Taxation and Regulation of Banks to Manage Systemic Risk

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Abstract

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5 November 2012

Abstract

As a form of negative externality, a natural economic response to systemic risk is to look to taxation to correct it. However, we argue in this paper that the problem of systemic risk is not a standard externality problem. First, a 'polluter pays' approach is inapplicable because the polluter is insolvent in a systemic crisis and so cannot pay. Second, we show an equivalence between taxation and regulation under a set of strict assumptions: the same economic outcome arises if banks maintain higher capital ratios or prepay into a central fund that is used to bail them out in the case of a crisis. Third, we show that any levy that is not solely in the form of pure capital is a double-edged sword. The imposition of a levy increases the per-loan funding requirement of banks and potentially the total amount of debt in the system. The levy may thereby perversely exacerbate potential systemic crises unless paid in capital, in which case it returns full circle to capital regulation.

1 Introduction

The systemic costs of bank failures are typically addressed by capital regulation rather than taxation. This contrasts with other externalities, where taxation is generally viewed as the least distortionary intervention. In the wake of the financial crisis, there has been extensive discussion about taxation to address systemic externalities in banking. This paper argues that these proposals may have shortcomings and that the conventional preference for capital regulation over taxation has a sound underlying rationale.

The first reason for this is that approaches to externalities involving the principle that 'polluters should pay' are imperfectly applicable to bank failures. At first sight, the effect of a bank failure on systemic instability appears to bear a close resemblance to that of a polluting firm on the environment. If banks' actions involve socially excessive risk-taking, they place the larger economy in jeopardy. A natural suggestion is to tax the marginal contribution of a bank's risk taking to systemic instability so that banks internalise the costs they impose on the larger economy. But if

* Coulter: Saïd Business School, University of Oxford; Mayer: Saïd Business School, University of Oxford, CEPR and ECGI; Vickers: All Souls College, University of Oxford. Paper prepared for the CESifo Summer Institute on Taxation of the Financial Sector. For helpful comments and discussion, we thank, without implication, Viral Acharya, Charles Calomiris, Michael Devereux and Matthew Richardson. All errors are our own.

this Pigovian tax is imposed after the bank has 'polluted' the system and become insolvent, it is uncollectible. The polluter in banking is not in a position to pay ex post.

Taxes can therefore only be levied ex ante, pre-crisis. The tax is then a levy requiring banks to pay for the costs to others when their failures have to be resolved. Equity capital requirements are also a kind of pre-payment, requiring banks to post a minimum amount of equity funds. We show that, under certain conditions, there is an economic equivalence between ex ante levies ('taxation') and requirements that banks hold capital themselves ('regulation').

Three key assumptions are required for our equivalence results. First, losses are perfectly correlated across banks such that the risks are systemic not idiosyncratic in nature. If this assumption is violated, then the central pooling of capital by the government may have an insurance benefit over the private holding of capital by individual banks. But insofar as risks are idiosyncratic rather than systemic in nature, they can be insured through private markets rather than public insurance. The theoretical advantage of taxation in pooling capital therefore occurs when, from a social perspective, it is not needed. There is little pooling advantage in relation to systemic risks, which are our focus.

The second assumption is that the returns on funds must be independent of who owns or manages them. Thus, funds invested by governments are as productively employed as those run by private investors. Relaxing this assumption, self-insurance is beneficial to the extent that funds are more productively employed privately than publicly because, for example, moral hazard problems arise when banks' investment choices are insured by a pool of collectively held capital. Capital requirements on banks can in this regard be likened to deductibles on insurance contracts, limiting the moral hazard problems to which insured persons are otherwise prone.

The third assumption for the equivalence result is that there are no flows to or from the government – so no bail-outs beyond collected levies and full reimbursement to equity-holders of any levy funds not used in bailouts. In reality, contrary to this assumption, governments tend to get drawn into large-scale bail-outs, the anticipation of which can distort ex ante risk-taking incentives. Taxation to fund future bail-outs, and moreover the externalities associated with them, is however a double-edged sword. For unless levied in pure capital – which would be akin to capital regulation – the taxation increases debt funding needed per loan, which could exacerbate rather than diminish potential externality problems.

These findings suggest that taxation per se has limitations as an instrument to address systemic externalities, and that bank capital is of prime importance. This is not to reject the logic of Pigovian taxation. Rather, it is to say that, in view of the special features of systemic externalities arising from bank failures, capital needs to be central to the policy approach.

The rest of the paper is organised as follows. Section 2 has a short review of the literature on bank taxation and regulation. Section 3 discusses limitations of the pollution analogy, in particular the 'polluter cannot pay' problem in the presence of bank failures. Section 4 is the central section of the paper. It sets out a simple model and uses it to show the economic equivalence between capital regulation and taxation under the conditions outlined above. The implications of relaxing those assumptions is then considered. Section 5 analyses (constrained) optimal taxation in the presence of anticipated bail-outs and shows the double-edged nature of taxation that is not in the form of pure capital. Section 6 concludes by discussing some implications, and possible extensions, of the

analysis in the context of current policy debates on bank regulation.

2 Literature Review

A seminal paper in the general 'taxation versus regulation' debate is Weitzman (1974), which compares price (i.e. tax) and quantity (e.g. quota) approaches to externality control when there is uncertainty about the curvature of the marginal cost and marginal benefit curves. In the present paper, which is focused on systemic externalities associated with bank failure, we explore a quite different aspect of the 'taxation versus regulation' question. The kind of regulation at issue is not quantity control but requirements on the funding pattern of producers, in particular the minimum proportion of bank funding that is required to be equity. The review of related literature in this section starts with taxation, and then proceeds to regulation.

2.1 Taxation

The recent academic literature has proposed a number of different tax regimes. We classify these regimes into two different types: revenue-focused taxation and corrective taxation. Of course, the various tax regimes all fall somewhere on a continuum between these two extremes. However, for illustrative purposes, we attempt to classify each proposal as one of these two.

First, we discuss revenue-focused taxation. The argument for revenue-focused taxation is that governments periodically need to invest large sums of money into the financial system. Taxation, it is argued, can make the financial system bear this cost. We describe the four most popular types of revenue-focused taxation regimes; for a further account see Keen (2011).

First, a Financial Activities Tax (FAT) is levied on the profit or rent generated by the bank. The FAT is designed to be as nondistortionary as possible in generating revenues. Shaviro (2012) describes one possible variant as a tax on all 'supra-normal' profits and wages; alternate versions tax all profits and wages and thereby serve as a surrogate VAT.

Second, a Financial Services Contribution (epitomised by the US Financial Crisis Responsibility Fee) taxes all outstanding bank debt. This tax has been recommended for both retributive purposes, and also as a 'neutralization' of the implicit subsidy given to bank borrowing by the Too Big To Fail guarantee.

Third, a Financial Transactions Tax (FTT) is levied on the notional value of all executed financial transactions. This tax is generally accepted to be distortionary, but its proponents suggest that the primary distortion will be a reduction in socially wasteful high-frequency trading.

Fourth, bank employee bonuses may be subject to taxation. Temporary taxes of this type were instituted in the United Kingdom and France, and a permanent 10% tax on bonuses exists in Italy. The primary justification for bonus taxes is retributive.[1] Thanassoulis (2012) considers possible implications from intervening in bonus pay structures; however, he concludes that bonus taxation

[1] The justification for the imposition of the temporary taxes in the UK and France was partially macroprudential: it was argued that taxes on bonuses would incentivise firm managers to keep capital within the firm instead of distributing it to employees. This would be unlikely to apply for a permanent tax, though.

will have minimal macroprudential implications.[2]

While these proposed taxes all have some corrective impact, their central focus is on the generation of tax revenue. Next, we focus our attention on corrective taxation: taxation that aims to change the behaviour of banks with a view to reducing systemic risks. We cover four main interventions: statistical default risk taxes, liquidity-based taxes, market-based taxes, and debt-bias related action.

In one example of a statistical default rate tax, Acharya et al. (2010) propose a tax levied in proportion to the calculated default risk of a bank. This tax would encourage banks to reduce their probability of default. Acharya et al. (2010) suggest calculating the probability of default through a combination of historic data and current balance sheet information. The authors create a measure of Systemic Expected Shortfall (SES): the expected loss of a firm conditional on a left-tail event for the market for the whole. They report that SES had predictive power for the systemic problems caused by institutions' defaults in the most recent crisis, and suggest that it would in the future as well. A qualitatively similar proposal, CoVaR, is made by Adrian and Brunnermeier (2011).

Statistical default risk taxes have an advantage over other taxes in that they explicitly take account of systemic effects of default. This approach is thus directly corrective, whereas most other interventions are corrective only indirectly through considering firms' individual actions and default risks. The major disadvantage with these approaches, however, is the difficulty in calculating the tax base. While calculations of SES and CoVaR are theoretically possible, it is unclear that they are sufficiently well-defined (and sufficiently current) to be used as a tax base.[3]

One proposed alternative to the complexity of statistical default risk taxes is the imposition of taxes that vary with a market parameter. Proponents of market-based taxes argue that the market can combine available information more efficiently and more accurately than any static calculation algorithm. In one of the most cited examples, Hart and Zingales (2009) recommend taxing banks in proportion to the price of their credit default swap contracts (CDS). As a bank's risk increases, its CDS spread rises as well, placing a tax burden on the bank. Anticipating this, the authors argue, banks will have incentives to reduce the riskiness of their portfolios. Kocherlakota (2010) presents a similar proposal which accounts for the size of a default, but necessitates the creation of a new traded security. A major concern with market-based default risk taxes is the potential for market manipulation by third parties and by the banks themselves.

Liquidity taxes, a third proposal, are perhaps less susceptible to manipulation. Bank's reliance on short-term funding exposes them to damaging runs. By shifting the funding structure of banks to decrease reliance on short-term funding, liquidity taxes aim to minimise possible contagion risk.

The "liquidity risk charges" recommended in Perotti and Suarez (2009) have received particular attention. Their idea is that "a unit of short term funding should be taxed in proportion to its marginal contribution to a bank's contribution to systemic vulnerability." Perotti and Suarez propose

[2] Thanassoulis (2012) suggests that regulation of bonus *structure* may have macroprudential implications, but taxation by itself cannot.

[3] Statistical default rate taxes generally have the property that a firm's tax payable is impacted by the actions of other firms in the industry. If other firms take greater risks, then the systemic expected shortfall for a third-party firm likely increases, resulting in an increase in taxes payable for the firm. Economically, this is not problematic. Politically, though, it may not be tenable.

a tax that is levied with high frequency (weekly or monthly) on the outstanding debt of a bank, multiplied by a factor representing the average time-to-maturity (and thereby refinancing risk) of the debt. The closer a bank-issued debt instrument is to maturity, the greater will be the bank's tax burden. This tax would impose an additional cost on banks for short-term financing and encourage them to utilise funding subject to less re-financing risk.

A similar proposal is raised by Shin (2010). In his paper, Shin argues that the use of non-core liabilities (generally any financing that is not equity or deposits) spikes during booms because risk is under-priced. A tax on the use of these non-core liabilities would then serve as a counter-cyclical intervention. Additionally, the tax would encourage banks to internalise the possible spillover effects of their risk-taking insofar as this is generally financed through non-core liabilities.

Liquidity taxes may also have the advantage that cross-country coordination is not as critically important as it is with certain other taxes (an FTT, for example). However, there are definitional issues that plague the liquidity taxes. It is unclear how to define 'non-core liabilities', and unclear what constitutes 'short-term debt'. Liquidity taxes may also be vulnerable to circumvention by off-balance-sheet financing. Still, liquidity risk taxation, possibly for its ease of implementation, is one of the leading corrective taxes being considered by many countries.

A final set of proposed interventions focuses on the well-known bias caused by the asymmetric tax treatment of debt and equity. In general, even taking into account personal tax rates on interest, dividends, and capital gains, there is a tax incentive for banks to finance themselves with debt. This debt bias leads to significant amounts of leverage in the financial system. While it is generally agreed that debt bias was not itself responsible for the most recent crisis, it probably contributed to it (e.g. Keen, 2011, de Mooij and Keen, 2012). The simplest way to remove the debt bias would be to eliminate the tax deductibility of interest payments. But this might be politically untenable (see Devereux, 2011).

The primary alternative is an Allowance for Corporate Equity (ACE). In its simplest form, this allows companies to deduct an amount equal to the outstanding value of their corporate equity multiplied by the risk-free rate from their tax payable, thereby providing an off-setting benefit to the issuance of equity. So instead of making neither debt nor equity tax-deductible, an ACE instead makes them both tax-deductible, at an obvious cost to public finances. A major difficulty in analyzing the ACE, moreover, is that scant data exist of such systems in practice. Keen and King (2002) outline the Croatian ACE system, but given the data quality problems, they are unable to draw firm conclusions. Indeed, the Croatian ACE is no longer in existence. Klemm (2007) provides another overview of ACE data, focusing largely on Brazil. Its ACE, however, makes the payment of dividends tax deductible, rather than equity itself, adding an additional distortion. With this, Klemm finds only very weak data that the ACE achieved its desired goal of reducing corporate leverage. Therefore, while the ACE has a theoretical justification, it imposes a tax burden on a country for an unproven systemic benefit.

Next, we overview the major types of proposed regulation.

2.2 Regulation

One of the most popular regulatory interventions requires that banks maintain a minimum proportion of equity financing. These equity capital requirements are often a function of the riskiness of the assets of the bank, as with the Basel system of risk-weighted assets (RWAs). As described in Admati et al. (2010), the mechanism through which equity capital requirements improve the stability of the financial system is straightforward. The greater the proportion of equity in a bank's funding, the greater the losses that it can withstand before becoming insolvent. Prior to the crisis, many banks had greater than fifty times leverage.[4] At this leverage, losses of even 2% would cause insolvency. With more equity, larger shocks can be safely weathered. Also, by increasing the 'skin in the game' of bank owners, equity capital requirements may mitigate moral hazard problems.

The role of equity capital requirements is supported by the results of Black et al. (1978). They consider the relationship between banks and governments as analogous to that between a debtor and creditor. Governments implicitly guarantee banks' debt for reasons of systemic stability, and are therefore analogous to final (albeit contingent) creditors. Black et al. (1978) argue that the optimal form of bank regulation should therefore mirror that which is seen in the private market between freely contracting creditors and debtors. The imposition of an equity capital requirement is analogous to mortgage lender requirements that homeowners maintain a certain level of equity in their homes. Risk-weighted equity follows in the same way: required equity is greatest for the riskiest borrowers.

A second form of explicitly macroprudential regulation is proposed by Morris and Shin (2008). The authors' liquidity regulation forces banks to maintain certain levels of liquidity, to ensure that they are able to meet short-term demands for cash.[5] Morris and Shin (2008) argue that liquidity requirements reduce the likelihood of bank fire sales, because banks are more likely to have liquid assets on hand with which to settle short-term debts. As fire sales impose a negative externality on other market participants by driving down asset prices, this supports the solvency of all banks in the financial system. The authors also argue, however, that liquidity ratios must account for the systemic nature of certain instruments. The problem to which they draw attention is that of a struggling bank which cuts loans to other banks to meet its own liquidity requirement. By cutting loans to other banks, a bank may strengthen its own liquidity situation at the cost of depleting the liquidity of the entire system. Therefore, Morris and Shin (2008) argue for liquidity requirements that provide systemic stability both through encouraging banks to maintain sufficient liquidity on-hand, and also by discouraging the payment of debts through the withdrawal of systemically important loans to other banks.

A third set of recommendations to improve the stability of the financial system focuses on bank competition. Keeley (1990) argued that bank charter values may serve as an undiversifiable asset that is valuable conditional on the continued solvency of the bank. High bank charter values may then encourage more banks to act prudently, to safeguard their future value. Restrictions on bank

[4] Simon Nixon, 'G-20 Protesters are Aiming at Wrong Target,' *Wall Street Journal*, 2 April 2009.

[5] Liquidity regulation also satisfies the desired analogy between regulation and privately contracting creditors-debtors. Just as bank loan covenants require debtors to meet certain short-term solvency ratios, liquidity regulation forces banks to maintain a minimum proportion of liquid assets.

competition, the argument goes, could achieve these high charter values, and could theoretically improve financial sector stability. Actual equity has a significant advantage over the intangible equity of charter value, however, in that only the former is loss-absorbent. Also, the possible benefit of high charter value may be offset by a different impact of competition. Boyd and De Nicolò (2005) argue that an uncompetitive banking sector leads to higher interest rates being charged. Higher interest rates attract riskier borrowers in a process they describe as "risk shifting", such that a less competitive banking sector may be less stable. These results are combined in Martinez-Miera and Repullo (2010), who argue that there is not a monotonic relationship between bank competition and bank stability. As the relationship between competition and financial sector stability is mixed, there is no good case for competition-lessening regulatory interventions. Furthermore, bank competition may already be artificially low because untreated too-big-to-fail problems distort competition in favour of large and complex institutions at the expense of others.

Many reform recommendations integrate a number of these possible interventions. The Squam Lake Report, for example, combines aspects of bank equity capital requirements, centralization of regulation, improved resolution processes, and many others (French et al., 2010).

3 Polluter Cannot Pay

Banks that take on undue risk impose a probabilistic negative externality on the wider economy. Parallels are often drawn between this negative externality and the problem of pollution control. This suggests that banks' risk-taking should be controlled in the same way as the actions of potentially polluting companies: for example, through Pigovian taxation. As stated succinctly by Kocherlakota (2010), "just as taxes are imposed to deal with pollution externalities, taxes can also address risk externalities", and "a well-designed tax system can entirely eliminate the risk externality generated by inevitable government bailouts".

While pollution may be a useful analogy for thinking about banks' contributions to systemic risk, there are several critical differences. One, not considered in this paper, is the problem of apportioning responsibility among multiple banks for bad systemic outcomes and measuring their respective contributions to it. The same issue could arise if, say, several chemical plants were on the same polluted river, but it is much more complex in the financial context.

In this paper, we focus on the difference in the ex post solvency of 'polluters'. Whereas in standard settings companies generally remain solvent after polluting, this is not true of banks in crisis. Banks that generate systemic risk become insolvent in the process: insolvency is the mechanism by which the 'pollution' occurs. It follows that forms of taxation or regulation in which the 'polluter pays' after the event do not work. Banks responsible for causing a crisis are unable to pay any taxes imposed ex post.

We can illustrate the problem of the ex post imposition of taxation. Suppose a bank can invest in an asset costing 100 that either yields 150 or 0 with equal probability, or a riskless asset also costing 100 that will be worth 100. It can finance its investment from deposits and equity. Suppose that there is a state-run scheme that guarantees depositors the full value of their deposits in the event of bank failure in recognition of the positive social value associated with each unit of deposits.

There is no interest rate and the bank's shareholders and depositors are risk neutral. Assume that individuals benefit from the option to invest in informationally-insensitive assets: deposits. Then, it is socially optimal for the bank to invest in the riskless assets funded from as high a proportion of bank deposits as possible.

Contrast two sequences. In sequence one, in period 1 the government announces a capital requirement and the bank selects its form of financing. In period 2, it makes the investment choice and in period 3 the investment outcome is realised and the deposit insurance is paid if required. In sequence two, in period 1 the government announces a tax rate and the bank selects its form of financing, in period 2 the bank makes its investment choice and in period 3 the investment outcome is realised, the deposit insurance is paid if required and the bank pays any tax due, if it can.

Sequence 1. The social optimum is achieved by the government setting a minimum capital requirement of 50% in which case the bank will earn the expected return of 0% on its equity capital.[6]

Sequence 2. The government sets a tax rate of just in excess of 50% on the holding of deposits, in which case the bank chooses the riskless asset funded from all equity and earns a zero return.

If the government sets a tax rate below 50% in sequence 2 then the bank chooses the risky asset funded entirely from deposits, earns an expected return of zero (on the essentially zero equity investment) and the government expects to earn 25 less in tax revenue than it pays in insurance to depositors.[7] The reason that sequence 2 cannot achieve the social optimum with taxation is that there is a moral hazard problem regarding the bank's choice of investment because the tax on deposits can only be paid when the bank is solvent, which encourages the bank inefficiently to select risky investments in preference to riskless ones.

It is possible, in theory, to design a Pigovian tax that takes into account the likelihood with which a given bank is insolvent at the time of payment. However, banks are able to select their own assets, and thus to control the risks to which they are exposed. Thus, any ex ante imposition of tax would encourage banks to take on greater risks than if the tax could be collected ex post. Therefore, the 'polluter cannot pay' problem generates significant problems for the imposition of an ex post levy on banks. 'Polluter pre-pays' approaches will be considered shortly.

There is a further respect in which the pollution analogy is imperfect. In a standard pollution context, the imposition of taxation does not directly impact pollution production. Pollution is impacted indirectly, as taxation encourages firms to change their behaviour. In a banking context, however, government imposition of taxes may also directly impact systemic risk, by changing the funding requirements of banks. This direct impact on 'pollution' is absent from standard pollution analyses, but will feature prominently in the analysis that follows.

[6] At 50% leverage, the expected equity return on the risky investment is 0.5 (150 – 50) which equals the equity capital invested of 50. The risky investment therefore yields the same expected return of zero as the riskless investment.

[7] As the tax rate on deposits approaches 50%, the expected equity return on the risky investment falls to zero [0.5 (150 – (100 x 1.5))] on the optimal level of leverage of 100%. The government's expected revenue is 0.5 x 100 x 0.5 = 25 and its expected payment to depositors is 0.5 x 100 = 50, the net subsidy of 25 compensating for the expected loss of 25 on the risky investment. Above a tax rate of 50%, the riskless investment yields a higher return of 0% at the optimal level of leverage of 0%.

4 A Simple Model of Bank Taxation and Regulation

We now set out a simple model and use it first to show an equivalence between two different types of 'polluter pre-pays' policies: capital regulation and an up-front levy paid into a government-run crisis fund.

4.1 The Model

Consider an economy with a continuum of banks and a continuum of borrowers. Every borrower has access to a project which requires a unit bank loan to proceed. Projects of type R pay $(1+R)$ with probability p or else zero. The random variable $p \sim F(p)$ on $[p_L, 1]$, where $0 < p_L < 1$, is uncorrelated with R. So p measures the degree of systemic shock, if any. Let $X(R)$ be the number of projects of type R or better. A borrower pays its bank $(1+r)$ if and only if its project succeeds, so the number of projects financed is $X(r)$. Fraction k of each loan is financed by equity, and fraction $(1-k)$ is financed by debt. The risk-free rate is zero and all agents are risk-neutral. There is perfect competition. Each bank finances many projects, so the law of large numbers applies. Bondholders receive gross return $(1+b)$ if their bank is solvent, and receive the value of bank assets under bank insolvency. In the absence of any crisis fund (see later), there is a negative externality of γ times the extent of uncovered losses – i.e. losses not absorbed by k or (if such exists) by the crisis fund.[8]

Banks are always solvent if

$$(1+b)(1-k) \leq (1+r)p_L \,. \tag{1}$$

Solvency is maintained in (1) because even in the worst state bondholders get repaid in full. When solvency is guaranteed, in equilibrium, $b = 0$. Bondholders are not promised any excess repayment, because they do not accept any risk. Then the rate charged to borrowers, r, must be such that the gross return to equity is unity:

$$(1+r)\bar{p} = 1 \,, \tag{2}$$

where $\bar{p} \equiv E[p]$. So from (1) and (2) there is an always-solvent equilibrium if

$$k \geq 1 - \frac{p_L}{\bar{p}} \,. \tag{3}$$

When (3) is satisfied, banks hold sufficient capital such that bondholders are completely insulated from losses. The first best is achieved in this case: the optimal r is given by (2) and negative externalities never arise.

In a Modigliani-Miller (MM) world, this outcome could be achieved. Banks would be indifferent to their financial structure, so would not object to structures meeting (3). But MM does not hold. First, if there is any tax and/or subsidy advantage to debt over equity, no matter how small, banks would want to minimise k. In fact tax systems do favour debt over equity, and moreover debt has a subsidy advantage over equity unless the probability of bail-out is precisely zero (as is assumed for equity). Second, if debt providers cannot (or do not have an incentive to) observe a bank's choice of

[8] Ideally, the negative externality, γ, would be non-linear, representing the greater proportionate cost of a major banking crisis. We use the simpler formulation for analytic tractability.

k, then the bank would deviate from a candidate equilibrium in which (3) holds. If a bank deviated by funding itself with less capital than (3), so that default was possible, the expected return to each unit of debt would fall below one. But the overall (private) return would not decrease, so the expected return to equity would exceed one, making the deviation worthwhile for the holders of equity in these circumstances. Third, if we start from a situation where (3) does not hold, increasing k lowers the probability of default so confers a positive externality on bondholders, for which equity holders effectively pay. This is the debt overhang problem.

For several reasons, then, we now consider the (much more common) situation in which (3) does not hold: banks maintain insufficient capital to shield bondholders from losses. Assume then that (1) does not hold and define $P(k) > p_L$ as the p such that with equity ratio k there is insolvency if and only if $p < P(k)$. The function $P(k)$ is defined implicitly by

$$(1+b)(1-k) = (1+r)P(k) \ . \tag{4}$$

Assume (for now) that there are no transfers to or from government in any circumstances. Then overall, investors (i.e. bank bondholders plus equity holders) must get back unity on average per unit loan so (2) continues to hold. Therefore $P(k)$ and b are related by

$$P(k) = (1+b)(1-k)\bar{p} \ . \tag{5}$$

Bondholders get back $(1-k)(1+b)$ per unit loan if $p \geq P(k)$. That is, so long as the bank is solvent, bondholders receive their promised amount. Otherwise, using (4), bondholders get

$$(1+r)p = \frac{p}{\bar{p}} = (1-k)(1+b)\frac{p}{P}$$

in state p. On average, because of risk neutrality, bondholders get back unity per unit of debt. Therefore

$$\begin{aligned} 1 &= (1+b) - \frac{1}{(1-k)\bar{p}} \int_{p_L}^{P} (P-p) dF(p) \\ &= (1+b) - \frac{1}{(1-k)\bar{p}} \int_{p_L}^{P(k)} F(p) dp \, . \end{aligned} \tag{6}$$

For convenience define

$$\phi(P) \equiv \int_{p_L}^{P} F(p) dp \ . \tag{7}$$

So $\phi(P)$ is a strictly increasing function with $\phi(p_L) = 0$ and $\phi(1) = 1 - \bar{p}$. From (6) we have

$$(1-k)b = \frac{\phi(P(k))}{\bar{p}} \ . \tag{8}$$

Combining with (5) it follows that

$$(1-k)\bar{p} = P(k) - \phi(P(k)) \ , \tag{9}$$

so, in turn,

$$\begin{aligned} k\bar{p} &= \int_{P(k)}^{1} [p - P(k)]dF(p) \\ &= \int_{P(k)}^{1} [1 - F(p)]dp \ . \end{aligned} \tag{10}$$

This implicitly defines P in terms of k. The greater the fraction of equity, k, the less likely insolvency becomes, so the lower is P.

The expected negative externality per-project $z(k)$ with capital k is taken to be γ times the expected loss not absorbed by capital – i.e. the loss in insolvency. In the absence of bail-outs this expected loss is the difference between the contracted payment to bondholders, $(1-k)(1+b)$, and what they receive on average, i.e. $(1-k)$. So using (8),

$$\begin{aligned} z(k) &= \gamma b(1-k) \\ &= \gamma \frac{\phi(P(k))}{\bar{p}} \ . \end{aligned} \tag{11}$$

Then, from (10)

$$z'(k) = \frac{\gamma F(P(k))}{1 - F(P(k))} \ .$$

Given externality $z(k)$, there is in a sense 'too much lending'. The bank does not internalise the negative externality created by the issuance of loans, because the losses conditional on default fall on the bondholders. We discuss below that while tax can partially internalise the externality, it does not address the underlying problem of insufficient loss-absorbency.

4.2 Neutrality Result

The obvious policy to adopt in this setting is to require sufficient k to meet (3). Suppose however that such a requirement is impossible to achieve, perhaps for political reasons, and that for exogenous reasons k is insufficient to meet (3). In theoretical terms this is an unsatisfactory assumption, but given the manifest difficulties of raising banks' capital ratios it leads to important and practically relevant questions for (second-best) policy analysis.

The aim of this subsection is to compare capital ratio regulation with 'taxation' in the form of a levy to create a crisis fund. In particular, suppose that banks must pre-pay an amount s per unit bond, so $(1-k)s$ per unit loan, into a crisis fund. A number of questions then arise. On what basis is s calculated? When and how is the fund disbursed? Who owns it if, or to the extent that, it is not disbursed? How is it invested in the meantime? Assume first that any payouts from the fund go to bondholders and that its residual value (all of it if no payouts) is returned to equity owners. Suppose that the fund is invested in the risk-free asset. Then (2) still holds, so r is as in the previous analysis.

The fund is then equivalent to a higher k. To see this, compare the situation with capital k and

no crisis fund with that with capital $k_0 < k$ and a crisis fund as above with

$$s = \frac{k - k_0}{1 - k_0} \,. \tag{12}$$

(In the special case $k_0 = 0$, we have $s = k$.) Shareholders have to pay $(1 - k_0)s = (k - k_0)$ per unit loan into the crisis fund in addition to their capital of k_0 per unit loan, making k in total. Let b_0 be the return on bonds in this situation. Bondholders receive less than $(1 + b_0)$ only if

$$\begin{aligned} p &< (1 + b_0 - s)(1 - k_0)\bar{p} \\ &= [(1 + b_0)(1 - k_0) - (k - k_0)]\bar{p} \\ &\equiv P_0 \ , \end{aligned} \tag{13}$$

say. Since bondholders get unity on average per unit of debt, we have that

$$\begin{aligned} 1 &= (1 + b_0) - \frac{1 + r}{1 - k_0} \int_{p_L}^{P_0} (P_0 - p) dF(p) \\ &= (1 + b_0) - \frac{\phi(P_0)}{(1 - k_0)\bar{p}} \ . \end{aligned}$$

Rearranging the above equation yields

$$(1 - k_0)b_0 = \frac{\phi(P_0)}{\bar{p}} \ . \tag{14}$$

With (13), this gives

$$P_0 = (1 - k)\bar{p} + \phi(P_0) \ .$$

It is now apparent from (9) that

$$P_0 = P(k) \ ,$$

and moreover, that

$$(1 - k_0)b_0 = (1 - k)b \ . \tag{15}$$

From (11), the externality is also the same in the two situations. Hence we have a neutrality result: capital ratio k with no crisis fund achieves the same economic outcome as capital ratio k_0 and levy s set as in (12).

4.3 Imperfect Correlation

Our neutrality result between taxation and capital ratio regulation is based on three key assumptions:

1. Banks face perfectly correlated risks of failure (there are no idiosyncratic failures),
2. Return on levy funds is independent of who owns or manages them,
3. No flows to or from government (neither taxes and nor subsidies).

We now consider deviation from the first assumption, and examine the implications of imperfect correlation in risks among banks. To do this sharply, we consider the extreme situation of bank-specific, but not aggregate, uncertainty in returns. If bank losses are not perfectly correlated, there is a risk-pooling benefit to holding capital centrally. Any capital held by an individual bank that does not default is effectively 'wasted' if others default. This capital could have been more useful if held centrally, and allocated to failing banks.

Consider an economy as above, but with $p_i \sim F(p_i)$ the proportion bank i's loans that succeed. Therefore there is bank-specific but not aggregate uncertainty: the economy-wide proportion of projects that succeed is always $\bar{p}$. So this variant is a model of idiosyncratic but not systemic risk. In this situation, a pre-paid crisis fund of

$$\kappa = (1+r)\phi(\bar{p}) = \frac{\phi(\bar{p})}{\bar{p}} \tag{16}$$

per loan is sufficient to ensure no defaults. The banks with $(1+r)p < 1$, i.e. with $p < \bar{p}$, would receive funds. Their shortfall in total is κ. Note that

$$\kappa = \frac{\phi(\bar{p})}{\bar{p}} < \frac{1}{\bar{p}}(\bar{p} - p_L)F(\bar{p}) < 1 - \frac{p_L}{\bar{p}},$$

the last term of which is the capital ratio such that no bank had a shortfall. So it is evident that with uncorrelated returns across banks, a central fund can avert any shortfalls with less capital than with decentralised capital held in each bank. This is simply the insurance benefit – if capital is costly – of pooling capital. However, it raises a number of issues. First, if (as in the model) capital is not socially costly, there is no benefit. Second, an appropriately designed market mechanism might be able to achieve the same result. Third, who would operate the fund, and how? Finally, serious moral hazard problems could result from a crisis fund, whereas decentralised capital ownership has shareholders (more) on the hook for their bank's decisions. A crisis fund results in socialised bank losses, yet private bank gains: this encourage banks to take on undue risk.

In any event, the major concern in financial regulation is that of systemic risk: the concern that banks sustain heavy losses simultaneously. The benefits of risk-pooling are least in that case, but it is when the crisis fund is needed most. Because systemic risk is the main subject of this paper, we now return to the case of perfectly correlated returns across banks.

5 Taxes and Implicit Subsidies

We now relax another of the assumptions upon which the neutrality result depended – that of no flows to or from government. This enables us jointly to consider taxation and anticipated bail-outs. Suppose that there is a tax $t \geq 0$ per unit loan that is pre-paid by banks, and that the government bears fraction $\lambda \geq 0$ of losses in insolvency. (Suppose that taxes and bail-out subsidies are transfers to and from the exchequer, and that there is no specific crisis fund.) Each loan now requires $(1+t)$ of funding, and, consistent with before, we let k denote the proportion that is capital.

It remains true that there is never insolvency if

$$1 - k \leq \frac{p_L}{\bar{p}} \ .$$

This is because bondholders, who supply $(1-k)(1+t)$ of funding per loan, can be repaid in full even in the worst state, when the gross return is $(1+r)p_L = (1+t)p_L/\bar{p}$. We assume however that there is insufficient capital to rule out insolvency, so bail-outs might happen. Then the critical P below which there is insolvency is given by

$$(1+b)(1-k)(1+t) = (1+r)P \ . \tag{17}$$

The return to bondholders satisfies

$$(1-k)(1+t)b = (1+r)(1-\lambda)\phi(P) \ .$$

With (17) this gives

$$(1-k)(1+t) = (1+r)[P - (1-\lambda)\phi(P)] \ . \tag{18}$$

Since the overall expected return to the private sector equals unity in equilibrium it must be that

$$1 + t = (1+r)[\bar{p} + \lambda\phi(P)] \ . \tag{19}$$

The implicit subsidy is measured by $(1+r)\lambda\phi(P)$. Combining (18) and (19) we get

$$1 - k = \frac{P - (1-\lambda)\phi(P)}{\bar{p} + \lambda\phi(P)} \ . \tag{20}$$

As P increases from p_L to 1, the RHS of (20) increases monotonically from $p_L/\bar{p}$ to 1, so there is a unique P that satisfies (20) given k and λ. The RHS is also increasing in λ, so P is decreasing in λ as well as k. But P is independent of t, which just scales things up. Expected losses from insolvency per unit loan are

$$(1+r)\phi(P) = \frac{1+t}{\lambda + \bar{p}/\phi(P)} \ , \tag{21}$$

which is decreasing in k and in λ, and increasing in t. The implicit subsidy is naturally increasing in λ.

The special case of neutral tax-and-subsidy has

$$t = \frac{\lambda\phi(P)}{\bar{p}} \ ,$$

for then

$$t = (1+r)\lambda\phi(P)$$

and $1 + r = 1/\bar{p}$ as in the previous analysis. The expected insolvency loss per unit loan is then $\phi(P)/\bar{p}$.

What is the optimal tax rate t given k and λ? To answer this it is useful to allow for the possibility that there is a social value of public funds in addition to the externality cost of losses not absorbed by capital. The γ parameter above related to the latter. Separately from that, let the social value of public funds be $1+\beta$, so taxes/bail-outs have welfare benefit/cost $\beta \geq 0$ per unit. A reason for $\beta > 0$ is that taxation distorts economic incentives, so bail-outs are costly to the economy – rather than being welfare-neutral transfers – because they increase the taxes needed to restore the public finances to the condition they would be in without the bail-outs.

Expected welfare can be written as

$$\begin{aligned} W &= \bar{p}\int_r^{R_{\max}} (1+R)[-X'(R)]dR - [1+(\beta\lambda+\gamma)(1+r)\phi(P)-\beta t]X(r) \\ &= \bar{p}\int_r^{R_{\max}} (1+R)[-X'(R)]dR - [1+\beta(1-(1+r)\bar{p})+\gamma(1+r)\phi(P)]X(r)\ , \end{aligned} \tag{22}$$

using (19). From (21) it is apparent that choosing optimal t is equivalent to choosing r to maximise (22). Optimal r satisfies

$$\frac{(1+r)\bar{p}-1}{(1+r)\bar{p}} = \frac{\beta}{1+\beta}\frac{1}{\eta(r)} + \frac{\gamma}{1+\beta}\frac{\phi(P)}{\bar{p}}(1-\frac{1}{\eta})\ , \tag{23}$$

where

$$\eta(r) \equiv -\frac{(1+r)X'(r)}{X(r)}$$

is the elasticity of demand for loans. This is a sort of Ramsey equation. On the LHS is a price/cost mark-up because $(1+r)\bar{p}$ is the effective 'price' per loan and 1 is its cost. The first term on the RHS is an inverse elasticity formula. The second term, which captures negative externalities, is ambiguous in sign, depending on whether or not the elasticity $\eta > 1$. If $\eta > 1$, then the externality term has a positive effect on the optimal tax rate: higher t reduces the number of loans more than it increases funding per loan. But if $\eta < 1$ its effect is negative because the effect of higher t on funding per loan dominates the loan reduction effect. This is the 'double-edged' nature of taxation as an instrument to curb the negative externalities arising from systemic bank failures.

6 Conclusions

Systemic banking crises generate large negative externalities but the standard economics of pollution control do not apply. Approaches involving the principle of 'polluter pays' for damage cannot work because banks are insolvent in a crisis. That focuses attention on the ex ante properties of taxation. The normal risk-pooling benefits associated with the central holding of funds do not apply in the context of correlated systemic risks and the moral hazard problems that central holding creates argue against it. Furthermore, ex ante Pigovian taxes are a double-edged sword: for a given capital ratio, they increase the debt funding needed per loan, and so might increase the scale of negative externalities in the event of a crisis. Thus the externality is directly and undesirably as well as indirectly and desirably affected by taxation. This issue, which is absent from standard externality

settings, would not arise if taxes were levied in terms of capital alone. But, as our equivalence result illustrated, capital levies and the regulation of capital ratios have similar economic effects. The question is not therefore 'taxation versus regulation' because the two are fundamentally the same. Rather, the issue concerns the terms in which ex ante taxes are paid: unless pure capital, the double-edged aspect of taxation arises.

Most of our analysis has been based on the theoretically arbitrary but realistic assumption that required capital ratios are fixed at too low a level. The first-best solution would be to raise capital and/or loss absorbency more generally, through contingent capital (e.g. cocos) and bail-inable debt. Structural reform – as proposed in the US Dodd-Frank Act (2010), the UK Independent Commission on Banking Report (2011) and the Liikanen Report (2012) – in tandem with enhanced loss-absorbency may further reduce the prospective damage from future banking crises and improve banks' ex ante incentives.

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