(Q)$ is equal to average revenues, i.e. $P(Q) = AR$, because $AR = avg.Profit + AC = \frac{profit}{Y} + \frac{TOC}{Y} = \frac{TOR_{jt}}{Y_{jt}}$ with TOR_{jt} denoting total revenues of bank j in year t, and TOC total costs.

[21] In a robustness check, we verified that including financial transactions does not make a substantial difference in the results.

and money market operations, and revenues from fee-based business. Total output is commonly defined as the sum of loans to non-financial customers (i.e. households and private firms), inter-bank loans and securities (Mester, 1996).

To derive marginal costs, we estimate total costs for each bank in our sample using a translog cost function (Christensen, Jorgenson, and Lau, 1973).[22] We follow the literature and account for potential cost inefficiencies that make the optimizing agent (here banks) deviate from the optimal cost-minimum, e.g. through suboptimal use of input factors. As stressed by Koetter, Kolari, and Spierdijk (2012), the LI may be biased downwards if perfect efficiency is assumed. We do not impose an assumption on why banks might operate inefficiently but we explicitly allow them to act according to the *quiet life hypothesis* which states that market power is negatively correlated with cost efficiency (Koetter and Vins, 2008).[23] Total costs are thus estimated with maximum likelihood, in a stochastic frontier model (Aigner, Lovell, and Schmidt, 1977; Meeusen and van Den Broeck, 1977; Greene, 2005).

Taking it to the data, we impose linear homogeneity of the total cost function with respect to input prices. Our functional form for the cost function follows Koetter et al. (2012) and Kick et al. (2015) and is:

$$\begin{aligned}\ln \frac{TOC_{jt}}{w_{1jt}} = \alpha + \beta_1 \ln Y_{jt} + \frac{\beta_2}{2}(\ln Y_{jt})^2 + \sum_{h=2}^{3} \gamma_h \ln \frac{w_{hjt}}{w_{1jt}} + \frac{\gamma_{22}}{2}\left(\ln \frac{w_{2jt}}{w_{1jt}}\right)^2 + \\ \frac{\gamma_{33}}{2}\left(\ln \frac{w_{3jt}}{w_{1jt}}\right)^2 + \frac{\gamma_{23}}{2} \ln \frac{w_{2jt}}{w_{1jt}} \ln \frac{w_{3jt}}{w_{1jt}} + \sum_{h=2}^{3} \frac{\delta_h}{2} \ln \frac{w_{hjt}}{w_{1jt}} \ln Y_{jt} + \\ \zeta_1 \ln z_{jt} + \frac{\zeta_2}{2}(ln\, z_{jt})^2 + \sum_{h=2}^{3} \frac{\eta_h}{2} \ln \frac{w_{hjt}}{w_{1jt}} \ln z_{jt} + \theta \ln Y_{jt} \ln z_{jt} + \\ \sum_{h=1}^{2} \kappa_h\, tr^h + \kappa_3\, tr \ln Y_{jt} + \kappa_4\, tr \ln z_{jt} + \sum_{h=1}^{2} \kappa_{h+4}\, tr \ln \frac{w_{h+1,jt}}{w_{1jt}} + v_j + u_j \quad (6)\end{aligned}$$

where w_{1jt}, w_{2jt} and w_{3jt} denote bank $j's$ input prices for loanable funds, labour and fixed capital, respectively. Akin to Kick et al. (2015), we calculate the input price for loanable funds as interest expenses divided by interest-paying liabilities and for labour as the ratio of personnel expenses and the number of full-time employee equivalents. Finally, we approximate capital expenses by other administrative expenses to fixed assets. Y_{jt} is as defined above. We include a bank's equity z_{jt} to control for heterogeneity in total costs across different bank sizes. Cross products between input prices and output with equity, respectively (η_2, η_3, θ), allow the effect of prices and output on total costs to vary between smaller and larger banks. We also include a linear trend, tr, single and squared, as well as interacted with input prices, output, and equity. The error term of the cost function estimation consists of two components, v_j, a random, i.i.d. term ($v_j \sim \mathcal{N}(0, \sigma_v)$), and an inefficiency term u_j for which we assume an exponential distribution. Assuming that

[22] A detailed derivation of a bank's cost function can be found in Appendix B.

[23] Following Koetter (2013), we abstain from estimating profits before taxes taking into consideration profit inefficiencies but rather take total revenues and output directly from the data. See e.g. Kick et al. (2015) for an estimation of the LI with profit inefficiencies.

the two components are independent, the above reduced-form model is estimated with maximum-likelihood. Consecutively, we derive banks marginal costs as:

$$\begin{aligned} MC_{jt} &= \frac{\partial \ln TOC_{jt}}{\partial \ln Y_{jt}} \frac{TOC_{jt}}{Y_{jt}} \\ &= \left(\beta_1 + \beta_2 \ln Y_{jt} + \sum_{h=2}^{3} \frac{\delta_h}{2} \ln \frac{w_{hjt}}{w_{1jt}} + \theta \ln z_{jt} + \kappa_3 tr \right) \frac{TOC_{jt}}{Y_{jt}} \end{aligned} \tag{7}$$

Finally, one LI per bank and year can be calculated based on Equation (5).[24] Figure 2 depicts the evolution of the average LI over time.

Figure 2: Evolution of average pricing power over time

Notes: The figure shows the unweighted mean of pricing power of all German banks over time. Smaller values mean lower levels of average pricing power indicating higher competitive pressure. Vertical red line in (i.e. at the end of) 2008.

While in the final analyses we only use the 2016 values, the graph can serve as a plausibility check. Banks generally compete most severely for prices during expansions and competition in various EMU states increased until 2008 after which trends reverted (Ruckes, 2004; Brämer, Gischer, Richter, and Weiß, 2013). Our calculations show that also in Germany, (price) competition rose in the boom years leading up to the financial crash and reached its peak at the end of 2008.[25] Lately, pricing power has been on the rise again, with average pricing power reaching an unprecedented level on our scale from 1994 – 2016. Dynamics are furthermore in line with earlier analyses for Germany (Koetter, 2013).

[24] Summary statistics of all variables used or estimated in this section can be found in Table B1 in Appendix B.

[25] During that time, average revenues dropped while marginal costs rose on average, a trend that reversed for both variables from 2009 onwards (see Figure B1 in Appendix B).

4.2 Market concentration: Herfindahl-Hirschman Index

Structural indicators seek to derive the degree of competition from market characteristics, because in strongly concentrated markets, firms should be able to exert market power (Mason, 1939; Bain, 1956). The *structure-conduct-performance paradigm* formulates that margins such as loan spreads are positively related to concentration (Coccorese, 2009). However, few firms in a market might also operate in strong competition to each other. Hence, the relationship between individual pricing power and concentration is not trivial and we challenge our estimations using these two alternative measures.

The Herfindhal-Hirschman Index which assigns a single value of concentration to a market is calculated as

$$HHI_d^p = \sum_j (LMS_{jd}^p)^2 \tag{8}$$

where the sum of bank-level (j) local market shares (LMS) goes over all banks that have their head quarter in administrative or urban district d.[26] In a highly concentrated market, the HHI_d^p approaches a value of 1. A bank j's local market share is the share of a specific portfolio p in the aggregate per district:

$$LMS_{jd}^p = \frac{X_{jd}^p}{\sum_i X_{id}^p} \tag{9}$$

where the sum goes again over all i banks in a district; for X^p we alternatively use deposits, loans to non-financial private customers and interbank loans.

Figure 3 shows the geographic variation in loan market concentration across Germany in 2016. Markets tend to be more concentrated in the north-east of Germany, meaning that there are cases in which one single bank is located in a county (darkest green).[27]

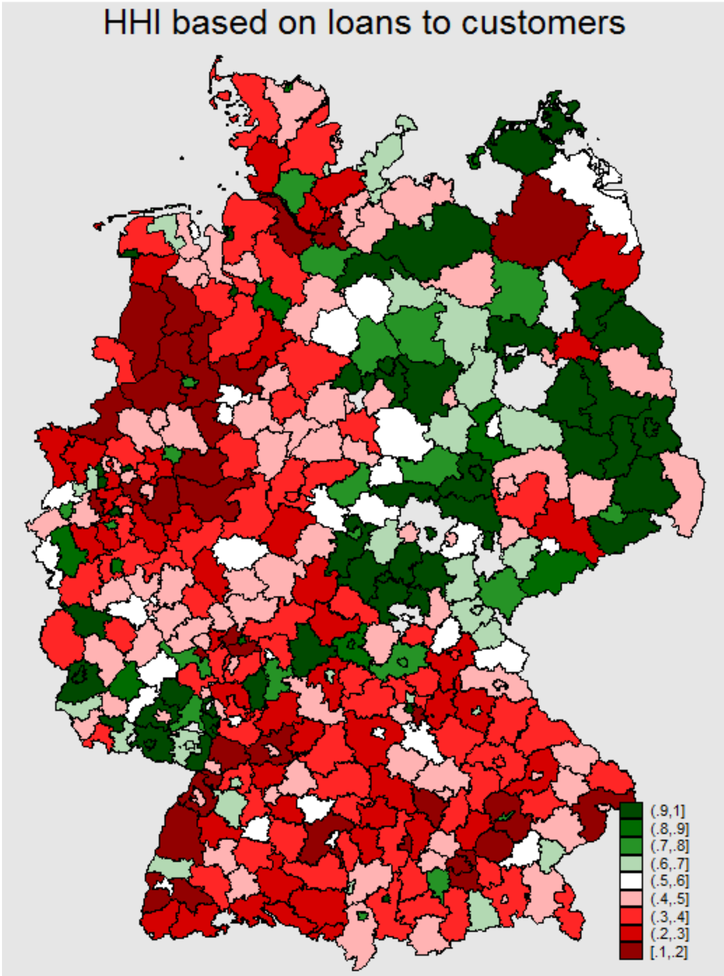
Our approach suffers from shortcomings. When seeking to determine market concentration in a bank's relevant market, we assign the total value of deposits and loans to a bank's head-quarter which reports balance sheet information to the Bundesbank. This implies the assumption that a bank conducts all business within the district of its head-quarter. This should not lead to a bias for savings and cooperative banks because they mostly report as separate entities (i.e. head-quarters) and due to the *regional principle* are bound to operate locally (Stolz and Wedow, 2011).[28] However, it significantly biases results for the big banks. If, for instance, a large private bank conducts business outside of its head-quarter district in a region and market segment where a local savings bank operates, then our measure of concentration for the district in which that savings bank is located is biased upwards. If, however, big banks compete with the small and medium-sized banks in our sample only on specific, limited markets, then the bias is limited, too. Many papers work with information on branch locations to infer a clearer picture on market concentration (Kick and Prieto, 2014; Drechsler et al., 2017). Information on branches

[26]In 2016, Germany consists of 294 administrative districts and 107 urban districts, leading to a total of 401.

[27]Concentration in the loan and deposit market has been on a steady rise up until 2008 after which it stagnated (but never fell). See Figure B2 in Appendix B.

[28]Because banks are only bound to operate locally when providing credit, the regional principle does not necessarily hold for deposits. Due to the housebank-principle in Germany and because the HHI for deposits is highly correlated with the HHI for loans, we still believe the measure to be informative.

Figure 3: Geographical variation of loan market concentration



Notes: The figure shows the HHI's in the market for loans to private customers across the 401 counties (i.e. administrative and urban districts) in Germany in 2016. Dark red stands for low level of concentration, dark green for high level of concentration.

in Germany is, however, only reliably available until 2004. Furthermore, because data are not available at the branch level, assumptions would have to be made to assign shares of exposure to the various branches, leading to a different level of insecurity and lack of precision. We therefore desist from hand-collecting all bank branches and instead run additional robustness tests below.

4.3 Competition and concentration

Panel A, B and C of Table 1 present summary statistics of district and bank characteristics in 2016 for the banks that were part of the stress test. Panel D looks at bank characteristics of the entire population of German banks over the period 1994–2016. In panels A and B, we look at low-LI versus high-LI districts, and low-HHI$_{loans}$ versus high-HHI$_{loans}$ districts with at least one bank in 2016, respectively. Because the LI is bank-specific, we first calculate district-level averages of the LI. We then divide the sample at the respective median of the (district-level) LI and the HHI distribution. Column (I) furthermore only presents data for banks for which a meaningful LI could be estimated.[29]

High-LI and high-HHI districts respectively have on average a smaller population in absolute terms and are characterised by a somewhat lower share of individuals over the age of 65 (Panel A). High-HHI counties are furthermore smaller while high-LI counties are on average larger. When averaging bank characteristics at the county level, both high-LI and HHI counties exhibit banks with on average higher return on assets and profits (Panel B). Similarly, high-LI and HHI banks are more profitable (Panel C). Over the full time period, when taking into account all banks (also the SI's), that pattern is even more pronounced (Panel D). Differences across the two measures of imperfect competition arise when looking at the banks' average exposure in the loan market: high-LI banks and counties appear to have on average lower loan volumes while high HHI banks and counties have higher loan volumes (Panels B and C). Over the full time period, when taking into account all banks, both high LI and HHI banks have smaller loan volumes (Panel D).[30]

Regarding volumes and market concentration, respectively, the pattern seems to be similar to the banking market in the U.S. There, high HHI institutions have larger portfolios regarding deposits (Drechsler et al., 2017).[31] However, high HHI counties in the U.S. are larger and have a higher population share that is older than 65.

Summing up, county-level pricing power and market concentration are related in opposite ways to county size, and county-average and bank-level size of the loan portfolio, respectively (in 2016). However, both higher market concentration and higher pricing power seem to indicate higher profitability. This is in line with both theory and previous empirical evidence on the relationship between local market concentration and profits (Berger and Mester, 1997; Pilloff and Rhoades, 2002).

4.4 Additional control variables

We control for several bank characteristics that might affect interest rate levels, and potentially the interest rate pass-through. Equity financing is associated with higher costs as opposed to external financing (Maudos and De Guevara, 2004). Hence, we control for a bank's *leverage* defined as the fraction of total assets over equity and expect a negative relationship with loan rate levels (Barattieri, Moretti, and Quadrini, 2016). On a similar note, De Graeve, De Jonghe, and Vander Vennet (2007) find a positive relationship between loan spreads and capital buffers since holding equity is associated with costs e.g. in the form of forgone profit; thus, we control for excess capital over total assets, *excess capital*. We will furthermore use this variable to test whether our results on imperfect competition are driven by the fact that banks with more market power have a weaker incentive to downplay the severity of the stress effect as they already hold larger capital buffers. We also control for *liquidity* by including securities over total liabilities, a variable which is important for the pass-through of monetary policy shocks to credit volumes

[29] In some occasions, the LI was negative or above one and we replaced these data entries by *missings* in the analysis and exclude them for this section.

[30] Results are qualitatively similar when applying the HHI in the deposit market and splitting the samples analogously.

[31] Patterns in our data do not change when applying the HHI for deposits and relating that to deposit volumes. Because the regional principle does not need to hold in the deposit market in Germany, we focus on loan volumes and corresponding market concentration.

Table 1: Descriptive statistics

	(I) Lerner Index			(II) Herfindahl Index		
	All	Low LI	High LI	All	Low HI	High HI
Panel A: County characteristics (2016)						
Popul. (in 1000)	210	235	185	210	265	156
Area (sq. km)	891	786	1000	891	995	791
Over 65 (%)	19.2	19.8	18.5	19.2	19.4	18.9
Obs. (counties)	385	192	192	385	192	192
Panel B: Bank characteristics by county (2016)						
Profits (mill.)	2085	1859	2294	2011	1683	2343
ROA (%)	0.77	0.67	0.87	0.74	0.72	0.76
Loans (mill.)	921	1151	685	910	859	961
LI/HHI	0.37	0.32	0.42	0.547	0.36	0.74
Obs. (counties)	385	192	192	385	192	192
Panel C: Bank characteristics (2016)						
Profits (mill.)	1,964	1,531	2,397	1,854	1,527	2,181
ROA (%)	0.77	0.60	0.94	0.72	0.007	0.75
Loans (mill.)	961	1307	615	960	886	1034
Deposits (mill.)	669	815	523	661	611	711
LI/HHI	0.37	0.29	0.45	0.43	0.28	0.58
Obs. (banks)	1,442	721	721	1,482	741	741
Panel D: Bank characteristics (all banks, 1994-2016)						
Profits (mill.)	444	379	509	425	330	520
ROA (%)	1.0	0.68	1.3	0.86	0.91	0.81
Loans (mill.)	1116	1865	367	1261	1479	1042
LI/HHI	0.30	0.23	0.37	0.36	0.22	0.5
Obs. (bank x year)	51,565	25,782	25,782	54,228	27,114	27,114

Notes: Summary statistics at the county and bank x year level. Panels break the sample into the median of the LI (I) and the HHI (II) distribution, respectively. All banks for which a plausible LI (i.e. a number between 0 and 1) could be calculated are considered for exercise (I) and only counties with at least one bank are considered for exercise (II). The HHI is concentration in the market for loans to private customers. Return on assets (ROA) is calculated as profits (i.e. the difference between total revenues and total costs) over total assets and reported in millions of Euros. Loans are the yearly reported volumes for loans to private customers in banks' balance sheets, in millions of Euros. Sources: Bundesbank supervisory data. Statistisches Bundesamt.

by banks (Kashyap and Stein, 2000). Monetary policy tightening aggravates liquidity constraints and therefore banks with lower levels of liquidity tighten lending by more. De Graeve et al. (2007) furthermore find that liquid banks have a lower pass-through. A bank's *funding* structure has been found to matter for its pass-trough of monetary policy (Weth, 2002; De Graeve et al., 2007). We thus include the ratio of deposits to interest paying liabilities to test its effect on the level of banks' interest rates. Given the low interest environment and mostly negative EURIBOR rates in 2016, it is plausible that our funding variable is positively associated with interest rate levels for loans. Then again, deposits are a more stable source of funding (Hanson, Shleifer, Stein, and Vishny, 2015) and banks relying more on deposit funding are found to be less vulnerable to financial shocks (Jensen and Johannesen, 2017). Therefore, a negative relationship between loan rates and deposit funding could also occur. We explicitly do not control for bank size in our estimations as it has been shown that (in contrast to the US) this is likely not to be adequate for the European and, in particular, the German banking market (Ehrmann and Worms, 2001; Worms, 2001). Due to the institutional structure of the German banking system, bank size is not a good predictor for access to funds via e.g. the interbank market. Small and medium sized banks mostly belong to the savings cooperative banks sector and are well interconnected within the respective sector via their central institutions (Worms, 2001). However, we do not completely abstract from potential heterogeneities related to bank size since we take it into account when estimating marginal costs.

5 Analysis

This section discusses the relationship between imperfect competition and interest rate levels and the pass-through, respectively.

5.1 Summary statistics

Table 2 highlights asymmetries within banks across the pricing of their products according to the *2017 low-interest-rate survey*. Column (1) displays averages and standard deviations for interest rates in the constant scenario, $ir^p_{constant}$, representing retail rates for noted categories p which reporting banks would set in 2017 in the absence of a sudden shift in the yield curve. In that occasion, average loan rates would lie at 3.2 percent and rates for interbank loans would be slightly negative. The average rate for deposits would be zero. Column (2) provides average retail rates for the shock scenario, ir^p_{shock}, and column (3) the pass-through of the shock in percent, $PT\,ir^p$, calculated as the difference between a bank's interest rate in the shock and in the constant scenario, normalised by the size of the shock. Following a 200 BP shock, banks would on average pass on 78 percent of the shock corresponding to an increase in loan rates by 1.57 percentage points. At the same time, banks would on average only offer higher deposit rates by 0.64 percentage points which implies a pass-through of 32 percent, confirming a certain stickiness of deposit rates in general (Hannan and Berger, 1991). Interest rates for interbank loans are closest to market rates with a pass-through of 90 percent.

Table 2: Summary statistics

	(1) $\text{ir}^p_{constant}$		(2) ir^p_{shock}		(3) PT ir^p		Obs.
p	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Loans	3.20	0.95	4.77	0.94	78.42	15.5	1,466
Bank loans	-0.025	0.30	1.79	0.46	90.24	19.56	1,433
Deposits	0.010	0.05	0.65	0.40	31.76	20.06	1,478

Notes: Summary statistics for interest rate levels and the pass-through for noted categories. Interest rate levels and the pass-through are winsorised at the bottom 1st and the top 99th percentile of the distribution, respectively. In particular, *Loans* consist of loans to non-financial customers which include all customers (such as households, firms and public entities) except banks. *Bankloans* denote interbank loans. All variables to be interpreted in percent. Source: 2017 low-interest-rate survey (BaFin/Bundesbank).

5.2 Market power and interest rate levels

In this section, we examine the relationship between market concentration and retail rate levels. Because the LI measures price setting power at the bank-level, it is already implied by a bank's interest rate *level*. To avoid endogeneity issues, we therefore only work with our structural measure of imperfect competition and estimate at the bank-level j:

$$ir_j^p = \alpha_0 + \alpha_1 HHI_d^p + \sum_{m=2}^{M} \alpha_m X_{jm} + \epsilon_j \qquad (I)$$

where ir_j^p consists of 2017 interest rate levels (in percent) for different product categories p. We control for ex-ante, i.e. 2016 values of all explanatory variables, denoted by $\sum_{m=2}^{M} X_{jm}$, which we outlined in Section 4.4. HHI_d^p measures the concentration in the respective product market p in district d in which a bank has its headquarter, equally measured in 2016. Our main focus lies on interest rate levels in the constant scenario. To test the quality of the survey data, we additionally run the same regression with retail rates from the shock scenario as a dependent variable. The coefficient of interest is α_1, measuring the effect of market concentration on levels of interest rates.

We find that loan rates in both the constant and the shock scenario are on average higher in more concentrated markets (columns 1 and 4 of Table 3). Deposit rates do not vary significantly across different levels of concentration in the absence of a policy contraction. This is likely to be the result of a long period of low policy rates. However, after an increase in policy rates, interest rates for deposits would on average be significantly lower in more concentrated markets (columns 3 and 6). These results are in line with the structure-conduct-performance paradigm where imperfect competition on average implies higher loan and lower deposit rates and are in line with previous analyses on the U.S. and Europe (Hannan and Berger, 1991; Maudos and De Guevara, 2004).[32] Because we do not control for borrower characteristics, our results for loans to non-banks do not rule

[32]Note that there is also work pointing at opposite results for interest margins in the EU (Maudos and De Guevara, 2004) and corporate loan pricing in Germany (Fungáčová et al., 2017).

Table 3: Interest rates levels and market concentration

Scenario	(1) ir_{loans} constant	(2) $ir_{bankloans}$ constant	(3) $ir_{deposits}$ constant	(4) ir_{loans} shock	(5) $ir_{bankloans}$ shock	(6) $ir_{deposits}$ shock
HHI_{loans}	0.55**			0.41**		
	(0.22)			(0.21)		
$HHI_{bankloans}$		-0.055			-0.047	
		(0.063)			(0.075)	
$HHI_{deposits}$			0.0079			-0.25***
			(0.0094)			(0.079)
funding	-0.28	-0.25*	-0.032	-0.24	-0.12	0.27**
	(0.27)	(0.13)	(0.020)	(0.23)	(0.18)	(0.13)
excess cap.	2.34*	0.060	-0.10	3.21**	0.080	-1.29***
	(1.42)	(0.22)	(0.073)	(1.31)	(0.35)	(0.38)
liquidity	0.064	-0.0001***	-0.000	-0.033	-0.000	-0.0001*
	(0.56)	(0.0000)	(0.000)	(0.54)	(0.0000)	(0.00004)
leverage	-0.032***	-0.000	-0.0014	-0.029***	-0.0006	-0.01***
	(0.006)	(0.003)	(0.0009)	(0.0061)	(0.005)	(0.004)
Constant	3.48	0.12	0.051	5.015	1.87	0.88
	(0.21)	(0.14)	(0.023)	(0.18)	(0.20)	(0.15)
N	1466	1433	1478	1466	1433	1478
R^2	0.0591	0.0181	0.0270	0.0569	0.0023	0.0514

Notes: Results from estimating specification (*I*). The dependent variables are interest rates for noted categories and scenarios in percent, winsorised at the bottom 1st and the top 99th percentile of the distribution. In particular, *Loans* consist of loans to non-financial customers which include all customers (such as households, firms and public entities) except banks. *Bankloans* denote interbank loans. Standard errors clustered at the county level in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sources: Bundesbank supervisory data & 2017 low-interest-rate survey (BaFin/Bundesbank).

out relationship lending as formulated by Rajan (1992) and Petersen and Rajan (1995). Accordingly, only for young firms with the lowest quality, credit is expected to be comparably cheaper in more concentrated markets as a result of relationship lending. Provided that borrower firms in our sample are e.g. on average rather old than young – or more generally speaking, ongoing relationships as opposed to new ones prevail – higher loan rates in more concentrated markets are in line with that theory. This is because banks in imperfectly competitive markets can back-load interest payments, making loan rates comparatively low only in the beginning of the relationship. The market for interbank loans seems to be unaffected by local market concentration (columns 2 and 5).

Turning to the additional bank controls, despite low interbank lending rates, the fraction of stable deposit funding (*funding*) is associated with lower loan rates, as are lower shares of costly equity financing (*leverage*). As expected, capital buffers (*excess capital*) translate into on average higher loan and lower deposit rates. Effects of bank controls are furthermore largely consistent across both scenarios. This can serve as an additional plausibility check for reported rates in response to the hypothetical shock.

5.3 Interest rate pass-through

In our main analyses, we examine the interest rate pass-through. Because the additional control variables ($\sum_{m=2}^{M} X_{jm}$) should affect interest rate levels in both scenarios in a similar way, their effects should cancel out in the pass-through regression.

We examine whether banks' pass-through is on average more or less complete the higher their individually exerted market power or the more concentrated the market environment is by estimating:

$$PT\,ir_j^p = \alpha_0 + \alpha_1 LI_j + \epsilon_j \qquad (II)$$

$$PT\,ir_j^p = \alpha_0 + \alpha_1 HHI_d^p + \epsilon_j \qquad (III)$$

where $PT\,ir_j^p$ denotes the pass-through of the shock for bank j, calculated as $(ir_{j,shock}^p - ir_{j,const}^p)/200\,BP$ for product category p. Coefficients are to be interpreted in percentage points (henceforth *p.p.*), where in both regressions α_1 is our coefficient of interest, telling us the direction of Equation (4). In (II), the coefficient gives by how many p.p. the pass-through changes with a marginal unit-increase in individual pricing power, measured by the Lerner Index, LI_j, in 2016. In (III) we assess the analogous relationship between the interest rate pass-through and market concentration in the respective product market, HHI_d^p, in 2016.

Table 4 provides estimation results according to specifications (II) and (III) for loans to non-financial customers and for deposits.[33] Columns (1) and (2) consistently show that the interest rate pass-through to loan rates significantly falls in market power.

On average, a one-standard-deviation increase in the LI is associated with a lower pass-through to loan rates by 1.06 p.p. or 0.068 standard deviations. Furthermore, after an increase in banks' marginal cost of funds, banks in more concentrated markets ceteris paribus (henceforth *c.p.*) pass a smaller share of the shock on (column (2)): a one-standard-deviation increase in concentration on average leads to a lower pass-through by 1.17 p.p. or 0.075 standard deviations.

After partialling out banks' expectations of credit demand shifts that are orthogonal to the two scenarios, our results corroborate a relatively more incomplete pass-through to loan rates with rising levels of market power. If different bank-level predictions of demand shifts between the baseline and the shock scenario entirely drove our results, we would observe the opposite, namely a larger pass-through with more market power: as discussed above, in the shock scenario credit demand should be expected to contract more at banks with less market power, c.p. making the pass-through relatively larger at more monopolistic banks. Thus, to the extent that banks do make these different demand predictions, our results are likely to be a lower bound for the hampering effect of market power on the interest rate pass-through.

Doubts may furthermore arise because according to the instructions, all banks have to replace maturing business with identical new business (static balance sheet assumption).

[33] Neither bank-level pricing power nor market concentration matter significantly for the pass-through to interbank loan rates (see Table C2 in Appendix C) and we therefore focus on loan rates for non-financial customers and deposit rates.

Table 4: Interest rate pass-through and market power

	(1) PT ir_{loans}	(2) PT ir_{loans}	(3) PT $ir_{deposits}$	(4) PT $ir_{deposits}$
LI	-9.86**		4.45	
	(4.84)		(6.72)	
HHI_{loans}		-5.85***		
		(2.11)		
$HHI_{deposits}$				-13.57***
				(4.33)
Constant	81.91	80.92	29.83	37.63
	(1.79)	(1.01)	(2.53)	(2.56)
N	1427	1466	1438	1478
R^2	0.0047	0.0057	0.0006	0.0177

Notes: Results from estimating specification (II) and (III). The dependent variable is the interest rate pass-through for noted categories in percent, winsorised at the bottom 1st and the top 99th percentile of the distribution. In particular, *Loans* consist of loans to non-financial customers which include all customers (such as households, firms and public entities) except banks. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are robust for columns (1) and (3), and clustered at the county level for columns (2) and (4), respectively. Sources: Bundesbank supervisory data & 2017 low-interest-rate survey (BaFin/Bundesbank).

This inter alia implies that loan quantities are not allowed to adjust, neither to the new market environment nor to the change in prices. Hence, if high-market power banks consistently have higher loan exposures, our results could be driven by these banks factoring in that they would have to hold back on raising rates to keep up their high loan volumes. The positive relationship between exposure and market concentration (HHI) is indeed prevalent in our data (see Table 1). However, we have shown in Table 1 that high-LI banks on average have *lower* loan exposures. The fact that both indices still imply the same direction of imperfect competition on the pass-through of the hypothetical shock to loan rates should therefore mitigate this concern.

Results so far indicate that the supply side of credit mainly drives a hindered interest rate pass-through in imperfectly competitive banking markets. An analysis of within-bank heterogeneities can potentially provide further insights on the underlying mechanism by e.g. helping to understand potential strategic bank behaviour. In particular, distorted competition in the deposit market has been proven to be crucial for monetary policy transmission (Drechsler et al., 2017).[34] The possibility to save expenses on their liability sides may thus enable banks to smooth loan rates for their borrowers. Strong ties between credit institutions and their customers could be the mechanism which keeps depositors attached to their banks. Similarly, relationships could then lead banks to smooth loan rates over the course of the match, insuring borrowers against sudden shocks.

While individual pricing power does not seem to significantly affect the sensitivity of deposit rates to an upward shift in the yield curve, market concentration plays a

[34]See also Sopp (2018) who builds a model where banks strategically use deposit rates to smooth overall profits. In that set-up, deposit rates depend on a bank's return on its loan portfolio.

substantial role (columns (3) and (4) of Table 4). On average, a one-standard-deviation increase in concentration leads to a lower pass-through by 0.13 p.p or 0.133 standard deviations.[35]

To get a deeper understanding of the heterogeneities and magnitudes of the coefficients, we calculate ceteris paribus effects from specifications (II) and (III) at two different percentiles of the LI and HHI distributions, respectively. That is, $\alpha_1 * LI_{10th}$ gives the c.p. effect of individual pricing power on the pass-through for a bank with a LI at the 10th percentile of its distribution in 2016, $\alpha_1 * LI_{90th}$ analogously the effect of a bank with a price setting power at the 90th percentile. The logic carries through for the HHI. In response to an upward shift in the yield curve, a bank with a low price setting power c.p. reduces the interest rate pass-through to loan rates by 2.4 p.p. while at a bank with a high LI this amounts to a reduction in the pass-through by 4.8 p.p., respectively compared to a bank operating under perfect competition (first row of Table 5). If a market is moderately concentrated, banks on average withhold 2.7 and 1.2 p.p. in the pass-through to deposit rates and loan rates, respectively, and this amounts to 9.6 and 4.2 p.p. in highly concentrated markets (second row of Table 5). Given an average pass-through to deposit rates of 30 percent, the effect on this market seems to be of substantial magnitude.

Table 5: Ceteris paribus effects for different percentiles of LI and HHI

(1)		(2)	
PT ir$_{loans}$		PT ir$_{deposits}$	
LI10	LI90	LI10	LI90
- 2.4	- 4.8	-	-
HHI10$_{loans}$	HHI90$_{loans}$	HHI10$_{deposits}$	HHI90$_{deposits}$
- 1.2	- 4.2	- 2.7	- 9.6

Notes: Results from estimating specifications (II) and (III). LI10 is the value of the LI at the 10th percentile of the sample distribution (in 2016), HHI10$_{loans}$ is the value of the HHI in the loan market at the 10th percentile, that logic carries through for the rest of the table. Source: Bundesbank supervisory data & 2017 low-interest-rate survey (BaFin/Bundesbank).

Presented results indicate that the interest rate pass-through is hampered by imperfect competition. Our estimations are in line with previous work on actual interest rate responses to monetary policy shocks for both Europe (Van Leuvensteijn et al., 2013; Gropp et al., 2014) and Germany (Schlueter et al., 2016).

We can provide suggestions for the driving mechanism. The reason could lie in the shape of banks' marginal cost curves (see section 2). It, however, seems more likely that strategic bank behaviour motivates banks. That is, banks operating in more imperfectly competitive markets withhold part of the increase in interest rates from those who deposit savings with them and in turn spare their borrowers a part of the general rise in funding

[35]In Table C3 in Appendix C, we include the additional bank controls into the regressions. Largely confirming our hypothesis, these seem to have no interaction effect with a shift in the yield curve on our pass-through variables (in particular for loan rates) and the effect of imperfect competition remains robust throughout.

costs. Sticky relationships could promote that objective. Because interest payments of new matches can be back-loaded in concentrated markets (Rajan, 1992), banks can more easily form long-term relationships with their borrowers the more concentrated the market is. While the two measures of imperfect competition seem to be related in opposite ways to several county and bank characteristics, both indicate that banks with higher market power have higher profits (in absolute terms and measured as return on assets). In addition, our results are largely consistent across the two measures of imperfect competition.[36] Because banks with market power on average charge higher than competitive loan rates and subsequently do not pass positive interest rate shocks on to depositors, they are likely to have the ability to absorb potential downside shocks to profits and thus insure their borrowers against such movements in the policy rate. In doing so, they also smooth their profits. Together with the *housebank* (or regional) principle in Germany, this indicates that strong ties between credit institutions and their customers could be the driving mechanism for our results.

6 Robustness of results

In the following section, we address potential concerns regarding strategically biased survey responses and our measure of market concentration.

6.1 Biased survey responses

Despite extensive data quality checks, we need to mitigate concerns that a bias due to strategic incentives correlated with market power drives our results. In particular, the positive (but insignificant) effect of the LI for the pass-through to deposit rates in combination with its significant negative effect for loan rates (columns 1 and 3 of Table 4) may give rise to this hypothesis. Certain banks (i.e. those with higher LI's) could for some reason be less concerned about the stress effect and therefore have reported a lower (higher), and thus more accurate pass-through to loan (deposit) rates.

Banks are likely to seek to avoid consequences from the stress test results which might curtail their leeway in conducting (lending) business, the most obvious example being high excess capital requirements. From the stress test, supervisors derive capital guidance which is higher the larger the resulting *stress effect* (i.e. the difference between a bank's interest incomes in the two scenarios). Banks with already larger excess capital in 2016 are likely to be less worried about the stress effect and thus might strategically report a smaller and more accurate pass-through to loan rates and a relatively more complete and truthful pass-through to deposit rates. If furthermore excess capital is systematically positively correlated with market power, our results in Table 4 could reflect these differential incentives.

Indeed, banks with more pricing power tend to have slightly higher capital buffers while capital buffers and market concentration are barely correlated (see Table 6). Note that higher capital buffers can indicate lower bank risk and therefore this is also in line with our above narrative of a negative relationship between risk and market power.

[36] Despite the effect of individual market power (LI) being insignificant for the pass-through to deposit rates, the positive sign of the coefficient may give rise to the concern that differential strategic responses

Table 6: Correlations between capital buffers and market power

	LI	HHI_{loans}	$HHI_{bank\,loans}$	$HHI_{deposits}$
Capital buffer	0.10	0.03	0.03	0.06

Notes: Correlation between Lerner indices, market concentration (as measured by the Herfindahl index) and capital buffers. Capital buffer is defined as excess capital (i.e. surplus of T1 capital) over total assets. Source: Bundesbank supervisory data. Own calculations.

Table 7: Pass-through to rates for loans and deposits in relation to capital buffers

	(1)	(2)	(3)
	PT ir_{loans}	PT $ir_{bank\,loans}$	PT $ir_{deposits}$
Capital buffer	23.84	0.43	-47.84***
	(17.50)	(15.65)	(15.87)
Constant	77.11	90.21	34.52
	(1.06)	(0.99)	(0.98)
N	1,466	1,433	1,478
R^2	0.0017	0.0000	0.0099

Notes: Results from regressing the different pass-through variables on excess capital. The dependent variable is the interest rate pass-through for noted categories in percent, winsorised at the bottom 1st and the top 99th percentile of the distribution. Capital buffer is defined as excess capital over risk-weighted assets. Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sources: Bundesbank supervisory data & 2017 low-interest-rate survey (BaFin/Bundesbank).

Results in Table 7, however, indicate that the pass-through to loan rates does not vary significantly with excess capital buffers of banks. Moreover, the direction of the effect is opposite to what strategic behaviour would lead us to expect: in line with work on realised interest rates, the pass-through to loan rates, if anything, rises with costly excess capital (De Graeve et al., 2007). Similarly, banks tend to withhold increases in deposit rates from their customers the higher their ex-ante capital buffers are, which again falsifies a strategic bias. This should rule out that our results could be driven by differential strategic incentives to avoid additional capital guidance.[37]

6.2 Market concentration

Analyses regarding market concentration have hinged on the *regional principle*, implying that banks mainly conduct business in the county in which they have their head quarter. While this is likely to hold for loans provided by small and medium-sized banks, it is problematic for larger banks. To mitigate this concern, we run two types of robustness tests in this section.

We first exclude all SI's which operate nationwide and calculate market concentration solely based on the sample of small and medium sized banks which are predominantly

drive our results. We address this concern in the following robustness analyses.

[37]Note also that the effect of imperfect competition remains significant after we control for ex-ante capital buffers, see Table C3 in Appendix C.

bound to operate locally.[38] This exercise leaves our main results qualitatively and quantitatively unchanged, both with and without additional controls, and the interest rate pass-through remains significantly hampered in more concentrated markets (Table 8).

Table 8: Pass-through and market concentration based on small and medium sized banks only

	(1)	(2)	(3)	(4)
	PT ir_{loans}	PT ir_{loans}	PT $ir_{deposits}$	PT $ir_{deposits}$
HHI_{loans}	-5.38***	-5.90***		
	(2.03)	(2.11)		
$HHI_{deposits}$			-14.10***	-13.48**
			(5.31)	(5.41)
funding		1.80		15.41**
		(4.65)		(6.05)
excess capital		43.37**		-57.61***
		(18.39)		(17.54)
liquidity		-2.73		-0.0045**
		(2.17)		(0.0021)
leverage		0.14		-0.46***
		(0.137)		(0.15)
Constant	80.76	76.14	37.84	41.20
	(0.98)	(4.27)	(2.94)	(6.75)
N	1466	1466	1478	1478
R^2	0.0047	0.0092	0.0200	0.0534

Notes: Results from estimating specification (III). Market concentration is calculated based on all small and medium sized banks only, i.e. large banks that operate nationwide are excluded. The dependent variable is the interest rate pass-through for noted categories in percent, winsorised at the bottom 1st and the top 99th percentile of the distribution. In particular, *Loans* consist of loans to non-financial customers which include all customers (such as households, firms and public entities) except banks. Standard errors clustered at the county level in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sources: Bundesbank supervisory data & 2017 low-interest-rate survey (BaFin/Bundesbank).

Second, we introduce a different and very simple proxy for the competitive pressure in a bank's surrounding area: we move away from bank data and exploit that cities are usually both more densely populated and characterised by higher bank penetration as well as better access to financial services in a wider sense. For instance, outdoor advertising by online banks are likely to be more present in cities as opposed to more suburban areas. Thus, we promote that population density and competitive pressure on a bank in an area are positively correlated and include population density (in 2016) instead of the previous competition/concentration measures into $(II)/(III)$. For that purpose, we

[38]The new HHI's are highly correlated to the old ones (with correlation coefficients above 0.95). Still, for 890 (153) and 843 (139) banks (counties) the HHI_{loans} and the $HHI_{deposits}$ changes, respectively.

move to a more granular level and include population density at the municipality-level into our estimation.

Table 9: Pass-through to interest rates for loans to non-financial customers and deposits

	(1) PT ir_{loans}	(2) PT $\text{ir}_{deposits}$
population density	2.33***	3.24*
	(0.38)	(1.81)
Constant	76.71	29.35
	(0.49)	(0.93)
N	1455	1467
R^2	0.0183	0.0217

Notes: Results from estimating (III) with municipality-level population density as measure for imperfect competition. The dependent variable is the interest rate pass-through for noted categories in percent, winsorised at the bottom 1st and the top 99th percentile of the distribution. In particular, *Loans* consist of loans to non-financial customers which include all customers (such as households, firms and public entities) except banks. Population density is municipality-level population density in 1000's of population per square kilometre. Standard errors clustered at the municipality level in parenthesis, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sources: 2017 low-interest-rate survey (BaFin/Bundesbank) & Statistisches Bundesamt.

Table 9 confirms our results: more competitive pressure measured by a more dense population increases the pass-through to both loan and deposit rates.[39] Higher density by 1,000 people per square kilometre in a municipality c.p. means a higher pass-through by 2.3 p.p. to loan rates and 3.2 p.p. to deposit rates. Coefficients are highly significant for loan rates but only marginally significant for deposit rates.[40] The latter could mirror that the regional principle does not exist for the deposit market.[41]

7 Conclusion

The 2017 stress test covering all small and medium sized banks in Germany provides us with an exceptional data set on the interest rate pass-through for various retail rates. Because the data delivers two data points per bank for the same point in time, rates for after a hypothetical upward shift in the yield curve and in the absence thereof, we can to a large extent control for potential demand shifts. We show that banks in imperfectly competitive markets charge higher loan rates but pass on smaller fractions of the rising market rates on to their borrowers. At the same time, these banks raise deposit rates to a relatively smaller extent. This strategic behaviour, coupled with higher profits of market-power banks and the housebank principle of the German credit market, leads us to conclude that banks in imperfectly competitive markets have the capacity to build

[39] We also test the dependence of interest rate levels on population density and find that loan rates in both scenarios are lower in more competitive markets as measured by higher population density (Table C1 in Appendix C).

[40] When we also include the additional bank controls, results are unchanged (Table C4 in Appendix C).

[41] Just as the LI and the HHI are no determinants of the pass-through to interbank loan rates, population density has barely any influence (columns 5 and 6 of Table C2 in Appendix C).

long-term relationships. Consequently, they seem to insure their borrowers against adverse shocks – at the expense of their depositors.

Policy makers know that some degree of market power ensures financial stability. We highlight that this, however, comes at a cost: the interest rate pass-through is hampered which inter alia implies that monetary policy is less effective. Because in boom phases which tend to precede financial and economic turmoil, market power seems to generally rise, monetary policy could be least effective when needed most.

A Appendix: Derivations for conceptual framework

A.1 Proof of Equation (2)

For convenience, we repeat Equation (2):

$$\mathrm{d}p = \frac{\partial p}{\partial q}\frac{\partial q}{\partial x}\mathrm{d}x + \left(\frac{\partial p}{\partial i} + \frac{\partial p}{\partial q}\frac{\partial q}{\partial i}\right)\mathrm{d}i$$

Consider the following functional forms for the curves in a standard IO model with monopolistic competition, using common textbook notation:

Inverse demand is $p(q) = i - bq$ with $i, b > 0$, marginal revenues are $mr = i - 2bq$ and marginal costs are $mc = zq^2 - yq + x$ with $x, y, z > 0$ and $i > x$. Note, in a simpler version where marginal costs are linear, $z = 0$, $x > 0$, $y < 0$ or where marginal costs are constant, $z = 0$, $x > 0$, $y = 0$. Three parameters are of particular interest here. First, the higher b, the steeper inverse demand and the more market power a monopolist can exert by applying a mark-up on marginal costs when setting the optimal price. The slope of demand is the partial derivative of the demand function with respect to (henceforth w.r.t.) q:

$$\frac{\partial p}{\partial q} = -b. \tag{10}$$

Second, the value of i determines the intercept of the inverse demand curve with $q = 0$. An exogenous demand shock thus changes i and can be interpreted as the maximum price a (marginal) customer would be willing to pay (in the limit when $q \to 0$). The partial derivative of the demand function w.r.t. i is:

$$\frac{\partial p}{\partial i} = 1. \tag{11}$$

Third, x is the intercept of the marginal cost curve and therefore a shock to marginal costs changes x.

Profit maximisation leads to the equilibrium condition of $mr = mc$. As a result, the equilibrium quantity, q^*, and price, p^*, are:

$$q^* = \frac{y - 2b + \sqrt{(2b-y)^2 + 4z(i-x)}}{2z} > 0 \tag{12}$$

$$p^* = i - \frac{b(y - 2b + \sqrt{(2b-y)^2 + 4z(i-x)})}{2z} > 0 \tag{13}$$

When $z = 0$, $y < 0$

$$p^* = i - \frac{b(i-x)}{2b+y} > 0$$

and $p^* = i - \frac{i-x}{2}$ when marginal costs are constant. The corresponding equilibrium quantities are

$$q^* = \frac{i-x}{2b+y}$$

and $q^* = \frac{i-x}{2b}$, respectively.

The pass-trough of a cost shock to the price is derived as the change in the price in response to a parallel shift in the curve of marginal costs, i.e. a change in x. The total derivative of (13) w.r.t. x gives:

$$\frac{\mathrm{d}p^*}{\mathrm{d}x} = \frac{b}{\sqrt{(2b+y)^2 + 4z(i-x)}} > 0 \tag{14}$$

An increase in marginal costs results in an increase in the price. With $z = 0$, $y < 0$

$$\frac{\mathrm{d}p^*}{\mathrm{d}x} = \frac{b}{2b+y} > 0$$

Note that the change in the equilibrium price depends on the slope of demand and hence on the level of market power. If marginal costs are constant, $y = 0$ and the pass-through simplifies to a constant, $\frac{1}{2}$.

The corresponding change in the equilibrium quantity from differentiating Equation (12) is:

$$\frac{\partial q}{\partial x} = -\frac{1}{\sqrt{(2b-y)^2 + 4z(i-x)}} < 0 \tag{15}$$

Following a cost shock, the equilibrium quantity shrinks. Note, this is identical to the total derivative $\frac{\mathrm{d}q^*}{\mathrm{d}i}$ since q is a (direct) function of i, x. With $z = 0$, $y < 0$

$$\frac{\partial q}{\partial x} = -\frac{1}{2b+y} < 0$$

In the case of constant marginal costs this simplifies to $-\frac{1}{2b}$.

Equations (10), (11), (15) are the components of Equation (2) when marginal costs are convex. The following derivation shows that $\frac{\mathrm{d}p^*}{\mathrm{d}x}$ is equivalent to the first part in Equation (2) which is repeated above:

$$\frac{\partial p}{\partial q}\frac{\partial q}{\partial x} = -b * \left(-\frac{1}{\sqrt{(2b-y)^2 + 4z(i-x)}}\right) = \frac{b}{\sqrt{(2b-y)^2 + 4z(i-x)}} = \frac{\mathrm{d}p^*}{\mathrm{d}x} \quad q.e.d. \tag{16}$$

It is easy to see that this also holds true for the cases where marginal costs are linear or constant.

The price change in response to a change in demand is derived by totally differentiating (13) w.r.t. i:

$$\frac{\mathrm{d}p^*}{\mathrm{d}i} = 1 - \frac{b}{\sqrt{(2b-y)^2 + 4z(i-x)}}$$

A demand shock has a direct effect on the price which goes into the same direction of the shock, $\frac{\partial p}{\partial i} = 1$, and an indirect effect, $\frac{\partial p}{\partial q}\frac{\partial q}{\partial i}$, which works in the opposite direction of the direct effect: in the case of a negative demand shock, the direct effect pushes the equilibrium price down. However, the more market power the monopolist has, i.e. the relatively less elastic demand (or the steeper demand), the smaller the price reduction towards the new equilibrium. When $z = 0$, $y < 0$, this is

$$\frac{\mathrm{d}p^*}{\mathrm{d}i} = 1 - \frac{b}{2b + y}$$

In the case of constant marginal costs this simplifies to $\frac{1}{2}$.

The corresponding change in the equilibrium quantity is:

$$\frac{\partial q}{\partial i} = \frac{\mathrm{d}q^*}{\mathrm{d}i} = \frac{1}{\sqrt{(2b - y)^2 + 4z(i - x)}}$$

When $z = 0$, $y < 0$, this is

$$\frac{\mathrm{d}q^*}{\mathrm{d}i} = \frac{1}{2b + y}$$

In the case of constant marginal costs this simplifies to $1/2b$.

The following derivation shows that $\frac{\mathrm{d}p^*}{\mathrm{d}i}$ is equivalent to the second part in Equation (2) which is repeated above:

$$\left(\frac{\partial p}{\partial i} + \frac{\partial p}{\partial q}\frac{\partial q}{\partial i}\right)\mathrm{d}i = 1 - b * \frac{1}{\sqrt{(2b + y)^2 + 4z(i - x)}} = \frac{\mathrm{d}p^*}{\mathrm{d}i} \quad q.e.d. \tag{17}$$

It is easy to see that this also holds true for the cases where marginal costs are linear or constant.

A.2 Dependence of the pass-through on market power

The following Equation derives how the pass-through depends on the slope of demand which measures market power in this framework:

$$\begin{aligned} \frac{\mathrm{d}(\mathrm{d}p^*/\mathrm{d}x)}{\mathrm{d}b} &= \frac{1}{\sqrt{(2b - y)^2 + 4z(i - x)}} - \frac{b(8b - 4y)}{2[(2b - y)^2 + 4z(i - x)]^{\frac{3}{2}}} \\ &= \frac{y^2 - 2by + 4iz - 4xz}{[(2b + y)^2 + 4z(i - x)]^{\frac{3}{2}}} \end{aligned} \tag{18}$$

The pass-through is smaller for banks with more market power, i.e. $\frac{\mathrm{d}(\mathrm{d}p/\mathrm{d}x)}{\mathrm{d}b} < 0$ if

$$b > \frac{y}{2} + \frac{2z(i - x)}{y}$$

Intuitively, when demand is "steep enough", the pass-through can fall in market power. To be precise, as long as demand does not intersect marginal costs in their increasing part of the curve, the pass-through falls in b.

Otherwise, the pass-through is larger the steeper demand, $\frac{\mathrm{d}(\mathrm{d}p/\mathrm{d}x)}{\mathrm{d}b} > 0$. Note that if marginal costs are linear($z = 0$, $y < 0$), the pass-through always increases in b:

$$\frac{\mathrm{d}(\mathrm{d}p^*/\mathrm{d}x)}{\mathrm{d}b} = \frac{y}{(2b - y)^2} > 0$$

When marginal costs are constant, the pass-through does not depend on the slope of demand. Note that in this model, a monotonic dependence of the Lerner Index on b is always given for the linear version of marginal cost, while it is a possible and plausible case in the quadratic model.

B Appendix: Theoretical background for marginal costs

In economic theory, banks fulfil an intermediary role, hence a bank's financial assets, i.e. loans (to customers and banks) as well as securities are considered as its output. As inputs it is assumed that banks use labour, capital and loanable funds.

Following Clark (1984) we assume a (homogenous) Cobb-Douglas production function of the following form:

$$Y_i = AK_j^{\alpha_1} L_j^{\alpha_2} F_j^{\alpha_3}$$

where Y_j is bank $j's$ total output, K_j represents capital inputs, L_j labour inputs and F_j loanable funds. While the choice of the functional form may seem arbitrary, Clark (1984) discussed that the assumption of a Cobb-Douglas production function does not appear to be inappropriate.

The cost function of bank j is given by

$$TOC_j = p_j K_j + w_i L_j + r_i F_j$$

where p_j denotes bank j's price of capital, w_j the price of labour, and r_j the price of loanable funds. Total costs as a function of inputs and outputs can be derived from minimising total costs with respect to the inputs, while having the constraint of the production function:

$min\ TOC_j$ subject to $Y_j = AK_j^{\alpha_1} L_j^{\alpha_2} F_j^{\alpha_3}$

Using the method of Lagrange multipliers, the first order conditions w.r.t. labour, capital and funds, and the Lagrange multiplier λ are:

$$(K_j) : p_j - \lambda A \alpha_1 K_j^{\alpha_1 - 1} L_j^{\alpha_2} F_j^{\alpha_3} \equiv 0 \tag{19}$$

$$(N_j) : w_j - \lambda A \alpha_2 K_j^{\alpha_1} L_j^{\alpha_2 - 1} F_j^{\alpha_3} \equiv 0 \tag{20}$$

$$(F_j) : r_j - \lambda A \alpha_3 K_j^{\alpha_1} L_j^{\alpha_2} F_j^{\alpha_3 - 1} \equiv 0 \tag{21}$$

$$(\lambda) : Y_j - AK_j^{\alpha_1} L_j^{\alpha_2} F_j^{\alpha_3} \equiv 0 \tag{22}$$

From (19) and (20) we obtain

$$K_j = \frac{w_j}{p_j} \frac{\alpha_1}{\alpha_2} L_j$$

and from (20) and (21)

$$F_j = \frac{w_j}{r_j}\frac{\alpha_3}{\alpha_2}L_j\,.$$

Plugging these expressions into (22) and solving for L_j gives

$$L_j = \left[\frac{Y_j}{A}\left(\frac{p_j}{w_j}\frac{\alpha_2}{\alpha_1}\right)^{\alpha_1}\left(\frac{r_j}{w_j}\frac{\alpha_2}{\alpha_3}\right)^{\alpha_3}\right]^{\frac{1}{\alpha_1+\alpha_2+\alpha_3}}$$

The cost function can furthermore be written as

$$TOC_j = p_j\frac{w_j}{p_i}\frac{\alpha_1}{\alpha_2}L + w_jL_j + r_j\frac{w_j}{r_j}\frac{\alpha_3}{\alpha_2}L_j \tag{23}$$

After plugging in the above expression for L_j, total costs can be written as a function of output Y_j, and input prices, w_j, r_j, p_j

$$TOC(Y_j, w_j, r_j, p_j) = XA^{-\frac{1}{X}}(\alpha_1^{\frac{\alpha_1}{X}}\alpha_2^{\frac{\alpha_2}{X}}\alpha_3^{\frac{\alpha_3}{X}})^{-1}Y_j^{\frac{1}{X}}p_j^{\frac{\alpha_1}{X}}w^{\frac{\alpha_2}{X}}r_j^{\frac{\alpha_3}{X}} \tag{24}$$

where $X = \alpha_1 + \alpha_2 + \alpha_3$. Note, $XA^{-\frac{1}{X}}(\alpha_1^{\frac{\alpha_1}{X}}\alpha_2^{\frac{\alpha_2}{X}}\alpha_3^{\frac{\alpha_3}{X}})^{-1}$ is not bank specific.

Taking logs gives

$$\log(TOC_j) = XA^{-\frac{1}{X}}(\alpha_1^{\frac{\alpha_1}{X}}\alpha_2^{\frac{\alpha_2}{X}}\alpha_3^{\frac{\alpha_3}{X}})^{-1} + \frac{1}{X}\log(Y_j) + \frac{\alpha_1}{X}\log(p_j) + \frac{\alpha_2}{X}\log(w_j) + \frac{\alpha_3}{X}\log(r_j) \tag{25}$$

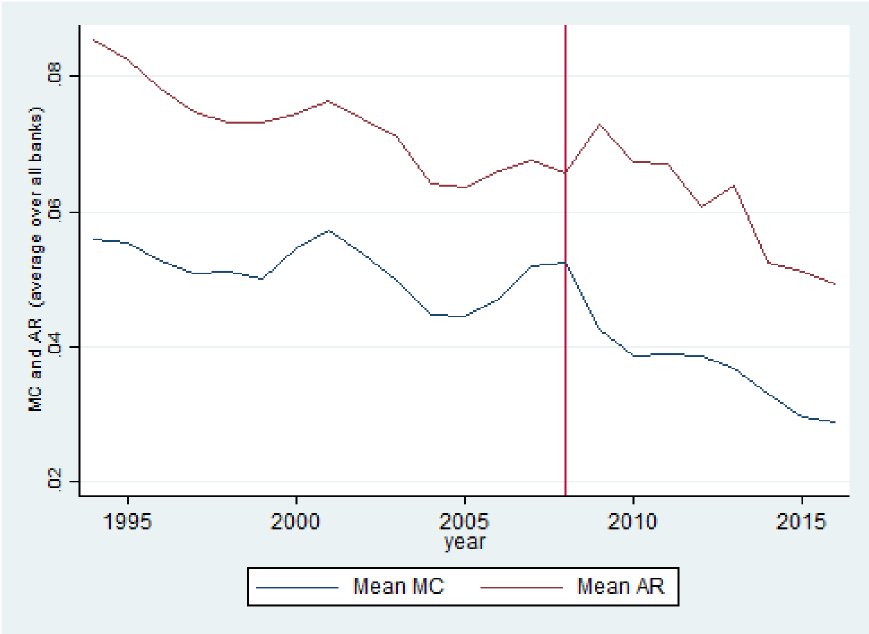
That translog cost function can be estimated from the data and marginal costs derived from it as the first derivative of costs with respect to total output.

Table B1: Summary statistics

variable	N	mean	sd
Total costs, TOC	54228	1.12e+08	9.48e+08
Total revenues, TOR	54228	1.21e+08	9.35e+08
Total output, Y	54228	2.34e+09	1.93e+10
Interbank loans	54228	5.87e+08	6.64e+09
Loans to non-financial customers	54228	1.26e+09	9.50e+09
Securities	54228	4.90e+08	4.27e+09
Cost of fixed labour	52540	62258.81	168385.9
Cost of borrowed funds	54170	.286	57.864
Cost of fixed assets	54228	.243	13.328
Marginal costs, MC	52525	.048	.058
Lerner Index, LI	51565	.301	.092

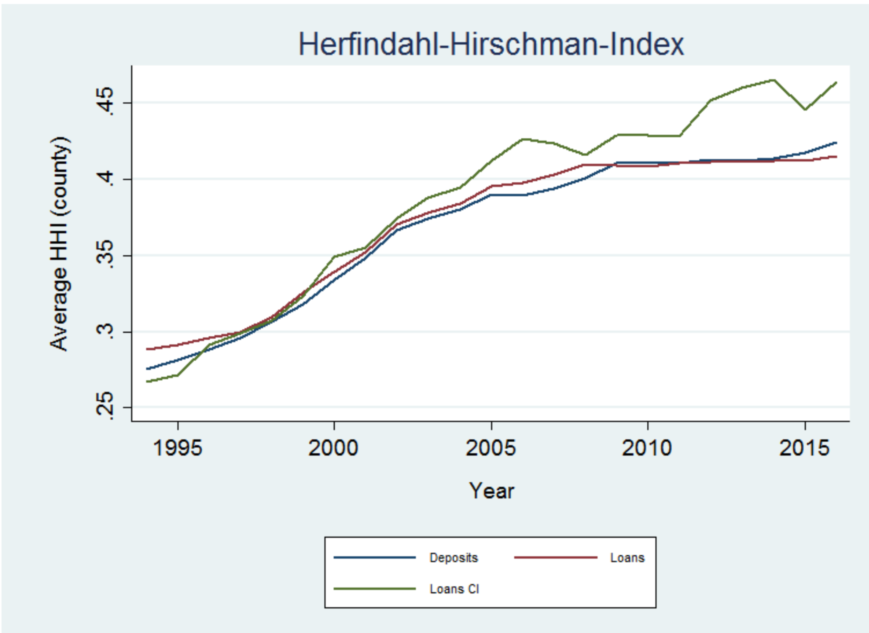
Notes: Summary statistics over the full time period 1994-2016. Source: Bundesbank supervisory data. Own calculations.

Figure B1: Evolution of marginal costs and average revenues over time



Note: Unweighted mean of marginal costs and average revenues of all German banks over time. Vertical red line in (i.e. at the end of) 2008.

Figure B2: Evolution of average concentration over time



Note: The figure shows the unweighted mean of county-level concentration of all German banks over time in the deposit, loan and interbank loan ("Loans CI") market, respectively. County reforms are taken into account.

C Appendix: Robustness tables

Table C1: Interest rate levels for loans to non-financials, financials and for deposits

	(1)	(2)	(3)	(4)	(5)	(6)
	ir_{loans}	$\text{ir}_{bank\,loans}$	$\text{ir}_{deposits}$	ir_{loans}	$\text{ir}_{bank\,loans}$	$\text{ir}_{deposits}$
	constant	constant	constant	shock	shock	shock
popul. density	-0.34***	0.041	-0.0024	-0.29***	0.014	0.071*
	(0.043)	(0.035)	(0.0026)	(0.038)	(0.040)	(0.036)
funding	-0.18	-0.27**	-0.031	-0.16	-0.13	0.24*
	(0.22)	(0.13)	(0.019)	(0.20)	(0.18)	(0.13)
excess capital	2.75*	-0.057	-0.089	3.52***	0.009	-1.63***
	(1.43)	(0.24)	(0.065)	(1.30)	(0.38)	(0.40)
liquidity	0.21	-0.0002***	-0.000	0.097	-0.000	-0.0001*
	(0.43)	(0.000)	(0.000)	(0.43)	(0.000)	(0.000)
leverage	-0.025***	-0.001	-0.001	-0.023***	-0.001	-0.013***
	(0.0059)	(0.0032)	(0.00087)	(0.0059)	(0.0060)	(0.0039)
Constant	3.74***	0.098	0.054**	5.22***	1.86***	0.79***
	(0.17)	(0.11)	(0.025)	(0.19)	(0.18)	(0.12)
N	1455	1422	1467	1455	1422	1467
R^2	0.1478	0.0309	0.0282	0.1259	0.0025	0.0621

Notes: Results from estimating specification (I) with municipality-level population density as only competition/concentration measure. The dependent variable is the interest rate pass-through to banks' retail rates for noted categories in percent, winzorised at the upper and lower percentile. Population density is municipality-level population density in 1000's of population per square kilometre. Standard errors clustered at the municipality level in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sources: Bundesbank supervisory data & Low-interest-rate survey 2017 & Statistisches Bundesamt.

Table C2: Pass-through to rates for interbank loans

	PT $\text{ir}_{bank\,loans}$					
	(1)	(2)	(3)	(4)	(5)	(6)
LI	4.17	3.22				
	(6.40)	(6.29)				
$\text{HHI}_{bank\,loans}$			0.80	0.38		
			(2.44)	(2.48)		
population density					-1.098*	-1.14*
					(0.59)	(0.63)
funding		3.92		6.68		7.013
		(4.89)		(4.49)		(4.53)
excess capital		2.46		-0.12		1.80
		(18.95)		(15.84)		(16.03)
liquidity		0.004*		0.004**		0.0052**
		(0.0021)		(0.0022)		(0.0023)
leverage		0.004		-0.049		-0.033
		(0.17)		(0.17)		(0.18)
Constant	88.84***	87.09***	89.86***	87.67	91.048***	88.14
	(2.42)	(5.33)	(1.35)	(4.35)	(0.63)	(4.31)
N	1398	1398	1433	1433	1422	1422
R^2	0.0005	0.0015	0.0001	0.0027	0.0024	0.0054

Notes: Results from estimating specifications (II) and (III). The dependent variable is the interest rate pass-through to banks' rates for interbank loans, winzorised at the upper and lower percentile. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are robust for column (1) and (3), clustered at the county level for column (2) and (4), and clustered at the municipality level for column (5) and (6). Sources: Bundesbank supervisory data & Low-interest-rate survey 2017. Statistisches Bundesamt.

Table C3: Pass-through for loans to non-financials, and to deposits

	(1)	(2)	(3)	(4)
	PT ir$_{loans}$	PT ir$_{loans}$	PT ir$_{deposits}$	PT ir$_{deposits}$
LI	-9.251*		4.703	
	(5.12)		(6.69)	
HHI$_{loans}$		-6.48***		
		(2.11)		
HHI$_{deposits}$				-12.85***
				(4.26)
funding	1.638	2.118	14.64**	15.39**
	(3.98)	(4.54)	(6.20)	(6.20)
excess capital	30.16	43.59**	-72.18***	-57.94***
	(24.24)	(18.26)	(16.81)	(17.64)
liquidity	-5.281	-3.102	-0.002	-0.004*
	(4.77)	(2.14)	(0.0019)	(0.0020)
leverage	0.167	0.142	-0.467***	-0.464***
	(0.12)	(0.14)	(0.14)	(0.15)
Constant	77.84***	76.21***	34.59***	41.03***
	(4.11)	(4.37)	(5.25)	(6.55)
N	1427	1466	1438	1478
R^2	0.0100	0.0105	0.0393	0.0509

Notes: Results from estimating specification (II) and (III). The dependent variable is the interest rate pass-through to banks' retail rates for noted categories in percent, winzorised at the upper and lower percentile. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are robust for columns (1), (3) and (5), and clustered at the county level for columns (2), (4) and (6). Sources: Bundesbank supervisory data & Low-interest-rate survey 2017.

Table C4: Pass-through to rates for loans to non-financial customers and deposits

	(1)	(2)
	PT ir_{loans}	PT $\text{ir}_{deposits}$
population density	2.399***	3.692*
	(0.44)	(1.91)
funding	0.962	13.85**
	(4.13)	(5.88)
excess capital	39.45**	-75.85***
	(19.18)	(18.51)
liquidity	-3.941*	-0.00520**
	(2.14)	(0.0026)
leverage	0.0752	-0.591***
	(0.13)	(0.17)
Constant	73.81***	36.61***
	(3.94)	(4.93)
N	1455	1467
R^2	0.0229	0.0636

Notes: Results from estimating (II) with municipality-level population density as only competition/concentration measure. The dependent variable is the interest rate pass-through to banks' retail rates for noted categories in percent, winzorised at the upper and lower percentile. Population density is municipality-level population density in 1000's of population per square kilometre. Standard errors clustered at the municipality level in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sources: Bundesbank supervisory data & Low-interest-rate survey 2017. Statistisches Bundesamt.

References

Adams, R. M. and D. F. Amel (2011). Market structure and the pass-through of the federal funds rate. *The Journal of Banking & Finance 35*(5), 1087–1096.

Agarwal, S., S. Chomsisengphet, N. Mahoney, and J. Stroebel (2017). Do banks pass through credit expansions to consumers who want to borrow? *The Quarterly Journal of Economics 133*(1), 129–190.

Aigner, D., C. Lovell, and P. Schmidt (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics 6*(1), 21–37.

Altavilla, C., M. Boucinha, S. Holton, and S. Ongena (2018). Credit supply and demand in unconventional times. Working Paper no. 2202, European Central Bank.

BaFin/Bundesbank (2017, April). Methodological guidelines of low-interest-rate survey 2017. http://www.bundesbank.de/Bankenaufsicht/nzu-umfrage, viewed 20 January 2018.

Bain, J. S. (1956). *Barriers to new competition*, Volume 3. Harvard University Press Cambridge, MA.

Barattieri, A., L. Moretti, and V. Quadrini (2016). Banks interconnectivity and leverage. CEPR Discussion Paper no. DP11502.

Berger, A. N. (1995). The profit-structure relationship in banking–tests of market-power and efficient-structure hypotheses. *Journal of Money, Credit and Banking 27*(2), 404–431.

Berger, A. N., L. F. Klapper, and R. Turk-Ariss (2009). Bank competition and financial stability. *Journal of Financial Services Research 35*(2), 99–118.

Berger, A. N. and L. J. Mester (1997). Inside the black box: What explains differences in the efficiencies of financial institutions? *The Journal of Banking & Finance 21*(7), 895–947.

Bernanke, B. and M. Gertler (1989). Agency costs, net worth, and business fluctuations. *The American Economic Review 79*(1), 14–31.

Bernanke, B., M. Gertler, and S. Gilchrist (1999). The financial accelerator in a quantitative business cycle framework. *In: Taylor, J.B. Woodford, M. (Eds.), Handbook of Macroeconomics 1.1*, 1341–1393.

Bikker, J. A., S. Shaffer, and L. Spierdijk (2012). Assessing competition with the Panzar-Rosse model: The role of scale, costs, and equilibrium. *The Review of Economics and Statistics 94*(4), 1025–1044.

Brämer, P., H. Gischer, T. Richter, and M. Weiß (2013). Competition in banks' lending business and its interference with ECB monetary policy. *Journal of International Financial Markets, Institutions and Money 25*, 144–162.

Christensen, L. R., D. W. Jorgenson, and L. J. Lau (1973). Transcendental logarithmic production frontiers. *The Review of Economics and Statistics*, 28–45.

Claessens, S. and L. Laeven (2004). What drives bank competition? Some international evidence. *Journal of Money, Credit, and Banking 36*(3), 563–583.

Clark, J. A. (1984). Estimation of economies of scale in banking using a generalized functional form. *Journal of Money, Credit and Banking 16*(1), 53–68.

Coccorese, P. (2009). Market power in local banking monopolies. *The Journal of Banking & Finance 33*(7), 1196–1210.

Corbae, D. and R. Levine (2018). Competition, stability, and efficiency in financial markets. Unpublished manuscript.

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

Di Maggio, M., A. Kermani, B. J. Keys, T. Piskorski, R. Ramcharan, A. Seru, and V. Yao (2017). Interest rate pass-through: Mortgage rates, household consumption, and voluntary deleveraging. *The American Economic Review 107*(11), 3550–88.

Drechsler, I., A. Savov, and P. Schnabl (2017). The deposits channel of monetary policy. *The Quarterly Journal of Economics 132*(4), 1819–1876.

Duffie, D. and A. Krishnamurthy (2016). Passthrough efficiency in the Fed's new monetary policy setting. Unpublished manuscript.

Ehrmann, M. and A. Worms (2001). Interbank lending and monetary policy transmission – Evidence for Germany. Working Paper no. 73, European Central Bank.

European Parliament and Council (2010). Regulation (EU) No. 1093/2010 of the European Parliament and of the Council of 24 November 2010 establishing a European Supervisory Authority (European Banking Authority), amending Decision No. 716/2009/EC and repealing Commission Decision 2009/78/EC.

Fungáčová, Z., A. Shamshur, and L. Weill (2017). Does bank competition reduce cost of credit? Cross-country evidence from Europe. *The Journal of Banking & Finance 83*, 104–120.

Fungáčová, Z., L. Solanko, and L. Weill (2014). Does competition influence the bank lending channel in the euro area? *The Journal of Banking & Finance 49*, 356–366.

Gerali, A., S. Neri, L. Sessa, and F. M. Signoretti (2010). Credit and banking in a DSGE model of the euro area. *Journal of Money, Credit and Banking 42*(1), 107–141.

Greene, W. (2005). Reconsidering heterogeneity in panel data estimators of the stochastic frontier model. *Journal of Econometrics 126*(2), 269–303.

Gropp, R., C. Kok, and J.-D. Lichtenberger (2014). The dynamics of bank spreads and financial structure. *The Quarterly Journal of Finance 4*(4), 1–53.

Güntner, J. H. (2011). Competition among banks and the pass-through of monetary policy. *Economic Modelling 28*(4), 1891–1901.

Hannan, T. H. and A. N. Berger (1991). The rigidity of prices: Evidence from the banking industry. *The American Economic Review 81*(4), 938–945.

Hanson, S. G., A. Shleifer, J. C. Stein, and R. W. Vishny (2015). Banks as patient fixed-income investors. *Journal of Financial Economics 117*(3), 449–469.

Jensen, T. L. and N. Johannesen (2017). The consumption effects of the 2007–2008 financial crisis: Evidence from households in Denmark. *The American Economic Review 107*(11), 3386–3414.

Kashyap, A. K. and J. C. Stein (2000). What do a million observations on banks say about the transmission of monetary policy? *The American Economic Review 90*(3), 407–428.

Kick, T. and E. Prieto (2014). Bank risk and competition: Evidence from regional banking markets. *Review of Finance 19*(3), 1185–1222.

Kick, T. K., T. Pausch, and B. Ruprecht (2015). The winner's curse: Evidence on the danger of aggressive credit growth in banking. Discussion Paper no. 32, Deutsche Bundesbank.

Koetter, M. (2013). Market structure and competition in German banking: Modules I and IV. Working Paper no. 06/2013, German Council of Economic Experts.

Koetter, M., J. W. Kolari, and L. Spierdijk (2012). Enjoying the quiet life under deregulation? Evidence from adjusted Lerner indices for US banks. *The Review of Economics and Statistics 94*(2), 462–480.

Koetter, M. and O. Vins (2008). The quiet life hypothesis in banking: Evidence from German savings banks. Working Paper no. 190, Finance & Accounting.

KWG. Gesetz über das Kreditwesen (Kreditwesengesetz - KWG).

Lapteacru, I. (2014). Do more competitive banks have less market power? The evidence from Central and Eastern Europe. *Journal of International Money and Finance 46*, 41–60.

Leroy, A. (2014). Competition and the bank lending channel in Eurozone. *Journal of International Financial Markets, Institutions and Money 31*, 296–314.

Martinez-Miera, D. and R. Repullo (2018). Interest rates, market power, and financial stability. Unpublished manuscript.

Mason, E. S. (1939). Price and production policies of large-scale enterprise. *The American Economic Review 29*(1), 61–74.

Maudos, J. and J. F. De Guevara (2004). Factors explaining the interest margin in the banking sectors of the European Union. *The Journal of Banking & Finance 28*(9), 2259–2281.

Meeusen, W. and J. van Den Broeck (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review 18*(2), 435–444.

Mester, L. J. (1996). A study of bank efficiency taking into account risk-preferences. *The Journal of Banking & Finance 20*(6), 1025–1045.

Petersen, M. A. and R. G. Rajan (1995). The effect of credit market competition on lending relationships. *The Quarterly Journal of Economics 110*(2), 407–443.

Pilloff, S. J. and S. A. Rhoades (2002). Structure and profitability in banking markets. *Review of Industrial Organization 20*(1), 81–98.

Rajan, R. G. (1992). Insiders and outsiders: The choice between informed and arm's-length debt. *The Journal of Finance 47*(4), 1367–1400.

Ruckes, M. (2004). Bank competition and credit standards. *Review of Financial Studies 17*(4), 1073–1102.

Sääskilahti, J. (2016). Local bank competition and small business lending after the onset of the financial crisis. *The Journal of Banking & Finance 69*, 37–51.

Sapienza, P. (2002). The effects of banking mergers on loan contracts. *The Journal of Finance 57*(1), 329–367.

Schlueter, T., R. Busch, S. Sievers, and T. Hartmann-Wendels (2016). Loan pricing: Do borrowers benefit from cost-efficient banking? *Credit and Capital Markets 49*(1), 93–125.

Schwert, M. (2018). Bank capital and lending relationships. *The Journal of Finance 73*(2), 787–830.

Shaffer, S. and L. Spierdijk (2015). The Panzar-Rosse revenue test and market power in banking. *The Journal of Banking & Finance 61*, 340–347.

Sopp, H. (2018). Interest rate pass-through to the rates of core deposits: A new perspective. Discussion Paper no. 25, Deutsche Bundesbank.

Stolz, S. and M. Wedow (2011). Banks regulatory capital buffer and the business cycle: Evidence for Germany. *Journal of Financial Stability 7*(2), 98–110.

Valverde, S. C. and F. R. Fernandez (2007). The determinants of bank margins in european banking. *The Journal of Banking & Finance 31*, 2043–2063.

Van Leuvensteijn, M., C. K. Sorensen, J. A. Bikker, and A. A. van Rixtel (2013). Impact of bank competition on the interest rate pass-through in the euro area. *Applied Economics 45*(11), 1359–1380.

Weth, M. A. (2002). The pass-through from market interest rates to bank lending rates in Germany. Economic Research Centre Discussion Paper no. 11, Deutsche Bundesbank.

Worms, A. (2001). The reaction of bank lending to monetary policy measures in Germany. Working Paper no. 96, European Central Bank.