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Do Bank Capital Requirements Make Resource Allocation Suboptimal?

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ABSTRACT

Bank capital requirements would entail large social costs if they made resource allocation suboptimal and banking services costly by unduly limiting the banks' ability to lend. This paper considers three main factors that may make capital requirements relevant, namely, deposit insurance subsidies, stock valuation errors, and tax shields derived from debt financing. The theoretical model analyzes the combined effects of the three factors on the banks' incentives to make fairly priced loans, which should also be socially optimal loans. A key finding is that the long-term cost of capital requirements is likely to be very small when deposit insurance is underpriced. Increased funding costs resulting from higher capital requirements are absorbed by shareholders of banks, rather than passed on to borrowers. Under some reasonable assumptions, higher capital requirements improve resource allocation by countervailing distortionary effects of deposit insurance subsidies. Short-term adjustment costs can still be large, but it should be relatively easy to mitigate the short-term effects.

KEYWORDS

Costs of Capital Requirements; Deposit Insurance; Stock mispricing; Tax shields

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1. Introduction

The minimum ratio of equity capital to assets (capital requirement) has been a primary means to limit the risk of bank failures in many countries. Recognizing the critical roles of bank capital in ensuring the stability of financial markets and leveling the banks' ability to compete, developed nations have been tightening, refining, and standardizing capital requirements through several rounds of Basle Accords.

There is little doubt that a higher capital ratio, holding asset quality constant, would make the banking sector more stable. A more challenging question is whether capital requirements involve significant costs that can countervail their benefits.

The widespread financial crisis of 2008 spurred movements to regulate financial markets more tightly, and in turn heightened interest in the benefits and costs of financial regulation, including capital requirements. It is complex to analyze the economic effects of financial regulation because financial intermediation has indirect and far-reaching effects. (See Alfon and Andrews (1999) and Goodhart et al. (2011) for discussion of issues surrounding the cost-benefit analysis of financial regulation.)

Despite complexities, many studies attempt to quantify the benefits and costs of capital requirements (e.g., Almenberg et al., 2017; Angelini et al., 2011; Bank for International Settlements, 2010; Basel Committee on Bank Supervision, 2010; Cline, 2017; Hanson et al., 2011; and Kashyap et al., 2010). In their analyses, the main benefit of a higher capital ratio is lower economic costs of financial crises, and the main cost is the loss of economic output resulting from reduced bank lending. A higher capital ratio makes financial crises less frequent and less severe, while in normal times it can reduce bank lending by increasing funding costs for banks.

Although most studies find that higher capital requirements produce a positive net benefit in the relevant range of capital ratios, the estimate of the net benefit varies widely across studies (Basel Committee on Banking Supervision, 2019). Researchers must make many assumptions to estimate the key components of benefits and costs, including the probability of a financial crisis, the expected output loss from a financial crisis, the funding cost for banks, and the effect of bank lending on economic output. Naturally, differing assumptions lead to differing estimates. To obtain a robust estimate, it is necessary to scrutinize each factor affected by capital requirements.

This paper focuses on the effect of capital requirements on bank lending. The key assumption in previous studies is that equity is more expensive than debt. Under this assumption, higher capital requirements increase banks' funding costs, and banks raise lending rates in response. Higher lending rates in turn reduce bank loans and economic output. Higher funding costs may also limit the banks' ability to create liquidity by making banks less competitive in the lending market (Van den Heuvel, 2008).

Based on Modigliani and Miller (1958) and later works, the capital ratio does not affect the weighted average cost of capital (WACC) in a frictionless market. The risk profiles of equity and debt change with the capital ratio. The costs of equity and debt adjust to changes in the risk profiles of equity and debt, such that the WACC remains constant. Previous studies focus on the tax advantage of debt financing (tax shield), which is the most widely recognized friction. Higher capital requirements increase the WACC by reducing the tax shield.

To analyze the effect of capital requirements more comprehensively, this paper also looks at deposit insurance subsidies and stock mispricing. Chan, Greenbaum, and Thakor (1992) show in a theoretical model that fairly priced deposit insurance is possible only in very limited circumstances. During normal times, it is difficult to estimate deposit insurance subsidies empirically because of significant tail risk. Park (2002) estimates that for many thrifts, the put option value derived from deposit insurance subsidies amounted to over 20 percent of their market values in the late 80's, when tail risk was realized. Deposit insurance subsidies are unique to the banking sector, and stock mispricing may matter more in the banking sector because the market value of bank assets is hard to evaluate and highly sensitive to economic conditions. Deposit insurance subsidies lower the cost of debt, and stock mispricing either increases or decreases the cost of equity.

Another contribution of this paper is the analysis of socially optimal lending decisions. Reduced lending does not necessarily decrease social welfare. It is a deviation from the optimal level of lending that decreases social welfare. Define the net present value (NPV) of a project as the project's net return discounted by the equilibrium return fully reflecting economic fundamentals (e.g., intertemporal preference, production technology, and risk), as opposed to the WACC for a specific entity. Then the level of investment should be optimal when the marginal investment is a zero-NPV project for all entities. When the effects of the three frictions are taken together, higher capital requirements could either take bank lending away from the optimal level or bring it closer to the optimal level. The incentive to make zero-NPV loans increases with the deposit insurance subsidy, the stock overvaluation, and the tax shield derived from debt financing. Suppose the following initial conditions: fairly priced deposit insurance, fairly priced stock, and the normal tax shield that makes the WACC equal to the equilibrium rate of return. In this situation, a decreased tax shield resulting from higher capital requirements would reduce the bank's incentive to make zero-NPV loans. With underpriced deposit insurance, however, higher capital requirements might incentivize banks to reduce negative-NPV loans, but not zero-NPV loans.

Based on comprehensive analyses of the three frictions, the long-term cost of bank capital requirements should be insignificant. It is a well-established result that the put option value arising from the underpricing of deposit insurance decreases with the capital ratio (the ratio of equity capital to assets) and increases with the variance of the asset return (Merton, 1977; and Park, 1997). Thus, higher capital requirements reduce the wealth of bank shareholders which consists of the intrinsic value of equity and the option value. Higher capital requirements, however, are unlikely to shrink the banking sector to a suboptimal size. For banks maximizing the wealth of existing shareholders, the optimal response to higher capital requirements, in most cases, is to raise equity rather than reduce zero-NPV loans. The negative effect of higher capital requirements on bank shares must be absorbed by existing shareholders, regardless of the method of meeting new capital requirements. Reducing zero-NPV loans and hence assets decreases the option value more than necessary because the option value increases with assets, holding the capital ratio and the variance of the asset return constant. As long as banks have the incentive to make zero-NPV loans, banks carry out their critical functions efficiently.

Under normal circumstances, reducing assets is rarely optimal. Conceptually, it is possible that the effect of seriously undervalued shares or the effect of an unusually small tax shield outweighs the effect of deposit insurance subsidies. These possibilities are of little practical significance unless regulators raise the minimum capital ratio in the midst of a financial crisis or raise it to a dramatic level. Serious stock undervaluation should be ad hoc and short-lived. Even with capital requirements, banks are highly leveraged.

The rest of the paper is organized as follows. The next section discusses the roles of banks and explains why the banks' incentive to make zero-NPV loans is the key to performing those roles efficiently. Section 3 presents a model showing how capital requirements affect the bank's lending decisions under various assumptions about the option value, stock mispricing, and the tax shield. Section 4 concludes.

2. Costs of Bank Capital requirements in Relation to the Roles of Banks

Since banks are financial intermediaries linking various economic agents, their economic contributions are mostly indirect, and their influences are far-reaching. To measure the economywide effects of capital requirements, therefore, one needs to identify the roles of banks and understand how capital requirements affect the banks' ability to fulfill those roles.

The roles of banks include resource allocation, liquidity creation, transaction facilitation, and risk taking. These roles are subject to serious disruptions: An unexpectedly large number of borrowers may default; depositors may lose confidence in banks; the payment system may be impaired by liquidity problems or technical glitches; and some banks may take excessive risks. Regulators aim to minimize these disruptions, while preserving the banks' ability to perform their key roles effectively and efficiently.

The most important type of bank regulation is safety and soundness regulation, of which capital requirements are a centerpiece. Perverse incentives or mismanagement of banks can lead to a financial crisis, which in turn seriously damages the entire economy. Thus, the main benefit of safety and soundness regulation is a reduced probability and/or reduced magnitude of the financial crisis. Regulations intended to prevent financial crises including capital requirements, however, could interfere with banks' ability to fulfill their key roles.

Social welfare is maximized when resources are allocated optimally between consumption and investment and among investment alternatives. A bank regulation is beneficial if it brings resource allocation closer to the optimum, and costly in the opposite case. An increase in investment is not necessarily beneficial. Reducing investment could be beneficial if there was overinvestment. Reducing bank loans could also be beneficial if other intermediaries would direct savings to more productive investments.

Banks create liquidity by pooling idiosyncratic liquidity needs in the form of demand deposits. With enhanced liquidity, individuals and businesses can more flexibly allocate resources. Provided that liquidity creation takes valuable resources, however, more liquidity is not necessarily better. Subsidizing liquidity creation may decrease social welfare. The welfare-maximizing quantity of liquidity is the one determined by an unfettered price mechanism. A regulation, however, could influence the efficiency of liquidity creation. Social welfare would improve (deteriorate) if the regulation decreased (increased) the total resources devoted by banks and other financial intermediaries to create a given amount of liquidity.

Banks facilitate the settlement of transactions through checks, credit cards, and electronic fund transfers. Facilitating transactions also consumes valuable resources. Thus, a lower price or a larger quantity resulting from subsidies may not improve social welfare. As in the case of liquidity creation, the key factor determining the benefits and costs of a regulation is its effect on cost efficiency.

Social welfare improves if more risks are born by individuals who are less risk-averse. Park (1996), for example, shows that deposit insurance increases the aggregate utility by transferring risks from risk-averse depositors to risk-neutral entrepreneurs. Bank shareholders are rewarded for offering deposits which are of low risk and making loans which are of relatively high risk. Social welfare would deteriorate, however, if banks take excessive risks to take advantage of deposit insurance. A good regulation should neither discourage banks from taking fairly priced risks nor allow them to take excessive risks.

The effectiveness of banks in performing their key roles discussed above critically depends on their incentive to make zero-NPV loans. Resource allocation is optimal when a zero-NPV investment is the marginal investment for every entity, including banks. If banks collectively reduce zero-NPV loans, some borrowers may be forced to pass up profitable investment opportunities, and resource allocation may become suboptimal. Given that the banking sector is huge, other financial intermediaries may fail to fulfill the loan demand unmet by banks. The literature on relationship lending (see Elyasiani and Goldberg (2004) for a survey of the literature) also suggests that other financial intermediaries may not make information-intensive loans in which banks specialize.

If banks are more efficient in creating liquidity and facilitating transactions, a decrease in zero-NPV loans implies higher costs of providing those services. With limited ability to make zero-NPV loans, banks would need fewer deposits and might provide less of those services. If the reduced supply had to be made up by less efficient providers, the cost efficiency would drop, and social welfare would decrease.

Limiting the banks' ability to make zero-NPV loans is equivalent to limiting their ability to take fairly priced risks. For small risk-averse savers, bank deposits might be a very efficient means to transfer risks. If they had to rely more on less efficient alternatives, social welfare would decrease.

Provided that the WACC depends on capital structure, capital requirements can significantly influence the lending decisions of banks. An increase in the banks' funding cost, however, does not necessarily decrease zero-NPV loans or social welfare. If deposit insurance is subsidized, for example, loan contractions induced by higher capital requirements can be limited to negative-NPV loans. Reducing negative-NPV investments would improve resource allocation. If banks had been passing on part of deposit insurance subsidies to depositors, forcing them to reduce risky loans might increase the prices of liquidity, transaction settlements, and risk transfer. Removing the subsidies for those activities should improve social welfare by eliminating excessive consumption of those services. Thus, the focus should be on zero-NPV loans.

In sum, the total cost of capital requirements critically depends on the banks' incentive to make zero-NPV loans. The cost is insignificant if banks do not reduce zero-NPV loans. Furthermore, reducing negative-NPV loans produces a benefit, rather than a cost.

3. Effects of Capital Requirements on Lending Decisions

This section first looks at the option value arising from deposit insurance subsidies and subsequently considers stock valuation and the tax shield. In the state-preference model presented below, the bank with an option value maximizes the wealth of existing shareholders. The key question to be addressed is how likely it is for the bank to reduce zero-NPV investments in response to higher capital requirements. For simplicity, the bank is assumed to make investment directly in production projects bypassing borrowing firms. Making zero-NPV loans leads to the same results with regard to resource allocation and the bank's ability to perform other roles.

3.1. The economy

In this two-period (period 1 and period 2) economy, period 2 can turns out to be either good or bad (two states of the world). There is only one good that can be either consumed or invested. Production technology exhibits constant returns to scale. One unit of the good invested in project G yields Y_G units in the good state and 0 in the bad state, while one unit invested in project B yields Y_B units in the bad state and 0 in the good state ($\pi_G Y_G > \pi_B Y_B$, where π_i is the probability that the state of the economy will be i in period 2). Prices are determined competitively. Thus, with constant returns to scale, the prices of one unit of the good to be delivered in the good state and in the bad state are $1/Y_G$ and $1/Y_B$, respectively, and all projects are zero-NPV projects. Since the price of a future good equals its present value, the discounting factors are Y_G for the good-state good and Y_B for the bad-state good.

One can eliminate risk in this economy by purchasing the equal units of the good-state good and the bad-state good. Thus, the per-unit price of the risk-free good is $1/Y_G + 1/Y_B$, and the risk-free return (1 plus the risk-free rate of return) is:

$$R_f = 1 + r_f = \frac{Y_G Y_B}{Y_G + Y_B} \tag{1}$$

Given that $\pi_G Y_G > \pi_B Y_B$, bad-state goods are more valuable. Thus, for a package containing n_G units of good-state goods and n_B units of bad-state goods, the discount factor is less than R_f if $\pi_B n_B$ is greater than $\pi_G n_G$, and it increases with the ratio of $\pi_G n_G$ to $\pi_B n_B$.

3.2. The bank

The Bank raises equity capital (K), takes deposits (D), and fully invests its assets (A = D + K) in projects G and B. The bank becomes insolvent in the bad state. The capital ratio (k = K/A) is determent by capital requirements. The share of the bank's assets invested in project G (α) is determined by the stringency of bank supervision. This paper assumes that α is fixed to focus on the effect of capital requirements. If regulators allowed the bank to increase the portfolio risk at its will, higher capital requirements would be ineffective in promoting the stability of financial markets.

The bank can meet higher capital requirements by raising equity or reducing assets. The bank makes the choice in the best interest of existing shareholders. The wealth of shareholders is:

$$SW = \frac{1}{Y_G}[\alpha A Y_G - R_D D] \tag{2}$$

where R_D is the gross return offered to depositors. Shareholders keep the difference between the return on assets and the payment to depositors $(\alpha A Y_G - R_D D)$ in the good state and receive nothing in the bad state. Thus, SW is the price of the good-state good times the number of the good-state good belonging to shareholders.

In a frictionless market, R_D is determined such that the wealth of depositors (DW) is the present value of deposits. That is, they get what they paid for. The wealth of depositors is:

$$DW = \frac{1}{Y_G} R_D D + \frac{1}{Y_B}(1-\alpha) A Y_B = D \tag{3}$$

Solving equation (3) for RD,

$$R_D = \frac{[D-(1-\alpha)A]Y_G}{D} = \frac{(\alpha - k)Y_G}{1-k} \tag{4}$$

Substituting this R_D into equation (2), SW = K. The Modigliani-Miller proposition holds in this framework. Everybody gets what he/she paid for, and capital structure does not matter. Deposit insurance does not change this result if it is fairly priced.

3.3. Subsidized deposit insurance

Now suppose that the government provides subsidized deposit insurance. Since deposits are fully insured, R_D is the risk-free return. The insurance premium is assumed to be zero, for simplicity.[1]

When $R_D = R_f$, from equations (1) and (2),

$$SW = \frac{1}{Y_G}[\alpha A Y_G - R_D D] = \alpha A - \frac{Y_B}{Y_G + Y_B}(1-k)A$$

$$= K + \frac{(\alpha - k)Y_G + (\alpha - 1)Y_B}{Y_G + Y_B} A \tag{5}$$

Defining $\frac{(\alpha - k)Y_G + (\alpha - 1)Y_B}{Y_G + Y_B} A \equiv ovA \equiv OV$

$$SW = K + OV \tag{6}$$

The wealth of shareholders consists of K, which is the intrinsic value of equity, and OV, which is the option value arising from deposit insurance subsidies (wealth transfer from the deposit insurer to bank shareholders).

Proposition 1. Holding the capital ratio and the asset composition constant, the option value increases with assets.

[1] It is analytically simple to introduce a deposit insurance premium as a fraction of deposits. Provided that the premium is below the fair level, all results will be qualitatively the same. This model can easily accommodate the case of over-priced deposit insurance. In that case, the bank could not make zero-NPV loans unless over-priced deposit insurance were countervailed by over-priced stock and/or an above-normal tax shield.

It is rather intuitive that the option value, which arises from subsidized deposit insurance, increases with insured deposits and hence assets. It can be shown that ov, which is not a function of A, is positive, given that the bank fails in the bad state. Thus, $\partial OV/\partial A > 0$.

3.4. Maximizing the wealth of existing shareholders

The wealth of existing shareholders depends on exogenous factors affecting the option value and the division of shareholder wealth between existing shareholders and new shareholders. Since the portfolio risk (α) is held constant by bank supervision, the key exogenous factor is capital requirements determining the capital ratio (k). The only decision that the bank makes in this model is whether it issues new equity or reduce assets to meet the capital requirement.

This section focuses on the effect of stock valuation errors arising from asymmetric information between the bank's managers and investors, which can force managers to pass up good investment opportunities (Myers and Majluf, 1984). While bank managers with inside information know the true value of the bank, investors must estimate the value based on publicly available information.

The wealth of existing shareholders (SW_{ext}) is the difference between total shareholder wealth (SW_{ttl}) and the wealth of new shareholders (SW_{new}). Suppose that investors undervalue the shareholder value of the bank by a fraction ε ($-\infty < \varepsilon < 1$) of SW_{ttl}. Then SWext after changes in the capital requirement and assets is:

$$SW_{ext} = K_{aft} + OV_{aft} - \frac{K_{aft} - K_{bfr}}{(1-\varepsilon)\left(K_{aft} + OV_{aft}\right)}\left(K_{aft} + OV_{aft}\right)$$

$$= K_{bfr} + OV_{bfr} + \Delta OV - \frac{\varepsilon}{(1-\varepsilon)}\Delta K \tag{7}$$

where subscripts aft and bfr denote after and before changes, $\Delta OV = OV_{aft} - OV_{bfr}$, and $\Delta K = K_{aft} - K_{bfr}$. After changes, SW_{ttl} is $K_{aft} + OV_{aft}$. Investors providing ΔK of equity to the bank price the bank's shares based on their estimate of SW_{ttl}, such that the estimated value of their shares to be ΔK. When the estimate of SW_{ttl} is $(1 - \varepsilon)SW_{ttl}$, the portion of SW_{ttl} belonging to new shareholders must be $\Delta K/[(1 - \varepsilon)SW_{ttl}]$ to make the estimated SWnew equal to ΔK. The last term of equation (7) may be interpreted as wealth transfer from existing shareholders to new shareholders. If investors underestimate the shareholder value of the bank by 50 percent ($\varepsilon = 0.5$), then to raise ΔK, the bank is forced to give shares that are worth $2\Delta K$ to new shareholders. Then existing shareholders lose ΔK and new shareholders unknowingly gain ΔK. Thus, SW_{ext} is determined by the initial wealth, the change in the option value, and the wealth transfer to (from if $\varepsilon < 0$) new shareholders.

If the bank reduces assets instead of raising capital, ΔK is zero, and OV_{aft} is smaller by Proposition 1. Holding k constant, the difference in SW_{ext} between the case of raising equity (high-asset case) and the case of reducing assets (low-asset case):

$$SW_{ext\uparrow} - SW_{ext\downarrow} = OV_{aft\uparrow} - OV_{aft\downarrow} - \frac{\varepsilon}{(1-\varepsilon)}\Delta K \tag{8}$$

where subscripts ↑ and ↓ respectively denote the case of raising equity and the case of reducing assets. The optimal strategy depends on the effect of assets on the option value and the size of the valuation error. This result leads to the following proposition.

Proposition 2. Raising equity is the optimal strategy as long as the negative effect of the stock valuation error on the wealth of existing shareholders does not outweigh the positive effect of the option value.

The following lemmas show that raising equity is optimal in most cases.

Lemma 1. Holding the capital ratio constant, pursuing growth by raising equity is the optimal strategy if the magnitude of stock undervaluation is smaller than the option value [$\varepsilon(K_{aft} + OV_{aft}) < OV_{aft}$].

See Appendix 1 for proof. Based on Lemma 1, the capital requirement is not a major deterrence to the bank's growth in the normal course of business. In a growing economy where insured deposits and loan demand increase, the bank will grow unless its stock is significantly undervalued.

Lemma 2. When the bank's stock is fairly valued ($\varepsilon = 0$), a higher capital requirement decreases the wealth of existing shareholders, regardless of the method of meeting the new capital requirement. The decrease is larger when the bank reduces assets.

See Appendix 2 for proof. Since investors demand the market return, existing shareholders must absorb all shocks to the shareholder value, barring valuation errors. Thus, when a higher capital requirement reduces the option value, the wealth of existing shareholders decreases as much as the decrease in the option value. Since OV is a decreasing function of k and an increasing function of A, reducing assets results in a larger decrease in OV and hence a larger decrease in SW_{ext}. Thus, issuing equity is the optimal strategy in this case.

Lemma 3. In meeting a higher capital requirement, it is optimal for the bank to raise equity if the magnitude of stock undervaluation is smaller than the option value [$\varepsilon(K_{aft} + OV_{aft}) < OV_{aft}$].

See Appendix 3 for Proof. Even when the negative effect of a higher capital requirement is compounded by stock undervaluation, the bank does not necessarily reduce zero-NPV investments. Fundamentally, higher capital requirements should not matter unless there is a market friction. A possible market friction is stock undervaluation. However, it is countervailed by another market friction, namely, subsidized deposit insurance.

3.5. Tax Advantage of Debt Financing

While stock valuation errors may significantly affect financing and investment decisions in the short run, the tax advantage of debt financing may be the most widely recognized factor affecting the funding cost in the longer run. Since interest payment is tax-deductible, a higher capital requirement might raise the weighted average cost of capital and reduce investment.

A key assumption in this paper is that in the absence of other frictions, there exists a critical capital ratio ($0 < k^* < 1$) corresponding to the normal tax shield at which the weighted average cost of capital is consistent with the zero-NPV investment. In other words, for a corporation with a capital ratio k^*, the after-tax funding cost equals the equilibrium return. Provided that the tax effect is not offset by other factors, therefore, the funding cost is abnormally high (low) for corporations with a capital ratio higher (lower) than k^*.

With the tax shield, shareholder wealth:

$$SW = K + OV + \beta(k^* - k)A \tag{9}$$

where β is a positive constant. The difference between the tax shield for the bank and the normal tax shield is capitalized; an above-normal tax shield ($k < k^*$) adds to the wealth of shareholders, and a below-normal tax shield ($k > k^*$) subtracts from the wealth of shareholders.

Under this assumption, what matters is the relative tax advantage. In other words, the tax disadvantage of equity financing matters only if it is abnormally large or abnormally small.

Define $TS \equiv \beta(k^* - k)A$. Then:

$$\frac{\partial TS}{\partial k} = -\beta A \text{ and } \frac{\partial TS}{\partial A} = \beta(k^* - k) \tag{10}$$

The tax shield derived from debt financing decreases with the capital ratio, and it increases with assets if the bank's capital ratio is lower than the critical level and decreases with assets if the bank's capital ratio is higher than the critical level.

Suppose that a change in the capital requirement have changed OV and TS and that the bank issues new equity at the fair price (ε = 0). Then the wealth of new shareholders,

$$SW_{new} = \frac{\Delta K}{K_{bfr} + \Delta K + OV_{aft} + TS_{aft}}\left(K_{bfr} + \Delta K + OV_{aft} + TS_{aft}\right) = \Delta K \tag{11}$$

The wealth of existing shareholders,

$$SW_{ext} = shareholders\ \frac{K_{bfr} + OV_{aft} + TS_{aft}}{K_{bfr} + \Delta K + OV_{aft} + TS_{aft}}\left(K_{bfr} + \Delta K + OV_{aft} + TS_{aft}\right)$$

$$= K_{bfr} + OV_{aft} + TS_{aft} \tag{12}$$

Since new shareholders demand the market return, the price of new shares fully reflect the change in TS. Barring other market frictions, therefore, existing shareholders must fully absorb the change in TS. This result leads to the following proposition.

Proposition 3. Raising equity is the optimal strategy as long as the sum of the negative effects of the stock valuation error and the tax shield on the wealth of existing shareholders does not outweigh the positive effect of the option value.

As shown above, the option value, the wealth transfer to new shareholders, and the tax shield all change with assets. Holding other things constant, at a higher level of assets, the option value is larger, the wealth transfer to new shareholders is larger if the bank's stock is undervalued, and the tax shield is smaller if the bank's capital ratio is higher than k*. If the stock is overvalued and the capital ratio is lower than k*, both the effect of the wealth transfer and the effect of the tax shield on the wealth of existing shareholders are positive, and raising equity is unambiguously the optimal strategy. If only one of the two effects is negative (either stock undervaluation or a capital ratio higher than k*), the combined effect is indeterminate in sign and smaller in magnitude than the effect of any one factor. With both stock undervaluation and a capital ratio higher than k*, the combined negative effect is the largest. Even in this case, issuing equity is still the optimal strategy if the effect of the option value outweighs the sum of the two negative effects. The lemmas below clarify this point in a more rigorous manner.

Lemma 4. Holding the capital ratio constant, pursuing growth by raising equity and increasing assets is the optimal strategy if the magnitude of stock undervaluation is smaller than the sum of the option value and the tax shield [$\varepsilon(K_{aft} + OV_{aft} + TS_{aft}) < (OV_{aft} + TS_{aft})$].

See Appendix 4 for proof. To clarify proposition 3, the combined negative effect of the stock valuation error and the tax shield is [$\varepsilon(K_{aft} + OV_{aft} + TS_{aft}) - TS_{aft}$]. The combined negative effect is larger when the bank's stock is undervalued ($\varepsilon > 0$) and when the tax shield is smaller than the normal tax shield ($TS_{aft} < 0$). Even in this case, raising equity is the optimal strategy if the effect of the option value is larger the combined negative effect, that is, if $OV_{aft} > \varepsilon(K_{aft} + OV_{aft} + TS_{aft}) - TS_{aft}$.

Lemma 5. When the bank's stock is fairly valued (ε = 0), a higher capital requirement decreases the wealth of existing shareholders, regardless of the method of meeting the new capital requirement. Relative to the case of reducing assets, raising equity results in a smaller decrease if its positive effect on the option value outweighs the possible negative effect on the tax shield. [$(OV_{aft}\uparrow - OV_{aft}\downarrow) > -(TS_{aft}\uparrow - TS_{aft}\downarrow)$].

See Appendix 5 for proof. As in the case considering only the option value, existing shareholders must absorb all shocks to the shareholder value when new shareholders receive the market return. A higher capital ratio decreases both the option value and the tax shield. Thus, existing shareholders cannot avoid the loss. When the bank raises equity instead of reducing assets, the loss in option value is smaller, while the loss in tax shield can be either smaller (if $k_{aft} < k^*$) or larger (if $k_{aft} > k^*$). Thus, the combined loss is smaller as long as the option value gain exceeds the possible tax shield loss resulting from the increase in assets. To induce the bank to choose asset reduction over equity issuance, the tax disadvantage for the bank relative to other corporations may have to be large.

Lemma 6. In meeting a higher capital requirement, it is optimal for the bank to raise equity if the magnitude of stock undervaluation is smaller than the sum of the option value and the tax shield [$\varepsilon(K_{aft} + OV_{aft}\uparrow + TS_{aft}\uparrow) < (OV_{aft}\uparrow + TS_{aft}\uparrow)$].

See Appendix 6 for proof. The qualitative result is similar to that without the tax effect. The option value strengthens the bank's incentive to expand. It also functions as a buffer against external factors that discourage expansion, namely, higher capital requirements and stock undervaluation. The tax effect reinforces the effect of the option value if the bank's capital ratio is lower than the critical level, and it weakens the effect of the option value in the opposite case.

4. Conclusion

This paper has analyzed the effect of bank capital requirements on bank lending in relation to deposit insurance, stock valuation, and corporate taxation. While bank capital requirements can amplify some market frictions, they are intended to counter an important market friction, namely the option value arising from deposit insurance subsidies. Stock undervaluation and corporate taxation can cause bank capital requirements to constrain bank lending by raising the cost of equity financing. The option value functions as a buffer. Even in adverse circumstances for a bank where its stock is undervalued and the tax shield becomes smaller, the bank will not reduce zero-NPV loans as long as the option value is large enough to offset the negative effects of other factors on shareholder wealth. Higher capital requirements reduce the wealth of existing shareholders, and the wealth reduction cannot be avoided by reducing assets. When the option value is substantial, raising equity results in a smaller loss unless the bank's stock is significantly undervalued and/or the tax shield for the bank is exceptionally small.

Based on this analysis, the long-term cost of bank capital requirements should be insignificant. Capital requirements entail large social costs if they interfere with key roles of banks that other financial intermediaries cannot perform as efficiently as banks. When banks have the incentive to make zero-NPV loans, they allocate resources optimally and provide banking services efficiently. In the long run, capital requirements are unlikely to reduce the banks' incentive to make zero-NPV loans. In most circumstances, the option value is likely to be positive, considering the difficulty of pricing deposit insurance fairly. Chronic and significant stock undervaluation is unlikely, as all information should become public eventually. Given that banks are highly leveraged, it is also unlikely that the tax shield is significantly smaller for banks than for other corporations.

The short-term cost, however, could still be substantial if adapting to new capital requirements caused a serious disruption in the economy. In the short run, stocks of some banks could be significantly undervalued, especially during an economic downturn, forcing them to pass up zero-NPV loans instead of raising equity. With a significant option value, banks might have made some negative-NPV loans. If higher capital requirements induced banks to reduce those loans, it would improve long-term resource allocation and economic wellbeing. Abrupt loan contractions, however, could disrupt the economy. These short-term effects could be mitigated by some policy efforts. Short-term stock undervaluation should not matter much if banks were given a sufficient time to raise equity. Monetary and fiscal policies could counter temporary negative effects of reducing negative-NPV loans.

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The author claims that the manuscript is completely original. The author also declares no conflict of interest.

Appendix 1: Proof of Lemma 1

Increasing assets is optimal if $SW_{ext\uparrow} > SW_{ext\rightarrow}$, where $\rightarrow$ denotes the case of no change in assets. With no change,

$$SW_{ext\rightarrow} = K_{bfr} + OV_{bfr}$$

When the bank issues equity and increases assets,

$$SW_{new} = \frac{\Delta K}{(1-\varepsilon)(K_{bfr} + \Delta K + OV_{aft})}\left(K_{bfr} + \Delta K + OV_{aft}\right)$$

$$SW_{ext\uparrow} = \left(1 - \frac{\Delta K}{(1-\varepsilon)\left(K_{bfr} + \Delta K + OV_{aft}\right)}\right)\left(K_{bfr} + \Delta K + OV_{aft}\right)$$

$$Since\ A_{bfr} = \frac{K_{bfr}}{k}\ and\ A_{aft} = \frac{K_{bfr} + \Delta K}{k},\ OV_{bfr} = \frac{K_{bfr}}{K_{bfr} + \Delta K} OV_{aft}$$

$SW_{ext\uparrow} > SW_{ext\rightarrow}$ if:

$$1 - \frac{\Delta K}{(1-\varepsilon)\left(K_{bfr} + \Delta K + OV_{aft}\right)} > \frac{K_{bfr} + OV_{bfr}}{K_{bfr} + \Delta K + OV_{aft}}$$

Solving for ε and substituting $\frac{K_{bfr}}{K_{bfr}+\Delta K} OV_{aft}$ for OV_{bfr},

$$\varepsilon < 1 - \frac{\Delta K}{\Delta K + (OV_{aft} - OV_{bfr})} = \frac{(OV_{aft} - OV_{bfr})}{\Delta K + (OV_{aft} - OV_{bfr})}$$

$$= \frac{\frac{\Delta K}{K_{bfr} + \Delta K} OV_{aft}}{\Delta K + \frac{\Delta K}{K_{bfr} + \Delta K} OV_{aft}} = \frac{OV_{aft}}{K_{aft} + OV_{aft}}$$

The magnitude of undervaluation that reduces $SW_{ext\uparrow}$ to $SW_{ext\rightarrow}$ is: $\varepsilon(K_{aft} + OV_{aft}) = OV_{aft}$.
Therefore, raising equity is the optimal strategy if the magnitude of undervaluation is less than OV_{aft}.

Appendix 2: Proof of Lemma 2

At the initial capital ratio k_{bfr},

$$SW_{ext} = K_{bfr} + OV_{bfr}$$

When the bank raises equity at the fair value,

$$SW_{new} = \frac{\Delta K}{K_{bfr} + \Delta K + OV_{aft\uparrow}}\left(K_{bfr} + \Delta K + OV_{aft\uparrow}\right) = \Delta K$$

$$SW_{ext\uparrow} = \frac{K_{bfr} + OV_{aft\uparrow}}{K_{bfr} + \Delta K + OV_{aft\uparrow}}\left(K_{bfr} + \Delta K + OV_{aft\uparrow}\right) = K_{bfr} + OV_{aft\uparrow}$$

Holding insured deposits constant, $\Delta A_{\uparrow} = \Delta K$, $A_{aft\uparrow} = A_{bfr} + \Delta K$, and $k_{aft} = \frac{K_{bfr}+\Delta K}{A_{bfr}+\Delta K}$

When $k_{aft} = \frac{K_{bfr}+\Delta K}{A_{bfr}+\Delta K}$, $\Delta K = \frac{k_{aft}-k_{bfr}}{1-k_{aft}}$ and $A_{aft} = \frac{1-k_{bfr}}{1-k_{aft}} A_{bfr}$. Then:

$$OV_{aft\uparrow} = \frac{\left(\alpha - k_{aft}\right)Y_G + (\alpha - 1)Y_B}{Y_G + Y_B}\left(A_{bfr} + \Delta K\right) + OV_{bfr} - OV_{bfr}$$

$$= OV_{bfr} - \frac{(k_{aft} - k_{bfr})Y_G}{Y_G + Y_B} A_{bfr} + \frac{(\alpha - k_{aft})Y_G + (\alpha - 1)Y_B}{Y_G + Y_B} \frac{k_{aft} - k_{bfr}}{1 - k_{aft}} A_{bfr}$$

$$= OV_{bfr} - \frac{(1-\alpha)(k_{aft} - k_{bfr})}{1 - k_{aft}} A_{bfr} < OV_{bfr}$$

If the bank reduces assets instead of raising capital,

$$SW_{ext\downarrow} = K_{bfr} + OV_{aft\downarrow}$$

Since $A_{aft\downarrow} = \frac{k_{bfr}}{k_{aft}} A_{bfr}$, $\Delta A_{\downarrow} = A_{aft\downarrow} - A_{bfr} = -\frac{k_{aft}-k_{bfr}}{k_{aft}} A_{bfr}$ $and\ A_{aft\downarrow} = A_{bfr} - \frac{k_{aft}-k_{bfr}}{k_{aft}} A_{bfr} = \frac{k_{bfr}}{k_{aft}} A_{bfr}$.

Then:

$$OV_{aft\downarrow} = \frac{(\alpha - k_{aft})Y_G + (\alpha - 1)Y_B}{Y_G + Y_B} \frac{k_{bfr}}{k_{aft}} + OV_{aft\uparrow} - OV_{aft\uparrow}$$

$$= OV_{aft\uparrow} + \frac{(1-\alpha)(k_{aft} - k_{bfr})}{1 - k_{aft}} \frac{k_{bfr}}{k_{aft}} A_{bfr}$$

$$- \frac{(1-\alpha)(k_{aft} - k_{bfr})}{1 - k_{aft}} \frac{1 - k_{bfr}}{1 - k_{aft}} A_{bfr}$$

$$= OV_{aft\uparrow} - \frac{(\alpha - k_{aft})Y_G + (\alpha - 1)Y_B}{Y_G + Y_B} \frac{k_{aft} - k_{bfr}}{(1 - k_{aft})k_{aft}} A_{bfr} < OV_{aft\uparrow}$$

Therefore, $OV_{bfr} < OV_{afr\uparrow} < OV_{afr\downarrow}$ and $SW_{ext} < SW_{ext\uparrow} < SW_{ext\downarrow}$.

Appendix 3: Proof of Lemma 3

Raising equity is optimal if it $SW_{ext\uparrow} > SW_{ext\downarrow}$.

$$SW_{new} = \frac{\Delta K}{(1-\varepsilon)(K_{bfr} + \Delta K + OV_{aft\uparrow})} (K_{bfr} + \Delta K + OV_{aft\uparrow})$$

$$SW_{ext\uparrow} = (1 - \frac{\Delta K}{(1-\varepsilon)(K_{bfr} + \Delta K + OV_{aft\uparrow})})(K_{bfr} + \Delta K + OV_{aft\uparrow})$$

$$SW_{ext\downarrow} = K_{bfr} + OV_{aft\downarrow}$$

$$Since\ A_{aft\downarrow} = \frac{K_{bfr}}{k_2}\ and\ A_{aft\uparrow} = \frac{K_{bfr} + \Delta K}{k_2}, OV_{aft\downarrow} = \frac{K_{bfr}}{K_{bfr} + \Delta K} OV_{aft\uparrow}$$

$SW_{ext\uparrow} > SW_{ext\downarrow}$ if:

$$1 - \frac{\Delta K}{(1-\varepsilon)(K_{bfr} + \Delta K + OV_{aft\uparrow})} > \frac{K_{bfr} + OV_{aft\downarrow}}{K_{bfr} + \Delta K + OV_{aft\uparrow}}$$

Solving for ε and substituting $\frac{K_{bfr}}{K_{bfr}+\Delta K} OV_{aft\uparrow}$ for $OV_{aft\downarrow}$,

$$\varepsilon < 1 - \frac{\Delta K}{\Delta K + (OV_{aft\uparrow} - OV_{aft\downarrow})} = \frac{(OV_{aft\uparrow} - OV_{aft\downarrow})}{\Delta K + (OV_{aft\uparrow} - OV_{aft\downarrow})}$$

$$= \frac{\frac{\Delta K}{K_{bfr} + \Delta K} OV_{aft\uparrow}}{\Delta K + \frac{\Delta K}{K_{bfr} + \Delta K} OV_{aft\uparrow}} = \frac{OV_{aft\uparrow}}{K_{bfr} + \Delta K + OV_{aft\uparrow}}$$

The magnitude of undervaluation that reduces $SW_{ext\uparrow}$ to $SW_{ext\downarrow}$ is: $\varepsilon(K_{aft} + OV_{aft\uparrow}) = OV_{aft\uparrow}$.

Therefore, raising equity is the optimal strategy if the magnitude of undervaluation is smaller than $OV_{aft\uparrow}$.

Appendix 4: Proof of Lemma 4

Increasing assets is optimal if it $SW_{ext\uparrow} > SW_{ext\rightarrow}$. With no change,

$$SW_{ext\rightarrow} = K_{bfr} + OV_{bfr} + TS_{bfr}$$

When the bank issues equity and increases assets,

$$SW_{new} = \frac{\Delta K}{(1-\varepsilon)(K_{bfr} + \Delta K + OV_{aft} + TS_{aft})}\left(K_{bfr} + \Delta K + OV_{aft} + TS_{aft}\right)$$

$$SW_{ext\uparrow} = \left(1 - \frac{\Delta K}{(1-\varepsilon)\left(K_{bfr} + \Delta K + OV_{aft} + TS_{aft}\right)}\right)\left(K_{bfr} + \Delta K + OV_{aft} + TS_{aft}\right)$$

$$Since\ A_{bfr} = \frac{K_{bfr}}{k}\ and\ A_{aft} = \frac{K_{bfr} + \Delta K}{k}$$

$$OV_{bfr} = \frac{K_{bfr}}{K_{bfr} + \Delta K} OV_{aft}\ and\ TS_{bfr} = \frac{K_{bfr}}{K_{bfr} + \Delta K} TS_{aft}$$

$SW_{ext\uparrow} > SW_{ext\rightarrow}$ if:

$$1 - \frac{\Delta K}{(1-\varepsilon)\left(K_{bfr} + \Delta K + OV_{aft} + TS_{aft}\right)} > \frac{K_{bfr} + OV_{bfr} + TS_{bfr}}{K_{bfr} + \Delta K + OV_{aft} + TS_{aft}}$$

Solving for ε and substituting $\frac{K_{bfr}}{K_{bfr}+\Delta K} OV_{aft}$ for OV_{bfr} and $\frac{K_{bfr}}{K_{bfr}+\Delta K} TS_{aft}$ for TS_{bfr},

$$\varepsilon < 1 - \frac{\Delta K}{\Delta K + (OV_{aft} - OV_{bfr}) + (TS_{aft} - TS_{bfr})}$$

$$= \frac{(OV_{aft} - OV_{bfr}) + (TS_{aft} - TS_{bfr})}{\Delta K + (OV_{aft} - OV_{bfr}) + (TS_{aft} - TS_{bfr})}$$

$$= \frac{\frac{\Delta K}{K_{bfr} + \Delta K}(OV_{aft} + TS_{aft})}{\Delta K + \frac{\Delta K}{K_{bfr} + \Delta K}(OV_{aft} + TS_{aft})} = \frac{OV_{aft} + TS_{aft}}{K_{aft} + OV_{aft} + TS_{aft}}$$

The magnitude of undervaluation that reduces $SW_{ext\uparrow}$ to $SW_{ext\rightarrow}$ is: $\varepsilon(K_{aft} + OV_{aft} + TS_{aft}) = OV_{aft} + TS_{aft}$.

Therefore, increasing assets is the optimal strategy if the magnitude of undervaluation is smaller than $OV_{aft} + TS_{aft}$.

Appendix 5: Proof of Lemma 5

At the initial capital ratio k_{bfr}, $SW_{ext} = K_{bfr} + OV_{bfr} + TS_{bfr}$.

When the bank raises equity at the fair value,

$$SW_{new} = \frac{\Delta K}{K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}}\left(K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}\right) = \Delta K$$

$$SW_{ext\uparrow} = \frac{K_{bfr} + OV_{aft\uparrow} + TS_{aft\uparrow}}{K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}}\left(K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}\right)$$

$$= K_{bfr} + OV_{aft\uparrow} + TS_{aft\uparrow}$$

$OV_{aft\uparrow}$ is the same as the one derived in the proof of lemma 2. Also from the proof of lemma 2, $\Delta A_{\uparrow} = \Delta K = \frac{k_{aft} - k_{bfr}}{1 - k_{aft}} A_{bfr}$. Then:

$$TS_{aft\uparrow} = \beta\left(k^* - k_{aft}\right)A_{aft\uparrow} + TS_{bfr} - TS_{bfr}$$

$$= TS_{bfr} + \beta\left(k^* - k_{aft}\right)(1 + \frac{k_{aft} - k_{bfr}}{1 - k_{aft}})A_{bfr} - \beta\left(k^* - k_{bfr}\right)A_{bfr}$$

$$= TS_{bfr} - \beta\left(k_{aft} - k_{bfr}\right)A_{bfr} + \beta\left(k^* - k_{aft}\right)\frac{\left(k_{aft} - k_{bfr}\right)}{1 - k_{aft}} A_{bfr}$$

$$= TS_{bfr} - \beta\big(k_{aft} - k_{bfr}\big)\frac{(1-k^*)}{1-k_{aft}}A_{bfr} < TS_{bfr}$$

If the bank reduces assets instead of raising equity,

$$SW_{ext\downarrow} = K_{bfr} + OV_{aft\downarrow} + TS_{aft\downarrow}$$

$OV_{aft\downarrow}$ is the same as the one derived in the proof of lemma 2. Also from the proof of lemma 2, $\Delta A_{\downarrow} = -\frac{k_{aft}-k_{bfr}}{k_{aft}}A_{bfr}$. Then:

$$TS_{aft\downarrow} = \beta\big(k^* - k_{aft}\big)A_{aft\downarrow} + TS_{bfr} - TS_{bfr}$$

$$= TS_{bfr} + \beta\big(k^* - k_{aft}\big)(1 - \frac{k_{aft} - k_{bfr}}{k_{aft}})A_{bfr} - \beta\big(k^* - k_{bfr}\big)A_{bfr}$$

$$= TS_{bfr} - \beta\big(k_{aft} - k_{bfr}\big)A_{bfr} - \beta\big(k^* - k_{aft}\big)\frac{k_{aft} - k_{bfr}}{k_{aft}}A_{bfr}$$

$$= TS_{bfr} - \beta\big(k_{aft} - k_{bfr}\big)\frac{k^*}{k_{aft}}A_{bfr} < TS_{bfr}$$

Subtracting $SW_{aft\downarrow}$ from $SW_{aft\uparrow}$, $SW_{aft\uparrow} - SW_{aft\downarrow} = (OV_{aft\uparrow} - OV_{aft\downarrow}) + (TS_{aft\uparrow} - TS_{aft\downarrow})$.

From lemma 2, $OV_{aft\uparrow} - OV_{aft\downarrow}$.

$TS_{aft}\uparrow - TS_{af}t\downarrow < 0$ if $k_{aft} > k^*$, and $TS_{aft}\uparrow - TS_{aft}\downarrow > 0$ if $k_{aft} < k^*$.

$$TS_{aft\uparrow} - TS_{aft\downarrow} = \beta\big(k^* - k_{aft}\big)\frac{1-k_{bfr}}{1-k_{aft}}A_{bfr} - \beta\big(k^* - k_{aft}\big)\frac{k_{bfr}}{k_{aft}}A_{bfr}$$

$$= \beta\big(k^* - k_{aft}\big)\frac{k_{aft} - k_{bfr}}{k_{aft}\big(1-k_{aft}\big)}A_{bfr}$$

$TS_{aft\uparrow} - TS_{aft\downarrow} < 0$ if $k_{aft} > k^*$, and $TS_{aft\uparrow} - TS_{aft\downarrow} > 0$ if $k_{aft} < k^*$.

Thus, $SW_{aft\uparrow} > SW_{aft\downarrow}$ if $(OV_{aft\uparrow} - OV_{aft\downarrow}) > -(TS_{aft\uparrow} - TS_{aft\downarrow})$.

Appendix 6: Proof of Lemma 6

Raising equity is optimal if it $SW_{ext\uparrow} > SW_{ext\downarrow}$.

$$SW_{new} = \frac{\Delta K}{(1-\varepsilon)(K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow})}\big(K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}\big)$$

$$SW_{ext\uparrow} = (1 - \frac{\Delta K}{(1-\varepsilon)\big(K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}\big)})\big(K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}\big)$$

$$SW_{ext\downarrow} = K_{bfr} + OV_{aft\downarrow} + TS_{aft\downarrow}$$

$$Since\ A_{aft\downarrow} = \frac{K_{bfr}}{k_2}\ and\ A_{aft\uparrow} = \frac{K_{bfr} + \Delta K}{k_2}$$

$$OV_{aft\downarrow} = \frac{K_{bfr}}{K_{bfr} + \Delta K}OV_{aft\uparrow}\ and\ TS_{aft\downarrow} = \frac{K_{bfr}}{K_{bfr} + \Delta K}TS_{aft\uparrow}$$

Thus, $SW_{ext\uparrow} > SW_{ext\downarrow}$ if:

$$1 - \frac{\Delta K}{(1-\varepsilon)\big(K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}\big)} > \frac{K_{bfr} + OV_{aft\downarrow} + TS_{aft\downarrow}}{K_{bfr} + \Delta K + OV_{aft\uparrow} + TS_{aft\uparrow}}$$

Solving for ε,

$$\varepsilon < 1 - \frac{\Delta K}{\Delta K + (OV_{aft\uparrow} - OV_{aft\downarrow}) + (TS_{aft\uparrow} - TS_{aft\downarrow})}$$

$$= \frac{(OV_{aft\uparrow} - OV_{aft\downarrow}) + (TS_{aft\uparrow} - TS_{aft\downarrow})}{\Delta K + (OV_{aft\uparrow} - OV_{aft\downarrow}) + (TS_{aft\uparrow} - TS_{aft\downarrow})}$$

$$= \frac{\frac{\Delta K}{K_{bfr} + \Delta K}(OV_{aft\uparrow} + TS_{aft\uparrow})}{\Delta K + \frac{\Delta K}{K_{bfr} + \Delta K}(OV_{aft\uparrow} + TS_{aft\uparrow})} = \frac{OV_{aft\uparrow} + TS_{aft\uparrow}}{K_{aft} + OV_{aft\uparrow} + TS_{aft\uparrow}}$$

The magnitude of undervaluation that reduces $SW_{ext\uparrow}$ to $SW_{ext\downarrow}$ is: $\varepsilon(K_{aft} + OV_{aft\uparrow} + TS_{aft\uparrow}) = OV_{aft\uparrow} + TS_{aft\uparrow}$.

Therefore, raising equity is the optimal strategy if the magnitude of undervaluation is smaller than $OV_{aft\uparrow}$ + $TS_{aft\uparrow}$.

References

Alfon, I., Andrews, P. (1999). Cost-Benefit Analysis in Financial Regulation, *Journal of Financial Regulation and Compliance* 7 (4), 339-352. https://doi.org/10.1108/eb025021

Almenberg, Johan, Markus Andersson, Daniel Buncic, Cristina Cella, Paolo Giordani, Anna Grodecka, Kasper Roszbach, and Gabriel Söderberg. (2017). Appropriate capital ratios in major Swedish banks – new perspectives, Sveriges Riksbank Staff Memo. https://www.riksbank.se/globalassets/media/rapporter/staff-memo/engelska/2017/staff_memo_170519_eng.pdf

Angelini, P., L. Clerc, V Curdia, L. Gambacorta, A. Gerali, A Locarno, R. Motto, W. Roeger, S. Van den Heuvel, and J. Vicek. (2011). Basel III: Long-term Impact on Economic Performance and Fluctuations, *BIS Working Papers* No. 338. https://doi.org/10.1111/manc.12056

Basel Committee on Bank Supervision. (2010). An Assessment of the Long-Term Economic Impact of Stronger Capital and Liquidity Requirements, *Bank for International Settlements Working Paper*.

Basel Committee on Banking Supervision. (2019). The costs and benefits of bank capital – a review of the literature, *Bank for International Settlements Working Paper*.

Chan, Yuk-Shee, Stuart I. Greenbaum, and Anjan V. Thakor. (1992). Is Fairly Priced Deposit Insurance Possible? *Journal of Finance* 47 (1), 227-245. https://doi.org/10.1111/j.1540-6261.1992.tb03984.x

Cline, William R. (2017). The right balance for banks: Theory and evidence on optimal capital requirements, Columbia University Press. https://lccn.loc.gov/2016035251

Elyasiani, Elyas and Lawrence G. Goldberg. (2004). Relationship Lending: A Survey of the Literature, *Journal of Economics and Business* 56 (4), 315-30. https://doi.org/10.1016/j.jeconbus.2004.03.003

Goodhart, Charles A.E., Anil K. Kashyap, Dimitrios P. Tsomocos, and Alexandro P. Vardoulakis. (2011). Financial Regulation in General Equilibrium, *Working Paper*, University of Chicago. https://www.nber.org/papers/w17909

Hanson, Samuel G., Anil K. Kashyap, and Jeremy C. Stein. (2011). A Macroprudential Approach to Financial Regulation, *Journal of Economic Perspectives* 25 (1), 3-28. https://doi.org/10.1257/jep.25.1.3

Kashyap, Anil K., Jeremy C. Stein, and Samuel G. Hanson. (2010). An Analysis of the Impact of 'Substantially Heightened' Capital Requirements on Large Financial Institutions, *Working Paper*, University of Chicago. https://scholar.harvard.edu/files/stein/files/impact_of_substantially_heightened.pdf

Merton, Robert C. (1977). An analytic derivation of the cost of deposit insurance and loan guarantees, *Journal of Banking and Finance* 1 (1), 3–11. https://doi.org/10.1016/0378-4266(77)90015-2

Modigliani, Franco and Merton H. Miller. (1958). The Cost of Capital, Corporation Finance and the Theory of Investment, *The American Economic Review* 48 (3), 261-297. http://www.jstor.org/stable/1809766

Myers, Stewart C. and Nicholas S. Majluf. (1984). Corporate financing and investment decisions when firms have information that investors do not have, *Journal of Financial Economics*, 13(2), 187–221. https://doi.org/10.1016/0304-405X(84)90023-0

Park, Sangkyun. (1996). Banking and Deposit Insurance as a Risk-Transfer Mechanism, *Journal of Financial Intermediation* 5 (3), 284-304. https://doi.org/10.1006/jfin.1996.0016

Park, Sangkyun. (1997). Risk-taking behavior of banks under regulation, *Journal of Banking and Finance* 21(4), 491–507. https://doi.org/10.1016/S0378-4266(96)00050-7

Park, Sangkyun. (2002). Put Option Values of Thrifts in the 1980s: Evidence from Thrift Stock Reactions to the FIRREA, *Journal of Financial and Quantitative Analysis* 37(1), 157-176. https://doi.org/10.2307/3594999

Van den Heuvel, Skander J. (2008). The Welfare Cost of Bank Capital Requirements, *Journal of Monetary Economics* 55 (2), 298-320. https://doi.org/10.1016/j.jmoneco.2007.12.001