SOME SIMPLE ANALYTICS OF THE TAXATION OF BANKS AS CORPORATIONS: EFFECTS ON LOANS AND SYSTEMIC RISK, DEPOSITS, AND BORROWING

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I develop a simple model of banks that includes financial regulations and systemic risk. It is utilized to examine the effects of five possible taxes (on bank loans, deposits, liabilities, equity, and profits), and I discuss extensions to consider depositor access to international capital markets and tax avoidance by multinational banks. The model emphasizes systemic risk in a bank's loan choice. An externality arises because a bank's loan decisions affect the economy-wide probability of loan success. The bank takes account of the effect of its loan decisions on itself but ignores the effects on other banks in the system.

Keywords: taxation of banks, corporate tax, financial services, financial taxes, systemic risk

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I. INTRODUCTION

Taxation of the banking sector has become an important policy issue since the financial crisis. For instance, a 2014 tax reform proposal by Congressman Camp in the United States includes a 0.035 percent quarterly excise tax on bank assets of more than $500 billion (Nunns, Eng, and Austin, 2014), the Obama Administration proposed a tax on bank liabilities (White House, 2010), and the International Monetary Fund (IMF) has proposed two distinct financial company taxes for different purposes: a Financial Stability Contribution (FSC) to cover direct fiscal costs of financial sector failure and a Financial Activities Tax (FAT) to cover wider fiscal costs and potentially reduce the size and risk-taking of the financial sector (Claessens, Keen, and Pazarbasioglu, 2010).

Avoiding taxes through financial transactions, such as deducting interest in a high-tax country while booking equity or interest income in a low-tax country, has also been a recent concern. For instance, Action 4 of the Organisation for Economic Co-operation and Development (OECD) (2017) initiative on base erosion and profit shifting (BEPS) concerns limitations on interest deductions and financial payments. For the banking sector (as opposed to nonfinancial companies), this issue is complicated by the nature of a financial company's business in which net interest is a main revenue source, as well as by a country's capital regulations, and for these reasons a general interest limitation or fixed debt-asset ratio rule was not recommended by the OECD for the banking sector in general. However, the OECD indicates that such a rule could be applied to corporate groups that include a bank by use of group computations that exclude the bank, and other targeted rules could be used in specific cases.

Despite the focus of policymakers, the effects of taxes on banks remain an under-researched area in public economics both theoretically and empirically. On the theoretical side, the literature lacks a simple model that can be used to evaluate various reforms of the taxation of the financial sector. For instance, Shackelford, Shaviro, and Slemrod (2010) discuss many of the taxes that have been proposed in the wake of the financial crisis, but do not provide a rigorous model for evaluation. Of the few existing models of taxation of banks (reviewed in the next section), a main focus is on liquidity risk, the risk associated with bank runs due to a funding source (deposits) that is more liquid than assets (loans), as first formally modeled by Diamond and Dyvbig (1983). In the United States, deposit insurance, financed with a premium paid by banks, has reduced this type of risk. Other models concentrate on the well-known moral hazard risk that arises when a bank has too little equity relative to debt. This can have two causes in the financial sector: (1) the bias towards debt in the tax system, as occurs with any corporation, and (2) the deposit insurance itself. A debt bias can create incentives for overly risky investments, but minimum capital equity ratios imposed by bank regulators in the United States and many other countries, and international standards agreed to in the Basel Accords are aimed at controlling this type of risk in the banking sector.

A particularly important risk in the financial sector that is often discussed as one of the reasons for the recent collapse of the financial system is that the banks invested in overly risky loan portfolios, particularly those related to the housing market. It therefore seems worth asking whether corporate taxes on the banking sector, either current or proposed, tend to alter the riskiness of a bank's loan portfolio, a question that I address in this paper. Moreover, I examine this in a model that incorporates a reserve requirement and a capital requirement, important regulations that any model of the taxation of banks should incorporate, as emphasized by Devereux (2014, p. 25) who states "any attempt to influence the behavior [of banks] through taxation … must take account of financial sector regulations."

The riskiness of a bank's loan portfolio, especially loans related to the housing market, is an important source of instability in the financial system. Indeed, Geanakoplos (2010) argues that a primary cause of economic cycles is the buildup of leverage in the economy — both by homeowners and firms, which has large effects on asset prices contributing to asset bubbles. Haughwout et al. (2011) find empirical support for this theory in the U.S. housing market bubble, which peaked in approximately 2006.[1] They find that investors in homes (rather than owner-occupiers) took on more leverage, contributing to higher rates of default.

Shackelford, Shaviro, and Slemrod (2010) emphasize the importance of this channel when they invoke the following quote from Acharya and Richardson (2009, p. 195), "[t]here is almost universal agreement that the fundamental cause of the [2008–2009 financial] crisis was a combination of a credit boom and a housing bubble." Banks contributed to the buildup of problems on the supply side of the loan market by making riskier, more highly leveraged loans. Slemrod (2009, p. 389) indicates that the "role of the tax system in the level and growth of financial system leverage has not to my knowledge been addressed …." Thus, investigation of the effect that taxes have on the risk of the bank's loan portfolio decision is both important and unexplored.

Externalities related to systemic risk in the banking sector have also played a prominent role in several recent papers on the taxation of banks (again, reviewed in the next section). These models discuss various approaches related to the design of a Pigouvian tax on banks to internalize such externalities as well as the merits of taxation versus regulation of banks. These models generally incorporate the riskiness of banks by assuming that banks encounter moral hazard problems when they have high levels of debt, just like any company (bank or non-bank)

[1] For data on housing prices, see the S&P/Case-Shiller U.S. National Home Price Index, https://fred.stlouisfed.org/series/CSUSHPISA.

with such characteristics, and analyze how taxes affect the debt or debt to equity margin. My model differs from these in two respects: (1) the nature of the externality and (2) the modeling of systemic risk.

The externality in my model results from the assumption that the probability of success of a loan depends on the aggregate of loans in the economy. A single bank recognizes the effect that it has on the probability of its own success but ignores the effect on other banks in the system.

With respect to systemic risk, in my model a greater volume of aggregate loans in the economy means that less qualified borrowers are being funded, increasing macroeconomic risk. To the extent that taxes affect a bank's supply of loans, the aggregate risk in the economy changes. Bank debt may also change with aggregate loans, but increased borrowing by banks on international or interbank markets resulting from a tax is not enough to infer that macroeconomic risk is higher.

As part of the normal course of doing business, a bank assesses the credit worthiness of its loan customers, and makes loans based on an expected return of the loan portfolio. Banks can diversify, and following Allen and Gale (2001), I assume each bank chooses a portfolio of perfectly correlated risks, which is equivalent to assuming that the risk of each investment can be decomposed into a common component and an idiosyncratic component.[2] With a large number of investments, the idiosyncratic component is perfectly pooled and disappears from the analysis, leaving only the common component which is taken to represent systemic or macroeconomic risks.

[2] While this assumption is made mainly for simplicity, it accords with the traditional argument that financial intermediaries should fully diversify made by, for instance, Diamond (1984) and Boyd and Prescott (1986). This argument has recently been questioned on theoretical grounds by Winton (1999) who notes that the corporate finance literature, for instance, Jensen (1986), argues that specialization allows a firm to take advantage of management expertise and reduce agency problems. An accompanying empirical literature has emerged, as exemplified by Acharya and Saunders (2006). It seems too early to generalize these findings. In practice, Stiroh (2012) notes that U.S. banks have become more diversified in the past two decades as regulatory barriers have fallen.

Each bank contributes to macroeconomic risk through its loan decisions, with the total macroeconomic risk depending on the aggregate amount of loans in the economy. Banks are assumed to be large enough to affect the overall macroeconomic probability of success of loans in the market and thus each bank has some market power over the expected return of loans. Each bank recognizes this and takes into account the effect of their actions on their own loan choice. However, each bank does not take into account the effect of its decisions on other banks, and this constitutes the externality in the model.

The basic approach to modeling banks on which I build is to appeal to the role of banks in offering services to customers, both borrowers and depositors, typified by the models of Monti (1972) and Klein (1971), as discussed in Freixas and Rochet (1999). I add to the basic model a reserve requirement, a minimum capital ratio on equity, macroeconomic risk that depends on the aggregate supply of loans, and the externality discussed earlier.

It is straightforward to analyze many types of financial taxes in this model, including the recently proposed FAT. Since the FAT is a tax on the profits plus remuneration of financial institutions, it is simply a variation of the corporate tax without deductibility for payments to labor. A Financial Transaction Tax (FTT) on the banking sector is another tax variation that could be analyzed using the model presented in this paper. There are a number of different varieties of a FTT (Burman et al., 2016; Matheson, 2011, 2012) and its effects would clearly depend on the exact features of the tax implemented. Nevertheless, the model presented provides a natural way to understand the basic effects of an FTT as it lays out financial transactions that occur on both sides of a bank's balance sheet.

I analyze five types of taxes on banks in this paper: a tax on bank loans (or assets exempting reserves), a tax on bank deposits, a tax on bank liabilities, a tax on bank equity, and a tax on bank profits (with nondeductible equity). To simplify the analysis, in all cases the return in the interbank market is taken as exogenous (determined in international capital markets) and a bank's management costs for loans and deposits are assumed to be separable.

Each tax has particular impacts on the market for loans and deposits, and consequent effects on interbank borrowing and the riskiness of a bank's loan portfolio. All of the taxes except the tax on deposits will decrease the supply of loans and the riskiness of loans in the economy. The tax on deposits does not affect either of these variables due to the assumption of separability of the management costs of deposits and loans. All of the taxes will decrease a bank's demand for deposits except the tax on loans, again due to the separability assumption. A bank's borrowing will rise with the tax on deposits, fall with the tax on loans, and will be indeterminate for the other taxes.

I then discuss extensions that consider the possibility that some depositors have access to international capital markets and the possibility that multinational banks can avoid profit taxes. Results for the former case will depend on the degree of substitutability between deposits and funds in international capital markets. An interesting result for the latter case is that tax avoidance by multinational banks tends to increase the riskiness of a bank's loan portfolio in some cases.

II. LITERATURE REVIEW

The few theoretical public finance models that examine the effect of taxation of banks focus on liquidity risk, the risk associated with bank runs due to a funding source (deposits) that is more liquid than assets (loans), first formally modeled by Diamond and Dybvig (1983). For instance, Caminal (2003) develops a model of perfect competition based on Diamond and Dybvig (1983) that abstracts from risk diversification and focuses instead on liquidity to analyze taxes on banks. In contrast, the model that I develop explicitly considers a bank that chooses a risk portfolio for loans based on the size of its loan portfolio and the expected rate of return. In addition, Caminal (2003) assumes that deposit and loan interest rates are determined independently so that a tax on deposits does not affect lending and vice versa. I also assume separability for the costs of monitoring and administering loans and deposits, but the taxes I consider sometimes impact both margins.

Several recent models examine externalities related to systemic risk in the banking sector. These include Keen (2011), Acharya et al. (2010), Coulter, Mayer, and Vickers (2014), and less formally Kocherlakota (2010) and Perotti and Suarez (2009). These models discuss various approaches to the design of a Pigouvian tax on banks to internalize such externalities and Keen (2011) examines as well the merits of taxation versus regulation of banks. I next describe these models and relate them to my model.

Keen (2011) develops a model to study the consequences of two externalities of the banking sector that have proved to be important during the recent financial crisis. The first of these is a "collapse" externality that results from the assumption that a bank's collapse generates wider social costs because of the nature of banking. While the exact nature of wider social costs is not modeled, these could arise either because the bank is involved in financing businesses so its collapse could lead to a collapse of private businesses throughout the economy, or because collapse of one bank leads to collapse of another because the banks themselves are interconnected. In either case, the threat that a bank collapse has on the wider economy can lead the government to bail out a bank. This leads to a second externality, a "bailout" externality, whereby the expectation of a bailout by the government leads to a lower interest rate on a bank's borrowing which leads to too much risk (in the sense of a higher probability of bankruptcy) and an even larger bailout. Keen further examines taxation versus regulation in this context and derives an optimal tax scheme that depends on the extent to which the government is able to commit to its bailout policy.

Risk in Keen's model takes the form of a probability of bankruptcy of a bank that is assumed to depend negatively on the equity to loan ratio (or equivalently positively on the deposit to loan ratio as loans equal equity plus deposits in his model). Bankruptcy thus implicitly relies on the well-known moral hazard argument that a company (bank or non-bank) that finances with too much debt will have a greater risk of bankruptcy. Indeed, if the bank has no deposits and relies entirely on equity finance, the probability of failure in Keen's model is zero.

As noted earlier and discussed later, risk in my model concentrates on macroeconomic risk which depends on the aggregate amount of loans in the economy. In the model the probability of success depends negatively on aggregate loans in the economy and each bank increases systemic risk (lowers the probability of success) as it increases its loans. While each bank takes into account the effect that its decision has on the probability of success for its own expected loan revenue, it ignores the impact that its loan decision has on expected loan revenue of the other banks in the system. This is a different sort of externality than modeled previously but could be related to the "collapse" externality of Keen.

The differences in modeling risk imply that the consequences of taxation are also different. Keen finds that a tax on borrowing (deposits in his model) is optimal to discourage excessive bank defaults (from the bailout externality). In my model, taxation will affect risk-taking to the extent that it alters aggregate loans, but there is not necessarily a one-to-one relationship between deposits and risk — indeed a direct tax on deposits will increase borrowing (on international capital markets) but not affect risk in the model, at least if the cost function is separable.

Besides the differences in modeling risk and the externality, another difference between Keen's model and mine is that I focus on different markets. I focus on both sides of the balance sheet, especially the loan and deposit markets, while Keen concentrates on the liabilities side, equity and deposits. As equity plus deposits is equal to loans in Keen's model this difference would seem to be innocuous but it highlights the different implications of the taxation of banks in the two models.

The difference in market focus is mainly because the loan market is especially important for my modeling of risk whereas the equity to deposit ratio is especially important for Keen's analysis of risk. This difference in modeling and the source of the externality result in different tax implications. Keen derives two parts to the optimal tax on banks to correct his two externalities, a tax on borrowing (to discourage excessive bank defaults) and a tax on equity (to discourage excessive social costs due to the effect of bank size). In my model it is not possible to separate out the effects of a tax on borrowing from the effects of a tax on equity — the tax on equity will include an effect on borrowing as well. This is because (1) borrowing is not the same as deposits in my model and depends on loans and deposits, and (2) a tax on equity in my model affects both the market for loans and the market for deposits, and thereby borrowing on the international or interbank market as well as equity.

Keen's analysis is closely related to the less formal discussion of Kocherlakota (2010) that relates deposit insurance and inevitable bailouts to an externality manifested by lower debt costs of banks and thus the moral hazard of too much risk taking. Kocherlakota (2010) proposes to use tradeable "rescue bonds" whose market price can help inform authorities of the appropriate pricing of risk and thus the appropriate Pigouvian tax. Such rescue bonds could presumably also capture the risk associated with the macroeconomic risk that I model — at least to the extent that this risk is known to market participants.

Another paper that addresses the issue of externalities is Coulter, Mayer, and Vickers (2014), who, like Keen (2011), focus on risk in terms of the solvency of the bank and particularly the relationship of the capital ratio to solvency. Because losses fall partly on bondholders in the case of insolvency, there is an externality in the form of moral hazard that results in too much lending. They find that taxes can partially internalize the externality but will not address the underlying moral hazard problem.

While Coulter, Mayer, and Vickers (2014) consider risk, it results from an externality in which banks do not take account of losses on bondholders. The externality in my model is different and arises because a bank's loan volume is large enough that it impacts the overall probability of success of a loan in the economy. Like Keen (2011), Coulter, Mayer, and Vickers are concerned with how the amount of bondholder debt relative to equity affects risk, the well-known issue of moral hazard associated with a company (bank or non-bank) that finances with too much debt, and how taxes affect that margin. In my model, macroeconomic risk may also change with debt, but additional borrowing by the bank is not the main catalyst of any increase in macroeconomic risk. Rather, in my model the tax may decrease a bank's supply of loans, and thereby correct for the externality in macroeconomic risk. Thus in my model it is the volume of total loans, even loans financed by equity, that can have an effect on the overall riskiness of loans in the economy.

Acharya et al. (2010) also address externalities. As in Coulter, Mayer, and Vickers described earlier, there is an opportunity cost of using equity capital instead of debt and banks holding too much debt. The model does not include an explicit mechanism for excessive debt but simply assumes that for some reason (for instance, the tax system) debt is favored over equity. Banks are heterogeneous and thus may hold different amounts of debt and equity. In this paper, it is the aggregate capital ratio that matters for a systemic externality. A systemic externality occurs if aggregate capital in the financial system falls below some fraction of aggregate assets. Acharya et al. (2010) develop a measure of a bank's contribution to the systemic externality, its propensity to be undercapitalized when the system as a whole is undercapitalized. They call this a bank's systemic expected shortfall (SES) and show that it increases with a bank's leverage and other factors and propose a tax based on a bank's SES to internalize the externality.

Perotti and Suarez (2009) view the externality as caused by excessive reliance on short-term funding which can come under pressure in a crisis situation. They propose to tax a bank based on its short-term uninsured funding (that is, exempting capital and insured deposits) and would base the tax on a measure of the liability maturity structure of the bank.

Finally, Lockwood (2014) contributes to the literature on taxation of banks by adding financial intermediation to a standard model of optimal capital taxation. If pure profits are taxed at 100 percent, Lockwood finds that the tax on interest income and financial intermediation are both optimally set to zero in the steady-state. However, if the financial sector generates rents that are not taxed at 100 percent, a tax on financial intermediation at the rate of tax on capital is justified in the steady-state. He finds that the rate of tax on financial intermediation can optimally be higher or lower than the optimal tax on consumption.

III. THE MODEL

I develop a simplified model to study the taxation of financial companies with the following characteristics. Banks are modeled along the lines of a commercial bank and assumed to take in deposits, D, from households, and make loans, L, to businesses. Banks are also assumed to have a cost function for managing deposits and loans $C(L,D)$ that is convex in both arguments, $C_L \geq 0$, $C_D \geq 0$, $C_{LL} \geq 0$, $C_{DD} \geq 0$, and separable so $C_{LD} = 0$.[3] Banks charge an interest rate r_L on loans and pay an interest rate r_D on deposits. Besides deposits, banks may also obtain equity funds, E, and may borrow on international capital markets, with the volume of borrowing denoted as B. The interest rate on the international capital market, r, is exogenously determined.

I incorporate two main regulations of the banking sector into the model: a minimum capital ratio and a reserve requirement. The bank is subject to a minimum capital ratio on equity, $E \geq k^*$ *Assets*. The assets of a bank are composed of its reserves, R, and its loans, L, and I assume that the capital ratio is binding (perhaps because equity finance is more expensive than debt finance) so banks hold the minimum equity requirement, $E = k(R + L)$. Banks must hold a certain proportion, α, of their deposits as non-interest bearing cash reserves and since cash earns no interest, it is optimally chosen to be the minimum αD. Given reserves of αD, the equity requirement can be written in terms of deposits and loans: $E = k(\alpha D + L) = E(L,D)$. Notice that although equity is not a choice variable in the analysis, it is not fixed, deposits and loans change equity holdings as well.

It is also useful to recall the balance sheet identity that assets must be equal to liabilities plus owner's equity, $R + L = D + B + E$. Rewriting the bank's borrowing needs in terms of deposits and loans yields:

$$(1) \qquad \begin{aligned} B &= L-(1-\alpha)D-E = L-(1-\alpha)D-k(\alpha D+L) \\ &= L(1-k)-(1-\alpha+\alpha k)D = B(L,D) \end{aligned} .$$

[3] Thus the MC curve is upward sloping. As long as the cost function is convex in the relevant range the results will still hold. If the function is concave in the relevant range this would of course be problematic as the MC curve would be downward sloping, and if it is downward sloping everywhere we would be in the case of a natural monopoly — MC pricing would not cover total costs. A natural and often used solution is then regulation, as is for instance, often the case for utilities.

To incorporate risk, I follow Allen and Gale (2001) and Boyd and De Nicoló (2005) in assuming that a bank chooses a risk portfolio based on the size of its investment and the rate of return. Following Allen and Gale, each bank chooses a portfolio of perfectly correlated risks, which is equivalent to assuming that the risk of each investment can be decomposed into a common component and an idiosyncratic component. With a large number of investments, the idiosyncratic component is perfectly pooled and disappears from the analysis, leaving only the common component which is taken to represent systemic or macroeconomic risks.

A bank that invests L receives a return of r_L with probability $p(\tilde{L})$ (where $\tilde{L}$ represents aggregate loans) and a return of zero with probability $1-p(\tilde{L})$, where it is assumed that $p'(\tilde{L})<0$ and $p''(\tilde{L})\leq 0$.[4] The greater the total loans in the economy, the lower is the probability of success and the more rapidly the probability of success falls. A bank in my model chooses the riskiness of its portfolio by choosing the size of its loan portfolio. As the bank increases its loans it increases risk in the economy and lowers the overall probability of success of a loan. The bank takes the increased riskiness into account in its own profit-maximizing choice of loans, but does not take into account the effect its decision has on the other banks in the economy. With respect to the supply of funds, I assume (again following Allen and Gale) that all deposits are insured so this supply of funds is independent of the macroeconomic risk.

The model is a variation of Allen and Gale's (2001) formulation of the risk portfolio choice, who assume the probability of an investment paying off depends on the return $p(r_L)$ rather than aggregate loan size $p(\tilde{L})$. Of course loan revenue is $r_L L$ and the firm's problem is to maximize expected profits. One can view expected loan revenue as $p(r_L)r_L L$ and allow firms to choose r_L, or view expected loan revenue as $p(\tilde{L})r_L L$ and allow firms to choose L. These

[4] The extreme assumption of a zero return for the bad outcome is a simplification.

formulations are inverses of each other and in either case a bank is trading off profits and the risk of failure as it maximizes expected profits. The essential risk-profit trade-off is the same. The first-order conditions and externality will also be the same, allowing for the difference in choice variables. For instance, with the interest rate as choice variable, the bank will also underprice its contribution to systemic risk from a social point of view. It will take into account the effect of its choice on its own revenue while ignoring the effect on other banks of its contribution to systemic risk.

The approach that I take also comports with the expected sign of the comparative statics of the other parameters of the model that normally are thought to influence risk, the minimum capital constraint k and, more controversially, the size of a bank. To develop informally the effects of these parameters on risk, recall that deposit insurance is widely thought to lessen the problem of bank runs, but it also distorts the risk incentives of banks by creating a moral hazard in which large losses are absorbed by the government. Several solutions are possible. One is forcing banks to pay more for the insurance if risk is higher, a path that is difficult to implement in practice (in part because measurement of risk in banks is difficult) as argued by Boyd, Chang, and Smith (2002).[5] A second solution is embodied in mandatory capital requirements, denoted k earlier, which force bank shareholders to hold larger stakes than they willingly do. Looking ahead to Figure 1, it is easy to see that a smaller k (k = 0 for instance) will result in greater loans and greater risk, consistent with the intent of those policies. A third path is to give equity holders a larger stake by intentionally allowing banks to earn economic rents, which is of course related to the current debate about whether to break up big banks.

Whether larger banks increase risk has been debated in the literature. In the Allen and Gale (2001) model, larger banks in fact decrease risk, although the empirical literature on this

[5] Note though that the U.S. finances its deposit insurance through a tax on banks.

question is mixed. The essential point of Boyd and de Nicoló (2005) is that there is an offsetting effect on equilibrium risk that Allen and Gale do not consider: the same market power that increases the rents of banks and results in less risk also squeezes borrowers and those borrowers may become riskier in their investment choices. Here I simply take as given that, for the economy as a whole, expansion of loans will increase the probability of borrower default as, for instance, entrepreneurs invest in riskier projects. A bank in my model is aware of this and takes into account its own effect on macroeconomic risk, but ignores the impact on other banks in the system. In my model there are two extremes that both eliminate the externality. At one extreme is the case of no market power in the sense of no impact on macroeconomic risk. At the other extreme is pure monopoly in which one bank comprises all loans and macroeconomic risk; in this case, the bank will internalize the externality and again the externality will be eliminated.

The externality will exist for the more realistic intermediate case, and there may well be some trade-off between the efficiency of the banking system and the need to contain systemic risk. This is an interesting issue but a complete examination is beyond the scope of this paper. A recent paper that empirically finds a trade-off between competition and bank risk is Jiang, Levine, and Lin (2017). They use differences in regulations between states in different years to construct state-year measures of the regulation-induced competitive pressures facing individual bank holding companies in the United States. They find that an intensification of bank competition increases bank risk, suggesting a trade-off between the two.

IV. EQUILIBRIUM WITH NO TAXES

A bank's expected profit is the expected interest income that it earns on loans less its interbank or international capital market borrowing costs less the interest that it pays on deposits less equity costs less its management costs, or:

$$E(\pi) = p(\tilde{L})r_L L - rB(L,D) - r_D D - r_E E(L,D) - C(L,D), \tag{2}$$

where management costs are assumed to be incurred whether or not the loan is successful and thus do not depend on $p(\tilde{L})$. Management costs will also be assumed to be separable throughout.[6] While the bank can finance loans through borrowing, equity, or deposits, as noted earlier both equity and borrowing can be written in terms of loans and deposits, so the choice of *L* and *D* will also determine *B*(*L*,*D*) and *E*(*L*,*D*). Systemic risk is determined by aggregate loan volume in the economy, with greater loan volume increasing risk by lowering the probability of success of loans and thus increasing the loan risk of all banks. Substituting for *B* and *E* and choosing *L* and *D* to maximize profits yields[7]:

$$\begin{aligned}
&\frac{\partial E(\pi)}{\partial L} = p(\tilde{L})r_L + r_L L\frac{\partial P}{\partial L} - (1-k)r - kr_E - \frac{\partial C}{\partial L} = 0 \\
&\qquad \Rightarrow p(\tilde{L})r_L\left[1+\varepsilon_{P,L}\right] = (1-k)r + kr_E + \frac{\partial C}{\partial L} \\
&\frac{\partial E(\pi)}{\partial D} = -r_D + r(1-\alpha+\alpha k) - \alpha kr_E - \frac{\partial C}{\partial D} = 0 \\
&\qquad \Rightarrow r(1-\alpha+\alpha k) = r_D + \alpha kr_E + \frac{\partial C}{\partial D}
\end{aligned}, \tag{3}$$

where $\varepsilon_{P,L}$ is the elasticity of the probability of success of a loan with respect to the volume of loans.

[6] Separability of the cost function assumes no economies of scope. If this is not true, then the loan and deposit markets immediately become intertwined. For instance a tax on loans that decreases loans would change the marginal cost of deposits.

[7] I assume a bank's loans are large enough to affect *p*; if not, then this term is zero.

The interpretation of the first-order conditions is straightforward. With respect to loans, the bank equates the expected marginal revenue with the marginal cost of financing a new loan. The bank's expected marginal revenue lies below the expected return on a loan since an additional loan lowers the macroeconomic probability of success of a loan in the economy. The bank takes into account the greater risk it is taking on its own loans (but not those of other banks) as it lowers the probability of success and increases the bad loan risk of itself and other banks. Taking deposits as given, the marginal cost of a new loan is the marginal cost of borrowing (the first term) plus the marginal equity cost (the second term as the equity constraint requires k additional units of equity for one additional unit of loans) plus the marginal management costs.

Note that the bank considers the additional risk it incurs but since the decision affects the total risk in the economy it is also imposing additional risk on the other banks in the system, and it does not take into account this latter risk. This is the externality in the model, and it is useful to expand on this. Without any government regulation or taxes, the social marginal damage imposed by bank i is:

$$r_L \sum_{j \neq i} \frac{\partial P}{\partial L_i} L_j .$$

This is the sum of the loan revenue of banks other than bank i, times the fall in the probability of success of a loan in the economy caused by an additional loan by bank i. Bank i does not take this social cost into account and the externality thus leads to too much risk from a social point of view.

With respect to deposits, the bank equates the marginal benefit of the deposit with the marginal cost. The marginal benefit is the savings from not borrowing, $r(1 - \alpha)$ directly and $r\alpha k$ indirectly because having more in reserves lessens the equity constraint and the need to borrow by αk. The marginal cost of deposits is the interest paid on deposits plus the increase in financing costs due to the increase in required equity plus the marginal management costs.

While these are the profit-maximizing conditions for a single bank it is also useful to consider the market equilibrium of the banking sector. Equilibrium is characterized by equilibrium in three markets: the loans/investment market, the deposit/savings market, and the international capital market; however, as mentioned previously the return on international capital markets is exogenous, so I simply examine the loans and deposit markets.

The demand for loans by the private sector is given by $I(r_L)$ where I assume $I'(r_L) < 0$. The aggregate supply of loans is the sum over banks of their individual loan supplies L_n. If there are N banks, the equilibrium in the market for loans is given by:

$$I(r_L) = \sum_{n=1}^{N} L_n = \tilde{L}. \tag{4}$$

The savings of households is given by $S(r_D)$ where I assume $S'(r_D) > 0$.[8] Equilibrium in the savings market is thus characterized by:

$$S(r_D) = \sum_{n=1}^{N} D_n. \tag{5}$$

Figure 1 illustrates the firm and market solutions with no taxes in the markets for loans and deposits. The upper left and right hand diagrams represent the market and firm, respectively, solutions for loans while the bottom diagrams show the corresponding diagrams for deposits. With respect to an individual bank's supply of loans, the marginal revenue lies below the

[8] Households can hold cash or save in interest bearing deposits. The financial instruments available to households are thus limited, though I extend access of international capital markets to domestic savers in an extension later in the paper.

expected return and is equated with the marginal cost of a loan as noted earlier. With respect to deposits, the (constant) marginal benefit is equated to the marginal cost.

FIGURE 1 ABOUT HERE

V. ANALYSIS OF THE EFFECTS OF TAXES

A. A Tax on Loans (or Bank Assets Exempting Reserves)

We first consider the effect of a proportional tax on bank assets, t_A. The assets of a bank in this setting are its loans plus its reserves. Assuming that the tax on assets would exempt reserves implies a simple tax on loans and the taxes owed by bank *n* would be:

(6) $$T_A = L_n t_A.$$

After-tax expected profits are:

(7) $$E(\pi) = p(\tilde{L}) r_L L - t_A L - rB(L,D) - r_D D - r_E E(L,D) - C(L,D).$$

The first-order conditions for *L* and *D* are:

(8)
$$\begin{aligned}
&\frac{\partial E(\pi)}{\partial L} = p(\tilde{L}) r_L + r_L L \frac{\partial P}{\partial L} - t_A - (1-k)r - kr_E - \frac{\partial C}{\partial L} = 0 \\
&\qquad \Rightarrow p(\tilde{L}) r_L \left[1 + \varepsilon_{P,L} \right] = (1-k)r + kr_E + t_A + \frac{\partial C}{\partial L} \\
&\frac{\partial E(\pi)}{\partial D} = -r_D + r(1-\alpha+\alpha k) - \alpha k r_E - \frac{\partial C}{\partial D} = 0 \\
&\qquad \Rightarrow r(1-\alpha+\alpha k) = r_D + \alpha k r_E + \frac{\partial C}{\partial D}.
\end{aligned}$$

This implies the following (proofs of all propositions are provided in the appendix):

Proposition 1: A tax on loans (or assets exempting reserves), reduces a bank's supply of loans, and has no effect on its demand for deposits if management costs are separable. A bank's borrowing and the riskiness of its investment portfolio falls.

The absence of an effect on a bank's demand for deposits follows from the assumptions of separable management costs and full deposit insurance, which effectively insulates the market for deposits from a tax on assets. In the market for loans, the tax on assets increases the marginal cost of loans and leaves the marginal expected revenue unchanged. Thus, a bank's supply of loans falls, and with it the riskiness of the bank's investment portfolio. As deposits are unaffected, a bank's borrowing also falls. This is illustrated in Figure 2.

FIGURE 2 ABOUT HERE

Recall that there is an externality that leads to too much risk from a social point of view since bank *i* does not take into account the impact of its loan decision on the probability of success of the loans of banks other than it. Without any government regulation or taxes, the social marginal damage imposed by bank *i* is:

(9) $$MD_i = r_L \sum_{j \neq i} \frac{\partial P}{\partial L_i} L_j .$$

The equity requirement will increase the marginal cost of loans by $kr_E + (1 - k)r$. To internalize any remaining external effect, the optimal tax after taking into account the minimum equity requirement should thus be set equal to the remaining marginal damage:

(10) $$t_A^* = r_L \sum_{j \neq i} \frac{\partial P}{\partial L_i} L_j - \left[k r_E + (1-k) r \right].$$

B. A Tax on Bank Deposits

I next consider the effect of a proportional tax on deposits, t_D, which would raise revenues:

(11) $$T_D = D_n t_D.$$

After-tax profits are:

(12) $$E(\pi) = p(\tilde{L}) r_L L - rB(L,D) - r_D D - t_D D - r_E E(L,D) - C(L,D).$$

Choosing D and L to maximize profits yields:

(13) $$\begin{aligned} \frac{\partial E(\pi)}{\partial L} &= p(\tilde{L}) r_L + r_L L \frac{\partial P}{\partial L} - (1-k) r - k r_E - \frac{\partial C}{\partial L} = 0 \\ &\Rightarrow p(\tilde{L}) r_L \left[1 + \varepsilon_{P,L} \right] = (1-k) r + k r_E + \frac{\partial C}{\partial L} \\ \frac{\partial E(\pi)}{\partial D} &= -r_D - t_D + r(1 - \alpha + \alpha k) - \alpha k r_E - \frac{\partial C}{\partial D} = 0 \\ &\Rightarrow r(1 - \alpha + \alpha k) = r_D + t_D + \alpha k r_E + \frac{\partial C}{\partial D} \end{aligned},$$

which implies:

Proposition 2: If management costs are separable, a tax on deposits lowers a bank's demand for deposits, has no effect on its supply of loans, increases a bank's borrowing, and does not change the riskiness of a bank's investment portfolio.

Figure 3 illustrates this result. The market for loans is unaffected by the tax on deposits as shown in the upper diagrams. This is due in part to the assumption of separability in the management cost function, as neither the marginal benefit nor the marginal cost of a loan is affected. Since the externality flows through the loan market, the tax on deposits also has no impact on the externality and does not affect the riskiness of the loan portfolio.

FIGURE 3 ABOUT HERE

In the market for deposits, the intercept of the marginal cost of deposits for a bank shifts up as shown in the lower right hand diagram, leading to a lower demand for deposits. As loans are unaffected and deposits are lower, the bank's borrowing must be higher. The riskiness of the bank's loan portfolio nevertheless remains unchanged since loans are unaffected.

C. A Tax on Bank Liabilities

Consider next a tax on bank liabilities. I will assume that the tax exempts equity since this type of tax has been proposed in part to discourage borrowing on the part of banks (I consider a tax on bank equity in the next section). A tax on liabilities exempting equity amounts to a tax on deposits plus a tax on borrowing. Using the definition of borrowing given by Equation (1), this tax raises revenues of:

$$\begin{aligned}(D_n + B_n)(t_B) &= (D_n - (1-\alpha+\alpha k)D_n + L_n(1-k))(t_B) \\ &= (\alpha D_n + L_n)(1-k)(t_B)\end{aligned} \quad , \tag{14}$$

and is equivalent to a tax on assets other than those that must be held to satisfy the capital requirement and is inclusive of reserve assets. After-tax profits are:

(15) $$\begin{aligned} E(\pi) = p(\tilde{L})r_L L - (1-k)Lt_B - r_D D - (1-k)\alpha D t_B \\ - rB(L,D) - r_E E(L,D) - C(L,D) \end{aligned}.$$

Choosing *D* and *L* to maximize profits yields:

(16) $$\begin{aligned} \frac{\partial E(\pi)}{\partial L} &= p(\tilde{L})r_L + r_L L \frac{\partial P}{\partial L} - t_B(1-k) - (1-k)r - kr_E - \frac{\partial C}{\partial L} = 0 \\ &\Rightarrow p(\tilde{L})r_L\left[1+\varepsilon_{P,L}\right] = (1-k)r + kr_E + t_B(1-k) + \frac{\partial C}{\partial L} \\ \frac{\partial E(\pi)}{\partial D} &= -r_D - (1-k)\alpha t_B + r(1-\alpha+\alpha k) - \alpha k r_E - \frac{\partial C}{\partial D} = 0 \\ &\Rightarrow r(1-\alpha+\alpha k) = r_D + \alpha k r_E + (1-k)\alpha t_B + \frac{\partial C}{\partial D} \end{aligned},$$

which leads to:

Proposition 3: If management costs are separable, a tax on liabilities reduces the demand for deposits and a bank's supply of loans. The tax lowers the riskiness of the bank's loan portfolio but has an ambiguous effect on a bank's borrowing.

Figure 4 illustrates this result. A tax on liabilities is proportionate to a tax on all assets including reserves. It consequently affects both the demand for deposits and the supply of loans. The tax on liabilities increases the marginal cost of loans and thus has a similar effect in the market for loans as a tax on assets, inducing the bank to lower its supply of loans. The effect is however weaker since the tax on liabilities increases the marginal cost of making a loan by (1 – *k*) of the tax rate rather than the full tax rate as in the case of the tax on assets.

FIGURE 4 ABOUT HERE

In the market for deposits, the marginal cost of deposits is shifted up by the fraction $(1 - k)\alpha$ of the tax, lowering the demand for deposits. This is again similar to but less than the effect of a direct tax on deposits since the tax on liabilities shifts the marginal cost up by a fraction of the tax rather than by the full tax as would occur with a direct tax on deposits.

The effect of the tax on a bank's borrowing is ambiguous. Recall that borrowing depends on the difference between loans and deposits. Loan supply falls but so does a bank's demand for deposits. And while the tax increases the marginal cost of deposits by less than the marginal cost of loans, the marginal benefit of deposits for the bank is constant. Whether loan supply falls by more or less than deposit demand will depend on elasticities in the two markets as well as the other parameters. A bank's loan risk will however fall since the riskiness of the loan portfolio increases in L.

D. A Tax on Bank Equity

As noted previously, Keen (2011) derives an optimal tax on banks that consists of two parts: a tax on borrowing and a tax on equity. I therefore consider next the effect of a tax on bank equity in the model, $t_E E$. After-tax profits are:

$$(17) \qquad E(\pi) = p(\tilde{L}) r_L L - rB(L,D) - r_D D - (r_E + t_E) E(L,D) - C(L,D).$$

The first-order conditions for L and D are:

$$
(18)\quad
\begin{aligned}
&\frac{\partial E(\pi)}{\partial L} = p(\tilde{L})r_L + r_L L\frac{\partial P}{\partial L} - (1-k)r - (r_E + t_E)k - \frac{\partial C}{\partial L} = 0 \\
&\quad \Rightarrow p(\tilde{L})r_L\left[1+\varepsilon_{P,L}\right] = (1-k)r + (r_E + t_E)k + \frac{\partial C}{\partial L} \\
&\frac{\partial E(\pi)}{\partial D} = -r_D + r(1-\alpha+\alpha k) - (r_E + t_E)\alpha k - \frac{\partial C}{\partial D} = 0 \\
&\quad \Rightarrow r(1-\alpha+\alpha k) = r_D + (r_E + t_E)\alpha k + \frac{\partial C}{\partial D}
\end{aligned}
,
$$

and lead to:

Proposition 4: If management costs are separable, a tax on equity reduces the demand for deposits and a bank's supply of loans. The tax lowers the riskiness of the bank's loan portfolio but has an ambiguous effect on a bank's borrowing.

Figure 5 illustrates this result. The tax on equity increases the marginal cost of loans and thus has a similar effect in the market for loans as a direct tax on loans, inducing the bank to lower its supply of loans. For a given tax rate, the tax on loans yields a greater reduction in loans since the tax on equity increases the marginal cost by the fraction k times the tax rate rather than the full tax rate as in the case of a tax on loans.

FIGURE 5 ABOUT HERE

In the market for deposits, a bank's demand for deposits is lower since the tax on equity increases the marginal cost of deposits. This is similar to but less than the effect of a direct tax on deposits since the tax on equity shifts the marginal cost up by only the fraction αk of the tax.

Since the supply of loans falls, the riskiness of the bank's loan portfolio is lower. The effect on borrowing is again ambiguous since the relative magnitudes of the changes in deposits and loans depend on the elasticities and other parameter values.

E. A Tax on Bank Profits

Finally, consider the effect of a tax on bank profits, t_π. If all costs are deductible, profits are simply multiplied by a constant, $(1 - t_\pi)$, the first-order conditions are the same as those in Equation (3) without the tax, and the tax has no effects on loans and deposits. As with any corporation tax, however, its effects depend crucially on what costs are deductible. Under current law, equity costs are not deductible for tax purposes and a tax on bank profits will affect loans as well as deposits, and hence bank borrowing and the risk portfolio of the bank. De Mooij and Keen (2016) examine empirically the effect of a tax on bank profits with deductibility of debt but not equity costs when bank assets are fixed. They find that the corporate tax leads banks to be more highly leveraged than otherwise, with the marginal effect being similar to non-financial companies. Heckemeyer and de Mooij (2017) also examine the responsiveness of banks to tax incentives for debt and find that banks are less responsive than non-banks on average, though small banks are more responsive and large banks less responsive than their non-bank counterparts. The result that banks are less responsive on average is somewhat surprising given that banks could be subject to two reasons for holding more debt, the usual bias of the tax system and the existence of deposit insurance. Regulations designed with the second reason in mind may also help control the first reason for holding more debt.

My model results with respect to bank profit taxes are consistent with these results, but I examine the case of endogenously variable bank assets. With non-deductible equity costs, after-tax profits are:

(19) $$E(\pi)=[p(\tilde{L})r_L L-rB(L,D)-r_D D-C(L,D)](1-t_\pi)-r_E E(L,D),$$

where management costs are fully deductible for simplicity. Choosing *D* and *L* to maximize profits yields:

(20) $$\begin{aligned}&\frac{\partial E(\pi)}{\partial L}=\left[p(\tilde{L})r_L+r_L L\frac{\partial P}{\partial L}-(1-k)r-\frac{\partial C}{\partial L}\right](1-t_\pi)-r_E k=0\\&\Rightarrow p(\tilde{L})r_L\left[1+\varepsilon_{P,L}\right]=(1-k)r+\frac{r_E k}{(1-t_\pi)}+\frac{\partial C}{\partial L}\\&\frac{\partial E(\pi)}{\partial D}=\left[-r_D+r(1-\alpha+\alpha k)-\frac{\partial C}{\partial D}\right](1-t_\pi)-r_E\alpha k=0\\&\Rightarrow r(1-\alpha+\alpha k)=r_D+\frac{r_E\alpha k}{(1-t_\pi)}+\frac{\partial C}{\partial D}\end{aligned},$$

which implies:

Proposition 5: If equity costs are not deductible and management costs are separable, a tax on profits lowers both a bank's demand for deposits and its supply of loans. The tax lowers the riskiness of the bank's loan portfolio but has an ambiguous effect on a bank's borrowing.

Figure 6 illustrates this result. In the market for loans, a tax on profits with no deductibility for equity costs increases the cost of equity and thus the marginal cost of loans. Since the minimum equity requirement must be met, the tax cannot be avoided by reducing equity so the marginal cost of a loan is increased and the amount of loans supplied is reduced. This implies a reduction in the riskiness of the loan portfolio.

FIGURE 6 ABOUT HERE

In the market for deposits, financing loans by more deposits also requires the bank to hold more equity through the minimum equity requirement because of reserves and thus total assets in the denominator of the equity to asset ratio rise. The non-deductibility of equity implies that this equity is more expensive. But there is no way to avoid holding the equity given the minimum equity requirement, so the marginal cost of deposits rises and a bank's demand for deposits falls.

Borrowing again depends on the relative changes in loans and deposits. Since the relative magnitudes of these changes depend on the elasticities and other parameter values, the impact of the tax on bank borrowing is ambiguous. It is perhaps surprising that borrowing by the bank is indeterminate, given that debt is deductible and equity is not. However, borrowing is indeterminate because loans (assets) are also changing. Indeed if one holds fixed the level of loans, borrowing must rise since deposits fall and the financing of the same level of loans requires additional borrowing.

VI. EXTENSIONS

A. Allowing Depositor Access to International Capital Markets

If customers have access to international capital markets they have an alternative place to deposit their money. This might happen legally (e.g., through money market funds) or illegally as depositors move from domestic to foreign deposits to avoid a domestic tax on deposits. In fact, Huizinga and Nicodème (2004) find evidence that higher interest income taxes and greater interest income reporting are associated with larger non-bank international deposits.

If depositors have access to international capital markets, the results will depend on the degree of substitutability between bank deposits and funds in international capital markets for savers. Greater substitutability implies the supply of deposits will be more elastic so that a tax on deposits will be more likely to be absorbed by the bank, thus decreasing the domestic return earned by the bank on deposits. This implies a larger decline in demand for deposits for domestic banks.

This discussion takes the return in international capital markets as a given. For the case of a large country, an influx of funds into the international capital market will lower the international return, attenuating any flow of funds towards international capital markets resulting from a domestic tax on deposits. This means that domestic supply of deposits by savers is less elastic for the large country case and the bank will absorb less of a domestic tax on deposits. Moreover, a domestic tax on deposits that alters the return in international capital markets will change the borrowing rate of the domestic bank. This in turn affects the supply of loans, as can be seen from the first-order condition for loans. Thus even with separability in the cost function, a tax on deposits affects the supply of loans offered by domestic banks.

B. Allowing for Tax Avoidance by Multinational Banks

Multinational banks can avoid profit taxes by well-known tax planning strategies. Demirguc and Huizinga (2001) provide evidence that foreign bank profits change little with increases in domestic taxes as well as with increases in the local tax rate. This is consistent with tax avoidance by multinational banks. Merz and Overesch (2014) also find significant avoidance behavior on the part of financial institutions and a marginal effect that is double that of non-financial corporations.

While an investigation of the many ways that multinationals can avoid each type of tax analyzed is beyond the scope of this paper, the model allows illustration of the general effects. If some banks can avoid the tax, the results would be a combination of the no-tax and with-tax outcomes. The effects are easy to discern from the graphs for each case. For instance, Figure 2 shows the equilibrium in the market for loans with and without the tax on loans or assets. If some banks can avoid the tax, the resulting equilibrium would be something in-between — essentially a weighted average of the two cases. For example, if some firms avoid the tax, in Figure 2 total loan supply and bank borrowing would not fall by as much. Relative to the case without tax avoidance, some additional loans would be financed with a higher probability of failure. Thus tax avoidance by multinational banks would tend to increase the riskiness of a bank's loan portfolio.

VII. CONCLUSION

Taxation of the banking sector is an important but under-researched policy issue. In the few existing models of taxation of banks, a main focus is on liquidity risk, the risk associated with bank runs due to a funding source (deposits) that is more liquid than assets (loans), a risk that is reduced by deposit insurance (Diamond and Dyvbig, 1983). A number of additional models examine various approaches to the design of a Pigouvian tax on banks to internalize externalities related to systemic risks. Risk in these approaches is implicitly or explicitly modeled on the well-known moral hazard argument that a company (bank or non-bank) that finances with too much debt will have a greater risk of bankruptcy. A different source of systemic risk that is often discussed as one of the reasons for the recent collapse of the financial system is that the banks may invest in overly risky loan portfolios.

In this paper, I develop a simple model that includes regulatory rules regarding deposit reserve and minimum equity ratios to investigate the effect of taxes on a bank's decisions including its impact on systemic risk. The model that I develop emphasizes the role that taxes can play in alleviating systemic risk resulting from loan decisions taken by banks. In my model, as the bank finances a greater volume of loans, it is funding loans that have a lower probability of success, which adds to systemic risk in the economy. While a bank takes into account the increased risk on its own loans, it ignores the increased risk incurred by other banks in the system. Taxes can help to correct this type of externality.

As in some other models there is an externality in risk-taking, but the source of the systemic risk is different. In other models the externality results because of moral hazard as the bank's debt to equity ratio gets too high. In my model the probability of success of a loan depends on aggregate loans in the economy. The externality results because each bank takes into account only its effect on itself, ignoring the effect on other banks in the system. Unlike models with systemic risk resulting from moral hazard, increased bank borrowing on international or interbank markets resulting from a tax is not enough to infer the bank will increase the risk of its loan portfolio.

I analyze five types of taxes on banks in this simplified model: a tax on bank loans (or assets exempting reserves), a tax on bank deposits, a tax on bank liabilities, a tax on bank equity, and a tax on bank profits (with nondeductible equity). All of the taxes except the tax on deposits will decrease the supply of loans and the riskiness of loans in the economy. The tax on deposits does not affect either of these variables due to the assumption of separability of the management costs of deposits and loans. All of the taxes will decrease a bank's demand for deposits except the tax on loans, again due to the separability assumption. A bank's borrowing will rise with the tax on deposits, fall with the tax on loans, and will be indeterminate for the other taxes.

Finally, I show that the model can be extended without difficulty to examine depositor access to international capital markets and tax avoidance by international banks. Results for the former extension depend heavily on the degree of substitutability between domestic and international deposits, while the latter extension leads to the interesting observation that tax avoidance by multinational banks could increase the riskiness of a bank's loan portfolio in some cases.

The welfare consequences of the taxation of banks are complicated by the existence of deposit insurance, the deposit reserve, and minimum equity requirements. While one can compute from the model the optimal Pigouvian tax given parameters for these regulations, it is much more difficult to put this into practice. More work is needed to quantify the factors that contribute to systemic risk, to measure the amount that each bank contributes to systemic risk, and to understand how regulations and taxes contribute to a reduction in systemic risk and how they interact. Empirical or simulation work on these questions is needed to be able to design and implement optimal public policies toward banks.

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Figure 1

The No-Tax Banking Equilibrium

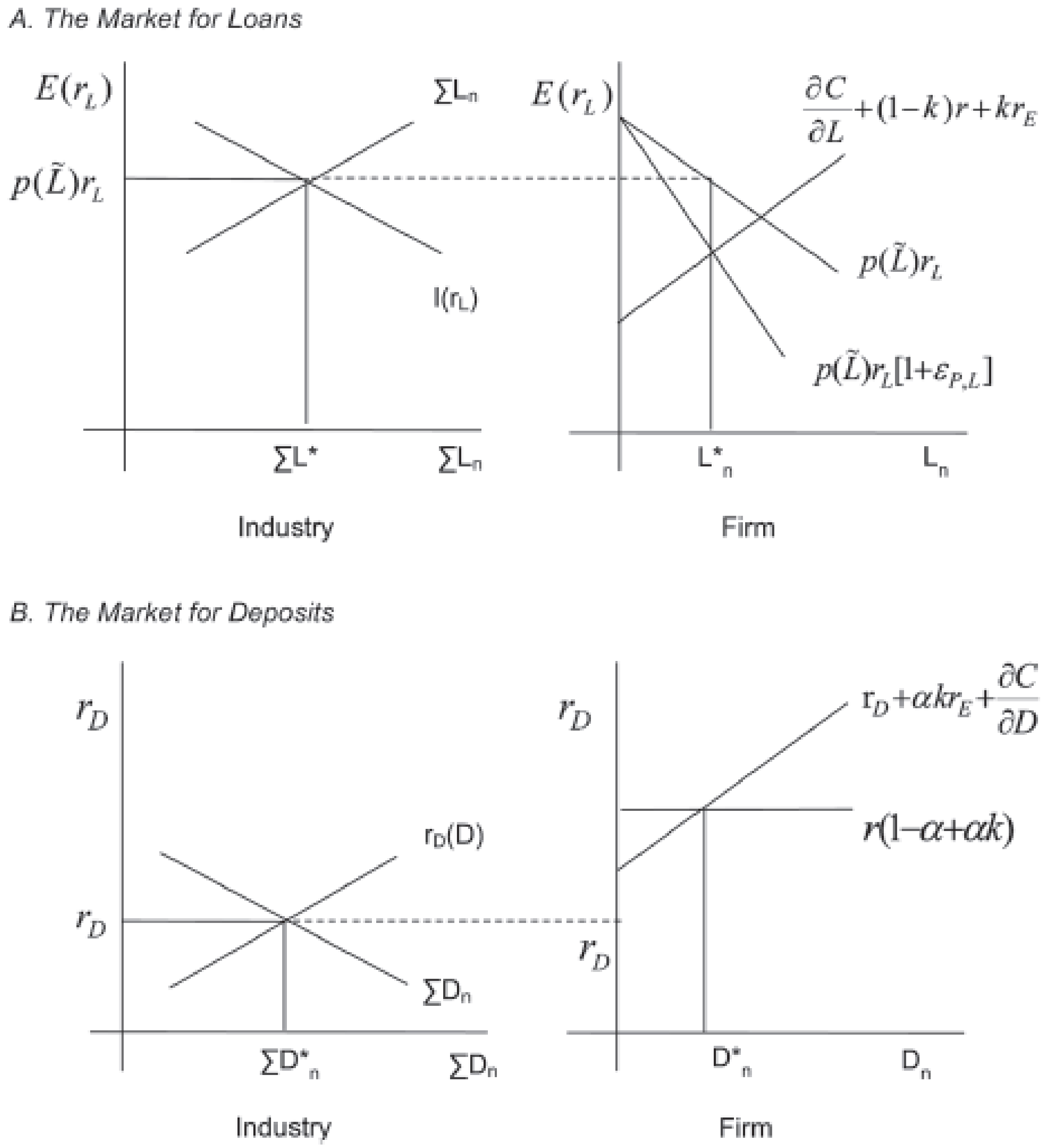
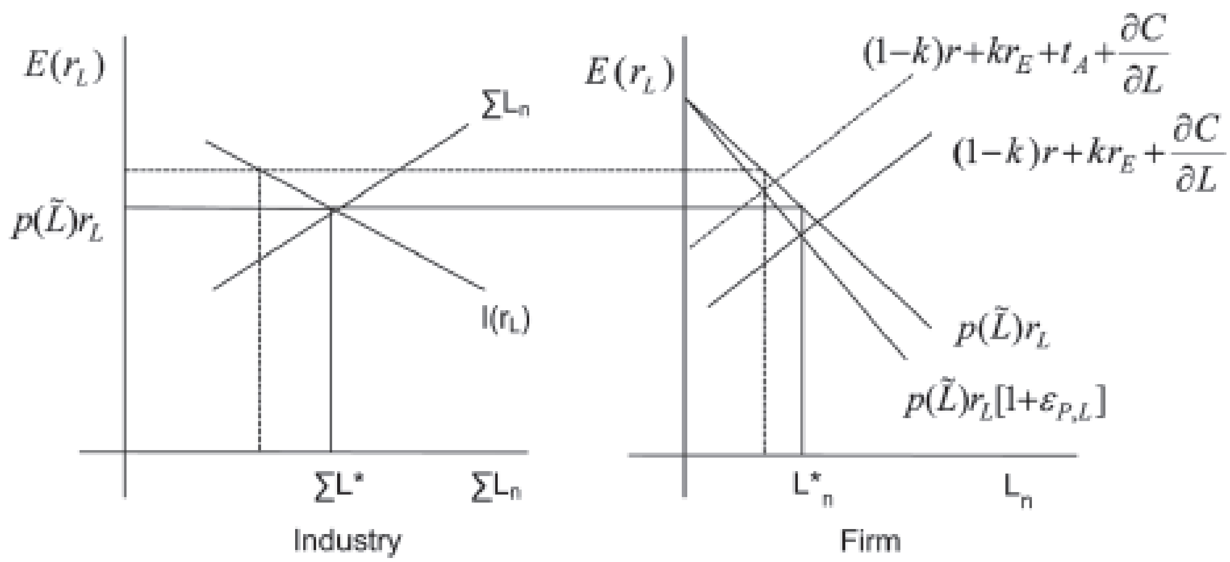


Figure 2

A Tax on Bank Loans (Assets Exempting Reserves)

A. The Market for Loans



B. The Market for Deposits

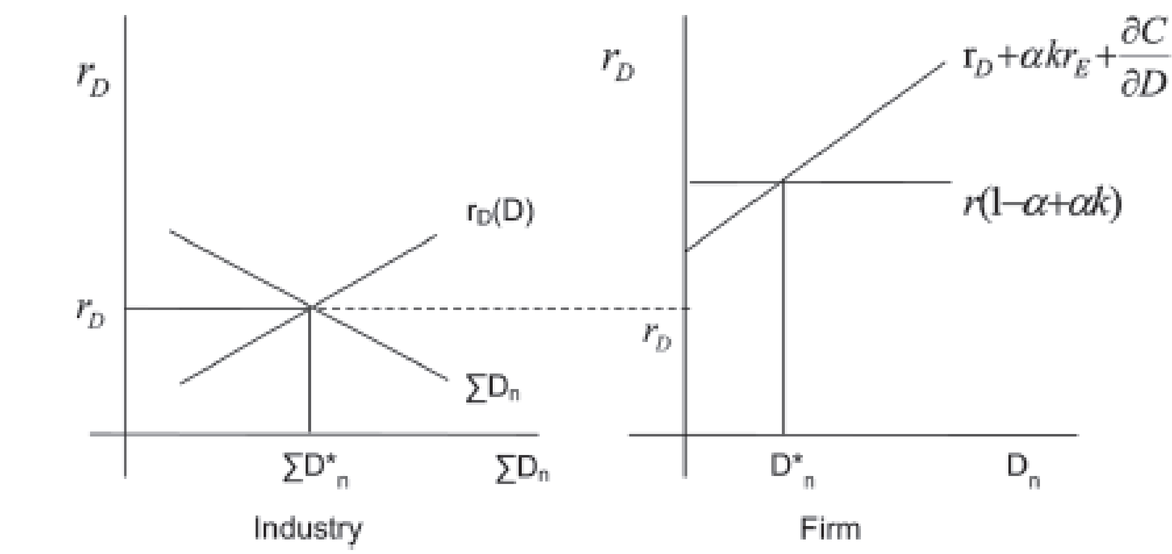


Figure 3

A Tax on Bank Deposits

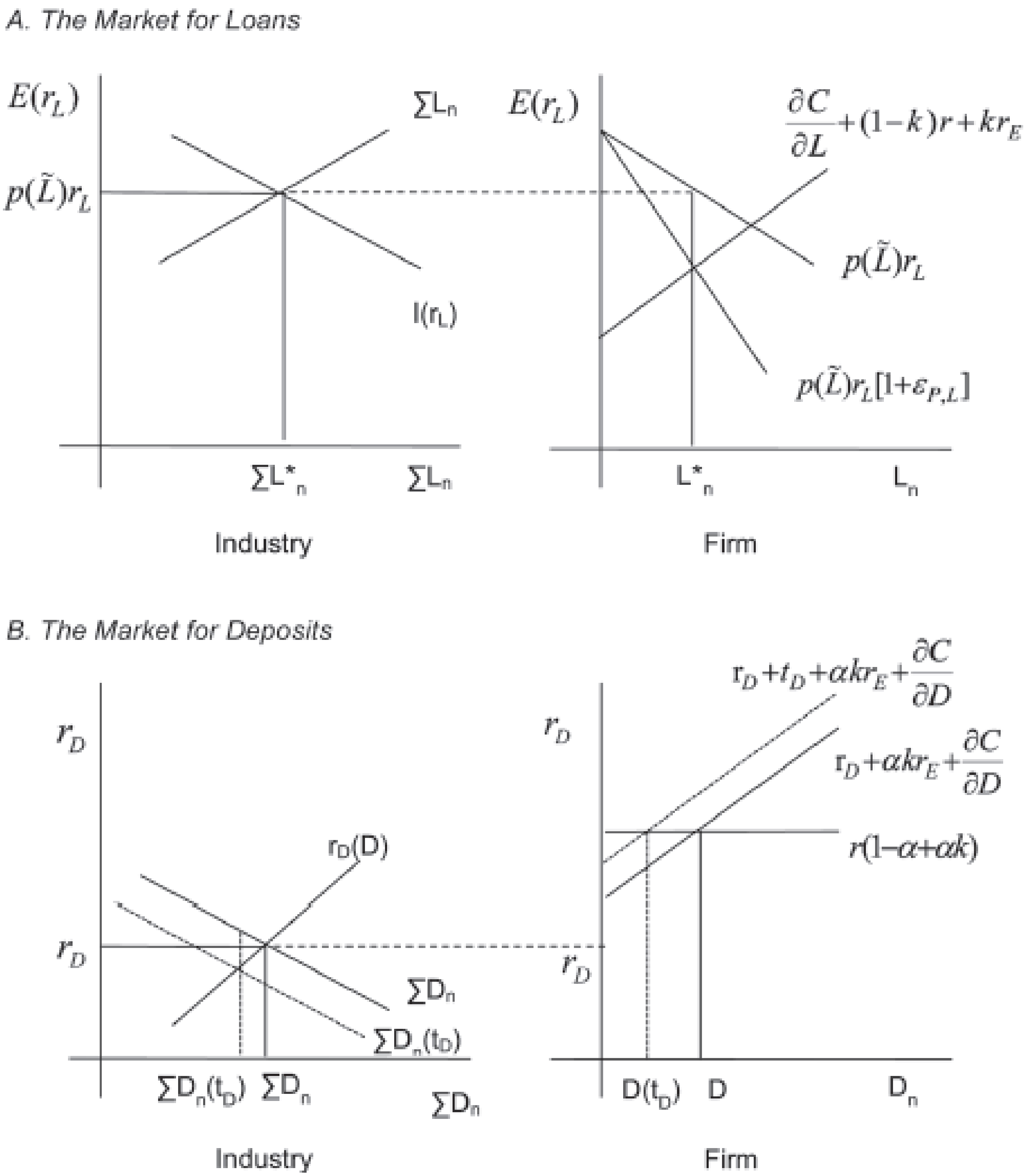
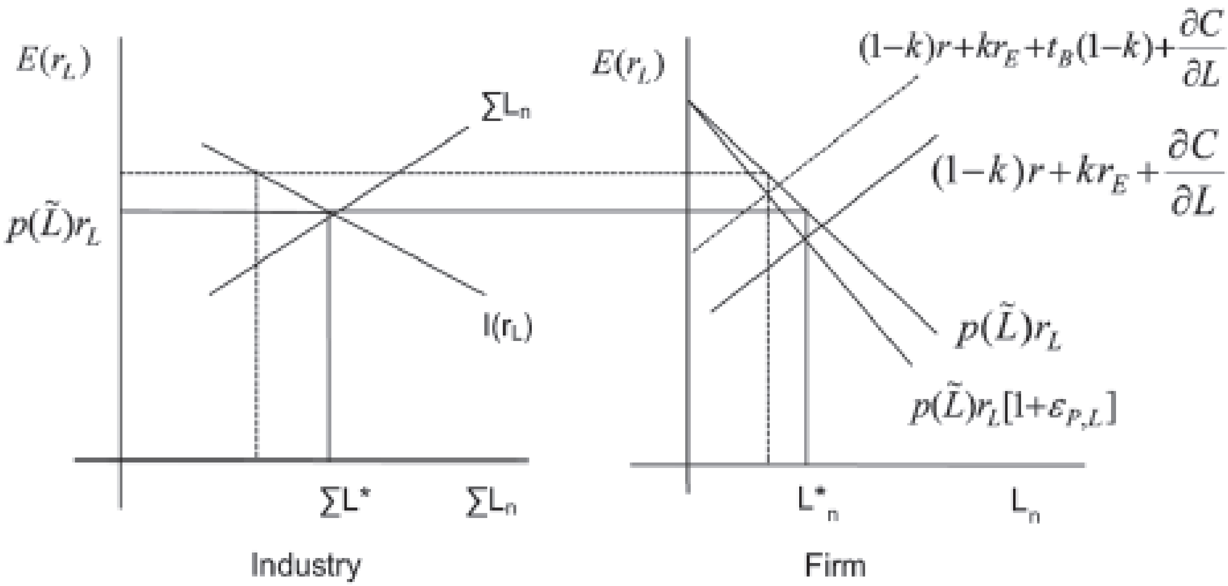


Figure 4
A Tax on Bank Liabilities

A. The Market for Loans



B. The Market for Deposits

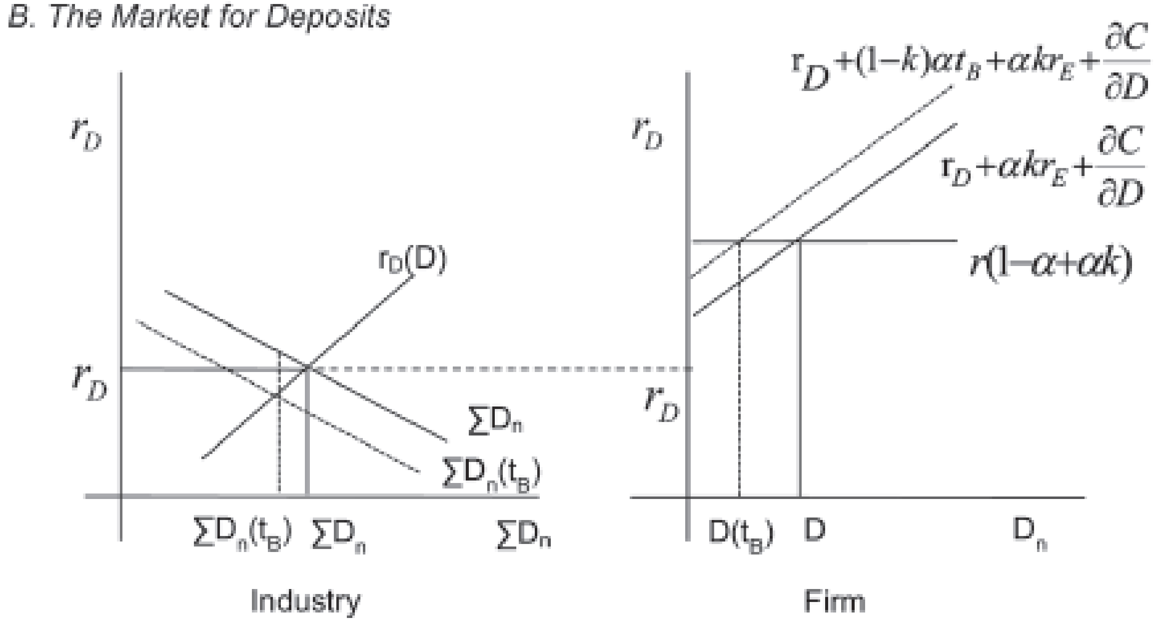
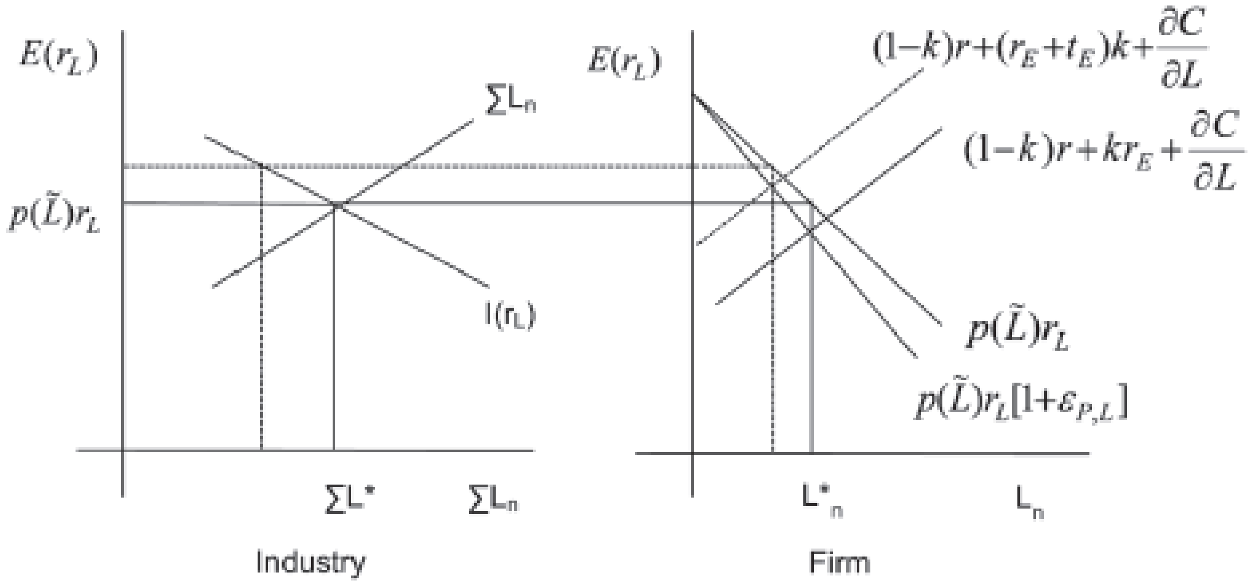


Figure 5

A Tax on Bank Equity

A. The Market for Loans



B. The Market for Deposits

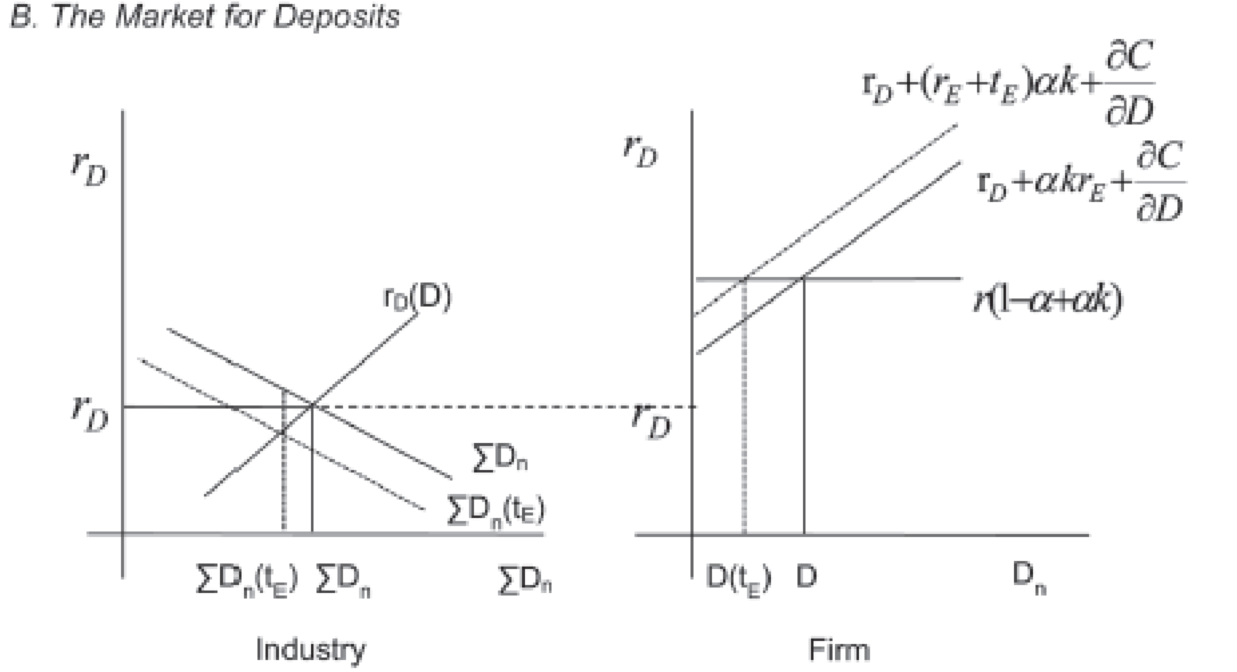
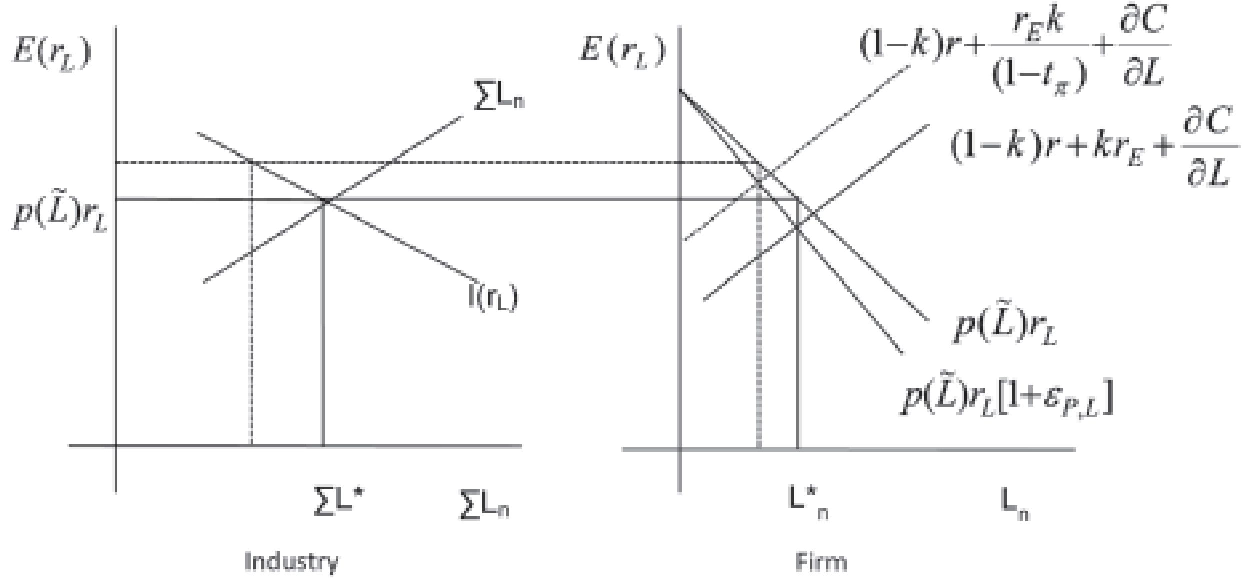


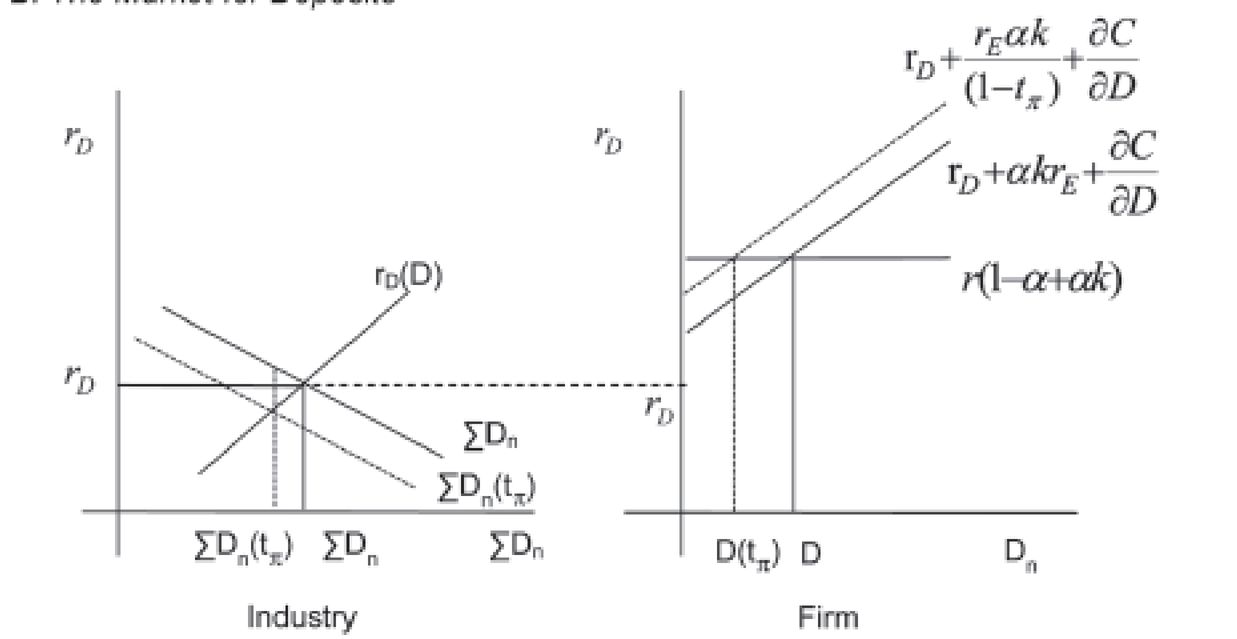
Figure 6

A Tax on Bank Profits, Equity Costs Not Deductible

A. The Market for Loans



B. The Market for Deposits



Appendix

The proofs follow directly from the first order conditions. Let ϕ_L represent the first order condition with respect to L and ϕ_D represent the first order condition with respect to D. Using the implicit function theorem leads to the following.

Proposition 1 Proof:

$$\text{(A1)}\quad \begin{aligned} \frac{\partial L}{\partial t_A} &= -\frac{\partial \phi_L / \partial t_A}{\partial \phi_L / \partial L} = -\frac{-1}{2r_L p'(L) + p''(L) r_L L - \partial^2 C / \partial L^2} < 0 \\ \frac{\partial D}{\partial t_A} &= -\frac{\partial \phi_D / \partial t_A}{\partial \phi_D / \partial D} = -\frac{0}{-p(L)[\partial^2 C / \partial D^2]} = 0 \end{aligned}$$

Proposition 2 Proof:

$$\text{(A2)}\quad \begin{aligned} \frac{\partial L}{\partial t_D} &= -\frac{\partial \phi_L / \partial t_D}{\partial \phi_L / \partial L} = -\frac{0}{2r_L p'(L) + p''(L) r_L L - \partial^2 C / \partial L^2} = 0 \\ \frac{\partial D}{\partial t_D} &= -\frac{\partial \phi_D / \partial t_D}{\partial \phi_D / \partial D} = -\frac{-1}{-\partial^2 C / \partial D^2} < 0 \end{aligned}$$

Proposition 3 Proof:

$$\text{(A3)}\quad \begin{aligned} \frac{\partial L}{\partial t_B} &= -\frac{\partial \phi_L / \partial t_B}{\partial \phi_L / \partial L} = -\frac{-(1-k)}{2r_L p'(L) + p''(L) r_L L - \partial^2 C / \partial L^2} < 0 \\ \frac{\partial D}{\partial t_B} &= -\frac{\partial \phi_D / \partial t_B}{\partial \phi_D / \partial D} = -\frac{-\alpha(1-k)}{-\partial^2 C / \partial D^2} < 0 \end{aligned}$$

Proposition 4 Proof:

$$\text{(A4)}\quad \begin{aligned} \frac{\partial L}{\partial t_E} &= -\frac{\partial \phi_L / \partial t_E}{\partial \phi_L / \partial L} = -\frac{-k}{2r_L p'(L) + p''(L) r_L L - \partial^2 C / \partial L^2} < 0 \\ \frac{\partial D}{\partial t_E} &= -\frac{\partial \phi_D / \partial t_E}{\partial \phi_D / \partial D} = -\frac{-\alpha k}{\partial^2 C / \partial D^2} < 0 \end{aligned}$$

Proposition 5 Proof:

(A5)
$$\frac{\partial L}{\partial t_\pi} = -\frac{\partial \phi_L / \partial t_\pi}{\partial \phi_L / \partial L} = -\frac{-\left[p(\bar{L})r_L + r_L L p'(L) - (1-k)r - C_L \right]}{(1-t_\pi)\left[2r_L p'(L) + p''(L) r_L L - \partial^2 C / \partial L^2 \right]} < 0$$
$$\frac{\partial D}{\partial t_\pi} = -\frac{\partial \phi_D / \partial t_\pi}{\partial \phi_D / \partial D} = -\frac{-\left[r_D + r(1-\alpha+\alpha k) - C_D \right]}{-(1-t_\pi)\partial^2 C / \partial D^2} < 0$$