Can taxes tame the banks?
Evidence from the European bank levies*

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Abstract

In the wake of the 2007-2008 financial crisis, a large number of countries have introduced levies on bank borrowing with the aim of reducing risk in the financial sector. This paper studies the behavioral responses to the bank levies and finds that banks exposed to levies increased their reliance on equity financing, but at the same time increased the risk of their assets. This represents the first empirical evidence of banks shifting risk from the liability side of their balance sheets to the asset side to mitigate the impact of government intervention. Our analysis also shows that while levies were succesful in reducing the overall risk of the average bank, the effect was concentrated among banks that pose no or little threat to financial stability.

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1 Introduction

Excessive risk-taking by financial institutions is widely regarded as the main cause of the global financial crisis in 2007-2008 (Diamond and Rajan, 2009; Brunnermeier, 2009). Prior to the crisis, banks invested heavily in mortgage-backed securities, the risk of which was grossly underestimated, while at the same time relying increasingly on short-term borrowing for funding. As real estate markets weakened and losses on mortgage-backed securities mounted, the equity capital of many banks was quickly wiped out and uncertainty about the solvency of counterparts caused money markets to freeze (Gorton and Metrick, 2012; Shin, 2009). To avoid a collapse of the entire financial system, governments intervened by providing banks with credit lines, loan guarantees and new capital (Laeven and Valencia, 2013). While the collapse was avoided at a staggering cost, the crisis nevertheless spread to the real economy where firms suffered from the ensuing decline in lending by troubled banks (Ivashina and Scharfstein, 2010; Santos, 2011; Chodorow-Reich, 2014).

By making it painfully clear that distressed banks can impose very significant costs on tax payers, other banks and non-financial firms, the financial crisis has revived an old debate about government intervention in the financial sector. Many scholars have argued in favor of tightening capital requirements (e.g. Admati et al., 2010; Hart and Zingales, 2011). This stance is supported by the theoretical arguments that banks with more capital have more incentives to monitor borrowers (Allen, Carletti and Marquez, 2011) and less incentives to invest in excessively risky assets (Acharya, Mehran and Thakor, 2011) and by empirical analysis showing that banks with more capital generally fare better during a financial crisis (Berger and Bouwman, 2013; Beltratti and Stulz, 2012). In response to the crisis, the Basel capital requirements, the cornerstone of international financial regulation, have indeed been strengthened moderately.

Recognizing that externalities can be addressed with taxation as well as regulation, a number of countries, including the UK and Germany, have introduced a new type of bank levy proposed by the IMF (2010). The bank levies typically fall directly on bank borrowing and have a clear Pigouvian rationale: given that the social cost of bank distress exceeds the private cost, there is scope for a corrective tax on the types of bank funding that increase the risk of distress. By raising the cost of borrowed funds, the levies are

designed to increase stability in the financial sector by inducing banks to rely more on own capital. Besides their corrective effects on bank behavior, the introduction of bank levies were also often motivated by the desire to increase the revenue extracted from the financial sector; in some cases to cover the fiscal costs of the most recent financial crisis and in other cases to finance future resolutions of distressed banks.

This paper first makes the theoretical argument that while bank levies directly affect the incentives underlying banks' funding choices, they may also indirectly affect banks' portfolio choices. Our main theoretical prediction is that a levy on bank borrowing induces banks to rely more on equity funding, but also to hold more risky assets. The shifting of risk from the liability side of the balance sheet to the asset side occurs because of an interaction between the bank levy and the Basel rules that require banks to hold a minimum amount of capital per euro of risk-weighted assets. Banks essentially choose an optimal level of risk while taking into account the expected cost of breaching the Basel rules as well as an optimal mix of funding risk and portfolio risk. The bank levy makes funding risk more costly, which causes a substitution toward portfolio risk partly offsetting the reduction in total risk. While the mechanism in our model is distinct, it relates to the classical literature on risk shifting showing that when funding risk is limited by regulation, risk-averse banks at least partly undo the effect on their total risk by taking on more portfolio risk (Koehn and Santomero, 1980; Kim and Santomero, 1988). Our model draws on more recent treatments of bank taxation and regulation (Keen, 2011; Keen and de Mooij, 2015), but improves on them by considering both funding structure and portfolio structure as fully endogenous outcomes.

We then turn to an empirical analysis of how banks responded to the levies. We draw on detailed information from the financial reports of more than 2,700 European banks as well as market information for listed banks and exploit the fact that the adoption of bank levies constitutes a rich natural experiment with several types of variation. First, 14 countries in the European Union ("EU") adopted levies over the period 2009-2012 while the remaining 13 countries did not. Second, levy rates vary substantially *between countries* that have adopted a levy. Third, marginal levy rates vary *within countries* both in the cross-sectional dimension due to progressivity in the rate structure and in the time dimension due to rate changes. We exploit all these types of variation in a panel

model that spans the period 2004-2012. The model includes standard determinants of capital structure at the bank and country levels as well as bank fixed effects to capture the permanent components of capital structure (Lemmon, Roberts and Zender, 2008).

The main empirical challenge is to measure the different dimensions of risk. In our baseline regressions, we measure banks' total risk by their regulatory capital ratio defined as the amount of regulatory capital per euro of risk-weighted assets. This is the key variable used by financial regulators to assess the risk of individual banks and it conveniently breaks down into measures of funding risk (capital/assets) and portfolio risk (average risk weights of assets). The most serious weakness of this measure is that the risk weights assigned to banks' assets only imperfectly capture their true risk properties and may even be subject to deliberate manipulation by banks (Haldane, 2013; Mariathasan and Merrouche, 2014). To address these concerns, we also use the volatility of market and book returns on equity as measures of total risk and we use loan losses and the volatility of trading returns as measures of portfolio risk.

We find that the bank levies reduced banks' total risk, but also induced considerable shifting of risk from the liability side to the asset side of banks' balance sheet. Our baseline results imply that banks exposed to a bank levy raised their regulatory capital ratio by around 0.9 percentage points relative to non-exposed banks suggesting a material decrease in total risk. However, the increase in the regulatory capital ratio is the compound effect of a much larger increase in the equity-asset ratio and a substantial increase in asset risk weights suggesting that around half of the reduction in funding risk was offset by an increase in portfolio risk.

These patterns are robust to a number of extensions of the baseline model. We include country-specific linear trends to account for any differences in underlying trends unrelated to the levies. We also include region specific, bank-size specific and equity-ratio specific non-linear time trends to account for shocks specific to banks in certain regions, banks of certain sizes and banks with certain capital structures. These specifications imply that the effect of the levies is effectively identified from a comparison of banks within the same region, of the same approximate size and with the same approximate equity-asset ratio. We consistently find significant shifting of risk from the liability side to the asset side of the balance sheet: banks increase funding with equity, but also increase asset risk weights

in response to the bank levies. In the specification allowing for region-specific shocks, the increase in portfolio risk is so large that it fully offsets the reduction in funding risk and leaves total risk unaffected.

The baseline results also extend to our other risk measures. On the one hand, we find clear evidence that banks exposed to a levy experienced a drop in the volatility of daily market returns to equity suggesting a reduction in total risk. Consistent with this result, we estimate that the absolute distance between banks' own book return to equity and a reference return decreased when banks were exposed to a levy. On the other hand, we find that bank levies were associated with higher loan charge-offs suggesting an increase in the risk of the loan portfolio. Moreover, we estimate that the absolute distance between the return on a banks' trading assets and a reference return increased when banks were exposed to a levy suggesting an increase in the risk of the trading portfolio.

In the remainder of the paper we explore the heterogeneity in banks' responses to the levies. Our theoretical model points to a particularly interesting dimension of heterogeneity by suggesting that banks with a high probability of receiving a government bailout in the case of distress generally choose a lower capital ratio than banks with a low bailout probability. This also leads to heterogeneity in the effect of the levies with banks almost certain to be bailed out optimally reducing their total risk less than banks with a lower bailout probability when a levy is introduced.

Since bailout probabilities are not directly observable, our empirical analysis conditions banks' responses to the levies on their pre-levy regulatory capital ratio. In essence, we are testing whether high-risk banks responded differently to the levies than low-risk banks. We find that high-risk banks raise their portfolio risk more than low-risk banks when exposed to a levy and that in most specifications, consistent with the theoretical predictions, levies have little or no impact on the total risk of high-risk banks, but significantly reduce the total risk of low-risk banks.

The evidence on heterogeneous responses to the bank levies are of considerable policy relevance. From a micro-prudential perspective, it is of limited value to reduce the risk of banks that are already relatively safe whereas it is highly desirable to reduce the risk of banks with a high probability of failure. If, as our theoretical and empirical results suggest, the corrective effect of bank levies is concentrated among banks that pose no

or little threat to financial stability, it reduces the appeal of bank levies as a policy instrument. It also raises some doubt as to the value of a levy on non-core liabilities as a macro-prudential measure to dampen the procyclicality of the financial system, as proposed by Shin (2010).

The main contribution of the paper is to produce empirical evidence of risk shifting between the two sides of bank balance sheets in response to government intervention. While the theoretical possibility of risk shifting is well-known, we are not aware of existing papers that have documented it empirically. Risk shifting has important implications for contemporary discussions about fiscal and regulatory intervention in the financial sector. First, it suggests that the bank levies themselves, which are becoming an integral part of the financial architecture in an increasing number of countries, would be more effective if the levy base were adjusted for portfolio risk. Indeed, current policy reforms in Europe are likely to modify most of the existing bank levies to this effect. Second, it calls into question the effectiveness of a key innovation in the post-crisis regulatory framework, the leverage ratio, which requires a minimum amount of capital for each unit of assets and thus complements the existing capital requirement formulated in terms of risk-weighted assets. While the leverage ratio may force some banks to reduce funding risk, our results suggest that the effect on total risk may be eroded because banks are likely to respond by increasing portfolio risk.

While our results on risk shifting by banks have broad implications for the design of government interventions in the financial sector, the analysis relates most directly to an emerging literature on bank taxation. Notably, two recent papers studying corporate taxes (Keen and de Mooij, 2015) and mandatory charges financing deposit insurance (Kreicher, McCauley and McGuire, 2013) find that banks' funding structure respond strongly and sharply to changes in fiscal incentives, which is consistent with our results on the bank levies.

The remainder of the paper is structured in the following way. Section 2 provides background information about the bank levies; Section 3 sets out a conceptual framework; Section 4 describes the data; Section 5 discusses the empirical framework; Section 6 presents the results; and Section 7 concludes.

2 Background

In the wake of the financial crisis, the IMF promoted levies on the risky part of bank funding as a tool to increase revenue collection from the financial sector while at the same time contributing to financial stability by incentivizing banks to adopt less risky capital structures. Bank levies of some form have been adopted in a number of countries and are still under consideration in many others. In the U.S., the Financial Crisis Responsibility Fee has been part of all government budget proposals since 2010, but has still not been passed into law. In the European Union, recent legislation requires all member states to adopt bank levies that finance a bank resolution fund.

Table 1 describes key characteristics of the 14 bank levies that had been implemented by member states of the European Union by the end of 2012. These levies were adopted independently and thus vary considerably both in terms of the definition of the bases and the applicable rates. The Table captures only the most important features of the bank levies; more details are provided in the Online Data Appendix.[1]

The most common levy design adopted by 11 countries (Austria, Belgium, Cyprus, Germany, Netherlands, Latvia, Portugal, Romania, Slovakia, Sweden and the UK) taxes some measure of bank liabilities. While the levies are conceptually similar, they vary along several dimensions. First, most of the levies fall on total liabilities net of own funds and customer deposits that are guaranteed under a deposit insurance scheme, but two countries (Cyprus and Portugal) include insured deposits in the levy base. Second, most levies treat short-term and long-term liabilities symmetrically, but two countries (Netherlands and the UK) apply a reduced rate to liabilities with a maturity exceeding one year. Third, most of the levies apply a flat rate, but four countries (Austria, Germany, Netherlands and the UK) have a progressive rate structure where small banks are taxed at lower rates than large banks or not taxed at all. Finally, the UK rules have several provisions that narrow the taxable base, which are not found in other countries: most notably, they allow for the netting of gross assets and liabilities against the same counterpart and grant a deduction for highly liquid assets.

[1] Available at the webpage: www.nielsjohannesen.net.

Table 1 around here

Most of these departures from the general principle of a flat levy on bank borrowing can be rationalized within a Pigouvian framework: provided that the deposit insurance is correctly priced, there is no rationale for additional taxes on insured deposits; long-term liabilities reduce the exposure to volatile money markets and thus the risk of distress (Perotti and Suarez, 2011); and the distress of large banks is likely to be associated with disproportionately large externalities due to their systemic role. One feature of the Austrian levy, however, seems to be motivated mostly by other considerations: the levies paid by Austrian banks in 2011-2013 were made with reference to the balance sheet in 2010, presumably to enhance the predictability of the government revenue to be raised by the levy. The fact that the law was passed very close to year-end in 2010 effectively eliminates the scope for behavioral responses to the levy during our sample period.

Three countries (France, Hungary and Slovenia) have adopted bank levies that are conceptually quite different from the design described above. In France, the taxable base is the minimum amount of capital necessary to comply with the regulatory requirements. In Hungary, the bank levy falls on total assets net of inter-bank lending. In Slovenia, the taxable base is total assets with no deductions; however, the levy is not due if either the level of lending to the non-financial sector or the growth in lending to the non-financial sector exceeds a threshold. It is not immediately clear how we should expect these three levies to affect banks' funding and portfolio choices. None of them directly change the incentives underlying funding choices and while one should expect the French levy to cause a decrease in portfolio risk, this is not obvious for the Hungarian and Slovenian levies. Because of these ambiguities, our empirical analysis omits the French, Hungarian and Slovenian banks from the sample and focuses on the 11 bank levies that fall on a similar and well-defined measure of bank liabilities.

While most governments motivated the levies with the need to raise more revenue from the financial sector as well as the likely desirable effect of levies on financial stability, the actual use of the revenue varied. In some countries (e.g. Germany), the proceeds went into a bank resolution fund whereas in other countries (e.g. the U.K.) there was no link to specific types of expenditures.

It is important to note that several other policy initiatives aiming to enhance stability in the financial sector may directly and indirectly have affected banks' funding and portfolio choices. First, the new international framework for financial regulation, Basel III, phased in from 2013, increased the minimum capital requirements in terms of risk-weighted assets and introduced a minimum leverage ratio in terms of total consolidated assets. It is likely that banks anticipating future regulatory requirements started adopting their capital structure already during our period of analysis. Note, however, that bank capital requirements are regulated at the EU level, hence it seems reasonable to assume that two otherwise similar banks located in two different countries within the EU were affected similarly by the regulatory changes.[2] Second, in the aftermath of the financial crisis many governments intervened in the banking sector by providing distressed banks with new equity and by guaranteeing their debt to third parties. In the countries most adversely affected by the crisis, these measures were very significant in size. In Ireland, for instance, government equity injections accumulated to around 4% of total bank assets over the period 2008-2011 and government guarantees of bank debt peaked at around 20% of total bank assets in 2009 (European Commission, 2012).

3 Conceptual Framework

We argued in the introduction that a levy on bank liabilities should be expected to affect not only banks' funding choices but also their portfolio choices because of the interaction with bank regulation. The impact on a bank's overall risk should depend on both channels. To illustrate this, we develop a simple model of bank behavior in the presence of regulation and a bank levy. The model draws on Keen (2011) and Keen and de Mooij (2015), extending these models primarily by treating portfolio structure as a choice variable of the bank. The model is not intended to capture all the complex channels through which a levy may affect bank choices; it makes a number of simplifying assumptions to focus on the key channel we aim to investigate, the interaction between the levy and bank regulation. Among other things, for expositional purposes we do not include corporation tax in the model. While corporation tax makes the use of debt more

[2]It cannot be excluded, however, that differences in enforcement means that regulation effectively varies across countries.

attractive, it does not add any insights to the issues we discuss here.

We consider a one period model. At the beginning of the period, a bank raises funds equal to 1, of which a fraction E_0 is in the form of equity and the remaining fraction L is in the form of debt, $E_0 + L = 1$. Interest on debt is charged at rate R, determined by a no-arbitrage condition that applies in the credit market, defined below. We assume that all shareholders and creditors are risk-neutral. Shareholders have limited liability. In the event of default, we allow for the possibility that the government will support systemically important institutions. Specifically, we assume that creditors believe that there is some probability, p, that the government will provide a full bailout to creditors in the event that the bank cannot otherwise repay its debt. Of course, even in the event of default, government may impose a haircut on creditors; more generally then, we use p to characterize the expected bailout. We take p to be an exogenous policy variable, which depends on the potential social consequences of a bank defaulting.

The bank invests a proportion α of its funds in risky assets with an uncertain, but on average positive, return $\theta - 1$, and the remaining proportion $1 - \alpha$ into a risk-free asset rate with a return, r. The random variable θ is distributed with a twice differentiable distribution function $F(\theta)$ on support $(0, \infty)$. A non-linear bank levy $T(L)$ is imposed on the level of borrowing, L, which for simplicity we assume must be paid in all states of the world. It is after the realization of θ that the regulatory requirements are applied and the tax levied. The value of equity at the beginning of the period is therefore

$$E = \int_{\theta^D}^{\infty} \{\alpha\theta + (1-\alpha)(1+r) - L(1+R)\} f(\theta) d\theta - T(L) - P^E \tag{1}$$

where P is a penalty associated with breaching the Basel regulations, defined below, P^E is its expectation, θ^D is the value of θ below which the bank defaults, defined as

$$\theta^D = \frac{L(1+R) - (1-\alpha)(1+r)}{\alpha}. \tag{2}$$

3.1 No arbitrage condition and implications

We assume that creditors lend to the bank in full knowledge of the possibility of default, and take this possibility into account in setting the interest rate at which they will lend,

R. For $\theta \geqslant \theta^D$ creditors receive a full return of $(1+R)L$. For $\theta < \theta^D$, then in the absence of a bailout, the creditors receive the remaining value of the bank, $\alpha\theta + (1-\alpha)(1+r)$. In addition, with probability p, the creditors also receive a bailout from the government which raises their return to $(1+R)L$. The risk-neutral creditor's no-arbitrage condition is therefore:

$$\begin{aligned} L(1+r) &= L(1+R)(1-F(\theta^D)) + pL(1+R)F(\theta^D) \\ &\quad +(1-p)\int_0^{\theta^D} \{\alpha\theta + (1-\alpha)(1+r)\} f(\theta)d\theta \end{aligned} \tag{3}$$

In general, changing p, L or α would affect the expected income of the debtholders, and so $R = R(\alpha, L, p)$. Rearranging this expression yields

$$R(\alpha, L, p) = r - \frac{(1-p)}{L}\left\{\int_0^{\theta^D} \{\alpha\theta + (1-\alpha)(1+r) - L(1+R(\alpha, L, p))\} f(\theta)d\theta\right\}$$

The integral on the RHS of this expression is negative, and hence $R(\alpha, L, p) \geqslant r$. Only in the extreme case of a certain bailout, $p = 1$, does $R(\alpha, L, p) = r$. It can be shown that $R_L > 0, R_\alpha > 0$, and $R_p < 0$.[3]

3.2 Basel penalty

The Basel regulations stipulate a minimum ratio of the value of equity to the value of risk-weighted assets; we denote this minimum value as B. At the end of the period, for the purposes of modeling Basel regulations, we take the value of risk-weighted assets to be $\alpha\theta$. That is, the Basel regulation is that

$$\frac{E}{\alpha\theta} \geqslant B \tag{4}$$

where for simplicity we define E before tax. Given the initial choice of debt L and the asset portfolio α, the bank will fail to meet the Basel condition if the ex-post rate of

[3]Details of all derivations are available on request from the authors.

return on risky assets falls below a cut-off value, θ^B given by

$$\theta^B = \frac{\theta^D}{1-B} \tag{5}$$

For $\theta = \theta^B$, the bank has a value of equity, defined as E^B, which puts it exactly at the Basel constraint. We assume that the regulator levies a penalty on the bank in the event that condition (4) is not met. In practice the penalty may vary with the severity of the violation and between countries, and may include, for example, limits on dividend payments and bonus payments. We follow Keen and de Mooij (2015) in not modelling the penalty explicitly, but in assuming that it is proportional to the extent to which equity falls short of the minimum required. That is,

$$P = c(E^B - E) = c\alpha(\theta^B - \theta) \tag{6}$$

where c is the rate of the penalty applied.

3.3 Maximizing shareholder value

We assume that the bank chooses L and α to maximize the expected return to the risk-neutral shareholders, equal to E, defined above, less the opportunity cost of capital $E_0(1+r)$. We assume for simplicity that the penalty is paid in all states of the world for which $\theta < \theta^B$. Substituting from the no-arbitrage condition (3), this is equivalent to maximizing

$$\begin{aligned} W \;=\; & \int_0^{\infty} \left[\alpha\theta + (1-\alpha)(1+r)\right] f(\theta)d\theta \\ & + p\int_0^{\theta^D} \left\{L(1+R(\alpha,L,p)) - \left[\alpha\theta + (1-\alpha)(1+r)\right]\right\} f(\theta)d\theta \\ & - T(L) - \int_0^{\theta^B} c\alpha(\theta^B - \theta) f(\theta)d\theta - (1+r) \end{aligned} \tag{7}$$

The first line of this expression is the expected value of the bank's assets, the second line is the expected value of the bailout and the third line contains the expected levy, the expected penalty and the opportunity cost of funds. Note that in the absence of government intervention through three channels - the bank levy, Basel regulation and

potential bailout - this is equal to the expected value of the bank's assets net of the opportunity cost of funds. For $p = c = T = 0$, the Modigliani-Miller condition would hold with shareholders indifferent as to the level of borrowing. The no-arbitrage condition in the credit market, combined with assuming symmetric information implies that any profits are captured by the shareholders.[4]

The first order conditions are:

$$W_L = 0 = (1 + R + LR_L) \left\{ pF(\theta^D)) - \frac{c}{(1-B)} F(\theta^B) \right\} - T' \tag{8}$$

$$\begin{aligned} W_\alpha &= 0 = \overline{\theta} - (1+r) + p \int_0^{\theta^D} \{LR_\alpha - [\theta - (1+r)]\} f(\theta) d\theta \\ &\quad - \int_0^{\theta^B} c(\frac{1 + r + LR_\alpha}{(1-B)} - \theta) f(\theta) d\theta \end{aligned} \tag{9}$$

where $\overline{\theta}$ is the unconditional expectation of θ, T' is the marginal bank levy rate, and we have used the definitions of θ^D and θ^B.

The condition for L reflects the three forms of government intervention, which the bank must balance. First, the term in $F(\theta^D)$ measures the expected rise in the value of the bailout resulting from a rise in L if the bank defaults. A rise in L directly increases the bailout for a given p, and in addition, increases R and hence further increase the size of the bailout. Second, offsetting this effect, the term in $F(\theta^B)$ measures the effects of a rise in L on the expected Basel penalty. And third, the last term is the increase in the bank levy due an increase in L.

The condition for α also has three terms. The first is the effect on the expected value of the bank's assets from a rise in α. The second is the effect of a rise in α on the expected bailout, in the event of default. This arises from a higher α increasing R, and also by affecting the value of the assets in default. This term is positive. The third term is the effect of a rise in α on the expected Basel penalty.

The second order conditions require $W_{LL} < 0, W_{\alpha\alpha} < 0$ and $\Delta = W_{LL}W_{\alpha\alpha} - (W_{L\alpha})^2 > 0$. The Appendix sets out conditions under which these hold; these conditions depend on the relative size of government intervention through the levy, the penalty and the

[4] This would not hold with asymmetric information: see, for example, Sinn (2010).

possibility of bailout.

Heterogeneity across banks in the probability of bailout, p, is likely to generate heterogeneity in the choice of L and α. It is possible to show that $\partial L/\partial p > 0$ and $\partial \alpha/\partial p > 0$, which suggests that banks with a high bailout probability optimally choose a higher level of total risk

3.4 Effects of the levy

To identify the effects of the levy, we parameterize it as $T(L) = tL + u(L)$ and assume convexity, so that $u' > 0, u'' > 0$. We identify the effects of an increase in the linear component of the levy, ie. an increase in t. Assuming that the second order conditions hold, then the effect of the levy on the two choice variables is given by

$$\frac{dL}{dt} = -\frac{W_{\alpha\alpha}W_{Lt}}{\Delta} < 0 \tag{10}$$

$$\frac{d\alpha}{dt} = \frac{W_{\alpha L}W_{Lt}}{\Delta} > 0 \tag{11}$$

Given the second order conditions and the fact that $W_{Lt} < 1$, the signs of the impact of a rise in the levy on L and α are as shown in (10) and (11). That is, a rise in the levy on borrowing leads to a reduction in borrowing and a rise in the use of equity.[5] A reduction in borrowing moves the bank further away from the Basel constraint, and hence reduces its overall risk - at least measured by the regulation. But the bank can offset this effect to some extent by increasing its portfolio risk, α.

We can go one stage further to analyze a measure of the total risk of the bank. Following Keen (2011), we measure total risk as the degree to which the bank initially holds a buffer over and above the Basel minimum capital ratio, denoted Ω. That is:

$$\Omega = \frac{1-L}{\alpha} - B \tag{12}$$

We demonstrate in the Appendix that, in general, the buffer rises with the levy rate:

[5] In this framework we keep constant the size of the bank; however, a rise in equity is consistent with our empirical results below.

$$\frac{d\Omega}{dt} = [\alpha W_{\alpha\alpha} - (1-L)W_{\alpha L}]\,\frac{W_{LT}}{\alpha^2 \Delta} > 0. \tag{13}$$

So in general, although the rise in portfolio risk to some extent offsets the reduction in risk due to lower borrowing, it does not undo it completely. These conditions can be summarized as:

Proposition 1 *A rise in the levy rate leads to a reduction in the use of debt, which tends to reduce the total risk of the bank. To some extent this effect on total risk is offset by an increase in portfolio risk. In general, the total risk of the bank - as measured by the ex-ante buffer - is reduced.*

Proof. See Appendix. ■

Intuitively, banks choose an optimal level of total risk as well as an optimal mix of funding risk and portfolio risk. The bank levy makes funding risk more costly, which causes substitution toward portfolio risk and a reduction in total risk.

The first part of the proposition mirrors the finding of Keen and de Mooij (2015) that the corporate tax increases borrowing, except that our result is derived in a framework that accounts for indirect effects through the portfolio structure.

3.5 Heterogeneity in responses

The indirect effect on α from a rise in the levy stems from an interaction with the Basel regulation. It is therefore interesting to consider how the size of the effects of the levy on L, α and Ω varies across banks that are more or less likely to be close to the Basel constraint. Specifically, we investigate the extent to which the size of the effects in Proposition 1 depend on the perceived probability of a bailout, p.

It is possible to show that, in this simple framework, the effect of the levy on borrowing is independent of p. The intuition is that the bank has two instruments available to determine its total risk. Broadly, all banks can therefore choose L independently of a target for total risk, in the knowledge that portfolio risk can be adjusted to achieve the target. Generally, this implies that if the levy has a larger (smaller) effect on α for banks with a large p, it also has a smaller (larger) effect on Ω.

We can show that in the case of a certain bailout, $p = 1$, raising the levy has no impact on Ω at all; in this case the rise in α completely offsets the reduction in L so the total risk of the bank is unaffected. This implies

Proposition 2 *As $p \to 1$, the indirect effect of a rise in the levy on portfolio risk increases, and the effect on total risk falls. In the extreme of $p = 1$, a rise in the levy has no effect on total risk.*

Proof. *See Appendix.* ■

We might expect this local result to hold more generally so that a bank levy leads to a larger offsetting increase in portfolio risk α and consequently a smaller increase in the buffer Ω, the higher the bailout probability p. Intuitively, funding costs R are less sensitive to bank risk the higher the bailout probability, which suggests that increasing α is less costly for banks with a high p. And, as shown above, in the limit when $p = 1$ and funding costs are invariant to risk, banks fully offset the reduction in L with an increase in α leaving Ω unchanged. In general, however, the expressions for $\partial \left(d\alpha/dt \right) /\partial p$ and $\partial \left(d\Omega/dt \right) /\partial p$ are too complex to be signed unambiguously.

In sum, our conceptual framework points to the following implications of a bank levy. First, a bank levy should induce all banks to increase their capital ratio through an increase in the use of equity and an offsetting increase in the risk of the asset portfolio. Second, the increase in portfolio risk should be greater for banks with a high level of risk and, hence the increase in the capital ratio should be greater for banks with a low level of risk.

4 Data

Our main source of data is *Bankscope*, which contains information on balance sheets, income statements and in many cases regulatory reports taken from banks' annual reports. We limit our sample to banks for which information on the regulatory capital ratio and the stock of regulatory capital is available since this information is necessary to compute basic risk measures. This information is available for around 40% of banks accounting for around 65% of all bank assets. Strictly speaking, we cannot be certain that the results extend to banks outside the sample due to potential selection issues.

Table 2 summarizes key characteristics for our sample of 2,754 banks from 27 European countries for the time period 2004-2012.[6] As shown in column (2), the main source of funding was customer deposits, which accounted for around 58% of total assets, whereas deposits from other banks accounted for around 10% and equity accounted for around 9%. Banks lent around 60% of their funds to customers, around 9% to other banks and held around 21% in securities. The average book return on equity was around 7% and the average return on trading assets around 0%. The average banks reported a regulatory capital ratio of around 16% and an average regulatory risk weight of assets of around 64%.

Table 2 around here

We also report variable means separately for four subsamples. The key distinction in our empirical analysis is between banks that are subject to a levy and banks that are not. We therefore split the bank sample on whether the home country introduced a bank levy at some point during the period 2009-2012. As reported in columns (4)-(5), banks in levy countries and non-levy countries are reasonably comparable in terms of observable characteristics although banks in levy countries are larger, rely more on deposits for financing and have somewhat less risky assets than banks in other countries. Moreover, an important endeavor of the paper is to investigate whether bank responses to the levies are correlated with the extent to which they were constrained by regulation. For this purpose we split the sample on whether the ratio of regulatory capital to risk-weighted assets was above or below the sample median in 2008. As reported in columns (6)-(7), banks with high regulatory capital ratios were a lot smaller and had slightly less risky assets than banks with low regulatory capital ratios.

The main explanatory variables concern the bank levies. Combining hand-collected information from national legal texts, a survey by KPMG (2012) and other notes by professional tax advisers in the relevant countries, we have created a comprehensive database with detailed information on the bank levies, which is available in the Online Data Appendix.

Finally, we employ a number of country-level and bank-level control variables includ-

[6] Croatia joined the EU in 2013, raising the number of member states to 28, and is not included in the sample.

ing inflation rates and real GDP growth rates from Eurostat; statutory corporate tax rates collected from the OECD Tax Database and the KPMG Corporate and Indirect Tax Survey 2011; information on government recapitalizations of distressed banks and government guarantees of bank debt from the European Commission (2012); and a list of the European banks faced with temporary additional capital requirements from the European Banking Authority (2011). These data are all available and documented in the Online Data Appendix.

5 Empirical strategy

5.1 Estimation and identification

Our main research question is whether the levies have affected banks' risk-taking along various dimensions. We study that question by estimating variants of the following model:

$$risk_{ict} = \alpha + \beta levy_{ict} + \gamma_{ic} + \theta_t + \phi \mathbf{X}_{ict} + \psi \mathbf{Z}_{ct} + \epsilon_{ict} \tag{14}$$

where $risk_{ict}$ measures the risk of bank i in country c at time t; $levy_{ict}$ measures exposure to the bank levies; γ_{ic} denotes bank fixed effects, θ_t denotes time dummies and $\mathbf{X}_{ict}$ and $\mathbf{Z}_{ct}$ are vectors of bank-level and country-level control variables. Bank fixed effects absorb all cross-sectional variation so the levy variable is identified solely by *changes* in the dependent variable. We are essentially testing whether banks that were exposed to a bank levy changed their risk relative to other banks experiencing similar changes in bank-level and country-level controls.

Identification requires the assumption that the risk of banks exposed to a bank levy would have evolved in the same way as the risk of other banks in the absence of the levies. To strengthen the credibility of this assumption, we introduce various sets of dummy variables that serve to enhance the comparability of exposed banks and the unexposed banks to which they are compared. Most regressions include interactions between time dummies and indicators of the deciles in the bank size distribution (size measured prior to the levies being introduced), which implies that the effect of levies is identified by a comparison of banks of a roughly similar size. This is important because large banks

are systematically more exposed to bank levies in the countries with progressive levy rates. If small and large banks have been affected differently by the sovereign debt crisis and other major shocks to the financial sector during the sample period due to differences in their funding and portfolio structure, identifying from a comparison of exposed large banks and unexposed small banks may be problematic. Similarly, our robustness tests include interactions between time dummies and geographical indicators to identify from comparisons of banks within the same European region as well as between time dummies and capitalization indicators (capitalization measured prior to the levies being introduced) to identify from comparisons of banks that are similar in terms of capital structure. Finally, we also include interactions between country dummies and a linear time trend to control for country differences in the underlying time trends of bank risk.

Generally, banks' effective exposure to bank levies depends on their characteristics and is therefore most appropriately considered an endogenous variable. For instance, the applicable levy rate is increasing in bank size in Germany and several other countries and the applicable levy rate depends on the maturity of the banks' debt in Netherlands and the UK. To address this issue, we instrument each bank's levy exposure $levy_{ict}$ with the levy exposure $levy_{ict}^{IV}$ that would have prevailed if the bank had kept the exact same characteristics as before the levies were introduced. The instrument is clearly exogenous to any behavioral responses to the levies and is very strongly correlated with actual levy exposure. This instrumentation strategy is similar to the one developed by Gruber and Saez (2002) in the context of personal income taxation and has been used by many subsequent studies in the tax literature.

Some variables are not naturally bounded and may take extreme values. For instance, the ratio of equity to assets approaches negative infinity for troubled banks with few assets and large liabilities. To prevent the results being driven by extreme values, we conservatively winsorize these variables at the 5% and 95% level. Our results are generally robust to other ways of handling extreme observations.

5.2 Measurement

We study three dimensions of risk: a bank's *total risk* which in turn depends on its *funding risk*, for instance the extent to which it relies on debt financing, and its *portfolio risk*, for instance the share of its funds allocated to risky asset classes. While the different dimensions of bank risk are conceptually quite clear, measurement represents a serious challenge, which we discuss in detail in this section.

Total risk

Our baseline measure of total risk is the regulatory capital ratio defined as the amount of regulatory capital held by the bank per euro of risk-weighted assets. This ratio effectively combines measures of funding risk (capital /assets) and portfolio risk (average risk weight of assets) and is the key variable used by financial regulators to assess the risk of individual banks. From a practical perspective, an important advantage of this measure is data availability: the regulatory capital ratio is reported in financial statements by more than 2,700 European banks during our sample period. Moreover, it relates directly to the notion of total risk in our conceptual framework and changes can conveniently be expressed in terms of changes in funding risk and portfolio risk.

It is well-known, however, that regulatory risk weights are far from perfect measures of true portfolio risk. The risk weights set directly by regulators apply to broad asset classes and thus capture portfolio risk in a very crude way. Since the adoption of the Basel II agreement, many banks have relied on their own estimates of asset risk, but some commentators have expressed concern that the use of internal risk models allow banks effectively to circumvent the regulatory capital requirements by understating the risk of their portfolio (Haldane, 2013), a notion that has found some support in recent academic work (Mariathasan and Merrouche, 2014). If regulatory risk weights can be manipulated by banks, it is unclear whether an observed improvement in a bank's regulatory capital ratio reflects a reduction in its real risk or a change in the (costly) effort exerted to manipulate risk weights.

Despite the weaknesses of this measure, regulatory risk weights have been used to approximate portfolio risk in the literature on bank responses to financial regulation (e.g. Rime, 2001) and taxation (Keen and de Mooij, 2012). In our context, risk weights have

the conceptual advantage that they correspond precisely to the regulatory definition of portfolio risk, hence it is exactly this measure that should change if banks whose risk taking is effectively constrained by the regulatory capital requirements shift risk from the liability side of their balance sheet to the asset side in response to the levies. In principle, this leaves open the impact on true portfolio risk. However, if banks generally attempt to understate portfolio risk, it is hard to see why observed increases in regulatory risk weights should reflect anything other than a rise in true portfolio risk.

In any case, to address this concern, we complement the analysis with two alternative measures of total risk. First, for the subsample of banks listed on a stock exchange, we use the standard deviation of their daily stock returns. This is one of the most common measures of bank risk.[7] Its main drawback is low coverage: stock prices are only available for around 120 European banks. Second, we develop a measure based on the book return on equity. We typically observe book returns only twice after the introduction of the levies and therefore do not have sufficient observations to compute and compare bank-level volatility before and after the levies.[8] Instead, we base our inference on the cross-sectional distribution of book returns. Specifically, we compute the absolute distance between a bank's own book return and the median book return within a narrow reference group of banks belonging to the same size decile, the same capitalization decile and the same geographical region within Europe and use this distance measure as dependent variable in our baseline model. Intuitively, more risky banks should on average experience more extreme outcomes, so assuming that the levies reduced risk, we should observe that banks exposed to the levies experienced book returns closer to the reference level relative to their own pre-levy volatility (captured by bank fixed effects) and relative to the general time trend in volatility (captured by time dummies). It should be noted that this procedure introduces significant noise compared to a situation where some measure of risk is observed directly. Even if all banks exposed to a levy reduced their risk, some of them would still experience more extreme outcomes than before the

[7] See, for example, Laeven and Levine (2009), Pathan (2009), Ellul and Yerramilli (2013), and Cheng, Hong and Scheinkman (2015).

[8] A common book measure of risk is the z-score defined as the return on assets plus the capital-asset ratio divided by the standard deviation of asset returns (see, for example, Laeven and Levine, 2009; Pathan 2009; Houston et al, 2010; and de Haan and Poghosyan, 2012). Several years of data are required to compute the standard deviation of asset returns, which makes the measure unsuited for our purposes.

levies, hence only on average across a large number of banks could we hope to identify the effect of the levies using this method.

Funding risk

Our measure of funding risk is the ratio of equity to total assets both measured at book value. For several reasons, book values are more appropriate than the market values for our purposes. First, we would like our measure of funding risk to depend on the funding structure but not on the portfolio structure. While the book value of equity is unaffected by portfolio choices, at least until these choices give rise to gains or losses, the market value of equity is likely to reflect all types of risk. Second, we are ultimately interested in active responses to the bank levies, such as share issues and changes in dividend policy, and we would therefore like to purge our measure of funding risk from the influence of other factors to the greatest extent possible. This suggests that book values are more suitable than market values, because the latter but not the former are affected by changes in expectations about future income and costs. One example of this mechanism is the bank levies themselves, which represent future costs for the banks and may therefore mechanically drive down the market value of equity holding banks' funding and portfolio choices constant. Finally, book values of equity and total assets are available for all banks in the sample and, hence, do not cause the same severe sample attrition as market measures.

Portfolio risk

Our baseline measure of portfolio risk is the ratio of risk-weighted assets to total assets or, equivalently, the average regulatory risk weight of assets. We also consider two alternative measures of portfolio risk that are not prone to manipulation by banks. First, we use loan charge-offs as a measure of the riskiness of the loans extended by the bank. Under standard financial accounting rules, charge-offs must be made when certain objective criteria for non-performance are met. The objectivity makes charge-offs preferable to other accounting measures of loan riskiness, such as loan loss provisions and reserves for impaired loans, both of which depend on banks' subjective *ex ante* judgments about the riskiness of the loan portfolio. Second, we study the volatility of the return on banks'

portfolios of securities and derivatives. We face the same constraints as in our analysis of book returns on equity (discussed above) and use the same methodology. Specifically, we compute the absolute distance between a bank's own return on its trading assets and the median return on trading assets within a narrow reference group of banks and use this distance measure as dependent variable in our baseline model. In the same way as for the volatility of the book return on equity, the reference group is determined as belonging to the same size decile, the same capitalization decile and the same geographical region within Europe.

Levies

Drawing on the database with detailed information about the bank levies, we construct two variables to measure the incentives facing banks. First, we construct a dummy variable for the existence of a bank levy at the country-year level. This variable is useful for policy evaluation purposes because it allows us to estimate the *average* effect of the levies on the outcomes of interest. Note that since we are interested in behavioral responses to the levies and the Austrian levy was effectively retroactive for 2011-2013, we code the dummy variable zero for this country. Since this measure of levy exposure is exogenous to bank choices, it does not need to be instrumented. Second, we construct a measure of the marginal levy rate, which we define as the additional levy cost associated with a unit increase in taxable liabilities, at the bank-year level. In principle, this measure fully captures the within-country and between-country variation in marginal incentives across banks and allows us to directly estimate the tax responsiveness of the outcomes of interest. To construct the variable, we estimate the levy base for each individual bank and year on the basis of the balance sheet information and the legal definition of the levy base and identify the applicable marginal levy rate as the increment in the levy bill that would follow from a unit increase in short-term debt. This procedure is similar to the simulation of effective marginal tax rates in studies of income taxes and transfers. Details of the construction of marginal levy rates are available in the Online Data Appendix.

6 Results

This section presents our regression results. Unless indicated otherwise, the sample includes banks in the 27 EU countries except France, Hungary and Slovenia and the sample period is 2004-2012. Regression coefficients are reported with robust standard errors clustered at the bank level.

6.1 Average effects of the bank levies

Baseline results

Table 3 reports the results obtained from estimating (14) augmented with interactions between time dummies and bank size indicators to ensure that identification comes from comparisons of similar-sized banks. The dependent variables are our baseline measures of total risk, funding risk and portfolio risk. Columns (1)-(2) suggest that bank levies had a sizeable effect on total risk. The coefficient on *levy* in column (1) implies that banks levies increased regulatory capital ratios by around 0.9 percentage points on average. The sample mean of the regulatory capital ratio is around 0.16, hence this estimate translates into a 6% increase in the amount of regulatory capital per unit of risk-weighted assets. Column (2) shows that the positive effect of levies on regulatory capital ratios is somewhat smaller, but remains economically and statistically significant when using the instrumented marginal levy rate as explanatory variable. The coefficient on *marginal levy rate* implies that a bank levy at the rate of 0.06% (the top marginal rate in Germany) increased regulatory capital ratios by around 0.4 percentage points corresponding to around 3% at the sample mean.

Table 3 around here

The covariates have very similar effects in the two specifications. The negative coefficient on assets (conditional on bank fixed effects) suggests that expansions of bank balance sheets tend to be financed with debt, which causes an erosion of the capital ratio. This is consistent with the findings in Adrian and Shin (2010). The positive coefficient on profitability reflects that profits in a given financial year mechanically translate into retained earnings on the end-of-year balance sheet and thus, everything else equal, increase

the capital ratio. The negative coefficient on the corporate tax rate suggests that the tax advantage to debt leads to higher risk. Inflation and GDP growth do not seem to systematically affect capital ratios.

In columns (3)-(6), we investigate whether the increase in regulatory capital ratios was driven by adjustments on the liability side of the balance sheet (funding risk) or on the asset side (portfolio risk). Columns (3)-(4) suggest that bank levies had a very strong effect on funding risk. The coefficient on *levy* in column (3) implies that bank levies increased equity-asset ratios by around 1.3 percentage points corresponding to a 14% increase at the sample mean. Again, the coefficient on *marginal levy rate* in column (4) implies a somewhat smaller, but statistically and economically significant effect.[9] Columns (5)-(6) suggest, however, that some of the reduction in funding risk was offset by an increase in portfolio risk. The coefficient on *levy* in column (5) implies that banks changed their asset portfolios in response to the levies in such a way that the average risk weight increased by around 4 percentage points corresponding to a 7% increase at the sample mean. The coefficient on *marginal levy rate* in column (6) implies a somewhat smaller, but statistically and economically significant effect.

These baseline results suggest that bank levies were successful at reducing the total risk of banks on average: measured by *levy*, banks appear to have increased their capital ratio by around 6% on average in response to the levies. But the results are also suggestive of considerable shifting of risk from the liability side to the asset side of the balance sheet: again measured by *levy*, banks increased their equity-asset ratios by around 14% and at the same time increased the average risk-weights on their assets by around 7%. In other words, around half of the reduction in total risk coming from the reduction in funding

[9] It is instructive to compare the magnitude of our estimated coefficients to those of Keen and de Mooij (2015). Their analysis suggests that a 1 percentage point increase in the corporate tax rate reduces the equity-asset ratio by around 0.25 percentage points. By comparison, our baseline estimate suggests that a levy of 0.1 percent increases the equity-asset ratio by 1.2 percentage points. Taking these estimates at face value, a 0.1 percent bank levy has roughly the same effect on the equity-asset ratio as a reduction in the corporate tax rate of 5 percentage points. To assess whether the two estimates are consistent with the same underlying responsiveness to tax incentives, note that a levy of 0.1 percent increases the annual cost of a euro of debt by 0.1 cent. Assume that banks borrow at 2 percent such that each percentage point reduction in the corporate tax rate increases the after-tax cost of a euro of debt by 0.02 cent. This implies that a reduction in the corporate tax rate of 5 percentage points increases the after-tax cost of a euro of debt by 0.1 cent. Hence, under the plausible assumption of a 2 percent borrowing rate, our central estimate implies precisely the same sensitivity of equity-asset ratios to tax incentives as found by Keen and de Mooij (2015).

risk was offset by an increase in portfolio risk.

Robustness

Table 4 explores the robustness of these results. For ease of comparison, the first column reiterates the main coefficients of interest from the baseline regressions in Table 3 and each subsequent column represents an extension of this model. Panel A presents results for total risk, Panel B for funding risk and Panel C for portfolio risk. The coefficients on covariates are not reported.

A first concern is that the levy variables may pick up pre-existing differential trends in risk variables. If banks exposed to a levy were for some reason on different trajectories than other banks, this could show up in the estimated effects of the levies. We control directly for differential underlying trends by including interactions between a linear trend and country dummies. Column (2) shows that results for all three measures of risk are qualitatively unchanged although the magnitude of the estimated coefficients is somewhat smaller.

Table 4 around here

Another and perhaps more general concern is that the baseline results are driven by shocks, which had a significant impact on bank risk and which were correlated with the introduction of the levies.

First, there were several other governments interventions in the banking sector besides the bank levies during the sample period. We attempt to control directly for those by augmenting the model with the following four variables: (i) cumulative government spending on bank recapitalizations measured as a fraction of total bank assets (using data from European Commission, 2012); (ii) government guarantees of bank borrowing measured as a fraction of total bank assets (European Commission, 2012); (iii) the share of bank assets invested in trading securities, which became subject to increased capital coverage requirements in 2011 (Bankscope) and; (iv) a dummy variable coded one for banks that temporarily became subject to stricter capital requirements in 2011 (European Banking Authority, 2011). Column (3) shows that the coefficients for all three measures of risk barely change relative to the baseline specification.

Second, if the sovereign debt crisis in Greece, Portugal, Spain and Italy caused banks in Southern Europe to suffer greater losses than banks in other regions and if governments in Southern Europe were less likely to adopt bank levies than governments in other regions, this could cause a correlation between bank levies and our risk measures. We control for region-specific shocks by adopting a specification where the levy variables are identified solely from within-region comparisons. Specifically, we define five geographical regions in Europe and augment the model with interactions between region dummies and time dummies.[10] As shown in column (4), the levies still increase both equity-asset ratios and average risk weights, however, the two effects offset each other fully so that the effect on the regulatory capital ratios is very close to zero and statistically insignificant.

Third, it is likely that highly leveraged banks faced strong market pressure to reduce leverage in the wake of the financial crisis. If countries with more leveraged banks were also more likely to adopt a bank levy, the baseline model would produce biased estimates. To address this concern, we adopt a specification where the levy variables are identified from comparisons of banks with similar equity-asset ratios. Specifically, we construct dummy variables for each decile of the distribution of equity-asset ratios in 2008 and include their interactions with time dummies. Column (5) shows that the levies still have a highly significant effect on both equity-asset ratios and average risk weights whereas the effect on regulatory capital ratios is only borderline significant.

In sum, when introducing additional controls, the levies are still found to decrease funding risk and increase portfolio risk. While the point estimates are often considerably lower than in the baseline specification, notably for funding risk, these effects are highly statistically significant in all specifications, which provides strong evidence of risk shifting. The effect of the levies on banks' total risk is, however, somewhat less robust. Most notably, when inference is based solely on comparisons of banks within the same geographical region, the estimated decrease in funding risk is so small that it is fully offset by the increase in portfolio risk, which makes the net effect on total risk precisely zero.

[10] *Eastern Europe* is Poland, Estonia, Latvia, Lithuania, Czech Republic, Slovakia, Slovenia, Hungary, Romania and Bulgaria; *Southern Europe* is Spain, Portugal, Greece, Italy, Cyprus and Malta; *Northern Europe* is Denmark, Sweden and Finland; *Central Europe* is Austria, Germany, Netherlands, Belgium, France and Luxembourg; and the *British Isles* is the UK and Ireland. Incidentally, each of these regions includes at least one country that has introduced a levy and at least one country that has not.

Alternative risk measures

This section investigates whether the results are robust to using alternative measures of total risk and portfolio risk given the weaknesses of regulatory risk weights as a measure of true asset risk discussed in detail above. Table 5 reports the results obtained from estimating (14) on the alternative risk measures. Columns (1)-(2) use the standard deviation of daily stock market returns as a measure of total risk for the subset of banks listed on a stock exchange. Both levy measures have a negative and strongly significant effect on the volatility of stock market returns. The point estimates imply that a bank levy at the rate of 0.06% (the top marginal rate in Germany) reduced the standard deviation of daily market returns by around 0.3 corresponding to roughly 10% of the sample mean. Columns (3)-(4) employ the absolute difference between a bank's own book return and the median book return within a narrow reference group of banks as dependent variable. The reference group is defined as all banks belonging to the same size decile, the same capitalization decile and the same geographical region as the bank itself. Both levy measures significantly reduced the absolute distance to the median return in the reference group. The finding that banks exposed to a levy on average realized less extreme book returns is suggestive that bank levies reduced banks' total risk. The point estimates imply that a bank levy at the rate of 0.06% reduced the distance between a banks' book return and the reference book return by around 0.6 percentage points, which corresponds to roughly 8% of the sample standard deviation of the book return.

Table 5 around here

Columns (5)-(6) use loan charge-offs normalized by gross interest income as a measure of the portfolio risk that derives from default risk on loans. Both levy measures have a positive and statistically significant effect on loan charge-offs consistent with our previous finding of levies increasing portfolio risk. Finally, columns (7)-(8) employ the absolute difference between a bank's return on its trading assets and the median return on trading assets within the reference group as dependent variable. The reference group is again defined as all banks belonging to the same size decile, the same capitalization decile and the same geographical region as the bank itself. The return on trading assets is defined as the net gain from trading and derivatives relative to net assets tied in securities and

derivatives. In the first specification, the bank levies significantly increased the average absolute distance to the median trading return in the reference group, which is suggestive that banks on average increased the riskiness of their trading positions when exposed to a levy. The results imply that levy exposure increased the distance between a banks' trading return and the reference trading return by around 0.15 percentage points corresponding to roughly 7.5% of the sample standard deviation of the trading return. In the second specification, the levy variable is also positive, but statistically insignificant.

Table 5 shows that the patterns found in the baseline analysis are robust to the use of risk measures that do not rely on regulatory risk weights. There is evidence that bank levies reduce the volatility of market returns and bring book returns closer to their benchmark, both suggesting a lower level of overall risk, as well as increase loan losses and bring trading returns further away from their benchmark, both suggesting a higher level of portfolio risk.

Behavioral mechanisms

For policy purposes, it is important whether the increase in the equity-asset ratio identified above was achieved by a substitution of debt funding for equity funding for a given level of assets or by a reduction in assets for a given level of equity. In the latter case, the adverse effects on the real economy could potentially be severe if the reduction in assets were driven by a contraction in lending to non-financial firms. Table 6 sheds light on this question. To test which of the two possible channels is most empirically relevant, we estimate the model where the dependent variable is the equity stock (in logs) and the asset stock (in logs) respectively. Columns (1)-(2) show that equity stocks increased significantly in response to the levies; the first specification implies an average increase of around 15% among exposed banks. Columns (3)-(4) show that there was little or no effect on asset stocks; the first specification implies a decrease of around 3% whereas the second specification implies that there was no significant effect on asset stocks at all. Clearly, the increase in equity-asset ratios was mainly driven by increases in equity stocks rather than by contractions of bank balance sheets.

Table 6 around here

Of particular concern for policy makers is the part of banks' balance sheets that concern lending. To test whether the bank levies lead to a contraction in bank lending, we estimate the model with total lending (in logs) as dependent variable. Columns (5)-(6) show no signs that banks reduced the level of lending in response to the levies.

6.2 Heterogeneous effects of the bank levies

In the previous section, we found evidence that bank levies reduce the total risk of an *average* bank, but that the large effect working through a reduction in funding risk was partly offset by an increase in portfolio risk. Our theoretical framework implied that we should expect to observe more risk shifting by banks with a high bailout probability and a capital ratio close to the regulatory constraint. In this section, we test this hypothesis by allowing the effect of bank levies to differ between banks with high and low levels of capital. Specifically, we construct separate dummy variables for banks with a regulatory capital ratio above the median ("high capital") and below the median ("low capital") respectively and introduce interactions between these two dummy variables and the levy measures into the model. The dummy variables are defined in terms of regulatory capital ratios in 2008, which is exogenous to later changes in risk induced by the levies.

Baseline results

Table 7 reports results obtained from reestimating the models presented in Table 3 while allowing for heterogeneous responses to the levies. Further, these models also contain interactions between the two dummies for high and low capital and the time dummies. By conditioning the time trend on the regulatory capital ratio in 2008, we ensure that the coefficients are identified from comparisons of banks with approximately the same pre-levy regulatory capital ratio of which some were exposed to a bank levy and some were not.

Table 7 around here

Columns (1)-(2) show the heterogeneous effects of bank levies on banks' regulatory capital ratios. In the first specification, there is a positive effect for high-capital banks and

no effect for low-capital banks. As indicated in the bottom row, the null hypothesis that the two coefficients are identical can be rejected at the 1% level. In the second specification, the effect is positive for both types of banks, but almost twice as large for high-capital banks than low-capital banks. Here, however, it cannot be rejected that the two coefficients are identical.

We then investigate whether the heterogeneous effect of bank levies on regulatory capital ratios derives from heterogeneous changes in the funding or portfolio choices. Columns (3)-(4) show that the bank levies increased the equity-asset ratios of both types of banks, but that the effect is considerably larger for high-capital banks than for low-capital banks. The difference between the two coefficients is highly significant in both specifications. Columns (5)-(6) show that the bank levies induced an increase in the average risk weight for both types of banks. In the first specification, the effect was significantly larger for low-capital banks than for high-capital banks. In the second specification, the responses by the two types of banks cannot be distinguished at conventional levels of statistical significance.

The results suggest that bank levies were successful at reducing the total risk of banks with a high level of regulatory capital prior to being exposed to a levy while it is unclear if there was any such effect on banks with a low level of regulatory capital. The results also suggest that the differential effect on total risk was partly because high-capital banks raised more new equity in response to the levies and partly because low-capital banks offset more of the reduction in funding risk with increased portfolio risk.

Robustness

Table 8 applies the same robustness exercises conducted in Table 4 to the specifications allowing for heterogeneous responses tested in Table 7. The first column repeats the baseline results and the following four columns each represents a robustness test.

Panels A-B show that the positive effect on the regulatory capital ratios of high-capital banks is robust to all the extensions when the dummy is used as a levy measure, but that the effect loses statistical significance in columns (4)-(5) when the marginal levy rate is used as a levy measure. By contrast, the effect on the regulatory capital ratios of low-capital banks found in one of the baseline specifications only survives a single one of

the four robustness tests.

Table 8 around here

Panels C-D show that the positive effect on the equity-asset ratios of high-capital banks is robust to all the extensions when the dummy is used as a dummy measure, but the effect is not significant in column (4) when the marginal levy rate is used as a dummy measure. The effect on the equity-asset ratios of low-capital banks is also fairly robust, but is insignificant in column (4) for both levy measures.

Panels E-F show that the positive effect on the risk weights of low-capital banks is robust to all the extensions regardless of the measure used. The effect on the risk weights of high-capital banks is insignificant in columns (2), (4) and (5) when the dummy is used as a levy measure and in column (2) when the marginal levy rate is used as a levy measure.

The results tend to confirm the patterns found in the baseline regressions. The reduction in the total risk of high-capital banks survives most robust tests whereas almost all evidence of a similar effect on low-capital banks vanishes with the additional controls. To the extent that the levies reduced average risk in the banking sector, it was very likely driven by banks that were already relatively well capitalized.

Alternative risk measures

Table 9 reports results obtained from reestimating the models presented in Table 5 while allowing for heterogeneous responses to the levies. Columns (1)-(2) show the heterogeneous effects of bank levies on the volatility of daily stock market returns.[11] Bank levies reduce the volatility for both types of banks regardless of the levy measure used. The point estimate is more negative for high-capital banks than for low-capital banks, however, only in column (2) is the difference statistically significant. Columns (3)-(4) show that bank levies tended to reduce the absolute distance between banks' own book return and the median return within their reference group, but only for high-capital banks. These results support our previous finding that the reduction in total risk for the average bank is largely driven by high-capital banks while it is much more uncertain whether

[11] Note that in columns (1) and (2) we classify banks into high- and low-capital relative to the median of the sample with market data.

low-capital banks reduced their risk at all.

Table 9 around here

Columns (5)-(6) show that the bank levies increased loan charge-offs for low-capital banks, but not for high-capital banks. Columns (7)-(8) report somewhat conflicting evidence on the effect of levies on the absolute distance between banks' trading return and the median trading return within their reference group. The first specification suggests that bank levies increased the volatility of the trading returns of low-capital banks, but had no impact on high-capital banks. The second specification instead suggests that bank levies reduced the volatility of the trading returns of high-capital banks, but had no impact on low-capital banks. The results in columns (5)-(7) thus support our previous finding that the average increase in portfolio risk is largely driven by a more risky portfolio in low-capital banks whereas the results in column (8) are hard to reconcile with our theoretical framework and our previous findings.

7 Concluding remarks

Levies on bank borrowing have become an important dimension of government intervention in financial markets. This paper has shown that while the bank levies introduced by a number of European countries achieved some reduction of risk in the banking sector, they suffer from two fundamental weaknesses. First, the levies only penalize funding risk so the incentive to reduce total risk is eroded by the ability to substitute toward portfolio risk. Second, the incentive to engage in risk shifting instead of risk reduction is stronger for weakly capitalized banks, which are the banks that pose the greatest threat to financial stability.

Our analysis has several implications for policy design. First, the bank levies would be more effective in curbing bank risk if they penalized both funding risk and portfolio risk since this would reduce the scope for risk shifting. Indeed, current reforms in the European Union aim to introduce bank levies in all member states where banks' levy payments are a function of their total borrowing as well as several other dimensions of risk. Second, the key innovation of the Basel III regulatory framework, the leverage

ratio, which imposes a minimum ratio of regulatory capital to assets of 3%, is likely to suffer from the same weakness as the bank levies. Since it constrains only funding risk, it is likely to induce substitution towards portfolio risk that could undermine the reduction in banks' total risk. This potential weakness has been widely discussed in policy circles, but advocates of the leverage ratio have appealed to a lack of empirical evidence on risk shifting (e.g. Bank of England, 2014). The results presented in this paper reinforces the concern that risk shifting may limit the value of the leverage ratio. There is also an important question over the appropriate measure of risk that should be used in Pigouvian taxation or in regulation. Acharya (2009) shows that regulatory mechanisms that are based only on a bank's own risk may fail to mitigate aggregate risk-shifting incentives and may even accentuate systemic risk. Acharya et al. (2010) develop a measure of a financial institution's contribution to systemic risk which directly addresses such macro-prudential considerations.

This discussion relates to broader questions about externalities in financial markets, the scope for corrective taxation and the interaction of such taxes with existing regulation. Stein (2013) argues that negative externalities in markets for securities financing transactions where distress and asset fire-sales by some borrowers may depress asset prices and tighten collateral constraints on other borrowers, creates a scope for Pigouvian taxes. Importantly, he points to complementarities in enforcement between existing regulation and new corrective taxes. Perotti and Suarez (2011) directly address the choice between bank regulation in the form of capital requirements and taxation in the form of taxes on short-term bank borrowing and show that the relative merits of the two corrective instruments depend on the precise nature of bank heterogeneity: regulation is more desirable when banks differ in their propensity to take gambles whereas taxation is more desirable when banks differ in their lending opportunities. In the presence of both types of heterogeneity, the optimal policy uses both taxation and regulation. Since Perotti and Suarez (2011) assume that regulation and taxation address exactly the same type of risky behavior, they do not find the same interaction between the two policy tools as in our model where regulation restricts total risk and bank levies fall only on funding risk. In general, regulation and taxation should be expected to interact to create risk shifting as long as they target dimensions of risk that are not perfectly aligned.

References

[1] Acharya, V., 2009. A theory of systemic risk and design of prudential bank regulation, *Journal of Financial Stability* 5, 224–255.

[2] Acharya, V., Mehran, H., Thakor, A., 2011. Caught between Scylla and Charybdis? Regulating bank leverage when there is rent seeking and risk shifting. Unpublished working paper. New York University.

[3] Acharya, V., Pedersen, L., Philippon, T., Richardson, M. 2010. Measuring Systemic Risk, Federal Reserve Bank of Cleveland Working Paper 10-02.

[4] Admati A., Demarzo, P., Hellwig, M., Pfleiderer, P., 2010. Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Expensive, Stanford GSB Research Paper No. 2063

[5] Adrian, T., Shin, H., 2010. Liquidity and leverage. *Journal of Financial Intermediation* 19, 418–437

[6] Allen, F., Carletti, E., Marquez, R., 2011. Credit Market Competition and Capital Regulation. *Review of Financial Studies* 24(4), 983-1018.

[7] Avery, R., Berger, A., 1991. Risk-based Capital and Deposit Insurance Reform. *Journal of Banking and Finance* 15, 847-874.

[8] Bank of England, 2014, The Financial Policy Committee's review of the leverage ratio: A Consultation Paper, July 2014.

[9] Beltratti, A., Stulz, R.M., 2012. The credit crisis around the globe: Why did some banks perform better? *Journal of Financial Economics* 105, 1-17.

[10] Berger, A., Bouwman, C., 2013. How does capital affect bank performance during financial crisis? *Journal of Financial Economics* 109, 146-176.

[11] Brunnermeier, M., 2009. Deciphering the Liquidity and Credit Crunch 2007–2008. *Journal of Economic Perspectives* 23(1), 77–100.

[12] Cheng, I-H, Hong H., Scheinkman, J.A., 2015, Yesterday's Heroes: Compensation and Risk at Financial Firms, *Journal of Finance* 63,1575-1608.

[13] Chodorow-Reich, G., 2014. The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-09 Financial Crisis. *Quarterly Journal of Economics* 129(1), 1-59.

[14] De Haan, J.. Poghosyan, T. 2012. Bank size, market concentration, and bank earnings volatility in the US. *Journal of International Financial Markets, Institutions and Money* 22, 35–54.

[15] Diamond, D., Rajan, R., 2009. The Credit Crisis: Conjectures about Causes and Remedies. *American Economic Review* 99(2), 606-610.

[16] Ellul, A., Yerramilli, V. 2013. Stronger Risk Controls, Lower Risk: Evidence from U.S. Bank Holding Companies. *Journal of Finance* 68, 1757–1803

[17] European Commission, 2012. Facts and figures on State aid in the EU Member States. Commission Staff Working Document, COM(2012) 778 final

[18] European Banking Authority, 2011. EBA Recommendation on the creation and supervisory oversight of temporary capital buffers to restore market confidence. 8 December 2011.

[19] Gorton, G., Metrick, A., 2012. Securitized Banking and the Run on the Repo. *Journal of Financial Economics* 104, 425-451

[20] Gruber, J., Saez, E., 2002. The elasticity of taxable income: evidence and implications. *Journal of Public Economics* 84, 1-32.

[21] Haldane, A., 2013. Constraining discretion in bank regulation. Bank of England mimeo

[22] Hart, O., Zingales, L., 2011. A New Capital Regulation for Large Financial Institutions. *American Law and Economics Review* 13, 453–490.

[23] Hellwig, M., 2010. Capital regulation after the crisis: Business as usual? Preprints of the Max Planck Institute for Research on Collective Goods, No. 2010/31

[24] Houston, J.F., Lin, C., Lin, P., Ma, Y. 2010. Creditor rights, information sharing, and bank risk taking. *Journal of Financial Economics* 96, 485–512.

[25] International Monetary Fund, 2010. Financial Sector Taxation. The IMF's Report to the G-20 and Background Material.

[26] Ivashina, V., Scharfstein, D., 2010. Bank lending during the financial crisis of 2008. *Journal of Financial Economics* 97, 319-338.

[27] Iyer, R., Peydro, J., 2011. Interbank Contagion at Work: Evidence from a Natural Experiment. *Review of Financial Studies* 24(4), 1337-1377.

[28] Jacques, K., Nigro, P., 1997. Risk-based Capital, Portfolio Risk and Bank Capital: A Simultaneous Equations Approach. *Journal of Economics and Business* 49, 533-547.

[29] Keen, M., 2011, The Taxation and Regulation of Banks. IMF Working Paper WP/11/206

[30] Keen, M., de Mooij, R., 2014. Debt, Taxes and Banks. *Journal of Money, Banking and Credit*, forthcoming

[31] Kim, D., Santomero, A.M.,1988. Risk in Banking and Capital Regulation. *Journal of Finance* 43,1219-1233.

[32] Koehn, M., Santomero, A.M.,1980. Regulation of bank capital and portfolio risk. *Journal of Finance* 35,1235–1250.

[33] KPMG, 2011. Corporate and Indirect Tax Survey.

[34] KPMG, 2012. Bank Levies - comparison of certain jurisdictions. Edition IX.

[35] Kreicher, L., McCauley, R., McGuire, P., 2013. The 2011 FDIC Assessment on Banks' Managed Liabilities: Interest Rate and Balance-Sheet Responses, BIS Working Paper No. 413

[36] Laeven, L., Levine, R., 2009. Bank governance, regulation and risk taking. *Journal of Financial Economics* 93, 259-275.

[37] Laeven, L., Valencia, F., 2013. Resolution of Banking Crises: The Good, the Bad, and the Ugly. In Stijn Claessens, M. Ayhan Kose, Luc Laeven and Fabián Valencia (eds.), Financial Crises: Causes, Consequences, and Policy Responses, IMF.

[38] Lemmon, M., Roberts, M., Zender, J., 2008. Back to the Beginning: Persistence and the Cross-Section of Corporate Capital Structure. *Journal of Finance* 63,1575-1608.

[39] Mariathasan, M., Merrouche, O., 2014. The manipulation of basel risk-weights. *Journal of Financial Intermediation* 23(3), 300-321.

[40] Pathan, S., 2009. Strong boards, CEO power and bank risk-taking. *Journal of Banking and Finance* 33, 1340–1350.

[41] Perotti, E., Suarez, J., 2011. A pigouvian approach to liquidity regulation. CEPR Discussion Paper No. 8271

[42] Rime, B., 2001. Capital Requirements and Bank Behaviour: Empirical Evidence for Switzerland. *Journal of Banking and Finance* 25, 789-805.

[43] Santos, J., 2011. Bank Corporate Loan Pricing Following the Subprime Crisis. *Review of Financial Studies* 24(6), 1916-1943.

[44] Shin, H.S., 2009. Reflections on Northern Rock: The Bank Run That Heralded the Global Financial Crisis. *Journal of Economic Perspectives* 23(1), 101-120.

[45] Stein, J., 2013. The Fire-Sales Problem and Securities Financing Transactions. Speech, November 7

[46] Thakor, A.V., 2012. Incentives to innovate and financial crises. *Journal of Financial Economics* 103,130–148.

8 Appendix

Proof of Proposition 1

Assuming $W_L = 0$ and $W_\alpha = 0$, then totally differentiating (8) and (9), and noting $W_{\alpha t} = 0$, implies

$$\begin{bmatrix} W_{LL} & W_{L\alpha} \\ W_{\alpha L} & W_{\alpha\alpha} \end{bmatrix} \begin{bmatrix} dL \\ d\alpha \end{bmatrix} = -dt \begin{bmatrix} W_{Lt} \\ 0 \end{bmatrix} \tag{15}$$

and hence

$$\frac{dL}{dt} = -\frac{W_{\alpha\alpha}W_{Lt}}{\Delta}; \frac{d\alpha}{dt} = \frac{W_{\alpha L}W_{Lt}}{\Delta}; \tag{16}$$

where $\Delta = W_{LL}W_{\alpha\alpha} - W_{\alpha L}^2$. Substituting for θ^B and θ^D and their derivatives with respect to L and α, and rearranging, it is possible to derive the following expressions for the second order conditions and the elements of (16):

$$W_{LL} = -T'' + (2R_L + LR_{LL})A + \frac{(1 + R + LR_L)^2}{\alpha}B \tag{17}$$

$$W_{\alpha\alpha} = LR_{\alpha\alpha}A + \frac{\left[L(1 + R - \alpha R_\alpha) - (1 + r)\right]^2}{\alpha^3}B \tag{18}$$

$$W_{L\alpha} = (R_\alpha + LR_{L\alpha})A + \frac{(1 + R + LR_L)\left[(1 + r) - L(1 + R - \alpha R_\alpha)\right]}{\alpha^2}B \tag{19}$$

$$W_{Lt} = -1$$

where

$$A = pF(\theta^D) - \frac{c}{(1 - B)}F(\theta^B) \tag{20}$$

$$B = pf(\theta^D) - \frac{c}{(1 - B)^2}f(\theta^B). \tag{21}$$

Using first and second derivatives of R, it is possible to show that $A < 0$, $B < 0$ are sufficient conditions for $W_{LL} < 0$, $W_{\alpha\alpha} < 0$, $W_{L\alpha} < 0$ and $\Delta > 0$.

Finally, it is possible to show under reasonable conditions that

$$\alpha W_{\alpha\alpha} - (1-L)W_{\alpha L} < 0$$

from which (13) implies:

$$\frac{d\Omega}{dt} > 0$$

Proposition 1 follows.■

Proof of Proposition 2

We aim to investigate the signs of the following:

$$\frac{\partial\left(dL/dt\right)}{dp}, \frac{\partial\left(d\alpha/dt\right)}{dp} \text{ and } \frac{\partial\left(d\Omega/dt\right)}{dp}$$

We have:

$$\frac{dL}{dt} = -\frac{W_{\alpha\alpha}W_{Lt}}{\Delta} = \frac{W_{\alpha\alpha}W_{Lt}}{T''W_{\alpha\alpha}} = \frac{W_{Lt}}{T''} = -\frac{1}{T''} < 0 \tag{22}$$

which implies that

$$\frac{\partial\left(dL/dt\right)}{dp} = 0.$$

Next,

$$\frac{d\alpha}{dt} = \frac{W_{\alpha L}}{T''W_{\alpha\alpha}} \text{ and } \frac{d\Omega}{dt} = \left[\alpha - (1-L)\frac{W_{\alpha L}}{W_{\alpha\alpha}}\right]\frac{1}{\alpha^2 T''} \tag{23}$$

This implies that the signs of $\frac{\partial(d\alpha/dt)}{dp}$ and $\frac{\partial(d\Omega/dt)}{dp}$ are opposite to each other, and depend on the relative magnitude of $\frac{dW_{\alpha L}}{dp}$ and $\frac{dW_{\alpha\alpha}}{dp}$, with, for example:

$$\frac{\partial\left(d\alpha/dt\right)}{dp} > 0 \text{ iff } \frac{dW_{\alpha L}}{dp} > \frac{dW_{\alpha\alpha}}{dp}$$

In general, we are not able to identify the signs of $\frac{dW_{\alpha L}}{dp}$ and $\frac{dW_{\alpha\alpha}}{dp}$. However, in the special case in which $p = 1$ and hence $R = r$, it is possible to show that

$$\alpha W_{\alpha\alpha} - (1-L)W_{\alpha L} = 0 \Rightarrow \frac{d\Omega}{dt} = 0$$

Since, in general, for $p < 1$, $\frac{d\Omega}{dt} > 0$, this implies that $\frac{\partial(d\Omega/dt)}{dp} < 0$ and $\frac{\partial(d\alpha/dt)}{dp} > 0$ at least as $p \to 1$. Proposition 2 follows.■

Table 1: Bank levies in the European Union

	Base	Rate structure in 2012	Entry into force
LEVIES ON BANK BORROWING:			
Austria*	total liabilities net of equity and insured deposits	0.000% up to €1 billion 0.055% up to €20 billion 0.085% above €20 billion	2011
Belgium	total liabilities net of equity and insured deposits	0.035%	2012
Cyprus	total liabilities net of equity	0.090%	2011
Germany	total liabilities net of equity and insured deposits	0.000% up to €300 million 0.020% up to €10 billion 0.030% up to €100 billion 0.040% up to €200 billion 0.050% up to €300 billion 0.060% above €300 billion	2011
Latvia	total liabilities net of equity and insured deposits	0.036%	2011
Portugal	total liabilities net of equity and subordinated debt	0.050%	2011
Romania	total liabilities net of equity and insured deposits	0.100%	2011
Slovakia	total liabilities net of equity and insured deposits	0.400%	2012
Sweden	total liabilities net of equity and insured deposits	0.036%	2009
Netherlands	total liabilities net of equity and insured deposits	0.000% up to €20 billion 0,044% above €20 billion (half rate for long-term funding)	2012
UK	total liabilities net of equity and insured deposits but netting of gross assets and liabilities against the same counterpart and deduction for liquid assets	0.000% up to £20 billion 0.088% above £20 billion (half rate for long-term funding)	2011
OTHER LEVIES:			
France	minimal amount of own funds required to comply with coverage ratio	0.250%	2011
Hungary	total assets net of interbank loans	0.150% up to HUF 50 billion 0.530% above HUF 50 billion	2010
Slovenia**	Total assets	0.100%	2011

Notes: * Levy payments in 2011-2013 were a function of the balance sheet in 2010; **Exceptions apply depending on the stock and growth of lending to non-banks

Table 2 : Summary statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		All banks		**Levy**	**Non-levy**	**High capital**	**Low capital**
	Obs	Mean	S.d.	Mean	Mean	Mean	Mean
Total Assets (euro million)	13,658	24,391	134,452	35,581	13,676	3,850	45,443
Liabilities (share of total assets)							
Customer deposits	13,658	0.58	0.23	0.67	0.49	0.61	0.53
Deposits from banks	13,658	0.10	0.15	0.11	0.09	0.08	0.11
Other liabilities	13,658	0.23	0.22	0.14	0.31	0.19	0.29
Equity	13,658	0.09	0.06	0.08	0.11	0.12	0.07
Assets (share of total assets)							
Loans to customers	13,658	0.60	0.19	0.56	0.63	0.55	0.64
Loans to banks	13,658	0.09	0.13	0.10	0.08	0.10	0.07
Securities	13,658	0.21	0.14	0.23	0.18	0.23	0.18
Other assets	13,658	0.11	0.12	0.11	0.11	0.11	0.11
Income statement							
Return on equity	13,652	0.07	0.08	0.08	0.07	0.07	0.08
Return on trading assets	11,545	0.00	0.02	0.00	0.01	0.00	0.01
Regulatory measures							
Regulatory capital ratio	13,658	0.16	0.06	0.16	0.16	0.20	0.13
Average risk weight	13,658	0.64	0.20	0.59	0.69	0.62	0.67
Stock market volatility							
Standard deviation of daily returns	568	2.92	1.63	2.81	3.17	3.17	2.94

Note: Columns (1)-(3) provide summary statistics for our full sample of banks for the sample period 2004-2012 except for stock market volatility where the sample period is only 2008-2012. Columns (4)-(5) report variable means for banks located in countries that did / did not introduce a bank levy during the period 2009-2012. Columns (6)-(7) report variable means for banks with a ratio of regulatory capital to risk-weighted assets above / below the sample median in 2008.

Table 3: Baseline results

	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
	Capital/RWA		**Equity/Assets**		**RWA/Assets**	
levy	0.0089***		0.0135***		0.0394***	
	(0.0015)		(0.0012)		(0.0049)	
marginal levy rate		0.0701***		0.1222***		0.4650***
		(0.0181)		(0.0145)		(0.0634)
log assets	-0.0297***	-0.0308***	-0.1284***	-0.1301***	-0.1282***	-0.1325***
	(0.0102)	(0.0033)	(0.0229)	(0.0026)	(0.0359)	(0.0114)
log assets squared	0.0003	0.0004*	0.0057***	0.0057***	-0.0005	-0.0003
	(0.0007)	(0.0002)	(0.0013)	(0.0002)	(0.0023)	(0.0008)
profitability	0.2631***	0.3009***	0.5585***	0.6142***	0.4918*	0.6403***
	(0.0704)	(0.0416)	(0.0737)	(0.0334)	(0.2661)	(0.1459)
inflation	0.0000	-0.0001	-0.0013**	-0.0014***	-0.0021	-0.0024**
	(0.0005)	(0.0003)	(0.0005)	(0.0002)	(0.0016)	(0.0011)
gdp growth	0.0000	0.0002	-0.0008***	-0.0005***	0.0003	0.0010
	(0.0003)	(0.0002)	(0.0003)	(0.0001)	(0.0009)	(0.0006)
corporate tax rate	-0.0840**	-0.1003***	0.0159	-0.0097	0.4493***	0.3692***
	(0.0344)	(0.0186)	(0.0265)	(0.0149)	(0.1332)	(0.0651)
Observations	13,091	13,091	13,091	13,091	13,091	13,091
R-squared	0.2027		0.3657		0.4445	
Number of banks	2,754	2,754	2,754	2,754	2,754	2,754
Bank fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects × bank size	YES	YES	YES	YES	YES	YES

Note: The dependent variable is the ratio of regulatory capital to risk-weighted assets in columns (1)-(2), the ratio of book equity to assets in columns (3)-(4) and the ratio of risk-weighted assets to assets in columns (5)-(6); levy is a dummy variable at the country-year level taking the value one when there is a bank levy in place; marginal levy rate is an estimate at the bank-year level of the levy saving created by subsituting one unit of debt with one unit of equity; log assets is the log of total assets; log assets squared is the log of assets squared; profitability is the ratio of pre-tax profits to assets; inflation is the rate of inflation at the country-year level; gdp growth is the rate of GDP growth at the country-year level; corporate tax rate is the corporate tax rate at the country-year level.

Table 4: Robustness of baseline results

	(1)	(2)	(3)	(4)	(5)
PANEL A			**Capital / Risk weighted assets**		
levy	0.0089***	0.0049***	0.0088***	0.0003	0.0038*
	(0.0015)	(0.0014)	(0.0016)	(0.0029)	(0.0020)
marginal levy rate	0.0701***	0.0380*	0.0714***	0.0122	0.0312*
	(0.0181)	(0.0216)	(0.0182)	(0.0192)	(0.0182)
PANEL B			**Equity / Assets**		
levy	0.0135***	0.0132***	0.0139***	0.0049**	0.0091***
	(0.0012)	(0.0013)	(0.0012)	(0.0021)	(0.0016)
marginal levy rate	0.1222***	0.0537***	0.1242***	0.0321**	0.0873***
	(0.0145)	(0.0172)	(0.0146)	(0.0152)	(0.0144)
PANEL C			**Risk weighted assets /Assets**		
levy	0.0394***	0.0247***	0.0400***	0.0239***	0.0350***
	(0.0049)	(0.0048)	(0.0049)	(0.0092)	(0.0063)
marginal levy rate	0.4650***	0.1959***	0.4839***	0.2947***	0.4035***
	(0.0634)	(0.0759)	(0.0636)	(0.0670)	(0.0636)
Covariates	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES
Time fixed effects × bank size	YES	YES	YES	YES	YES
Country × linear trend	NO	YES	NO	NO	NO
Controls for govt. interventions	NO	NO	NO	NO	NO
Time fixed effects × region	NO	NO	NO	YES	NO
Time fixed effects × equity ratio	NO	NO	NO	NO	YES

Note: The dependent variable is the ratio of regulatory capital to risk-weighted assets in Panel A, the ratio of book equity to assets in Panel B and the ratio of assets to risk-weighted assets in Panel C.; levy is a dummy variable at the country-year level taking the value one when there is a bank levy in place; marginal levy rate is an estimate at the bank-year level of the levy saving created by subsituting one unit of debt with one unit of equity. The following covariates are included in the regressions but the coefficients not reported: log assets, log assets squared, profitability, inflation, gdp growth and corporate tax rate.

Table 5: Alternative risk measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	Volatility of market return		**Volatility of ROE**		**Loan charge-offs**		**Volatility of return to trading**	
levy	-1.0311***		-0.0061**		0.0422***		0.0015**	
	(0.2420)		(0.0030)		(0.0101)		(0.0007)	
marginal levy rate		-5.3251***		-0.0979**		0.2919**		0.0038
		(1.2953)		(0.0438)		(0.1450)		(0.0122)
log assets	0.6439	0.6107	-0.0375***	-0.0374***	-0.0458	-0.0539*	0.0010	0.0008
	(1.2022)	(1.0375)	(0.0107)	(0.0068)	(0.0577)	(0.0290)	(0.0042)	(0.0020)
log assets squared	-0.0596	-0.0589	0.0018**	0.0018***	0.0016	0.0019	-0.0001	-0.0001
	(0.0628)	(0.0527)	(0.0007)	(0.0005)	(0.0034)	(0.0017)	(0.0003)	(0.0001)
profitability	-11.8493	-14.1220**	-0.0016	-0.0016**	-0.0074**	-0.0079***	0.0272	0.0370
	(10.2388)	(6.4642)	(0.0015)	(0.0007)	(0.0029)	(0.0022)	(0.0488)	(0.0290)
inflation	0.1001**	0.1037**	-0.0038***	-0.0040***	-0.0025	-0.0020	0.0012***	0.0012***
	(0.0480)	(0.0434)	(0.0010)	(0.0004)	(0.0016)	(0.0013)	(0.0004)	(0.0002)
gdp growth	-0.0457*	-0.0579**	0.1868***	0.2007***	0.8403***	0.8104***	0.0001	0.0001
	(0.0272)	(0.0238)	(0.0718)	(0.0411)	(0.1774)	(0.1649)	(0.0002)	(0.0001)
corporate tax rate	-14.3940*	-12.2672**	0.0108***	0.0107***	0.0220	0.0215	0.0001	-0.0021
	(7.3148)	(5.4196)	(0.0026)	(0.0031)	(0.0173)	(0.0195)	(0.0192)	(0.0116)
Observations	545	545	13,639	13,639	4,794	4,794	11,535	11,535
R-squared	0.2739		0.0227		0.0484		0.0190	
Number of banks	122	122	3,087	3,087	1,014	1,014	2,571	2,571
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES

Note: The dependent variable is the standard deviation of daily stock returns in columns (1)-(2), the absolute difference between the book return to equity of the bank itself and the median book return to equity within a reference group of banks in the same region, the same size decile and the same equity-asset decile as the bank itself in colums (3)-(4); the ratio of loan charge-offs to interest income incokumns (5)-(6); and the absolute difference between the trading return of the bank itself and the median trading return within a reference group of banks in the same region, the same size decile and the same equity-asset decile as the bank itself in colums (7)-(8); levy is a dummy variable at the country-year level taking the value one when there is a bank levy in place; marginal levy rate is an estimate at the bank-year level of the levy saving created by subsituting one unit of debt with one unit of equity; log assets is the log of total assets; log assets squared is the log of assets squared; profitability is the ratio of pre-tax profits to assets; inflation is the rate of inflation at the country-year level; gdp growth is the rate of GDP growth at the country-year level; corporate tax rate is the corporate tax rate at the country-year level.

Table 6: Behavioral mechanisms

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
VARIABLES	**log equity**		**log assets**		**log loans**	
Dlevy	0.1459***		-0.0319***		-0.0070	
	(0.0131)		(0.0091)		(0.0130)	
marglevyrate		1.5615***		0.0322		0.3124
		(0.1709)		(0.1660)		(0.2373)
profitability	6.8801***	7.4445***	-0.6161	-0.7880**	0.8413	0.7644
	(0.7321)	(0.3939)	(0.3839)	(0.3817)	(0.5508)	(0.5472)
inflation	-0.0058	-0.0071**	0.0059**	0.0068**	-0.0029	-0.0022
	(0.0072)	(0.0029)	(0.0028)	(0.0028)	(0.0040)	(0.0041)
gdpgrowth	-0.0106***	-0.0076***	-0.0150***	-0.0158***	-0.0230***	-0.0234***
	(0.0031)	(0.0017)	(0.0017)	(0.0017)	(0.0024)	(0.0024)
corptax	0.3143	0.0142	0.7225***	0.7682***	0.8730***	0.8674***
	(0.3114)	(0.1761)	(0.1703)	(0.1701)	(0.2442)	(0.2437)
Observations	13,079	13,079	13,091	13,091	13,072	13,072
R-squared	0.3763		0.3589		0.4172	
Number of banks	2,753	2,753	2,754	2,754	2,751	2,751
Bank fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects × bank size	YES	YES	YES	YES	YES	YES

Note: The dependent variable is the log of bank equity in columns (1)-(2), the log of total assets in columns (3)-(4) and the log of total loans in columns (5)-(6); levy is a dummy variable at the country-year level taking the value one when there is a bank levy in place; marginal levy rate is an estimate at the bank-year level of the levy saving created by subsituting one unit of debt with one unit of equity; profitability is the ratio of pre-tax profits to assets; inflation is the rate of inflation at the country-year level; gdp growth is the rate of GDP growth at the country-year level; corporate tax rate is the corporate tax rate at the country-year level.

Table 7: Heterogenity of levy effects - baseline results

	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
	Capital/RWA		**Equity/Assets**		**RWA/Assets**	
levy × low capital	0.0032		0.0113***		0.0532***	
	(0.0020)		(0.0014)		(0.0070)	
levy × high capital	0.0157***		0.0173***		0.0264***	
	(0.0025)		(0.0019)		(0.0071)	
marg. levy rate × low capital		0.0535**		0.0866***		0.4568***
		(0.0221)		(0.0176)		(0.0775)
marg. levy rate × high capital		0.0935***		0.1646***		0.5032***
		(0.0324)		(0.0259)		(0.1139)
log assets	-0.0304***	-0.0327***	-0.1223***	-0.1245***	-0.1198***	-0.1220***
	(0.0105)	(0.0033)	(0.0231)	(0.0027)	(0.0356)	(0.0117)
log assets squared	0.0003	0.0005**	0.0053***	0.0054***	-0.0007	-0.0006
	(0.0007)	(0.0002)	(0.0013)	(0.0002)	(0.0022)	(0.0008)
profitability	0.2765***	0.3164***	0.5718***	0.6312***	0.5588**	0.7078***
	(0.0727)	(0.0427)	(0.0730)	(0.0341)	(0.2749)	(0.1499)
inflation	-0.0000	-0.0001	-0.0012**	-0.0014***	-0.0023	-0.0026**
	(0.0005)	(0.0003)	(0.0005)	(0.0003)	(0.0016)	(0.0011)
gdp growth	0.0001	0.0003	-0.0007**	-0.0004***	-0.0003	0.0005
	(0.0003)	(0.0002)	(0.0003)	(0.0001)	(0.0009)	(0.0007)
corporate tax rate	-0.0806**	-0.1020***	0.0153	-0.0132	0.3720***	0.2995***
	(0.0343)	(0.0189)	(0.0269)	(0.0151)	(0.1305)	(0.0663)
Observations	11,896	11,896	11,896	11,896	11,896	11,896
R-squared	0.2200		0.3636		0.4582	
Number of banks	2,228	2,228	2,228	2,228	2,228	2,228
Bank fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects × bank size	YES	YES	YES	YES	YES	YES
Time fixed effects × high capital	YES	YES	YES	YES	YES	YES
p-value of identical levy effects for high-cap and low-cap banks	*0.0001*	*0.3060*	*0.0077*	*0.0126*	*0.0064*	*0.7357*

Note: The dependent variable is the ratio of regulatory capital to risk-weighted assets in columns (1)-(2), the ratio of book equity to assets in columns (3)-(4) and the ratio of risk-weighted assets to assets in columns (5)-(6); levy is a dummy variable at the country-year level taking the value one when there is a bank levy in place; marginal levy rate is an estimate at the bank-year level of the levy saving created by subsituting one unit of debt with one unit of equity; low capital is a dummy variable indicating that the bank's capital ratio was below the median in 2008; high capital is a dummy variable indicating that the bank's capital ratio was above the median in 2008; log assets is the log of total assets; log assets squared is the log of assets squared; profitability is the ratio of pre-tax profits to assets; inflation is the rate of inflation at the country-year level; gdp growth is the rate of GDP growth at the country-year level; corporate tax rate is the corporate tax rate at the country-year level.

Table 8: Heterogenity of levy effects - robustness

	(1)	(2)	(3)	(4)	(5)
PANEL A			**Capital / Risk weighted assets**		
levy × low capital	0.0032	-0.0013	0.0032	-0.0046	0.0009
	(0.0020)	(0.0019)	(0.0020)	(0.0032)	(0.0024)
levy × high capital	0.0157***	0.0117***	0.0154***	0.0075*	0.0124***
	(0.0025)	(0.0024)	(0.0025)	(0.0039)	(0.0034)
PANEL B					
marg. levy rate × low capital	0.0535**	0.0287	0.0568**	0.0042	0.0358
	(0.0221)	(0.0246)	(0.0222)	(0.0226)	(0.0221)
marg. levy rate × high capital	0.0935***	0.0604*	0.0911***	0.0146	0.0238
	(0.0324)	(0.0350)	(0.0324)	(0.0333)	(0.0332)
PANEL C			**Equity / Assets**		
levy × low capital	0.0113***	0.0119***	0.0118***	0.0031	0.0093***
	(0.0014)	(0.0016)	(0.0014)	(0.0023)	(0.0017)
levy × high capital	0.0173***	0.0165***	0.0176***	0.0073***	0.0086***
	(0.0019)	(0.0020)	(0.0019)	(0.0028)	(0.0024)
PANEL D					
marg. levy rate × low capital	0.0866***	0.0469**	0.0903***	0.0213	0.0804***
	(0.0176)	(0.0195)	(0.0177)	(0.0179)	(0.0174)
marg. levy rate × high capital	0.1646***	0.0689**	0.1647***	0.0348	0.0697***
	(0.0259)	(0.0277)	(0.0259)	(0.0264)	(0.0261)
PANEL E			**Risk weighted assets /Assets**		
levy × low capital	0.0532***	0.0427***	0.0543***	0.0382***	0.0390***
	(0.0070)	(0.0068)	(0.0070)	(0.0104)	(0.0081)
levy × high capital	0.0264***	0.0071	0.0262***	0.0041	0.0141
	(0.0071)	(0.0072)	(0.0070)	(0.0109)	(0.0095)
PANEL F					
marg. levy rate × low capital	0.4568***	0.2356***	0.4819***	0.3313***	0.4026***
	(0.0775)	(0.0867)	(0.0778)	(0.0793)	(0.0769)
marg. levy rate × high capital	0.5032***	0.0980	0.5024***	0.2738**	0.3659***
	(0.1139)	(0.1230)	(0.1138)	(0.1168)	(0.1156)
Covariates	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES
Time fixed effects × bank size	YES	YES	YES	YES	YES
Time fixed effects × high capita	YES	YES	YES	YES	YES
Country × linear trend	NO	YES	NO	NO	NO
Controls for govt. interventions	NO	NO	YES	NO	NO
Time fixed effects × region	NO	NO	NO	YES	NO
Time fixed effects × equity ratio	NO	NO	NO	NO	YES

Note: The dependent variable is the ratio of regulatory capital to risk-weighted assets in Panels A-B, the ratio of book equity to assets in Panels C-D and the ratio of assets to risk-weighted assets in Panels E-F.; levy is a dummy variable at the country-year level taking the value one when there is a bank levy in place; marginal levy rate is an estimate at the bank-year level of the levy saving created by subsituting one unit of debt with one unit of equity; low capital is a dummy variable indicating that the bank's capital ratio was below the median in 2008; high capital is a dummy variable indicating that the bank's capital ratio was above the median in 2008. The following covariates are included in the regressions but the coefficients not reported: log assets, log assets squared, profitability, inflation, gdp growth and corporate tax rate.

Table 9: Heterogenity of levy effects - alternative risk measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	Volatility of market return		**Volatility of ROE**		**Loan charge-offs**		**Volatility of return to trading**	
levy × low capital	-0.9847***		-0.0048		0.0565***		0.0018*	
	(0.3248)		(0.0040)		(0.0092)		(0.0009)	
levy × high capital	-1.5264***		-0.0067**		0.0054		0.0009	
	(0.4053)		(0.0033)		(0.0308)		(0.0008)	
marg. levy rate × low capital		-4.2091***		-0.0817		0.3629**		0.0099
		(1.4280)		(0.0521)		(0.1477)		(0.0130)
marg. levy rate × high capital		-17.9624***		-0.1518**		-0.0303		-0.0788***
		(4.2636)		(0.0754)		(0.4184)		(0.0301)
log assets	0.7454	1.1342	-0.0410***	-0.0410***	-0.0171	-0.0402	0.0022	0.0020
	(1.7995)	(1.1932)	(0.0114)	(0.0071)	(0.0490)	(0.0281)	(0.0045)	(0.0021)
log assets squared	-0.0656	-0.0819	0.0021***	0.0021***	0.0002	0.0015	-0.0001	-0.0001
	(0.0808)	(0.0568)	(0.0008)	(0.0005)	(0.0030)	(0.0017)	(0.0003)	(0.0001)
profitability	-12.8195	-13.4133**	-0.0013	-0.0014*	-0.0078***	-0.0083***	0.0335	0.0470
	(11.8363)	(6.4538)	(0.0015)	(0.0008)	(0.0030)	(0.0021)	(0.0512)	(0.0299)
inflation	0.0874	0.0950**	-0.0038***	-0.0039***	-0.0032**	-0.0031**	0.0011**	0.0010***
	(0.0538)	(0.0434)	(0.0010)	(0.0004)	(0.0016)	(0.0013)	(0.0005)	(0.0002)
gdp growth	-0.0542*	-0.0618***	0.1718**	0.1856***	0.8488***	0.7571***	0.0001	0.0002
	(0.0299)	(0.0231)	(0.0742)	(0.0421)	(0.1689)	(0.1504)	(0.0002)	(0.0001)
corporate tax rate	-17.6512**	-18.4225***	0.0101***	0.0101***	0.0276	0.0237	0.0009	-0.0017
	(7.7659)	(5.4540)	(0.0027)	(0.0033)	(0.0179)	(0.0175)	(0.0195)	(0.0119)
Observations	459	459	11,915	11,915	4,794	4,794	10,304	10,304
R-squared	0.3499		0.0225		0.0484		0.0193	
Number of banks	97	97	2,231	2,231	1,014	1,014	1,988	1,988
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
p-value of identical levy effects for high-cap and low-cap banks	*0.2594*	*0.0019*	*0.5864*	*0.4217*	*0.1087*	*0.3687*	*0.3121*	*0.0044*

Note: The dependent variable is the standard deviation of daily stock returns in columns (1)-(2), the absolute difference between the book return to equity of the bank itself and the median book return to equity within a reference group of banks in the same region, the same size decile and the same equity-asset decile as the bank itself in colums (3)-(4); the ratio of loan charge-offs to interest income incokumns (5)-(6); and the absolute difference between the trading return of the bank itself and the median trading return within a reference group of banks in the same region, the same size decile and the same equity-asset decile as the bank itself in colums (7)-(8); levy is a dummy variable at the country-year level taking the value one when there is a bank levy in place; marginal levy rate is an estimate at the bank-year level of the levy saving created by subsituting one unit of debt with one unit of equity; low capital is a dummy variable indicating that the bank's capital ratio was below the median in 2008; high capital is a dummy variable indicating that the bank's capital ratio was above the median in 2008; log assets is the log of total assets; log assets squared is the log of assets squared; profitability is the ratio of pre-tax profits to assets; inflation is the rate of inflation at the country-year level; gdp growth is the rate of GDP growth at the country-year level; corporate tax rate is the corporate tax rate at the country-year level.