Universität St.Gallen

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April 2016 Discussion Paper no. 2016-06

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Publisher: School of Economics and Political Science
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Electronic Publication: Fax +41 71 224 31 35
http://www.seps.unisg.ch

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[1] I thank Christian Keuschnigg, Michael Devereux, Stefan Legge, Martin Simmler, seminar participants at University of St.Gallen, and participants at the 8th RGS Doctoral Conference in Economics in Essen, the Doctoral Meeting at Oxford University Centre for Business Taxation, and the Royal Economic Society 2016 Annual Conference in Brighton for helpful discussions and comments. Financial support of the Swiss National Science Foundation (Project no. 100018_146685/1) is gratefully acknowledged.

Abstract

Several European countries have recently introduced levies on bank liabilities to internalise the fiscal costs of banking crises. This paper studies the tax incidence: Building on the Monti-Klein model, we predict that banks shift the burden to borrowers by raising lending rates and that deposit rates may increase as deposits are partly exempt. Bank-level evidence for 23 EU countries in the period 2007-2013 implies a moderate increase in lending and deposit rates and net interest margins. Market characteristics and capital structure influence the magnitude: The lending rate strongly increases in concentrated markets, whereas the pass-through is weak for well-capitalised banks.

Keywords

Taxation of banks, Tax Incidence, Pigovian taxes.

JEL Classification

G21, G28, H22.

1 Introduction

Banking crises are expensive: Beyond their impact on the real economy, they often involve large fiscal costs as a substantial amount of public funds is spent on the stabilization of the banking sector. During the recent financial crisis, EU member states, for example, incurred a fiscal cost for bank recapitalisation and asset relief (2008-13) of 4.9 percent of GDP (European Commission, 2013). In addition, government guarantees and liquidity assistance were provided that 2009 reached a peak value of 6.9 percent of GDP. There are, however, large differences in those magnitudes across countries: While the fiscal costs were rather moderate in Germany or Austria, the UK incurred costs of recapitalisation and guarantees worth 7.4 and 10.1 percent of GDP respectively. In Ireland, they even reached extreme values of 39.9 and 173.8 percent. Therefore, the G-20 asked the IMF to prepare a report that studies the scope for special taxes on banks for a 'fair and substantial contribution by the financial sector'. Subsequently, 15 European countries including Germany, the Netherlands, and the United Kingdom introduced such a bank levy. In the United States, President Obama proposed a 'Financial Crisis Responsibility Fee' but an implementation in the near future seems unlikely. The objective of this tax is to (i) raise revenue to (partly) cover the fiscal cost of banking crises thereby compensating taxpayers for guarantees and bailouts and (ii), as a Pigovian tax, to internalise externalities associated with such guarantees thus reducing bank risk and complementing regulation. A key aspect of every tax is the incidence. In case of the bank levy, the main question is whether bank owners bear the burden of the levy themselves or whether they can shift it to their customers by raising lending or lowering deposit rates. The incidence allows drawing some conclusions about whether the burden of the levy is indeed borne by those who benefited the most from government guarantees and bailouts. Moreover, there are concerns that higher lending rates and a contraction of the loan supply may hamper firms' access to finance and lower investment thus slowing down economic growth. Slovik and Cournède (2011), for instance, estimate that a one percentage point increase in (long-term) lending rates reduces annual GDP growth by up to 0.4 percentage points in the Euro area. Small, credit-constrained firms are most likely to be affected as they have difficulties to substitute bank loans with other funds. With banking reforms (e.g., Basel III, Banking Union) that tighten regulatory constraints being implemented at the same time, such adverse effects on the real economy could be amplified.

This paper both theoretically and empirically examines the incidence of the newly introduced bank levies. The focus is on a pass-through of the tax to borrowers and depositors, which is motivated by its economic relevance as well as by the empirical finding of Goodspeed and Havrylchyk (2014) that the incidence on wages is generally of minor importance for banks as opposed to manufacturing. Building on the Monti-Klein framework, we develop a model that characterises the lending and borrowing decisions of oligopolistic banks and the equilibrium interest rates. We derive several scenarios for the tax incidence thereby carving out potential determinants such as bank competition and capital structure. Subsequently, our predictions are taken to the data: Using a cross-country panel dataset with financial information of 2'987 EU banks for the period 2007-2013, the impact of the bank levy on lending and deposit rates as well as net interest margins is estimated. For that purpose, we exploit the variation between banks in countries adopting and not adopting a levy during the sample period as well as the variation in tax rates.

The main findings are that banks shift part of the tax burden to borrowers by raising the lending rate, while depositors even benefit from a higher interest rate because deposits are partly exempt. However, the average effects are moderate: For example, the lending rate and the net interest margin with average values of 5.85 and 2.48 percent only rise by 0.24 and 0.05 percentage points respectively if a bank is taxed. The magnitude crucially depends on bank competition: In particular, the pass-through to borrowers is strong and economically significant in highly concentrated markets where the lending rate is up to 0.77 percentage points higher. The capital structure also influences the incidence: Well-capitalised banks are less affected by a tax on liabilities such that the pass-through measured by the net interest margin is weaker. The results are robust to different measures of the bank levy and to a broad set of controls and survive several robustness tests that account for specific shocks during the recent crisis.

This paper draws from two strands of the literature on the taxation of banks: First, several theoretical contributions analyse the role of Pigovian taxes in banking: Keen (2011) studies their role in internalizing externalities associated with the collapse and bailout of banks and suggests a tax on bank borrowing with marginal tax rates that sharply increase at low capital ratios. Perotti and Suarez (2011) explore to what extent a Pigovian tax can internalise a bank's contribution to systemic risk associated with short-term funding. Whether such a tax is preferable to quantity-based regulation crucially

depends on bank characteristics. Acharya et al. (2016) propose a Pigovian tax in order to internalise the systemic risk externality. The optimal tax relates to the degree of a bank's undercapitalisation in case of a systemic crisis, which is a proxy of its contribution to systemic risk. Furthermore, Devereux et al. (2015) both theoretically and empirically examine how banks that become subject to a levy adjust their capital structure and risk taking: They find that banks indeed reduce their leverage but they also increase risk taking measured by the average risk weight. The latter is due to a mechanical effect as more equity increases the maximum risk-weighted assets of a bank, which tends to favour riskier assets instead of a larger size. Schweikhard and Wahrenburg (2013) simulate the hypothetical levy payments during the recent crisis had such a tax already been in place. Compared the funding benefit of systemically important banks, they find that the levies only partly internalise systemic risk.

A second strand of the literature analyses the tax incidence on banks and financial markets: On the theoretical side, Caminal (2003) develops a model of banks' behavioural responses to different taxes including the value added and corporate income tax and taxes on loans and deposits. He stresses the importance of the separability of loans and deposits and of market power. Albertazzi and Gambacorta (2010) examine the incidence of the corporate income tax using a variant of the Monti-Klein model. They show that it leads to a higher lending rate but has no impact on the deposit rate and the price of financial services. Bierbrauer (2014) studies the tax incidence on financial markets in a model with fire sales and focuses on the proposed financial transactions tax. On the empirical side, only two papers provide evidence on the incidence of bank levies: Buch et al. (2014) analyse the levy in Germany. Using a difference-in-difference approach that exploits the variation between large banks that are taxed and small banks that are exempt, they find that the levy reduces the loan volume, has no effect on the lending rate, and increases the deposit rate. The latter can be explained by the exemption of customer deposits that induces banks to shift the funding sources towards deposits. For Hungary, Capelle-Blancard and Havrylchyk (2013) find a positive effect of the levy on the lending rate. Especially, the burden is shifted to customers who already have an ongoing borrowing relationship with a bank and thus face high cost of switching to another bank. These two studies provide evidence for a single country and the post-introduction period is quite short such that a more pronounced effect is likely in the long run. The

literature on the incidence of the corporate income tax on banks, which usually involves cross-country studies, is more extensive: Demirgüç-Kunt and Huizinga (1999) find evidence that the tax is fully passed onto customers as net interest margins increase one by one with the tax rate. In the same spirit, Demirgüç-Kunt and Huizinga (2001) show that the pre-tax profitability of international banks varies little with domestic tax rates as they can exploit profit shifting opportunities such that their adjustment to the tax is weaker. Furthermore, Albertazzi and Gambacorta (2010) show that corporate income taxes raise the lending rate such that banks can pass up to 90 percent of the burden onto borrowers. Chiorazzo and Milani (2011) estimate that European banks can pass through 45 percent of the tax burden in the short- and 80 percent in the long-run. Relying on a different measure of the bank's tax burden, Capelle-Blancard and Havrylchyk (2014), however, find no evidence for a pass-through.

The main contribution of this paper is a comprehensive theoretical and empirical analysis of the incidence of the newly introduced bank levies. Such a combination identifies the main adjustment mechanisms of banks to a levy and assesses its quantitative impact. Importantly, the article highlights how the incidence relates to bank competition and capitalisation, the latter of which has not been addressed yet. To my knowledge, it is the first paper with cross-country evidence on the incidence of bank levies. This is common approach when studying the incidence of the corporate income tax and allows for more general insights and a robust measurement of banks' exposure to the levy by exploiting cross-country variation. In addition, the paper uses more recent data with a longer post-introduction period than previous studies.

The remainder of this paper is organised as follows: Section 2 provides an overview about bank levies in Europe. Section 3 outlines the model and derives several predictions about the incidence, which are taken to the data in section 4. Eventually, section 5 concludes.

2 Bank Levies

The IMF's report on financial sector taxation published in 2010 examines the scope for special taxes on banks. An essential part is the proposal of a bank levy, the so-called 'financial stability contribution': Its main objectives are (i) a contribution by the banking sector to compensate taxpayers for the costs of guarantees and bailouts and

(ii) the internalisation of these fiscal costs as to reduce the risk of future banking crises and to complement regulation. Externalities may emerge because of implicit government guarantees for large, systemically important banks. This creates a funding benefit - the 'too-big-to-fail' subsidy - which makes a bank's cost less sensitive to its risk profile thereby strengthening risk taking incentives. This benefit is well documented in the empirical literature, for example, by Flannery and Sorescu (1996), Balasubramnian and Cyree (2011), and Acharya et al. (2016). Importantly, the tax should be related to a bank's contribution to systemic risk and to all potential costs associated with its failure. The IMF (2010) proposes a tax on bank liabilities excluding capital and insured deposits such that the risky part of funds like uninsured deposits and wholesale funding is taxed; the tax base may also include derivatives. The exemption of insured deposit avoids double taxation due to insurance premia. The tax rate should reflect the funding benefit for large, systemically important banks due to implicit guarantees but a lower rate may apply for smaller banks: The IMF (2010, p. 55) estimates a benefit between 10 and 50 basis points with an average of 20 basis points. For the U.S., Acharya et al. (2016) find a benefit of 30 basis points on average (1990-2012) that strongly increases in a crisis. The tax revenue could either accumulate a resolution fund or be used for the general budget. Since 2009, 15 countries in the European Union have introduced a bank levy.[1] Table 1 summarises bank levies currently in place in selected countries.[2] Germany, the UK, and the Netherlands closely follow the proposed financial stability contribution, whereas Hungary and France adopt a different design. In general, levies differ in at least four aspects: First, the tax base usually consists of liabilities excluding equity and insured deposits as suggested by the IMF. In Germany, even all customer deposits are exempt but off-balance sheet derivatives are taxed as well. Hungary and France, however, impose a levy on total assets and minimum regulatory capital respectively. Second, the tax rates are flat (e.g., Belgium, Sweden), progressive (e.g., Austria, Germany, Hungary) or differ between short- and long-term liabilities (e.g., Netherlands, UK). In addition, some countries exempt small banks by an allowance or tax them at lower rates because they are unlikely to benefit from implicit guarantees. Third, the tax rates reach from values clearly below the IMF's proposal of (at most) 20 basis points (e.g., Germany, UK,

[1] See, OECD (2013) for detailed information. Australia and Greece had already imposed bank levies before; however, their purpose is different and differs from the IMF's proposal.

[2] An extensive summary can be found in Devereux et al. (2015, Appendix) or OECD (2013).

	Tax Base	Tax Rates	Exemptions
Austria 1.1.2011	Total Liabilities	< EUR 20bn: 0.09%* > EUR 20bn: 0.11%	Insured Deposits Allowance: EUR 1bn
Belgium 1.1.2012	Total Liabilities	0.035%	Insured Deposits
Germany 1.1.2011	Total Liabilities Derivatives	< EUR 10bn: 0.02% EUR 10bn-100bn: 0.03% EUR 100bn-200bn: 0.04% EUR 200bn-300bn: 0.05% > EUR 300bn: 0.06% Derivatives: 0.0003%	Customer Deposits Allowance: EUR 200m Cap: 20% of Net Income Minimum charge**: 5%
France 1.1.2011	Min. Regulatory Capital	0.5%	Allowance: EUR 500m
Hungary 27.9.2010	Total Assets	< HUF 50bn: 0.15% > HUF 50bn: 0.53%	Interbank Loans
Netherlands 1.10.2012	Total Liabilities	0.044% (short-term) 0.022% (long-term)	Insured Deposits Allowance: EUR 20bn
Slovakia 1.1.2012	Total Liabilities	0.4%	Insured Deposits, Subordinated Debt
Sweden 30.12.2009	Liabilities and Provisions	0.044%	Subordinated Debt, Selected Securities
UK 1.1.2011	Total Liabilities	0.036% (short-term) 0.071% (long-term)	Insured Deposits, Liquid Assets Allowance: GBP 20bn

Table 1: *Bank Levies: Overview*
This table summarises bank levies in selected countries, information as of 2014. *Until 2014: 0.055% (<EUR 20bn), 0.085% (>EUR 20bn), surcharge 25%; **only 5% of the tax liability is payable if a bank has losses; source: Devereux et al. (2015, Appendix).

Sweden) to high values of 40 to 50 basis points (e.g., Hungary, Slovakia). Fourth, the bank levy as a Pigovian tax is forward-looking in the sense that its goal is to cover the fiscal costs of future banking crises. However, it is backward-looking and imposed on past balance sheets in Austria (balance sheet 2010) and Hungary (2009). Since banks cannot reduce their tax burden, adjustments are less likely[3] unless this feature is temporary like in Austria[4] where forward-looking banks may aim at lowering the future tax burden.

3 Theoretical Analysis

We study how loans and deposits and, most importantly, the equilibrium interest rates adjust to a bank levy. The theoretical analysis yields predictions of how banks shift

[3]This does not rule out pure price adjustments, e.g., raising lending rates or fees, if a bank has market power. Capelle-Blancard and Havrylchyk (2013) find evidence for such behaviour in Hungary.

[4]The levy was imposed on the 2010 balance sheet for the years 2011 to 2013; from 2014 on, it is imposed on the previous year balance sheet.

the tax burden to customers and characterises the main determinants of the incidence. For that purpose, we rely on a variant of the Monti-Klein model complemented with regulation and taxation, which is a popular approach in the incidence literature [e.g., Albertazzi and Gambacorta (2010) and Capelle-Blancard and Havrylchyk (2013)]. This static, industrial organization model of banks goes back to Klein (1971) and Monti (1972); both oligopolistic and monopolistic variants exist.[5] It captures the main determinants of banks' lending and borrowing decisions and yields testable predictions that can be taken to the data. At a first stage, the incidence is analysed using a textbook variant of this model to establish a benchmark. Subsequently, we add risky loans and bank failure following Dermine (1986). This extension captures the risk dimension given that internalizing the fiscal costs of banking crises is the main rationale for bank levies. The Monti-Klein model is not without controversy, however: In the neoclassical tradition, the bank is modelled as a banking firm and the only friction is imperfect competition. It is, nevertheless, an appropriate framework to study the impact of a tax on interest rates.

3.1 Monti-Klein Model with Taxation and Regulation

Suppose a number of identical banks indexed by $i = 1, ..., N$ compete for loans and deposits in a Cournot fashion; they face a downward-sloping inverse loan demand $r_L = r_L\left(\sum_{i=1}^{N} l_i\right)$ and an upward-sloping inverse deposit supply $r_D = r_D\left(\sum_{i=1}^{N} d_i\right)$. Each bank is owned and operated by a license holder with no private wealth (henceforth: bank owner). Bank i supplies credit l_i and is funded by deposits d_i and equity e_i. To raise equity, the owner promises a share ϕ_i of the bank's end-of-period value to outside shareholders, who elastically supply equity at a required return ρ. The bank can also raise an amount m_i of funds from other sources at a fixed interest rate r determined by monetary authorities or on the international capital market. Such non-deposit liabilities may consist of interbank and money market borrowing, bonds or wholesale funding. Whenever m_i is negative, the bank is a (net) lender on the money market. The option of borrowing or lending at a fixed interest rate makes loans and deposits separable, which is a well-known feature of the Monti-Klein model and affects the tax incidence.[6] It persists if the bank incurs administrative cost as long as they additively separable but is not

[5] For a detailed discussion of the Monti-Klein model, see, Freixas and Rochet (2008, Ch. 3).

[6] For a more detailed analysis of separability and tax incidence, see, Caminal (2003).

robust to bankruptcy risk as shown by Dermine (1986). Thus, the bank's profit equals

$$\pi_i = (1 + r_L)l_i - (1 + r_D)d_i - (1 + r)m_i \tag{1}$$

and its objective is to maximise the value appropriated by the bank owner:

PROGRAM 1 *A bank chooses loans l_i, deposits d_i, money market funding m_i, equity e_i, and the share of outside equityholders ϕ_i to maximise the surplus of its owner*

$$\max_{l_i, d_i, m_i, e_i, \phi_i} (1 - \phi_i)\pi_i \tag{2}$$

subject to capital requirements

$$e_i \geq k l_i \tag{3}$$

the participation constraint of outside equityholders

$$\frac{\phi_i \pi_i}{e_i} = 1 + \rho \tag{4}$$

and the funding constraint

$$l_i + T_i = d_i + m_i + e_i \tag{5}$$

where T_i denotes the bank's tax liability.

The constraints are interpreted as follows: Standard capital regulation requires a fraction $k \in [0, 1]$ of loans[7] to be financed with equity. In order to attract equity, the bank needs to promise sufficiently large dividends (i.e., value share ϕ_i) to outside equityholders such that the (gross) return on equity equals their opportunity cost $1 + \rho$. This is captured by the participation constraint (4). Suppose that equity is privately costly and earns an excess return over debt: $\rho \geq r$. This typical assumption can be rationalised, for example, by the agency cost of equity or the debt bias of the corporate income tax. Costly equity leads to a binding regulatory constraint, which is restrictive but appropriate in the context of regulatory reforms and higher capital requirements. Eventually, the funding constraint holds at the beginning. The focus on a levy paid upfront illustrates the forward-

[7]Whenever the bank is a net lender on the money market, its assets consist of loans and money market lending, $l_i - m_i$, and the regulatory constraint is $e_i \geq k(l_i - m_i)$.

looking aspect of this tax.[8] Substituting the constraints and the definition of π_i and using $L = \sum_{i=1}^{N} l_i$ and $D = \sum_{i=1}^{N} d_i$ allows rewriting the bank's problem:

$$\max_{l_i, d_i} [r_L - r(1-k) - \rho k] l_i + [r - r_D] d_i - (1+r) T_i \tag{6}$$

The first two terms capture the surplus earned on loans and deposits respectively. The corresponding first-order conditions are:

$$r_L + r'_L(L) l_i - [\rho k + r(1-k) + (1+r) T_L] = 0 \tag{7}$$

$$r - [r_D + r'_D(D) d_i + (1+r) T_D] = 0 \tag{8}$$

T_L and T_D denote the partial derivatives of the tax with respect to l_i and d_i. The problem is separable in loans and deposits (if $T_{LD} = 0$). The first condition characterises the lending decision and requires that the marginal return of loans and the marginal funding cost (in square brackets) are equalised. The second condition implies that optimal deposits balance the marginal cost of deposits and interbank borrowing. The tax burden is multiplied by $1 + r$ due to the upfront payment. In the symmetric equilibrium with $l_i = l = \frac{L}{N}$ and $d_i = d = \frac{D}{N}$, the first-order conditions are:

$$\frac{r_L(L) - [\rho k + r(1-k) + (1+r) T_L]}{r_L(L)} = \frac{1}{N \varepsilon_L} \tag{9}$$

$$\frac{r - [r_D(D) + (1+r) T_D]}{r_D(D)} = \frac{1}{N \varepsilon_D} \tag{10}$$

This formulation relies on the interest rate elasticities of loan demand, $\varepsilon_L = -\frac{1}{r'_L} \frac{r_L}{L} > 0$, and deposit supply, $\varepsilon_D = \frac{1}{r'_D} \frac{r_D}{D} > 0$. The Lerner index equals the inverse interest rate elasticity: Banks charge a markup on loans and a markdown on deposits (compared to its non-deposit funding cost) that is inversely related to the elasticity and the number of competitors, that is, to market power. As a result, the lending rate exceeds the cost of capital, and the deposit rate falls short of the interbank rate (i.e., $r_L > r > r_D$). Finally, the model nests two special cases: For $N \to \infty$, the perfect competition outcome with no markup or markdown is realised. In this case, outside shareholders receive the entire profit as dividends (i.e., $\phi_i = 1$). For $N = 1$, it coincides with the monopoly.

[8] Note this assumption does not affect the results but it allows for a more realistic interpretation in a variant with bank risk (see, section 3.3.2).

3.2 A Tax on Bank Liabilities

This section specifies the benchmark model of the bank levy, namely, a tax on liabilities as proposed by IMF (2010) and adopted in most countries that introduced a levy. Hence, we assume that the levy is imposed on the bank's total liabilities consisting of deposits d_i and money market funding m_i. In case the latter is negative (i.e., if the bank is a net lender), however, taxable liabilities consist of deposits only. With a uniform tax rate τ, the bank's tax liability is:

$$T_i = \tau[d_i + \max\{m_i, 0\}] \tag{11}$$

We first focus on the case $m_i \geq 0$; substituting the funding constraint (5) and the capital requirements (3) yields $T_i = \tau^e(1-k)l_i$ where $\tau^e \equiv \frac{\tau}{1-\tau}$ denotes the effective levy rate. Hence, the levy is essentially a function of loans. Substituting the partial derivatives $T_L = \tau^e(1-k)$ and $T_D = 0$ into (9) and (10) yields the symmetric Cournot-Nash equilibrium:

$$\frac{r_L(L) - [\rho k + r(1-k) + (1+r)(1-k)\tau^e]}{r_L(L)} = \frac{1}{N\varepsilon_L} \tag{12}$$

$$\frac{r - r_D(D)}{r_D(D)} = \frac{1}{N\varepsilon_D} \tag{13}$$

Therefore, the levy influences the loan supply and the lending rate by raising the marginal funding cost. In contrast, condition (13) reveals a fixed relation between deposit and money market rate irrespective of the levy such that deposits and the corresponding interest rate are unaffected. The reason is that both liabilities are equally taxed and the cost of deposits relative to money market funding remains unchanged. The sensitivities to the levy follow from differentiating these conditions.[9] As usual in the Monti-Klein model, we assume constant interest rate elasticities ε_L and ε_D. This establishes:

PROPOSITION 1 *The bank levy is passed onto borrowers as it lowers the loan supply,* $\frac{\partial L}{\partial \tau} < 0$*, and raises the lending rate:*

$$\frac{\partial r_L}{\partial \tau} = \frac{(1+r)(1-k)}{(1-\tau)^2\left(1 - \frac{1}{N\varepsilon_L}\right)} > 0 \tag{14}$$

The pass-through is stronger if the number of competitors is small and the loan demand

[9] Note that we assume that the levy rate is small enough such that the regulatory constraint is still binding [i.e., $\rho > r + (1+r)\tau^e$]. Otherwise, banks could substitute equity for non-deposit liabilities.

inelastic and weaker if banks face high capital requirements; it increases in the levy rate. The bank levy is not passed onto depositors as it neither affects deposits nor the deposit rate, $\frac{\partial D}{\partial \tau} = \frac{\partial r_D}{\partial \tau} = 0$.

Proof: See Appendix A.1.

The levy increases a bank's marginal funding cost irrespective of the liability structure.[10] Recall that banks supply loans until the marginal return equals the marginal cost of funds and taxes. Since the levy raises the latter, banks reduce loans which leads to a higher lending rate given the downward-sloping demand. Therefore, borrowers bear part of the tax burden as they face higher funding cost and a smaller loan supply. The extent of the pass-through depends on bank competition and capitalisation: First, the number of competitors N and the elasticity of loan demand ε_L influence the magnitude of the effect. If there are few competitors and the loan demand is inelastic, the increase in the lending rate is *ceteris paribus* stronger because of market power in the sense that the balance sheet adjustment of one bank has a more pronounced impact on the equilibrium interest rate. Hence, bank concentration and an inelastic loan demand, which may reflect few alternative sources of funding and high switching cost of borrowers, reinforce the increase. Second, the capital structure, which is essentially given by capital regulation in this model, determines the exposure of a bank to a tax on liabilities. Whenever banks face tighter capital requirements, they are less affected by the levy such that the balance sheet adjustments and the increase in the lending rate are smaller. This effect is purely mechanical. Proposition 1 also implies that the lending rate increases more than proportionately, that is, $\frac{\partial r_L}{\partial \tau} > 1$, unless banks have an extremely high capital ratio. In contrast, deposits are insensitive to the levy, and depositors do not bear the tax burden because optimal deposits balance the marginal costs of deposits and alternative funding sources such as money market or interbank borrowing. As long as both types of liabilities are subject to the levy, the relative marginal cost and the deposit choice are unaffected. In other terms, the levy uniformly imposed on total liabilities does not influence the fixed relation between deposit and money market rate. This is an implication of the separability of loans and deposits. Hence, any changes on the liability side[11] concern

[10] This is due to the assumption of binding capital requirements; otherwise, substituting equity for debt would lower the tax burden.

[11] There are two counteracting effects: Banks may reduce their funds because of the smaller loan supply or increase them to pay the upfront tax.

non-deposit liabilities with a fixed interest rate. As a result, the tax burden is borne by borrowers, who face higher lending rates, and inside shareholders, who earn a smaller surplus.[12] Money market lenders and outside shareholders, in contrast, do not bear the tax burden because their returns are fixed.

A typical profitability ratio that features prominently in the incidence literature and represents a main outcome variable in our empirical analysis is the net interest margin (NIM): It measures the lending spread and is defined as net interest revenue divided by average interest-bearing assets. In our framework, the NIM is

$$NIM = \frac{r_L l_i - r m_i - r_D d_i}{l_i} = r_L - r(1+\tau^e)(1-k) + \frac{(r-r_D)D}{L} \tag{15}$$

where the second equality uses the funding constraint and $\frac{d_i}{l_i} = \frac{D}{L}$ in the symmetric equilibrium. The NIM depends on both the interest rates and the composition of the balance sheet. The partial derivative of (15) implies:

COROLLARY 1 *The bank levy raises the net interest margin:*

$$\frac{\partial NIM}{\partial \tau} = \frac{1-k}{(1-\tau)^2}\left[\frac{1+r}{1-\frac{1}{N\varepsilon_L}}\left(1+\frac{r_D D}{r_L L}\frac{\varepsilon_L}{N\varepsilon_D}\right) - r\right] > 0 \tag{16}$$

The effects of bank competition and the capital structure on the pass-through can be of either sign.

Proof: See Appendix A.1.

The response of the net interest margin has three sources as one can see from (15): an increase in the lending rate, a decrease in loans, and a larger proportion of interbank and money market borrowing due to the upfront payment. Whereas the first two effects are positive, the third is negative; overall, the response is clearly positive. The sensitivities of the response to bank competition and capitalisation, however, remain ambiguous due to counteracting price and compositional effects.

So far, the focus has been on banks that borrow from the money market (i.e., $m_i \geq 0$). The equalization of marginal funding cost effectively fixes the deposit rate such that the

[12] Since the bank owner has no private wealth, the return on (inside) equity is not defined. The decrease of their surplus follows from an Envelope argument: $\frac{\partial(1-\phi_i)\pi_i}{\partial \tau} < 0$.

burden is not passed onto depositors. This typically characterises the response of loan-rich, deposit-poor banks in the sense that they rely on funds apart from deposits and equity to finance the initial expenditures. However, some banks are net lenders on the money market (i.e., $m_i < 0$); they have a richer asset structure but their liabilities consist of deposits only. There are two implications: First, the tax liability now equals $T_i = \tau d_i$ with partial derivatives $T_L = 0$ and $T_D = \tau$. Second, capital requirements are charged on total assets now consisting of both customer and money market loans: $e_i \geq k(l_i - m_i)$. Hence, the bank's optimisation problem is

$$\max_{l_i, d_i} [r_L - r] l_i + \left[(r - \rho k) \frac{1 - \tau}{1 - k} - r_D - \tau \right] d_i \tag{17}$$

and the first-order conditions characterizing the symmetric equilibrium are:

$$\frac{r_L(L) - r}{r_L(L)} = \frac{1}{N \varepsilon_L} \tag{18}$$

$$\frac{(r - \rho k) \frac{1-\tau}{1-k} - (r_D(D) + \tau)}{r_D(D)} = \frac{1}{N \varepsilon_D} \tag{19}$$

Obviously, the lending rate is now fixed, and the levy only affects the deposit side. Note that the mark-down on deposits is determined by the effective return, which is the money market rate net of the required return on equity[13], and the cost consisting of deposit rate and bank levy. Differentiating these two conditions establishes:

PROPOSITION 2 *Whenever banks are deposit-rich (i.e., $m_i < 0$), the levy is passed onto depositors as it lowers the deposit supply, $\frac{\partial D}{\partial \tau} < 0$, and the deposit rate:*

$$\frac{\partial r_D}{\partial \tau} = - \frac{1 + r - \frac{(\rho - r)k}{1-k}}{1 + \frac{1}{N \varepsilon_D}} < 0 \tag{20}$$

The pass-through is weaker if the number of competitors is small and the deposit supply inelastic and if banks are strongly capitalised. The bank levy is not passed onto borrowers as it neither affects loans nor the lending rate, $\frac{\partial L}{\partial \tau} = \frac{\partial r_L}{\partial \tau} = 0$.

Proof: See Appendix A.1.

[13] An additional unit of deposits creates $\frac{1-\tau}{1-k}$ units of assets.

Compared to the first scenario, the results are reversed as the tax burden is now passed onto depositors instead of borrowers. Intuitively, banks choose loans and money market lending as to balance the marginal returns of both assets such that the lending rate is fixed. Since it is imposed on liabilities, the levy does not influence the relative returns of customer and money market loans. Deposits, in contrast, are raised until their marginal cost equal the marginal return earned on both assets. As the levy raises the cost, the deposit demand falls and leads to a lower interest rate. Its response is usually weaker than that of the lending rate in the first scenario provided that capital requirements are not too tight. This can be attributed to the relative stickiness of deposits, a phenomenon well documented in the empirical literature, for example, by Hannan and Berger (1991). The sensitivity is even weaker if banks face few competitors and an inelastic loan demand, which is a standard implication of the Monti-Klein model. In case banks are lenders on the money market, the tax burden is thus borne by depositors and by inside shareholders but borrowers and outside shareholders are unaffected.

The analysis reveals two scenarios - shifting the burden to borrowers or depositors - depending on whether banks raise too small or too large an amount of deposits compared to loans. This distinction follows from the separability of loans and deposits: If banks did not borrow or lend on the money market, loans and deposits would be directly connected by the funding constraint such that the levy, by raising the funding cost, would eventually lead to an increase in the lending and a decrease in the deposit rate. As a result, the burden would be shifted to both sides. As soon as banks can also borrow and lend at a given rate on the money market, either the deposit or the lending rate is *de facto* fixed and insensitive to the levy. The prediction that only one side bears the tax burden is rather conservative. Which of these scenarios is realised is mainly an empirical question: Generally, the money and interbank markets clear on a worldwide scale such that there are markets with banks borrowing from others and markets with banks lending to others. Hence, the incidence may differ depending on whether the tax is mainly levied on deposit-poor or deposit-rich banks. Since the levy, by construction, targets the risky part of bank funding like uninsured deposits or short-term debt, which may entail a funding benefit due to implicit guarantees, the first scenario with a richer set of liabilities appears more relevant. Most importantly, the main empirical findings are consistent with this scenario where banks shift the burden to borrowers, and we find only weak evidence for a pass-

through to depositors. One may also argue that deposit rates can hardly decrease in economies at the zero lower bound. For these reasons, a pass-through to borrowers is considered the main scenario, and the subsequent extensions focus on this case.

3.3 Extensions

We explore the robustness of the main scenario by adding two features: insured deposits that are exempt and risky loans.

3.3.1 Differential Tax Treatment of Deposits

Usually, deposits protected by a guarantee scheme are not taxed to avoid double taxation. This extension analyses how the differential tax treatment of bank liabilities affects the incidence: Suppose there are two distinct markets for insured and uninsured deposits each with an inverse supply $r_D^I(D^I)$ and $r_D(D)$ respectively. The interest rates on insured and uninsured deposits differ; it is likely that the latter is *ceteris paribus* higher $r_D > r_D^I$ whenever $D \geq D^I$. Without loss of generality, the deposit insurance premium is normalised to zero. The liabilities of a bank thus consist of insured and uninsured deposits and interbank borrowing; the funding constraint is $l_i + T_i = d_i + d_i^I + m_i + e_i$. The bank maximises its owner's surplus and solves the optimisation problem:

$$\max_{l_i, d_i, d_i^I} [r_L - r(1-k) - \rho k] l_i + [r - r_D] d_i + [r - r_i^I] d_i^I - (1+r) T_i \tag{21}$$

Profit equals the surplus earned on loans, uninsured and insured deposits minus the levy payment. Since insured deposits are exempt, taxable liabilities include uninsured deposits and money market borrowing giving $T_i = \tau(m_i + d_i)$. Using the funding constraint, the tax liability is $T_i = \tau^e[(1-k)l_i - d_i^I]$ with partial derivatives $T_L = \tau^e(1-k)$, $T_{D^I} = -\tau^e$, and $T_D = 0$. A bank can lower its tax burden by substituting insured deposits for money market and interbank funding. The conditions for the symmetric equilibrium are:

$$\frac{r_L(L) - [\rho k + r(1-k) + (1+r)(1-k)\tau^e]}{r_L(L)} = \frac{1}{N\varepsilon_L} \tag{22}$$

$$\frac{r + (1+r)\tau^e - r_D^I(D^I)}{r_D^I(D^I)} = \frac{1}{N\varepsilon_D^I} \tag{23}$$

$$\frac{r - r_D(D)}{r_D(D)} = \frac{1}{N\varepsilon_D} \tag{24}$$

Compared to the benchmark, the levy also affects insured deposits. The tax advantage creates an additional gain relative to other liabilities. If the elasticities of insured and uninsured deposits are equal, the bank is even willing to offer a higher interest rate on insured deposits.[14] Totally differentiating the first-order conditions yields:

COROLLARY 2 *The bank levy raises the lending rate and leaves the interest rate on uninsured deposits unchanged as shown by proposition 1. It also increases insured deposits,* $\frac{\partial D^I}{\partial \tau} > 0$*, and the corresponding interest rate:*

$$\frac{\partial r_D^I}{\partial \tau} = \frac{(1+r)}{(1-\tau)^2\left(1+\frac{1}{N\varepsilon_D^I}\right)} > 0 \tag{25}$$

The magnitude of the interest rate's response positively depends on bank competition but is independent of the capital structure. The bank levy increases the net interest margin provided that the levy rate and number of competitors are not too large and the supply of insured deposit is inelastic.

Proof: Follows from differentiating (22) and (23). *Q.E.D.*

Whereas the impact on borrowers is unchanged, the differential taxation of liabilities establishes a direct link between the levy and insured deposits by making the latter less costly compared to other sources of funding. Since insured deposits are more attractive, banks may substitute them for liabilities that are fully taxed in order to reduce the tax burden. The higher demand for insured deposits, in turn, raises the corresponding interest rate thereby even benefiting depositors. The somewhat ambiguous response of the NIM is due to the higher interest rate on insured deposits; this effect is less pronounced in case of strong market power and low tax rates. Consequently, the main scenario also involves a higher interest rate on deposits that are exempt. Since we cannot distinguish between the interest rates on insured and uninsured deposits in the data and the latter remain insensitive to the levy, a slight increase of the overall deposit rate is expected. Nevertheless, this substitution effect should be cautiously interpreted: The above formulation with two distinct markets and interest rates is restrictive and it is difficult for banks to actively influence the exact amount of insured (e.g., deposits below EUR 100'000) and uninsured deposits. Moreover, deposit rates are sticky as discussed

[14] A positive insurance premium paid by banks may offset this effect.

above such that its response is less pronounced. The substitution effect of the levy, however, still results in case of a uniform deposit rate and a fixed share of insured deposits.

3.3.2 Bank Risk

Since internalizing the fiscal costs of bank failure is the main objective of bank levies, we examine the incidence in a model variant with bank risk. To keep the analysis tractable and in line with the main scenario, we abstract from imperfect competition for deposits. More precisely, the deposit supply is elastic and characterised by $r_D = r$ thereby ruling out any adjustment of the deposit rate. Thus, banks are indifferent about the liability structure as borrowing from depositors and money market lenders is equally costly, and the focus is on banks that only attract deposits (i.e., $m_i = 0$).

We follow Dermine (1986) who extends the Monti-Klein framework by a model of lending risk à la Jaffee and Modigliani (1969): Borrowers invest in risky projects with a stochastic gross return A distributed according to some continuous, differentiable distribution function $F(A)$. Hence, the loan is only repaid if the realised return exceeds the gross lending rate, $A > 1 + r_L$. Otherwise, the borrower defaults and the assets are transferred to the bank. Bank failure risk depends on the correlation of loans: As long as they are uncorrelated, the portfolio is perfectly diversified and the bank is safe. If there is some positive correlation, however, the bank may fail whenever too many of its loans perform poorly. As Dermine (1986), we focus on perfectly correlated returns, and the bank fails as soon as its assets fall short of its liabilities. The failure threshold A^* thus follows from $A^* l_i = (1 + r)d_i$, and the corresponding failure probability is $F(A^*)$. Since government guarantees are the main rationale for bank levies, we focus on the case where they are indeed present: Hence, depositors consider deposits risk-free require no risk premium because they are compensated if the bank fails.

Compared to the benchmark, there is a modification of capital requirements: Although our setup with a single asset offers little scope for typical risk weights, one may alternatively define the latter as a function of the bank's own risk profile given by its failure probability: $\alpha = \alpha[F(A^*)]$. Hence, capital requirements are $e_i \geq k\alpha l_i$ where αl_i denote the risk-weighted assets. Importantly, the risk weight α may increase in failure risk, $\alpha'[F(A^*)] \geq 0$, to ensure that riskier banks have more equity. This captures a potential interaction of the levy with risk-sensitive capital regulation. The bank solves

PROGRAM 2 *A bank chooses loans l_i, deposits d_i, equity e_i, and the share promised to outside equityholders ϕ_i to maximise the expected surplus of its owner*

$$\max_{l_i,d_i,e_i,\phi_i} (1-\phi_i)\left[(1-F(1+r_L))(1+r_L)l_i + \int_{A^*}^{1+r_L} AdF(A)l_i - (1-F(A^*))(1+r)d_i\right] \tag{26}$$

subject to investors' participation constraint (4), capital requirements $e_i \geq k\alpha l_i$, and the funding constraint $l_i + T_i = d_i + e_i$.

Expected bank profits consist of the revenue from fully repaid loans (if $A \geq 1 + r_L$) and the liquidation value of failed loans (if $1 + r_L > A \geq A^*$) net of deposit repayment. The levy is imposed on deposits such that $T_i = \tau d_i = \tau^e(1 - k\alpha)l_i$. Based on the first-order conditions of this problem, one can derive the lending decision

$$\frac{r_L(L) - \int_{A^*}^{1+r_L} F(A)dA - [\rho k\alpha + r(1-k\alpha) + (1+r)\tau^e(1-k\alpha)]}{r_L(L)} = \frac{1-F(1+r_L)}{N\varepsilon_L} \tag{27}$$

which characterises the symmetric Cournot-Nash equilibrium with $l_i = l = \frac{L}{N}$. Again, the Lerner index is inversely related to the interest rate elasticity of loan demand and the number of competitors. Note that the bank's cost include the loan losses if borrowers default, which are captured by the integral. Differentiating condition (27) yields:

COROLLARY 3 *The bank levy lowers the loan supply, $\frac{\partial L}{\partial \tau} < 0$, and raises the lending rate*

$$\frac{\partial r_L}{\partial \tau} = \frac{(1-k\alpha)(1+r)[1-F(A^*)+(1+\rho)k\alpha']}{(1-\tau)^2\left[1+(1+r)(1+\tau^e)k\alpha'\right]\left[(1-F)\left(1-\frac{1}{N\varepsilon_L}\right)+\frac{fr_L}{N\varepsilon_L}\right]} > 0 \tag{28}$$

where $F = F(1+r_L)$, $f = f(1+r_L)$, $\alpha' = \alpha'[F(A^*)]f(A^*) > 0$. The pass-through is usually stronger in concentrated markets. The levy raises the net interest margin.

Proof: See Appendix A.1.

The main finding that banks shift part of the burden to borrowers also results in this extension. The levy raises the lending rate through its impact on the bank's funding cost: First, there is a direct effect as the levy makes borrowing more expensive like in the benchmark model. Second, it also mechanically raises the bank's failure threshold[15] such that the risk weight α is higher and the funding cost increase as long as equity is expensive. The second effect may arise because of risk-sensitive capital requirements

[15]This arises because banks borrow more to pay the levy upfront. The effect would also result if the levy had to be paid *ex post* as it would constitute an additional liability at the end of the period.

and reinforces the pass-through. However, it vanishes as soon as $\alpha'[F(A^*)] = 0$. The magnitude of the pass-through still negatively depends on bank concentration but no clear conclusion about the impact of capital regulation can be drawn.

3.4 Predictions

The theoretical analysis yields two scenarios for the tax incidence: First, the levy leads to a higher lending rate and net interest margin. The key finding that the tax burden is partly shifted to borrowers persists in two extensions. Banks may also increase deposits in case a differential tax treatment induces them to shift funds from those fully taxed to deposits that are partly or fully exempt. This eventually raises the deposit rate. Since all countries that introduce a levy in the sample except for Sweden at least partly exempt deposits, such an effect seems likely. Moreover, the magnitude of the response depends on two factors: First, a low degree of competition mainly reflected by a concentrated banking sector and small elasticities reinforces the increase in the lending rate but weakens a potential response of the deposit rate. This is a typical finding in the incidence literature as market power determines how the tax burden is shared. Second, banks' capital structure strongly influenced by regulation determines their exposure to the levy. Since the latter is charged on liabilities, a higher capital ratio mechanically reduces the tax burden and the response of the lending rate. The main predictions for this scenario are summarised in table 2. The alternative scenario where the burden is shifted to depositors with no impact on the lending side may emerge whenever the levy is introduced in markets with many deposit-rich banks that lend to other banks or money market borrowers. Since deposit rates are sticky especially in concentrated markets, however, the pass-through to depositors is expected to be rather weak.

	Lending Rate	Deposit Rate	Net Interest Margin
Levy	+	(+)	+
Concentration	↑	(↓)	ambiguous
Capital Ratio	↓	(none)	ambiguous

Table 2: *Main Scenario: Predictions*
This table summarises the predictions about the levy's impact on interest rates and NIM and indicates whether bank concentration and a high capital ratio reinforce (↑) or weaken (↓) the effect.

Finally, one should be aware of the model's limitations and interpret its predictions cau-

tiously: The model is static such that there is no gradual transition to a new equilibrium. In reality, the levy will mainly affect new loans and deposits as it is difficult to change existing contracts. In addition, Austria initially imposed the levy on past balance sheets such that the tax burden is, in principle, unrelated to a bank's current loans and deposits. In this case, the static model implies that the choices are unaffected thereby ruling out any adjustment. In a dynamic framework, banks would, nevertheless, respond in order to lower their future tax burden. Moreover, capital requirements are binding such that no substitution of equity for debt takes place. This feature conflicts with Devereux et al. (2015), who find evidence that the levy induces banks to lower their leverage.

4 Empirical Evidence

This section provides empirical evidence about the incidence of bank levies. We conduct reduced-form tests based on the theoretical predictions, which is common in related contributions such as Albertazzi and Gambacorta (2010) and Devereux et al. (2015). We employ a panel dataset from Bankscope with balance sheet data of 2'987 EU banks between 2007 and 2013.[16]

4.1 Estimation Strategy

The empirical strategy closely follows Devereux et al. (2015) who use a similar dataset to estimate the impact of levies on banks' capital structure and risk taking.

4.1.1 Baseline Model

The baseline model captures the effect of the levy on an average bank. The main econometric specification is

$$y_{ijt} = \alpha_i + \gamma_t + \beta_1 Levy_{ijt} + \varphi X_{ijt} + \epsilon_{ijt} \tag{29}$$

where y_{ijt} and $Levy_{ijt}$ are outcome and main explanatory variable respectively. α_i and γ_t denote bank and time fixed effects and $\mathbf{X}_{ijt}$ the vector of controls. Bank fixed effects absorb all time-constant heterogeneity, time fixed effects all common shocks.

[16]This *de facto* captures the (post-)crisis period 2008-13 as several bank-level variables are lagged.

We estimate the levy's impact on three different outcome variables: the interest income on loans as a share of average loans, IIL_{jit}, the interest expenses on customer deposits as a share of average deposits IED_{jit}, and the net interest margin, NIM_{jit}. The first two variables measure the average interest rates paid by borrowers and to depositors and approximate lending and deposit rate that are not available in the data. For Euro area banks, it can be shown that they are of comparable magnitude and exhibit similar patterns than a broad array of bank interest rates on loans and deposits (see, figures A.1 and A.2 in appendix A.3). These two ratios are rather conservative measures for the incidence such that we may underestimate the real magnitude of the pass-through: In particular, they do not allow distinguishing between interest rates associated with old and new loans and deposits. Since the levy was difficult to anticipate, it mainly affects interest rates of new loans and deposits such that the impact on new customers is stronger than observed. In addition, the interest income on loans is affected by defaults such that the impact on good borrowers may in fact be more pronounced.[17] In line with the literature, we also include the net interest margin, NIM, defined as the ratio of net interest income to average interest-bearing assets; it captures the pass-through to customers by increasing the spread between lending and borrowing rates.

The main explanatory variable $Levy_{ijt}$ is represented by three proxies that exploit three different sources of variation: First, only some EU countries introduced a bank levy; second, in some countries that impose a levy not all banks are taxed due to an allowance (e.g., Germany, Austria, and the UK); third, banks face different marginal tax rates across and in case of a progressive tax schedule also within countries. Following Devereux et al. (2015), we first construct a dummy variable $Levy1_{jt}$ that indicates whether a bank is located in a country that charges a levy in a certain year or not. This defines the levy at the country-year level and captures its effect on interest rates and margin of an average bank in a country with a levy. However, this variable might be affected by other country-year level variations such as changes in corporate taxation or government interventions in the banking sector that need to be controlled for. Second, four countries exempt small banks by an allowance. Since we have no information about whether a particular bank is taxed or not, we approximate the taxable liabilities[18] of each bank using the information

[17] This holds *a fortiori* if a higher lending rate as a result of the levy increases borrowers' risk taking and defaults in the sense of Stiglitz and Weiss (1981).

[18] For the calculation of the taxable liabilities, refer to appendix A.2.

provided by Devereux et al. (2015). We create a dummy variable $Levy2_{ijt}$ that equals one if both a levy is in place in the country and year and the taxable liabilities of a bank exceed the allowance threshold. Hence, this variable indicates whether a bank is effectively taxed. A similar measure is also applied by Buch et al. (2014) who analyse the German levy. In countries that tax all banks, $Levy1$ and $Levy2$ coincide. Eventually, we calculate the marginal tax rate $Levy3_{ijt}$ for each bank given its taxable liabilities. As suggested by Albertazzi and Gambacorta (2010), we also include the quadratic term $Levy3^2$ to account for potential non-linearities. Overall, the bank-level proxies are more informative but they rely on a rather rough approximation of the tax base. The country-level levy variable is, in contrast, clearly identified thus providing a robustness check.

Since the bank-level variables $Levy2$ and $Levy3$ by construction depend on balance sheet characteristics, they should be considered endogenous. For instance, a withdrawal of funds affects both interest expenses and the exposure to the levy such that the explanatory variable is correlated with the error term. Or, banks with taxable liabilities around the allowance threshold might strategically lower their exposure to avoid the levy. We address this issue by instrumenting the two variables: Following Devereux et al. (2015) who apply a methodology developed by Gruber and Saez (2002) in the context of personal income taxation, we instrument the possibly endogenous variable with a measure that would have prevailed if the balance sheet was exactly the same after the levy was introduced. More precisely, we construct two bank-level instruments, a dummy variable that indicates whether the bank is taxed and the marginal levy rate, based on the balance sheet in the year prior to the levy's introduction.[19] This instrument is clearly exogenous and strongly correlated with the actual levy variable.[20] The first stage regressions are very strong and the usual F-statistic easily exceeds the value of ten.[21]

The vector of controls $\mathbf{X}_{ijt}$ is motivated by the Monti-Klein model: At the bank level, we include the capital ratio $Equity_{ijt}$ and the non-interest expenditures divided by total assets as a proxy for the cost structure, $Cost_{ijt}$. We also add the interbank rate $Interbank_{jt}$, the statutory corporate income tax rate CIT_{jt} that may affect bank lending

[19]The instrument is based on 2010 balance sheets for Germany and the UK, and on 2011 balance sheets for the Netherlands. For Austria, the tax base is the 2010 balance sheet for the full sample period.

[20]The correlation coefficients 0.947 (Levy2) and 0.976 (Levy3) are significant at the 1% level.

[21]Since we specify clustered standard errors but the usual test statistic for weak instruments relies on i.i.d. errors, we use an F-Statistic based on the Kleinbergen-Paap rk statistic as suggested by Baum et al. (2007).

due to the debt bias, and a proxy for the number of banks, the Herfindahl-Hirschman index of bank concentration HHI_{jt}. Additional controls are chosen in line with the incidence literature: In particular, we add bank size measured by the log of total assets squared, $Assets_{ijt}$, which due to allowances and progressive tax rates determines a bank's exposure to the levy. Following Chiorazzo and Milani (2011), we rely on the quadratic values to avoid interfering with other variables defined in terms of total assets. Given the finding of Devereux et al. (2015) that the bank levy may increase asset risk, a concern is that observed higher interest rates may primarily reflect risk premia instead of a pass-through. However, the interest income on loans consists of interest received: Since lending to riskier borrowers is also associated with more defaults, the interest income on loans should not be affected *ex post* provided that the risk premia are accurate. Thus, a higher interest income on loans can indeed be interpreted a pass-through. Nevertheless, it is unlikely that both effects exactly offset each other, and a proxy for the risk of the loan portfolio is included: The average regulatory risk weight or the NPL ratio would be appropriate measures but they are available for a small subsample only. We instead rely on the loan loss provisions as a fraction of average loans, $Provisions_{ijt}$; high values point to poor loan quality and high portfolio risk. To account for different macroeconomic conditions that affect loan demand, the real growth rate of GDP, $Growth_{jt}$, and inflation, $Inflation_{jt}$, are included. Since government interventions in the banking sector during and after the financial crisis partly overlap with the introduction of levies and influence bank behaviour, the fiscal costs of bank recapitalisation and asset relief as a share of GDP, $Recap_{jt}$, are included as suggested by Devereux et al. (2015). All bank-level stock variables are lagged by one period to avoid simultaneity.

Model (29) is estimated using the fixed-effects (OLS or 2SLS) estimator. The main advantage is that this method controls for time-invariant, unobserved heterogeneity. In this context, one might think of the nature of the bank-borrower relationship: In case of a long-standing borrowing relation, the lending rate is *ceteris paribus* lower as monitoring entails a smaller cost but, at the same time, it facilitates shifting the burden because switching to another bank becomes very costly for a borrower (lock in effect). The bank-borrower relationship, in turn, depends on the bank's general strategy, expertise, and reputation, which is usually constant in the short- and medium-term. Compared to the difference-in-difference methodology applied in the country studies by Buch et al. (2014)

and Capelle-Blancard and Havrylchyk (2013), the fixed-effects estimator is more suitable for cross-country data because the levy was introduced at different points in time and different tax rates captured by the measure $Levy3$ apply. The key identifying assumption is strict exogeneity, which requires that the independent variables - especially the main explanatory variable - are uncorrelated with past, present, and future values of the time-varying errors ε_{ijt}. Apart from the possible endogeneity of the bank-level levy variables that is addressed by using instruments, a concern is that banks might have anticipated the levy and already adjusted their balance sheets in advance in order to lower or even avoid paying this tax. Such an adjustment before the introduction would be part of the error term that is thus correlated with post-introduction values of the levy variable thereby violating strict exogeneity. However, the levy was introduced on short notice and at the same time in many countries (see, section 2). For Germany, Buch et al. (2014) argue that there was substantial uncertainty about the levy's design thereby making it difficult for banks to anticipate their precise exposure. Although anticipation is unlikely especially in countries that introduced the levy in 2011 or earlier, we address this concern as a robustness check using a subsample without banks in countries that introduced the levy after 2011. Another concern is that countries strongly affected by the financial crisis were more likely to adopt a bank levy such that increases in lending rates are mainly driven by stronger deleveraging in those countries. Although there is no levy in Ireland and Spain that experienced the worst banking crises in the EU, this concern is taken into account by controlling for the cost of government intervention in the banking sector and by several robustness checks that account for country-specific shocks.

4.1.2 Heterogeneity in Responses

The theoretical analysis implies that the magnitude of the pass-through differs in the degree of bank competition and the capital structure. We thus extend the baseline specification and add two interaction terms

$$y_{ijt} = \alpha_i + \gamma_t + \beta_1 Levy_{ijt} + \beta_2 Levy_{ijt} * BC_{ijt} + \varphi X_{ijt} + \epsilon_{ijt} \tag{30}$$

$$y_{ijt} = \alpha_i + \gamma_t + \beta_1 Levy_{ijt} + \beta_2 Levy_{ijt} * CAP_{ijt} + \varphi X_{ijt} + \epsilon_{ijt} \tag{31}$$

where BC_{ijt} and CAP_{ijt} denote competition and capitalisation measures respectively. Regarding competition, theory highlights the importance of the number of competitors and the interest rate elasticity: Thus, we include the Herfindahl-Hirschman index that is a popular measure of bank concentration; it equals the sum of bank market shares squared. We rely on the HHI based on assets of the entire banking industry in a country provided by the ECB. Furthermore, we add the branch density, that is, the number of bank branches per 10'000 inhabitants: On the one hand, this represents an alternative concentration measure, on the other hand, it can be interpreted as a proxy for the cost of switching to another bank and thus for the corresponding elasticity.[22]

Similarly, to account for the effect of the capital structure on the incidence, we interact the levy variable with the bank's capital ratio (equity/total assets) and its regulatory capital ratio (regulatory capital/risk-weighted assets). All competition and capitalisation variables are based on 2009 values, the year before the bank levy was adopted for the first time.[23] They are thus clearly exogenous to possible later changes in capital structure and bank concentration induced by the levy.

4.2 Data and Measurement

We employ an unbalanced panel dataset that includes bank-level information of (at most) 2'987 banks from 23 European countries between 2007 and 2013. All countries that were members of the EU for the full period except for France, Hungary, Slovenia, and Finland, which adopted a conceptually different levy, are included. The sample consists of 18'747 bank-year observations. Four different types of banks are represented: commercial banks (18.6% of all bank-year observations), savings banks (24.1%), cooperative banks (53.5%), and real estate and mortgage banks (3.8%). The sample covers approximately 44 percent of all banks in the 23 countries (see, table A.2 in appendix A.3). German and Italian banks are overrepresented accounting for 55% (18%) of sample versus 28% (11%) of existing banks in 2010. This issue is addressed as a robustness test, and most results do not appear to be driven by the behaviour of banks from Germany or Italy.

A list of variables, their definitions and sources is provided in appendix A.2. The main

[22] Another way to account for differences in elasticities is distinguishing between new and outstanding loans as in Capelle-Blancard and Havrylchyk (2013), which would require individual loan data.

[23] The main effect is absorbed by the fixed effect. The contemporaneous effect is captured by the covariates HHI and $Equity$; whenever the branch density is used in (30), we also replace HHI by the branch density in the controls.

source is *Bankscope*, a database provided by the Bureau van Dijk that contains information on balance sheets and income statements of banks based on their annual reports. Since taxes are levied on single entity accounts, we rely on unconsolidated financial statements. This removes the problem that multinational banks may face levies in several countries as we have separate data for the parent bank and its foreign subsidiaries.[24] Detailed information about bank levies is taken from Devereux et al. (2015), who provide hand-collected data about the levy's design (tax base, allowance, tax rates) in all countries. Macroeconomic data (real growth and inflation rates) are from Eurostat and bank sector characteristics from the ECB Banking Structures Report. Data on interbank rates are from the OECD financial statistics or from national central banks[25]. Some adjustments of the sample were made: First, observations with closing date between April and September are excluded because they cannot be clearly attributed to a specific year; observations with closing date between January and March are attributed to the previous and observations with closing date between October and December to the current year. Second, all observations in a currency other than Euro are transformed into Euro. Third, inactive banks as well as banks with negative assets or equity are deleted.[26] Fourth, some variables are ratios typically expressed in terms of bank assets, loans, or deposits. They may take extreme values if, for example, the assets are very small or misreported. We reduce the influence of such outliers by winsorizing all bank-level ratios and growth rates at the 2.5 and 97.5 level. The main findings also result for different winsorization levels. The bank-level levy measures[27] are constructed based on the approximation of banks' taxable liabilities in those four countries that exempt small banks or apply a progressive tax rate: Austria, Germany, the Netherlands, and the UK. The taxable liabilities are approximated according to the information provided by Devereux et al. (2015, appendix). They usually equal the balance sheet total net of equity and insured deposits; in Germany, all customer deposits are exempt. Insured deposits are, in turn, calculated by multiplying a bank's customer deposits by the coverage ratio (i.e., the volume share of insured in total deposits); this measure is provided by the EU Commission. The bank-level proxy $Levy2$

[24]Foreign branches subject to a levy are included in the unconsolidated data of the domestic bank.

[25]Information from central banks for Bulgaria, Cyprus, Latvia, Lithuania, Malta, and Romania

[26]This might give rise to the survivorship bias if banks exit because they cannot pass through the levy. However, this is highly unlikely in the short run as most countries introduced the levy not earlier than 2011 and the sample includes just two follow-up periods.

[27]The detailed construction of the tax base is explained in appendix A.2.

equals one if the current-year taxable liabilities exceed the allowance threshold and a levy is charged. The variable *Levy*3 equals the marginal tax rate based on the taxable liabilities; if short- and long-term liabilities are taxed at a different rate, a simple average is chosen. For Austria, the levy variable is determined according to the 2010 balance sheet for the entire period. The Netherlands and the United Kingdom impose the levy on the consolidated balance sheet: For the two countries, we thus restrict the sample to banks for which both consolidated and unconsolidated data are available. The variables *Levy*2 and *Levy*3 are determined based on its consolidated balance sheet but the subsequent empirical analysis of the incidence relies on unconsolidated data.

The summary statistics are provided in table A.3 in appendix A.3 for the full sample (column 1) and for different groups of banks depending on their exposure to the levy (columns 2-5). Total assets of the average bank amount to EUR 5.49bn, 8.7 percent of which are funded by equity. In general, banks located in levy countries are smaller and funded by a lower share of equity (7.83% vs. 10.72%). Banks that are effectively taxed are, however, considerably larger (total assets of EUR 13.38bn vs. EUR 3.4bn) and have a lower capital ratio (7.96% vs. 8.9%). This is due to the fact that small banks are often exempt and that equity is not taxed.

	Banks in Levy Country		Banks Subject to Levy		
	Fraction	Banks	Fraction	Banks	Total Banks
2010	2.68	76	2.68	76	2836
2011	68.29	2017	18.81	542	2911
2012	70.75	2054	19.66	565	2903
2013	68.20	1398	23.09	469	2050

Table 3: *Banks Subject to Levy*

The first two columns refer to banks in a country that charges a bank levy (i.e., $Levy1 = 1$); the next two columns refer to banks that are effectively taxed (i.e., $Levy2 = 1$).

In general, roughly 70 percent of banks in the sample are located in 11 out of 23 countries that adopt the bank levy during the observation period (see table A.2 in appendix A.3). The distribution of banks depending on their tax exposure is summarised in table 3: In 2010, the levy was first effective in Sweden[28] and applied to all banks such that 76 out of 2'836 banks in the sample were taxed. In 2011, the share of banks in countries that charge a levy substantially increased to 68 percent as seven countries including Germany

[28]Officially, it was enacted in October 2009 and formally introduced on 30 December such that the first payment was already due in 2009 (see, table 1). Following Devereux et al. (2015, Appendix), banks are considered unaffected by the levy in 2009 (i.e., $Levy1 = 0$) because many banks had already drawn up their balance sheet when the levy was enacted and very little time was left for an adjustment.

and the United Kingdom introduced such a tax. However, only 19 percent of banks faced a positive tax rate as many small banks were exempt. These shares slightly increased in 2012 when three additional countries adopted a bank levy. On average, a bank that is taxed faces a marginal levy rate of 0.0345 percent; the lowest rate is 0.018 percent in Sweden (2010), the highest rate is 0.4 percent in Slovakia.

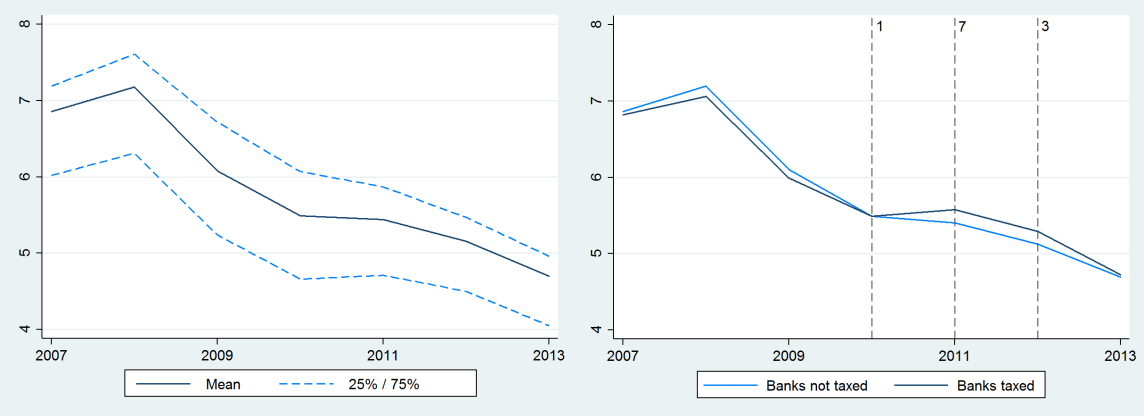

Figure 1: *Interest Income on Loans*
The left panel illustrates the mean interest income on loans as well as the upper and lower quartile. The right panel shows the mean interest income of banks that become subject to a levy (i.e., $Levy2 = 1$) during the sample period and for those that do not. The dashed vertical lines indicate the introduction of the levy in 2010 (one country), 2011 (7 countries), and 2012 (3 countries).

On average, banks earn an interest income on loans of 5.85 percent of loans; those in countries that adopt the levy at one point in time show higher values (6.03%) than those in countries without (5.43%). Figure 1 shows the mean interest income as well as the lower and upper quartile of the distribution (left panel): It steadily decreased from an average value of more than 7 percent in 2008 to less than 5 percent in 2013. This pattern reflects the general decline of interest rates given the expansionary monetary policy and low growth and inflation. The right panel illustrates the mean interest income on loans depending on whether a bank becomes subject to the levy at one point during the observation period or not. Before the levy was adopted for the first time, the interest income of both groups follows a similar pattern. In 2011 when seven countries introduce a levy, the interest income on loans of banks subject to the tax slightly increases, while that of unaffected decreases. Thus, the descriptive analysis points to a slight increase associated with the levy.

The interest expenses on customer deposits are on average 1.69 percent of deposits; they are higher for banks located in countries adopting a levy (2.19% vs. 1.56%) and for those effectively taxed (2.16% vs. 1.60%). Figure 2 (left panel) shows a decline of interest

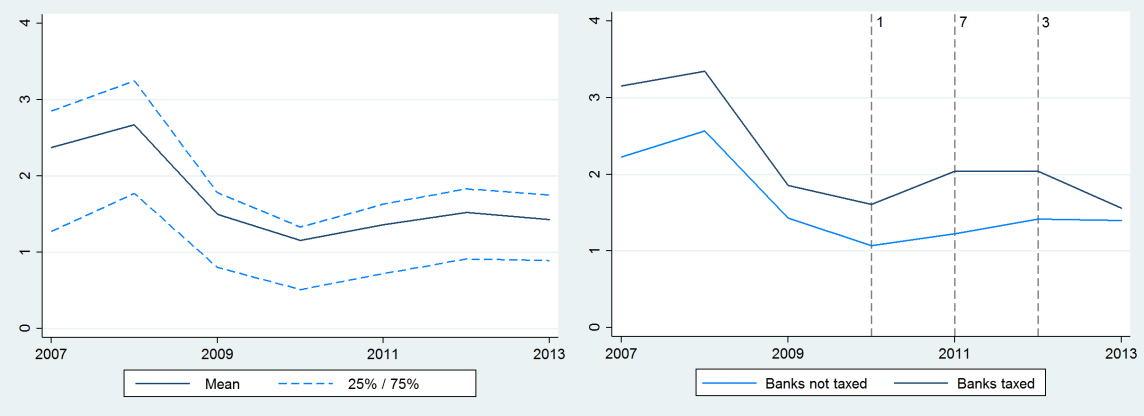

Figure 2: *Interest Expenses on Deposits*

The left panel illustrates the mean interest expenses on customer deposits as well as the upper and lower quartile. The right panel shows the mean interest expenses of banks that become subject to a levy (i.e., $Levy2 = 1$) during the sample period and for those that do not. The dashed vertical lines indicate the introduction years of the levy.

expenses during the sample period. From 2010 on, they remained rather stable. The right panel illustrates the mean interest expenses depending on the levy exposure. Again, one can observe that in the most relevant introduction year 2011, the interest expenses of affected increase more strongly than those of unaffected banks. Note that data on interest expenses on deposits are available only for a subsample of roughly 1'000 banks where, contrary to the full sample, Italian banks are over- and German underrepresented.

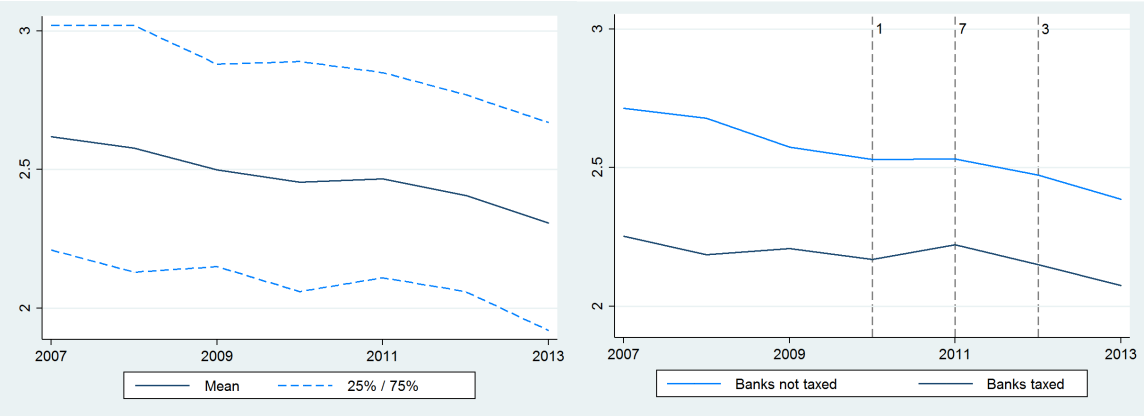

Figure 3: *Net Interest Margin*

The left panel illustrates the mean net interest margin as well as the upper and lower quartile. The right panel shows the mean net interest margin of banks that become subject to a levy (i.e., $Levy2 = 1$) during the sample period and for those that do not. The dashed vertical lines indicate the introduction years of the levy.

The third outcome variable, the net interest margin, reaches an average of 2.48 percent. It is lower for banks in countries that adopt the levy (2.41% vs. 2.64%) and that are effectively taxed (2.18% vs. 2.56%). Compared to the interest rates, the NIM only slightly declined as shown in the left panel of figure 3. The right panel shows the mean

net interest margin depending on whether banks become subject to the levy at one point in time or not: For the former, it slightly increases in 2011 when the levy was introduced in seven countries, whereas the NIM of unaffected banks remains constant. Subsequently, the NIM of taxed banks does not decline more strongly than that of the control group. Overall, the descriptive evidence indicates that the interest rates and margins of banks that became subject to the levy slightly increased around its introduction (especially in 2011). This hints at the positive responses implied by theory.

4.3 Main Results

This section summarises the main results, namely, the estimates of the baseline model and of the heterogeneous response models.

4.3.1 Baseline Model

Table 4 reports the coefficient estimates of the baseline regression (29). For each of the three outcome variables, we run five regressions, using country- and bank-level levy dummies, $Levy1$ and $Levy2$, as well as the marginal tax rate $Levy3$. When relying on the bank-level levy variables, both the OLS and the IV (2SLS) estimates are reported. First of all, the interest income on loans increases as soon as a bank is indeed affected by the levy, while the country-level variable $Levy1$ remains insignificant: The coefficient of the bank-level dummy $Levy2$ is positive and significant, it implies an increase in the average lending rate between 0.2 and 0.24 percentage points. The coefficients of the marginal levy rate, $Levy3$, indicate a positive and non-linear relation: The total effect of introducing a marginal tax rate $Levy3 = \tau$ is $\beta_1\tau + \beta_1'\tau^2$. Taxed banks on average face a marginal levy rate of 0.0345 percent such that the interest income on loans is between 0.19 and 0.31 percentage points higher depending on whether the OLS or IV estimates are considered. In a more extreme case of a 0.06 percent marginal levy rate corresponding to the top levy rate in Germany, the interest income even increases between 0.33 and 0.51 percentage points. Apart from the last case, the estimates are rather small given a mean interest income of 5.85 percent.

	Interest Income on Loans					Interest Expenses on Deposits					Net Interest Margin				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Levy1	0.0417					0.1927**					0.1531***				
	(0.0620)					(0.0749)					(0.0210)				
Levy2		0.1957***	0.2407***				0.1550*	0.1812**				0.0394**	0.0498***		
		(0.0348)	(0.0405)				(0.0826)	(0.0864)				(0.0156)	(0.0178)		
Levy3				5.9058***	9.4214***				2.6840	2.8793				1.3401*	2.1606**
				(1.5166)	(2.0607)				(2.0502)	(2.5841)				(0.7069)	(0.8590)
$Levy3^2$				-7.4635	-15.9897**				-7.3457	-7.8063				-2.6055	-4.5766**
				(5.5869)	(6.6287)				(4.9661)	(6.2881)				(1.8162)	(2.1829)
Assets	-0.0099	-0.0104	-0.0105	-0.0102	-0.0104	0.0221**	0.0220**	0.0217**	0.0228**	0.0227**	-0.0100***	-0.0099***	-0.0099***	-0.0099***	-0.0099***
	(0.0095)	(0.0095)	(0.0095)	(0.0094)	(0.0094)	(0.0101)	(0.0102)	(0.0102)	(0.0100)	(0.0101)	(0.0030)	(0.0029)	(0.0029)	(0.0029)	(0.0029)
Equity	-0.0287*	-0.0297**	-0.0304**	-0.0296**	-0.0305**	0.0163	0.0171*	0.0167	0.0187*	0.0187*	0.0180***	0.0232***	0.0230***	0.0234***	0.0231***
	(0.0162)	(0.0151)	(0.0151)	(0.0142)	(0.0142)	(0.0104)	(0.0103)	(0.0103)	(0.0103)	(0.0103)	(0.0051)	(0.0048)	(0.0048)	(0.0048)	(0.0048)
Cost	0.0955**	0.0931**	0.0933**	0.0943**	0.0943**	-0.0769 ***	-0.0752***	-0.0749***	-0.0763***	-0.0762***	0.1434***	0.1375***	0.1380***	0.1374***	0.1377***
	(0.0415)	(0.0418)	(0.0419)	(0.0418)	(0.0419)	(0.0251)	(0.0250)	(0.0250)	(0.0250)	(0.0250)	(0.0197)	(0.0196)	(0.0195)	(0.0196)	(0.0196)
Provisions	0.0228	0.0244	0.0252	0.0226	0.0237	0.1090***	0.1075***	0.1078***	0.1053***	0.1053***	-0.0624***	-0.0678***	-0.0676***	-0.0680***	-0.0676***
	(0.0259)	(0.0258)	(0.0259)	(0.0258)	(0.0259)	(0.0261)	(0.0261)	(0.0261)	(0.0260)	(0.0261)	(0.0115)	(0.0114)	(0.0114)	(0.0114)	(0.0114)
Inflation	-0.0783***	-0.0739***	-0.0728***	-0.0699***	-0.0656***	-0.0020	-0.0015	-0.0011	0.0006	0.0009	0.0450***	0.0541***	0.0544***	0.0547***	0.0557***
	(0.0213)	(0.0209)	(0.0209)	(0.0207)	(0.0207)	(0.0210)	(0.0212)	(0.0212)	(0.0221)	(0.0224)	(0.0099)	(0.0099)	(0.0099)	(0.0100)	(0.0100)
Growth	-0.0338**	-0.0401***	-0.0420***	-0.0404***	-0.0446***	-0.1175***	-0.1156***	-0.1168***	-0.1119***	-0.1122***	0.0067	0.0151***	0.0148***	0.0151***	0.0143***
	(0.0137)	(0.0126)	(0.0126)	(0.0126)	(0.0125)	(0.0124)	(0.0126)	(0.0127)	(0.0123)	(0.0126)	(0.0057)	(0.0051)	(0.0051)	(0.0051)	(0.0051)
Interbank	0.3191***	0.3105***	0.3074***	0.3231***	0.3246***	0.2549***	0.2535***	0.2520***	0.2651***	0.2652***	0.0596***	0.0736***	0.0730***	0.0764***	0.0767***
	(0.0378)	(0.0362)	(0.0360)	(0.0360)	(0.0358)	(0.0317)	(0.0325)	(0.0323)	(0.0315)	(0.0313)	(0.0219)	(0.0225)	(0.0224)	(0.0223)	(0.0221)
CIT	-0.0029	-0.0049	-0.0062	-0.0346**	-0.0477***	0.0769***	0.0686***	0.0678***	0.0652***	0.0644***	-0.0163*	-0.0101	-0.0102	-0.0150	-0.0179*
	(0.0180)	(0.0172)	(0.0172)	(0.0168)	(0.0163)	(0.0130)	(0.0135)	(0.0136)	(0.0162)	(0.0164)	(0.0095)	(0.0094)	(0.0094)	(0.0097)	(0.0094)
Recap	0.1191***	0.1155***	0.1156***	0.1099***	0.1086***	0.0301**	0.0271**	0.0271**	0.0264**	0.0264**	0.0205***	0.0083**	0.0078**	0.0075**	0.0067*
	(0.0261)	(0.0220)	(0.0220)	(0.0213)	(0.0213)	(0.0134)	(0.0132)	(0.0132)	(0.0132)	(0.0132)	(0.0048)	(0.0038)	(0.0038)	(0.0038)	(0.0038)
HHI	13.8475***	16.0865***	16.6674***	17.5240***	19.2472***	6.4982**	6.0633*	6.4934*	4.6173	4.7161	5.2519***	4.6352***	4.7557***	4.7932***	5.1130***
	(2.7859)	(2.6545)	(2.6924)	(2.6957)	(2.8293)	(3.2102)	(3.2938)	(3.3513)	(3.0765)	(3.1758)	(1.0958)	(1.0328)	(1.0406)	(1.0914)	(1.1146)
Obs.	13586	13575	13522	13575	13522	4765	4763	4763	4763	4763	15215	15191	15135	15191	15135
No. banks	2550	2549	2524	2549	2524	921	921	921	921	921	2837	2837	2811	2837	2811
R^2	0.6381	0.6400	0.6398	0.6407	0.6402	0.5869	0.5858	0.5858	0.5855	0.5855	0.1345	0.1268	0.1275	0.1269	0.1274
Method	OLS	OLS	IV	OLS	IV	OLS	OLS	IV	OLS	IV	OLS	OLS	IV	OLS	IV
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 4: *Baseline Regressions*

Dependent variable: interest income on loans/av. loans in (1) - (5); interest expenses on customer deposits/av. customer deposits in (5) - (10); net interest margin in (11) - (15); standard errors clustered at the bank level in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All estimations are performed in Stata using the `xtivreg2` module.

Moreover, the results suggest that the levy increases the bank's interest expenses on customer deposits. In line with theory, this points to a substitution effect that arises because deposits are largely exempt from the levy such that depositors even benefit. Given mean interest expenses on deposits of 1.69 percent, the effect is not negligible: A bank located in a country with a levy pays a 0.19 percentage points higher interest rate on deposits. For banks effectively taxed (columns 7-8), slightly lower increases are observed. The coefficients for the marginal levy rate, in contrast, remain insignificant. Recall that this outcome variable is only available for a subsample such that the estimates need to be interpreted with some caution. Eventually, the results for the net interest margin (NIM) shown in columns (11) - (15) are positive and significant: When using the country-level proxy $Levy1$, one finds that the NIM of banks located in a country that adopts a levy increases by 0.15 percentage points. The coefficient of $Levy2$ also implies a positive but smaller increase between 0.04 and 0.05 percentage points. The coefficients for the marginal levy rate have opposite signs pointing to a concave relation: The NIM of banks facing the mean marginal levy rate is between 0.04 and 0.07 percentage points higher; a levy rate of 0.06 percent implies an increase between 0.07 and 0.11 percentage points. Compared to an average NIM of 2.48 percent, the effects imply an increase between two and six percent and their economic significance should not be overstated. The NIM is clearly less sensitive to the bank levy than the interest rates, which may be explained by the higher deposit rate that weakens the increase in the lending spread and by the fact that it also includes interest rates on other assets and liabilities.

Overall, one concludes that the tax burden is indeed passed onto borrowers and raises the lending spread, while depositors my even benefit from higher interest rates. The quantitative effects are moderate especially for the lending rate and the net interest margin. One could partly attribute this to the fact that the outcome variables are averages and thus measure the incidence in a rather conservative way. The estimates are broadly consistent with the literature: The positive effect on deposit rates is in line with Buch et al. (2014). For the Hungarian bank levy, Capelle-Blancard and Havrylchyk (2013) find positive but stronger effects on lending rate and net interest margin: They estimate increases in the interest rate on housing loans between 0.57 and 1.08 percentage points and in the net interest and fee margin of 0.84 percentage points whenever a bank is taxed. However, the levy in Hungary involves a broader tax base and higher tax rates, and the effect is

estimated for borrowers with outstanding loans such that their demand is likely inelastic. For the incidence of the corporate income tax, Albertazzi and Gambacorta (2010) estimate that a 10 percentage points decrease of the tax rate lowers the pre-tax profit as a share of total assets by 9.4 percent, which is stronger than our estimated response of the NIM (the most closely related outcome) of at most six percent. Compared to tighter capital regulation, the levy's impact on the NIM is not stronger than a one percentage point increase in capital requirements, which is associated with a 0.14 percentage points higher lending spread in the Euro area (Slovik and Cournède, 2011).

These findings - the levy increases lending and deposit rate - are fully consistent with the main scenario of the Monti-Klein model. Recall that two scenarios may materialise depending on whether banks are deposit-poor or deposit-rich in the sense that they are (net) borrowers or lenders on the interbank and money markets. We explore this aspect based on banks' loan-to-deposit ratio[29]: High values suggest that a bank is loan-rich and deposit-poor and needs to finance its loans partly by non-deposit liabilities, whereas a low ratio implies that part of a bank's deposits finance substantial asset holdings apart from loans. Hence, the sample is split into two subsamples of banks with a loan-to-deposit ratio above the 70th (103.76%) and below the 30th percentile (71.07%). The results are not very sensitive to these cutoffs; one obtains similar results by splitting the sample at the median, for example. Based on the 2009 distribution, the cutoffs are exogenous to later changes induced by the levy.

Table 5 reports the coefficients of interest. In line with theory, there are striking differences between deposit-poor and deposit-rich banks: The estimates for the former shown in the upper section imply increases in the average lending and deposit rate. Similar to the results for the full sample, this mirrors the main scenario with differential taxation of deposits. In contrast, there is little evidence for higher lending rates of deposit-rich banks: Instead, they tend to lower the deposit rate although the effect is significant in one specification only. The differential responses depending on the loan-to-deposit ratio can be rationalised by the two scenarios implied by the model. Essentially, the behaviour of loan-rich, deposit-poor banks appears to drive the results for the full sample, while the response of deposit-rich banks - shifting the burden to depositors - is at most weak.

[29]Using the bank's funding constraint, one can express the condition for the main scenario, $m_i > 0$, in terms of a minimum loan-to-deposit ratio: $l_i/d_i > (1-\tau)/(1-k)$.

	Interest Income on Loans			Interest Expenses on Deposits		
	(1)	(2)	(3)	(4)	(5)	(6)
	Deposit-poor banks (Loans/Deposits > 70th percentile)					
Levy1	0.2168***			0.2927***		
	(0.0662)			(0.1131)		
Levy2		0.1711**			0.3528***	
		(0.0709)			(0.1126)	
Levy3			4.9983			8.8688***
			(3.0827)			(2.9911)
Levy3^2			-1.4465			-22.5581***
			(12.4713)			(7.2546)
Obs.	4541	4478	4478	3026	3025	3025
No. banks	900	874	874	589	589	589
R^2	0.6628	0.6627	0.6649	0.5975	0.5981	0.5967
	Deposit-rich banks (Loans/Deposits < 30th percentile)					
Levy1	-0.0247			-0.0799		
	(0.1544)			(0.1650)		
Levy2		0.0958			-0.0728	
		(0.0888)			(0.1978)	
Levy3			4.2737			-7.9566*
			(4.5410)			(4.5582)
Levy3^2			-3.1682			19.9430*
			(10.8536)			(11.0505)
Obs.	3705	3705	3705	590	590	590
No. banks	685	685	685	117	117	117
R^2	0.6415	0.6415	0.6419	0.5324	0.5329	0.5338
Method	OLS	IV	IV	OLS	IV	IV
Bank FE, Controls	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Table 5: *Main vs. Alternative Scenario*
Dependent variable: interest income on loans/av. loans in (1) - (3); interest expenses on customer deposits/av. customer deposits in (4) - (6); clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.3.2 Heterogeneity in Responses

A key theoretical prediction is that the magnitude of the pass-through depends on bank competition, more precisely, concentration, and capitalisation. Table 6 reports the coefficients for regression (30) with interactions term of the levy variable and Herfindahl-Hirschman index and branch density respectively.

The upper section summarises the results for the interest income on loans: As expected, the interaction terms of the levy and concentration variables are positive and significant in two out of three cases if the HHI is used (columns 1-3) and negative and significant if the branch density is used (columns 4-6). The average lending rate thus increases more strongly in concentrated banking markets. For a quantitative interpretation, one needs to compute the combined effect, which is $\beta_1 + \beta_2 * BC$ whenever the levy is represented by a dummy variable and $\tau * [\beta_1 + \beta_1' * \tau + \beta_2 * BC]$ whenever the marginal tax rate $Levy3 = \tau$ is applied. Table 7 shows the levy's impact on interest income on loans depending on market concentration for three different scenarios: the bank is located in a country that charges a levy (i.e., $Levy1 = 1$, column 1), the bank faces a positive

	(1)	(2)	(3)	(4)	(5)	(6)
			Interest Income on Loans			
Levy1	-0.2123**			0.6912***		
	(0.0863)			(0.1506)		
Levy2		0.0030			0.6836***	
		(0.0680)			(0.1536)	
Levy3			4.8959*			14.8380***
			(2.7160)			(3.2594)
Levy3^2			-30.9939**			-22.5297***
			(13.1133)			(7.4797)
Levy*BC	8.0159***	6.4934***	82.8444	-0.1492***	-0.1112***	-1.4246***
	(1.5532)	(1.5872)	(51.1973)	(0.0340)	(0.0331)	(0.3887)
Obs.	13586	13522	13522	13557	13495	13495
No. banks	2550	2524	2524	2548	2522	2522
R^2	0.6415	0.6419	0.6402	0.6395	0.6395	0.6383
			Interest Expenses on Deposits			
Levy1	0.4025***			0.3771***		
	(0.1303)			(0.0987)		
Levy2		0.4497**			0.3714***	
		(0.2045)			(0.1097)	
Levy3			24.5843**			9.2633***
			(11.1169)			(3.1188)
Levy3^2			16.0335			-17.8560***
			(12.9625)			(6.2641)
Levy*BC	-2.6003*	-3.0091	-245.7498**	-0.0780***	-0.0760***	-1.1786***
	(1.4930)	(2.1282)	(121.8664)	(0.0210)	(0.0215)	(0.3017)
Obs.	4765	4763	4763	4739	4739	4739
R^2	0.5874	0.5859	0.5848	0.5955	0.5949	0.5953
No. banks	921	921	921	919	919	919
			Net Interest Margin			
Levy1	0.2054***			-0.0645		
	(0.0246)			(0.0625)		
Levy2		0.0638***			-0.2743***	
		(0.0221)			(0.0682)	
Levy3			1.5221*			-1.7394
			(0.8263)			(1.5695)
Levy3^2			-6.7927			1.7174
			(5.0575)			(2.7814)
Levy*BC	-1.4839***	-0.3431	12.0325	0.0415***	0.0668***	0.4839*
	(0.5300)	(0.5743)	(18.7406)	(0.0129)	(0.0148)	(0.2535)
Obs.	15215	15135	15135	15186	15108	15108
No. banks	2837	2811	2811	2835	2809	2809
R^2	0.1359	0.1275	0.1273	0.1330	0.1300	0.1282
BC		HHI			Branch Density	
Method	OLS	IV	IV	OLS	IV	IV
Bank FE, Controls	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Table 6: *Heterogeneous Responses: Bank Competition*

The levy variables are interacted with the HHI in (1) - (3) and with the branch density in (4) - (6); clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

marginal tax rate (i.e., $Levy2 = 1$, column 2), and the bank faces a marginal tax rate of 0.06 percent corresponding to the top marginal tax rate in Germany (i.e., $Levy3 = 0.06$, column 3). Since we explore cross-country heterogeneity, it is appropriate to focus on a simple, country-level distribution of HHI and branch density.[30] Accordingly, we show the effects for banks located in countries with bank concentration at the 25th, 50th, and 75th percentile. The effect for the weighted sample median (Germany) is also reported.

The increase is clearly stronger in concentrated banking markets: Whenever the levy

[30]The full sample distribution of the competition measures is less meaningful for a cross-country comparison as fragmented markets are overrepresented due to the large number of German banks.

			(1)	(2)	(3)
HHI	25th Percentile	UK	0.164***	0.308***	0.416***
	Median	CY	0.661***	0.711***	0.724***
	75th Percentile	SK	0.734***	0.769***	0.769***
	Weighted Median	DE	-0.047	0.137***	0.285**
Branch Density	25th Percentile	SK	0.349***	0.429***	0.613***
	Median	RO	0.220**	0.332***	0.539***
	75th Percentile	AT	-0.059	0.124***	0.379***
	Weighted Median	DE	-0.019	0.154***	0.403**

Table 7: *Heterogeneous Responses: IIL and Bank Competition*

variable is interacted with the HHI, the interest income on loans increases by more than 0.7 percentage points in concentrated markets (Slovakia, HHI=0.127) irrespective of the scenario. The increase of 0.66 to 0.72 percentage points at the median (Cyprus, 0.109) is strong but it is clearly weaker in less concentrated markets like the UK (0.047). For the branch density, one observes more variation across the scenarios as the bank-level have a stronger effect than the country-level variables: The interest income on loans is between 0.35 and 0.61 percentage points higher in countries at the 25th percentile (Slovakia, 2.29 branches/10'000 inhabitants). At the median (Romania, 3.16), one observes an increase between 0.22 and 0.54 percentage points, while the effect is clearly weaker or even insignificant at the 75th percentile (Austria, 5.03). Overall, the pass-through in concentrated markets is economically significant given a mean interest income on loans of 5.85 percent. Evaluating the heterogeneous response model at the weighted sample median (Germany, HHI=0.021, 4.76 branches/10'000 inhabitants), yields estimates broadly consistent with the baseline model.

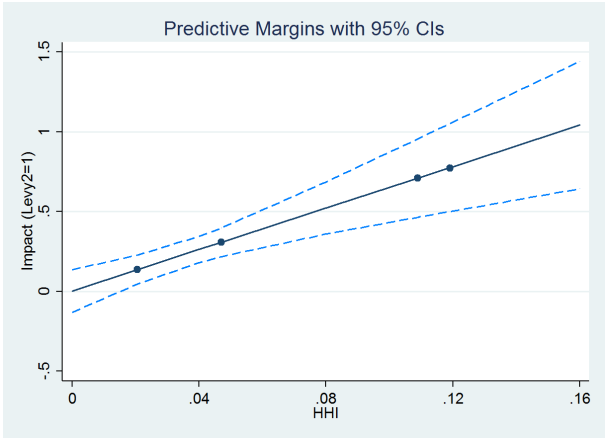

Figure 4: *Heterogeneity: Interest Income on Loans and HHI*
This figure illustrates the effect of a bank being taxed ($Levy2 = 1$) on IIL depending on market concentration. The points indicate the unweighted sample median (0.021) as well as the quartiles (0.047, 0.107, 0.127) of the simple HHI distribution.

Figure 4 illustrates the response of a bank that faces a positive marginal tax rate depend-

ing on the HHI (scenario 2). The blue points indicate the quartiles as well as the weighted sample median. The response of the average lending rate is significant already at a very low degree of bank concentration and rapidly increases in the HHI. Figure 5 shows the increase in the average lending rate of a bank that faces a 0.06 percent marginal tax rate depending on the branch density (scenario 3). The relation is negative as a higher branch density implies a less concentrated market and more alternatives for borrowers. Whenever it exceeds 7.5, the effect becomes insignificant but this only concerns Cyprus. Hence, the evidence supports the prediction that strong bank concentration reinforces the pass-through to borrowers. Depending on the scenario, we find increases up to between 0.6 to 0.75 percentage points in highly concentrated markets that are economically significant and clearly larger than the moderate average effects.

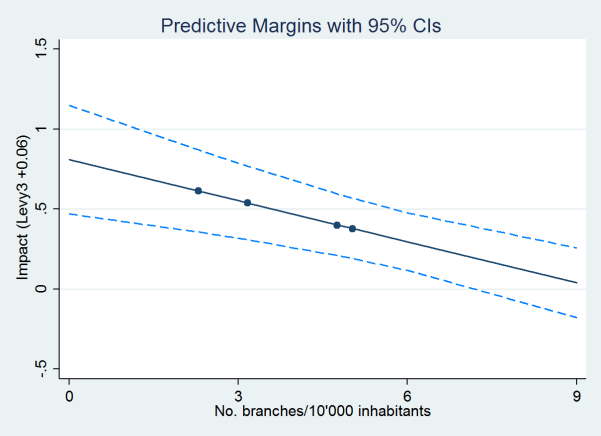

Figure 5: *Heterogeneity: Interest Income on Loans and Branch Density*
This figure illustrates the effect of a 0.06% marginal tax rate on IIL depending on the branch density. The points indicate the unweighted sample median (4.76) as well as the quartiles (2.29, 3.16, 5.03) of the simple BD distribution.

In the middle section of table 6, the estimates for impact of concentration on the sensitivity of the deposit rate are shown. Interacting the levy with the HHI yields negative and significant coefficients in two out of three specifications (columns 1-3), which imply that the increase in the average deposit rate is weaker in more concentrated markets. This is in line with the prediction that deposit rates are stickier in concentrated markets such that their increase is less pronounced. The interaction terms with the branch density (columns 4-6), in contrast, show negative and significant coefficients suggesting that the increase is stronger in markets with relatively few branches. This leaves some uncertainty about how bank competition influences the response of the deposit rate.

Eventually, the lower section reports the estimates for the net interest margin. Recall

that counteracting price and composition effects do not allow for a clear prediction of how the sensitivity varies with competition. Interacting the levy with the HHI yields only one significant, negative coefficient, whereas those with the branch density are positive and significant. This points to a negative effect of concentration on the increase in the NIM. The second dimension of heterogeneity is the capital structure of banks: Table 8 reports the coefficients of the interaction terms between the levy variable and the 2009 capital ratio (columns 1-3) and the regulatory capital ratio (columns 4-6). We focus on the impact of the capital structure on the sensitivities of the interest income on loans and the net interest margin. The regressions of the interest expenses on deposits are omitted as, in line with theory, no significant impact of the capital structure is found.

	(1)	(2)	(3)	(4)	(5)	(6)
			Interest Income on Loans			
Levy1	-0.0446			0.3933***		
	(0.0910)			(0.1009)		
Levy2		0.0521			0.3143*	
		(0.0780)			(0.1840)	
Levy3			9.6834***			6.3674***
			(2.0645)			(2.3500)
Levy3^2			-15.3378**			-5.2665
			(7.0275)			(5.8176)
Levy*CAP	0.0114	0.0283**	-0.0443	-0.0211***	-0.0114	-3.4737**
	(0.0080)	(0.0115)	(0.1970)	(0.0047)	(0.0126)	(1.6877)
Obs.	13296	13283	13283	10262	10254	10254
No. banks	2432	2431	2431	1863	1863	1863
R^2	0.6427	0.6443	0.6443	0.6858	0.6852	0.6852
			Net Interest Margin			
Levy1	0.3243***			0.3282***		
	(0.0331)			(0.0430)		
Levy2		0.1679***			0.0809	
		(0.0337)			(0.0750)	
Levy3			3.7437***			3.1214***
			(0.8212)			(0.9983)
Levy3^2			-4.2270*			-4.4600
			(2.3072)			(2.7535)
Levy*CAP	-0.0224***	-0.0170***	-0.1849**	-0.0054**	-0.0001	-0.4761
	(0.0042)	(0.0055)	(0.0857)	(0.0022)	(0.0052)	(0.8425)
Obs.	14886	14859	14859	10636	10628	10628
No. banks	2702	2702	2702	1905	1905	1905
R^2	0.1487	0.1346	0.1331	0.1666	0.1483	0.1481
CAP		Capital Ratio			Regulatory Capital Ratio	
Method	OLS	IV	IV	OLS	IV	IV
Bank FE, Controls	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Table 8: *Heterogeneous Responses: Bank Capitalisation*
The levy variables are interacted with the capital ratio in (1) - (3) and the regulatory capital ratio in (4) - (6); clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The evidence remains somewhat inconclusive about how capitalisation affects the sensitivity of the lending rate to the levy: On the one hand, a high regulatory capital ratio has a negative and significant effect in two specifications, on the other hand, the coefficient of the interaction term with the capital ratio is even positive and significant in one case. In contrast, the increase in the net interest margin is clearly less pronounced for well-

capitalised banks as all interaction terms are negative and significant. A high regulatory capital ratio also weakens the effect if the levy is measured at the country level.

			(1)	(2)	(3)
Average Effect			0.153***	0.050***	0.110**
Capital Ratio	25th Percentile	5.53%	0.200***	0.074***	0.148***
	Median	7.12%	0.165***	0.047**	0.130***
	75th Percentile	10.0%	0.100***	-0.025	0.098**
	90th Percentile	14.34%	-0.003	-0.076	0.050

Table 9: *Heterogeneous Responses: NIM and Bank Capitalisation*

Based on the coefficients, one can compute the marginal effects for three similar scenarios as above, which are summarised in table 9: the bank is located in a country with a bank levy (column 1), is subject to a levy (2), and faces a 0.06 percent marginal tax rate (3). In general, banks with a capital ratio at the 25th percentile of the 2009 capital ratio distribution (5.53%) raise the net interest margin by more than in the baseline estimations. The response of banks with a median capital ratio (7.12%) is roughly similar to the baseline estimates. For banks with a capital ratio of ten percent (75th percentile), the increase in the NIM is less pronounced or insignificant; whenever the capital ratio is 14.34 percent (90th percentile), the effect completely vanishes. For example, if a country adopts a bank levy (column 1), the net interest margin is on average 0.15 percentage points higher. Poorly capitalised banks even raise the NIM by 0.2 percentage points. Banks with a capitalisation at the 75th percentile show a 0.1 percentage point increase only but no effect is observed for banks at the 90th percentile.

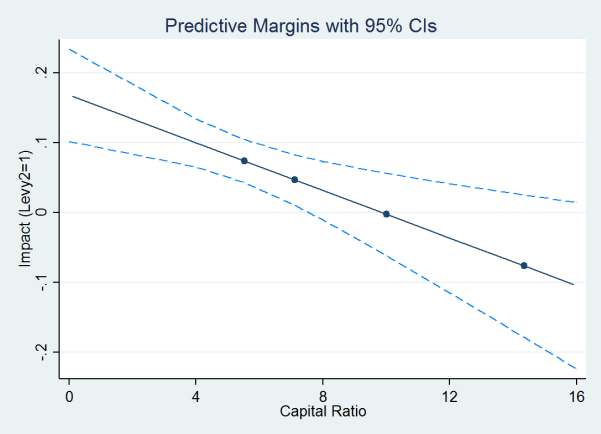

Figure 6: *Heterogeneity: NIM and Capital Ratio*
This figure illustrates the effect of a bank being taxed ($Levy2 = 1$) on the NIM depending on the capital ratio. The points indicate capital ratio at the corresponding percentiles in table 9 (5.53, 7.12, 10, 14.34).

Scenario 2 that describes the response whenever a bank is taxed is illustrated in figure 6:

A higher capital ratio weakens the pass-through to customers, which becomes insignificant above a capital ratio of 7.9 percent. The blue points indicate the four quantiles specified in table 9. Hence, well-capitalised banks do not pass the tax burden onto their customers, whereas the pass-through is stronger for those poorly capitalised. The former may in part explain the rather moderate increase of the NIM on average.

4.4 Robustness Tests

The main results are robust in the sense that three different measures of the bank levy are applied and that we control for a broad set of bank- and country-level factors. This section provides additional robustness tests: First, we introduce separate time trends for different groups of banks to capture specific shocks that are likely in the context of financial crisis and regulatory reform. Second, the concern that some covariates are endogenous is addressed using additional instruments. Third, we estimate the baseline models in subsamples; in particular, we study the incidence at the country level in Austria and Germany. Finally, we estimate the levy's effect on bank lending.

4.4.1 Specific Shocks

The sample period 2007-13 is characterised by the financial and the Eurozone crisis and by massive government and central bank interventions in the banking sector. In addition, regulatory reforms (Basel III, Banking Union) were enacted or at least discussed during the sample period although the introduction took place later. A concern is that such shocks may influence the results if they are correlated with interest rates and coincide with the adoption of bank levies. Importantly, the losses and uncertainty during the crisis and the envisaged reforms may lead to deleveraging, which could ultimately drive the increase in the lending rate but does hardly account for the higher deposit rate.

Although the baseline specification includes macroeconomic controls and the fiscal costs of the banking crisis as well as time fixed effects that absorb all common shocks, we perform a robustness check that also controls for specific shocks following an approach of Devereux et al. (2015). We estimate several variants of the baseline model (29) with differential time trends, namely, separate time fixed effects for different groups of banks depending on their characteristics and location.

On the one hand, we add bank-specific time trends: First, large and small banks have a

different exposure to the crisis and the regulatory reforms; the former are more likely to be systemically important thus benefiting from government guarantees during and facing tighter regulatory constraints after the crisis in the context of 'too-big-to-fail' policies. Evidence, for example, by Acharya et al. (2016) documents a sizeable funding advantage due to implicit guarantees. In countries where large banks are more likely to be taxed due to an allowance and progressive rates, the observed effect might be biased. Hence, we estimate a model with *size-specific time fixed effects* to control for size-specific shocks: For that purpose, a dummy variable for each decile of the total asset distribution in 2009 (i.e., the year before the levy was adopted for the first time) is interacted with the year dummy. Second, poorly capitalised banks may face tighter constraints after the crisis than well-capitalised banks, which leads to a stronger cut of lending and increases in interest rates. At the same time, their tax burden is larger as equity is exempt. Higher lending rates might thus rather reflect the compliance and recapitalisation cost. We include *capital ratio-specific time fixed effects* to control for capital-ratio specific shocks by interacting a dummy variable for each decile of the 2009 capital ratio distribution with the time fixed effect. Third, the behaviour of banks that suffered from severe losses during the crisis may differ from those less affected. If the former are more likely to be taxed, the observed effects could be driven by downsizing due to the severe losses during the crisis. We define a dummy variable for each decile of the distribution of banks' operational profit[31] (as a fraction of total equity) in the crisis year 2008 and interact it with the time dummy to account for *crisis loss-specific* shocks.

On the other hand, the exposure to the financial crisis differs depending on location; Ireland, for example, was severely affected, whereas some eastern European countries like Poland or Slovakia did not experience a banking crisis at all. Whenever countries that were more severely hit - implying a stronger cut of lending and possibly higher lending rates - are more likely to adopt a levy, the estimates can be biased. This concern is addressed in two ways[32]: First, a country's crisis exposure is measured by the fiscal costs for recapitalisation and asset relief for the entire sample period (as a share of 2013 GDP),

[31]The operational profit better captures the crisis impact than net income, which is also affected by taxation. Alternatively, one may rely on net gains or losses from trading, a major source of losses in 2008. However, only some banks report trading activities; for these, the results are roughly similar.

[32]An alternative are country-time fixed effects, which would, however, absorb all country-year variation (including $Levy1$). A significant but smaller increase in IIL and NIM is still observed for the bank-level levy dummy and most marginal tax rates but the increase in IED becomes insignificant.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9))
					Interest Income on Loans				
Levy1	0.0427	-0.0032	0.0479						
	(0.0622)	(0.0666)	(0.0679)						
Levy2				0.3426***	0.2245***	0.1958***			
				(0.0634)	(0.0447)	(0.0402)			
Levy3							11.2961***	8.2416***	6.8717***
							(2.6399)	(2.1274)	(1.9039)
Levy3^2							-20.2095***	-13.5413**	-9.9459
							(7.6190)	(6.8340)	(6.2094)
Obs.	13296	13296	12802	13283	13283	12788	13283	13283	12788
No. banks	2432	2432	2303	2431	2431	2302	2431	2431	2302
R^2	0.6456	0.6631	0.6635	0.6472	0.6642	0.6646	0.6473	0.6647	0.6653
					Interest Expenses on Deposits				
Levy1	0.2266***	0.2207***	0.1891**						
	(0.0782)	(0.0794)	(0.0814)						
Levy2				0.1970**	0.1753**	0.1577*			
				(0.0896)	(0.0891)	(0.0929)			
Levy3							2.8847	2.8206	3.0804
							(2.6472)	(2.6258)	(2.8814)
Levy3^2							-7.7767	-7.8950	-8.4299
							(6.4579)	(6.4092)	(7.0407
Obs.	4638	4638	4334	4637	4637	4332	4637	4637	4332
No. banks	870	870	796	870	870	796	870	870	796
R^2	0.6117	0.6032	0.6197	0.6102	0.6017	0.6185	0.6098	0.6014	0.6183
					Net Interest Margin				
Levy1	0.1589***	0.1066***	0.1405***						
	(0.0210)	(0.0237)	(0.0222)						
Levy2				0.0527**	0.0271	0.0337*			
				(0.0262)	(0.0180)	(0.0184)			
Levy3							2.4061**	1.2108	1.5129
							(1.0696)	(0.8553)	(0.9230)
Levy3^2							-5.0943*	-1.6601	-3.0746
							(2.6811)	(2.1884)	(2.3808)
Obs.	14886	14886	14284	14859	14859	14256	14859	14859	14256
No. banks	2702	2702	2543	2702	2702	2543	2702	2702	2543
R^2	0.1479	0.2597	0.1743	0.1406	0.2587	0.1678	0.1406	0.2588	0.1682
Method	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV
Bank FE, Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Size FE	YES	NO	NO	YES	NO	NO	YES	NO	NO
Time x Cap. Ratio FE	NO	YES	NO	NO	YES	NO	NO	YES	NO
Time x Crisis Loss FE	NO	NO	YES	NO	NO	YES	NO	NO	YES

Table 10: *Robustness: Bank-specific Time Trends*
Baseline regression with size-, capital ratio-, and crisis loss-specific time dummies; clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

which are provided by the European Commission (2013). Recall that the annual fiscal costs are included as covariates (*Recap*) but they capture the contemporaneous effect only. Hence, we define dummy variables for countries with zero fiscal costs and with fiscal costs below and above the (unweighted) median conditional on having incurred positive cost (Luxembourg: 5.7% of GDP) and thus include *crisis cost-specific time fixed effects*. However, large fiscal outlays may point to substantial government interventions, which mitigate the crisis impact on banks. We thus also measure the exposure by the cumulative output loss 2008-11 (compared to the trend) using the banking crisis database of Laeven and Valencia (2012). Again, we rely on dummy variables for countries with no output loss and an output loss below and above the median (Italy: 32%) that are interacted with the year dummies to include *output loss-specific time fixed effects*. Finally, we add

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Interest Income on Loans				
Levy1	0.0793	0.1620***	0.0897						
	(0.0717)	(0.0541)	(0.0777)						
Levy2				0.2505***	0.2326***	0.2599***			
				(0.0421)	(0.0404)	(0.0434)			
Levy3							11.2823***	8.5191***	11.0087***
							(2.1430)	(1.9144)	(2.2580)
Levy3^2							-20.1208***	-12.6955**	-20.1173***
							(6.7035)	(6.4131)	(7.0003)
Obs	13586	13586	13586	13522	13522	13522	13522	13522	13522
No. banks	2550	2550	2550	2524	2524	2524	2524	2524	2524
R^2	0.6407	0.6454	0.6402	0.6422	0.6463	0.6419	0.6428	0.6472	0.6422
					Interest Expenses on Deposits				
Levy1	0.4210***	0.0877	0.4063***						
	(0.0918)	(0.0645)	(0.0739)						
Levy2				0.2688***	0.0673	0.3965***			
				(0.0908)	(0.0770)	(0.0848)			
Levy3							4.2547	1.0792	8.4310***
							(3.2433)	(2.0946)	(2.5605)
Levy3^2							-9.1632	-0.8106	-21.6911***
							(8.0540)	(5.0502)	(6.2491)
Obs.	4765	4765	4765	4763	4763	4763	4763	4763	4763
No. banks	921	921	921	921	921	921	921	921	921
R^2	0.6010	0.6354	0.6084	0.5968	0.6348	0.6056	0.5965	0.6351	0.6044
					Net Interest Margin				
Levy1	0.1578***	0.1905***	0.1711***						
	(0.0225)	(0.0242)	(0.0226)						
Levy2				0.0501***	0.0531***	0.0619***			
				(0.0172)	(0.0180)	(0.0177)			
Levy3							2.2562***	2.0951**	2.7768***
							(0.8043)	(0.8577)	(0.8758)
Levy3^2							-4.4140**	-4.2652*	-6.0382***
							(2.0865)	(2.1783)	(2.2066)
Obs.	15215	15215	15215	15135	15135	15135	15135	15135	15135
No. banks	2837	2837	2837	2811	2811	2811	2811	2811	2811
R^2	0.1430	0.1520	0.1512	0.1362	0.1427	0.1432	0.1362	0.1430	0.1433
Method	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV
Bank FE, Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Recap. FE	YES	NO	NO	YES	NO	NO	YES	NO	NO
Time x Output Loss FE	NO	YES	NO	NO	YES	NO	NO	YES	NO
Time x Debt Crisis FE	NO	NO	YES	NO	NO	YES	NO	NO	YES

Table 11: *Robustness: Country-specific Time Trends*
Baseline regression with recapitalization-, output loss-, and debt crisis-specific time dummies; clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

specific time fixed effects depending on whether a country experienced a sovereign debt crisis in the sense that they required financial support from EU institutions[33] to control for specific shocks associated with a sovereign debt crisis.

Tables 10 and 11 report the coefficient estimates for the model with bank- and country-specific time trends respectively. In general, the results are robust to the inclusion of specific shocks: When regressing interest income on loans, the coefficients of the bank-level levy variables remain positive and significant. They are also quantitatively similar; with size-specific time fixed effects, the coefficients are even larger. The increases in interest expenses on deposit prevail. However, there are some quantitative differences whenever country-specific time trends are included and the coefficient becomes insignifi-

[33]Cyprus, Greece, Ireland, Portugal, and Spain are considered as crisis countries.

cant in one case. Eventually, the increase in the net interest margin is qualitatively and quantitatively similar. Only for capital ratio-specific time fixed effects, the coefficient is smaller or insignificant. Therefore, the main findings do not appear to be driven by shocks to specific groups of banks that are associated with financial and Eurozone crisis and regulatory reforms.

4.4.2 Instrumental Variables

Given the finding of Devereux et al. (2015) that the bank levy increases the capital ratio and may even encourage risk taking, one might be concerned about the endogeneity of two covariates: *Equity* and *Provisions*. To address this concern, we instrument these two variables with a measure that is independent of the levy. Pre-introduction values of capital ratio and loan loss provisions are obvious candidates but they are already absorbed by the fixed effect. Therefore, for banks located in a country that introduces a levy, we project the capital ratio and loan loss provisions based on the pre-introduction levels using the median growth rate of those two variables observed in countries that do not adopt a bank levy at all. This projection, which describes how capital ratio and loan loss provisions might have evolved in the absence of a bank levy, provides an instrument for the possibly endogenous covariates. Both instruments are correlated with the endogenous regressors[34] and the usual F-statistic exceeds the value of ten.

	Interest Income on Loans			Interest Expenses on Deposits			Net Interest Margin		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Levy1	-0.0036			0.1980***			0.1731***		
	(0.0687)			(0.0758)			(0.0223)		
Levy2		0.2208***			0.1794**			0.0583***	
		(0.0426)			(0.0874)			(0.0184)	
Levy3			8.8241***			2.8470			2.3877***
			(2.0811)			(2.6147)			(0.8722)
Levy3^2			-14.7630**			-7.6426			-5.1198**
			(6.5422)			(6.3629)			(2.2289)
Equity	-0.0054	-0.0080	-0.0099	0.0201*	0.0210*	0.0228**	0.0159**	0.0226***	0.0226***
	(0.0207)	(0.0192)	(0.0175)	(0.0110)	(0.0110)	(0.0110)	(0.0064)	(0.0063)	(0.0063)
Provisions	-0.0087	-0.0045	-0.0015	0.0979***	0.0969***	0.0974***	-0.0155	-0.0095	-0.0084
	(0.0522)	(0.0534)	(0.0535)	(0.0309)	(0.0308)	(0.0308)	(0.0194)	(0.0196)	(0.0197)
Obs.	13379	13365	13365	4719	4717	4717	14967	14940	14940
No. banks	2467	2466	2466	902	902	902	2740	2740	2740
R^2	0.6402	0.6419	0.6425	0.5918	0.5906	0.5902	0.1308	0.1199	0.1196
Bank FE, Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 12: *Robustness: Instruments for Equity and Provisions*

Clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 12 reports the coefficients of the model (29) where in addition to the bank-level levy variables, the variables *Equity* and *Provisions* are instrumented: Most importantly,

[34]The correlation coefficients are 0.9682 (Equity) and 0.698 (Risk).

the estimated sensitivities of interest rates and margins to the levy are qualitatively and quantitatively unchanged compared to the baseline estimates in table 4. The coefficients in the NIM regressions are even slightly larger. Hence, the main finding of higher interest rates and margins is not distorted by the two possibly endogenous covariates. Furthermore, the coefficient estimates of the instrumented covariates *Equity* and *Provisions* are smaller than in the baseline specification. *Equity*, for example, does not significantly affect interest income on loans.

4.4.3 Single Country Analysis: Austria and Germany

So far, we have presented cross-country evidence. Although the levies are comparable as they are taxes on liabilities, some differences remain especially when using dummy variables. Thus, we study the incidence at the country level in Austria and Germany: In these two countries, the exposure to the levy varies across banks due to an allowance of EUR 300m and EUR 1bn respectively as well as a progressive tax schedule, and a sufficiently large subsample is available. Recall that the Austrian levy is retroactive for the sample period as it is imposed on the 2010 balance sheet such that the levy variables are exogenous and we can rely on OLS. However, the static model implies no adjustment because banks cannot lower the current tax burden. Since the legislator decided and communicated[35] that the tax base will change to the past-year balance sheet from 2014 on, forward-looking banks may, nevertheless, adjust their balance sheets in order to lower the future tax burden. Note that we cannot estimate the sensitivity of the average deposit rate as it is reported only by few banks; in Austria, only the net interest margin is available for a sufficiently large number of banks.

The coefficients are shown in table 13: We find that the bank levy has a positive effect on the NIM of Austrian banks (columns 1 and 2), which suggests that they pass the burden onto their customers. More specifically, the levy raises the NIM by almost 0.14 percentage points, which is substantially larger than the baseline, cross-country estimate of 0.05 percentage points. This is likely due to the relatively high Austrian tax rates because at a marginal tax rate of 0.06 percent, the coefficients (column 2) imply a 0.13 percentage points higher NIM, which is only slightly larger than the baseline estimate of 0.11. In contrast, there is little evidence for a significant increase in the NIM of German

[35] See, § 2 Abs. 2 Stabilitätsabgabegesetz (BGBl I Nr. 111/2010).

	Austria		Germany			
	NIM		NIM		IIL	
	(1)	(2)	(3)	(4)	(5)	(6)
Levy2	0.1426***		0.0067		0.1552***	
	(0.0440)		(0.0163)		(0.0422)	
Levy3		8.8129**		3.8439**		9.1632*
		(3.6404)		(1.5772)		(5.3141)
Levy3^2		-109.7382*		-161.8677***		-79.4515
		(56.9789)		(46.8277)		(202.8622)
Obs.	995	995	8663	8663	8584	8584
No. banks	206	206	1572	1572	1572	1572
R^2	0.1965	0.1974	0.2573	0.2582	0.7171	0.7171
Method	OLS	OLS	IV	IV	IV	IV
Bank FE, Controls	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Table 13: *Robustness: Austria and Germany*

Dep. Variable: net interest margin (1) - (4), int. income on loans/av. loans (5) - (6); controls only include bank-level variables; clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

banks. Even the coefficients in column 4 are not jointly significant and positive for each marginal tax rate applied in Germany. However, the positive effect on interest income on loans (columns 5 and 6) suggests that the burden is partly passed onto borrowers: If a bank is taxed, its interest income increases by almost 0.16 percentage points. The latter is smaller than the baseline effect of 0.24 percentage points and - since the banking market in Germany is competitive - fully consistent with the heterogeneous response model (30), which implies an increase of 0.137 and 0.154 depending on whether HHI and branch density are used. The results for Germany differ from Buch et al. (2014), who find no significant effect. In contrast, our analysis relies on more recent data with a longer post-introduction period (three years instead of one).

4.4.4 Subsample Tests

We perform three additional robustness tests by estimating the baseline regression in subsamples (i) of Euro area banks, (ii) excluding banks from Belgium, the Netherlands and Slovakia, and (iii) excluding banks from the largest country in the sample (Germany, Italy). The first test provides a routine check in a subsample of more similar banks. The second test addresses an endogeneity concern as these three countries introduced the levy in 2012. Since it had already been in place elsewhere, anticipation seems more likely. However, the relevance of this concern should not be overstated as banks from these countries account for less than two percent of all banks. Eventually, we also check to what extent by the composition of the sample where German banks are overrepresented (see, appendix A.3) drives the results. One outcome variable, interest expenses on deposits, is

only available for subsample where Italian banks are overrepresented such that Italy is excluded instead.

	Interest Income on Loans			Interest Expenses on Deposits			Net Interest Margin		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Euro Area Banks									
Levy1	0.1515*			-0.1249			0.2585***		
	(0.0827)			(0.0966)			(0.0220)		
Levy2		0.1922***			-0.0952			0.0933***	
		(0.0422)			(0.0980)			(0.0160)	
Levy3			6.0665***			-1.7078			3.0260***
			(1.8634)			(2.4105)			(0.6886)
Levy3^2			-6.2963			2.2366			-7.1558***
			(6.7773)			(6.0851)			(1.8857)
Obs.	12214	12152	12152	3503	3503	3503	13812	13734	13734
No. banks	2290	2264	2264	679	679	679	2574	2548	2548
R^2	0.6623	0.6625	0.6637	0.5495	0.5493	0.5498	0.1446	0.1265	0.1262
Banks outside BE, NL, SK									
Levy1	0.0555			0.2295***			0.1713***		
	(0.0597)			(0.0815)			(0.0226)		
Levy2		0.2325***			0.2123 **			0.0524***	
		(0.0410)			(0.0934)			(0.0183)	
Levy3			20.4148***			21.8367***			3.3776***
			(2.7497)			(5.3306)			(1.2856)
Levy3^2			-202.9026***			-236.5771***			-22.4493
			(42.3869)			(58.2535)			(25.3580)
Obs.	13526	13462	13462	4711	4709	4709	15026	14946	14946
No. banks	2538	2512	2512	910	910	910	2798	2772	2772
R^2	0.6445	0.6461	0.6465	0.5887	0.5872	0.5894	0.1406	0.1318	0.1321
Sample Excluding Largest Country*									
Levy1	0.3438***			0.4744***			-0.0089		
	(0.0876)			(0.0711)			(0.0337)		
Levy2		0.3437***			0.4571***			0.0196	
		(0.1000)			(0.0843)			(0.0467)	
Levy3			4.8264*			7.6840***			1.3513
			(2.8978)			(2.6053)			(1.2944)
Levy3^2			-7.7731			-16.6538***			-1.4806
			(8.3371)			(6.3816)			(3.2319)
Obs.	4942	4938	4938	1928	1926	1926	6489	6472	6472
No. banks	953	952	952	409	409	409	1239	1239	1239
R^2	0.6752	0.6752	0.6746	0.6241	0.6180	0.6105	0.3407	0.3427	0.3434
Method	OLS	IV	IV	OLS	IV	IV	OLS	IV	IV
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 14: *Robustness: Subsample Tests*

*German banks excluded in (1) - (3) and (7) - (9), Italian banks in (4) - (6); clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The results are summarised in table 14: The upper part reports the coefficients for Euro area banks: Regarding the average lending rate and the net interest margin, the effects are even more pronounced; the estimates also imply a significantly higher interest income on loans whenever the country-level levy variable is used (column 1). However, no increase in the deposit rate is observed in the Euro area. The second part reports the coefficients for a subsample excluding three countries that introduced the bank levy after 2011: Again, the coefficients are of similar sign and magnitude as in the full sample. In case the largest country banks of which are overrepresented in the sample is excluded, the positive impact on interest income and expenses generally prevails such that the higher

interest rates do not appear to be driven by the behaviour of German or Italian banks. We do not find a significant increase in the net interest margin. This can be attributed to the considerably smaller sample size combined with the relatively small coefficients in the baseline estimations. Overall, the main findings also result in several subsamples; only the positive response of the deposit rate is not observed for Euro area banks.

4.4.5 Quantity Effects: Loan Supply

A particular concern about bank levies is an adverse effect on lending, which may reduce investment and slow down economic growth. Theory implies that the levy reduces the loan supply, which is the very reason for the higher lending rate. We examine its impact on loans by regressing growth rates of a bank's total loans, commercial and corporate loans, and residential mortgages on the three levy proxies and the standard controls. In line with Devereux et al. (2015) and Buch et al. (2014), a profitability measure (return on average assets) is included; this replaces the interbank rate. Using growth rates instead of levels as dependent variables better captures the effect on new loans. In case of mortgage and commercial loans, the sample is smaller due to data availability.

	Loans			Commercial loans			Mortgages		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Levy1	3.5210***			-6.5976**			5.3491		
	(0.5694)			(3.1410)			(3.5478)		
Levy2		-0.8202*			-4.1928**			-3.1567***	
		(0.4773)			(2.0944)			(1.0429)	
Levy3			-37.9973*			-133.6962*			-164.0802***
			(22.4775)			(77.5227)			(52.7737)
$Levy3^2$			77.2668			468.3332**			734.3030***
			(61.3707)			(201.9653)			(131.7840)
Obs.	15189	15110	15110	7063	7013	7013	7009	6966	6966
No. banks	2831	2805	2805	1647	1625	1625	1563	1542	1542
R^2	0.1573	0.1517	0.1514	0.0301	0.0296	0.0299	0.0314	0.0307	0.0342
Method	OLS	IV	IV	OLS	IV	IV	OLS	IV	IV
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 15: *Robustness: Quantity Effects*

Dep. Variable: growth rate of loans (1) - (3), commercial loans (4) - (6), residential mortgages (7) - (9); clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The estimation results are summarized in table 15: The levy's impact on total loan growth (columns 1-3) is ambiguous as the bank-level variables suggest a slowdown, whereas the country-level dummy even implies a higher growth rate. One explanation for these contrasting results is that in countries where small banks are exempt, the latter increase their loan supply and provide a substitute for loans of large banks that are taxed and

reduce lending. The evidence is more informative about how the levy affects the growth of two loan categories: First, the levy lowers commercial loan growth (columns 4-6). Whenever a bank is taxed, the growth rate with an average of 7.69 percent falls by 4.19 percentage points; if it faces a marginal levy rate of 0.06 percent, commercial loan growth even falls by 6.33 percentage points. Second, the growth rate of mortgage loans (columns 7-9) is significantly lower whenever the exposure to the levy is measured at the bank level: If a bank is affected, the growth rate with an average of 4.15 percent decreases by 3.16 percentage points. Overall, the bank levy slows down growth of lending, and shifting the tax burden to borrowers is associated with a smaller loan supply.

5 Conclusion

This paper theoretically and empirically analyses the question who bears the burden of the newly introduced bank levies. Using a variant of the Monti-Klein model, we develop several scenarios for the tax incidence: The main prediction is that the levy leads to a higher lending rate and net interest margin such that banks pass the tax burden onto borrowers. The magnitude of the pass-through depends on bank competition and capitalisation; it is particularly strong for banks that operate in concentrated markets and have a low capital ratio. Since (insured) deposits are usually not taxed, banks may shift funds towards deposits such that depositors earn higher interest rates. These predictions are taken to the data: We employ a cross-country panel dataset with financial information of 2'987 banks from 23 EU countries (2007-13) to estimate the levy's impact on interest rates and net interest margin. The empirical results support the main predictions and imply a positive effect on average lending and deposit rate as well as on the net interest margin: Whenever a bank is taxed, the interest income on loans (as a share of average loans) increases by 0.2 to 0.24, the interest expenses on deposits (as a share of average deposits) by 0.16 to 0.18, and the net interest margin by 0.04 to 0.05 percentage points. Although moderate compared to the corresponding sample means, the effects are not negligible; given that the outcome variables are conservative measures of the incidence, they rather represent a lower bound. In line with theory, the higher interest rates are mainly the result of the behaviour of loan-rich, deposit-poor banks. Bank competition and capitalisation influence the extent to which to burden is passed onto customers: In

highly concentrated markets, the average lending rate of a bank that is taxed is between 0.43 and 0.77 percentage points higher, which is economically significant. There is also evidence that banks with a very high capital ratio do not shift the burden to customers. The main estimates are robust as we rely on different measures of the bank levy and include a broad set of controls and as they survive several robustness checks.

The main contribution is a comprehensive analysis of the incidence of a novel tax on banks. In particular, we explore the heterogeneous responses of banks depending on market concentration and capital structure and find considerable differences in the tax incidence. To my knowledge, it is the first paper with cross-country evidence about the incidence of bank levies. This approach allows for a more robust measurement of banks' exposure to the levy by exploiting cross-country variation and is a prerequisite for studying how market characteristics that vary mainly across countries affect the incidence. In addition, the sample has a longer post-introduction period than previous studies, and effects that materialise with some delay are thus more likely to be captured.

One objective of the bank levy is a 'fair and substantial contribution by the financial sector' to compensate taxpayers for providing guarantees. Of course, this contribution should be made by those who - explicitly or implicitly - benefited from such guarantees. Since we find that the tax burden is at least partly borne by the borrowers, the question arises whether they benefited from government guarantees before the crisis: One could imagine that banks which were protected by such guarantees and enjoyed a funding advantage charged lower interest rates or had more lenient lending standards. In this case, the observed pass-through is unproblematic and part of an effective internalisation. However, it is likely that some borrowers who did not benefit from such favourable credit conditions now face higher lending rates as a result of banks' adjustment while others who benefited do not. Some of them might have defaulted in the meantime thus not making any contribution. The issue whether those borrowers who bear the tax burden were indeed the beneficiaries of such guarantees cannot be addressed with our dataset as it requires data about individual loans. This question is thus left for future research.

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A Appendix

A.1 Proofs and Derivations

Proof of Proposition 1: The partial derivative (14) follows from differentiating (9)

$$\frac{\partial L}{\partial \tau} = \frac{(1+r)(1-k)}{(1-\tau)^2 r'_L(L)\left(1-\frac{1}{N\varepsilon_L}\right)} < 0 \tag{A.1}$$

together with $r_L = r_L(L)$ and $r'_L(L) < 0$; the second derivatives yield the signs of the sensitivities with respect of N, ε_L and k. *Q.E.D.*

Proof of Corollary 1: The partial derivative of the NIM is given by:

$$\frac{\partial NIM}{\partial \tau} = \frac{\partial r_L}{\partial \tau} - \frac{r(1-k)}{(1-\tau)^2} - \frac{(r-r_D)D}{L^2}\frac{\partial L}{\partial \tau} \tag{A.2}$$

Using $\frac{\partial r_L}{\partial \tau} > 0$ and $\frac{\partial L}{\partial \tau} < 0$ from proposition 1 yields corollary 1. *Q.E.D.*

Proof of Proposition 2: The partial derivative follows from differentiating (19):

$$\frac{\partial D}{\partial \tau} = -\frac{1 + r - \frac{(\rho - r)k}{1-k}}{r'_L(L)\left(1+\frac{1}{N\varepsilon_D}\right)} < 0 \tag{A.3}$$

Using $r_D = r_D(D)$ with $r'_D(D) > 0$ yields (20); the second derivatives yield the signs of the sensitivities with respect of N, ε_L and k. *Q.E.D.*

Proof of Corollary 2: The sensitivities of the interest rates to the levy follow from (22) - (23). The net interest margin is $NIM = (r_L l_i - r m_i - r_D d_i - r_d^I d_i^I)/l_i = r_L - r(1+\tau^e)(1-k) + [(r-r_D)D + (r(1+\tau^e) - r_D^I)D^I]/L$. The partial derivative is:

$$\begin{aligned}\frac{\partial NIM}{\partial \tau} &= \frac{\partial r_L}{\partial \tau} - \frac{r(1-k)}{(1-\tau)^2} - \frac{(r-r_D)D + (r(1+\tau^e) - r_D^I)D^I}{L^2}\frac{\partial L}{\partial \tau} + \frac{\frac{rD^I}{(1-\tau)^2} + (r(1+\tau^e) - r_D^I - r_D^{I\prime}D^I)\frac{\partial D^I}{\partial \tau}}{L} \\ &= \frac{1-k}{(1-\tau)^2}\left[\frac{(1+r)}{1-\frac{1}{N\varepsilon_L}}\left(1 - \frac{(r-r_D)D + (r(1+\tau^e) - r_D^I)D^I}{r'_L(L)L^2}\right) - r\right] + \frac{D^I}{(1-\tau)^2 L}\left[r - \frac{\tau^e \varepsilon_D^I}{r_D^I}\frac{1+r}{1+\frac{1}{N\varepsilon_D^I}}\right]\end{aligned} \tag{A.4}$$

The first term is positive (see, proposition 1) but the sign of the second is ambiguous. By inspection, the negative part is small whenever N, ε_D^I, and τ are small. *Q.E.D.*

Proof of Corollary 3: The sensitivities of the lending rate follows from differentiating (27); second partial derivative with respect to the number of competitors N is:

$$\frac{\partial^2 r_L}{\partial \tau \partial N} = \frac{\partial r_L}{\partial \tau}\frac{\partial r_L}{\partial N}\frac{(1-F(1+r_L))\left(1-\frac{1}{N\varepsilon_L}\right) - \frac{f'(1+r_L)r_L^2}{N\varepsilon_L} - \frac{f(1+r_L)^2 r_L^2}{N\varepsilon_L(1-F(1+r_L))}}{r_L\left[(1-F(1+r_L))\left(1-\frac{1}{N\varepsilon_L}\right) + \frac{f(1+r_L)r_L}{N\varepsilon_L}\right]} \tag{A.5}$$

The sign depends on the numerator: The latter is positive if N or ε_L are large enough such that the whole expression is negative due to $\frac{\partial r_L}{\partial N} < 0$, and bank concentration weakens the pass-through. One cannot draw any conclusion about the sign of $\frac{\partial^2 r_L}{\partial \tau \partial k}$, and the impact of the capital ratio remains ambiguous. Eventually, the net interest margin, $NIM = r_L - rd/l = r_L - r(1+\tau^e)(1-k\alpha)$, responds to the levy according to

$$\frac{\partial NIM}{\partial \tau} = \frac{\partial r_L}{\partial \tau} - \frac{r(1-k\alpha)}{(1-\tau)^2} + r(1+\tau^e)k\alpha'\frac{\partial A^*}{\partial \tau} =$$
$$\frac{(1-k\alpha)}{(1-\tau)^2\left[1+(1+r)(1+\tau^e)k\alpha'\right]}\left[\frac{(1+r)[1-F(A^*)+(1+\rho)k\alpha']}{(1-F(1+r_L))\left(1-\frac{1}{N\varepsilon_L}\right)+\frac{f(1+r_L)r_L}{N\varepsilon_L}} - r\right] \tag{A.6}$$

where $\alpha' = \alpha'[F(A^*)]f(A^*) \geq 0$. The expression in square brackets is positive unless the term $f(1+r_L)r_L/N\varepsilon_L$ becomes very large. *Q.E.D.*

A.2 Variables: Construction and Definitions

In those four countries that exempt small banks from the levy or apply a progressive tax schedule, the bank-level levy variables *Levy*2 and *Levy*3 are based on the taxable liabilities constructed according to the information from Devereux et al. (2015, Appendix):

- Austria: Total liabilities (code No. 11750) - Insured deposits
- Germany: Total liabilities (code No. 11750) - Customer deposits (code No. 11550)
- Netherlands: Total liabilities and equity (code No. 11850) - Insured deposits - Regulatory Capital (code No. 30670) or Common Equity (code No. 11800) or Equity (code No. 11840) [Equity measure chosen depending on data availability]
- United Kingdom: Total liabilities and equity (code No. 11850) - Insured deposits - Tier 1 Equity (code No. 30660) or Common Equity (code No. 11800) or Equity

(code No. 11840) [Equity measure chosen depending on data availability]

For Austria, the taxable liabilities are based on the 2010 balance sheet, otherwise, the current year balance sheet is used. Insured deposits are computed by multiplying customer deposits (code No. 11550) by the coverage ratio, which is the volume share of insured deposits in a country. Data on the coverage ratio are from the EU Commission.

Variable	Description	Source
IIL	Interest income on loans/average loans	Bankscope, code No. 18030
IED	Interest expenses on deposits/average customer deposits	Bankscope, code No. 18035
NIM	Net interest margin	Bankscope, code No. 4018
LGR	Growth rate of loans, commercial loans, mortgages	Author's calculations
Levy1	Levy dummy at country level	Devereux et al. (2015)
Levy2	Levy dummy at bank level	Author's calculations
Levy3	Marginal levy rate (bank level)	Author's calculations
Assets	(Log of) Total assets squared	Bankscope, code No. 2025
BD	Bank branches per 10'000 inhabitants	ECB
CIT	Corporate income tax rate	Devereux et al. (2015)
Cost	Non-interest expenses/total assets	Bankscope, code No. 4021
Equity	Total equity/average assets	Bankscope, code No. 18165
Growth	Growth rate of real GDP	ECB
HHI	Herfindahl-Hirschman index (based on assets)	ECB
Inflation	Inflation rate	ECB
Interbank	Interbank rate (Euro area: 3-months EURIBOR)	OECD, Central Banks
Provisions	Loan loss provisions/average loans	Author's calculations
RCAP	Regulatory capital ratio	Bankscope, code No. 38300
Recap	Fiscal costs of recapitalisation and asset relief (% of GDP)	European Commission (2013)

Table A.1: *Definition of Variables*

A.3 Supplementary Figures and Tables

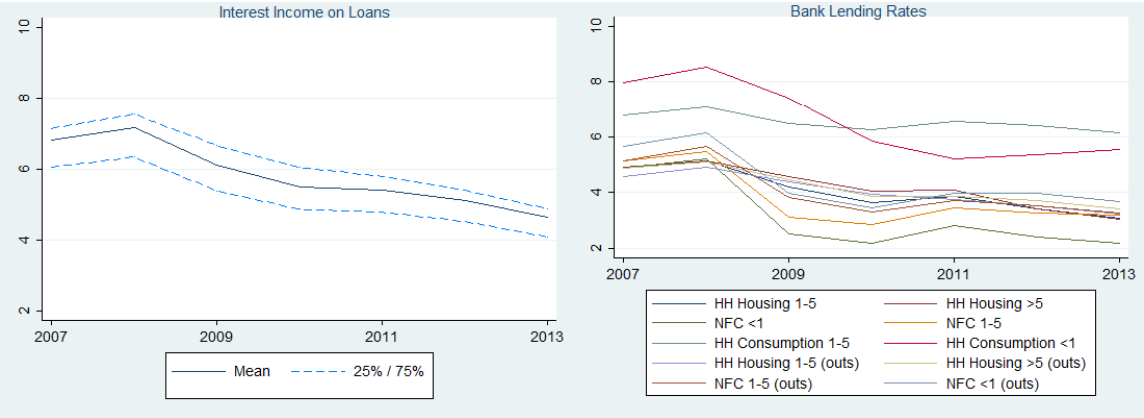

Figure A.1: *Euro Area: Interest Income and Bank Lending Rates*
The left panel shows mean interest income on loans of Eurozone banks and the upper/lower quartile of the distribution. The right panel shows interest rates on new and outstanding loans of households (HH; housing and consumption loans) and non- financial corporations (NFC, volume > EUR 1m) with different maturities (less than 1 year, 1 - 5 years, more than 5 years). Source: ECB MFI Statistics.

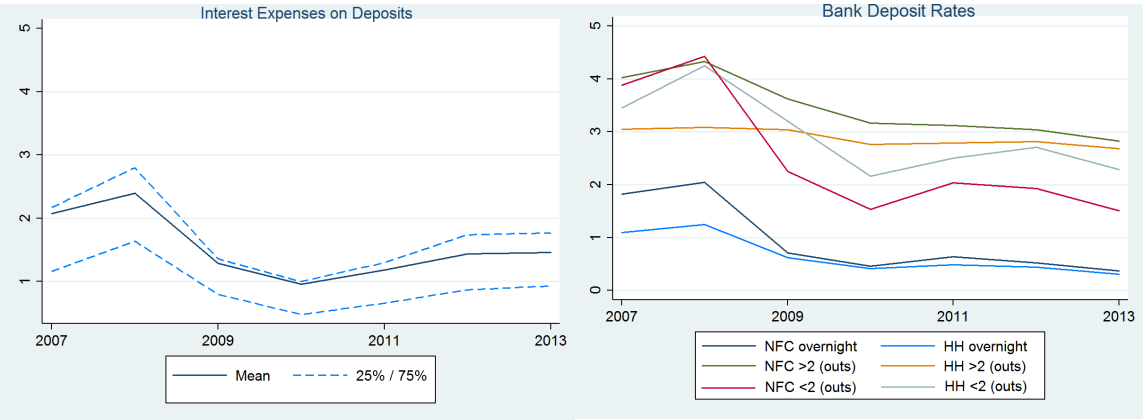

Figure A.2: *Euro Area: Interest Expenses and Bank Deposit Rates*

The left panel shows mean interest expenses on customer deposits of Eurozone banks and the upper/lower quartile of the distribution. The right panel shows interest rates on overnight deposits and outstanding deposits with different maturities (more or less than 2 years) of households (HH) and non-financial corporations (NFC). Source: ECB MFI Statistics.

	Banks 2010		Sample 2010	
	No.	Share	No.	Share
	11 Countries Adopt Levy 2010-13			
Austria	750	11.58	218	7.69
Belgium	48	0.74	29	1.02
Cyprus	127	1.96	8	0.28
Germany	1'819	28.08	1'579	55.68
Latvia	29	0.45	17	0.60
Netherlands	254	3.92	2	0.07
Portugal	133	2.05	20	0.70
Romania	33	0.51	15	0.53
Slovakia	15	0.23	9	0.32
Sweden	148	2.28	76	2.68
United Kingdom	239	3.69	31	1.09
	12 Countries do not Adopt Levy 2010-13			
Bulgaria	24	0.37	19	0.67
Czech Republic	36	0.56	19	0.67
Denmark	143	2.21	79	2.79
Estonia	7	0.11	4	0.14
Greece	36	0.56	9	0.32
Ireland	461	7.12	5	0.18
Italy	697	10.76	510	17.90
Lithuania	77	1.19	8	0.28
Luxembourg	118	1.82	50	1.76
Malta	26	0.40	8	0.28
Poland	685	10.57	33	1.16
Spain	255	3.94	88	3.10
TOTAL	6'160		2'836	

Table A.2: *Sample by Country*

For each country, this table compares the number of active banks to those in the sample in 2010. Source: ECB Monetary and Financial Statistics, Author's calculations.

	Full Sample					No Levy			With Levy			Banks not taxed			Banks taxed		
	Mean	Std. Dev.	Obs.	Min	Max	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.
IIL	5.85	1.69	16000	3.01	11.43	5.43	1.94	4717	6.03	1.53	11283	5.85	1.63	12561	5.85	1.87	3438
IED	1.69	2.26	5605	0.34	6.09	1.56	1.18	4507	2.19	1.42	1098	1.60	1.20	4707	2.16	1.44	898
NIM	2.48	0.83	18747	0.49	4.73	2.64	1.04	5618	2.41	0.72	13129	2.56	0.79	14767	2.18	0.87	3963
LGR Loans	4.67	10.29	15546	-15.70	44.58	5.29	12.73	4635	4.41	9.04	10911	4.68	10.14	12235	4.64	10.82	3304
LGR Commercial	7.68	34.39	7238	-60.00	127.59	5.28	30.03	664	7.93	34.79	6574	7.26	35.68	5466	8.99	30.02	1772
LGR Mortgage	4.14	14.87	7081	-20.92	65.53	8.93	19.49	118	4.06	14.76	6963	3.95	14.98	5354	4.47	14.51	1727
Assets	5490	42911	18746	0.32	2246381	7688	35508	5618	4505	45682	13128	3339	22223	14766	13376	82412	3963
Equity	8.70	4.35	18747	2.92	24.22	10.72	4.72	5618	7.83	3.88	13129	8.90	4.21	14767	7.96	4.77	3963
Cost	2.65	1.29	18735	0.25	7.25	2.96	1.40	5618	2.53	1.21	13128	2.75	1.23	14756	2.32	1.42	3963
Provisions	0.59	0.98	17852	-2.03	3.51	0.93	0.98	5244	0.44	0.95	12608	0.61	0.98	14061	0.51	0.97	3785
Inflation	2.05	1.13	18747	-1.70	12.00	2.35	1.32	5618	1.92	1.00	13129						
Growth	0.65	3.01	18747	-17.70	10.50	-0.45	2.83	5618	1.11	2.96	13129						
CIT	29.21	4.45	18747	10.00	38.90	27.11	4.25	5618	30.11	4.23	13129						
Recap	0.68	1.17	18747	0.00	24.60	0.38	1.43	5618	0.81	1.01	13129						
HHI	0.04	0.03	18747	0.02	0.34	0.05	0.03	5618	0.03	0.02	13129						
BD	4.83	1.22	18717	1.10	12.33	5.43	1.70	5614	4.57	0.82	13103						

Table A.3: *Summary Statistics*

In percent; assets in million EUR, the HHI is normalized in the unit interval. The second and third columns show the statistics for banks in countries that do (not) adopt a levy during the sample period (i.e., $Levy1 = 1$). The fourth and fifth columns show the statistics for banks that are (not) taxed during the sample period (i.e., $Levy2 = 1$).